NEMA STANDARDS PUBLICATION NO. ICS 4

nema

# Industrial Control and Systems Terminal Blocks

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ■ 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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# NEMA Standards Publication No. ICS 4-1993

*TERMINAL BLOCKS*

*Published by*

**National Electrical Manufacturers Association**
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# FOREWORD

This Standards Publication was prepared by a technical committee of the NEMA Industrial Control and Systems Section. It was approved in accordance with the bylaws of NEMA and supersedes the indicated NEMA Standards Publication. This Standards Publication supersedes ICS 4-1983 (R 1988).

This Standards Publication provides practical information concerning ratings, construction, test, performance and manufacture of industrial control equipment. These standards are used by the electrical industry to provide guidelines for the manufacture and proper application of reliable products and equipment and to promote the benefits of repetitive manufacturing and widespread product availability.

NEMA Standards represent the result of many years of research, investigation and experience by the members of NEMA, its predecessors, its Sections and Committees. They have been developed through continuing consultation among manufacturers, users and national engineering societies and have resulted in improved serviceability of electrical products with economies to manufacturers and users.

One of the primary purposes of this Standards Publication is to encourage the production of reliable control equipment which, in itself, functions in accordance with these accepted standards. Some portions of these standards, such as electrical spacings and interrupting ratings, have a direct bearing on safety; almost all of the items in this publication, when applied properly, contribute to safety in one way or another.

Properly constructed industrial control equipment is, however, only one factor in minimizing the hazards which may be associated with the use of electricity. The reduction of hazard involves the joint efforts of the various equipment manufacturers, the system designer, the installer and the user. Information is provided herein to assist users and others in the proper selection of control equipment.

The industrial control manufacturer has limited or no control over the following factors which are vital to a safe installation:

a. Environmental conditions
b. System design
c. Equipment selection and application
d. Installation
e. Operating practices
f. Maintenance

This publication is not intended to instruct the user of control equipment with regard to these factors except insofar as suitable equipment to meet needs can be recognized in this publication and some application guidance is given.

This Standards Publication is necessarily confined to defining the construction requirements for industrial control equipment and to providing recommendations for proper selection for use under normal or certain specific conditions. Since any piece of industrial control equipment can be installed, operated and maintained in such a manner that hazardous conditions may result, conformance with this publication does not by itself assure a safe installation. When, however, equipment conforming with these standards is properly selected and is installed in accordance with the National Electrical Code and properly maintained, the hazards to persons and property will be reduced.

To continue to serve the best interests of users of Industrial Control and Systems equipment, the Industrial Control and Systems Section is actively cooperating with other standardization organizations in the development of simple and more universal metrology practices. In this publication, the U.S. customary units are gradually being supplemented by those of the modernized metric system known as the

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International Systems of Units (SI). This transition involves no changes in standard dimensions, tolerances, or performance specifications.

NEMA Standards Publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress. Users should secure the latest editions. See the postal return card attached to the front cover of the Standards Publication for the proper procedure to obtain revision service for your copy of the publication.

Proposed revisions to this Standards Publication should be submitted to:

Vice President, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, D.C. 20037

## INTRODUCTION

The standards pertaining to terminal blocks in NEMA Standards Publication ICS 4 are subdivided into the following clauses:

1 General
  Referenced Standards
  Scope
  Normative References
2 Definitions
  Terms which supplement the IEC International Electrical Vocabulary (IEV 441) or assist in clarifying the product standard.
3 Classification
  Product classifications where they have been established.
4 Characteristics and Ratings
  Descriptions of the kinds of ratings applicable to the product and tables of standard ratings for the product where they have been established.
5 Product Marking, Installation and Maintenance Information
  Product information to be provided to assist the user in the installation, use and maintenance of the devices.
6 Service and Storage Conditions
  A description of service and storage conditions for which the devices are intended.
7 Construction
  Marking, color coding and similar production requirements to be incorporated into the product as manufactured, as well as production test requirements where they have been established, i.e., the rules that the manufacturer follows in producing the product.
8 Performance Requirements and Tests
  The performance required to pass each design test specified for the product.
9 Application
  Information and performance considerations of importance to those who specify or use the product.

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The standards for the products included within the scope of the Industrial Control and Systems Section are organized as follows:

NEMA Standards Title
Publication No.

**ICS 1-1993** Industrial Control and Systems
General Requirements

**ICS 2-1993** Industrial Control and Systems
Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC

**Part 1:** *General Standards for Manual and Magnetic Controllers*
**Part 2:** *AC Noncombination Magnetic Motor Controllers, Rated 600 Volts*
**Part 3:** *Nonmagnetic Motor Controllers*
**Part 4:** *Overload Relays*
**Part 5:** *DC General-Purpose Constant-Voltage Controllers*
**Part 6:** *AC Combination Motor Controllers*
**Part 7:** *Magnetic Lighting Contactors*

**ICS 3-1993** Industrial Control and Systems
Factory-built Assemblies

**Part 1:** *Motor Control Centers Rated Not More Than 600 Volts AC*
**Part 2:** *Medium Voltage Controllers Rated 2001 to 7200 Volts AC*
**Part 3:** *AC General-Purpose Controllers for Synchronous Motors*

**ICS 4-1993** Industrial Control and Systems
Terminal Blocks

**ICS 5-1993** Industrial Control and Systems
Control Circuit and Pilot Devices

**Part 1:** *General Standards for Control Circuit and Pilot Devices*
**Part 2:** *Industrial Control Relays*
**Part 3:** *Industrial Control Input Devices Actuated by Force, Temperature and Pressure*
**Part 4:** *Proximity Switches*
**Part 5:** *Pushbuttons, Selector Switches, Indicating Lights and Pushbutton Stations*

**ICS 6-1993** Industrial Control and Systems
Enclosures

**ICS 7-1993** Industrial Control and Systems
Adjustable Speed Drives

**Part 1:** *General Standards for Drive Converters, Drives, and Drive Systems*
**Part 2:** *Loop Position and Tension Control Drive Systems*
**Part 3:** *Wind and Unwind Drive Systems*
**Part 4:** *Variable-Frequency, Three-Phase Controllers, Rated Not More Than 600 Volts*
**Part 5:** *Adjustable-Voltage Packaged-Drive Systems (Where DC Armature Power Is Obtained from AC Lines Using Controlled Semiconductor Rectifiers)*
**Part 6:** *Variable-Frequency Drive Systems Rated Not More Than 600 Volts Using Semiconductor Power Conversion*
**Part 7:** *Variable-Frequency. Three-Phase Drives, Rated 601 to 7,200 Volts*

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**ICS 8-1993** Industrial Control and Systems
Crane and Hoist Controllers

- **Part 1:** *General Standards for Crane Controllers Rated 600 Volts or Less AC and DC*
- **Part 2:** *Constant-Voltage DC Magnetic Controllers for Motors on Cranes*
- **Part 3:** *Adjustable-Voltage DC Controllers for Motors on Cranes*
- **Part 4:** *Magnetic Controllers for AC Wound-Rotor Motors on Cranes*
- **Part 5:** *Static Controllers for AC Wound-Rotor Motors on Cranes*
- **Part 6:** *Crane and Hoist Power-Circuit Limit Switches*
- **Part 7:** *Heavy-Duty DC Magnetic Contactors Rated 600 Volts*

**ICS 9-1993** Industrial Control and Systems
Power Circuit Accessories

- **Part 1:** *Electromagnetic Brakes*
- **Part 2:** *Resistors and Rheostats*
- **Part 3:** *Autotransformers and Reactors*

**ICS 10-1993** Industrial Control and Systems
AC Transfer Switch Equipment

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# 1 General

## 1.1 Referenced Standards

The following standards contain provisions which, through reference in this text, constitute provisions of this NEMA Standard Publication. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

**National Electrical Manufacturers Association**
2101 L Street, NW Suite 300
Washington, DC 20037

| | |
|---|---|
| ICS 1-1993 | *Industrial Control and Systems (General Requirements)* |
| ICS 1.3-1986 (R1991) | *Preventive Maintenance of Industrial Control and Systems Equipment* |

**International Electrotechnical Commission**
1, rue de Varembe
Geneva, Switzerland

| | |
|---|---|
| IEV 441 | *International Electrical Vocabulary* |

## 1.2 Scope

This standard applies to terminal blocks with screw-type or screwless-type clamping units intended for industrial use, and to be fixed to a support to provide electrical and mechanical connection for the following round, solid, or stranded conductors:

Copper conductors only, without special preparation, having a cross section of 24 AWG to 2000 MCM (0.2 to 1014 $mm^2$).

Aluminum (uncoated) conductors only, without special preparation, having a cross section of 12 AWG to 6 AWG (2.5 to 16 $mm^2$) for solid conductors and of 12 AWG to 2000 MCM (3.3 to 1014 $mm^2$) for stranded conductors.

Aluminum (uncoated) and copper conductors, without special preparation, having a cross section of 12 AWG to 6 AWG (2.5 to 16 $mm^2$) for solid conductors and of 12 AWG to 2000 MCM (3.3 to 1014 $mm^2$) for stranded conductors.

The terminal blocks are intended for use in circuits of rated insulation voltage not exceeding 1000 volts AC at a frequency not greater than 60 hertz, or not exceeding 1500 volts DC.

This standard does not apply to connectors which are specifically designed for, and forming, an integral part of equipment and are dealt with in the relevant equipment standards.

NOTE: This standard may be used as a guide for the termination requirements for disconnect type or other special terminal blocks for which there is no standard at this time.

## 1.3 Normative References

The definitions and standards of ICS 1 apply to this publication unless otherwise stated.

# 2 Definitions

For the purpose of this standards publication the following definitions apply:

**clamping unit:** The part(s) of a terminal necessary for the mechanical clamping and the electrical connection of the conductor(s).

**clearance:** The distance between two conductive parts along a string stretched the shortest way between these conductive parts.

**connecting capability:** A range or number, or both, of connectable conductor cross-sections for which the terminal block is designed.

**creepage distance:** The shortest distance along the surface of an insulating material between two conductive parts.

A joint between two pieces of insulating material is considered part of the surface.

**rated cross section:** A value of connectable conductor cross section, stated by the manufacturer and to which certain thermal, mechanical, and electrical requirements are referred.

**rated insulation voltage:** The value of voltage - $U_i$ - stated by the manufacturer by which the terminal block is designated and to which the electrical tests, clearance and creepage distances are referred.

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**screw-type terminal:** A terminal for the connection and subsequent disconnection of a conductor or the interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of screws or nuts of any kind.

**screwless-type terminal:** A terminal for the connection and subsequent disconnection of a conductor or the interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of springs, wedges, eccentrics or cones.

**special preparation (of conductor end):** Alteration of the manufactured shape or surface of the conductor to enable it to be connected to the terminal.

**terminal:** A conductive part of a device, provided for electrical connection to external circuits.

**terminal assembly:** One or more terminals fixed to the same conductive part.

**terminal block:** An insulating part carrying one or more mutually insulated terminal assemblies and intended to be fixed to a support.

**terminal insulator:** An insulating part intended for maintaining in position or for covering live parts.

## 3 Classification

Distinction is made between various types of terminal blocks according to:

a. Method of fixing the terminal blocks to a support

b. Number of terminal assemblies

c. Type of terminals, for example, screw-type terminals and screwless-type terminals

d. Ability to receive conductors having particular terminations, for example, cable lugs

e. Terminal assemblies with identical or dissimilar clamping units

f. Number of terminals on each terminal assembly

g. Service conditions

h. Terminal blocks, suitable for the connection of copper conductor only (marked CU)

i. Terminal blocks, suitable for the connection of aluminum conductors only (marked AL)

j. Terminal blocks, suitable for the connection of aluminum conductors as well as copper conductors (marked AL-CU)

## 4 Characteristics and Ratings

The terminal block shall be rated in terms of maximum cross section of a single 75°C insulated conductor.

## 5 Product Marking, Installation and Maintenance Information

### 5.1 Product Information

#### 5.1.1 Connecting Capacity

The manufacturer shall state the types of conductors that can be connected, and their maximum and minimum cross sections, if applicable. Also stated is the number of such conductors simultaneously connectable to each terminal, while maintaining the spacing requirements of 7.4.

#### 5.1.2 Mandatory Product Information

A terminal block shall be marked in a permanent and legible manner with:

a. The name of the manufacturer or trademark by which he may be readily identified

b. A type reference to enable identification and the procurement of relevant information

The following product information shall be marked either on the terminal block or contained in the manufacturer's data sheet or on the smallest packing unit:

a. The rated cross section and the thermal rating of the conductor, if other than 75°C

NOTE: Tests in this standard are based on conductor ratings corresponding to 75°C thermal insulation rating and 30°C ambient. Results are also applicable to conductors of the same cross section and any higher thermal insulation rating.

b. The connecting capacity, including the type and number of conductors simultaneously connectable

c. The tightening torque values for the clamping screws

d. Rated insulation voltage

f. Service conditions if different from those stated in ICS 1, Part 6

g. Marking "Cu" for terminal blocks used for copper conductors only

h. Marking "Al" for terminal blocks used for aluminum conductors only

i. Marking "Al-Cu" for terminal blocks which are suitable for the connection of aluminum or copper conductors

### 5.2 Maintenance

See NEMA Standards Publication ICS 1.3 for general maintenance instructions.

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## 6 Service and Storage Conditions

See NEMA Standards Publication ICS 1, Clause 6 for standard service and storage conditions.

## 7 Construction

### 7.1 Terminal Assemblies

#### 7.1.1 Mechanical and Electrical Connection of Conductors

The terminal assembly shall allow the conductors to be connected by means that ensure reliable mechanical and electrical connection. The construction of the terminal blocks shall not allow the conductors attached to the terminals, the terminals themselves, or the terminal assemblies to be displaced in a manner detrimental to the insulation. Likewise, under the above conditions, the construction shall not allow a reduction of clearance or creepage distance, or both. The terminal shall be able to withstand the forces that can be applied through the connected conductors under the condition of 8.4.4 and 8.4.5.

#### 7.1.2 Terminal Assembly Material

The main current carrying parts of a terminal shall be of copper or copper alloy, aluminum or aluminum alloy, or steel. The steel shall be coated with an electrically conductive coating that will inhibit oxidation and corrosion.

#### 7.1.3 Protective Coating of Terminal Assembly

All combinations of terminal assembly and conductor materials shall have a protective coating, except the following combinations need not be coated:

a. Aluminum or aluminum alloy terminal assemblies used only for the connection of aluminum conductors

b. Copper or copper alloy terminal assemblies used only for the connection of copper conductors

Where protective coating is necessary, tin coating is acceptable for all combinations of terminal assemblies, including the clamping screws.

#### 7.1.4 Clamping of Conductors

Terminal assemblies shall be so designed that contact pressure is not transmitted through insulating material.

### 7.2 Mounting Means

Terminal blocks shall be provided with means that allow them to be securely attached to a rail or a mounting surface. Tests shall be made in accordance with 8.4.1.

### 7.3 Identification

A terminal block shall be permitted to have provisions for identification marks or numbers for each terminal or terminal assembly to be related to the circuit of which it is to form a part.

### 7.4 Clearance and Creepage Distances

Clearances and creepage distances shall be in accordance with ICS 1, Clause 7. For information regarding verification of clearances by testing, see ICS 1, Annex A.

Clearance and creepage distances shall be determined with the terminal blocks installed and connected according to the instruction of the manufacturer and for the most unfavorable combination of conductor cross sections.

## 8 Performance Requirements and Tests

### 8.1 Design (Type) Tests, General

Design or type tests are performed on terminal blocks of each design to determine compliance with the standard.

A particular design of terminal block, having one or more terminal assemblies, shall be permitted to be manufactured. Unless otherwise specified, terminal blocks with any number of terminal assemblies are permitted to be submitted for the tests.

For a range of terminal sizes of similar design the largest, smallest, and 2 intermediate sizes shall be tested; except that for a range of 3 terminal sizes, the largest and the smallest, and for ranges of 4 and 5 sizes, the largest, smallest and one intermediate size, need only be tested. A range of terminals is similar if all have the following common features:

a. Shape of terminal, shape of conductor opening and the shape of wire clamping screw

b. Material and coating of terminal body

c. Material of wire clamping screw

d. Quantity of clamping screws

### 8.2 Test Conditions

#### 8.2.1 Test Conductors

The stranding and construction for stranded copper and aluminum conductors shall be as given in Table 8-1.

Copper test conductors shall be soft annealed and uncoated.

The aluminum test conductors for terminals designated Al or Al-Cu shall be uncoated insulated aluminum conductors with the following characteristics:

a. Tensile strength: 14,000–17,000 psi (approximately 98–118 $N/mm^2$)

b. Elongation: 10 percent minimum

c. Specific resistance at 20°C: 17.01 ohm-circular mil/ft (0.0283 ohm-$mm^2$/M)

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### 8.2.2 Conductor Ends

Sufficient length of insulation shall be removed to enable a proper connection to be made. There shall be no mechanical removal or chemical treatment of the oxide surface from the conductor entering the clamping unit. However, oxide surface shall be removed at the points to which measuring leads are attached for the voltage drop test.

### 8.2.3 Terminal Block Mounting

Terminal blocks shall be mounted on a horizontal surface, using the mounting means provided, such as screwed to a flat surface or mounted on a rail.

**Table 8-1**
**STRANDED TEST CONDUCTOR FOR COPPER AND ALUMINUM**

| Conductor Cross Section | | | Conductor Material | |
|---|---|---|---|---|
| AWG/MCM | ($mm^2$) Approv. | Number of Strands | Copper | Aluminum |
| 24 AWG | ... | 7 | A | ... |
| 22 | ... | 7 | A | ... |
| 20 | (0.52) | 10 | A | ... |
| 18 | (0.82) | 16 | A | ... |
| 16 | (1.3) | 26 | A | ... |
| 14* | (2.1) | 7 | A | ... |
| 12* | (3.31) | 7 | A | A |
| 10* | (5.26) | 7 | A | A |
| 8 | (8.37) | 7 | A | A |
| 6 | (13.3) | 7 | A | A |
| 4 | (21.1) | 7 | A | A |
| 2 | (33.6) | 7 | A | B |
| 0 | (53.5) | 19 | A | B |
| 00 | (67.4) | 19 | A | B |
| 000 | (85.0) | 19 | A | B |
| 0000 | (107.0) | 19 | A | B |
| 250 MCM | (127.0) | 37 | A | B |
| 300 | (152.0) | 37 | A | B |
| 350 | (177.0) | 37 | A | B |
| 500 | (253.0) | 37 | A | B |
| 600 – 1000 | (304.0 – 507.0) | 61 | A | B |
| 1250 – 1500 | (634.0 –760.0) | 91 | A | A |
| 1750 – 2000 | (887.0 –1014) | 127 | A | A |

A = Concentric or compressed

B = Compact, unidirectional lay

*10 - 14 AWG to be tested with solid wire also

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### 8.2.4 Condition of Unit under Test

Unless specified otherwise, terminal blocks are tested new and in a clean condition.

### 8.2.5 Ambient Temperature

The ambient temperature during the tests shall be $20 \pm 5^{\circ}C$ unless specified otherwise.

### 8.2.6 Adjustments

For all tests, except those performed in 8.4.2.2, there shall be no readjustment or retightening of the pressure screw after it initially has been tightened to the specified torque.

### 8.3 Test Sequence

Tests shall be performed in the sequence shown in Table 8-2. Each test series is to be performed in sequence on all test samples without adjustment.

### 8.4 Type Tests

### 8.4.1 Mounting Secureness

#### 8.4.1.1 Test Samples

This test requires one terminal block with the least number of terminal assemblies. The sample used for this test shall not be used for any other tests.

#### 8.4.1.2 Test Procedure

A terminal block with the least number of terminal assemblies is mounted by its normal mounting means, either on a steel plate or on the mounting rail provided by the manufacturer. A steel pin of 6 inches (150 mm) length and a diameter as specified in Table 8-3 is clamped in the clamping unit on each side of the terminal block. A force given in Table 8-3 is applied gradually (without shock) at a distance of 4 inches (100 mm) from the center to the clamping unit, once in each direction, alternately on either side of the terminal, as shown in Figure 8-1.

#### 8.4.1.3 Test Criteria

When tested in accordance with 8.4.1.2 the terminal block shall not disengage from its mounting means, nor suffer any other damage.

### 8.4.2 Clamping Unit and Terminal Assembly Test

#### 8.4.2.1 Test Samples

This test requires two terminal assemblies mounted in a terminal block(s). The samples used for this test shall not be used for any other tests.

#### 8.4.2.2 Test Procedure

Two separate terminal assemblies are required for this test; one terminal assembly for the maximum rated cross section conductor, and one terminal assembly for the minimum cross section conductor.

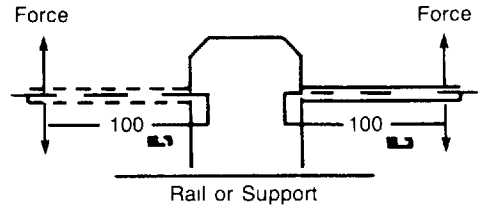



**Figure 8-1**
**VERIFICATION OF ATTACHMENT**

The terminal block shall be mounted by its normal mounting means. A conductor of the maximum rated cross section shall be inserted in the terminal assembly and a conductor of the smallest cross section of the connecting capacity (if specified) shall be inserted in another terminal assembly, and the clamping screws tightened to 110 percent of the torque specified by the manufacturer.

The clamping screws shall then be unscrewed and new conductors shall be inserted, and the screws tightened again to 110 percent. The test shall be repeated five times using the same clamping units and five new conductors for each terminal. In the case of screwless-type terminal blocks which employ clamping springs, the conductors are connected and disconnected according to the manufacturer's instructions.

#### 8.4.2.3 Test Criteria

When the terminal assembly is tested in accordance with 8.4.2.2, the conductor ends shall not be cut off or damaged in any way. No damage shall have occurred to the terminal assemblies, the terminal block or the mounting means.

### 8.4.3 Voltage Drop Test

#### 8.4.3.1 Test Samples

Two terminal assemblies in a terminal block(s) shall be the test samples for the conductor and terminal secureness test sequence shown in Table 8-2.

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**Table 8-2**
**TEST SEQUENCES**

| Seq. No. | Sample Idt. | Qty. | Test | Ref. | Notes |
|---|---|---|---|---|---|
| 1 | A | 1 | Mounting secureness | 8.4.1 | |
| 2 | B,C | 2 | Clamping unit and terminal assembly | 8.4.2 | (1) |
| 3 | D,E | 2 | Conductor and terminal secureness series | — | (2) |
| 3a | D,E | 2 | Initial voltage drop | 8.4.3 | |
| 3b | D,E | 2 | Secureness | 8.4.4 | |
| 3c | D,E | 2 | Pull | 8.4.5 | |
| 3d | D,E | 2 | Final voltage drop | 8.4.3 | |
| 4 | F | 1 | Temperature rise series | — | (3) |
| 4a | F | 1 | Initial voltage drop | 8.4.3 | |
| 4b | F | 1 | Temperature rise | 8.4.6 | |
| 4c | F | 1 | Final voltage drop | 8.4.3 | |
| 4d | F | 1 | Dielectric | 8.4.7 | |
| 5 | G,H | 2 | Current cycling | 8.4.8 | (4) |
| 6 | J | 1 | Material (brass w/less than 80% Cu) | 8.4.9 | (5) |
| 7 | K | 1 | Material (thermoplastic insulation parts) | 8.4.10 | (6) |

Notes:

1. Sample not to be used for any other tests.

2. Sequence No. 3 consists of tests listed as sequence Nos. 3a, 3b, 3c, and 3d.

3. Sequence No. 4 consists of tests listed as sequence Nos. 4a, 4b, 4c, and 4d, using three adjacent terminal assemblies of the same block.

4. Applies only to aluminium body terminals or terminals designated as suitable for use with aluminum or aluminum alloy conductors.

5. Applies only to brass posts containing less than 80% copper.

6. Applies only to insulating parts maade of thermoplastic material.

#### 8.4.3.2 Test Procedure

The voltage drop is measured at the points indicated in Figure 8-2. The test is made with DC equal to 0.1 times the value of the test current corresponding to the cross section of the conductor, as specified in Table 8-4.

Once the clamping screws are tightened to the torque specified by the manufacturer, there shall be no readjustment or retightening of the pressure screws during the complete sequence of tests specified in Table 8-2.

#### 8.4.3.3 Test Criteria

The voltage drop for the initial voltage drop test shall not exceed 3.2 millivolts. The voltage drop for the final voltage drop test shall not exceed 4.8 millivolts.

### 8.4.4 Secureness Test

#### 8.4.4.1 Test Samples

Two terminal assemblies in a terminal block(s) shall be the test samples for the sequence of tests shown in Table 8-2.

#### 8.4.4.2 Test Procedure

Two separate terminal assemblies are required for this test.

For a clamping unit rated to accept a range of single conductors, the maximum rated cross section conductor shall be tested in one of the terminal assemblies and the

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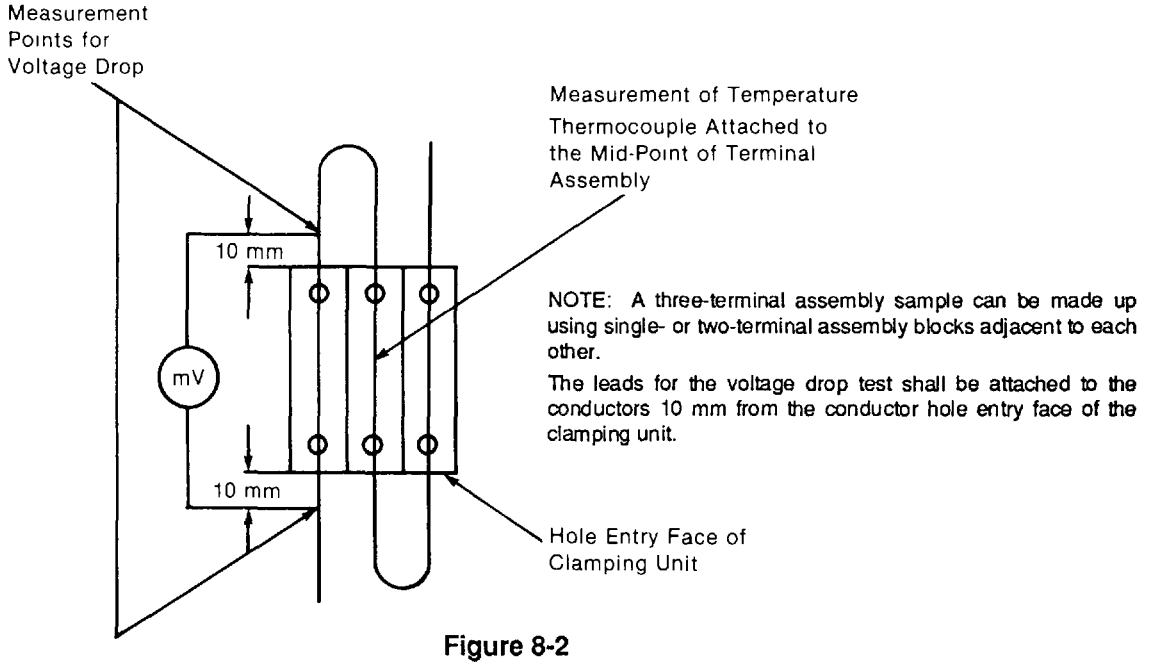



**Figure 8-2**
**ARRANGEMENT FOR VOLTAGE-DROP AND TEMPERATURE RISE MEASUREMENTS**

minimum cross section conductor shall be tested in the second terminal assembly.

For a clamping unit rated to accept more than one conductor, simultaneously, in the same opening, one terminal assembly shall be tested with a combination of a minimum and a maximum rated cross section conductor, with the tests being performed on the conductor with the minimum cross section only.

The second terminal assembly shall be tested with a combination of the maximum rated cross section conductors, with the tests being performed on one of the conductors only.

A length of conductor of a rated cross section at least 3 inches (76 mm) longer than the height specified in Table 8-5, shall be connected to one terminal assembly and a suitable length to the other side of the same terminal assembly. The clamping screws shall be tightened to the torque specified by the manufacturer. For screwless-type clamping units the conductor shall be attached as specified by the manufacturer. Leads for the measurement of voltage drop shall be attached as shown in Figure 8-2.

The terminal block shall be secured as shown in Figure 8-3.

**Table 8-3**
**ATTACHMENT TEST PARAMETERS**

| Rated Cross Section of Terminal Block | | Force | | Diameter of Pin | |
|---|---|---|---|---|---|
| AWG/MCM | ($mm^2$) | Lb | (N) | In. | (mm) (Approximate) |
| 24 to 12 AWG | (0.2 to 0.4) | 0.22 | (1) | 0.04 | (1.0) |
| 10 to 6 | (5 to 16) | 1.1 | (5) | 0.11 | (2.8) |
| 4 to 2/0 | (20 to 70) | 2.25 | (10) | 0.22 | (5.7) |
| 3/0 to 350 MCM | (95 to 185) | 3.37 | (15) | 0.50 | (12..8) |
| 400 to 1000 | (200 to 510) | 4.50 | (20) | 0.81 | (20.5) |
| 1250 to 2000 | (600 to 1014) | 5.62 | (25) | 1.0 | (25.4) |

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## Table 8-4
## TEST CURRENTS CORRESPONDING TO CROSS SECTION OF CONDUCTOR

| Rated Cross Section | | Test Currents Amperes | |
|---|---|---|---|
| AWG/MCM | ($mm^2$) | Copper Conductor | Aluminum Conductor |
| 24 AWG | (0.2) | 1.8 | ... |
| 22 | (0.33) | 3.0 | ... |
| 20 | (0.52) | 4.6 | ... |
| 18 | (0.82) | 7.3 | ... |
| 16 | (1.3) | 11.6 | ... |
| 14 | (2.1) | 18.4 | ... |
| 12 | (3.31) | 26.0 | 22.0 |
| 10 | (5.26) | 35.0 | 29.5 |
| 8 | (8.37) | 46.5 | 39.0 |
| 6 | (13.3) | 62.0 | 52.0 |
| 4 | (21.1) | 83.0 | 67.0 |
| 3 | (26.7) | 96.0 | 76.0 |
| 2 | (33.6) | 110.0 | 87.0 |
| 1 | (42.4) | 130.0 | 100.0 |
| 0 | (53.5) | 150.0 | 115.0 |
| 00 | (67.4) | 172.0 | 135.0 |
| 000 | (85.0) | 200.0 | 155.0 |
| 0000 | (107) | 235.0 | 187.0 |
| 250 MCM | (127) | 255.0 | 205.0 |
| 300 | (152) | 285.0 | 225.0 |
| 350 | (177) | 310.0 | 245.0 |
| 400 | (203) | 335.0 | 265.0 |
| 500 | (253) | 370.0 | 300.0 |
| 600 | (304) | 415.0 | 330.0 |
| 700 | (355) | 450.0 | 360.0 |
| 750 | (380) | 470.0 | 375.0 |
| 800 | (405) | 480.0 | 390.0 |
| 900 | (456) | 520.0 | 420.0 |
| 1000 | (507) | 550.0 | 440.0 |
| 1250 | (634) | 590.0 | 485.0 |
| 1500 | (760) | 620.0 | 515.0 |
| 1750 | (887) | 645.0 | 540.0 |
| 2000 | (1014) | 665.0 | 560.0 |

The value of the test current corresponding to the rated standard cross section of the conductor is given by the relationship:

$\text{Log}A = m\,\text{Log}I + c$

Where:

A = conductor cross section in $mm^2$

I = current in Amperes

The values of the constants *m* and *c* are given in Table 8-4a.

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**Table 8-4a**
**VALUES OF CONSTANTS M AND C FOR ALUMINUM AND COPPER CONDUCTORS**

| Conductor Material | Conductor Rated Cross Section $mm^2$ | Constants | |
|---|---|---|---|
| | | m | c |
| Al | 0–100 | 1.6856 | -1.7524 |
| | 101–507 | 1.7955 | -2.0437 |
| | 508–1014 | 3.2624 | -5.9597 |
| Cu | 0–2.5 | 1.0163 | -0.9664 |
| | 2.6–100 | 1.5945 | -1.7395 |
| | 101–507 | 1.8338 | -2.3165 |
| | 508-1014 | 3.9287 | -8.0839 |

The end of the length of conductor specified above shall be passed through an appropriate size bushing positioned at a height below the terminal block as given in Table 8-5. The bushing is to be positioned in a horizontal plane concentric with the conductor. The bushing is to be moved so that its center describes a circle of 3 inches (76 mm) diameter about its center line in the horizontal plane at a rate of approximately 9 rpm. The distance between the mouth of the clamping unit and the upper surface of the bushing shall be within 0.5 inch (13 mm) of the distance "height" in Table 8-5. The bushings are to be lubricated to prevent binding, twisting, or rotation of the insulated conductor. A weight as specified in Table 8-5 is to be suspended from the end of the conductor. The duration of the test shall be 30 minutes.

#### 8.4.4.3 Test Criteria

When tested in accordance with 8.4.4.2, the conductor shall not pull out of the clamping unit and the terminal assembly shall not separate from the terminal insulator.

### 8.4.5 Pull Test

#### 8.4.5.1 Test Samples

Two terminal assemblies in a terminal block(s) shall be the test samples for the sequence of tests shown in Table 8-2.

#### 8.4.5.2 Test Procedure

A pulling force corresponding to the conductor cross section given in Table 8-5 shall be applied gradually to the conductor and maintained at that value for one minute.

#### 8.4.5.3 Test Criteria

When tested in accordance with 8.4.5.2, the conductor shall not pull out of the clamping unit and the terminal assembly shall not separate from the terminal insulator.

### 8.4.6 Temperature Rise Test

#### 8.4.6.1 Test Samples

One terminal block containing three adjacent terminal assemblies is required for this sequence of tests.

#### 8.4.6.2 Test Procedure

A sample consisting of three terminal assemblies shall be connected in series, as shown in Figure 8-2, using conductors of the rated cross section.

The length of each of the four conductors shall be 3 feet (1 m) for cross sections up to and including AWG 8 (10 $mm^2$) and 6 feet (2 m) for larger cross sections. Voltage drop measuring leads shall also be attached to one of the terminal assemblies as shown in Figure 8-2.

The clamping screws of screw-type clamping units shall be tightened to the torque specified by the manufacturer.

The currents for the temperature rise test shall be in accordance with the values stated in Table 8-4.

The test sample is considered to have attained a stable temperature when three measurements taken at not less than 10-minute intervals show no more than a 2°C variation between any two of the three measurements.

The shortened current-off period ends when the test sample reaches a temperature within 2°C of room temperature.

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## Table 8-5
## VALUES FOR SECURENESS AND PULLOUT TEST

| Size of Conductors AWG or MCM | Diameter of Bushing Hole* | | Height | | Secureness Weight | | Pullout Force | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Copper | | Aluminum | |
| | Inches | mm | Inches** | mm† | Lb | Kg | Lb | N | Lb | N |
| 24 AWG | 1/4 | 6.5 | 10-1/4 | 260 | 0.66* | 0.3 | 2.25 | 10* | ... | ... |
| 22 | 1/4 | 6.5 | 10-1/4 | 260 | 0.66* | 0.3 | 4.5 | 20 | ... | ... |
| 20 | 1/4 | 6.5 | 10-1/4 | 260 | 0.66* | 0.3 | 6.75 | 30 | ... | ... |
| 18 | 1/4 | 6.5 | 10-1/4 | 260 | 1 | .45 | 6.75 | 45 | ... | ... |
| 16 | 1/4 | 6.5 | 10-1/4 | 260 | 1 | .45 | 9.0 | 45 | ... | ... |
| 14 | 3/8 | 9.5 | 11 | 279 | 1.5 | .68 | 11.5 | 45 | ... | ... |
| 12 | 3/8 | 9.5 | 11 | 279 | 2 | .9 | 13.5 | 45 | 10 | 45 |
| 10 | 3/8 | 9.5 | 11 | 279 | 3 | 1.4 | 18.0 | 45 | 10 | 45 |
| 8 | 3/8 | 9.5 | 11 | 279 | 4.5 | 2 | 20.5 | 67 | 10 | 45 |
| 6 | 1/2 | 13 | 11-3/4 | 296 | 6.5 | 3 | 21 | 94 | 28 | 125 |
| 4 | 1/2 | 13 | 11-3/4 | 296 | 10 | 4.5 | 30 | 133 | 36 | 160 |
| 3 | 9/16 | 14 | 12-1/2 | 317 | 13 | 5.9 | 35 | 156 | 42 | 187 |
| 2 | 9/16 | 14 | 12-1/2 | 317 | 15 | 6.8 | 42 | 187 | 50 | 223 |
| 1 | 5/8 | 16 | 13-1/2 | 343 | 19 | 8.6 | 53 | 236 | 61 | 271 |
| 1/0 | 5/8 | 16 | 13-1/2 | 343 | 21 | 9.5 | 64 | 285 | 72 | 320 |
| 2/0 | 3/4 | 19 | 14-1/2 | 368 | 23 | 10.4 | 64 | 285 | 78 | 347 |
| 3/0 | 3/4 | 19 | 14-1/2 | 368 | 31 | 14 | 79 | 351 | 97 | 432 |
| 4/0 | 3/4 | 19 | 14-1/2 | 368 | 31 | 14 | 96 | 427 | 116 | 516 |
| 250 MCM | 7/8 | 22 | 16 | 406 | 31 | 14 | 96 | 427 | 116 | 516 |
| 300 | 7/8 | 22 | 16 | 406 | 33 | 15 | 99 | 441 | 116 | 516 |
| 350 | 1 | 25 | 17 | 432 | 37 | 17 | 113 | 503 | 129 | 574 |
| 400 | 1 | 25 | 17 | 432 | 37 | 17 | 113 | 503 | 129 | 574 |
| 500 | 1-1/8 | 29 | 18-1/4 | 464 | 44 | 20 | 130 | 578 | 154 | 685 |
| 600 | 1-1/8 | 29 | 18-1/4 | 464 | 50 | 23 | 130 | 578 | 154 | 685 |
| 700 | 1-1/4 | 32 | 19-1/2 | 495 | 50 | 23 | 145 | 645 | 179 | 796 |
| 750 | 1-1/4 | 32 | 19-1/2 | 495 | 50 | 23 | 155 | 690 | 179 | 796 |
| 800 | 1-3/8 | 35 | 21-1/4 | 540 | 55 | 25 | 155 | 690 | 179 | 797 |
| 900 | 1-3/8 | 35 | 21-1/4 | 540 | 55 | 25 | 158 | 703 | 181 | 805 |
| 1000 | 1-1/2 | 38 | 22-1/2 | 572 | 55 | 25 | 175 | 779 | 199 | 885 |
| 1250 | 1-3/4 | 45 | 26 | 640 | 75 | 34 | 217 | 966 | 251 | 1116 |
| 1500 | 2 | 51 | 28 | 711 | 90 | 41 | 264 | 1175 | 302 | 1343 |
| 1750 | 2-1/8 | 54 | 30 | 762 | 99 | 45 | 303 | 1348 | 342 | 1521 |
| 2000 | 2-1/8 | 54 | 30 | 762 | 119 | 54 | 342 | 1522 | 382 | 1699 |

• If the bushing with the hole diameter specified is not adequate to accommodate the conductor, a bushing having the next larger hole may be used.

**For sizes 12-4 AWG aluminum, use 2-1/2 inches (317 mm)

† The tolerance on height is ±1/2 inch (12 mm)

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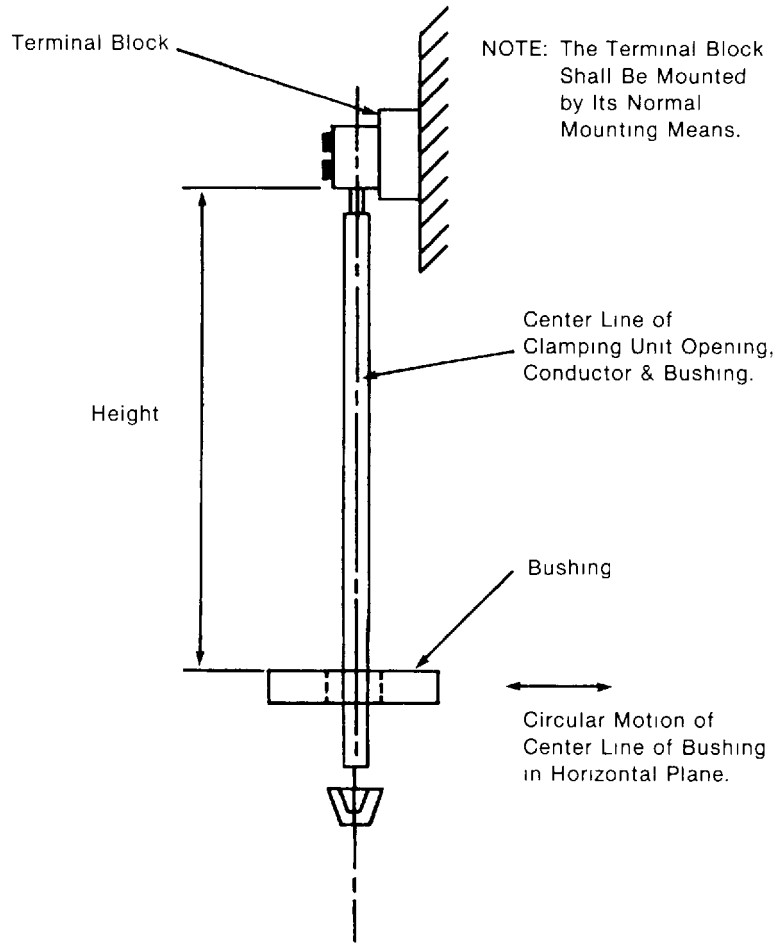



**Figure 8-3**
**ARRANGEMENT FOR THE VERIFICATION OF ATTACHMENT OF CONDUCTOR TO THE CLAMPING UNIT AND OF THE TERMINAL ASSEMBLY TO THE INSULATOR**

### 8.4.6.3 Test Criteria

When terminal blocks are tested in accordance with 8.4.6.2, the measured temperature rise of the terminal assembly shall not exceed 45°C.

### 8.4.7 Dielectric Strength

### 8.4.7.1 Test Sample

This test is to be performed on the test sample used for the temperature rise test series in the sequence shown in Table 8-2 following the final voltage drop test.

### 8.4.7.2 Test Procedure

The test sample is mounted on a sheet metal support or on a rail as in normal use.

a. The conductors which connect adjacent terminals are cut.

b. The voltage specified in Table 8-6 shall be applied for one minute, first between the adjacent terminal assemblies, and then between all the terminal assemblies connected together and the metal support or the rail, and then between the adjacent terminal assemblies

### 8.4.7.3 Test Criteria

When tested in accordance with 8.4.7.2, there shall be no dielectric breakdown during the tests.

### 8.4.8 Current-Cycling Tests

This test verifies the stability of the terminal assembly by comparing the temperature performance of the terminal assembly with that of the conductor under accelerated cycling conditions.

Combinations of terminal material and test conductors requiring a current-cycling test are shown in Table 8-7.

Terminal blocks with terminal assemblies made of various metals shall pass the current-cycling test of 8.4.8.4 using test conductor-terminal assembly combinations shown in Table 8-7 and designated by an X.

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**Table 8-6**
**DIELECTRIC TEST VOLTAGE**

| Rated Insulation Voltage $U_I$ v | Dielectric Test Voltage (AC) (rms) |
|---|---|
| $< U_I \leq 60$ | 1000 |
| $60 < U_I \leq 300$ | 2000 |
| $300 < U_I \leq 660$ | 2500 |
| $660 < U_I \leq 800$ | 3000 |
| $800 < U_I \leq 1000$ | 3500 |
| $1000 < U_I \leq 1500$* | 4000 |

* For DC only

**Table 8-7**
**TERMINAL ASSEMBLY AND CONDUCTOR COMBINATIONS WHICH REQUIRE CURRENT-CYCLING TESTS**

| Terminal Designation | Terminal Assembly Material: Aluminum or Aluminum Alloy | Terminal Assembly Material: Copper or Copper Alloy | Terminal Assembly Material: Other | Test Conductor |
|---|---|---|---|---|
| Al | X | X | X | Al |
| Al-Cu | X | X | X | Al |
| | X | ... | ... | Cu |
| Cu | X | ... | ... | Cu |

X indicates cycling test is to be performed.

**Table 8-8**
**TEST CONDUCTOR LENGTH**

| Conductor Size | Conductor Length Minimum: Inches | (mm) |
|---|---|---|
| 18–8 AWG | 8 | 203 |
| 6–3 AWG | 12 | 305 |
| 2 AWG–500 MCM | 18 | 457 |
| Larger than 500 MCM | 26 | 660 |

### 8.4.8.1 Test Samples

Two terminal assembly samples are required, each with two clamping units. The terminal assemblies are removed from the terminal block for this test.

Clamping units may be designed to employ either steel, aluminum, or brass clamping screws. Terminals with brass screws need not be subjected to the current-cycling test. Where aluminum or steel clamping screws are used, the terminals are subjected to the current-cycling test.

### 8.4.8.2 Test Conductors

Tests shall be performed using conductors of the rated cross section specified.

Tests shall be performed using the types of conductors for which the terminal block is rated, that is, solid or stranded, or solid and stranded, and using aluminum or copper, or aluminum and copper, as given in Table 8-7 and designated by an X. Separate samples shall be tested for each combination.

The insulation of the conductors shall be black.

### 8.4.8.3 Test Sample Preparation

a. The test sample shall consist of two terminal assemblies to which test conductors of the rated cross section are connected at each end as in service, in series with a control conductor of the same size. Figure 8-4 shows the arrangement, with thermal barriers.

b. The length of the test conductor from the point of entry to the terminal to the equalizer bar shall be as in Table 8-8. The length of the control conductor shall be approximately twice the length of the test conductor.

c. The insulation shall be stripped from the conductor prior to the installation. The length of the stripped end shall be sufficient to make full contact with the clamping unit and a length of 0.25 inch to 0.5 inch (6.3 to 13 mm) of exposed conductor between the conductor entry face of the clamping unit and the beginning of the insulation. If the conductor can project through the clamping unit without interference, it shall not project more than 0.25 inch (6.3 mm).

Where the manufacturer provides specific instructions for assembling the terminal to the wire, such instructions are to be followed except that the conductor is not to be brushed or abraded during or after removal of the insulation.

d. The conductor clamping screws shall be tightened to 80 percent of the torque values stated by the manufacturer. For screwless-type clamping

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units, the manufacturer's instructions shall be followed.

e. Each free end of the solid or stranded test and control conductor shall be welded or brazed to a short length of an equalizer bar of the same material as the conductor and of cross section not greater than that given in Table 8-9. All strands of the conductor shall be welded or brazed to make a thorough electrical connection with the bar.

f. The series connection of the test and control conductors shall be by means of short lengths of bars so that the distance between the conductors is 6 inches (152 mm) if thermal barriers are used, 18 inches (457 mm) if thermal barriers are not used. The bar cross section shall be the minimum necessary to provide sufficient contact area for the equalizer bar and not to exceed a current density of 1000 amperes per square inch (1.55 amperes per square millimeter) for copper and 800 amperes per square inch (1.24 amperes per square millimeter) for aluminum. See Table 8-9.

g. The equalizer to bar and to the supply conductor connections shall be made so as not to produce undesirable heating.

h. The test sample shall be suspended in free air by supporting the equalizers by nonmetallic supports so as not to subject the terminals to a tensile load. Thermal barriers, if used, shall be installed between the conductors (mid-point) and shall extend one inch (25 mm) horizontally and 6 inches (152 mm) vertically beyond the conductors. The test sample shall be located at least 24 inches (610 mm) from the floor, wall or ceiling.

**Table 8-9**
**EQUALIZER BAR DIMENSIONS**

| Range of Test Current, Amperes | Maximum Cross-Section, Inches* | |
|---|---|---|
| | 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 |

* SI equivalents of the values in Table 8-9 are:

| Inches | mm | Inches | mm | Inches | mm |
|---|---|---|---|---|---|
| 1/8 | 3.2 | 1-1/4 | 31.8 | 3 | 76.2 |
| 1/4 | 6.4 | 1-1/2 | 38.1 | 3-1/2 | 88.9 |
| 3/8 | 9.5 | 1-7/8 | 47.6 | 4 | 102.0 |
| 1/2 | 12.7 | 2 | 50.8 | 5 | 127.0 |
| 1 | 25.4 | 2-1/4 | 57.2 | | |

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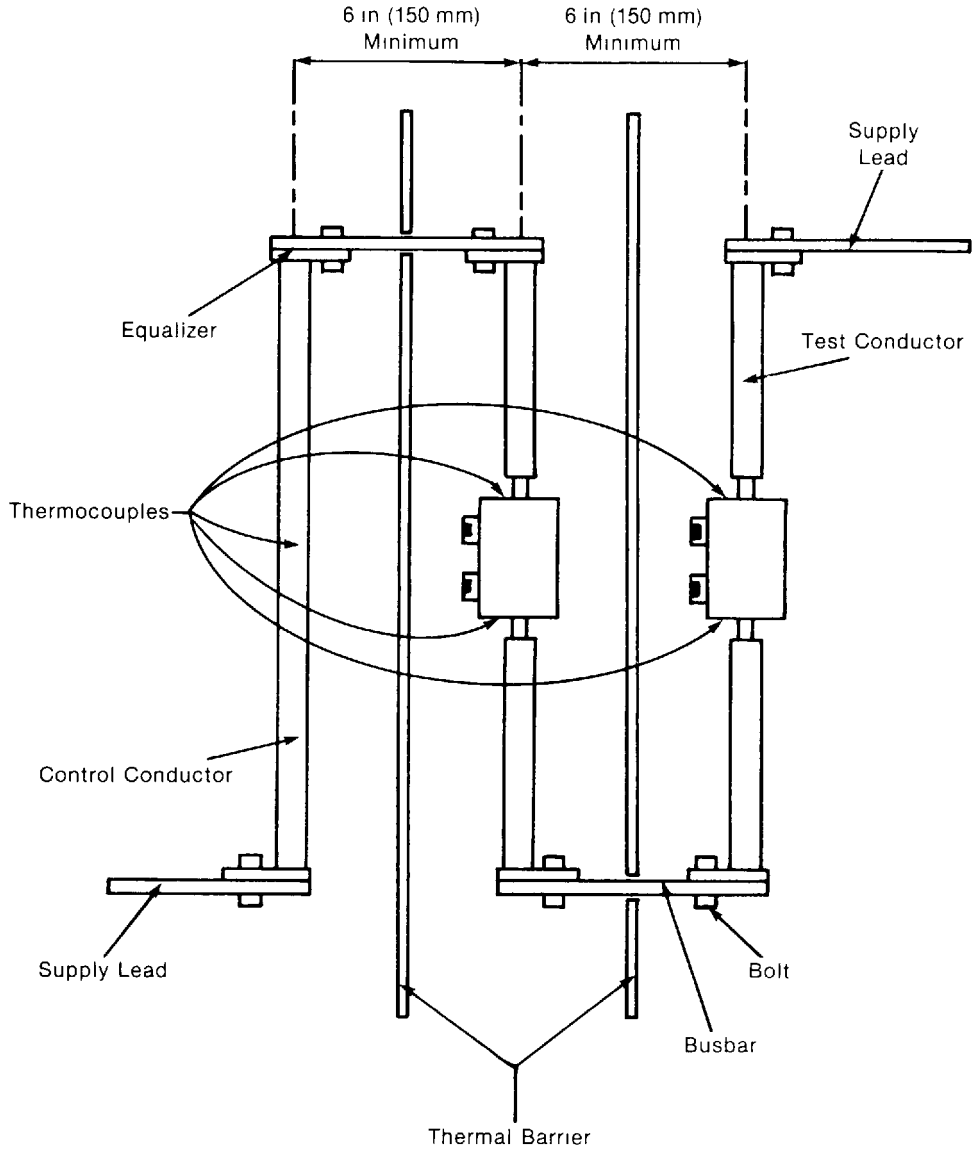



**Figure 8-4**
**ARRANGEMENT OF SAMPLE FOR THE CURRENT-CYCLING TEST**

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i. The sample shall be located in a substantially vibration and draft free location and in an ambient temperature between 15°C and 35°C.

j. The temperature of the terminal shall be measured by means of a thermocouple located on the conductor entry side of the clamping unit as close as possible to the conductor/clamping unit contact surface. The temperature of the control conductor shall be measured by a thermocouple located in the middle of the conductor and under the conductor insulation.

Thermocouple wire diameter shall be not smaller than AWG 30 (0.3 mm diameter) nor larger than AWG 24 (0.55 mm diameter). Iron-constantan is preferred.

For the control conductor, the thermocouple shall be located at the midpoint of conductor length and under the conductor insulation. The thermocouple shall be secured by soldering, by use of thermally conductive adhesive or by other equivalent means that will permit 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 of the conductor is not acceptable.

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

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

The flap of insulation is to be repositioned and secured by a tightly wrapped double layer of black thermoplastic tape extending approximately 0.5 inch (13 mm) on each side of the flap, or by another acceptable means of holding the test conductor insulation in place.

For the terminal, the thermocouple shall be located on one of the wire entry sides of the clamping unit and closest to the conductor/clamping unit contact surface.

The thermocouple is to be installed so as to obtain thermal and mechanical bonding with the surface of the terminal and without causing an appreciable change in the temperature of the terminal; for example, by peening thermocouples into small holes drilled in the terminal, or by the use of small quantities of thermally conductive adhesive.

### 8.4.8.4 Test Procedure

a. The ambient temperature shall be measured by means of two thermocouples attached to unplated copper plates approximately 2 inches (51 mm) square and 0.25 inch (6.3 mm) thick, and located 24 inches (610 mm) in front of the sample in the horizontal plane of the terminal assemblies.

b. The sample shall be subjected to 500 cycles of equal current-on and current-off operations for the periods of time and at the steady current corresponding to the conductor cross section specified in Table 8-10. Temperatures are to be recorded for at least one cycle during each work day, and after approximately 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles (key temperature measurements).

c. The stability factor "S" for each of the 11 key temperature measurements from the 25th to the 500th operation shall not exceed ±10. The temperature deviation "d" for the 11 individual temperature measurements is obtained by subtracting the associated control conductor temperature from the terminal temperature. The value of "d" is positive if the terminal temperature is higher than that of the control conductor and negative if the terminal temperature is lower.

The stability factor "S" for each of the 11 temperature measurements is to be determined by subtracting algebraically the average temperature deviation "d" from the value of the temperature deviation for the temperature measurement. See Table 8-11 for example calculation.

d. Temperatures are to be measured no sooner than the last 5 minutes of the normal current on-time. If the size of the 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.

e. The current-off time specified in Table 8-10 may be shortened, after the first 25 cycles of testing, to 5 minutes more than the maximum time it takes any terminal assembly to reach a stable temperature during the current-off period. Forced-air cooling may be employed to shorten the current-off time with the concurrence of those concerned. See paragraph f.

f. The test sample is considered to have attained a stable temperature when three measurements taken at not less than 10-minute intervals show

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## Table 8-10
## VALUES OF TEST CURRENT FOR CURRENT-CYCLING TEST

| Rated Cross Section | | Cycling Current (Amperes) | | On and Off Times (Hours) | Rated Cross Section | | Cycling Current (Amperes) | | On and Off Times (Hours) |
|---|---|---|---|---|---|---|---|---|---|
| AWG | $mm^2$ | Cu | Al | | MCM | $mm^2$ | Cu | Al | |
| 22 | .33 | 11.7 | ... | 1 | 250 | 127 | 443 | 345 | 1.5 |
| 20 | .52 | 14.7 | ... | 1 | 300 | 152 | 497 | 386 | 1.5 |
| 18 | .82 | 19.3 | ... | 1 | 350 | 177 | 548 | 425 | 1.5 |
| 16 | 1.3 | 25.2 | ... | 1 | 400 | 203 | 598 | 465 | 1.5 |
| 14 | 2.1 | 33.0 | ... | 1 | 500 | 253 | 689 | 534 | 2 |
| 12 | 3.31 | 43.0 | 34 | 1 | 600 | 304 | 775 | 600 | 2 |
| 10 | 5.26 | 57.5 | 45.5 | 1 | 700 | 355 | 850 | 660 | 2 |
| 8 | 8.37 | 77.3 | 61.0 | 1 | 750 | 380 | 894 | 692 | 2 |
| 6 | 13.3 | 104 | 82.0 | 1 | 800 | 405 | 920 | 720 | 2 |
| 4 | 21.1 | 140 | 110 | 1 | 900 | 456 | 983 | 777 | 2 |
| 3 | 26.7 | 163 | 128 | 1 | 1000 | 507 | 1044 | 830 | 2 |
| 2 | 33.6 | 189 | 148 | 1 | 1250 | 634 | 1183 | 958 | 3 |
| 1 | 42.4 | 219 | 171 | 1 | 1500 | 760 | 1310 | 1075 | 3 |
| 0 | 53.5 | 254 | 199 | 1 | 1750 | 887 | 1428 | 1185 | 3 |
| 00 | 67.4 | 295 | 230 | 1 | 2000 | 1014 | 1540 | 1290 | 3 |
| 000 | 85 | 342 | 267 | 1 | | | | | |
| 0000 | 107 | 397 | 309 | 1.5 | | | | | |

## Table 8-11
## STABILITY FACTOR "S" CALCULATION EXAMPLE

| Cycle Number | Control Terminal °C | Conductor °C | 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
average = + 1.5

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no more than 2°C variation between any two of the measurements.

The shortened current-off period ends when the test sample reaches a temperature within 2°C of room temperature.

#### 8.4.8.5 Test Criteria

The temperature rise of any terminal for any of the measurements shall not exceed 125°C.

### 8.4.9 Stress Corrosion Cracking Test

This test is to be conducted on brass parts containing less than 80 percent copper. Brass containing not less than 80 percent copper is known to be resistant to corrosion cracking.

#### 8.4.9.1 Test Samples

The test is to be conducted on one unused sample of each brass part with less than 80 percent copper. The sample shall not be attached to a wire or otherwise subjected to external stress.

#### 8.4.9.2 Test Procedure

All brass parts shall be resistant to corrosion cracking. The test samples shall be immersed for 15 minutes in an aqueous solution of 100 grams of mercurous nitrate and 13 milliliters of nitric acid per liter with a specific gravity of 1.42. After removal from the solution, the parts shall be examined visually without magnification.

#### 8.4.9.3 Test Criteria

There shall be no visible cracks. The terminal shall withstand the torque applied one time as specified in 8.4.2.2.

### 8.4.10 Thermoplastic Insulator Stress Relief Test

This test shall be performed on one sample of each insulating part made from thermoplastic. This test is not required for rigid or low-pressure formed thermosetting molded parts.

#### 8.4.10.1 Test Sample

The test sample shall be one terminal block with the maximum number of terminal assemblies.

#### 8.4.10.2 Test Procedure

The terminal block shall be placed in a full-draft circulating oven for 7 hours. The oven is to be maintained at a temperature that is 10°C above the manufacturer's stated maximum operating temperature for the insulating material in the terminal block. There shall be no softening of the insulator material, and immediately after removal from the oven, while being handled, there shall be no distortion or bending under its own weight. After allowing the terminal block to cool down to the room ambient temperature, the insulator shall again be examined.

#### 8.4.10.3 Test Criteria

There shall be no shrinkage, warping or other distortion resulting in the reduction of clearances or creepage distances below the specified values.

## 9 Applications

There are no application requirements unique to this standard

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# Supplement 1
# SCOPE OF THE INDUSTRIAL CONTROL AND SYSTEMS SECTION

The NEMA Standards Publications for Industrial Control and Systems cover the requirements for all industrial control apparatus except as modified below. These standards cover all devices, whether electric, magnetic, mechanical, or electronic (except those devices intended specifically for marine auxiliaries and propulsion control apparatus, mine locomotive control apparatus, and railway and railroad locomotion) which, individually or grouped, serve to govern in some predetermined manner the electric power delivered to the apparatus to which they are connected, and which are intended to function on commercial voltages of 750 volts or less, direct current and 7200 volts or less, alternating current.

Industrial Control and Systems Section equipment comprises, but is not limited to, mechanical, electromechanical and solid state devices, components, and controls.

The equipment is principally used in industrial applications for the control, or regulation, or both, of power utilization apparatus, including motors. Such equipment is rated not more than 750 volts DC or 7,200 volts AC.

These devices, components, and controls may be arranged to include one or more feedback loops. Functional elements in such arrangements include, sensors, programmable controllers, operational amplifiers, encoders, tape readers, gauging equipment and computer elements. Computer elements for the readout, logging, processing, and programming input and monitoring output of data may or may not be in the feedback loop. Devices, components and controls so arranged are used in functions such as:

a. Computer control of machines
b. Industrial process regulation
c. Integrated mill control
d. Energy management
e. Emergency and standby power control
f. Control of the cogeneration of electric power

The Industrial Control and Systems Section scope specifically includes, but is not limited to, products principally used:

a. To start, stop, protect, accelerate, decelerate, reverse, or control the speed of electric motors.
b. To automatically disconnect, connect, or transfer all classes of loads fed by primary or alternate power sources.
c. To provide some mechanical movement through the action of magnets or solenoids.
d. To start, stop and control AC or DC adjustable speed drives, whether unregulated, regulated, or automatically regulated, including semiconductor power converters and invertors for adjustable speed drives, and providing such functions as: regulating speed, tension, current, frequency and voltage.
e. To start, stop and control the function and operation of machine tools, including feedback control and speed, position and torque.
f. To start, stop and control the operation of automatic warehouses, including control of conveyors, stackers, and the like.
g. To start, stop and control the operation of cranes and hoists.
h. To start, stop and control the operation of AC motors applied to fans, pumps, and blowers, including provision for feedback control of speed by sensors such as for temperature, flow, and pressure.
i. To control the management of energy under normal and emergency conditions including peak load shaving.
j. To control generator equipment used in dispersed power generation systems for cogeneration, emergency, or stand-by electric power.

Also included, but not limited to, are:

a. Motor controllers
b. Motor control centers
c. Medium-voltage controllers
d. Programs and related documentation making up the software that is furnished with programmable devices for industrial control and systems equipment
e. Register and synchronizing controls
f. Digital display devices
g. Analog-digital convertors and transducers
h. Programmable controllers
i. Functional elements of systems, such as:
j. Operational amplifiers
k. Computer elements
l. Encoders
m. Tape readers
n. Sensors

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o. Man-machine interface devices

p. Gaging equipment

q. Renewal parts for Industrial Control and System products.

Examples of Industrial Control and System products are:

a. Manual, magnetic and solid-state (static) starters and controllers

b. Relays and contactors

c. Automatic transfer switches and controllers, and associated by-pass isolation switches

d. Drum switches

e. Overload devices intended primarily for the starting and running protection of electric motors, including inherent overload protective devices

f. Rheostats and resistors

g. Autotransformers and reactors of the type principally used in reduced-voltage starters

h. Control-circuit and pilot devices including, but not limited to, timers, pushbuttons, indicating (pilot) lights, solenoids, photoelectric relays, and plugging switches, speed switches, domestic water pump pressure switches

i. Limit, pressure, vacuum, temperature and liquid-level switches.

j. AC and DC brakes, clutches, and electrical operators

k. Resistance dimmers, autotransformer dimmers, reactor dimmers, and solid-state (static) dimmer systems

l. Solid-state logic devices

m. Control panels for machine tool and similar machines

n. Terminal blocks of the molded barrier or sectional type and terminal strips used for the connection of conductors, electrical and electronic circuits and equipment. These include, but are not limited to, terminal blocks using, wire binding screws, pressure wire connectors, stud and nut, quick connect, solder lug, and solderless wrapped terminations, and terminal blocks which incorporate fuse holders, test/disconnect features, indicator lamps, diodes, etc.

o. Automatically regulated adjustable speed drive systems such as: rolling mill drives, paper mill drives, slasher drives

p. Programmable controllers and their accessories devices used for the supervision, or control or command of industrial machines and processes.

Exclusions:

Excluded from the product scope are:

a. Specific components and systems covered by the product scopes of other NEMA sections

b. Automatic and manual temperature and humidity controls and panels that are in the scope of the Residential Controls Section of the types principally used in air conditioning, refrigeration, and comfort heating of nonindustrial areas

c. Motors, generators and motor-generators, which function as control when constituting part of adjustable speed drives.

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# NEMA STANDARDIZATION BACKGROUND

The purpose of NEMA standards, their classification, and status are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below:

## Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for their particular needs. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard.

## Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process, or procedure with reference to one or more of the following: nomenclature, composition, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

*(Standardization Policies and Procedures, p. 1)*

## Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the Standards Publication may be capable of otherwise equivalent performance.

*(Standardization Policies and Procedures, p. 6)*

## Categories of Standards

National Electrical Manufacturers Association Standards are of three classes, which have received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative:

1. NEMA Standard, which relates to a product, process, or procedure commercially standardized and subject to repetitive manufacture.
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development.
3. Adoptive Standard, which is adopted in whole or in part from the standards of another organization, either domestic, regional, or international.

*(Standardization Policies and Procedures, pp. 5)*

## Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has received the affirmative vote of at least two-thirds of the Subdivision votes cast in the affirmative or negative.

*(Standardization Policies and Procedures, pp. 5)*

## Identification of Status

Standards in NEMA Standards Publications are identified as "NEMA Standard," "Suggested Standard for Future Design," or "Adoptive Standard." These indicate the status of the standard. A statement incorporating the auxiliary verb "shall" indicates that compliance with a requirement is mandatory for compliance with the standard. These classes of standards are identified in the foreword or throughout the text.

The material identified as "Authorized Engineering Information" is designated similarly. Statements incorporating other auxiliary verbs such as "should," "may," etc. refer to the authorized engineering information and not to procedures required for compliance with the standard.

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CEGELEC Automation Inc.
Macon, GA 31206

Challenger Electrical Equipment Corp.
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Eaton Corporation
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Franklin, MA 02038

Lexington Switch & Controls
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Master Controls Systems, Inc.
Lake Bluff, IL 60044

Metron, Inc.
Denver, CO 80223

Micro Switch (Div. of Honeywell)
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Modicon Inc.
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