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STANDARDS PUBLICATION NO. PB 2

Deadfront Distribution Switchboards

NEMA

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

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PB 2

DEADFRONT DISTRIBUTION SWITCHBOARDS

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Washington, D.C. 20037

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FOREWORD

This Standards Publication is intended to provide a basis of common understanding within the electrical community and to aid the user in properly selecting deadfront distribution switchboards for specific applications.

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 this publication.

This Standards Publication is periodically reviewed by the Panelboard and Distribution Board Section of NEMA for any revisions necessary to keep it up to date with advancing technology. Proposed or recommended revisions should be submitted to:

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

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SCOPE

This Standards Publication provides information concerning floor-mounted deadfront switchboards rated 6000 amperes or less, 600 volts or less, and consisting of an enclosure, circuit breakers (molded case and low-voltage power), fusible or nonfusible switches, instruments, and metering or control equipment, with associated interconnections and supporting structures.

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SECTION 1
REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

The following standards and publications relate to this publication and copies are available from the sources indicated.

American National Standards Institute
1430 Broadway
New York, NY 10018

C12.7-1987	*Watthour Meter Sockets*
C12.8-1981(R1986)	*Watthour Meters, Test Blocks and Cabinets for Installation of Self-Contained "A" Base Meter Sockets*
ANSI/UL 414-1986	*Meter Sockets*
C12.11-1987	*Instrument Transformers for Metering Purposes, 15Kv and Less*
ANSI/IEEE C37.13-1981	*Low-voltage AC Power Circuit Breakers Used in Enclosures*
C37.16-1988	*Low-voltage Power Circuit Breaker and AC Power Circuit Breaker Protectors—Preferred Ratings, Related Requirements and Application Recommendations*
C37.17-1979	*Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breaker*
C37.50-1981	*Test Procedures For Low-voltage (AC) Power Circuit Breaker Used in Enclosures*
ANSI/IEEE 100-1988	*Standard Dictionary of Electrical and Electronics Terms*

Institute of Electrical and Electronics Engineers
445 Hoes Lane
P. O. Box 1331
Piscataway, NJ 08855-1331

IEEE Std 141-1986	*Recommended Practice for Electric Power Distribution for Industrial Plants*
IEEE Std 241-1986	*Electric Power Systems in Commercial Buildings*

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

AB 1-1986	*Molded Case Circuit Breakers*
BU 1-1988	*Busways*

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ICS 1-1988	*General Standards for Industrial Control and Systems*
KS 1-1983	*Enclosed Switches*
PB 1-1984	*Panelboards*
PB 2.1-1986	*General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less*
PB 2.2-1988	*Application Guide for Ground Fault Protective Devices for Equipment*
NEMA Publication 250-1985	*Enclosures for Electrical Equipment (1000 Volts Maximum)*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

NFPA 70-1990	*National Electrical Code*

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

ANSI/UL 67-1988	*Panelboards*
UL 891 - 1984	*Dead-Front Switchboards*
UL 508-1984	*Industrial Control Equipment*
UL 869-1984	*Service Entrance Equipment*
UL 198B-1988	*Class H Fuses*
UL 198C-1986	*High-Interrupting-Capacity-Limiting Type Fuses*
UL 198D-1988	*High-Interrupting-Capacity K Fuses*
UL 198E-1988	*Class R Fuses*
UL 198F-1988	*Plug Fuses*
UL 198G-1988	*Fuses for Supplementary Overcurrent Protection*
UL 198H-1988	*Class T Fuses*
UL 489-1986	*Molded Case Circuit Breakers and Circuit Breaker Endorsers*
UL 486A-1980	*Wire Connectors and Soldering Lugs for Use with Copper Conductors*
UL 486B-1982	*Wire Connectors for Use with Aluminum Conductors*

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1.2 DEFINITIONS

1.2.1 *Accessible* means not permanently closed in by the switchboard section structure and capable of being inspected and maintained, through access plates or doors, without disturbing the switchboard section structure.

NEMA Standard 9-6-1989.

This is not intended to imply that the switchboard should be maintained while energized.

WARNING: Before performing any maintenance operations, turn off all power supplying the switchboard. Check the voltage of all incoming line terminals to positively ascertain that the equipment is totally deenergized.

Authorized Engineering Information 9-6-1989.

1.2.1.1 *Front Accessible* means that all bus and device connections are accessible from the front. If necessary, a limited number of devices shall be permitted to be removed to achieve this accessibility.

1.2.1.2 *Rear Accessible* means that all incoming and outgoing cable or bus connections are accessible from the rear. Other connections shall be permitted to be front accessible.

NEMA Standard 5-16-1984.

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

When applied to switchboards, ambient temperature refers to the temperature of the air outside the switchboard enclosure.

NEMA Standard 9-15-1971.

1.2.3 *Ampacity* is the current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating. (See *Continuous Current.*)

NEMA Standard 5-16-1984.

1.2.4 *Asymmetrical Current* is alternating current having a waveform which 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 symmetrical and direct 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.

1.2.5 *Auxiliary Section* is any section other than the main, distribution or combination section.

NEMA Standard 1-10-1978.

1.2.6 *Auxiliary Switches* are switches which are mechanically operated by a main switching device for switching, interlocking or other purposes. Auxiliary switch contacts shall be permitted to be designated as "a" or "b" as indicated below, but other contact arrangement 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 9-6-1989.

1.2.7 *Available Short-Circuit Current* is the maximum current in rms symmetrical amperes which a circuit is capable of delivering at the system terminals ahead of the apparatus being supplied.

NEMA Standard 5-16-1984.

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

NEMA Standard 9-15-1971.

1.2.9 *Bonding* is a means of electrical connection which ensures the electrical continuity of a grounding circuit.

NEMA Standard 11-11-1970.

1.2.10 *Bonding Jumper* is a conductor which provides the necessary electrical conductivity between metal parts required to be electrically connected in a grounding circuit.

NEMA Standard 11-12-1970.

1.2.11 *Branch Circuit Device*, for the purpose of this standards publication, is the final overcurrent device protecting a circuit.

NEMA Standard 5-16-1984.

1.2.12 *Bus* is a conductor, or group of conductors, that serves as a common connection for two or more circuits. (See Figures 1-1, 1-2, and 1-3.)

1.2.12.1 *Branch Bus* is a bus that usually originates at a section bus and terminates in one or more overcurrent devices.

1.2.12.2 *Ground Bus* is a bus to which the equipment grounding conductors from individual pieces of equip-

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ment are connected and which, in turn, is connected to the grounding electrode conductor at one point. It grounds each switchboard section through which it passes. (See Figures 1-1, 1-2, and 1-3.)

1.2.12.3 *Mimic Bus* is a single-line diagram on the face of the switchboard showing the principal connections of a system.

1.2.12.4 *Neutral Bus* is a bus having the appropriate number of terminals to provide for the connection of the neutral line and load conductors. (See *Grounded Conductor.*)

1.2.12.5 *Section Bus* is that portion of a bus structure which serves an overcurrent device(s) in the switchboard section and comprises that part of the bus between the through bus and branch bus.

1.2.12.6 *Splice Bus* electrically connects switchboard sections.

1.2.12.7 *Supply Bus* conducts electric power from the source terminations to the main disconnect device(s).
NEMA Standard 9-6-89.

1.2.12.8 *Through Bus* extends through a switchboard section. It is sometimes called a horizontal, cross or main bus.
NEMA Standard 5-16-1984.

1.2.13 *Bus Structure* is an assembly of bus conductors, with associated connecting joints and insulating supports.
NEMA Standard 9-15-1971.

1.2.14 *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 injury to itself, when properly applied within its rating.

1.2.14.1 *Low voltage power circuit breaker* is a circuit breaker which is not assembled in an integral supporting and enclosing housing of insulating material.

1.2.14.2 *Molded case circuit breaker* is a circuit breaker which is assembled as an integral unit in a supporting and enclosing housing of insulating material.
NEMA Standard 1-10-1978.

1.2.15 *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.

1.2.16 *Combination Section* is a switchboard section which performs the functions of both the distribution and main sections.
NEMA Standard 9-15-1971.

1.2.17 *Compartment* is an area within a section that is so constructed as to isolate devices in that compartment from the surrounding area except for openings used for interconnections, control or ventilation.
NEMA Standard 9-15-1971.

1.2.18 *Continuous Current* is the amount of current a conductor, a device or a piece of equipment can carry continuously for an indefinite period of time without exceeding its allowable temperature rise. (See *Ampacity.*)
NEMA Standard 5-16-1984.

1.2.19 *Continuous Load* is one in which the current is expected to continue for three hours or more.
NEMA Standard 5-16-1984.

1.2.20 *Control Wiring* is the wiring for the circuit(s) of a piece of equipment that carries the electrical signals directing the performance of the devices in that equipment, but which does not carry power current.
NEMA Standard 5-16-1984.

1.2.21
Current-Limiting Device (ac) is an overcurrent protective device which 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.

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A - See 1.2.47
B - See 1.2.12.7
E - See 1.2.12.1
F - See 1.2.35
G - See 1.2.12.5
J - See 1.2.12.8
K - See 1.2.12.6
L - See 1.2.10
P - See 1.2.12.2
R - See 1.2.12.4
S - See 1.2.48
T - See 1.2.9
U - See 1.2.38

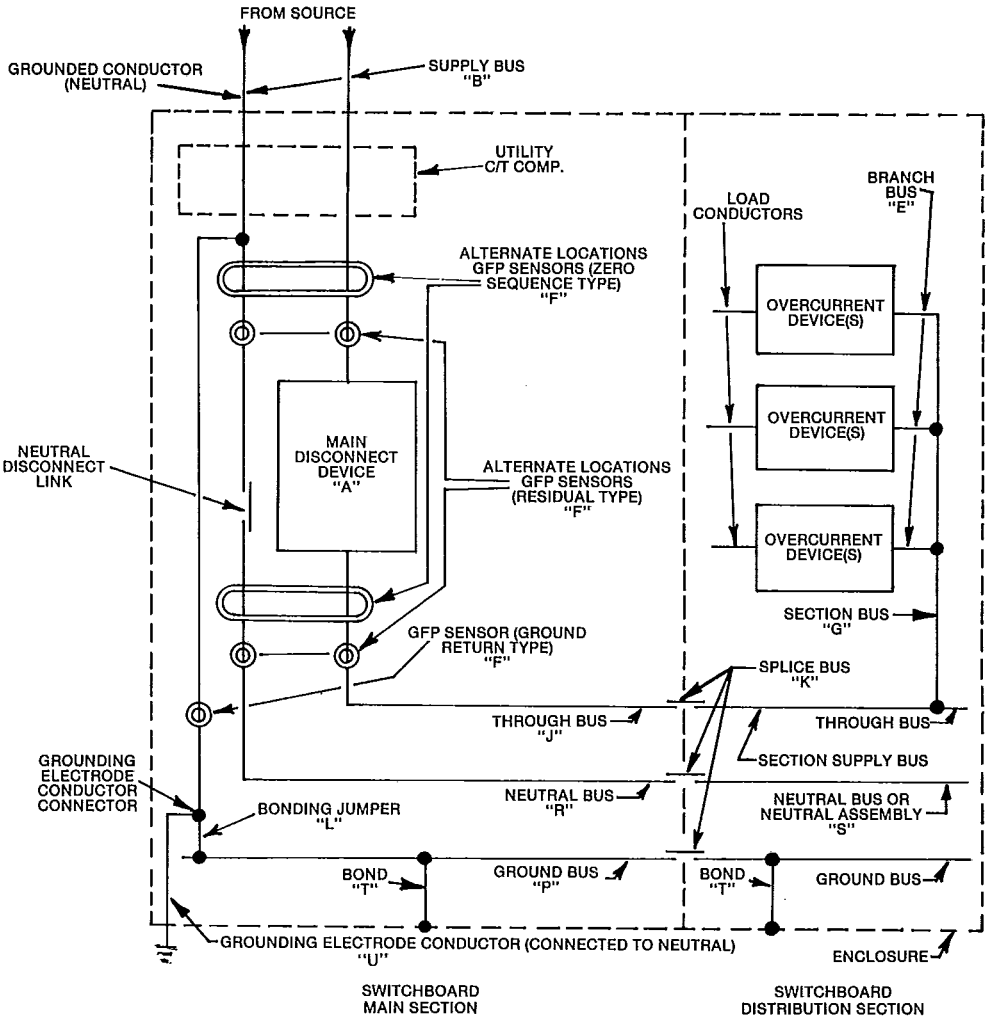


Figure 1-1
SERVICE EQUIPMENT – SYSTEM GROUND CONNECTED TO NEUTRAL TYPICAL DEADFRONT SWITCHBOARD LAYOUT

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A - See 1.2.47
B - See 1.2.12.7
E - See 1.2.12.1
F - See 1.2.35
G - See 1.2.12.5
J - See 1.2.12.8
K - See 1.2.12.6

L - See 1.2.10
P - See 1.2.12.2
R - See 1.2.12.4
S - See 1.2.48
T - See 1.2.9
U - See 1.2.38

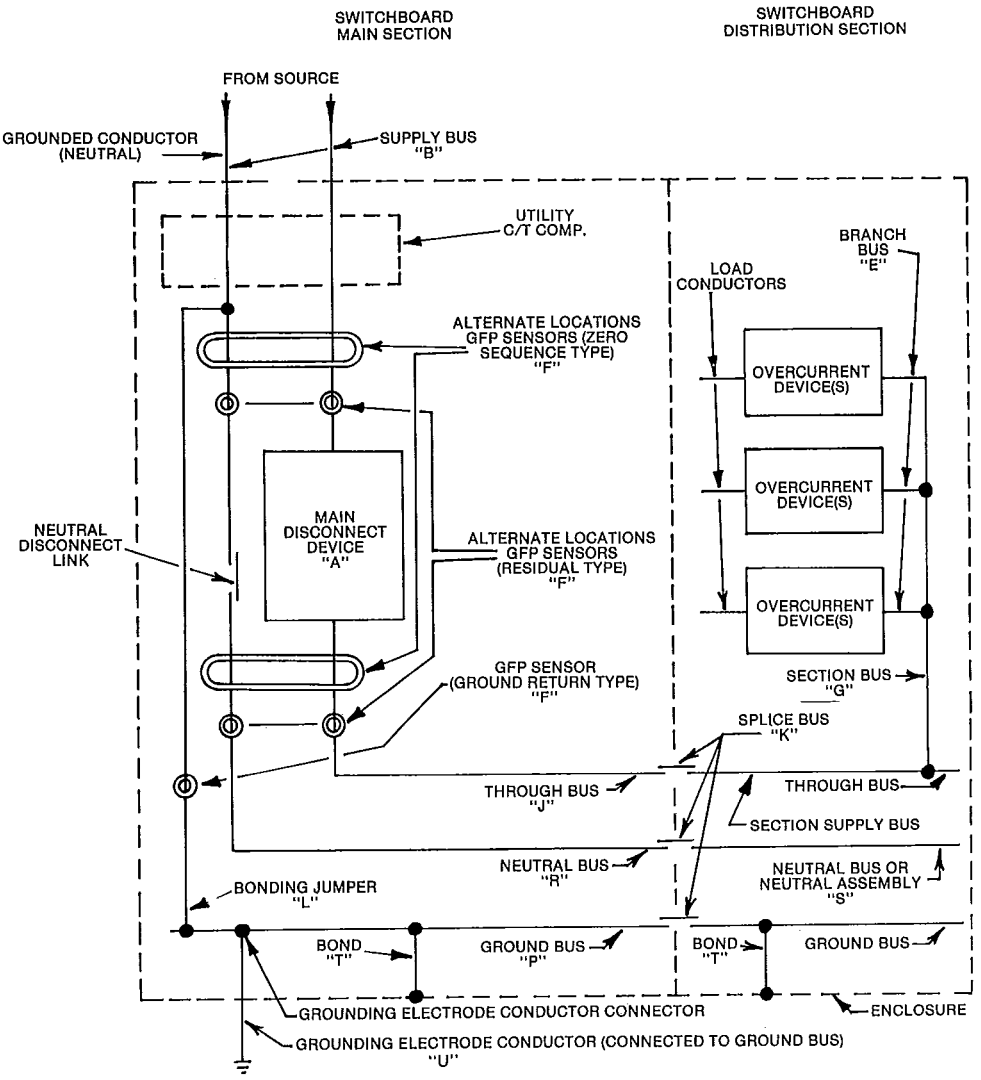


Figure 1-2
SERVICE EQUIPMENT—SYSTEM GROUND CONNECTED TO GROUND BUS TYPICAL DEADFRONT SWITCHBOARD LAYOUT

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A - See 1.2.47
B - See 1.2.12.7
E - See 1.2.12.1
F - See 1.2.35
G - See 1.2.12.5
J - See 1.2.12.8
K - See 1.2.12.6
P - See 1.2.12.2
R - See 1.2.12.4
S - See 1.2.48
T - See 1.2.9
V - See 1.2.30

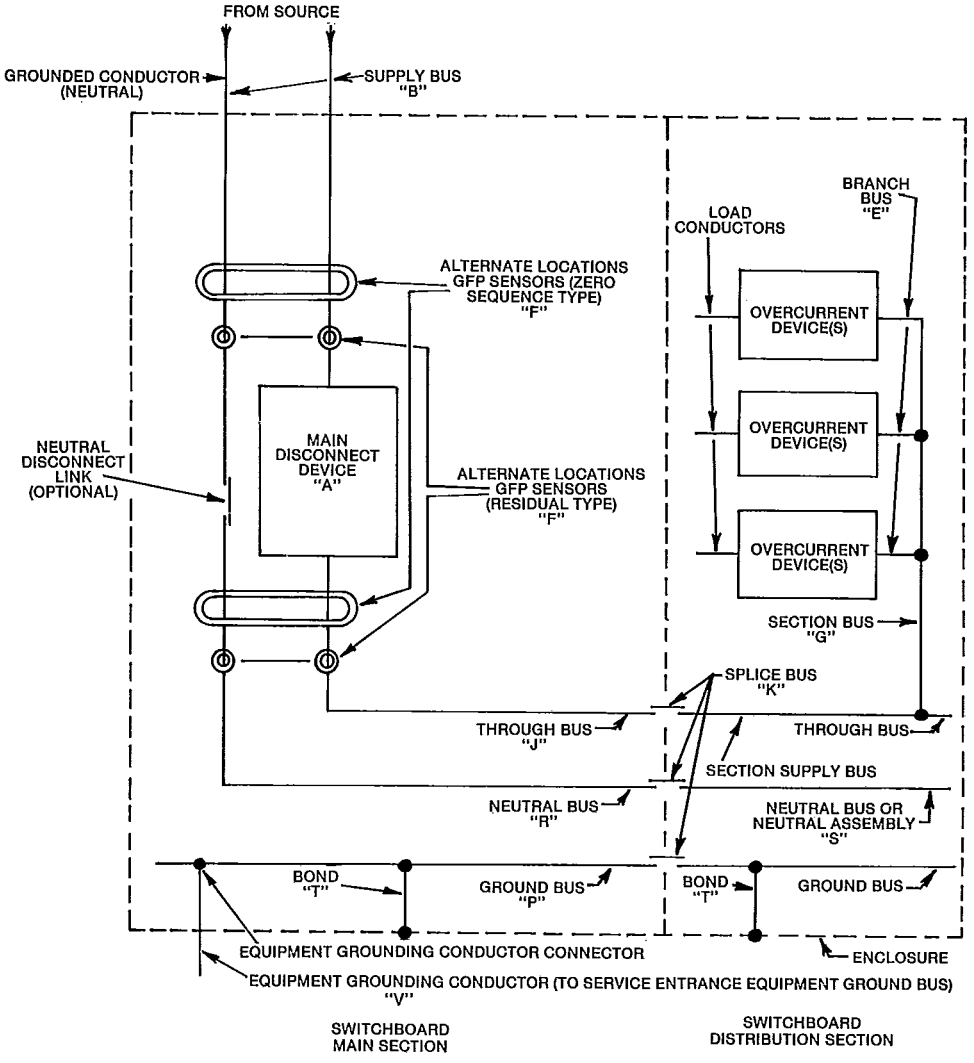


Figure 1-3
NON-SERVICE TYPICAL DEADFRONT SWITCHBOARD LAYOUT EQUIPMENT

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1.2.22 The *Current-Limiting Range (ac)* 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 one half cycle.
NEMA Standard 5-16-1984.

1.2.23 *Current Rating* of a Switchboard is the designated maximum direct current or alternating current in rms amperes at rated frequency which the switchboard bus can carry continuously without exceeding its temperature rise limits when subjected to specified heating tests.
NEMA Standard 5-16-1984.

1.2.24 *Deadfront Switchboard* is one which has no exposed live parts on the front.
NEMA Standard 9-15-1971.

1.2.25 *Device* is a component in an electrical system that is intended to carry or control but not utilize electric energy.
NEMA Standard 5-16-1984.

1.2.26 *Dielectric Withstand Tests* determine the ability of the insulating materials and spacings to withstand overvoltages.
NEMA Standard 5-16-1984.

1.2.27 *Distribution Section* is a switchboard section having branch or feeder circuit switching and overcurrent protective devices.
NEMA Standard 1-10-1978.

1.2.28 *Drawout-Mounted Device* is a device which may be removed from the stationary portion of a switchboard without unbolting connections or mounting supports.
NEMA Standard 9-15-1971.

1.2.29 *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.

1.2.30 *Equipment Grounding Conductor* is a conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor or the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.
NEMA Standard 5-16-1984.

1.2.31 *Fixed-Mounted Device.* See *Stationary-Mounted Device.*

1.2.32 *Frame Size* is a term applied to a group of circuit breakers which 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.

1.2.33 *Fuse* is a protective device which opens by the melting of a current-sensitive element during specified overcurrent conditions.
NEMA Standard 9-6-1989.

1.2.34 *Fusible Switch* is a switch in which one or more poles have a fuse in series in a composite unit.
NEMA Standard 9-6-1989.

1.2.35 *Ground Fault Protector (GFP)* is a device or system that provides protection for equipment (rather than 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 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 1-10-1978.

1.2.36 *Grounded Conductor* is a system or circuit conductor which is intentionally grounded.
NEMA Standard 5-16-1984.

1.2.37 *Grounded* means connected to earth or to some conducting body that serves in place of earth.
NEMA Standard 5-16-1984.

1.2.38 *Grounding Electrode Conductor* is a conductor used to connect the grounding electrode to the equipment grounding conductor or to the grounded conductor of the circuit, or both, at the service equipment or at the source of a separately derived system.
NEMA Standard 5-16-1984.

1.2.39 *Group-Mounted Device.* See *Panel-Mounted Device.*

1.2.40 *Individually Mounted Device* is a device which is not panel-mounted and which may or may not be enclosed in its own compartment.
NEMA Standard 1-10-1978.

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1.2.41 *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.

1.2.42 *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.

1.2.43 *Isolated* means that an object is not accessible to personnel unless special means for access are used.
NEMA Standard 9-15-1971.

1.2.44 *Isolated Device* is a device which is segregated from other devices by metal or insulating barriers or enclosures and which is not readily accessible to personnel unless special means for access are used.
NEMA Standard 9-15-1971.

1.2.45 *Insulation Level* of a material is its insulation strength expressed in terms of an rms withstand voltage.
NEMA Standard 5-16-1984.

1.2.46 *Main Section(s)* is that portion of a switchboard where the main or service disconnect device(s) is located. The section shall also be permitted to contain utility meters or other instruments. Incoming line conductors may be terminated in this section.
NEMA Standard 1-10-1978.

1.2.47 *Main Device* is a single device that disconnects all ungrounded switchboard conductors, other than control power conductors when used, from the supply bus. (See Figure 1-1.)
NEMA Standard 1-10-1978.

1.2.48 *Neutral Assembly* is an assembly consisting of an appropriate number of terminals for connecting neutral conductors.
NEMA Standard 1-10-1978.

1.2.49 *Neutral Conductor* is the grounded conductor of a three-wire, single-phase alternating current or direct current supply system or four-wire, three-phase alternating current supply system.
NEMA Standard 5-16-1984.

1.2.50 *Panel-Mounted Device* is one of a closely grouped assembly of devices which is mounted on a common base or mounting surface utilizing panelboard type construction. The total combination is then mounted in a switchboard combination or distribution section.
NEMA Standard 9-15-1971.

1.2.51 *Peak Let-Through Current (ac)* is the maximum instantaneous current through an overcurrent protective device during its total clearing time.
NEMA Standard 5-16-1984.

1.2.52 *Plug-In Mounted Device for Line Only* is a device which can be plugged in to make an electrical connection to a line bus bar. The device need not be self-supporting when withdrawn.
NEMA Standard 9-15-1971.

1.2.53 *Plug-In Mounted Device for Line and Load* is a device which can be plugged in to make electrical connections to line and load bus. The device need not be self-supporting when withdrawn.
NEMA Standard 9-15-1971.

1.2.54 *Rating* of a device is a designated limit of operating characteristics based on definite conditions. Such operating characteristics as current, voltage, frequency, and so forth, shall be permitted to be given in the rating.
NEMA Standard 9-15-1971.

1.2.55 *Section Disconnect* is a device by which all ungrounded power conductors in a switchboard section can be disconnected from their supply.
NEMA Standard 5-16-1984.

1.2.56 *Service Disconnect(s)* is a device or group of devices by which all ungrounded power conductors of a circuit can be disconnected from the supply.
NEMA Standard 1-10-1978.

1.2.57 *Service Equipment* is the equipment (usually consisting of circuit breakers or switches and fuses and their accessories) which 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 9-15-1971.

1.2.58 *Short-Circuit Current Rating (Equipment)* is the rating which indicates the ability of equipment to withstand the effects of a short-circuit current without exceeding specified damage criteria.
NEMA Standard 5-16-1984.

1.2.59 *Stationary-Mounted Device* is a device which can be removed only by unbolting electrical connections and mounting supports.
NEMA Standard 1-10-1978.

1.2.60 *Switch* is a device for making, breaking or changing the connections in an electric circuit.
NEMA Standard 9-15-1971.

1.2.61 *Switchboard* is a large single panel, structural frame or assembly of panels or structural frames on

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which may be mounted, on the face or back or both: switches, overcurrent, and other protective devices, buses, and instruments. Switchboards may be accessible from the rear as well as from the front and are not intended to be installed in cabinets.

NEMA Standard 5-16-1984.

1.2.62 A *Switchboard Section* is that portion of a switchboard which is prevented by the structural framework from being physically separated into smaller units.

NEMA Standard 9-15-1971.

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

NEMA Standard 9-15-1971.

1.2.64 *Temperature Rise* is the difference in temperature between the temperature of the part under consideration and the ambient temperature.

NEMA Standard 5-16-1984.

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Section 2
GENERAL STANDARDS

2.1 ARRANGEMENT

A switchboard consists of one or more main, distribution, combination, and auxiliary sections which are electrically and mechanically interconnected.

Devices shall be applied in accordance with the manufacturer's instructions.

NEMA Standard 1-10-1978.

Main disconnect devices are usually individually mounted but can be an integral part of a panel mounted assembly.

Authorized Engineering Information 5-16-1984.

2.2 EQUIPMENT SPECIFICATION

In order to ensure that the proper switchboard is selected for a particular application, the user should provide the manufacturer with the following equipment specifications:

1. Rating of Supply
   a. Voltage
   b. Number of Phases
   c. Current in Amperes
   d. Available Short Circuit-Current at the Line Terminals of the Switchboard in rms Symmetrical Amperes, and
   e. Frequency (if other than 60 Hz).
2. Neutral Ampacity as a Percentage of the Switchboard Ampere Rating.
3. Cables
   a. Size
   b. Type
   c. Number, and
   d. Entry Location (top or bottom).
4. Busway
   a. Entry Location(s), and
   b. Description.
5. Ground Fault Protection
   a. System Type, and
   b. Settings.
6. Enclosure Type.
7. Main Disconnect Devices
   a. Type (Circuit Breaker, Switch, etc.)
   b. Ampere rating
   c. Poles, and
   d. Quantity.
8. Branch Circuit Devices
   a. Type (Circuit Breaker, Switch, etc.)
   b. Ampere rating
   c. Poles, and
   d. Quantity.
9. Local Requirements
   a. National Electrical Code
   b. Local Electrical Codes
   c. Utility Codes, and
   d. Other.
10. Intended Application: Service Equipment or Non-service Equipment.
11. Construction Features (see Table 2-1).
12. Unusual Service Conditions (see 2.4).

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Table 2-1
CONSTRUCTION FEATURES

Feature	Switchboard	Main Section	Distribution Section	Combination Section	Auxiliary Section
1. Device Mounting	. . .	P;I;I/C	P;I;I/C	P;I;I/C	I;I/C
2. Section Alignment*	F;R;F&R	. . .	. . .	. . .	. . .
3. Accessibility					
Installation–					
Line Terminal	. . .	F;R	. . .	F;R	F;R
Load Terminal	. . .	. . .	F;R	F;R	F;R
Maintenance–					
Line Terminal	. . .	F;R(F)	F;R(F)	F;R(F)	F;R(F)
Load Terminal	. . .	F;R(F)	F;R(F)	F;R(F)	F;R(F)
Bus Connections	F;R(F)	. . .	. . .	. . .	. . .

P – Panel Mounted
I – Individually Mounted
I/C – Individually Mounted and Compartmented
F – Front
R – Rear
F & R – Front and Rear
R(F) – Rear, but may require some front accessibility for maintenance. Consult the manufacturer for details.

* Sections are aligned when their front or rear surfaces, or both, are in the same plane. This choice is important when sections vary in depth.

Authorized Engineering Information 5-16-1984.

Table 2-2
AMBIENT TEMPERATURE RANGES OF DEVICES COMMONLY MOUNTED IN SWITCHBOARDS

Device	Ambient Temperature Ranges	Reference Publications
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		UL 198B UL 198C UL 198D UL 198E UL 198F UL 198G UL 198H NEMA FU 1
Low-voltage power circuit breakers	-30°C through + 40°C	ANSI C37
Electromagnetic and manual motor control at 6000 feet and less	+ 40°C maximum	NEMA ICS series

NEMA Standard 5-16-1984.

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2.3 USUAL SERVICE CONDITIONS

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

1. When and where the ambient temperature is within the limits of devices mounted therein (See Table 2-2), and
2. Where the altitude does not exceed 6600 feet (2000 meters).

NEMA Standard 1-10-1978.

2.4 UNUSUAL SERVICE CONDITIONS

When unusual service conditions exist, such conditions should be brought to the manufacturer's attention when specifying the switchboard since additional construction or protection features may be required. Among such unusual conditions are unusual ambient temperatures, high humidity, high altitude, exposure to corrosive or explosive fumes, dust, vapors, abnormal vibration, mechanical shock, tilting or unusual operating duties.

Authorized Engineering Information 9-6-1989.

2.5 TEMPERATURE LIMITS

2.5.1 Temperature Limits for Switchboards

The maximum allowable temperature limit for switchboards is based on an allowable temperature rise over a prescribed ambient temperature as described in Underwriters Laboratories Inc., Publication No. UL 891.

2.5.2 Temperature Limits for Parts Subject to Contact by Personnel

A part handled by personnel or external surfaces accessible to personnel during the normal course of their duties shall not attain a total temperature higher than 60°C (140°F) if made of metal, or 85°C (185°F) if made of plastic.

2.5.3 Temperature Limits for Parts Not Subject to Contact by Personnel

External surfaces which are not accessible to personnel during the normal course of their duties shall not attain a total temperature higher than 110°C (230°F).

NEMA Standard 5-16-1984.

2.6 PRECAUTIONARY LABELS

To make the user aware of immediate or potential hazards in the application, installation, use or maintenance of switchboards, each switchboard section shall be conspicuously marked on all sides having removable covers with the following text (or effective equivalent) and symbol, and shall reflect the following format.

DANGER: HAZARD OF ELECTRICAL SHOCK OR BURN. TURN OFF POWER SUPPLYING THIS EQUIPMENT BEFORE WORKING INSIDE.

The symbol for danger shall have the proportions shown in Figure 2-1.

Vivid red Munsell Notation 7.5R4.0/14 shall be the predominant visual color for either the signal word DANGER and the symbol or for the background. Black, white or metallic shall be permitted to be used for contrast. These colors shall be permitted to be used either for the lettering or the background.

NEMA Standard 5-16-1984.

This requirement is not intended to rule out the use of other labels or markings which are required to comply with other nationally recognized standards or applicable laws or regulations, or which may be deemed necessary by the manufacturer.

Authorized Engineering Information 5-16-1984.

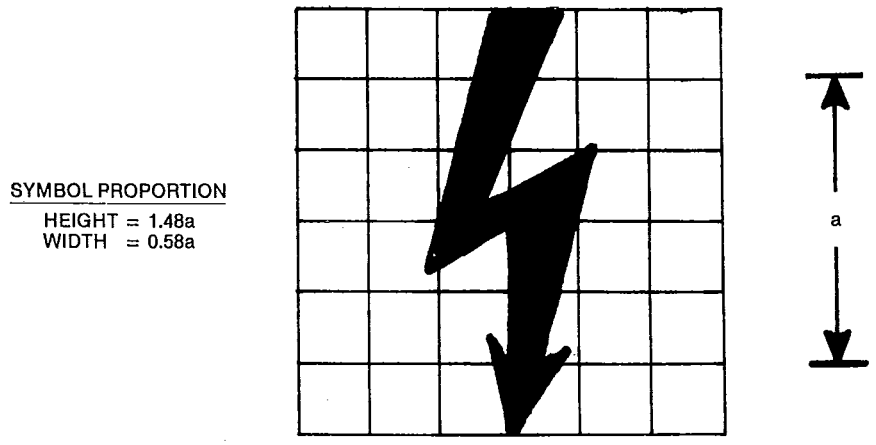


Figure 2-1
SYMBOL DENOTING HAZARD OF ELECTRICAL SHOCK OR BURN

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Section 3
RATING STANDARDS

3.1 GENERAL

The ratings of a switchboard are designations of operating limits under specified conditions of ambient temperature, temperature rise, and so forth.

Switchboards shall have the following ratings:

- Voltage (See 3.2);
- Short-Circuit Current (See 3.6 and 3.7);
- Frequency (See 3.3);
- Continuous Current (See 3.4); and,
- Insulation Level (See 3.5).

NEMA Standard 1-10-1978.

3.2 VOLTAGE RATINGS

The voltage ratings of switchboards shall be as indicated in Table 3-1.

NEMA Standard 1-10-1978.

3.3 FREQUENCY RATING

The frequency rating of ac switchboards shall be either 50, 60 or 50/60 hertz unless otherwise specified.

NEMA Standard 5-16-1984.

3.4 CONTINUOUS CURRENT RATING

3.4.1 Through Bus Rating

The continuous current rating of a switchboard through bus shall be 400, 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000 or 6000 amperes.

3.4.2 Section Supply Rating

A switchboard section shall be assigned a continuous current supply rating which does not exceed the ampacity of the bus or cable which supplies power to the section.

3.4.3 Section Rating

A switchboard section shall be assigned a continuous current section rating which does not exceed the ampacity of the section bus or section disconnect. If the ampacities of the several section bus bars in a section, including the neutral bus bar, are not identical, the section continuous current rating shall specify the ampacity of each section bus bar or terminal.

NEMA Standard 9-15-1971.

3.5 INSULATION LEVEL RATING

The insulation level rating of ac switchboards having a given voltage rating shall be twice the rated voltage plus 1000 volts. DC switchboards shall be permitted to be tested with alternating current equivalent. See 3.2 for system voltages.

NEMA Standard 5-16-1984.

3.6 BASIS OF SHORT-CIRCUIT CURRENT RATING OF SWITCHBOARDS

The short-circuit current rating assigned to the switchboard shall not exceed the short-circuit current rating of any component in the power circuit which is installed in its intended manner.

EXCEPTION: A higher rating shall be permitted to be assigned to a switchboard for a specific combination of components provided that the series combination has passed short-circuit tests qualifying it for its assigned short-circuit current rating and the switchboard is suitably marked to identify the required upstream overcurrent protective device.

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

NEMA Standard 5-16-1984.

3.7 SHORT-CIRCUIT CURRENT RATINGS OF SWITCHBOARD DEVICES

3.7.1 Circuit Breakers

The short-circuit current rating of a circuit breaker used as a device in a switchboard shall be its interrupting current rating of 5000, 7500, 10,000, 14,000, 18,000, 20,000, 22,000, 25,000, 30,000, 35,000, 42,000, 45,000, 50,000, 60,000, 65,000, 70,000, 75,000, 85,000, 100,000, 125,000, 150,000 or 200,000 rms symmetrical amperes. The manufacturer shall be consulted for interrupting current ratings at specific voltages.

3.7.2 Fusible Switches

The short-circuit current rating of a fusible switch as a device in a switchboard shall be the interrupting current rating of the installed fuses or the short-circuit current rating of the switch, whichever is the smaller. The ratings of fuses and switches used in combination shall be 10,000, 25,000, 50,000, 100,000 or 200,000 rms symmetrical amperes.

NEMA Standard 5-16-1984.

3.7.3 Other Devices

The manufacturer should be consulted for rating information for other devices or combination of devices used in switchboards.

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Table 3-1
VOLTAGE RATINGS OF SWITCHBOARDS

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

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Section 4
TEST AND PERFORMANCE STANDARDS

4.1 CLASSIFICATION OF TESTS

4.1.1 Design Tests

Design tests are those which are made to determine the adequacy of the design of a particular type, style or model of switchboard assembly to meet its assigned ratings and to operate satisfactorily under normal service application conditions or under special application conditions if specified. Design tests are made only on representative new switchboard assemblies to substantiate ratings assigned to all other assemblies of a similar design and are not contemplated under normal production.

Design tests for a switchboard shall include the following:

1. Temperature Rise Tests (See 4.2);
2. Short-circuit Current Test (See 4.3);
3. Enclosure Tests (See 4.4); and
4. Dielectric Test (See 4.5).

4.1.2 Production Tests

Production tests are those which are made on completed switchboard assemblies or component parts to check the quality and uniformity of the workmanship and materials used in the manufacture of switchboards.

Production tests (See 4.6—4.10) for a switchboard shall include:

1. 60-hertz Dielectric Tests (See 4.6);
2. Mechanical Operation Tests (See 4.7);
3. Grounding of Instrument Transformer Cases Test (See 4.8);
4. Electrical Operation and Control Wiring Tests (See 4.9); and
5. Ground Fault Sensing Equipment Test (See 4.10).

NEMA Standard 5-16-1984.

4.2 TEMPERATURE RISE TESTS (DESIGN 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 permitted by UL 891. However, regardless of bus size, a temperature rise test shall be made if a switchboard uses one or more switches, fuseholders, or circuit breakers having plug-in connections to the bus bars.

When temperature rise tests are made, they shall be conducted in accordance with requirements of UL 891.

NEMA Standard 5-16-1984.

For ratings above 4000 amperes, bus bar sizes are the subject of special considerations such as bus density; construction; bus location; spacing between bars; and structure, frame material and ventilation.

Authorized Engineering Information 9-6-1989.

4.3 SHORT-CIRCUIT TESTS (DESIGN TESTS)

Short-circuit current tests shall be conducted according to the requirements of UL 891.

The short-circuit current rating of a switchboard shall be determined by test of representative through, section and branch bus configurations, and cable arrangements and connections, which are integral to the switchboard assembly.

Tests shall be run to determine the adequacy of the bracing for different methods of routing incoming conductors, such as bus extensions, busways or cables, which are an integral part of the switchboard assembly.

Short-circuit current ratings shall be given in rms symmetrical amperes at the corresponding voltage (See 3.7).

NEMA Standard 5-16-1984.

4.4 ENCLOSURE TESTS (DESIGN TESTS)

Switchboard enclosures shall be tested to the applicable requirements of UL 891.

NEMA Standard 5-16-1984.

4.5 DIELECTRIC TESTS (DESIGN TESTS)

4.5.1 Test Voltage and Points of Application

A switchboard shall be capable of withstanding for 1 minute, without breakdown, the application of 60-hertz sinusoidal potential of 1000 volts plus twice rated voltage:

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

Overcurrent devices such as fuses, trip units of circuit breaker frames designed for use with interchangeable trip units, and so forth shall be in place wherever provisions are 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.

4.5.2 Testing Transformer and Duration of Application

The test potential shall be supplied from a suitable 500 volt-ampere or larger testing transformer, the output voltage of which can be adjusted. The applied potential shall be increased gradually from zero until the

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required test value is reached and shall be held at that level for one minute.

A smaller transformer shall be permitted to be used if the transformer is provided with a suitable voltmeter to directly measure the applied output potential.

NEMA Standard 1-10-1978.

4.6 DIELECTRIC TESTS (PRODUCTION TESTS) (Refer to 4.5)

As an alternate to applying a 60-hertz sinusoidal potential of 1000 volts plus twice rated voltage for 1 minute, 120 percent of the above test potential shall be applied for 1 second.

If a switchboard section involves a meter or meters, such instruments shall be disconnected from the circuit during the test. The meter or meters shall then be tested separately by applying for 1 minute a 60-hertz essentially sinusoidal potential between live parts and dead-metal parts. The test potential shall be 1000 volts in the case of an ammeter, and 1000 volts plus twice the rated voltage in the case of a voltmeter, wattmeter or other instrument.

NEMA Standard 1-10-1978.

4.7 MECHANICAL OPERATION TESTS (PRODUCTION TESTS)

Mechanical tests shall be performed to ensure that removable unit operating mechanisms, mechanical interlocks, and so forth, function properly and that removable units which are intended to be interchangeable are interchangeable.

NEMA Standard 5-16-1984.

4.8 GROUNDING OF INSTRUMENT TRANSFORMER CASES TEST (PRODUCTION TEST)

The continuity of the grounding of metallic instrument transformer cases or frames shall be checked with a low potential source (10 volts or less) using bells, buzzers or lights.

NEMA Standard 5-16-1984.

4.9 ELECTRICAL OPERATION AND CONTROL WIRING TESTS (PRODUCTION TESTS)

4.9.1 Control Wiring Continuity

The correctness of the control wiring of a switchboard assembly shall be verified by either:

1. Actual electrical operation of the component control devices; or,
2. Individual circuit continuity checks with electrical circuit testers.

4.9.2 Control Wiring Insulation Test

A 1500-volt, 60-hertz test voltage shall be applied from live metal parts to dead-metal parts in the control circuit after all circuit grounds have been disconnected. All circuits shall be wired together with small bare copper wire in order to short circuit voltage sensitive components such as coil windings and solid-state electronic devices.

4.9.3 Polarity Tests

Tests shall be made to ensure that instrument transformers are correctly connected for polarity.

Analog type instruments shall be tested to ensure that pointers move in the proper direction.

Meters and relays shall be tested to ensure that their polarity will not cause improper functioning.

4.9.4 Sequence Tests

Switchboard assemblies involving the sequential operation of devices shall be tested to ensure that these devices function properly and in their intended order.

The sequence test need not be made on remote equipment controlling or controlled by the switchboard assembly.

NEMA Standard 1-10-1978.

4.10 GROUND FAULT SENSING EQUIPMENT TEST (PRODUCTION TEST)

Switchboards containing ground fault sensing equipment shall be tested in accordance with UL 891.

NEMA Standard 9-6-89.

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Section 5
CONSTRUCTION

5.1 GENERAL

The construction of switchboard assemblies covered by this Standards Publication shall be in accordance with UL 891.

NEMA Standard 5-16-1984.

5.2 TYPE OF ENCLOSURE

Switchboards are typically provided with Type 1, 2, 3R enclosures as specified in UL 891, and type 5 as specified in NEMA Publication 250.

5.2.1 Type 1

Type 1 enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment.

NEMA Standard 5-16-1984.

5.2.2 Type 2

Type 2 enclosures are intended for indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.

NEMA Standard 5-16-1984.

5.2.3 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.

NEMA Standard 5-16-1984.

5.2.4 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 liquids. They shall meet drip, settling airborne dust, and rust resistance design tests. They are not intended to provide protection against internal condensation.

NEMA Standard 9-6-1989.

5.3 HEIGHT OF INDOOR ENCLOSURES

The nominal installed maximum height of the enclosure is 90 inches, excluding floor sills, lifting members, and pull boxes.

Authorized Engineering Information 1-10-1978.

5.4 PHASE OR POLARITY ARRANGEMENTS

The phase arrangement on three-phase switchboard buses and primary connections shall be A, B, C, from front to back, top to bottom, or left to right, as viewed from the front of the switchboard. The B phase shall be that phase having the higher voltage to ground on 3-phase, 4-wire Delta system.

An exception to this arrangement shall be permitted in the case of equipment within the same switchboard as the metering equipment on 3-phase, 4-wire Delta connected systems where the equipment shall be permitted to have the same phase configuration as the metering equipment.

The phase arrangement for a 240-volt, 3-phase, 3-wire switchboard section or interior for use on a grounded B phase system shall be permitted to be A, C, with the neutral assembly as the B phase.

Other arrangements shall be permitted where a switchboard section or interior is manufactured for addition to existing installations and the arrangement of the bus bars is indicated by marking.

Unless otherwise specified, polarities on dc assembled switchboard buses and connections shall be arranged positive, neutral, negative, front to back, top to bottom or left to right as viewed from the front of the switchboard.

NEMA Standard 9-15-1971.

5.5 GROUNDING AND BONDING

Refer to Underwriters Laboratories Inc., Publication No. UL 891 for grounding and bonding requirements for both single section and multi-section switchboards.

Grounding provisions shall be made for all drawout devices to ensure that they are grounded until all ungrounded electrical connections are disconnected by a safe distance.

When mounted on metal switchboard structures, metallic cases of instruments, instrument transformers, meters, relays, and similar devices shall be considered as being adequately grounded when secured by metal mounting screws having adequate provision for piercing the paint film.

NEMA Standard 9-15-1971.

5.6 UTILITY TRANSFORMER COMPARTMENT

Switchboard assemblies containing current transformer(CT) compartments for utility metering shall be arranged as shown in Figure 5-1.

Mounting provisions shall be provided for the installation of either bar or window type transformers built to the specifications of ANSI C12.11.

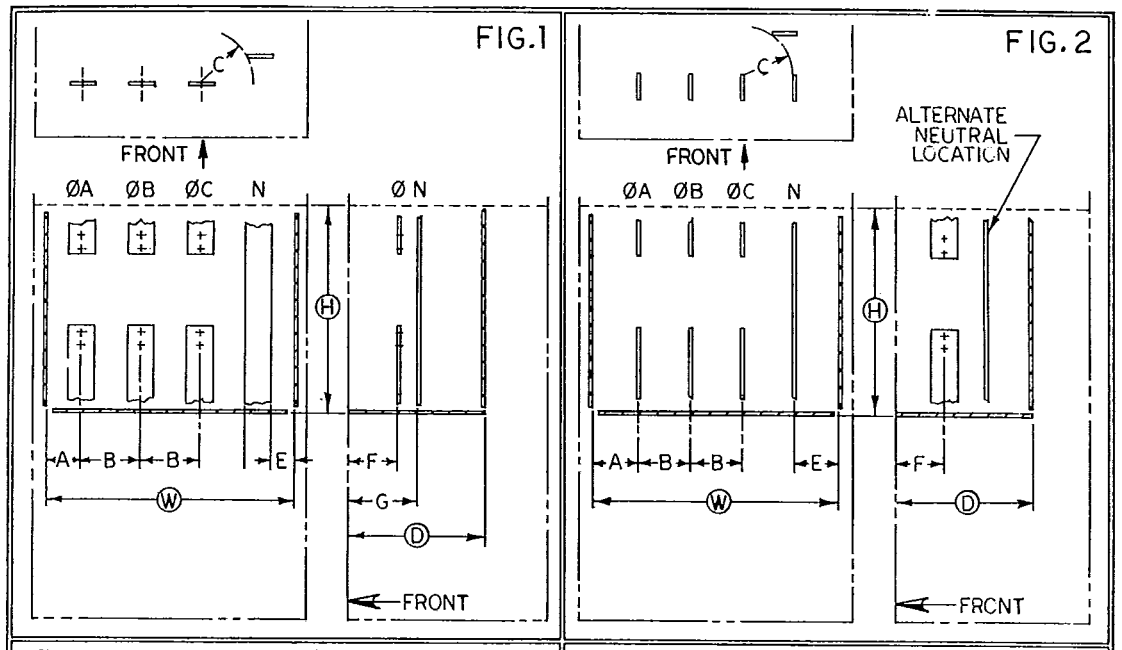
The front of the CT compartment shall be accessible through a sealable hinged single or double door or removable cover.

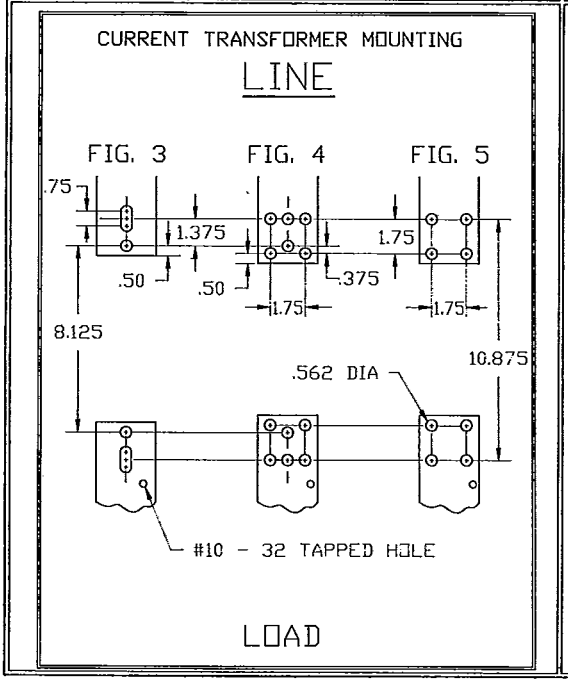
Barriers constructed in accordance with the material and thickness requirements of UL 891 shall be installed, as required, to prevent access to the compartment through other than the sealable doors or covers.

NEMA Standard 9-6-1989.

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NOTES:

1. All dimensions shown are in inches.
2. All illustrated dimensions shall be considered to be minimums except those for the current transformer mountings, which shall be considered nominal. (See Figures 3, 4, and 5.)
3. If the neutral conductor is not provided in the current transformer (CT) compartment, its location shall comply with Section 300-20 of the *National Electrical Code* and UL891 as they relate to induced currents.

   If located in the CT compartment, the neutral shall be permitted to be located to the rear of the compartment alongside 0A or 0C or alternatively to the rear of the compartment between 0A and 0B or 0B and 0C.
4. The utility CT compartment shall be permitted to be located in the upper of lower portion of the service section.
5. The quantity and size of bus shall be determined by referring to UL 891 or the manufacturer's listed sizes based on temperature rise.

AMPS.	FIG.	COMPARTMENT (H)	COMPARTMENT (W)	COMPARTMENT (D)	BUS DRILLING FIGURE	A	B	C	E	F	G
400-800	1	20	28	12	3	5	9	5	2	6	SEE NOTE 3
801-1200	1 OR 2	20	28	12	4	5	9	5	2	6	
1201-2000	1 OR 2	20	28	12	5	6	9	6	2	6	
2001-3000	1 OR 2	20	30	12	5	6.5	9	6.5	2	6.188	
3001-4000	1 OR 2	20	35	16	5	7	9	7	2	6.188	

Figure 5-1
UTILITY CURRENT TRANSFORMERS COMPARTMENTS

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Section 6
APPLICATION STANDARDS

6.1 SELECTION OF APPARATUS

Switchboards should be selected to ensure satisfactory service. Switchboards conforming to these standards are suitable for operation in accordance with their ratings under usual service conditions (see 2.3). Where switchboards are subjected to unusual service conditions (see 2.4), the manufacturer should be consulted.

Authorized Engineering Information 1-10-1978.

6.2 VOLTAGE RATINGS

The nominal voltage of the system to which a switchboard is connected shall not exceed the voltage rating of the switchboard (see 3.2).

NEMA Standard 1-10-1978.

6.3 CONTINUOUS CURRENT-CARRYING RATINGS

6.3.1 Switchboards Without Main Overcurrent Protective Devices (Main Lug Switchboard)

The total continuous load current on a switchboard shall not exceed the section supply rating of the main section (see 3.4).

6.3.2 Main Overcurrent Protective Device in a Switchboard

The total continuous load current on a main overcurrent protective device shall not exceed 80 percent of its ampere rating unless the device is rated for continuous operation at 100 percent of its ampere rating.

6.3.3 Branch-Circuit Overcurrent Protective Device in a Switchboard

The total continuous load current on a branch circuit overcurrent protective device shall not exceed 80 percent of its ampere rating unless the device is rated for continuous operation at 100 percent of its ampere rating.

NEMA Standard 1-10-1978.

6.4 DETERMINATION OF SECTION BUS AND THROUGH BUS AMPACITY IN A MULTISECTION SWITCHBOARD

The user is best qualified to specify the ampacity of section and through buses based on the nature and demand factor of the loads to be served by each section.

6.4.1 Calculation of Section Bus Ampacity

In the absence of a specified ampacity from the user, the section bus furnished by the manufacturer shall not be less than the percentage of the sum of the ratings for the number of branch circuit overcurrent protective devices provided as specified in Table 6-1.

Table 6-1
Minimum Ampacity of Section Bus*

Number of Branch Circuit Overcurrent-protectiveDevices Supplied	Percent of the Sum of the Ratings
1	100
2-3	80
4-6	70
7-12	60
over 12	50

*A switchboard that is designed for a specific installation where the loading is known may have section bus with less than this minimum ampacity. (This sentence is classified as Authorized Engineering Information 5-16-1984.)

The ampacity is based on 100 percent of the current rating of the branch circuit device. In the case of fusible devices, the fuse clip rating shall be used, and in the case of interchangeable trip breakers the frame size shall be used.

If provision is made for the future installation of one or more specific branch-circuit units, the section bus ampacity shall be calculated with the current values for these units added to those for the units which are factory-installed.

If space is provided for an unspecified future use, the calculated ampacity required of the section bus shall be increased by the multiplying factor specified in the following Table 6-2.

CAUTION: This calculated section rating may not be sufficient for all combinations of units which may be installed in the spare space. (This sentence is classified as Authorized Engineering Information 5-16-1984.)

Table 6-2
Multiplying Factor for Bus Ampacities

Unspecified Space in Percent of Total Section Space	Multiplying Factor
0-10	1.00
11-25	1.25
26-40	1.50
41-60	1.75
Over 60	2.00

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The section bus ampacity shall in no case be required to be greater than:

1. The supply rating of the switchboard section; or,
2. The rating of an overcurrent device protecting the bus as a main or submain.

When the calculated minimum ampacity is higher than that of a standard section rating, the next larger standard section bus shall be used.

6.4.2 Calculation of Through Bus Ampacity

The minimum ampacity of the through bus furnished by the manufacturer shall be based on the following:

1. A through bus which feeds one switchboard section shall have a minimum ampacity equal to the section bus rating of that section.
2. A through bus which feeds two or more switchboard sections shall have a minimum ampacity of 80 percent of the numerical sum of the section bus ratings when calculated in accordance with 6.4.1.
3. If the user's specification requires provision for the addition of switchboard section(s) in the future, the expected section bus rating(s) shall be added to the ratings of those sections which are factory-installed, and the through bus shall have an ampacity not less than 80 percent of that total.
4. The through bus ampacity shall in no case be required to be greater than:
   a. The supply rating of the switchboard; or,
   b. The rating of an overcurrent device protecting the bus as a main or submain.
5. The through bus ampacity shall in no case be less than 33.3 percent of:
   a. The supply rating of the switchboard; or,
   b. The rating of an overcurrent device protecting the bus as a main or submain.
6. When the calculated minimum ampacity of the through bus is higher than a standard through bus rating, the next larger standard through bus shall be used.

NEMA Standard 9-6-1989.

6.5 FREQUENCY RATING

The frequency rating for ac switchboard assemblies is usually 50, 60 or 50/60 hertz. For applications at other frequencies, consult the manufacturer.

NEMA Standard 5-16-1984.

6.6 SHORT-CIRCUIT CURRENT RATING

6.6.1 Application on System

A switchboard shall be applied only on a system having an available short-circuit current not greater than the short-circuit current rating of the switchboard. (See 3.7 for short-circuit current ratings and 4.3 for short-circuit test procedure.)

NEMA Standard 5-16-1984.

6.6.2 Current-limiting Devices

Where current-limiting devices are used to meet specific short-circuit current ratings, these means shall either be as an integral or external part of the switchboard, or provision shall be made to allow for the integral or external installation of specific current-limiting means upon installation of the switchboard.

NEMA Standard 5-16-1984.

6.6.3 Calculation

IEEE Publication No. Std. 141 contains detailed information for a method of calculating 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. However, it is important that the actual system data be compared with the values assumed in formulating the tables to determine the reliability of the results. Transformer impedance values are particularly important.

6.6.4 Examples for Application – Determination of Switchboard Short-Circuit Current Rating (See Figure 6-1)

Example 1. Assume:

a. 50,000 rms symmetrical amperes short-circuit current available at the line terminals of the switchboard supply bus at the rated voltage.
b. The individual overcurrent devices and their branch buses have short-circuit current ratings of 50,000 rms symmetrical amperes at the voltage rating of the system.
c. The through bus and section bus have short-circuit current ratings of 65,000 rms symmetrical amperes.
d. The main device has a short-circuit current rating of 75,000 rms symmetrical amperes.
e. The supply bus has a short-circuit current rating of 75,000 rms symmetrical amperes.

Since the individual overcurrent devices have the lowest short-circuit current rating, the short-circuit current rating of the assembled sections would be 50,000 rms symmetrical amperes, and the switchboard would be satisfactory for application on a system having an available short-circuit current up to 50,000 amperes.

Example 2. Assume:

a. 50,000 rms symmetrical amperes short-circuit current available at the line terminals of the switchboard supply bus at rated voltage.

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b. The individual overcurrent devices and their branch bus have short-circuit current ratings of 40,000 rms symmetrical amperes at the voltage rating of the system.
c. The through bus and section bus have short-circuit current ratings of 65,000 rms symmetrical amperes.
d. The main device has a short-circuit current rating of 75,000 rms symmetrical amperes.
e. The supply bus has a short-circuit current rating of 75,000 rms symmetrical amperes.

The short-circuit current rating of the assembled sections would be 40,000 rms symmetrical amperes, the same as the individual overcurrent devices. The switchboard would be unsatisfactory for application on a system having an available short-circuit current of 50,000 amperes. As the individual overcurrent devices and their branch bus are the only elements in the system not having sufficient short-circuit capacity, the switchboard could be made suitable for this application by replacing these devices and the bus with devices and bus having a short-circuit current rating of a least 50,000 rms symmetrical amperes.

Example 3. Assume:

a. The diagram shown in Figure 6-1 and assumptions a, b, and c as stated in Example 2.
b. Assume the rms symmetrical available short-circuit current at the line terminals of the main device is raised from 50,000 amperes to 65,000 amperes.

The switchboard is not satisfactory for use with this system. However, this situation could be corrected by:

1. Installing a switchboard with all devices and bus having a short-circuit current rating of at least 65,000 rms symmetrical amperes; or,
2. Protecting the switchboard on the line side of the branch bus with a main device which has been series combination tested with the branch devices with 65,000A rms minimum available.

Authorized Engineering Information 5-16-1984.

6.6.5 System With Supplementary Protection

Switchboards having short-circuit ratings less than that available from the system may be used if the current-limiting means is provided on the line side of the switchboard (e.g., devices such as current-limiting fuses, current-limiting circuit breakers, or reactors may furnish this protection). The switchboard manufacturer should be consulted for a suitable combination.

Authorized Engineering Information 9-15-1971.

6.7 LOCATION, INSTALLATION, OPERATION AND MAINTENANCE

In addition to the proper design and manufacturer of switchboards, their successful operation is dependent upon proper handling, location, installation, operation, and maintenance. For detailed information on these phases of application, refer to NEMA Standards Publication No. PB 2.1. Some installation guidelines, pertaining specifically to planning of the switchboard location and more appropriately covered in this Standards Publication, are listed as follows:

1. Locate the switchboard so that it is not exposed to physical damage or unqualified personnel.

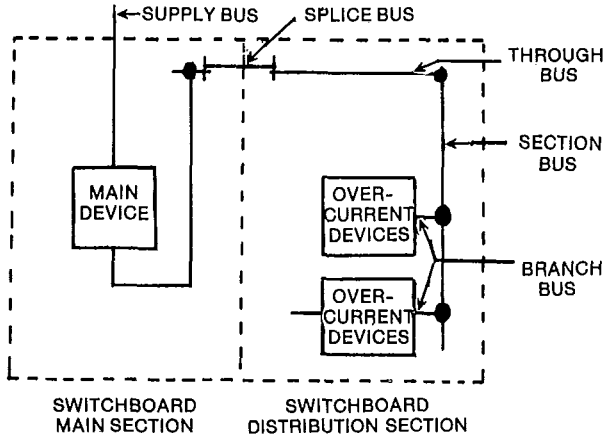


Figure 6-1
SWITCHBOARD DIAGRAM

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2. Locate the switchboard well away from combustible materials.
3. Unless specifically designed for the purpose, do not install switchboards where unusual service conditions exist (See 2.4.). To avoid nuisance tripping or fuse blowing, locate the switchboard so that normal ambient temperatures do not exceed 30°C (86°F).
4. In a wet location or outside of a building, use a Type 3R enclosure or provide the switchboard with means to prevent moisture or water from entering and accumulating within the enclosure.
5. Position the switchboard (not rear accessible) so there is clearance between it and adjacent walls, minimum of ½ inch for indoor and 6 inches for outdoor or wet locations.
6. When selecting a location, sufficient access and working space should be provided around the switchboard. Refer to Section 110-16 of the *National Electrical Code* for detailed requirements.
7. Provide adequate lighting for all working spaces around the switchboard.
8. Floor area or foundation should be of adequate strength to support the weight of the switchboard. It should be as smooth and level as possible.

Authorized Engineering Information 5-16-1984.

6.8 GROUND FAULT PROTECTION

Ground fault protection (GFP) is recommended to minimize damage in the event of a short-circuit to ground having sufficiently low magnitude so that the overcurrent protective device would normally not trip or would require an extended time to trip. See Underwriters Laboratories Inc., Publication No. UL 891, and the *National Electrical Code* for minimum requirements and NEMA Standards Publication PB 2.2 for additional information.

Switchboard ground fault protectors are generally of three types:

1. *Zero Sequence Type* — An individual sensor that vectorially sums current flow through all of the phase conductors and neutral conductors (if any). Any resulting current is directly proportional to the ground fault current in the system.
2. *Residual Type* — Separate individual sensors vectorially sum the current flow through each phase conductor and neutral conductor (if any). Any resulting current is directly proportional to the ground fault current in the system.
3. *Ground Return Type* — An individual sensor monitors the current in the grounding conductor only. This type of application is used with a single main device service switchboard only. To comply with the activating ground current and operating time requirements of the *National Electrical Code*, all ground connections must be on the load side of the sensor. No ground connections are permitted integral or external to the switchboard on the line side of the sensor.

To minimize the amount of switchboard bus unprotected by ground fault protection, single-ended switchboards should have a single main, and double ended switchboards should be limited to two mains. Construction of this type limits the number of operations necessary to deenergize the switchboard.

Consideration should be given to providing ground fault protection for individual feeder or branch circuits. Protectors which open only a main device may cause loss of power on circuits other than those circuits experiencing the ground fault. When there is no main protective device that can operate to open all ungrounded supply conductors, the switchboard bus is not protected from ground faults. The specifying engineer should be consulted as to the type of ground fault protection required and the recommended settings for a particular installation.

Authorized Engineering Information 5-16-1984.

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

Two-pole circuit breakers or switches intended to be installed on corner-grounded (grounded B phase) delta systems to supply three- phase loads shall be specifically rated for this purpose. Three pole circuit breakers or switches shall also be permitted when specifically rated for use on these systems.

NEMA Standard 5-16-1984.

6.10 BUS DENSITY

Bus shall meet the cross section or temperature rise tests of UL 891.

NEMA Standard 5-16-1984.

For equipment ratings above 4000 amperes, bus bar sizes are the subject of special considerations.

Consideration should be given to factors such as bus density; construction; bus location; spacing between bars; and structure, frame material and amount of ventilation.

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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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