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STANDARDS PUBLICATION NO. PB 1

Panelboards

NEMA

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PB 1

PANELBOARDS

Published by:

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TABLE OF CONTENTS

		Page
	FOREWORD	i
	SCOPE	ii
Section 1	REFERENCED STANDARDS	1
Section 2	DEFINITIONS	3
Section 3	GENERAL STANDARDS	
	Types of Panelboards	9
	Lighting and Appliance Branch-Circuit Panelboards	9
	Distribution Panelboards	9
	Panelboard Circuit Protective Devices—NEMA Standards	10
	UL Requirements	10
	Usual Service Conditions	10
	Unusual Service Conditions	10
	Suitability for Use as Service Equipment	11
	Lighting and Appliance Branch-Circuit Panelboard Mains	11
	Standard Main Bus, Switch, and Breaker Ratings	11
	Precautionary Labels	12
Section 4	RATING STANDARDS	
	Standard Voltage Ratings	13
	Current Rating	13
	Frequency Rating	13
	Basis of Short-Circuit Current Rating of Panelboards	13
	Standard Short-Circuit Current Ratings of Panelboard Devices	13
Section 5	TEST STANDARDS	
	Classification of Tests	15
	Design Tests	15
	Production Tests	16
Section 6	CONSTRUCTION	
	General	17
	Uninsulated Live Metal Parts	17
	Wiring Terminations	17
	Spacings	18
	Grounding and Insulating	18
	Cabinets, Gutters, and Wiring Space	20
	Fuse and Circuit Breaker Location	20
	Enclosures	20
Section 7	APPLICATION STANDARDS	
	Selection of Apparatus	22
	Voltage Ratings	22
	Continuous-Current-Carrying Ratings	22
	Calculation of Available Short-Circuit Current	22
	Short-Circuit Current Ratings	22
	Field-Installed Conductors	23
	Corner-Grounded (Grounded B Phase) Three-Phase Delta Applications	24
	Mounting of Enclosure	24

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		Page
Figure 2-1	Sub-feed Lugs Connected to Main Incoming Line Terminals	4
Figure 2-2	Sub-feed Lugs Connected to Bus Bars Protected by an Overcurrent Protective Device in the Panelboard	5
Figure 2-3	Feed Through Lugs for a Separate Circuit External to the Panelboard	5
Figure 2-4	Gutter Tap Lugs Connected to Panelboard Mains	7
Figure 2-5	Gutter Tap Lugs Connected to a Branch Circuit	7
Figure 3-1	Recommended Warning Label	12
Figure 3-2	Symbol Denoting Hazard of Electrical Shock or Burn	12
Figure 7-1	Typical Panelboard Schematic	23
Table 3-1	Standard Lighting and Appliance Branch-Circuit Panelboard Voltage Systems	9
Table 3-2	Standard Power Distribution Panelboard Voltage Systems	10
Table 3-3	Usual Ambient Limits of Devices Commonly Mounted in Panelboards	11
Table 4-1	Standard Panelboard Voltage Ratings	13
Table 6-1	Minimum Panelboard Spacing, Inch (mm)	18
Table 6-2	Size of Grounding Electrode Conductors and Main Bonding Jumper	19

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Foreword

This Standards Publication is intended to provide a basis of common understanding within the electrical community by aiding the user and specifier in properly selecting panelboards for specific applications by stating:

1. The general standards for panelboards including the types, insulating requirements, unusual service conditions, service equipment requirements, ampacity, and markings;
2. Standard panelboard ratings including short circuit current ratings;
3. Test procedures and tests for panelboard design and production;
4. Manufacturing standards for panelboards; and
5. Panelboard application standards to provide proper selection of a panelboard and its components to ensure satisfactory service.

To ensure a meaningful publication, copies were sent during the draft stage to a number of individuals and organizations in the public and private sector having an interest in or responsibility for the purchase, testing, application, use, or inspection of this product category. Their resultant comments and suggestions provided a vital user and general interest input prior to final NEMA approval and resulted in a number of substantive changes being made in the publication. As future major revisions to this publications are proposed, it is intended to offer the same or similar individuals or organizations a further opportunity to participate in the development of this publication.

PB 1-1990 completely revises and supersedes PB 1-1984.

These standards are periodically reviewed by the Panelboard and Distribution Board Section of NEMA for any revisions necessary to keep them up-to-date with advancing technology. Proposed or recommended revisions should be submitted to:

Vice President, Engineering
National Electrical Manufacturers Association
2101 L Street, N.W., Suite 300
Washington, DC 20037

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Scope

This Standards Publication covers single panelboards or groups of panel units suitable for assembly in the form of single panelboards, including buses, and with or without switches or automatic overload protective devices (fuses or circuit breakers), or both. These units are used in the distribution of electricity for light, heat, and power at 600 volts and less with:

- 1600-ampere mains and less
- 1200-ampere branch circuits and less

Specifically excluded are live-front panelboards, panelboards employing cast enclosures for special service conditions, and panelboards designed primarily for residential and light commercial service equipment.

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PANELBOARDS

Section 1
REFERENCED STANDARDS

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70-1987	*National Electrical Code*

Institute of Electrical and Electronics Engineers
445 Hoes Lane
Piscataway, NJ 08855-1331

IEEE Std. 141-1986	*Electric Power Distribution for Industrial Plants*
IEEE Std. 241-1983	*Electric Power Systems in Commercial Facilities*

National Electrical Manufacturers Association
2101 L Street, N.W., Suite 300
Washington, DC 20037

AB 1-1986	*Molded Case Circuit Breakers*
AB 3-1984	*Molded Case Circuit Breakers and Their Application*
FU 1-1986	*Low-Voltage Cartridge Fuses*
KS 1-1990	*Enclosed Switches*
PB 1.1-1986	*Instructions for Safe Installation, Operation, and Maintenance of Panelboards*
PB 2.2-1988	*Ground Fault Protective Devices for Equipment*
250-1985	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 50-1988 (Revised 5/18/89)	*Cabinets and Boxes*
UL 67-1988 (Revised 2/89)	*Panelboards*
UL 198B-1988 (Revised 3/88)	*Class H Fuses*
UL 198C-1986 (Revised 9/87)	*High-Interrupting-Capacity-Limiting Type Fuses*
UL 198D-1988 (Revised 7/88)	*High-Interrupting Capacity K Fuses*
UL 198E-1988 (Revised 7/88)	*Class R Fuses*
UL 198F-1988	*Plug Fuses*
UL 198G-1988 (Revised 5/88)	*Fuses for Supplementary Overcurrent Protection*
UL 198H-1988	*Class T Fuses*
UL 198L-1988	*D-C Fuses for Industrial Use*
UL 224-1981 (Revised 4/85)	*Extruded Insulating Tubing*
UL 486A-1980 (Revised 2/87)	*Wire Connectors and Soldering Lugs for Use with Copper Conductors*
UL 486B-1982 (Revised 2/87)	*Wire Connectors for Use with Aluminum Conductors*
UL 489-1986 (Revised 4/88)	*Molded Case Circuit Breakers and Circuit Breaker Enclosures*

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UL 746A-1978 (Revised 9/87)	*Polymeric Materials—Short Term Property Evaluations*
UL 746B-1979 (Revised 1/87)	*Polymeric Materials—Long Term Property Evaluations*
UL 746C-1978 (Revised 9/87)	*Polymeric Materials—Used in Electrical Equipment Evaluations*
UL 746D-1983 (Revised 5/85)	*Polymeric Materials—Fabricated Parts*
UL 746E-1985 (Revised 4/86)	*Polymeric Materials—Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre & Materials Used In Printed Wiring Boards*
UL 869-1989	*Service Equipment*
UL 869A-1987	*Reference Standard for Service Equipment*
UL 977-1984	*Fused Power Circuit Devices*
UL 1087-1986 (Revised 10/87)	*Standard for Molded Case Switches*
UL 1446-1980 (Revised 4/81)	*Systems of Insulating Materials—General*
UL 1429-1988	*Pullout Switches*

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Section 2
DEFINITIONS

For the purpose of this Standards Publication, the following definitions shall apply:

2.1 AMBIENT TEMPERATURE

Ambient temperature is the temperature of the surrounding medium that comes in contact with the device or equipment.

When applied to panelboards, ambient temperature refers to the temperature of the air outside of the panelboard's enclosing structure.

NEMA Standard 5-16-1984.

2.2 AMPACITY

Ampacity is the current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

NEMA Standard 5-16-1984.

2.3 ASYMMETRICAL CURRENT

Asymmetrical current is alternating current having a waveform that is offset with respect to the zero axis due to a transient condition. The offset occurs at the initiation of a short circuit or other change in current. The offset usually decays quickly until steady-state conditions are reached and the current becomes symmetrical. Asymmetrical current is composed of the direct and symmetrical current components. It is expressed in rms total amperes or rms asymmetrical amperes at a specific time (normally ½ cycle) after initiation of a short circuit or other change in current.

NEMA Standard 5-16-1984.

2.4 AUXILIARY SWITCH

Auxiliary switches are switches which are mechanically operated by the main switching devices for signaling, interlocking, or other purposes. Auxiliary switch contacts shall be permitted to be designated as a or b as indicated below but other contact arrangements shall be permitted to be used.

a Contacts – contacts that are open when the switching device contacts are open or tripped and closed when the switch contacts are closed.

b Contacts – contacts that are closed when the switching device contacts are open or tripped and open when the switch contacts are closed.

NEMA Standard 5-16-1984.

2.5 AVAILABLE SHORT-CIRCUIT CURRENT

Available short-circuit current is the maximum current in rms symmetrical amperes that a circuit is capable of delivering at the system terminals ahead of the apparatus being supplied.

NEMA Standard 5-16-1984.

2.6 BARRIER

Barrier is a partition for the insulation or isolation of electric circuits or electric arcs.

NEMA Standard 11-15-1956.

2.7 BONDING

Bonding is a means of electrical connection that ensures the electrical continuity of a grounding circuit.

NEMA Standard 11-12-1970.

2.8 BONDING JUMPER

Bonding jumper is a conductor that provides the necessary electrical conductivity between metal parts required to be electrically connected in a grounding circuit.

NEMA Standard 11-12-1970.

2.9 BONDING SCREW

Bonding screw is a screw that is used as a bonding jumper or to attach a bonding jumper to a metal part of a grounding circuit.

NEMA Standard 11-12-1970.

2.10 BUS

Bus is a conductor, or group of conductors, that serves as a common connection for two or more circuits.

NEMA Standard 3-16-1977.

2.11 CABINET

Cabinet is an enclosure designed for either surface or flush mounting and provided with a frame, matte, or trim in which swinging doors may be hung. See Enclosure.

NEMA Standard 5-16-1984.

2.12 CARTRIDGE FUSE

Cartridge fuse is a device consisting of a current-responsive element inside a fuse tube with ferrules or blades on both ends.

NEMA Standard 5-16-1984.

2.13 CIRCUIT BREAKER

Circuit breaker is a device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating.

NEMA Standard 5-16-1984.

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2.14 CLEARING I^2t

Clearing I^2t is an indicator of the let-through energy, in terms of current and time, of an overcurrent protective device during its total clearing time.

NEMA Standard 5-16-1984.

2.15 COMPRESSION WIRE CONNECTOR (CRIMP TYPE)

Compression wire connector (crimp type) is a nonreusable connector in which the pressure to affix the connector to the electrical conductor is applied by deformation of the connector and conductor by an application tool that is removed before service.

NEMA Standard 1-23-1990.

2.16 CONTINUOUS DUTY

Continuous duty is a requirement of service that demands operation at a substantially constant load for an indefinitely long time.

A panelboard shall be considered subject to continuous duty when more than 67 percent of the load is expected to be continuous.

NEMA Standard 5-16-1984.

2.17 CONTINUOUS LOAD

Continuous load is one in which the current is expected to continue for 3 hours or more.

NEMA Standard 5-16-1984.

2.18 CURRENT-LIMITING DEVICE (AC)

AC current-limiting device is an overcurrent protective device that interrupts all available overcurrents within its interrupting rating and, within its current-limiting range, limits the clearing time at rated voltage to a time interval equal to or less than the first major current loop duration, and limits peak let-through current to a value less than the peak current that would be possible with the device replaced by a solid conductor of the same impedance.

NEMA Standard 5-16-1984.

2.19 CURRENT-LIMITING RANGE (AC)

Current-limiting range of an overcurrent protective device is that range of symmetrical rms available currents equal to and less than the interrupting rating of the device in which the total clearing time at rated voltage and frequency is less than ½ cycle.

NEMA Standard 5-16-1984.

2.20 CURRENT RATING

Current rating of a panelboard is the designated maximum direct current or alternating current in rms amperes at rated frequency that a panelboard can carry continuously without exceeding its temperature rise limits.

NEMA Standard 5-16-1984.

2.21 DEVICE

Device is a component of an electrical system that is intended to carry or control, but not utilize, electrical energy.

NEMA Standard 5-16-1984.

2.22 DIELECTRIC WITHSTAND TESTS

Dielectric withstand tests determine the ability of the insulating materials and spacings to withstand overvoltages.

NEMA Standard 5-16-1984.

2.23 DISTRIBUTION (FEEDER OR POWER) PANELBOARD

Distribution (feeder or power) panelboard is a panelboard having circuit switching and overcurrent protective devices used primarily: (1) to supply distribution circuits to lighting and appliance branch circuit panelboards or to other distribution panels; or (2) to feed a group of circuits other than the lighting and appliance type or both. (See Lighting and Appliance Branch Circuit Panelboard.)

NEMA Standard 11-12-1970.

2.24 DOUBLE-LUG PANELBOARD

Double-lug panelboard is one that has two sets of main line terminals, each set having sufficient current-carrying capacity to supply the panelboard. (See Figures 2-1 and 2-2.)

NEMA Standard 11-12-1970.

2.25 DUMMY FUSE (TEST LINK)

Dummy fuse (test link) is a current-carrying part made of copper and having dimensions such that it will fit its fuse mounting means with the same conditions of pressure, contact, and cross-sectional areas as are obtained on terminals of the fuse that it is intended to replace. A dummy fuse is not a protective device and is intended for use only in design tests.

NEMA Standard 1-23-1990.

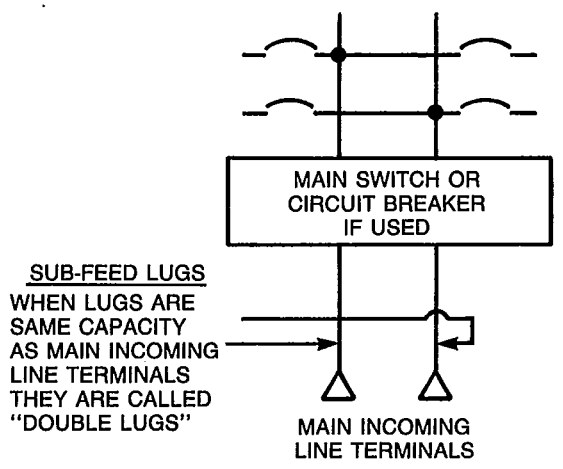


Figure 2-1
SUB-FEED LUGS CONNECTED TO MAIN INCOMING LINE TERMINALS

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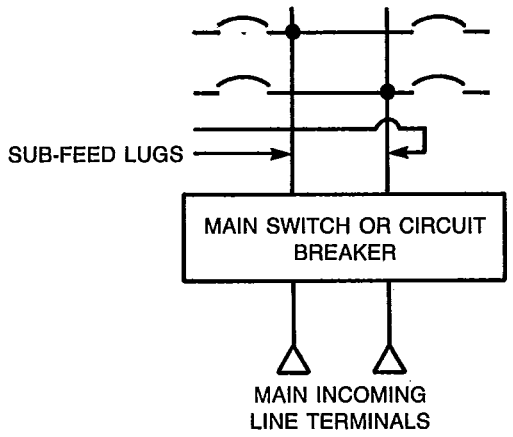


Figure 2-2
SUB-FEED LUGS CONNECTED TO BUS BARS PROTECTED BY AN OVERCURRENT PROTECTIVE DEVICE IN THE PANELBOARD

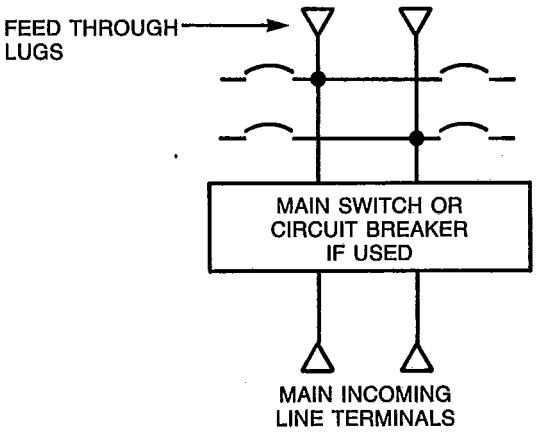


Figure 2-3
FEED THROUGH LUGS FOR A SEPARATE CIRCUIT EXTERNAL TO THE PANELBOARD

2.26 ENCLOSED PANELBOARD

Enclosed panelboard is a panelboard that is mounted in a suitable cabinet or enclosure.

NEMA Standard 11-12-1970.

2.27 ENCLOSURE (SEE CABINET)

Enclosure is a surrounding case constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

NEMA Standard 5-16-1984.

2.28 FEED-THROUGH LUGS

Feed-through lugs are terminals that are connected to the main bus bars at the end opposite from the incoming line terminals and that provide for connection to outgoing cables. (See Figure 2-3).

NEMA Standard 11-12-1970.

2.29 FLUSH MOUNTED (TYPE)

Flush mounted means designed to be set into and secured to a flat surface, with a minimal front projection.

NEMA Standard 11-12-1970.

2.30 FRAME SIZE

Frame size is a term applied to a group of molded case circuit breakers that are physically interchangeable with each other. Frame size is expressed in amperes and corresponds to the largest ampere rating available in the group. The same frame size designation may be applied to more than one group of circuit breakers. These groups may or may not be physically interchangeable with each other, whether furnished by one manufacturer or various manufacturers.

NEMA Standard 11-12-1970.

2.31 FUSE

Fuse is a protective device that opens by the melting of a current sensitive element during a specified overcurrent condition.

NEMA Standard 1-23-1990.

2.32 FUSE CLIPS

Fuse clips are the contacts of the fuseholder that support the fuse and connect the fuse terminals with the circuit.

NEMA Standard 11-12-1970.

2.33 FUSIBLE SWITCH

Fusible switch is a switch in which one or more poles have a fuse in series in a composite unit. (They should not be confused with switches in which the fuse forms the moving contact.)

NEMA Standard 5-16-1984.

2.34 FUSEHOLDER

Fuseholder is an assembly of a base, fuse clips, and necessary insulation for the mounting and connecting of a fuse into a circuit.

NEMA Standard 11-12-1970.

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2.35 GROUNDED

Grounded means connected to earth or to some conducting body that serves in place of the earth.

NEMA Standard 11-12-1970.

2.36 GROUNDED CONDUCTOR

Grounded conductor is a system or circuit conductor that is intentionally grounded.

NEMA Standard 5-16-1984.

2.37 GROUND FAULT PROTECTOR (GFP)

Ground fault protector is a device or system that provides protection for equipment (not for personnel) by opening the circuit in case of a predetermined ground fault current. A ground fault protector includes a ground fault current sensing device and relaying equipment or a combination of ground fault current sensing device and relaying equipment that will operate to cause a disconnecting means to function at a predetermined value of ground fault current.

NEMA Standard 5-16-1984.

2.38 GROUNDING CONDUCTOR

Grounding conductor is one that is used to connect equipment or the grounded circuit of a wiring system to the grounding electrode(s).

NEMA Standard 11-12-1970.

2.39 GROUNDING CONDUCTOR, EQUIPMENT

Equipment grounding conductor is one that is used to connect noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor at the service or grounding electrode conductor, or both.

NEMA Standard 3-16-1977.

2.40 GUTTER TAP LUGS

Gutter tap lugs are terminals that are located in a wiring gutter of a panelboard cabinet and that provide for: (1) the connection of the incoming and outgoing conductors and panelboard mains; or (2) the connection of two sets of outgoing conductors to a branch or other outgoing circuit. (See Figures 2-4 and 2-5.)

NEMA Standard 5-16-1984.

2.41 HINGED-COVER SWITCH

Hinged-cover switch is a switch that disconnects the circuit when the hinged cover is manually operated and in which suitable means are provided for reclosing the cover without reestablishing the circuit.

NEMA Standard 5-16-1984.

2.42 INTERLOCK

Interlock is an electrical or mechanical component actuated by the operation of a device or other means, with which it is directly associated, to govern succeeding operations of the same or allied devices.

NEMA Standard 5-16-1984.

2.43 INTERRUPTING RATING

Interrupting rating of an overcurrent protective device is a rating based upon the highest available rms symmetrical current, or direct current at a specified voltage, that the device is capable of interrupting under prescribed test conditions.

NEMA Standard 5-16-1984.

2.44 KNOCKOUT

Knockout is a portion of the wall of a box or cabinet so fashioned that it may be removed readily by a hammer, screwdriver, and pliers at the time of installation in order to provide a hole for the attachment of raceway, cable, or fitting.

NEMA Standard 11-12-1970.

2.45 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARD

Lighting and appliance branch-circuit panelboard is one having a maximum of 42 branch overcurrent protective devices and more than 10 percent of its overcurrent devices rated 30 amperes or less, for which neutral connections are provided.

NEMA Standard 5-16-1984.

2.46 LUGS

Lugs are terminals that provide for the connection of wire and cable to a panelboard or for connections between component parts of a panelboard.

NEMA Standard 11-12-1970.

2.47 MAINS (MAIN TERMINALS)

Mains of a panelboard are the terminals, or main device, which are provided for the connection of the main incoming line conductors.

NEMA Standard 5-16-1984.

2.48 METER LOOP

Meter loop is a form of split-bus construction in which each set of bus bars has terminals to provide for the metering of a portion of the panelboard.

NEMA Standard 11-12-1970.

2.49 NEUTRAL (ASSEMBLY)

Neutral (or solid neutral) is an assembly consisting of an appropriate number of terminals to provide for the connection of the grounded (neutral) line and load conductors. When used as a component of service equipment, the neutral also includes: (1) a means for making the required bonding connection between the

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neutral and the enclosure; and (2) a terminal for the service grounding conductor.

NEMA Standard 11-12-1970.

2.50 NEUTRAL CONDUCTOR

Neutral conductor is the grounded conductor of a three-wire single-phase ac or dc supply system or four-wire three-phase ac supply system.

NEMA Standard 5-16-1984.

2.51 NONVENTILATED

Nonventilated means so constructed as to provide no intentional circulation of external air through the enclosure.

NEMA Standard 11-12-1970.

2.52 OVERCURRENT PROTECTIVE DEVICE

Overcurrent protective device is an individual fuse or circuit breaker pole.

NEMA Standard 3-16-1977.

2.53 PANELBOARD

Panelboard is a single panel or a group of panel units designed for assembly in the form of a single panel, including buses, and with or without switches or automatic overcurrent protective devices, or both, for the control of light, heat, or power circuits designed to be placed in a cabinet or enclosure accessible only from the front.

NEMA Standard 3-16-1977.

2.54 PEAK LET-THROUGH CURRENT (AC)

Peak let-through current is the maximum instantaneous current through an overcurrent device during its total clearing time.

NEMA Standard 5-16-1984.

2.55 PLUG FUSE

Plug fuse is a device in which the fusible member is enclosed in a housing that provides for a coaxial arrangement of terminals, one terminal being at one end of the housing on the centerline of the fuse, the other in the form of a contact ring or threaded shell on the outside of the housing.

NEMA Standard 5-16-1984.

2.66 PRESSURE WIRE CONNECTOR (MECHANICAL TYPE)

Pressure wire connector (mechanical type) is a reusable connector in which the pressure to affix the connector to the electrical conductor is applied by integral screw, cone, or other mechanical parts.

NEMA Standard 1-23-1990.

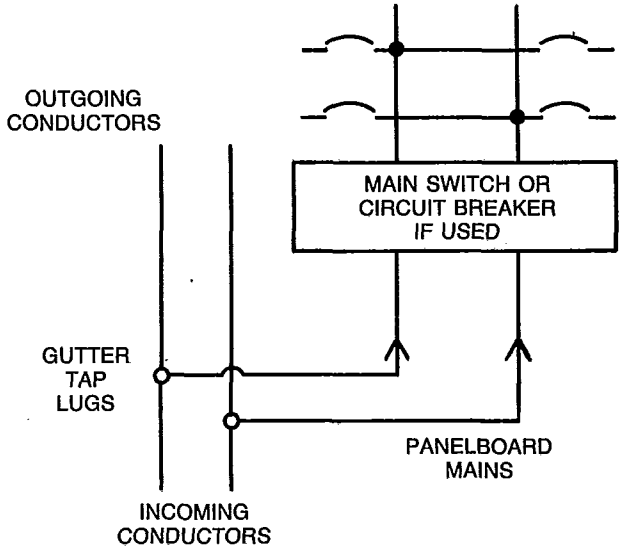


Figure 2-4
GUTTER TAP LUGS CONNECTED TO PANELBOARD MAINS

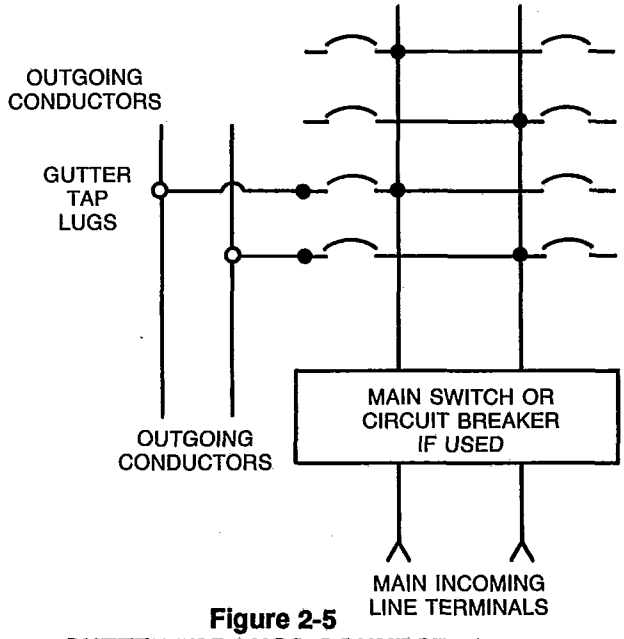


Figure 2-5
GUTTER TAP LUGS CONNECTED TO A BRANCH CIRCUIT

2.67 PULLOUT SWITCH

Pullout switch is a switch that disconnects the circuit when the movable contact assembly, which is a separable part, is manually withdrawn.

NEMA Standard 11-12-1970.

2.68 RATING

Rating of a device is a designated limit of operating characteristics based on definite conditions.

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Such operating characteristics as current, voltage, frequency, and so forth, shall be permitted to be given in the rating.

NEMA Standard 5-16-1984.

2.69 SERVICE

Service refers to the conductors and equipment which deliver energy from the electricity supply system to the wiring system of the premises served.

NEMA Standard 11-12-1970.

2.70 SERVICE EQUIPMENT

Service equipment is the equipment (usually consisting of circuit breakers or switches and fuses and their accessories) that is located near the point of entrance of supply conductors to a building and is intended to constitute the main control and means of cutoff for the supply to that building.

NEMA Standard 11-12-1970.

2.71 SHORT-CIRCUIT CURRENT RATING (EQUIPMENT)

Short-circuit current rating is the rating that indicates the ability of equipment to withstand the effects of short-circuit current without exceeding specified damage criteria.

NEMA Standard 11-12-1970.

2.72 SPLIT-BUS PANELBOARD

Split-bus panelboard is one in which two or more sets of bus bars supplying groups of overcurrent protective devices are fed from separate circuits or subfed one from another.

NEMA Standard 11-12-1970.

2.73 SUBFEED LUGS

Subfeed lugs are terminals that provide for the connection of cables:

1. To bus bars that are connected directly to the panelboard main incoming line terminals (see Figure 2-1); or
2. To bus bars fed by an overcurrent protective device in the panelboard (see Figure 2-2).

NEMA Standard 11-12-1970.

2.74 SWITCH

Switch is a device for making, breaking, or changing the connections in an electric circuit.

NEMA Standard 11-15-1956.

2.75 SYMMETRICAL CURRENT

Symmetrical current is alternating current having no offset or transient component and, therefore, having a wave form essentially symmetrical about the zero axis. Symmetrical current is expressed in terms of rms amperes.

NEMA Standard 11-12-1970.

2.76 VENTILATED

Ventilated means so constructed as to provide a means to permit circulation of external air through the enclosure to remove excess heat, fumes, and vapors.

NEMA Standard 5-16-1984.

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Section 3
GENERAL STANDARDS

3.1 TYPES OF PANELBOARDS

Panelboards shall be of the lighting and appliance branch-circuit or power and feeder distribution type.

NEMA Standard 5-16-1984.

3.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

Lighting and appliance branch-circuit panelboards shall be constructed or designed for application on one or more of the voltage systems indicated in Table 3-1.

NEMA Standard 5-16-1984.

3.3 DISTRIBUTION PANELBOARDS

Distribution panelboards shall be constructed or designed for application on one or more of the voltage systems indicated in Table 3-2.

NEMA Standard 5-16-1984.

Table 3-1
STANDARD LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARD VOLTAGE SYSTEMS

Type of Branch Circuit Device	Voltage Ratings		Type of Overcurrent Device
	Alternating Current	Direct Current	
Switch and Fuse	120V 1ϕ2W 120/240V 1ϕ3W 120V 3ϕ3W* 208Y/120V 3ϕ4W	125/250V 3W	Plug fuse
Switch and Fuse	120V 1ϕ2W 120/240V 1ϕ3W 120V 3ϕ3W* 208Y/120V 1ϕ3W 208Y/120V 3ϕ4W 240Y/120V 3ϕ4WΔ 277V 1ϕ2W 480Y/277V 1ϕ3W 480Y/277V 3ϕ4W 600Y/347V 3ϕ4W	125V 2W 125/250V 3W	Cartridge fuse
Molded Case Circuit Breaker	120V 1ϕ2W 120V 3ϕ3W* 120/240V 1ϕ3W 208Y/120V 1ϕ3W 208Y/120V 3ϕ4W 240/120V 3ϕ4W Δ 277V 1ϕ2W 480Y/277V 1ϕ3W 480Y/277V 3ϕ4W 600Y/347V 3ϕ4W	125V 2W 125/250V 3W	Molded Case Circuit Breaker

*Normally for marine application.

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Table 3-2
STANDARD DISTRIBUTION PANELBOARD VOLTAGE SYSTEMS

Type of Branch Circuit Device	Voltage Ratings		Type of Disconnect	Type of Overcurrent Device
	Alternating Current	Direct Current		
Switch and Fuse	120/240V 1ϕ3W 240V 3ϕ3W 208Y/120V 3ϕ4W 240/120V 3ϕ4WΔ 480V 3ϕ3W 480Y/277V 3ϕ4W	125/250V 3W 250V 2W	Pullout	Cartridge fuse
Switch and Fuse	120/240V 1ϕ3W 240V 1ϕ2W 240V 3ϕ3W 208Y/120V 3ϕ4W 208Y/120V 3W 240/120V 3ϕ4WΔ 480V 3ϕ3W 480Y/277V 1ϕ3W 480Y/277V 3ϕ4W 600V 3ϕ3W 600/347V 3ϕ4W	125/250V 3W 250V 2W	Dead front operated	Cartridge fuse
Molded Case Circuit Breaker	120V 1ϕ2W 120/240V 1ϕ3W 240V 3ϕ3W 208Y/120V 3W 208Y/120V 3ϕ4W 240/120V 3ϕ4WΔ 277V 1ϕ2W 480V 3ϕ3W 480Y/277V 1ϕ3W 480Y/277V 3ϕ4W 600V 3ϕ3W 600Y/347V 3ϕ4W	125V 2W 125/250V 3W 250V 2W	Molded Case Circuit Breaker	

3.4 PANELBOARD CIRCUIT PROTECTIVE DEVICES—NEMA STANDARDS

For additional information on panelboard circuit protective devices refer to NEMA Standards Publications:

1. AB 1 *Molded Case Circuit Breakers*
2. KS 1 *Enclosed Switches*
3. FU 1 *Low Voltage Cartridge Fuses*

3.5 UL REQUIREMENTS

Panelboards shall comply with UL 67. Enclosures for panelboards shall comply with UL 50.

NEMA Standard 5-16-1984.

3.6 USUAL SERVICE CONDITIONS

Panelboards conforming to this Standards Publication shall be suitable for operation:

- Where the altitude does not exceed 6600 feet (2000 meters).
- Where the temperature of the air surrounding the panelboard does not exceed the usual ambient temperature limits of devices commonly mounted in panelboards as indicated in Table 3-3.

NEMA Standard 5-16-1984.

3.7 UNUSUAL SERVICE CONDITIONS

The use of panelboards in ambient temperatures lower or higher than the temperature limits of the devices mounted therein or at altitudes greater than 6600 feet (2000 meters) requires further consideration.

There are other service conditions that may also require further consideration. Where such conditions exist, it is recommended that they be brought to the manufacturer's attention. Panelboards for use in such

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cases may require additional construction or protective features. Among such unusual conditions are exposure to corrosive or explosive fumes, high humidity, dust, vapors, abnormal vibration, mechanical shock, tilting, unusual operating duties, nuclear radiation, or conditions that can lead to internal condensation.

Authorized Engineering Information 5-16-1984.

Table 3-3
USUAL AMBIENT LIMITS OF DEVICES COMMONLY MOUNTED IN PANELBOARDS

Device	Ambient Temperature Limits	Reference Publication No.
Molded Case Circuit Breakers	–5°C through 40°C	NEMA AB 1
Enclosed Switches	–30°C through 40°C	NEMA KS 1
Low-Voltage Cartridge Fuses	See applicable standards	UL 198B UL 198C UL 198D UL 198E UL 198F UL 198G UL 198H UL 198L NEMA FU 1

3.8 SUITABILITY FOR USE AS SERVICE EQUIPMENT

Panelboards that are intended to be suitable for use as service entrance equipment shall meet the requirements of UL 67, UL 869, and UL 869A and have provisions for:

- Connecting to the neutral terminal a grounding electrode conductor the size of which is in accordance with UL 869 and UL 869A.
- Bonding the enclosure to the grounded conductor (neutral).
- Disconnecting all ungrounded load conductors from the source of supply by the operation of not more than six service disconnecting means. (For lighting and appliance panelboards, see 3.9.2.)
- Disconnecting the grounded service conductor when a neutral is provided.

NEMA Standard 1-23-1990.

3.8.1 Ground Fault Protection

Service disconnecting means rated 1000 amperes or more, mounted in a panelboard intended for use as service equipment on a solidly grounded wye electrical system of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase, shall be provided with ground fault protection.

The maximum setting of the ground fault protection equipment shall be 1200 amperes and the maximum time delay shall be one second for ground fault currents equal to or greater than 3000 amperes.

When a ground fault of a magnitude greater than the ground fault protection setting occurs, the ground fault protection equipment shall operate to cause the service disconnecting means to open all ungrounded conductors of the circuit.

3.9 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARD MAINS

3.9.1 The ampacity of the main bus bars in a lighting and appliance branch-circuit panelboard shall be no less than the value obtained by assuming an average load current of 10 amperes for each overcurrent protective device in a lighting and appliance branch-circuit connected to that main bus. If the number of lighting and appliance branch-circuit overcurrent protective devices connected to any main bus differs by no more than two from the number of such overcurrent protective devices connected to any other main bus in the panelboard, the average number of such overcurrent protective devices per main bus may be used in determining the minimum ampacity of all main buses. (See 3.10.) *Exception:* The ampacity of the main bus bars in a panelboard that has been designed for a specific installation where the loading is known and will be less than an average of 10 amperes per branch-circuit shall be permitted to be less than that calculated by this method.

NEMA Standard 1-23-1990.

3.9.2 Each lighting and appliance branch-circuit panelboard shall be protected on the supply side by not more than two main circuit breakers or two sets of fuses having a combined rating not greater than the rating of the panelboard.

NEMA Standard 5-16-1984.

3.9.3 The standard current ratings of main bus, main switches, main fuseholders, and main circuit breakers (trip-unit rating of breaker with interchangeable trip units) shall be in accordance with 3.10.

NEMA Standard 1-23-1990.

3.10 STANDARD MAIN BUS, SWITCH, AND BREAKER RATINGS

3.10.1 Standard ratings of main bus shall be: 30, 40, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 800, 1000, 1200, or 1600 amperes.

NEMA Standard 5-16-1984.

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3.10.2 Standard ratings for main switches and their fuse holders used in panelboards shall be: 30, 60, 100, 200, 400, 600, 800, or 1200 amperes.

NEMA Standard 5-16-1984.

3.10.3 Standard ratings of main circuit breakers used in panelboards shall be: 30, 40, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 800, 1000, 1200, or 1600 amperes.

NEMA Standard 5-16-1984.

3.11 PRECAUTIONARY LABELS

3.11.1 To make persons aware of immediate or potential hazards in the application, installation, use, or maintenance of panelboards, each panelboard shall be conspicuously marked on the trim or deadfront shield with the text (or equivalent), symbol, and format as shown in Figure 3-1. If the panel is supplied with a door, the precautionary label shall be visible when the door is in the open position.

NEMA Standard 5-16-1984.

3.11.2 The symbol for danger shall have the proportions shown in Figure 3-2. Vivid red Munsell Notation 7.5R 4.0/14 shall be the predominant visual color for either the signal word DANGER and the symbol or for the background. Black, white, or metallic may be used for contrast. These colors shall be permitted to be used either for the lettering or the background.

NEMA Standard 5-16-1984.

3.11.3 These requirements are not intended to rule out the use of other labels or markings that are required to comply with other nationally recognized standards or applicable laws or regulations or that may be deemed necessary by the manufacturer.

Authorized Engineering Information 5-16-1984.

DANGER: Hazard of electrical shock or burn. TURN OFF POWER supplying this equipment before working inside.

Figure 3-1

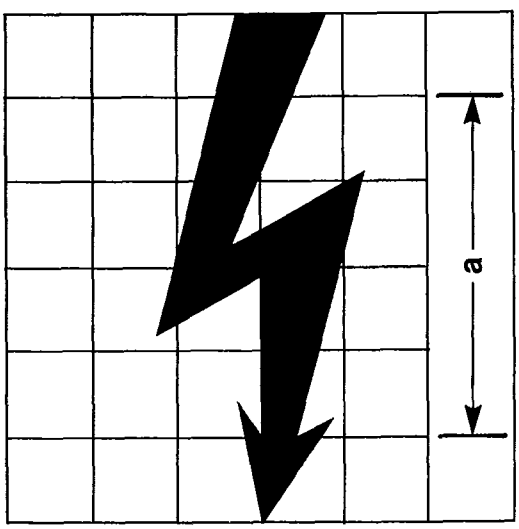


Figure 3-2
DANGER SYMBOL

Dimensions: Height = 1.48a
Width = 0.58a

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Section 4
RATING STANDARDS

4.1 STANDARD VOLTAGE RATINGS

The standard voltage ratings of panelboards shall be as shown in Table 4-1. (For system voltage ratings, see 3.3.)

NEMA Standard 5-16-1984.

4.2 CURRENT RATING

The current rating of a panelboard shall be no more than the smaller of the following:

1. The ampacity of the main bus bars; or
2. The current rating of the main switch and fuseholders or the current rating (trip rating) of the main circuit breaker.

NEMA Standard 5-16-1984.

4.2.1 Panelboards Using a Snap Switch

If a panelboard uses a snap switch rated at 30 amperes or less in any branch circuit, the rating of the panelboard shall be not more than 200 amperes unless there is overcurrent protection at 200 amperes or less within the panelboard on the line side of such a switch.

NEMA Standard 11-3-1983.

4.3 FREQUENCY RATING

The frequency rating of ac panelboards shall be 50, 60, or 50/60 Hz.

NEMA Standard 5-16-1984.

For applications at other than 50, 60, or 50/60 Hz, the manufacturer should be consulted.

Authorized Engineering Information 5-16-1984.

4.4 BASIS OF SHORT-CIRCUIT CURRENT RATING OF PANELBOARDS

The short-circuit rating assigned to a panelboard shall not exceed the short-circuit current rating of any component of that panelboard that is installed in its intended manner (see 5.2.3).

Exception: A higher rating may be assigned to a panelboard for a specific combination of components provided the combination has passed short-circuit current testing, qualifying it for its assigned short circuit current rating.

The short-circuit current rating of a panelboard shall be in rms symmetrical amperes.

NEMA Standard 1-23-1990.

4.5 STANDARD SHORT-CIRCUIT CURRENT RATINGS OF PANELBOARD DEVICES

4.5.1 Circuit Breakers

The standard short-circuit current rating of a circuit breaker used as a device in a panelboard shall be its interrupting current of 5000, 7500, 10,000, 14,000, 18,000, 20,000, 22,000, 25,000, 30,000, 35,000, 42,000, 50,000, 65,000, 85,000, 100,000, 125,000, 150,000, or 200,000 rms symmetrical amperes.

NEMA Standard 5-16-1984.

The manufacturer should be consulted for interrupting current ratings at specific voltages.

Authorized Engineering Information 5-16-1984.

4.5.2 Fusible Switches

The short-circuit rating of a fusible switch used as a device in a panelboard shall be the interrupting rating of the installed fuses or the short-circuit withstand rating of the switch, whichever is the smaller. The ratings of fuses and switches used in combination shall be 10,000, 50,000, 100,000, or 200,000 rms symmetrical amperes.

Fusible switches that are not marked with a short-circuit withstand rating shall be suitable for use on circuits

Table 4-1
STANDARD PANELBOARD VOLTAGE RATINGS

System		Voltage Ratings, Volts	
Number of Phases	Number of Wires	Alternating Current	Direct Current
1 (or direct current)	2	120,240, or 277	125 or 250
1 (or direct current)	3	120/240	125/250
1 (derived from 3-phase system)	3	208Y/120, or 480Y/277	...
3...	3	120,240,480 or 600	...
3...	4 wire delta with the neutral at midpoint of one phase	240/120	...
3...	4 wire wye with neutral	208Y/120, 480Y/277, or 600Y/347	...

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having a maximum available short-circuit current of 10,000 amperes.

NEMA Standard 5-16-1984.

4.5.3 Other Devices

The manufacturer should be consulted for rating information for other devices or combinations of devices used in panelboards.

Authorized Engineering Information 5-16-1984.

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Section 5
TEST STANDARDS

5.1 CLASSIFICATION OF TESTS

5.1.1 Design Tests

Design tests shall be considered to be those tests that are made to determine the adequacy of the design of a particular type, style, or model of panelboard to meet its assigned ratings and to operate satisfactorily under normal service application conditions or under special application conditions if specified.

NEMA Standard 5-16-1984.

Design tests are made only on representative new panelboards to substantiate ratings assigned to all other panelboards of a similar design and are not contemplated under normal production.

Authorized Engineering Information 11-3-1983.

5.1.2 Production Tests

Production tests are those tests that are made to check the quality and uniformity of the workmanship and materials used in the manufacture of panelboards.

NEMA Standard 5-16-1984.

5.2 DESIGN TESTS

Design tests for a panelboard shall include the following:
Temperature Rise Test—5.2.1
Dielectric Test—5.2.2
Short-circuit Test—5.2.3
Environmental Test—5.2.4
Strength of Insulating Base and Support Test—5.2.5

NEMA Standard 5-16-1984.

5.2.1 Temperature Rise Tests

A temperature rise test shall be made unless the bus bars are of a size sufficient to provide a current density not more than that indicated in UL 67.

Under any conditions, a temperature rise test shall be made if a panelboard uses one or more switches, fuseholders, or circuit breakers having plug-in connections to the bus bar.

When temperature rise tests are made, they shall be conducted in accordance with requirements of UL 67.

NEMA Standard 5-16-1984.

5.2.2 Dielectric Tests

A panelboard shall withstand for 1 minute without breakdown the application of a 60 Hz sinusoidal potential of 1000 volts plus twice rated voltage:

1. Between live metal parts and dead metal parts with all switching devices closed; and
2. Between live metal parts of opposite polarity with all switching devices closed.

During the test, overcurrent devices (such as fuses, the trip units of circuit-breaker frames designed for use with interchangeable trip units, and so forth) shall be in place wherever provision is made for their use. A transformer, coil, or other device normally connected between lines of opposite polarity shall be disconnected from one side of the line during the test specified in Item 2.

The test potential shall be supplied from a suitable adjustable voltage output 500 volt-ampere or larger testing transformer, unless the transformer to be used is provided with a suitable voltmeter to directly measure the applied output potential. The applied potential shall be applied spontaneously or be increased gradually from zero until the required test value is reached.

NEMA Standard 5-16-1984.

5.2.3 Short-Circuit Tests

5.2.3.1 TEST PROCEDURE

To determine the capability of a panelboard(s) to withstand a short-circuit current interruption by its main or branch-circuit overcurrent protective devices, short-circuit tests shall be conducted in accordance with the provisions of UL 67.

NEMA Standard 5-16-1984.

5.2.3.2 TEST SAMPLES

A representative number of types and ratings of panelboards shall be tested to adequately determine the satisfactory performance of all sizes.

NEMA Standard 5-16-1984.

5.2.4 Environmental Tests

Environmental tests on panelboard enclosures shall be conducted in accordance with the applicable requirements of UL 50.

5.2.5 Strength of Insulating Base and Support Test

The insulating base of a panelboard shall not be damaged when wire connectors securing short lengths of conductors of rated ampacity are torqued to 110 percent of the value marked on the panelboard.

Damage is considered to have occurred if the base insulating material cracks or rotates; bosses, recesses, or other means to prevent turning do not perform their intended function; straps or bus bars bend or twist; or members move at electrical joints. Minor chipping or flaking of brittle insulating material is acceptable if the performance is not otherwise impaired. Momentary

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flexing of metallic members without permanent deformation is acceptable.

NEMA Standard 5-16-1984.

5.3 PRODUCTION TESTS

Production tests for a panelboard containing ground fault sensing equipment shall include a ground-fault-sensing test as described in 5.3.1.

NEMA Standard 5-16-1984.

5.3.1 Ground-Fault-Sensing Test

When a panelboard contains ground-fault-sensing equipment, it shall be tested in the following manner to ensure proper operations:

With the primary of the control circuits supply transformer, if used, energized at 57 percent of its voltage rating, a simulated ground-fault current shall be supplied and shall cause the breaker or switch to open. The pickup point of the relay shall be permitted to be set at any convenient level.

Following this test, with no simulated ground-fault current flowing, an attempt shall be made to close the breaker or switch without performing a reset operation. If the breaker or switch will stay closed, the simulated ground-fault current shall be applied again and the ground-fault protection system shall function.

Exception: The test voltage shall be permitted to be rated voltage if the particular combination of transformer ground-fault-sensing and relaying equipment and disconnecting means has been previously tested at 57 percent of rated voltage.

NEMA Standard 5-16-1984.

One method of simulating a ground-fault current is by wrapping a number of turns of wire through the sensor. A current approximately 125 percent of the pickup setting of the relay divided by the number of turns is passed through the wire to simulate the ground fault current.

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Section 6
CONSTRUCTION

6.1 GENERAL

6.1.1 Marking Information

Panelboards shall be clearly marked with the following information:

1. Manufacturer's name or trademark;
2. Style or type designation;
3. Current rating;
4. Voltage rating;
5. Number of phases (if ac rated); and
6. Short-circuit rating.

These markings shall be located where they will be visible if a front or trim is removed.

NEMA Standard 1-23-1990.

6.1.2 Other Markings

The markings requirements specified in 6.1.1 are not intended to rule out the use of other labels or markings that are required to comply with other nationally recognized standards or applicable laws or regulations, or which may be deemed necessary by the manufacturers.

Authorized Engineering Information 5-16-1984.

6.2 UNINSULATED LIVE METAL PARTS

Uninsulated live metal parts, other than lugs and pressure wire connectors (see 6.4.4), shall be so secured to the base or mounting surface that they will not turn or shift in position. This may be accomplished by two screws or rivets, by square shoulders or mortises, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by some other equivalent method other than friction between the surfaces.

NEMA Standard 5-16-1984.

6.3 WIRING TERMINATIONS

6.3.1 Conductor Terminals

The manufacturer shall specify, or provide, suitable terminals such as pressure wire connectors, compression connectors, or wire binding screws for the connection of each conductor that is intended to be installed in the panelboard in the field except for those main connections that are specifically designed to be made to bus bars.

NEMA Standard 5-16-1984.

6.3.2 Main Terminal Kits

The main terminals shall be permitted to be in the form of a main terminal kit if the panelboard is specifically designed for use interchangeably with either the main terminals or with a main circuit breaker or switch.

A main terminal kit shall consist of individual terminals or an assembly of: (1) terminals; (2) bus bars that provide connections between those terminals and the main bus bars of the panelboards; and (3) a mounting means for those components. The kit shall be connectable to the main bus bars by either bolting or plugging in.

The main terminal kit shall be so constructed that: (1) installation can be readily accomplished without the use of a special tool; (2) live parts will be suitably supported after being assembled; and (3) reliable connection to the main bus bars will be afforded.

NEMA Standard 5-16-1984.

6.3.3 Main and Branch-Circuit Terminals

6.3.3.1 MAIN TERMINALS

Main terminals shall be capable of securing the smallest standard size single or multiple conductor having a current-carrying capacity adequate for the current rating of the panelboard as determined from the considerations set forth in 6.3.3.4.

6.3.3.2 BRANCH-CIRCUIT TERMINALS

Terminals for standard size branch-circuit conductors shall be capable of securing the smallest single or multiple conductor having a current-carrying capacity adequate for the application as determined from the considerations set forth in 6.3.3.3 and 6.3.3.4.

6.3.3.3 WIRE CONNECTION TO TERMINALS

In 6.3.3.2, it is assumed that the current-carrying capacity of a wire or wires to be connected to a terminal of:

1. A fuseholder shall be of a value within the range of current ratings of the fuses that the fuseholder will accommodate and for the wire temperature rating for which it or the panelboard is marked.
2. An interchangeable trip type circuit breaker shall be suitable for the rating of the installed trip units and for the wire temperature rating for which it or the panelboard is marked.
3. A noninterchangeable circuit breaker shall be suitable for the current rating of the breaker and for the wire temperature rating for which it or the panelboard is marked.

NEMA Standard 1-23-1990.

6.3.3.4 FIELD-INSTALLED CONDUCTORS

In 6.3.3.1 and 6.3.3.2, it is assumed that field-installed conductors shall be:

1. Of current-carrying capacities given in UL 67;

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2. Aluminum wire at any terminal identified on a wiring diagram or the like as being suitable for use with such wire; and
3. Of the temperature rating for which the panelboard is marked.

NEMA Standard 5-16-1984.

6.3.4 Connectors

The requirements of 6.3.3 do not preclude the use of connectors which will also accommodate a wire(s) of a size(s) different from that specified in 6.3.3.

Authorized Engineering Information 5-16-1984.

6.4 SPACINGS

6.4.1 Minimum panelboard spacings shall be according to Table 6-1 except as indicated in 6.4.3.

NEMA Standard 5-16-1984.

6.4.2 Insulating Material Other Than Air

A liner, barrier, or the like of suitable insulating material used to supplement a space through air which would otherwise be insufficient shall be considered as meeting the requirements of 6.4.1.

NEMA Standard 5-16-1984.

6.4.3 Screw Shells

The spacings between screw shells of plug fuseholders which are protected by surrounding walls of insulating material and between such screw shells and a metal cover plate may be less than those indicated in Table 6-1, but not less than 1/4 inch (6.35 mm) in any case, if the depth of the receptacle as measured from the top of the wall to the plane of the center contact is not less than 3/4 inch (19.1 mm).

NEMA Standard 5-16-1984.

6.4.4 Wire Connectors (Lugs)

Wire connectors (lugs) shall be prevented from turning so that spacings will not be reduced to less than those given in Table 6-1. If such spacings are maintained when connectors (lugs) are turned 30 degrees toward each other or toward other uninsulated live metal or grounded dead metal parts, no means to prevent turning need be provided.

NEMA Standard 5-16-1984.

6.5 GROUNDING AND INSULATING

6.5.1 Operating Handle

An operating handle that is fabricated of a conductive material shall be either insulated or in electrical connection with the panelboard enclosure.

NEMA Standard 5-16-1984.

6.5.2 Grounding and Bonding

There shall be provision for permanently and effectively grounding any metal plate that covers uninsulated live parts unless the plate is provided with means for effectively and adequately insulating it from live parts or unless the plate is so located that it is unlikely to become energized.

NEMA Standard 5-16-1984.

6.5.3 Size of Grounding Conductors

A panelboard that is marked as being suitable for use as service equipment and which is provided with a neutral shall have provision for connecting the service grounding conductor to the neutral terminal in accordance with 6.5.5. The connection shall not depend upon solder for securing the grounding conductor.

NEMA Standard 5-16-1984.

Table 6-1
MINIMUM PANELBOARD SPACING, INCH (mm)*

Voltage Involved	Between Uninsulated Live Parts of Opposite Polarity		Through Air or Over Surface‡ between Uninsulated Live Parts and Grounded Dead Metal
	Through Air	Over Surface†,‡	
125 or less	1/2 (12.7)	3/4 (19.1)	1/2 (12.7)
126–250	3/4 (19.1)	1 1/4 (31.8)	1/2 (12.7)
251–600	1 (25.4)	2 (50.8)	1 (25.4)**

*An isolated dead metal part, such as a screw head or washer, interposed between uninsulated live parts of opposite polarity or between uninsulated live part and grounded dead metal is considered to reduce the spacing by an amount equal to the dimension of the interposed part along the path of measurement.

†An air space of 0.013 inch (0.33 mm) or less between a live part and an insulated surface is to be disregarded and the part is to be considered in contact with the insulating material when measuring spacings.

‡In measuring over-surface spacings, any slots, grooves, and so forth, 0.013 inch (0.033 mm) wide or less in the contour of insulating material are to be disregarded.

**A through-air spacing of not less than 1/2 inch (12.7 mm) is acceptable (1) at a circuit breaker or a switch other than a snap switch and (2) between grounded dead metal and the insulated neutral of a 480Y/277 volt, 3-phase, 4-wire panelboard.

NEMA Standard 5-16-1984.

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6.5.4 Equipment Grounding Terminals

Terminals for equipment grounding conductors shall either be provided or be available in the field for connecting all feeder and branch-circuit equipment grounding conductors, when the panelboard is used with a nonmetallic raceway or cable wiring. Means shall be provided to bond the equipment grounding terminal bar to the panelboard cabinet. This bar shall not be connected to the insulated neutral bar except at service equipment as permitted in the *National Electrical Code.*

NEMA Standard 5-16-1984.

6.5.5 Size of Grounding Electrode Conductors and Main Bonding Jumper

Grounding electrode conductors and main bonding jumpers shall be sized according to Table 6-2.

6.5.6 Grounding of Three-Phase Delta Systems

6.5.6.1 Panelboards intended for use on three-phase three-wire delta systems with one phase corner grounded shall have the B phase grounded (see 7.7).

NEMA Standard 5-16-1984.

Table 6-2
SIZE OF GROUNDING ELECTRODE CONDUCTORS AND MAIN BONDING JUMPER

Ampere Rating Not Exceeding	Size of Main Bonding Jumper (Minimum)*,†,##				Cross-Section of Main Bonding Jumper (Minimum)†,‡				Size of Grounding Electrode Conductor (Minimum)†			
	Copper		Aluminum		Copper		Aluminum		Copper		Aluminum	
	AWG or MCM	mm	AWG or MCM	mm	Square Inches	mm^2	Square Inches	mm^2	AWG or MCM	mm	AWG or MCM	mm
90	8	(8.4)	6	(13.3)	0.013	(8.4)‡	0.021	(13.6)‡	8	(8.4)	6	(13.3)
100	6	(13.3)	4	(21.2)	0.021	(13.6)‡	0.033	(21.3)‡	6	(13.3)	4	(21.2)
125	6	(13.3)	4	(21.2)	0.021	(13.6)‡	0.033	(21.3)‡	6	(13.3)	4	(21.2)
150	6	(13.3)	4	(21.2)	0.021	(13.6)#	0.033	(21.3)#	6	(13.3)	4	(21.2)
200	4	(21.2)	2	(33.6)	0.033	(21.3)#	0.052	(33.6)#	4	(21.2)	2	(33.6)
225	2	(33.6)	0	(53.5)	0.052	(33.6)**,††	0.083	(53.5)**,††	2**,††	(33.6)	0	(53.5)
400	0‡‡	(53.5)	3/0‡‡	(85.0)	0.083	(53.5)††,‡‡	0.132	(85.0)	0‡‡	(53.5)	3/0‡‡	(85.0)
500	0	(53.5)	3/0	(85.0)	0.083	(53.5)	0.132	(85.0)	0	(53.5)	3/0	(85.0)
600	2/0	(67.4)	4/0	(107.2)	0.105	(67.7)	0.167	(107.7)	2/0	(67.4)	4/0	(107.2)
800	2/0	(67.4)	4/0	(107.2)	0.105	(67.7)	0.167	(107.7)	2/0	(67.4)	4/0	(107.2)
1000	3/0	(85.0)	250	(127)	0.132	(85.2)	0.196	(127.0)	3/0	(85.0)	250	(127)
1200	250	(127)	250	(127)	0.196	(127.0)	0.196	(127.0)	3/0	(85.0)	250	(127)
1600	300	(152)	400	(203)	0.236	(152.0)	0.294	(189.7)	3/0	(85.0)	250	(127)
2000	400	(203)	500	(253)	0.314	(203.0)	0.393	(253.0)	3/0	(85.0)	250	(127)

*The cross-section shall be permitted to be reduced to 12.5 percent of the total cross-section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase on a panelboard rated 1200 amperes and above. This applies when the cross-section of the service conductors is limited by the wire terminal connectors provided.

†For a panelboard rated 1200 amperes or more and that has wiring terminals intended to connect service conductor wires sized larger than 600 MCM copper or 750 MCM aluminum, the cross-section of the main bonding jumper shall be at least 12.5 percent of the total cross-section of the largest main service conductor(s) of the same material (copper or aluminum) for any phase.

‡A No. 8 or larger brass or No. 10 or larger steel screw shall be permitted to be used.

#A No. 10 or larger brass or steel screw shall be permitted to be used.

**A No. 10 or larger brass screw shall be permitted to be used.

††A 1/4 inch (6.4 mm) diameter or larger brass or steel screw shall be permitted to be used.

‡‡When the ampere rating is 400 and the wire terminal connectors for the main service conductors are acceptable for two No. 3/0 AWG copper or two No. 250 MCM aluminum conductor but will not accept a 600 MCM conductor, these values may be reduced to No. 2 AWG (0.52 square-inch) copper or No. 0 AWG (0.083 square-inch) aluminum.

##These are also sizes for the grounding service conductor mentioned in 3.8.

NEMA Standard 1-23-1990.

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6.5.6.2 Panelboards intended for use on three-phase four-wire delta systems with the midpoint of one phase grounded shall have the B phase the higher voltage to ground.

NEMA Standard 5-16-1984.

6.6 CABINETS, GUTTERS, AND WIRING SPACE

6.6.1 Cabinet

The cabinet (box, tub, or can), when made from sheet metal, shall be protected against corrosion by such means as painting, galvanizing, plating, or other equivalent means and shall provide minimum gutter spacings and wiring space in accordance with 6.6.2, 6.6.3, 6.6.5, and 6.6.6. The end walls shall be permitted to be removable.

The front (trim and frame) shall be protected against corrosion by such means as painting, galvanizing, plating, or other equivalent means and designed for either surface or flush mounting. When a door is furnished it shall be provided with a locking means. A directory frame or equivalent means to identify the units shall be provided.

NEMA Standard 5-16-1984.

6.6.2 Distance Between End of Wiring Lugs and Opposite Wall

The distance between the end of any wire connector or lug and the wall of the enclosure toward which the conductor is directed or through which the connected conductor may normally pass shall be as shown in Articles 373 and 384 of the *National Electrical Code* and the Underwriters Laboratories, Inc. Standard for *Panelboards,* UL 67.

NEMA Standard 5-16-1984.

6.6.3 Enclosed Panelboard

An enclosed panelboard shall have one or more side or end wiring gutters or spaces.

NEMA Standard 5-16-1984.

6.6.4 Knockouts

When provided, knockouts shall be so located to provide adequate space for the turning of lock nuts or bushings that may be used for securing conduit or armored cable connectors. Multiple knockouts shall be so constructed that any size knockout may be removed without disturbing the next larger size.

NEMA Standard 5-16-1984.

6.6.5 Wiring Gutters and Terminal Compartments

A panelboard that has provision for the connection of more than four ungrounded conductors, other than main supply conductors, at any one side, top, or bottom shall be provided with wiring gutters and terminal compartments to prevent contact between insulating conductors and bare live parts.

6.6.6 Wiring Space

The space within the enclosure of a panelboard shall be sufficient to provide ample room for the installation of wire and cables.

The minimum areas of the clear wiring space shall be in accordance with Underwriters Laboratories, Inc. Standard for *Panelboards,* UL 67.

6.7 FUSE AND CIRCUIT BREAKER LOCATION

6.7.1 Fuse

If both switches and fuses are provided in either mains or branches, the fuses shall be placed on the load side of the switches.

NEMA Standard 5-16-1984.

6.7.2 Circuit Breakers with Interchangeable Trip Units

A circuit breaker using an interchangeable trip unit shall be connected so that the trip unit will be de-energized when the circuit breaker is in the open position.

NEMA Standard 5-16-1984.

6.8 ENCLOSURES

Panelboards are typically furnished in the following enclosure types:

6.8.1 Types of Enclosures

6.8.1.1 TYPE 1

Type 1 enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment in locations where unusual service conditions do not exist. The enclosures shall meet the rod entry and rust-resistance design tests. (See NEMA Standards Publication 250.)

NEMA Standard 5-16-1984.

6.8.1.2 TYPE 3R

Type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain, sleet, and external ice formation. They shall meet rod entry, rain, external icing, and corrosion protection design tests. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing. (See NEMA Standards Publication 250.)

NEMA Standard 5-16-1984.

6.8.1.3 TYPE 5

Type 5 enclosures are intended for indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping non-corrosive

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liquids. They shall meet drip, settling airborne dust, and rust resistance design tests. They are not intended to provide protection against internal condensation. (See NEMA Standards Publication 250.)

6.8.1.4 TYPE 12

Type 12 enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping noncorrosive liquids. They shall meet drip, indoor dust, and rust-resistance tests. They are not intended to provide protection against conditions such as internal condensation. (See NEMA Standards Publication 250.)

NEMA Standard 5-16-1984.

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Section 7
APPLICATION STANDARDS

7.1 SELECTION OF APPARATUS

Panelboards should be properly selected to ensure satisfactory service. Panelboards conforming to these standards should be suitable for operation in accordance with their ratings under usual service conditions (see 3.6). Where panelboards are subjected to unusual service conditions (see 3.7) the manufacturer should be consulted.

Authorized Engineering Information 5-16-1984.

7.2 VOLTAGE RATINGS

The voltage of the system to which a panelboard is connected shall not exceed the voltage rating of the panelboard.

NEMA Standard 5-16-1984.

7.3 CONTINUOUS-CURRENT-CARRYING RATINGS

7.3.1 Panelboard Without Main Overcurrent Protective Devices (Main Lug Panelboard)

The total continuous load current on a panelboard without an integral main overcurrent protective device shall not exceed the current rating of the panelboard.

NEMA Standard 5-16-1984.

7.3.2 Panelboard Having One or More Main Overcurrent Protective Devices

The total continuous load current on a main overcurrent protective device in a panelboard shall not exceed 80 percent of the current rating of the main overcurrent protective device, unless the device is rated to carry 100 percent of its continuous load current when mounted in a panelboard.

NEMA Standard 5-16-1984.

7.3.3 Branch-Circuit Devices

The continuous load current on each branch-circuit device in a panelboard shall not exceed 80 percent of the current rating of the device, unless the device is rated to carry 100 percent of its continuous load current when mounted in a panelboard.

NEMA Standard 5-16-1984.

7.3.4 Lighting and Appliance Branch-Circuit Panelboards

The ampacity of a lighting and appliance branch-circuit panelboard is normally based on an average load current of 10 amperes per pole per phase bus to allow for load diversity.

The use of a lighting and appliance branch-circuit panelboard for loads larger than 10 amperes per pole per phase bus or loads with less diversity may require the use of a panelboard having higher ampacity.

Authorized Engineering Information 5-16-1984.

7.3.5 Panelboards Designed for Specific Installation

In a panelboard that has been designed for a specific installation where the loading is known and will be less than an average of 10 amperes per branch circuit, the ampacity of the main bus bars shall be permitted to be less than that required in 3.9.1.

NEMA Standard 1-23-1990.

7.3.6 Panelboards With Feed-Through or Sub-Feed Lugs

Feed-through lugs, sub-feed lugs, and diversity of loads should be considered in determining panelboard ampacity.

Authorized Engineering Information 5-16-1984.

7.4 CALCULATION OF AVAILABLE SHORT-CIRCUIT CURRENT

IEEE Standard 141 contains detailed information for the calculation of short-circuit currents. Information on such calculations and tables showing the short-circuit current available at various distances from transformers may also be found in NEMA Standards Publication AB 1.

Authorized Engineering Information 5-16-1984.

7.5 SHORT-CIRCUIT CURRENT RATINGS

7.5.1 A panelboard shall have a short-circuit current rating not less than the available short-circuit current at its incoming line terminals. See 4.5 for short-circuit current ratings and 5.2.3 for short-circuit test methods.

NEMA Standard 5-16-1984.

7.5.2 Examples For Application

7.5.2.1 For determination of panelboard short-circuit current rating, refer to Figure 7-1 for typical panelboard schematic.

7.5.2.1.1 Assume: 20,000 rms symmetrical amperes short-circuit current available at the line terminals of the panelboard.

Overcurrent protective devices 1, 2, 3, 4, and 5 have rms symmetrical interrupting current ratings of 42,000 amperes at the voltage rating of the system.

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Overcurrent protective device 6 has an rms symmetrical interrupting current rating of 25,000 amperes at the voltage rating of the system.

Spaces 7 and 8 are unused.

The maximum short-circuit current rating assigned to the panelboard by the manufacturer is 50,000 rms symmetrical amperes.

CONCLUSION: The rms symmetrical short-circuit current rating of the panelboard is 25,000 amperes as this is the lowest rating of a device installed in the panelboard (see 4.4.). The panelboard is satisfactory for application on the system because its rating exceeds the short-circuit current available from the system.

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7.5.2.1.2 Assume: The same situation as detailed in 7.5.2.1.1.

Spaces 7 and 8 are filled with devices having an rms symmetrical interrupting current rating of 10,000 amperes at the system voltage.

CONCLUSION: The short-circuit rating of the panelboard now becomes 10,000 amperes (see 4.4). The panelboard is not suitable for this application because its short-circuit current rating is lower than the short-circuit current available from the system.

Authorized Engineering Information 5-16-1984.

7.5.2.1.3 Assume The same situation as detailed in 7.5.2.1.1 with devices having rms symmetrical interrupting current ratings of 25,000 amperes at the voltage of the system installed in locations 7 and 8 and a:

25,000 ampere rms symmetrical short-circuit current available at the terminals of the panelboard.

CONCLUSION: Considering the presently available short-circuit current, this would be a satisfactory application because the short-circuit current rating of the panelboard is as great as the available short-circuit current at the panelboard terminals.

Authorized Engineering Information 5-10-1984.

7.5.2.1.4 Assume: The supply transformer or other features of the system are changed.

The change increases the available short-circuit current at the panelboard to 40,000 rms symmetrical amperes.

CONCLUSION: The panelboard is no longer satisfactory for this system. There are several methods available to correct this situation.

1. Since the maximum short-circuit current rating of the panelboard is sufficient (50,000 amperes), overcurrent protective devices having rms symmetrical interrupting current ratings of at least 40,000 amperes may be installed.

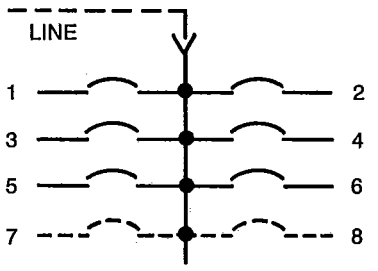


Figure 7-1
TYPICAL PANELBOARD SCHEMATIC

2. The panelboard may be replaced with one having a short-circuit current rating of at least 40,000 amperes.
3. The panelboard may be protected with an appropriate current-limiting device. It is recommended that the panelboard manufacturer be consulted.

Authorized Engineering Information 5-16-1984.

7.6 FIELD-INSTALLED CONDUCTORS

7.6.1 Wires used for a panelboard installation shall have ampacities based on 60°C (140°F) or 75°C (167°F) insulation, according to the marking on the panelboard, and shall be within the range of wire sizes for which the terminals are marked.

NEMA Standard 5-16-1984.

7.6.2 Higher temperature-rated conductors shall be permitted to be used if the size of the conductors is determined on the basis of the 60°C ampacity or 75°C ampacity within the range of wire sizes for which the terminals are marked and temperature ratings for which the panelboard is marked.

NEMA Standard 5-16-1984.

7.6.3 Only wires made of the conductor material for which the panelboard terminals have been marked shall be used.

NEMA Standard 5-16-1984.

7.6.4 Conductors installed in a panelboard should be kept as short as practical to reduce heating within the cabinet.

Authorized Engineering Information 1-23-1990.

7.6.5 When permitted by the *National Electrical Code,* a common neutral conductor should be used for multi-wire circuits to reduce heating within the panelboard cabinet. (See *National Electrical Code,* Section 210-4.)

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7.7 CORNER-GROUNDED (GROUNDED B PHASE) THREE-PHASE DELTA APPLICATIONS

Two-pole and three-pole circuit breakers or switches intended to be installed on corner-grounded (grounded B phase) delta systems shall be specifically rated for this purpose.

NEMA Standard 5-16-1984.

7.8 MOUNTING OF ENCLOSURE

Flush-mounted panelboard enclosures used in walls of concrete, tile, or other noncombustible material should be installed so that the front edge of the enclosure will not be set back of the finished surface more than ¼ inch. In walls of wood or other combustible material, cabinets should be flush with the finished surface or should project therefrom.

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NEMA STANDARDIZATION

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 purchasers 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. *(Standardization Policies and Procedures, p. 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.

(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.8)

Categories of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product, process, or procedure 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.

(Standardization Policies and Procedures, pp. 7 & 16)

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

(Standardization Policies and Procedures, pp. 7 & 16)

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, 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. 7 & 16)

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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