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INSTRUCTIONS FOR SAFE INSTALLATION, OPERATION, AND MAINTENANCE OF PANELBOARDS RATED 600 VOLTS OR LESS

RETAIN FOR USE OF MAINTENANCE PERSONNEL

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

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NEMA INSTRUCTIONS FOR THE SAFE INSTALLATION, OPERATION, AND MAINTENANCE OF PANELBOARDS RATED 600 VOLTS OR LESS

(Approved as Authorized Engineering Information 9-6-1979.)

This publication is a guide of practical information containing instructions for the safe and proper installation, operation, and maintenance of panelboards rated 600 volts or less. These recommendations of the Panelboard and Distribution Board Section of the National Electrical Manufacturers Association will be found useful by architects, electrical engineers, electrical contractors, electricians, maintenance engineers, and others. They will be reviewed periodically by the Section for the purpose of updating them to reflect advancing technology. Please address any comments or questions you may have on the text to:

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

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Part I
GENERAL

The successful and safe operation of panelboards is dependent upon proper installation, operation, and maintenance as well as upon proper design and manufacture. Neglecting certain fundamental installation and maintenance requirements may lead to serious trouble, if not to the failure and loss of the panelboard and connected equipment.

WARNING—THERE IS A HAZARD OF ELECTRIC SHOCK OR BURN WHENEVER WORKING IN OR AROUND ELECTRICAL EQUIPMENT. TURN OFF POWER SUPPLYING THIS EQUIPMENT BEFORE WORKING INSIDE.

Part II
INSTALLATION OF PANELBOARD CABINETS (BOXES)

Install the cabinet in a neat and workmanlike manner. Follow the manufacturer's installation instructions.

1. *Location in Building.* Locate the cabinet so that it is readily accessible and not exposed to physical damage.
2. *Flammable Material.* Locate the cabinet well away from flammable material.
3. *Unusual Service Conditions.* Do not locate the cabinet where it will be exposed to ambient temperatures above 40°C (104°F), corrosive or explosive fumes, dust, vapors, abnormal vibration or shock or tilting, or unusual operating conditions, unless cabinet has been designed for these conditions.
4. *Indoor Damp Locations.* Locate or shield the cabinet so as to prevent moisture and water from entering and accumulating therein. Mount the cabinet so that there is at least 1/4 inch of air space between the cabinet and the wall or other supporting surface.

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5. *Wet Locations.* Cabinets should be specifically approved for wet locations, i.e., they should be rainproof and sleet (ice) resistant if used outdoors and dripproof if used indoors. Mount the cabinet so that there is at least 1/4 inch of air space between the cabinet and the wall or other supporting surface.
6. *Clearance from Ceiling.* Do not locate the cabinet against a nonfireproof ceiling; allow a space of 3 feet between the ceiling and cabinet unless an adequate fireproof shield is provided.
7. *Space Around the Cabinet.* When selecting a location, provide sufficient access and working space around the cabinet. The width of the working space in front of the panelboard should be at least 30 inches and this space should not be used as storage. The working space should have adequate lighting and a minimum head room of 6-1/4 feet or the value given in the latest revision of par. 110-16 of the *National Electrical Code.**
8. *Mounting of Cabinet.* The cabinet should be reliably secured to the mounting surface. Do not depend on wooden plugs driven into holes in masonry, concrete, plaster, or similar materials. (See par. 110-13 of the *National Electrical Code.)*
9. *Flush Mounting in Wall.* In walls of concrete, tile, or other noncombustible material, install the cabinet so that its front edge will not set back more than 1/4 inch from the finished surface. In walls of wood or other combustible material, cabinets should be flush with or project beyond the finished surface. (See par. 373-3 of the *National Electrical Code.)*
10. *Unused Openings in Cabinet.* Effectively close unused openings in the cabinet to provide protection which is substantially equivalent to that afforded by the wall of the cabinet.
11. *Grounding of Panelboard Cabinets.* Ground the cabinet or box as specified in Article 250 of the *National Electrical Code.* When the cabinet or box contains service equipment, it will be necessary to bond the box to the (neutral) grounded supply conductor.

Part III
INSTALLATION OF CONDUIT AND WIRES

1. Conduits should be installed so as to prevent moisture or water from entering and accumulating within the enclosure. Provision shall be made to protect conductors from abrasion in accordance with Article 373 of the *National Electrical Code.*
2. Be sure that the lugs are suitable and approved for use with the cable being connected to the panelboard. See par. 7 of Part IV for making proper connections.
3. Keep conductor lengths to a minimum within the wiring gutter. Excessive cable lengths may result in overheating. However, cables should be long enough to reach the terminal location in a manner that avoids strain on the connecting lug.
4. Exercise care to maintain the largest practical bending radius of conductors; otherwise the insulation may be damaged and terminal connections may become loosened.

* NFPA Pub. No. 70, available from the National Fire Protection Association, 470 Atlantic Avenue, Boston, Massachusetts 02110.

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Part IV
INSTALLATION OF PANEL INTERIOR

WARNING—BE SURE THAT ALL POWER IS TURNED OFF AND REMAINS OFF DURING THE FOLLOWING INSTALLATION PROCEDURES.

1. *Proper Storage.* Store the panel interior in a clean and dry place and locate it so that mechanical damage from work personnel in the area is not likely to happen.
2. *Unpacking.* Care should be exercised in unpacking the panel interior to prevent damage.
3. *Inspection.* Check for shipping damage and check to make sure that the interior is the correct one for installation in the cabinet.
4. *Cleaning.* Clean the cabinet of all foreign matter prior to installation of the panel interior. If parts at connection points are spattered with cement, plaster, paint or other foreign material, remove the foreign material with great care to avoid damaging the plated surfaces.
5. *Manufacturer's Instructions.* Carefully follow the manufacturer's instructions and labels.
6. *Installation*
   a. Adjust alignment devices where provided.
   b. Install the interior, finalize its alignment, and tighten it securely in the cabinet.
   c. Adjust the interior so that the return flange of the deadfront pan is no more than 3/16 inch from (1) the front of the box for surface mounting or (2) the surrounding wall surfaces for flush mounting.
7. *Connect Line and Branch Conductors*
   a. *Conductors.* Use care in stripping insulation from conductors so as not to nick or ring the conductor. For aluminum, clean all oxide from the stripped portion and apply a joint compound.
   b. Distribute and arrange conductors neatly in the wiring gutters. (See Part III.)
   c. Tighten all lugs. Use the manufacturer's torque values, if furnished.
8. *Ground Panelboard.* (See par. 384-27 of the *National Electrical Code.*)
   a. *Cabinet.* Ground the panelboard cabinet in accordance with item 11 of Part II.
   b. *Equipment Grounding Conductors.* Prepare equipment grounding conductors in accordance with item 7.a and connect them to the equipment grounding terminal bar. Check to be sure that the terminal bar is securely bonded to the cabinet or panelboard frame and that it is *not* connected to the neutral bar except at service equipment as permitted in the latest revision of Section 250-52 of the *National Electrical Code.*
9. *Install fuses* of the proper class and rating in the fuseholders on fusible panels. Check the current ratings of circuit breakers on circuit breaker panels.
10. *Clean the cabinet* of all debris which has accumulated during the panel interior installation.
11. *In order to protect the panelboard interior* before completion of the job, cut and install a piece of cardboard to fit the outline of the box. If the job is complete, perform the steps in Part V and then install the cabinet front.

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Part V
STEPS TO BE TAKEN BEFORE ENERGIZING

1.a Retighten all accessible connections to the manufacturer's torque specifications, if furnished. If such information is not available, tighten steel hardware parts (except pressure wire connectors and Belleville type [spring] washers) to the values given in the following table:

Bolt Diameter	Tightening Torque
#8 (5/32″)	15 inch pounds
#10 (3/16″)	20 inch pounds
1/4″	7 foot pounds
5/16″	12 foot pounds
3/8″	20 foot pounds
1/2″	50 foot pounds
5/8″	95 foot pounds
3/4″	155 foot pounds

1.b Retighten connections using Belleville type (spring) washers until washer is flat.

1.c Retighten the wire clamping members of all accessible mechanical (pressure wire) type connectors to the torque value (inch-pounds) for the largest wire size the connector will accept as given in the tables on page 5, unless otherwise noted on the equipment.

2. Make certain that all blocks used for shipment have been removed from all component devices and the panelboard interior.

3. Manually exercise all switches, circuit breakers, and other operating mechanisms to make certain that they operate freely.

4. To make sure that the system is free from short circuits and grounds, conduct an insulation resistance test phase to ground and phase to phase with the switch or circuit breakers in both the open and closed positions. If the resistance reads less than 1 megohm while testing branch circuit devices in the open position, the system may be unsafe and should be investigated.

5. Check to determine that all grounding connections are properly made. If the panelboard is used as service equipment, make certain that the neutral is properly bonded to the enclosure.

6. Remove all debris, scrap wire, etc., from the panelboard interior and cabinet before installing the cabinet front. Make certain that all interior deadfront shields are properly aligned and tightened. Install the cabinet front in accordance with Part VI.

Part VI
INSTALLATION OF CABINET FRONT

The cabinet front or trim package is designed to prevent damage to the front during shipment and handling.

1. *Unpacking.* Care should be used when unpacking and handling the cabinet front.

2. *Touch-up.* A suitable paint or other corrosion-resistant finish should be applied to those places where the finish is damaged.

3. *Front Alignment.* The cabinet front may be provided with an adjusting means to align it squarely with the building even though the box may be slightly out of plumb with the building.

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Wire Size Installed, AWG or MCM	Torque Values, Inch-pounds			
	Slotted Head Screwdriver			
	No. 10 and Larger Screws			
	Slot Width 3/64 and Less Slot Length 1/4 and Less	Slot Width over 3/64 Slot Length over 1/4	External Drive Wrench	
			Split Bolt	Other
14	15	25	65	60
12	15	25	65	60
10	15	25	65	60
8	20	30	65	60
6	25	35	135	90
4	...	35	135	90
3	...	40	225	125
2	...	40	225	125
1	...	40	225	125
1/0	...	40	315	150
2/0	...	40	315	150
3/0	...	40	400	200
4/0	...	40	400	200
250	...	...	550	250
300	...	...	550	250
350	...	...	550	250
400	...	...	675	250
500	...	...	675	300
600	...	...	800	300
700	...	...	800	300
750	...	...	800	300
800	...	...	900	400
900	...	...	900	400
1000	...	...	900	400
1250	...	...	900	500
1500	...	...	900	500
1750	...	...	900	500
2000	...	...	900	500

Hex Socket Screws	
Socket Size (Across Flats), Inches	Tightening Torque, Inch-pounds
1/8	35
5/32	80
3/16	100
7/32	120
1/4	150
5/16	225
3/8	300
1/2	400
9/16	500

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Part VII
ENERGIZING EQUIPMENT

Following the successful completion of all of the installation steps outlined in Parts II through VI, you are now ready to energize the panelboard. When it is energized for the first time, qualified electrical personnel should be present. All branch circuit devices should be in the closed position, but loads should be disconnected downstream wherever practical. Where practical, panelboards should be energized by closing a disconnect switch on the supply side. Otherwise, the panelboard should be energized by closing its own main disconnect devices.

Part VIII
CARE AND MAINTENANCE

A care and maintenance program for panelboards should be conducted on a regularly scheduled basis in accordance with the following:

1. A panelboard which has been carrying its regular load for at least 3 hours just prior to inspection should be field tested by feeling the deadfront surfaces of circuit breakers, switches, interior trims, doors and cabinet sides with the palm of the hand. If the temperature of these surfaces does not permit you to maintain contact for at least 3 seconds, this may be an indication of trouble and investigation is necessary.

WARNING—BEFORE PERFORMING ANY OF THE FOLLOWING OPERATIONS, TURN OFF ALL POWER SUPPLYING THE PANELBOARD AND CHECK THE VOLTAGE OF ALL INCOMING LINE TERMINALS TO POSITIVELY ASCERTAIN THAT THE EQUIPMENT IS TOTALLY DEENERGIZED.

2. Inspect the panelboard once each year or after any severe electrical fault.
   a. Look for any moisture or signs of previous wetness or dripping inside the panelboard. Condensation in conduits or dripping from outside sources is a common cause of panelboard failure.
      (1) Seal off any conduits which have dripped condensate, and provide a means for the conduit to drain.
      (2) Seal off any cracks or openings which have allowed moisture to come in from outside the enclosure. Where possible, eliminate the source of any dripping on the enclosure or other source of moisture.
      (3) Replace or thoroughly dry and clean any insulating material which is damp or wet or shows an accumulation of deposited material from previous wettings.
   b. If there is an appreciable accumulation of dust and dirt, clean out the panelboard by using a brush, vacuum cleaner, or clean lint-free rags. Avoid blowing dirt into circuit breakers or other equipment.
   c. Carefully inspect all visible electrical joints and terminals.
      (1) Retighten bolts and nuts at bus joints if there is any sign of overheating or looseness. (See Part V, item 1.a for tightness recommendations.) If joints appear to be badly discolored, corroded, or pitted, the parts should be disassembled and replaced or cleaned.

CAUTION—DO NOT REMOVE PLATING ON ALUMINUM PARTS IN JOINTS. DAMAGED ALUMINUM PARTS SHOULD BE REPLACED.

      (2) Examine all wire or cable connections for evidence of looseness or overheating. Retorque if necessary. (See Part V, item 1.c.) If major discoloration or cable damage is apparent, replace the damaged parts and remove the damaged portion of the cable.

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(3) Closely examine fuse clips. If there is any sign of overheating or looseness, check spring pressure, tightness of clamps, etc. Replace the fuse clips if the spring pressure compares unfavorably with that of other identical fuse clips on the panelboard.
(4) Retighten plug fuses.
(5) Look for signs of deterioration in insulating material or melting of sealing wax. Replace such insulating parts, and assemblies where sealing wax has melted. Be sure the condition which caused the overheating has been corrected.

d. Check operation of all mechanical components.
(1) Exercise switch operating mechanisms and external operators for circuit breakers, making sure that they quickly and surely throw the contacts fully on and fully off.
(2) Check the integrity of all electrical and mechanical interlocks and padlocking mechanisms.
(3) Wherever possible, check all devices for missing or broken parts, proper spring tension, free movement, rusting or corrosion, dirt, and excessive wear.
(4) Adjust, clean, and lubricate or replace parts as required.

e. Examine all readily accessible arc chutes and insulating parts for cracks or breakage and for arc spatter, sooty deposits, oil, or tracking.
(1) Clean off arc spatter, oil, and sooty deposits, but replace parts if appreciable material has burned away or if material is charred or tracked.
(2) Replace insulating parts and arc chutes that are cracked or broken.

3. Clean and dress *copper* electrical contacts, blades and jaws when inspection indicates the need to do so. Avoid removing metal from silver contact surfaces.
a. Dress sliding contacts to remove projecting burrs or arc transferred material which interferes with free movement.
b. Clean contact surfaces to remove black oxides. Use fine aluminum oxide paper and remove as little material as possible. Keep metal and abrasive particles entirely out of the panelboard.
c. Replace blades or jaws which are burned away enough to appreciably change their shape or to interfere with the tapered edges, etc., which allow them to act freely.
d. Where contacts show signs of overheating, compare spring pressures and stiffness of parts with those of identical good contacts. Replace springs, jaws, blades, or contacts if they have been softened or otherwise damaged by heat.

4. Lubricate the operating parts of switch mechanisms, etc., according to the manufacturer's instructions which are usually printed on diagrams or labels.
a. Use clean, nonmetallic, light grease or oil as instructed.
b. Do *not* oil or grease parts of molded case circuit breakers.
c. If no instructions are given on the devices, sliding copper contacts, operating mechanisms and interlocks may be lubricated with clean, light grease.
d. Wipe off excess lubrication to avoid catching dirt.

5. Operate each switch or circuit breaker several times to make sure that all mechanisms are free and in proper working order.

6. Check insulation resistance:
a. If a severe electrical fault has occurred.
b. If it has been necessary to replace parts or clean insulating surfaces.
c. If the panelboard has been exposed to high humidity, condensation or dripping moisture.

7. Check fuses to make sure they have the proper ampere rating and interrupting rating. Make sure that noncurrent-limiting fuses are never used as replacements for current-limiting fuses. Never attempt to defeat rejection mechanisms which are provided to prevent the installation of the wrong type of fuses.

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Part IX
PERMISSIBLE LOADING OF PANELBOARDS

The ratio of load current to the ampere rating of the overcurrent protective device determines its operating temperature. In compliance with Section 384-16 of the *National Electrical Code,* the loads of panelboard circuits should be not more than 80 percent of the rating of the overcurrent protective device, unless the marking of the device indicates that it is suitable for continuous duty at 100 percent of its rating.

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted 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 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.

(Bylaw—Art. V, Sec. 1)

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

(Bylaw—Art. V, Sec. 2, Subsection A)

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.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

Classes of Standards

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;
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, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Bylaw—Art. V, Sec. 2, Subsection B)

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.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

Official Standards Proposal

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.

(Bylaw—Art. V, Sec. 4, Subsection A)

Identification of Status

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.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

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PANELBOARD AND DISTRIBUTION BOARD SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

Control Power Systems, Inc.
Manchester, NH 03108

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Distribution Apparatus Division
Florence, KY 41042

Cutler-Hammer Group, Eaton Corp.
Milwaukee, WI 53216

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Square D Company
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