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PROPOSED, NEW AND REVISED STANDARDS

September 28, 1988

TO ALL REPRESENTATIVES OF MEMBER COMPANIES IN THE
INDUSTRIAL CONTROL AND SYSTEMS SECTION

Subject: Revision No. **1** to NEMA Standards Publication for *Terminal Blocks for Industrial Use*, ANSI/NEMA Pub. No. **ICS 4-1983 (R 1988)**.

Dear Representative:

Revision No. **1**, consisting of printed pages dated MAY 1988, is enclosed for insertion into your copy of the subject publication. Also enclosed is a new title page to indicate that your book now contains the revision. Please note that this revision also reaffirms ICS 4.

To bring your copy of NEMA Publication No. ICS 4-1983 (R 1988) up-to-date, please insert the attached revised pages in their proper place and delete the pages they replace.

Sincerely,

Krystyna A. McIver
Standards Publications Editor
NEMA

Encl: Revision No. **1** to ICS 4-1983 (R 1988).
Copies to: All known holders of ICS 4.

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ICS 4-83 6470247 0007508 6

STANDARDS PUBLICATION NO. ICS 4

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Terminal Blocks for Industrial Use

NEMA

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

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ANSI/NEMA ICS 4-1983 (R 1988)

ICS 4

TERMINAL BLOCKS FOR INDUSTRIAL USE

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Foreword

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.

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.

1. Environmental conditions.
2. System design.
3. Equipment selection and application.
4. Installation.
5. Operating practices.
6. 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 International System of Units (SI). This transition involves no changes in standard dimensions, tolerances, or performance specifications.

Proposed or recommended revisions to this standards publication should be submitted to:

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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 V ac up to 60 Hz or 1500 V 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.

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TERMINAL BLOCKS FOR INDUSTRIAL USE

This entire document is classified as NEMA Standard.

Section 1
DEFINITIONS

1.1 TERMINAL (IEV 441-04-01)

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

1.2 CLAMPING UNIT

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

1.3 TERMINAL ASSEMBLY

One or more terminals fixed to the same conductive part.

1.4 TERMINAL INSULATOR

An insulating part intended for maintaining in position or for covering live parts.

1.5 TERMINAL BLOCK

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

1.6 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.

1.7 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.

1.8 CLEARANCE (IEV 441-05-25)

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

1.9 CREEPAGE DISTANCE (IEV 441-05-29)

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

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

1.10 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.

1.11 CONNECTING CAPABILITY

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

1.12 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.

1.13 SPECIAL PREPARATION (OF CONDUCTOR END)

Alteration of the manufactured shape or surface of the conductor to enable it to be connected to the terminal.

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Section 2
CLASSIFICATION OF TERMINAL BLOCKS

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

– method of fixing the terminal blocks to a support
– number terminal assemblies
– type of terminals (e.g. screw type terminals, screwless type terminals)
– ability to receive conductors having particular terminations, e.g. cable lugs
– terminal assemblies with identical or dissimilar clamping units
– number of terminals on each terminal assembly
– service conditions
– terminal blocks, suitable for the connection of copper conductor only (marked Cu)
– terminal blocks, suitable for the connection of aluminum conductors only (marked Al)
– terminal blocks, suitable for the connection of aluminum conductors as well as copper conductors (marked Al-Cu)

Section 3
CHARACTERISTICS

3.1 RATED CROSS-SECTION

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

3.2 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 6.2.1.

3.3 CONSTRUCTION

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.

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Section 4
MARKINGS

4.1 MANDATORY MARKINGS ON PRODUCT

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

– the name of the manufacturer or a trademark by which he may be readily identified,
– a type reference to enable identification and the procurement of relevant information.

4.2 ADDITIONAL MARKINGS

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

– 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.

– the connecting capacity, including the type and number of conductors simultaneously connectable

– the torque values for the clamping screws

– rated insulation voltage

– service conditions if different from those stated in Section 6

– marking "Cu" for terminal blocks used for copper conductors only

– marking "Al" for terminal blocks used for aluminum conductors only

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

Section 5
STANDARD CONDITIONS FOR OPERATION IN SERVICE

5.1 STANDARD SERVICE CONDITIONS

Standard conditions of operation shall be as stated in ICS 1-108.

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Section 6
STANDARD CONDITIONS FOR CONSTRUCTION

6.1 MECHANICAL CHARACTERISTICS

6.1.1 Terminal Assembly

The terminal assembly shall allow the conductors to be connected by means that ensure a 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 or by otherwise reducing clearance or creepage, or both, distances. The terminals shall be able to withstand the forces that can be applied through the connected conductors under the condition of 7.2.3 and 7.2.4.

6.1.2 Mounting

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 7.2.1.

6.1.3 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.

6.1.4 Clamping of Conductors

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

NEMA Standard 7-12-1983.

6.2 ELECTRICAL CHARACTERISTICS

6.2.1 Clearance and Creepage Distances

Clearances and creepage distances shall be in accordance with ICS 1-111 or ICS 1-111A.

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.

NEMA Standard 5-25-1988.

6.2.2 Dielectric Strength

The terminal block shall be capable of withstanding for one minute the dielectric test voltage indicated in 7.2.6.

6.2.3 Temperature Rise

When terminal blocks are tested in accordance with 7.2.7, the temperature rise of the terminals shall not exceed 45°C.

6.2.4 Voltage Drop

The potential difference caused by the insertion of a terminal block in a conductor measured according to 7.2.5 shall not exceed the values in 7.3.3 and 7.3.4.

Table 6-1
TERMINAL ASSEMBLY AND CONDUCTOR COMBINATIONS WHICH REQUIRE CURRENT CYCLING TESTS

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

X Indicates cycling test is to be performed

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6.2.5 Performance During Current Cycling Test

Terminal blocks with terminal assemblies made of various metals shall pass the current cycling test of 7.2.8 using test conductor-terminal assembly combinations shown in Table 6-1 and designated by an X.

When a clamping unit is designed to universally employ steel, aluminum, and brass clamping screws, terminals with brass screws need not be tested. In all other cases the terminal is to be tested using clamping screws of the metal for which it is designed.

6.3 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:

– aluminum or aluminum alloy terminal assemblies used for the connection of aluminum conductors only
– copper or copper alloy terminal assemblies used for the connection of copper conductors only.

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

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Section 7
TESTS

These 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, may be manufactured. Unless otherwise specified, terminal blocks with any number of terminal assemblies may be submitted for the tests.

For a range of terminal sizes of similar design the largest, smallest, and two 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:

1. Shape of terminal, shape of conductor opening and the shape of wire clamping screw
2. Material and coating of terminal body
3. Material of wire clamping screw
4. Number of clamping screws

7.1 GENERAL

7.1.1 Test Conductor

For terminals designated Al or Al-Cu, the aluminum test conductors shall be uncoated insulated aluminum conductor with the following characteristics.

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

Elongation: 10 percent minimum

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

Copper test conductors shall be soft annealed and uncoated.

For stranded copper and aluminum conductors the stranding and construction shall be as given in Table 7.1.

Table 7-1
STRANDED TEST CONDUCTOR FOR COPPER AND ALUMINUM

Conductor Cross Section		Numbers of Strands	Conductor Material	
AWG/MCM	(mm^2) (Approximate)		Copper	Aluminum
24	. . .	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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Table 7-2
ATTACHMENT TEST PARAMETERS

Rated Cross Section of Terminal Block		Force		Diameter of Pin	
AWG/MCM	(mm^2)	Lbs.	(N)	in	(mm) (approximately)
24 to 12	(0.2 to 4.0)	.22	(1)	.04	(1.0)
10 to 6	(5 to 16)	1.1	(5)	.11	(2.8)
4 to 2/0	(20 to 70)	2.25	(10)	.22	(5.7)
3/0 to 350	(95 to 185)	3.37	(15)	.50	(12.8)
400 to 1000	(200 to 510)	4.50	(20)	.81	(20.5)
1250 to 2000	(600 to 1014)	5.62	(25)	1.0	(25.4)

7.1.2 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.

7.1.3 Terminal Block Mounting and Ambient Temperature for the Tests

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. The ambient temperature during the tests shall be 20 ± 5°C unless specified otherwise.

7.1.3.1 Condition of Terminal Block

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

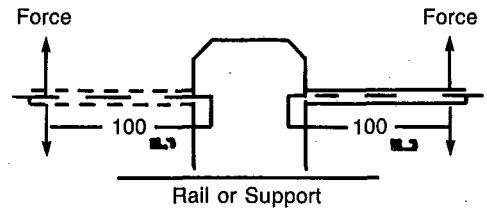
7.1.4 For all tests, except those performed in 7.2.2, there shall be no readjustment or retightening of the pressure screw after it initially has been tightened to the specified torque.

7.2 TYPE TESTS

The following defines the ten type tests which are performed to determine the compliance of a terminal block performance with this standard.

7.2.1 Verification of the Attachment of the Terminal Block to the Terminal Block Support

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 7-3 is clamped in the clamping unit on each side of the terminal block. A force given in Table 7-2 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 7-1. During the test the terminal block shall not disengage from its mounting means, nor suffer any other damage.



Verification of Attachment According to 7.2.1

Figure 7-1

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7.2.2 Verification of the Performance of the Terminal Assemblies of a Terminal Block

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.

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 5 times using the same clamping units and 5 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.

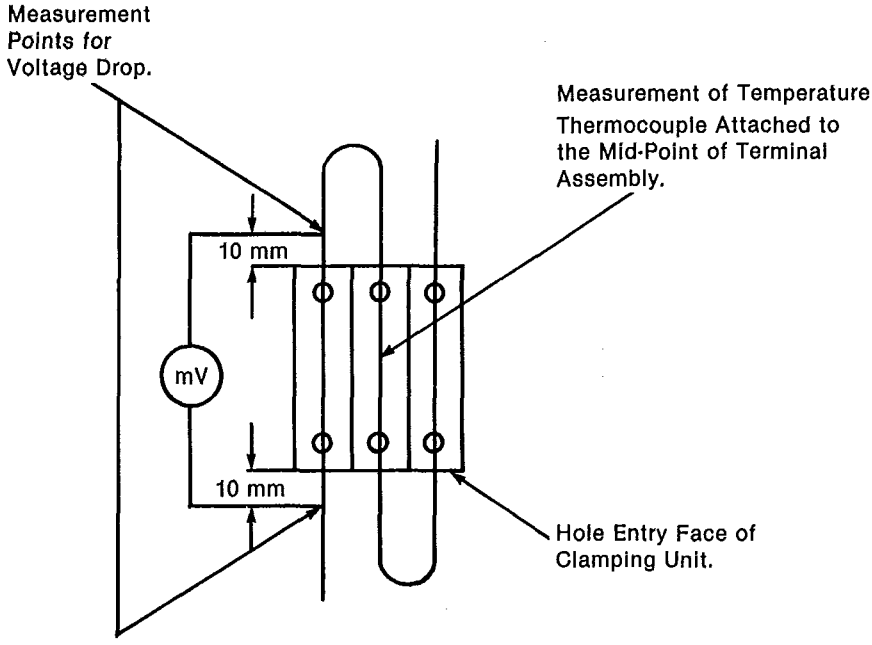
After the test, the conductor ends shall not be cut off or damaged in any way. No damage shall have occurred to the terminal assemblies, the terminal block or the mounting means.

7.2.3 Secureness Test

Two separate terminal assemblies are required for this test.

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

b. 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.



NOTE: A Three Terminal Assembly Sample Can Be Made Up Using Single or Two Terminal Assembly Terminal Blocks Adjacent to Each Other.

The Leads for the Voltage Drop Test Shall Be Attached to the Conductors 10 mm From the Conductor Hole Entry Face of the Clamping Unit.

Figure 7-2
ARRANGEMENT FOR VOLTAGE-DROP AND TEMPERATURE RISE MEASUREMENTS

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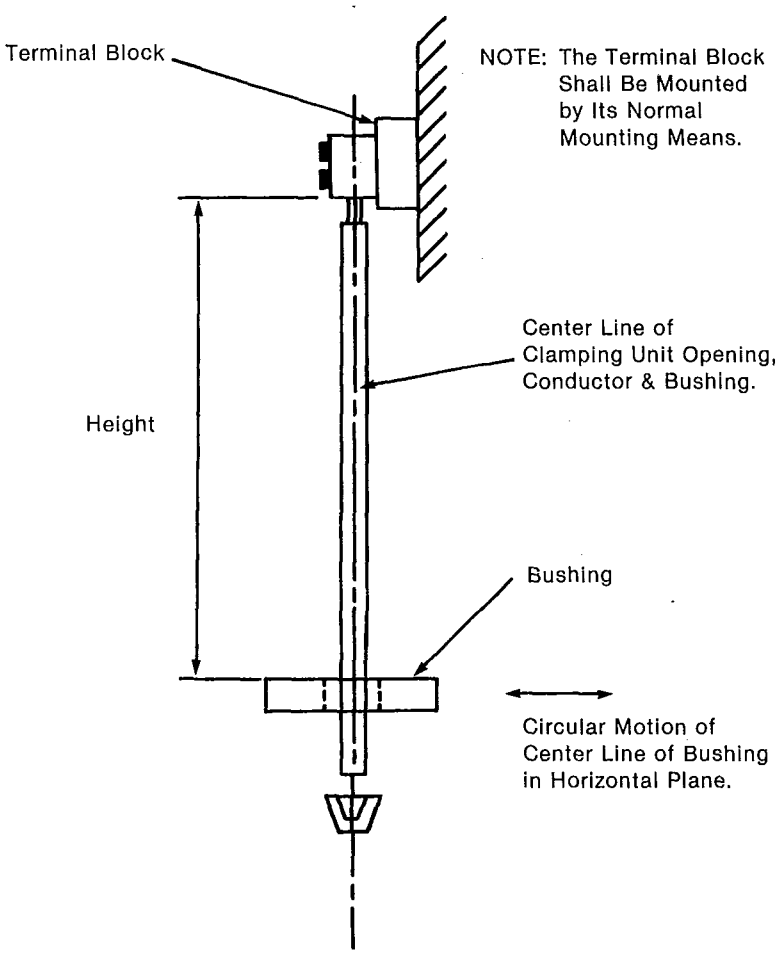
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The second terminal assembly shall be tested with a combination of the maximum rated cross section conductors, with the tests being performed on one of the conductors only.

A length of conductor of a rated cross section at least 3 inches (75 mm) longer than the height specified in Table 7-3, 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 7-2. The terminal block shall be secured as shown in Figure 7-3.

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 7-3. 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 (75 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 inches (13 mm) of the distance "height" in Table 7-3. The bushing is to be lubricated to prevent binding, twisting, or rotation, of the insulated conductor. A weight as specified in Table 7-3 is to be suspended from the end of the conductor. The duration of the test shall be 30 minutes.

During the test, the conductor shall not pull out of the clamping unit and the terminal assembly shall not separate from the terminal insulator.



Arrangement for the Verification of Attachment of Conductor to the Clamping Unit and of the Terminal Assembly to the Insulator.

Figure 7-3

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7.2.4 Pull Test

A pulling force corresponding to the conductor cross section given in Table 7-3 shall be applied gradually to the conductor and maintained at that value for 1 minute. The conductor shall not pull out of the clamping unit, and the terminal assembly shall not separate from the terminal insulator.

NEMA Standard 7-12-1983.

Table 7-3
VALUES FOR SECURENESS AND PULLOUT TEST

Size of Conductors AWG or MCM	Diameter of Bushing Hole (c) Inches	mm	Height (a) Inches	(b) mm	Secureness Weight Lbs.	Kg	Pullout Force Cooper Lbs.	N	Aluminum Lbs.	N
24	¼	6.5	10¼	260	0.66*	0.3	2.25	10*	.....	.....
22	¼	6.5	10¼	260	0.66*	0.3	4.5	20	.....	.....
20	¼	6.5	10¼	260	0.66*	0.3	6.75	30	.....	.....
18	¼	6.5	10¼	260	1	0.45	6.75	30	.....	.....
16	¼	6.5	10¼	260	1	0.45	9.0	40	.....	.....
14	3/8	9.5	11	279	1.5	0.68	11.5	50	.....	.....
12	3/8	9.5	11	279	2	0.9	13.5	60	10	45
10	3/8	9.5	11	279	3	1.4	18.0	80	10	45
8	3/8	9.5	11	279	4.5	2	20.5	90	10	45
6	½	13	11¾	296	6.5	3	21	94	28	125
4	½	13	11¾	296	10	4.5	30	133	36	160
3	9/16	14	12½	317	13	5.9	35	156	42	187
2	9/16	14	12½	317	15	6.8	42	187	50	223
1	5/8	16	13½	343	19	8.6	53	236	61	271
1/0	5/8	16	13½	343	21	9.5	64	285	72	320
2/0	¾	19	14½	368	23	10.4	64	285	78	347
3/0	¾	19	14½	368	31	14	79	351	97	432
4/0	¾	19	14½	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	18¼	464	44	20	130	578	154	685
600	1 1/8	29	18¼	464	....	23	130	578	154	685
700	1¼	32	19½	495	50	23	145	645	179	796
750	1¼	32	19½	495	50	23	155	690	179	796
800	1 3/8	35	21¼	540	55	25	155	690	179	797
900	1 3/8	35	21¼	540	55	25	158	703	181	805
1000	1½	38	22½	572	55	25	175	779	199	885
1250	1¾	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

NOTES: a. For sizes 12-4 AWG aluminum, use 2½ inches (317 mm)
b. The tolerance on height is ±½ inch (12 mm)
c. 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.

*Values taken from IEC 17B

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7.2.5 Voltage Drop Test

The voltage drop is measured at the points indicated in Figure 7-2. The test is made with direct current equal to 0.1 times the value of the test current corresponding to the cross section of the conductor, as specified in Table 7-4.

Table 7-4
TEST CURRENTS CORRESPONDING TO CROSS SECTION OF CONDUCTOR

Rated Cross Section		Test Current Amperes	
AWG/MCM	(mm^2)	Copper Conductor	Aluminum Conductor
24	(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 7-5.

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Table 7-5
VALUES OF CONSTANTS M & C FOR ALUMINUM & COPPER CONDUCTORS

Conductor material	Conductor Rated Cross Section mm²	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

7.2.6 Dielectric Test

The sample terminal block shall consist of at least 3 adjacent terminal assemblies and shall be mounted on a sheet metal support or on a rail as in normal use. The voltage specified in Table 7-6 shall be applied 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. There shall be no dielectric breakdown during the tests.

7.2.7 Temperature Rise Test

A sample consisting of three terminal assemblies shall be connected in series, as shown in Figure 7-2, 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 mm²) 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 7-2.

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 7-4, and the temperature rise shall not exceed the value specified in 6.2.3.

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 2°C variation between any two of the measurements.

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

Table 7-6

Rated Insulation Voltage U_i v	Dielectric Test Voltage (a.c.) (r.m.s.)
$< U_i \leq$ 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
1.000 $< U_i \leq$ 1500*	4000

*For dc only

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7.2.8 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.

This test is performed on terminal assembly-conductor combinations given in Table 6-1 (see Sub-clause 6.2.5).

This test is performed on the terminal assembly removed from the terminal block.

7.2.8.1 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 7-4 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 7-8. 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 .25″ – .5″ (6 to 12 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 .25 (6 mm).

If 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 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 7-9. 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 (150 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 Amp./in^2 (1.55 Amp./mm^2) for copper and 800 Amp/in^2 (1.24 Amp./mm^2) for aluminum. See Table 7-9.

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 1 inch (25 mm) horizontally and 6 inches (150 mm) vertically beyond the conductors. The test sample shall be located at least 24 inches (600 mm) from the floor, wall or ceiling.

i. The sample shall be located in a substantially vibration and draft free location and in an ambient temperature between 15 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 mid-point 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 inches (12 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.

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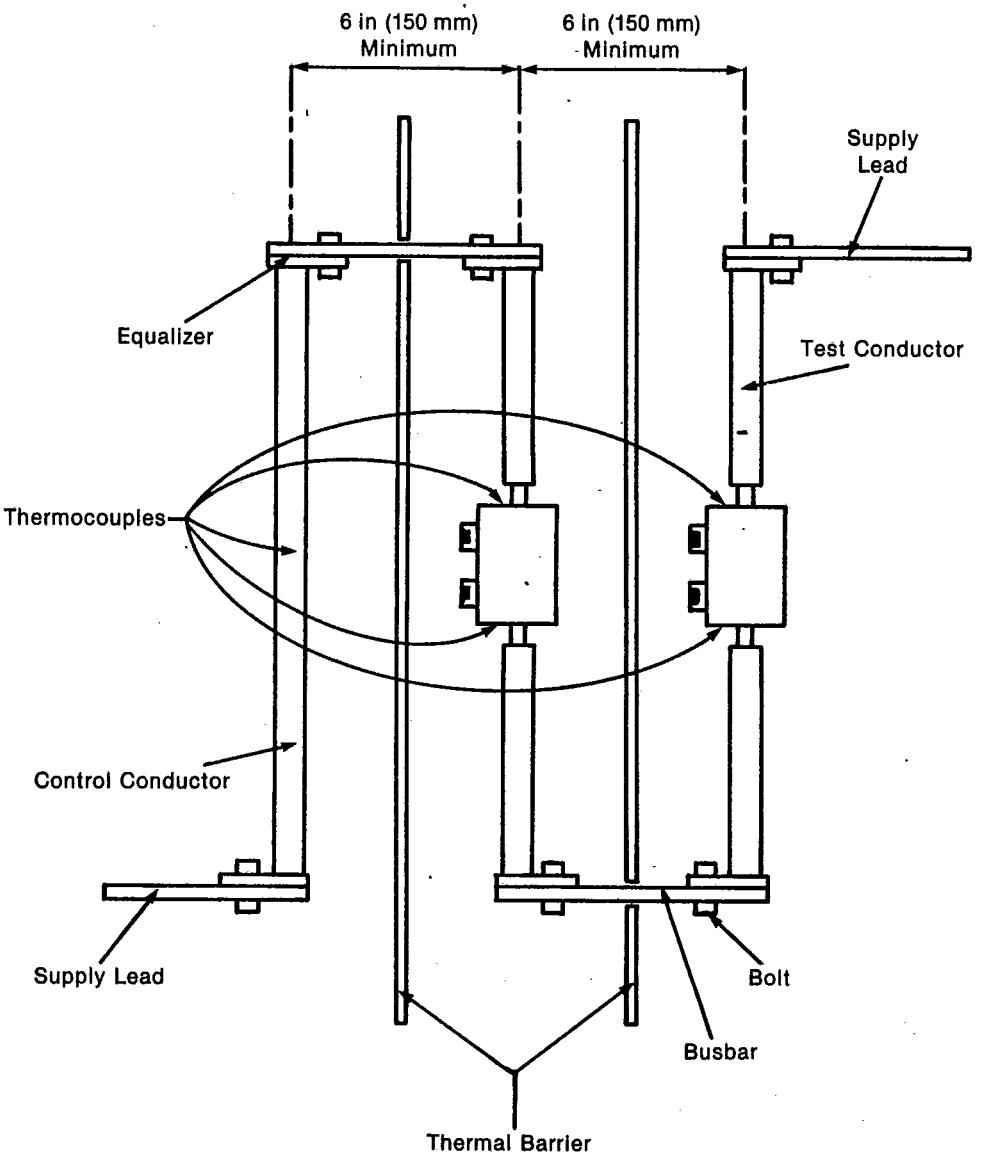


Figure 7-4
ARRANGEMENT OF SAMPLE FOR THE CURRENT CYCLING TEST

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7.2.8.2 Samples Required to be Tested

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

b. 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 6.2.5 and Table 6-1. Separate samples shall be tested for each combination. The insulation of the conductors shall be black.

7.2.8.3 Tests

a. The ambient temperature shall be measured by means of two thermocouples attached to unplated copper plates approximately 2 in (50 mm) square and 0.25 in (5 mm) thick, and located 24 in (600 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 7-7. Temperatures are to be recorded for at least 1 cycle of each working day, and after approximately 25, 50, 75, 100, 125, 175, 225, 350, 425, and 500 cycles. The temperature rise of any terminal for any of the measurements shall not exceed 125°C.

c. The stability factor "S" for each of the 11 (eleven) temperature measurements after the 25th to 500th operation shall not exceed ± 10.

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.

Table 7-7
VALUES OF TEST CURRENT FOR CURRENT CYCLING TEST

Rated Cross Section		Cycling Current (Amperes)		On and Off Times (Hours)
AWG	mm²	Cu	AL	
22	.33	11.7	. . .	1
20	.52	14.7	. . .	1
18	.82	19.3	. . .	1
16	1.3	25.2	. . .	1
14	2.1	33.0	. . .	1
12	3.31	43.0	34	1
10	5.26	57.5	45.5	1
8	8.37	77.3	61.0	1
6	13.3	104	82.0	1
4	21.1	140	110	1
3	26.7	163	128	1
2	33.6	189	148	1
1	42.4	219	171	1
0	53.5	254	199	1
00	67.4	295	230	1
000	85	342	267	1
0000	107	397	309	1.5

Rated Cross Section		Cycling Current (Amperes)		On and Off Times (Hours)
MCM	mm²	Cu	AL	
250	127	443	345	1.5
300	152	497	386	1.5
350	177	548	425	1.5
400	203	598	465	1.5
500	253	689	534	2
600	304	775	600	2
700	355	850	660	2
750	380	894	692	2
800	405	920	720	2
900	456	983	777	2
1000	507	1044	830	2
1250	634	1183	958	3
1500	760	1310	1075	3
1750	887	1428	1185	3
2000	1014	1540	1290	3

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The temperature deviation 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.

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
average = +1.5

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 7-7 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 no more than 2°C variation between any two of the measurements.

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

Table 7-8
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

7.2.9 Stress Corrosion Cracking Test

Brass parts shall be resistant to corrosion cracking. Brass containing not less than 80 percent copper is known to be resistant to corrosion cracking.

Brass parts containing less than 80 percent copper shall not crack when immersed for 15 minutes in an aqueous solution of 100 grams of mercurous nitrate and 13 milliliters of nitric acid per liter and specific gravity of 1.42. The test is to be conducted on a sample previously unused, and not attached to a wire or otherwise subjected to external stress. After removal from the solution, the parts shall be examined visually without magnification. There shall be no visible cracks. The terminal shall withstand the torque applied once as specified in 7.2.2.

7.2.10 Molded Insulator Stress Relief Test

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

NOTE: This test is not required for rigid thermosetting or low pressure formed molded parts.

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Table 7-9
EQUALIZER BAR DIMENSIONS

Range of Test Current, Amperes	Maximum Cross-Section, Inches[a]	
	Copper	Aluminum
0 - 50	⅛ × ½	⅛ × ½
51 - 125	⅛ × 1	⅛ × 1¼
126 - 225	⅛ × 1⅞	⅛ × 2¼
226 - 400	¼ × 1½	¼ × 2
401 - 600	¼ × 2	¼ × 3
601 - 800	¼ × 3	¼ × 4
801 - 1000	¼ × 4	⅜ × 3½
1001 - 1400	½ × 3 or two ¼ × 3	½ × 3½
1401 - 2000	½ × 4 or two ¼ × 4	½ × 5

[a]SI equivalents of the values in Table 7-9 are:

Inch	mm	Inches	mm	Inches	mm
⅛	3.2	1¼	31.8	3	76.2
¼	6.4	1½	38.1	3½	88.9
⅜	9.5	1⅞	47.6	4	102.0
½	12.7	2	50.8	5	127.0
1	25.4	2¼	57.2		

7.3 TEST SEQUENCE

The test samples required for the complete test sequence are:

a. For 7.3.1—A terminal block with the least number of terminal assemblies.

b. For 7.3.2—Two terminal assemblies mounted in a terminal block(s).

c. For 7.3.3—Two terminal assemblies mounted in a terminal block(s).

d. For 7.3.4—A terminal block containing three adjacent terminal assemblies.

e. For 7.3.5—Two terminal assemblies, each with two clamping units. The terminal assemblies are removed from the terminal block.

f. For 7.3.6.1—One sample of each brass part used in the terminal block assembly.

g. For 7.3.6.2—One terminal block with the maximum number of terminal assemblies.

7.3.1 Verification of Attachment of the Terminal Block to its Support

Shall be performed as stated in 7.2.1. The sample used for this test shall not be used for any other tests.

7.3.2 Verification of Performance of the Clamping Unit and Terminal Assembly

Shall be performed as stated in 7.2.2. The samples used for this test shall not be used for any other tests.

7.3.3 Verification of the Secureness of the Attachment of the Conductor to the Terminal and of the Terminal Assembly to the Insulator

Shall be performed using one terminal assembly in the terminal block as the test sample for the sequence of tests specified in 7.3.3.1 through 7.3.3.4.

Once the pressure screw has been tightened to the specified torque, there shall be no readjustment or retightening of the pressure screw during the complete sequence of tests specified in 7.3.3.1 through 7.3.3.4.

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7.3.3.1 Perform a voltage drop test as defined in 7.2.5. The voltage drop shall not exceed 3.2 millivolts.

7.3.3.2 Perform the Secureness Test outlined in 7.2.3.

7.3.3.3 Perform the Pull Test defined in 7.2.4.

7.3.3.4 Repeat the Voltage Drop Test defined in 7.2.5. The voltage reading shall not exceed 4.8 millivolts.

7.3.4 Verification of Temperature Rise Test

Shall be performed on a sample terminal block containing three adjacent terminal assemblies. The three adjacent terminal assemblies shall be connected in series as shown in Figure 7-2 using conductors of rated cross section.

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 7.3.4.1 through 7.3.4.2.

7.3.4.1 Perform a Voltage Drop Test as specified in 7.2.5. The voltage drop shall not exceed 3.2 millivolts.

7.3.4.2 Perform a Temperature Rise Test as specified in 7.2.7.

7.3.4.3 Repeat the Voltage Drop Test defined in 7.2.5. The voltage drop reading shall not exceed 4.8 millivolts.

7.3.4.4 Perform a Dielectric Test as specified in 7.2.6.

NOTE: Cut conductors which connect adjacent terminals and perform a dielectric test, as specified in 7.3.4.4.

7.3.5 Verification of the Current Cycling Tests

The current cycling tests shall be performed if the terminal block under evaluation contains aluminum body terminal assemblies or if it is being evaluated for use with aluminum or aluminum alloy conductors. Combinations requiring cycle testing are shown in Table 6-1.

Cycling tests, when required, shall be performed in accordance with the methods outlined in 7.2.8.

7.3.6 Verification of Materials Tests

These shall be performed on brass parts containing less than 80 percent copper and on molded insulating parts of thermoplastic materials.

7.3.6.1 Verification of the Stress Corrosion Cracking Test

This is to be conducted on brass parts containing less than 80 percent copper in accordance with the method specified in 7.2.9.

7.3.6.2 Verification of the Molded Insulator Stress Relief Test

Shall be performed on thermoplastic molded insulation parts as specified in 7.2.10.

NEMA Standard 7-12-1983.

Section 8
MAINTENANCE GUIDELINES

8.1 Preventive Maintenance

Refer to Part ICS 1-115 for preventive maintenance guidelines.

Authorized Engineering Information 5-25-1988.

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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 its particular need. 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. *(Standardization Policies and Procedures, p. 1)*

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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, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 2)

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. 9)

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National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
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(Standardization Policies and Procedures, pp. 8 & 17)

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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 been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 8 & 17)

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An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment, and/or approval, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 8 & 17)

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Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

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