



UL 67

STANDARD FOR SAFETY

Panelboards

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UL Standard for Safety for Panelboards, UL 67

Thirteenth Edition, Dated May 15, 2018

SUMMARY OF TOPICS:

This New Edition of ANSI/UL 67 is issued to include the following changes in requirements:

Addition of Requirements for Marking for Panelboards Intended to be Connected to Uninterruptible Power Supplies (UPS)

Addition of Requirements to Allow a Frequency Range for Dielectric Testing

Update of Requirements for Separation of Circuits Section

Clarification of Requirements for Temperature Testing of Panelboards with Breakers Incorporating Integral Neutral Connections

The new/revised requirements are substantially in accordance with Proposal(s) on this subject dated January 19, 2018 and March 16, 2018.

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Standard for Panelboards

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This ANSI/UL Standard for Safety consists of the Thirteenth Edition.

The most recent designation of ANSI/UL 67 as an American National Standard (ANSI) occurred on May 15, 2018. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

The Department of Defense (DoD) has adopted UL 67 on June 18, 1990. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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Explanatory Information Regarding Wire Deflection And Bending Distances

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INTRODUCTION

1 Scope

1.1 These requirements cover panelboards to be employed in accordance with the National Electrical Code, NFPA 70.

1.2 These requirements cover panelboards for the control and protection of electric lighting and appliance branch circuits, and power circuits, including feeder distribution panelboards. They also cover units specifically designed for panelboard assembly.

1.3 These requirements do not cover:

- a) Distribution equipment which sole function is the automatic or nonautomatic transferring of one or more load conductor connections from one power source to another. Reference the Standard for Transfer Switch Equipment, UL 1008.
- b) Factory wired assemblies of industrial control equipment intended to control industrial processes. Reference the Standard for Industrial Control Panels, UL 508A.
- c) Distribution equipment containing only one circuit subdivision, unless also provided with a meter socket. See 6.5.1. Reference the Standard for Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures, UL 489.
- d) Distribution equipment intended to serve as a means for distributing power required to operate mobile or temporarily installed equipment. Reference the Standard for Power Outlets, UL 231.
- e) Factory wired assemblies of controllers, timers, temperature regulating equipment and such, intended for control of equipment for use with swimming pools, hot tubs, and/or spas. Reference the Standard for Electric Spas, Equipment Assemblies, and Associated Equipment, UL 1563.
- f) Factory wired assemblies intended for the control of Architectural and Floating Fountains. Reference the Standards for Motor-Operated Water Pumps, UL 778, Underwater Luminaires and Submersible Junction Boxes, UL 676 and Industrial Control Panels, UL 508A.
- g) Portable power distribution equipment. Reference the Standard for Portable Power-Distribution Equipment, UL 1640.
- h) Panelboards with converter and/or inverter functions, intended for use as distribution equipment in recreational vehicles. Reference the Standard for Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts, UL 458.

2 Components

2.1 Except as indicated in 2.2, a component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.

2.2 A component is not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this standard, or
- b) Is superseded by a requirement in this standard.

2.3 A component shall be used in accordance with its rating established for the intended conditions of use.

2.4 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.5 A component not marked with a short-circuit current rating is considered rated for use in a circuit having a maximum available fault current as shown in Table 2.1.

Table 2.1
Assumed maximum short-circuit current rating for unmarked components

Components		Short circuit current rating, kA
1.	Circuit Breaker (Including GFCI Type)	5
2.	Clock-Operated Switch	5
3.	Fuseholder	10
4.	Plug Fuse	10
5.	Industrial Control Equipment:	
a.	Auxiliary Devices	5
b.	Switches	5
6.	Meter Socket Base	10
7.	Motor Controller, rated in horsepower (kW)	
a.	1.5 – 50 (1.1 – 37.3)	5
b.	51 – 200 (38 – 149)	10
c.	201 – 400 (150 – 298)	18
d.	401 – 600 (299 – 447)	30
e.	601 – 900 (448 – 671)	42
f.	901 – 1600 (672 – 1193)	85
8.	Photoelectric Switches	5
9.	Receptacle (GFCI Type)	2 ^a
10.	Receptacle (other than GFCI Type)	10
11.	Snap Switch	5
12.	Terminal Block	10
13.	Thermostat	5
14.	Direct Connected Meters	b

^a The short-circuit current available in a 120 volt secondary circuit of a transformer rated 5 kilovolt-amperes or less is considered to be 2 kiloamperes or less.

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Table 2.1 Continued on Next Page



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Table 2.1 Continued

Components	Short circuit current rating, kA
^b See 2.7.	

2.6 The short-circuit current available in the secondary circuit of a transformer rated 10 kilovolt-amperes or less is considered to be 5000 amperes or less.

2.7 For other than a plug-in meter, a current-sensing meter in a panelboard shall be a type that has been subjected to a 60 hertz rms short-circuit current of 12,000 amperes for four electrical cycles, and a peak current of 30,000 amperes for one-half electrical cycle, and shall be provided with overcurrent protection as described in 25.8.5.2. A plug-in meter such as a watt-hour meter to be plugged into a meter socket base is not considered to be a part of the panelboard.

Exception No. 1: A meter need not have been tested nor provided with overcurrent protection if it is intended for use with a current transformer.

Exception No. 2: A meter need not have been tested nor provided with overcurrent protection if it is used across a shunt that has been subjected to a short-circuit test as specified in Section 25, Short-Circuit Current Test.

Exception No. 3: A meter need not have been subjected to a peak current of 30,000 amperes nor provided with overcurrent protection if the short-circuit current rating of the panelboard or the available fault current of the circuit at the meter is 14,000 amperes or less.

Exception No. 4: The four electrical cycle test may be reduced to 10,000 amperes if the short-circuit current rating of the panelboard is 10,000 amperes or less.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purpose of this standard, the following definitions apply.

5.2 **AMBIENT TEMPERATURE** – The temperature of the surrounding medium that comes in contact with the panelboard. For an enclosed panelboard, it is the temperature of the medium outside the enclosure.

5.3 **AMPACITY** – The current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

5.4 **AVAILABLE SHORT-CIRCUIT CURRENT** – That current which would flow in a circuit if a short-circuit of negligible impedance were to occur at a given point.

5.5 **BARRIER** – A partition for the insulation or isolation of electric circuits or electric arcs.

5.6 **BONDING** – The permanent joining of metallic parts to form an electrical conductive path that ensures electrical continuity and the capacity to conduct safely any current likely to be imposed.

5.7 **BONDING JUMPER** – A reliable conductor to ensure the required electrical conductivity between metal parts required to be electrically connected.

5.8 **BONDING SCREW** – A screw that is used as a bonding jumper.

5.9 **BUS** – A conductor, or group of conductors, that serves as a common connection for two or more circuits.

5.10 **CABINET** – An enclosure designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.

5.11 **CARTRIDGE FUSE** – A fuse consisting of a current-responsive element inside a fuse body with contacts on both ends.

5.12 **CIRCUIT BREAKER** – 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.

5.13 **CLASS CTL PANELBOARD** – A panelboard that has physical means to prevent the installation of more than 42 overcurrent devices, or if fewer than 42, that number for which the panelboard was designed and rated.

Note 1 – When properly installed, Class CTL panelboards will comply with the Lighting and Appliance Branch-Circuit Panelboard requirements in the National Electrical Code.

Note 2 – Class CTL panelboards were included in 1965 through 2005 editions of the National Electrical Code. Requirements within this Standard dealing with Class CTL Panelboards are applicable to products for use with those Codes.

5.14 CONTINUOUS DUTY – Operation at a substantially constant load for an indefinitely long time.

5.15 CURRENT-LIMITING DEVICE (AC) – An overcurrent protective device that, when interrupting currents in its current-limiting range, will reduce the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having a comparable impedance.

5.16 CURRENT RATING – The designated maximum direct current or alternating current (RMS Amperes at rated frequency) that a device can carry continuously under specified conditions.

5.17 CUTOFF BOX – An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the box proper.

5.18 DEADFRONT – A barrier that prevents live parts from being exposed to a person on the operating side of the panelboard.

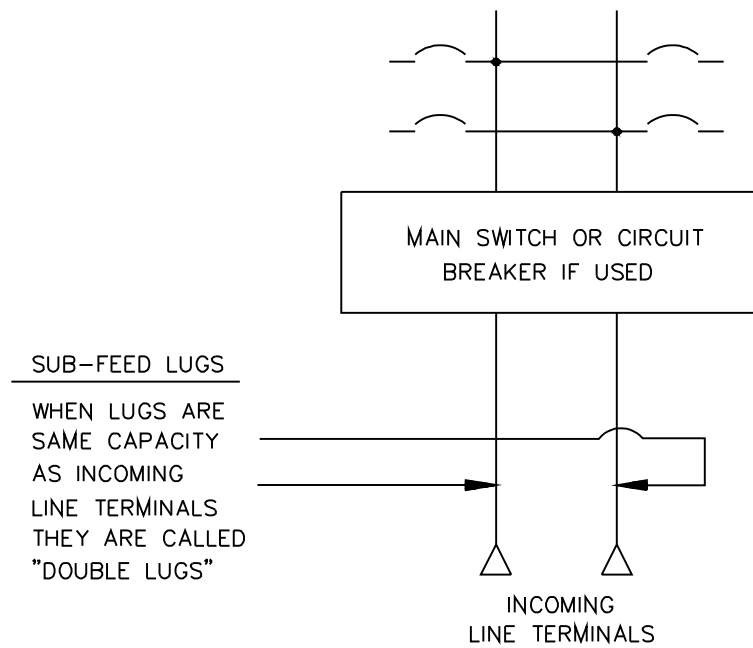
5.19 DEADFRONT SHIELD – A barrier that is used behind a door to cover wiring spaces and uninsulated live parts that would otherwise be exposed to a person when the door is open.

5.20 DEVICE – A unit of an electrical system that is intended to carry or control, but not utilize, electrical energy.

5.21 DIELECTRIC WITHSTAND TESTS – Tests to determine the ability of the insulating materials and spacings to withstand overvoltages.

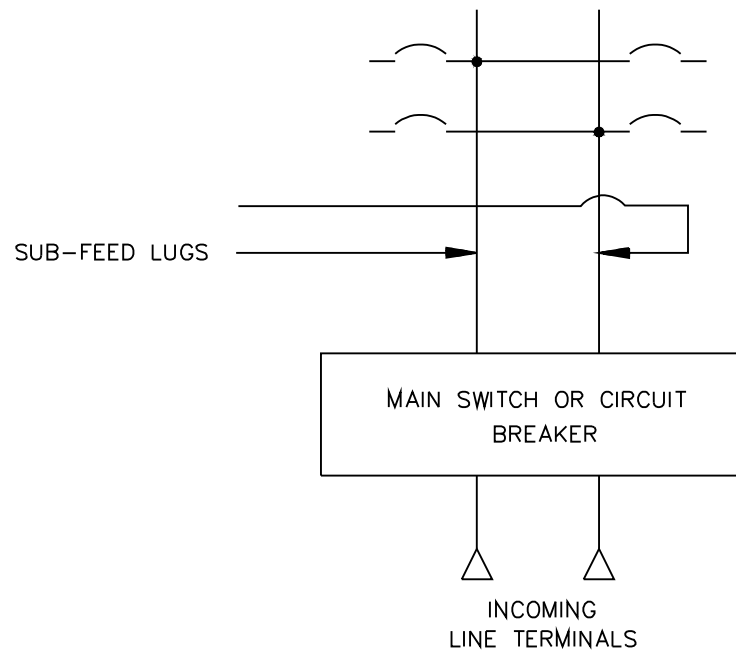
5.22 DOUBLE-LUG PANELBOARD – A panelboard that has two sets of main line terminals, each set having sufficient current-carrying capacity to supply the panelboard, see Figures 5.1 and 5.2.

Figure 5.1
Subfeed lugs connected to incoming line terminals



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Figure 5.2
Subfeed lugs connected to bus bars protected by an overcurrent protective device in the panelboard



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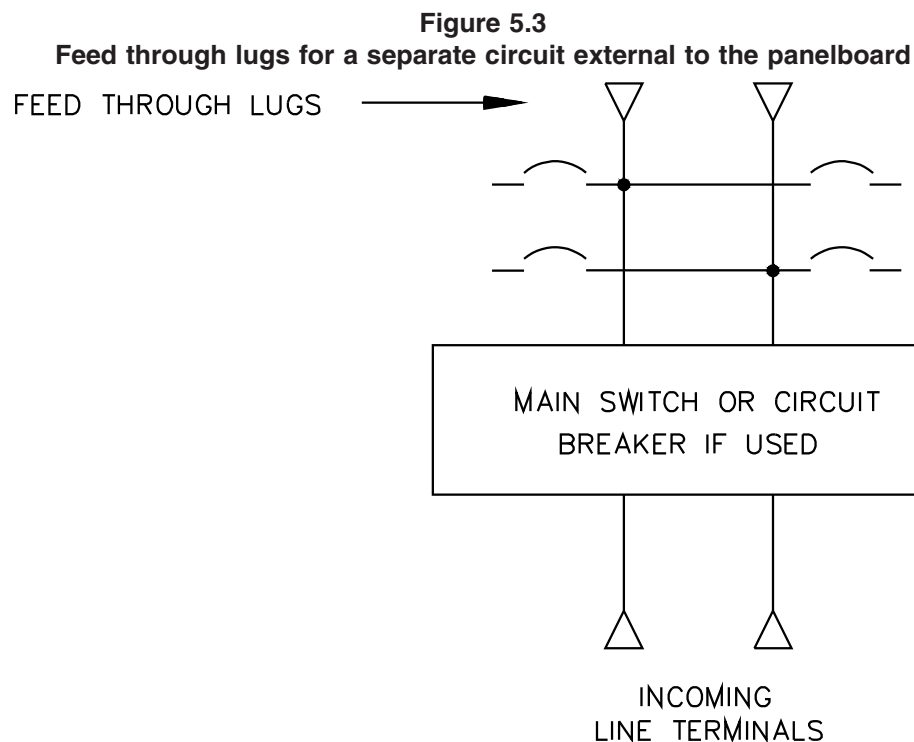
5.23 DUMMY FUSE (TEST LINK) – A current-carrying part made of copper and having dimensions such that it will fit its fuse-mounting means with the same conditions of pressure, contact, and cross-sectional areas as are obtained on terminals of the fuse that it is intended to replace. A dummy fuse shall not be a protective device.

5.24 ENCLOSED PANELBOARD – An assembly of buses and connections, overcurrent devices, and control apparatus with or without switches, or other equipment, installed in a suitable cabinet, cutout box, or enclosure suitable for a panelboard application.

5.25 ENCLOSED RECREATIONAL VEHICLE (RV) PANELBOARD – An enclosed panelboard intended to be installed in a recreational vehicle (RV) in accordance with Article 551 of the National Electrical Code, NFPA 70.

5.26 ENCLOSURE – 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.

5.27 FEED-THROUGH LUG – A terminal that is connected to a main bus bar at the end opposite from the incoming line terminal or main device, if used, and that is provided for connection to an outgoing wire or cable, see Figure 5.3.



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5.28 FILLER PLATE – A plate intended to close an opening that would otherwise be closed by the subsequent installation of a circuit breaker or other device.

5.29 FLUSH-MOUNTED (TYPE) – A device designed to be set into and secured to a flat surface, with a minimal front projection.

5.30 FRAME SIZE – A term applied to a group of molded case circuit breakers of similar physical configuration. 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.

5.31 FUSE – A non-resettable protective device which opens a circuit during specified overcurrent conditions by means of a current responsive element or elements.

5.32 FUSE CLIPS – The contacts of the fuseholder that support the fuse and connect the fuse terminals with the circuit.

5.33 FUSIBLE SWITCH – A switch in which one or more poles have a fuse in series in a composite unit.

5.34 FUSEHOLDER – An assembly of a base, fuse clips, and necessary insulation for the mounting and connecting of a fuse into a circuit.

5.35 GROUNDED CONDUCTOR – A system or circuit conductor that is intentionally grounded.

5.36 GROUND-FAULT CIRCUIT INTERRUPTER (GFCI) – A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.

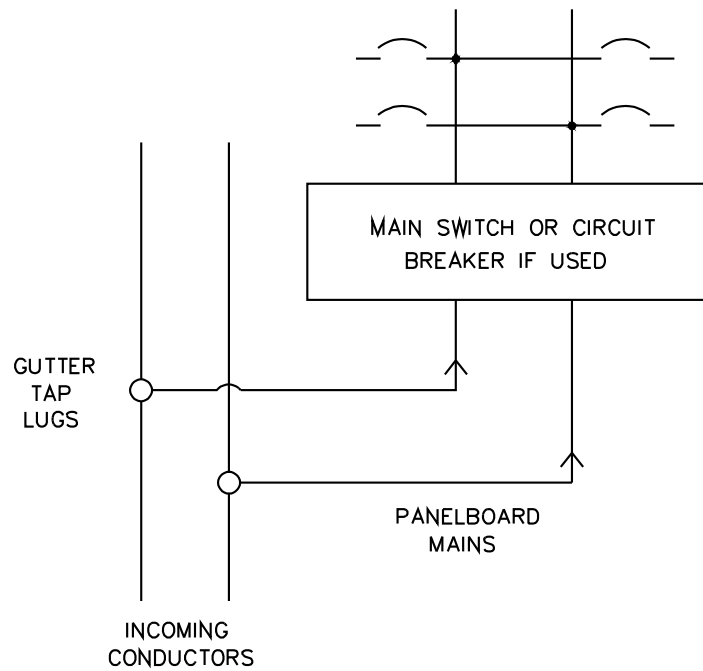
5.37 GROUND-FAULT PROTECTION OF EQUIPMENT – A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device.

5.38 GUTTER TAP LUG – A terminal that is located in a wiring gutter of a panelboard and that is provided for:

- a) The connection of an incoming or an outgoing conductor, or a panelboard main; or
- b) The connection of two sets of outgoing conductors to a branch or other outgoing circuit, see Figures 5.4 and 5.5.

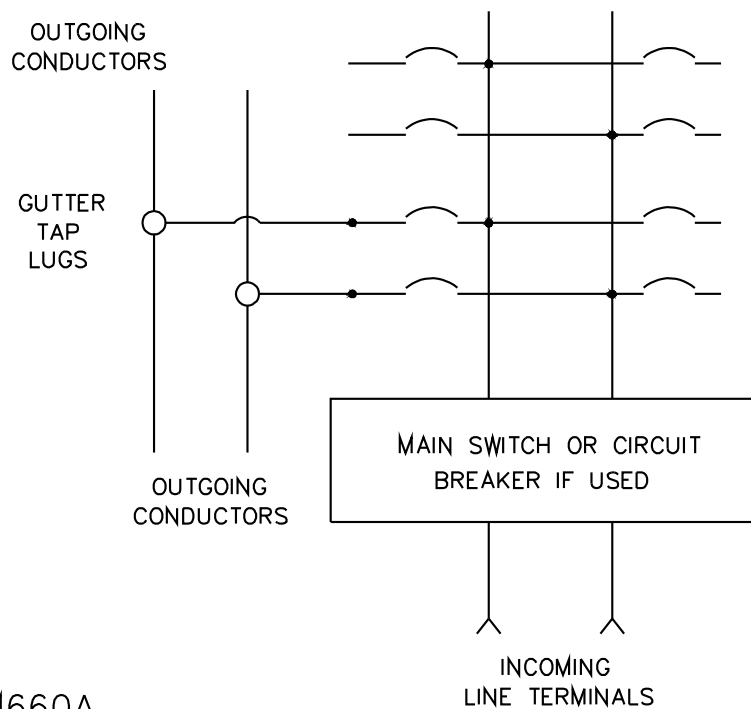
A lug connecting an outgoing conductor is also considered to be a subfeed lug, see 5.61(a).

Figure 5.4
Gutter tap lugs connected to panelboard mains



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Figure 5.5
Gutter tap lugs connected to a branch circuit



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5.39 I^2t (AMPERE SQUARED SECONDS) – An expression related to the circuit energy as a result of current flow. The “ I^2 ” stands for the square of the effective (rms) let-through current and the “ t ” stands for the time of current flow in seconds. “ I^2t ” is a common expression for the circuit energy between the initiation of the fault current and the clearing of the circuit.

5.40 INTERLOCK – An electrical or mechanical component actuated by the operation of a device with which it is directly associated to govern succeeding operations of the same or allied devices.

5.41 INTERRUPTING RATING – The highest current at rated voltage that a device is intended to interrupt under standard test conditions.

5.42 KNOCKOUT – A portion of the wall of an enclosure so fashioned that it is capable of being readily removed by a hammer, screw driver, and pliers at the time of installation in order to provide an opening or hole for the attachment of a raceway, cable, or fitting.

5.43 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARD – A lighting and appliance branch circuit panelboard is one having more than 10 percent of its overcurrent devices protecting lighting and appliance branch circuits. Such circuits have a connection to the neutral of the panelboard and overcurrent protection of 30 A or less in one or more conductors.

Note – Lighting and appliance branch circuit panelboards were included in editions of the National Electrical Code prior to 2008. Requirements within this Standard dealing with lighting and appliance branch-circuit panelboards are applicable to products for use with those Codes.

5.44 LUG – A terminal that is provided for the connection of a wire or a cable to a panelboard or for a wire or cable connection between component parts of a panelboard.

5.45 MAIN – A device that is provided for the connection of an incoming line conductor.

5.46 MAIN TERMINAL – A terminal that is provided for the connection of an incoming line conductor.

5.47 MAINS (MAIN TERMINALS) – The terminals, or main device, provided for the connection of the main incoming line conductors.

5.48 NEUTRAL (ASSEMBLY); SOLID NEUTRAL – An assembly consisting of enough 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 the following:

- a) A means for making the required bonding connection between the neutral and the enclosure; and
- b) A terminal for the grounding electrode conductor.

5.49 NEUTRAL CONDUCTOR – A conductor that is connected to the midpoint of a three-wire single-phase system, the center point of a wye-connected three-phase system, or the midpoint of one side of a delta-connected three-phase system.

Note: The neutral conductor is the grounded conductor.

5.50 OVERCURRENT PROTECTIVE DEVICE – An individual fuse or circuit breaker pole.

5.51 PANELBOARD – A single panel or a group of panel units designed for assembly in the form of a single panel; includes buses, automatic overcurrent devices, and may be equipped with switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front.

5.52 PEAK LET-THROUGH CURRENT (AC) – The maximum instantaneous current through an overcurrent device during the total clearing time.

5.53 PLUG FUSE – A screw-in type fuse for use in an Edison base type fuseholder.

5.54 POWER PANELBOARD – A power panelboard is one having 10 percent or fewer of its overcurrent devices protecting lighting and appliance branch circuits.

Note – Power Panelboards were included in 1999 through 2005 editions of the National Electrical Code. Requirements within this Standard dealing with power panelboards are applicable to products for use with those Codes.

5.55 PRESSURE WIRE CONNECTOR – A reusable connector into which the conductor (wire) is secured by mechanical pressure applied by an integral screw, cone, or other mechanical parts.

5.56 PULLOUT SWITCH – A switch, enclosed or nonenclosed, that is operated to open a circuit by manually separating the movable contact from the stationary contact, and is operated to close a circuit by manually reconnecting the movable contact and the stationary contact.

5.57 RATING – A designated limit of operating characteristics based on defined conditions.

5.58 SERVICE – The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

5.59 SERVICE EQUIPMENT – The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s), and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.

5.60 SHORT-CIRCUIT CURRENT RATING (EQUIPMENT) – The maximum rms available current to which a device can be connected. The rating is expressed in amperes and volts.

5.61 SUBFEED LUG – A terminal that is provided for the connection of a wire or a cable:

a) To a bus bar that is connected directly to the panelboard main incoming line terminal, see Figure 5.1; or

b) To a bus bar fed by an overcurrent protective device in the panelboard, see Figure 5.2.

5.62 SWITCH – A device, manually operated, unless otherwise designated, for opening and closing or for changing the connection of a circuit.

5.63 SYMMETRICAL CURRENT – 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 A.

5.64 VENTILATED – So constructed as to provide a means to permit circulation of external air through the enclosure to remove excess heat, fumes, and vapors.

CONSTRUCTION

6 General

6.1 All panelboards

6.1.1 A panelboard shall employ materials throughout that are acceptable for the particular use, and shall be made and finished with the degree of uniformity and grade of workmanship practicable in a well-equipped factory.

6.2 Equipment on supply side of disconnect

6.2.1 Only the following equipment shall be permitted to be connected to the supply side of the service disconnecting means:

- a) Meters, meter sockets, or meter disconnect switches nominally rated not in excess of 1000 volts;
- b) Instrument transformers (current and potential), high-impedance shunts and Type 1 surge-protective devices;
- c) Load management devices if overcurrent protection is provided;
- d) Taps for load management devices, optional standby power systems, and fire and sprinkler alarms;
- e) Control circuits of power operable service disconnecting means including control circuits of optional standby power systems, if overcurrent protection and disconnecting means are provided; and
- f) Ground-fault protection systems or Type 2 surge-protective devices, if overcurrent protection and disconnecting means are provided.
- g) Interconnected electric power production sources, such as solar photovoltaic, wind, or fuel cell systems.

6.2.2 In determining the allowable number of service disconnects, a disconnecting means used solely for equipment installed on the supply side of the service disconnecting means shall not be counted.

6.2.3 Disconnects and overcurrent protection which are located on the supply side of the service disconnecting means, and:

- a) Are installed as part of the equipment; and
- b) The circuit being controlled is contained within the panelboard enclosure

may be located behind a deadfront or screwed-on cover that is only intended to be removed by a qualified person. See 34.9.10.

6.3 Distribution equipment

6.3.1 A panelboard may be designed for mounting on a mounting post or pedestal for distribution equipment.

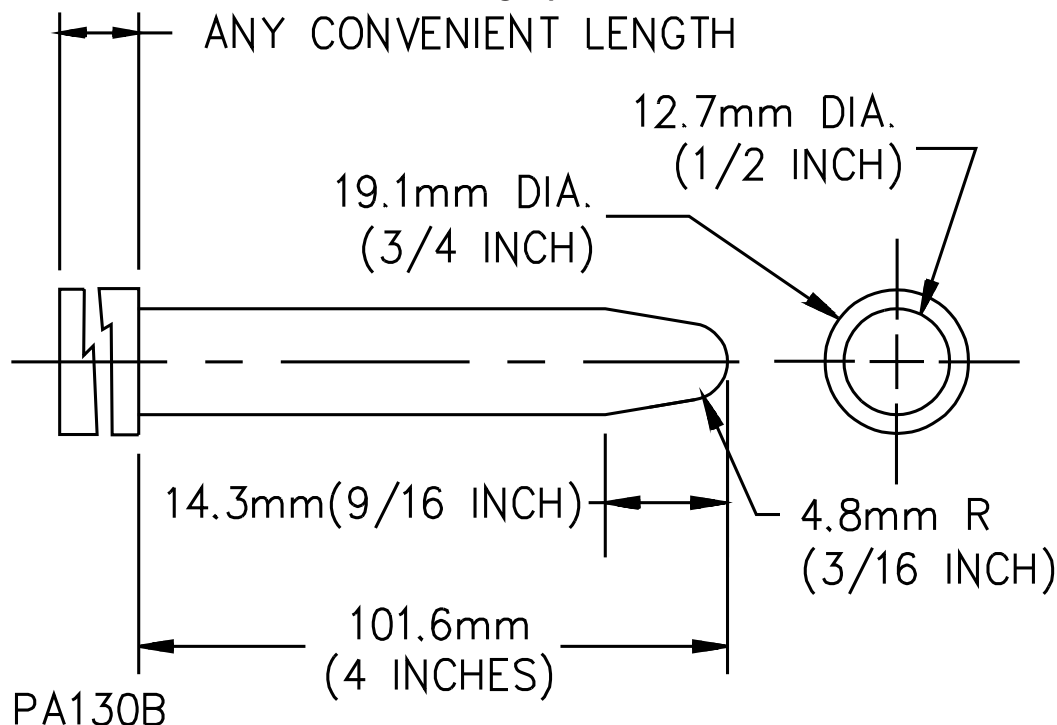
6.4 Service equipment

6.4.1 A panelboard intended for use as service equipment, shall comply with the applicable requirements in the Reference Standard for Service Equipment, UL 869A.

6.4.2 Panelboards with provisions for only a single service disconnect shall be constructed such that, with the service disconnect in the off position, no ungrounded uninsulated live part is exposed to inadvertent contact by persons while servicing any field connected load terminal, including a neutral load terminal, a branch circuit equipment grounding terminal, or the neutral disconnect link. Exposure to inadvertent contact is determined by use of the probe illustrated in Figure 6.1. If restriction to the line-side of the service disconnect is dependent on the installation of field installed service conductors, conductors sized in accordance with 12.1.10 shall be installed in the terminals when determining exposure to inadvertent contact. All live parts of the line side service terminal, including the connector body and pressure screw shall be evaluated.

NOTE: In accordance with the Standard for Electrical Safety in the Workplace, NFPA 70E, an electrically safe work condition should be established prior to working on electrical equipment. Accessibility requirements do not endorse working on energized electrical equipment.

Figure 6.1
Straight probe



6.4.3 Metal barriers provided to limit exposure to inadvertent contact shall:

- a) Have a thickness not less than 0.032 inch (0.81 mm) if uncoated, not less than 0.034 inch (0.86 mm) if galvanized, and not less than 0.050 inch (1.27 mm) if aluminum.
- b) Be constructed so that it can be readily removed or repositioned, and then re-installed, without the likelihood of contacting bare live parts or damage the insulation of any insulated live part.

Exception: Factory installed barriers that limit access to factory installed wiring and terminations are not required to be constructed so that they can be removed or repositioned.

6.4.4 Nonmetallic barriers provided to limit exposure to inadvertent contact shall:

- a) Comply with requirements in 16.3.3 for barriers used in conjunction with a minimum air space of 0.013 inch (0.33 mm).
- b) Be constructed so that it can be readily removed or repositioned, and then re-installed, to allow access to the terminal for servicing.

Exception: Factory installed barriers that limit access to factory installed wiring and terminations are not required to be constructed so that they can be removed or repositioned.

6.4.5 Panelboards marked "Suitable for use as service equipment" and

- a) Constructed in accordance with 6.7.4 and designed for use interchangeably either with main-terminal or a single service disconnect only, or
- b) Provided with a single service disconnect,

shall be permitted to provide the protection from inadvertent contact in 6.4.2 in a field installable kit when marked in accordance with 34.12.12. See also 34.9.11.

6.5 Branch circuits

6.5.1 A panelboard shall have more than one circuit subdivision. Terminals for a feed-through circuit are considered to be a circuit subdivision.

Exception: An enclosed panelboard having a meter socket may have only one load circuit.

6.5.2 A panelboard that is identified by the manufacturer as a lighting and appliance branch-circuit panelboard shall not have more than 42 nor provision for more than 42 overcurrent-protective devices, other than those in the mains. For the purpose of this requirement, a 2-pole fuseholder or circuit breaker is considered to be two overcurrent devices; a 3-pole fuseholder or circuit breaker is considered to be three overcurrent devices. If a panelboard is not identified by the manufacturer as a lighting and appliance branch-circuit panelboard the maximum number of circuits is only limited by the design of the panelboard.

6.5.3 For a panelboard that is identified by the manufacturer as a lighting and appliance branch-circuit panelboard, a branch circuit that has a connection to the neutral of a panelboard and that has overcurrent protection of 30 amperes or less in one or more wires is considered to be a lighting or appliance branch circuit. All branch-circuit overcurrent-protective devices rated at 30 amperes or less are considered to be intended for use in lighting and appliance branch circuits unless such devices are clearly identified as not being intended for use with a neutral connection.

6.5.4 With reference to 6.5.2, the boxes of two lighting and appliance branch-circuit panelboards, each of which complies with the limitation of 42 overcurrent devices, may be welded or bolted together under a common trim if:

- a) There is not more than one opening through the abutting walls, and
- b) This opening is not more than 4 inches (102 mm) in diameter.

The use of a barrier, with or without an opening, to subdivide an enclosure containing more than 42 overcurrent devices is not acceptable.

6.5.5 With reference to 6.5.4, a common enclosure with two complete facing – abutting– walls is also acceptable. Unremoved knockouts in the abutting walls are not considered openings.

6.6 Electrical connections

6.6.1 Other than as noted in 6.6.2 and 6.6.3, all electrical connections between switches, fuseholders, circuit breakers, and the like shall be complete so that only line, load, metering, and control circuits need be connected when a panelboard is installed.

6.6.2 With reference to the requirement in 14.6.2 regarding limitation of overcurrent protective devices in panelboards identified by the manufacturer as lighting and appliance branch-circuit panelboards, provisions for the addition of bus bars, such as tapped or untapped holes that can accommodate branch-circuit circuit breakers or switches shall not be provided. Where branch circuit units are intended, unused bus bar holes are acceptable and may be provided in the main bus bars by pre-drilling holes to a common spacing.

Exception: Holes for securing bus bars may be provided if the holes are plugged with solid rivets or with one-way screws. A deadfront shield over the portion of the bus with holes is not acceptable in lieu of plugging the holes in the bus bar. A separate shield secured by one-way screws onto the mounting pan behind the removable deadfront shield is acceptable in lieu of plugging holes in the bus bars.

6.6.3 A panelboard may be shipped from the factory without branch-circuit bus bars mounted in place. A barrier that is needed to comply with the spacing requirements in Section 16, Spacings, is to be permanently attached to the panelboard or the field-installed branch-circuit bus bars. See 11.2.7 and 34.12.4.

6.6.4 A panelboard shall be constructed so that any component intended to be field installed can be installed without the use of a special tool.

6.6.5 With reference to 6.6.4, if a panelboard is acceptable for use with or without a neutral bus bar, the neutral bus bar need not be mounted in place when the panelboard is shipped from the factory if:

- a) The panelboard and the neutral bus bar are marked in accordance with 34.12.6;
- b) The neutral bus bar is shipped completely assembled so that field assembly of barriers or other parts, other than terminals or the mounting of a separate cover after the neutral is wired in the field, is not necessary.

6.6.6 With reference to 6.6.4, separate wires or bus bars may be provided for making the connection:

- a) To or from a fusible switch or circuit breaker that will control a section of a panelboard, or
- b) To associated equipment.

One end of such a wire or bus bar may be connected in place when the panelboard is shipped from the factory. See 11.2.4 and 34.12.10.

6.6.7 If one end of the separate wire mentioned in 6.6.6 is not connected when the panelboard is shipped, the loose end shall be secured so that damage to itself and to the panelboard during shipment is not likely to occur. If the load end of the wire is not connected to the panelboard when shipped, it shall be:

- a) Secured to an insulating base that is acceptable for supporting uninsulated live parts, or
- b) Completely covered, including the cut end, with acceptable insulation.

6.6.8 A back-fed unit – such as a circuit breaker, a fused switch, or a main terminal kit – that uses a friction or plug-on bus bar connection shall not be used to terminate the field installed ungrounded supply conductors.

Exception: A back-fed unit provided with an additional fastener that requires other than a pull to release the unit from its mounting position on the panel (such as a hold-down kit for a back-fed main circuit breaker) may be used to terminate field installed ungrounded supply conductors. See 34.1.17 and 34.12.1.

6.6.9 Panelboards for use in accordance with Article 702 of the National Electrical Code, ANSI/NFPA 70, shall have both main disconnect units comply with 6.6.8 or its exception.

6.6.10 The operating mechanism in a panelboard used as transfer equipment in accordance with Article 702 of the National Electrical Code, ANSI/NFPA 70, shall be interlocked to prevent simultaneous connection to both the normal and alternate sources of supply. The interlock shall be installed as part of the panelboard assembly in the factory or provisions made for its field installation. The panelboard or field installed kit shall be marked in accordance with 34.12.18 or 34.12.19.

6.6.11 Panelboards intended for interconnection with one or more electric power production sources operating in parallel with a primary source(s) of electricity, in accordance with Article 705 of the National Electrical Code, NFPA 70, shall be permitted to have provisions for connection(s) as noted in (a) and (b). See 34.16 for marking requirements.

a) Supply Side Connection – Panelboards intended for use in accordance with Section 705.12(A) of Article 705 of the National Electrical Code, NFPA 70, shall be permitted to have provisions for interconnecting parallel power sources on the supply side of the service disconnecting means, see 6.2.1(g). The sum of the ratings of all supply side overcurrent devices connected to power production sources shall not exceed the rating of the panelboard.

b) Load Side Connection – Panelboards for use in accordance with Section 705.12(D) of Article 705 of the National Electrical Code, NFPA 70, shall be permitted to have one or more load side disconnects for the interconnection of parallel power sources. The total rating of all overcurrent devices supplying the panelboard shall not exceed the rating of the panelboard.

Exception: The total rating of all overcurrent devices supplying the panelboard may exceed the rating of the panelboard by up to 120% of the rating of the panelboard if the overcurrent device(s) intended for use with interconnected parallel power sources are positioned at the opposite end from the main input.

6.6.12 Panelboards intended to provide uninterruptible power supply to control circuitry shall be marked in accordance with 34.17.1.

6.7 Field installable equipment

6.7.1 Field Installable equipment shall comply with all applicable requirements of this standard.

6.7.2 A panelboard may have provision for field-installed accessories provided the following conditions are met:

- a) The panelboard is acceptable for use with or without the accessory.
- b) Instructions for the installation and operation are provided with each accessory.
- c) The installation of an accessory does not require the use of other than normally available tools, such as screwdrivers, pliers and wrenches, unless such a tool and instructions for its use are furnished with each accessory.
- d) A barrier that is necessary because spacings would otherwise be less than required is securely attached at the factory to either the panelboard, or to the accessory to be installed.
- e) The accessory is an essentially complete unit and does not require assembly in the field.
- f) The installation of the accessory does not expose uninsulated or mechanical functional parts that would not be exposed during the replacement of overcurrent protective devices.
- g) Except as noted in (h) and (i) means for mounting the accessory require no drilling, cutting, or filing of holes.
- h) Drilling, cutting, or filing is acceptable in the panelboard enclosure if such openings are indicated by drill points or breakouts on the enclosure.
- i) It is possible to accomplish the operation described in (h) in a manner so that debris inside the panelboard enclosure does not accumulate.
- j) The accessory complies with the marking requirements of 34.12, Field-installed equipment.

6.7.3 Pressure terminal connectors for line or load field connections that are available from the equipment manufacturer in the form of a field installable terminal kit, or as one or more terminal connectors specified for field installation on the equipment, shall comply with the following (reference 12.1.1, Exception No. 2):

- a) Fastening devices, such as studs, nuts, bolts, spring and flat washers, as required for an effective installation shall either be provided as part of the component terminal kit or be mounted on or separately packaged with the equipment.
- b) The installation of the terminal kit shall not involve the loosening or disassembly of parts other than a cover or other part giving access to the terminal location. The means for securing the terminal connector shall be readily accessible for tightening before and after installation of conductors.
- c) If the pressure terminal connector specified in (a) requires the use of a special tool for securing the conductor, any necessary instructions shall be included in the component terminal kit package or with the equipment.
- d) Installation of the pressure terminal connectors in the intended manner shall result in a product that meets the requirements in this standard.

- e) The equipment shall be marked in accordance with 34.12, Field-installed equipment.

6.7.4 The main terminals may be in the form of a main-terminal kit if the panelboard is specifically designed for use interchangeably either with those terminals or with a main circuit breaker or switch. A main-terminal kit may consist of individual terminals or may be an assembly consisting of:

- a) Terminals;
- b) Bus bars that provide connections between those terminals and the main bus bars of the panelboard; and
- c) A mounting means for those components.

The kit may be connected to the main bus bars by either bolting or plugging in. See 34.12.11.

7 Enclosure

7.1 General

7.1.1 A panelboard shall be constructed for use in a switchboard, cabinet, or cutout box. An enclosed panelboard shall be provided with an enclosure complying with the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, except for modification and additional requirements as specifically described in the standard.

7.1.2 A single-threaded nut designed to slip over the edge of sheet metal to receive a retaining screw may be used to secure a deadfront to supports, a unit such as a switch or circuit breaker to a mounting panel, a mounting pan to an enclosure, or a cover or a front to an enclosure if:

- a) The nut is protected against corrosion by enameling, galvanizing, sherardizing, plating, or other equivalent means.
- b) The threads do not strip when a torque of 30 pound-inches (3.4 N-m) is applied.

7.1.3 A Panelboard enclosure shall be sufficiently deep to allow the door or doors to be closed with any switches in either the open or the closed position.

7.1.3.1 The enclosure shall be constructed so that all doors accessing equipment that is likely to require examination, adjustment, servicing, or maintenance while energized shall open to a minimum of 90 degrees from the closed position.

7.1.4 An enclosed panelboard having provision for mounting a meter may have an opening to accommodate a watt-hour meter.

7.1.5 An opening for a watt-hour meter as mentioned in 7.1.4 and the metal from which it is cut shall comply with the Standard for Meter Sockets, UL 414.

7.1.6 For enclosed recreation vehicle (RV) panelboards, that portion of the enclosure associated with the low voltage compartment, may comply with the enclosure requirements in the Standard for Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts, UL 458. Unless the line voltage and low voltage compartment of the assembly are separated by a barrier that complies with enclosure requirements in the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, the overall assembly shall be mounted in an enclosure which complies with the requirements of UL 50.

7.2 Component arrangement

7.2.1 A fuse puller and a pull-out switch incorporating a fuseholder employed in a panelboard shall have no live parts exposed when the device is in the closed position, and cartridge-fuse clips in such a device shall be dead when accessible for the inspection or replacement of fuses.

7.2.2 The setting, adjustment, or manual operation of a clock-operated switch or similar device by an operator shall not result in exposure of wiring, other than that directly connected to the switch or device, or exposure to unintentional contact with live parts.

7.2.3 A meter-socket base shall be mounted independently of the cover unless it is intended to be used with a current transformer.

7.2.4 The enclosure of a meter socket shall house completely all live parts with an appropriate meter mounted in position.

7.2.5 In a meter socket, all bare live parts shall be recessed:

- a) Not less than 1/2 inch (12.7 mm) behind the plane of the outer edge of the meter-mounting rim, or behind the plane of the meter-mounting hole if a mounting rim is not provided.
- b) Behind the plane of the cover, unless a barrier or the like is provided so that the cover may be removed without the likelihood of its contacting a bare live part.

7.3 Ventilating openings

7.3.1 General

7.3.1.1 An enclosed panelboards rated 400 amperes or more may be provided with ventilating openings located as follows:

- a) In an enclosure intended for surface mounting only – in the front, side, top or bottom walls,
- b) In an enclosure not intended for surface mounting only – in the front only.

7.3.1.2 Ventilating openings shall be guarded so that there will be no direct access to a live part.

7.3.1.3 Guarding as required by 7.3.1.2 may be accomplished by:

- a) Screened or louvered openings with internal barriers,
- b) Hoods or stacks with labyrinth air passages.

7.3.2 Barriers

7.3.2.1 A ventilating opening in the top of the enclosure shall be covered by a hood or protective shield spaced above the opening to prevent the entry of foreign material.

7.3.3 Size, location, and covering or screening

7.3.3.1 A ventilating opening – slot, louver, or the like – shall be protected by one or more baffles, barriers, or other obstructions of such dimensions and locations that any access path to a live part requires at least two changes in direction from a straight line. If the minor dimension of a ventilating opening is larger than 1/4 inch (6.4 mm) it shall be protected by a screen having a minor dimension no larger than 1/4 inch.

7.3.3.2 A louver shall not be more than 12 inches (305 mm) long.

7.3.3.3 The size, shape, and location of a screened or otherwise covered opening shall be such that it will not unduly weaken the overall enclosure.

7.3.3.4 The area of all openings cut or formed from the enclosure metal shall not exceed 25 percent of the area of the wall in which the openings are located.

Exception: The 25 percent area limitation may be exceeded if reinforcing means, such as stiffeners, are employed and the enclosure complies with the requirement in 7.3.3.3.

7.3.3.5 The area of an opening covered by a louvered, perforated, or expanded metal panel that is thinner than the enclosure shall not exceed 200 square inches (1290 cm²). The area of an opening covered by 0.053 inch (1.35 mm) thick or thinner – 0.056 inch (1.42 mm) if zinc coated – steel panel or by a screen of 14 AWG (2.1 mm²) or smaller steel wire shall not exceed 80 square inches (516 cm²).

7.3.3.6 The wires of a screen shall not be smaller than 16 AWG (1.3 mm²) and the openings shall not exceed 1/4 inch (6.4 mm) in any dimension. A supplementary screen having smaller openings may be provided, but is not to be considered in evaluating the primary screen.

7.3.3.7 Perforated sheet steel and sheet-steel expanded mesh shall not be less than 0.042 inch (1.07 mm) thick – 0.045 inch (1.14 mm) thick if zinc coated – for mesh openings or perforations 1/2 square inch (3.2 cm²) or less in area; and shall not be less than 0.080 inch (2.03 mm) thick – 0.084 inch (2.13 mm) thick if zinc coated – for larger openings.

Exception: Perforated sheet metal or expanded metal mesh not less than 0.020 inch (0.51 mm) thick – 0.023 inch (0.58 mm) thick if zinc coated – may be employed for a guard or enclosure, the indentation of which will not alter the clearance between uninsulated live parts and grounded metal so as to adversely affect performance or reduce spacings below the minimum acceptable values specified in Table 16.1.

7.3.4 Rainproof and raintight

7.3.4.1 An enclosed panelboard without ventilating openings may be designated as Type 3, 3R, 3S, 4, 4X, 6, or 6P if it complies with the applicable requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E.

7.3.4.2 A ventilated enclosed panelboard may be designated as Type 3R if it complies with the applicable requirements in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E, and with the requirements in Section 22, Rain Test.

8 Bases and Supports – Insulating Material

8.1 An insulating material used for direct or indirect support of an uninsulated live part shall provide the level of performance specified in Table 8.1 for direct support and Table 8.2 for indirect support of a live part.

Exception: An insulating material may be accepted based on the end-product tests specified in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C.

Table 8.1
Maximum performance level category (PLC) for direct support insulating material

Test specified ^a	Flammability rating of material ^{a,d}		
	V-0	V-1	V-2
High voltage Arc Tracking Rate (HVTR)	1 ^b	1 ^b	1 ^b
Comparative Tracking Index (CTI) Under Moist Conditions	3 ^{c,e}	3 ^{c,e}	3 ^{c,e}
High Current Arc Ignition (HAI)	3	2	2
Hot Wire Ignition (HWI)	4	3	2
^a CTI, HAI, HVTR, and HWI are determined in accordance with the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A. Flammability ratings are determined in accordance with the Standard for Tests For Flammability of Plastic Materials For Parts in Device and Appliances, UL 94. ^b This requirement is only applicable to a component having spacings less than 1/2 inch over surface as covered by Table 16.3. ^c A material having a comparative tracking index PLC of 4 may be used if the voltage involved is 250 volts or less. ^d A material having a HB flame rating is not acceptable in any case. ^e Phenolics having a comparative tracking index PLC of 4 are acceptable if the voltage involved is 600 volts or less.			

Table 8.2
Maximum performance level category (PLC) for indirect support insulating material

Test specified ^a	Flammability rating of material ^a			
	V-0	V-1	V-2	HB
High Current Arc Ignition (HAI) ^b	3	2	2	1
NOTE – If the spacing between the indirect support material and the live part is less than 1/32 inch (either through air or over surface) the material shall be considered as providing direct support and shall comply with Table 8.1.				
^a See note a to Table 8.1. ^b If the end product through air spacing between the indirect support material and the live part is 1/16 inch or greater, but less than 1/2 inch, then consideration can be given to conducting the High Current Arc Ignition Test at the end product spacing. If the through air spacing is 1/2 inch or greater, then this requirement is not applicable.				

8.2 Thermoplastic insulating materials used for direct or indirect support of uninsulated live parts shall be subjected to the Mold Stress Relief Test, Section 24.

8.3 Slate, porcelain, and soapstone are acceptable materials for the support of an uninsulated live part. A base of slate or porcelain shall not be less than 1/2 inch (12.7 mm) thick.

8.4 Other than as indicated in 8.5, a live screwhead, a rivet, or a nut on the underside of a base designed for surface mounting shall be countersunk not less than 1/8 inch (3.2 mm) in the clear, and covered to a depth of not less than 1/8 inch (3.2 mm) with a waterproof, insulating sealing compound.

8.5 If the screw or nut mentioned in 8.4 is reliably prevented from loosening by being staked or upset, by a lock washer, or by other means, it may be insulated from the mounting surface by a material other than a sealing compound or by providing a spacing from the mounting surface not less than that specified in Table 16.1.

8.6 In a panelboard that has been found to be acceptable without a temperature test and in a panelboard incorporating fuseholders, the sealing compound mentioned in 8.4 shall not soften at a temperature of 90°C (194°F).

8.7 A determination of the softening point of a sealing compound as noted in footnote c to Table 21.1, is to be made in accordance with the test for softening point by ring and ball apparatus described in the Standard for Polymeric Materials – Short Term Property Evaluation, UL 746A.

Exception: A test is not required for a thermosetting material.

9 Covers, Barriers, and Partitions

9.1 General

9.1.1 A panelboard having a wiring gutter, wiring space, or termination area shall be provided with a cover, barrier, or partition extending around or from the side or sides of all bases or groups of bases of switches, fuseholders, or circuit breakers within the enclosure. Such a cover, barrier, or partition shall be firmly secured in position and shall fit closely with the bases of devices within the enclosure and with the door, frame, or side walls so as to enclose the wiring space, wiring gutter, or termination area and the wires stowed within it. A cover shall be provided to enclose a wiring space, wiring gutter, or termination area that would otherwise be exposed when a door giving access to a switch or fuse is open. See 17.2.2.1.

9.1.2 With reference to the requirement in the second sentence in 9.1.1, a cover, barrier, partition, or dead-front shield in a panelboard intended for use in an enclosure with no dimension more than 40 inches (1016 mm) and no area more than 1000 square inches (64.5 square decimeters) is considered to fit closely with:

- a) The bases of devices if the gap at any point is not more than 1/8 inch (3.2 mm) with the cover, barrier, partition or dead-front shield and the devices assembled in any normal position; and
- b) The front of the enclosure if the gap between the front and the return flange of a dead-front shield is not more than 3/16 inch (4.8 mm) with the panelboard properly positioned in the enclosure.

9.1.3 A panelboard shall be deadfront unless it is intended for use where it will be accessible only to qualified persons. See 34.1.6.

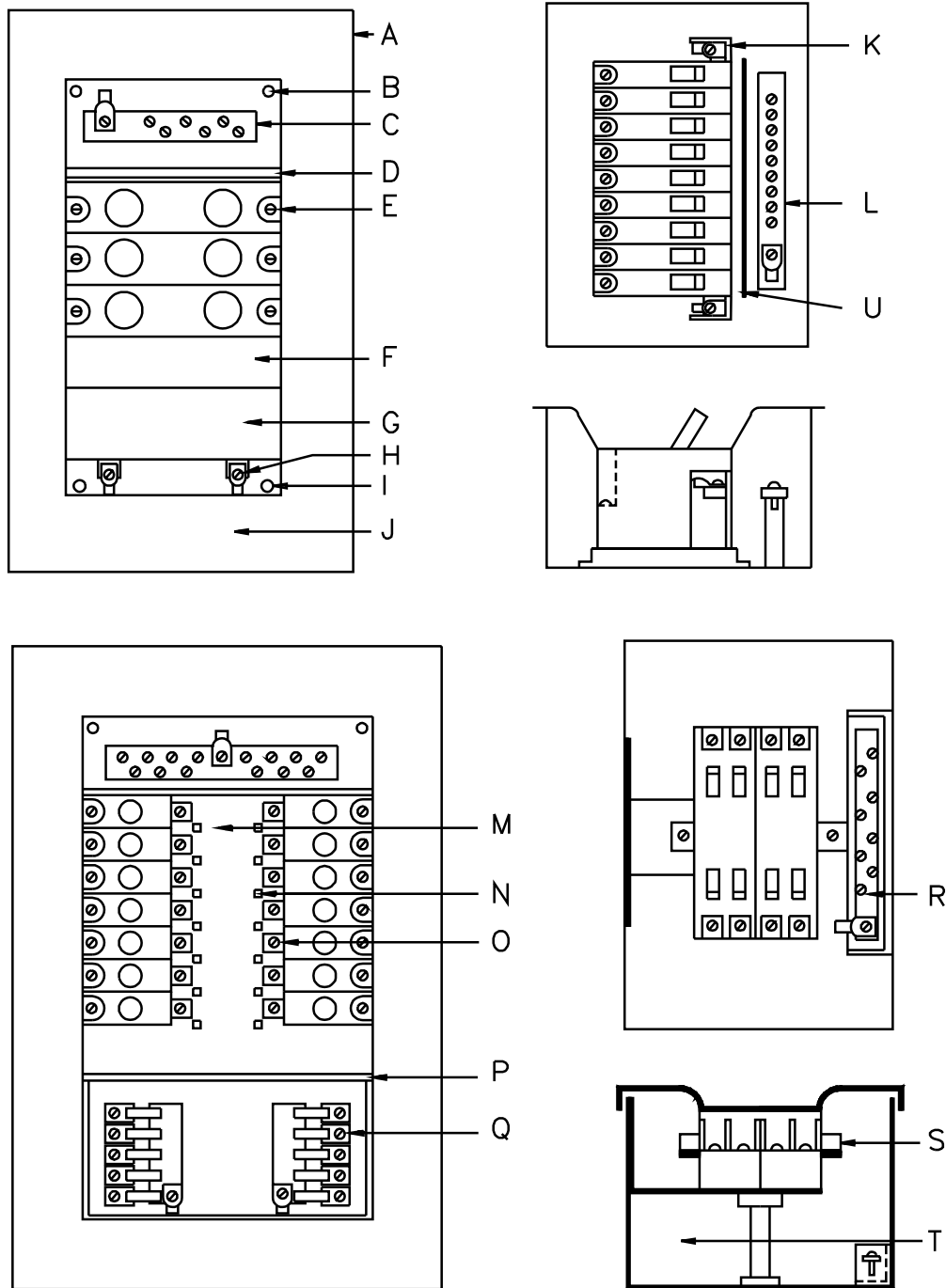
9.1.4 A barrier shall be provided between the installed wires and any part in the panelboard that may involve arcing in its operation. A barrier that is necessary for compliance with 17.2.2.1 is to be of such construction and so located that normally placed wires in a wiring gutter will be prevented from contacting an uninsulated live part. A barrier is not required to discourage the improper running of wires in a space intended for field addition of units, a space that contains uninsulated live parts, or both, if there are other spaces obviously intended for the placement of wiring and of adequate size for the wires.

9.1.5 A barrier shall be provided between bus bars and wiring and terminal spaces if the presence of the bus bars is not obvious when viewed from the front of the installed panelboard with the deadfront removed if it is removed for wiring and all units are in place.

Exception: The barrier may be omitted if the bus bars are recessed at least 1 inch (25.4 mm) back from the edge adjacent to the spaces of the installed main or branch-circuit units.

9.1.6 The illustrations and descriptions in Figure 9.1 indicate the locations where barriers are required.

Figure 9.1
Typical layouts of components, compartments, spaces, and barriers



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Figure 9.1 (cont'd)

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Notes for Figure 9.1

- A – Cabinet or cutout box.
- B – Barrier posts for insulated neutral-termination area (additional posts may be necessary to support cover). Posts must extend to within 1/8 inch (3.2 mm) of dead-front shield.
- C – Insulated neutral termination area.
- D – Barrier separating neutral termination area from compartment containing arcing parts; barriers separating bus bars from a neutral terminal space or wiring spaces if neutral is not provided. See 9.1.5.
- E – Recessed branch-circuit terminals.
- F – Space available for one or more additional units, containing uninsulated bus bars. Side barriers are not required to prevent wires from being run over the bus bars if there is adequate wiring space elsewhere, and if the bus bars are located in relation to the adjacent wiring space so that wires placed in the wiring space in a normal manner will not come in contact with them.
- G – Completely segregated main switch.
- H – Main-termination area.
- I – Barrier posts for main termination area. Posts must extend within 1/8 inch of dead-front shield.
- J – Wire-bending space between any wire connector and the wall or barrier toward which it is directed or through which the connected conductor may normally pass.
- K – Main terminal in gutter recessed between closely fitting walls.
- L – Termination area for insulated neutral; barrier or recessed terminals not required if only neutral wires will be present and knockouts are not located in sidewall of enclosure.
- M – Wiring gutter containing wires from meters.
- N – Barriers creating termination area.
- O – Terminals feeding branch-circuit units.
- P – Barriers completely separating meter-fuse compartment from wiring spaces. Individual openings in barriers are provided opposite each terminal.
- Q – Meter-fuse compartment with terminals for wires leading to meters.
- R – Insulated neutral located in wiring gutter recessed between end barriers.
- S – Main terminals in side wiring space that will contain not more than eight wires, excluding main feeders, if one or more of these wires may be of a polarity opposite to that of the terminal.
- T – Back wiring space.
- U – Barrier separating bus bars from wiring spaces. See 9.1.5.

9.1.7 Other than as indicated in 9.1.8 and 9.1.11, a metal barrier shall have a thickness not less than 0.053 inch (1.35 mm) if uncoated sheet steel, not less than 0.056 inch (1.42 mm) if galvanized sheet steel, and not less than 0.075 inch (1.91 mm) if aluminum.

9.1.8 A metal barrier may be of a thickness less than that specified in 9.1.7 if its strength and rigidity is not less than that of a flat sheet of the same metal having the same dimensions as the barrier and of the specified thickness.

9.1.9 A barrier of slate or marble shall not be less than 1/2 inch (12.7 mm) thick. Except as indicated in 9.1.10, a nonmetallic barrier other than slate, marble, or similar material shall not be less than 1/4 inch (6.4 mm) thick and shall be supported to provide the necessary strength and rigidity.

9.1.10 The thickness of a nonmetallic barrier other than slate, marble, or similar material, may be less than 1/4 inch (6.4 mm) if the barrier is located so that it will not be subject to mechanical abuse during installation and is located and supported so that it will have the necessary mechanical strength and rigidity. See 16.3, Barriers and liners.

9.1.11 A dead-front shield shall have a thickness not less than 0.032 inch (0.81 mm) if uncoated, not less than 0.034 inch (0.86 mm) if galvanized, and not less than 0.050 inch (1.27 mm) if aluminum.

9.1.12 In a dead-front panelboard that has a dead-front shield with a metal thickness in accordance with 9.1.11 and that also has a door as integral parts of the cover, the door may have a thickness less than the requirement of the Standard for Enclosures for Electrical Equipment, Non-Environmental Considerations, UL 50, but not less than 0.032 inch (0.81 mm) if uncoated steel, not less than 0.034 inch (0.86 mm) if galvanized steel, and not less than 0.050 inch (1.29 mm) if aluminum.

9.1.13 A dead-front shield shall be supported independently of any support that will be provided by units that may be field-installed. It shall be constructed so that it can be readily installed and removed without the likelihood of contacting a bare live part or damage the insulation of any insulated live part inside the enclosure.

9.1.14 With reference to the requirement in 9.1.13, a dead-front shield is considered to be likely to fall backward into the panelboard interior unless it is reliably supported during removal until it can be extracted directly from the enclosure without a further sliding or twisting motion.

9.1.15 In a panelboard of the dead-front type employing insulating material as a covering or protection of uninsulated live parts, the head of a screw or rivet that engages the mounting strap of a switch, or that may become live through malfunction or breakdown of the switch, shall be located or protected by countersinking or the equivalent so that it will not be exposed to unintentional contact from the front of the device.

9.2 Bushings

9.2.1 An opening in a metal barrier through which a factory-installed wire or cable or a field-installed wire may pass shall be provided with a bushing or shall be formed so that insulated conductors will not come in contact with sharp edges.

9.2.2 A bushing employed at the opening mentioned in 9.2.1 may be of glass, porcelain, hard fiber, phenolic composition, or cold-molded composition. A metal eyelet or grommet having a smooth, rounded surface on which the wire or cable may bear is acceptable in place of a bushing. A bushing of rubber, neoprene, polyvinyl chloride, or of hot-molded shellac-and-tar composition is not acceptable.

9.2.3 The bushing may be of material other than those mentioned in 9.2.2 if it has been investigated and found to be acceptable for the purpose.

10 Filler Plates

10.1 A filler plate as discussed in 10.2 – 10.10 is a plate intended to close an opening that would otherwise be closed by subsequent installation of a circuit breaker or other device. A breakout is not considered to be a filler plate. See 34.14.1 and 34.14.2.

10.2 If one or more openings are not closed when the panelboard is installed, filler plates complying with the requirements in 10.3 – 10.10 shall be available. If one or more branch-circuit units are factory installed, filler plates closing the remaining openings for field installation of such units shall be factory installed.

10.3 A sheet-steel filler plate shall have an average thickness not less than 0.056 inch (1.42 mm) if galvanized or 0.053 inch (1.35 mm) if uncoated.

Exception: The average thickness may be not less than 0.034 inch (0.86 mm) if galvanized or 0.032 inch (0.81 mm) if uncoated, if the plate is not larger than 1 inch by 3 inches (25.4 mm by 76.2 mm) or it is employed behind a door or a cover.

10.4 A filler plate of insulating material shall:

- a) Be of material that is acceptable for the indirect support of uninsulated live parts, in accordance with 8.1 and 8.3;
- b) Not be less than 3/32 inch (2.4 mm) thick at any point;
- c) Other than as noted in 10.5, have one dimension – length or width – not larger than 3 inches (76.2 mm) and have the other dimension not larger than 1 inch (25.4 mm); and
- d) Be located a minimum of 1/32 inch (0.8 mm) from a live part. Also see Note to Table 8.2.

10.5 A filler plate may have dimensions larger than those specified in 10.4(c) if it has been investigated and found to be acceptable for the purpose.

10.6 Other than as noted in 10.7, screws shall be employed for securing a filler plate in place.

10.7 Means other than screws for securing a filler plate may be employed if the plate, when secured in place, will not be dislodged as a result of normal use but may be readily removed if desired.

10.8 A filler plate shall:

- a) Be of such size and shape that it will extend at least 1/32 inch (0.8 mm) on all sides beyond the opening that it is intended to close (See 10.1 and 10.9);
- b) Have a 1/4 inch (6.4 mm) or wider right-angle flange or the equivalent around its perimeter that, except at the ends of a row of units, will closely abut a similar flange or the equivalent around the edge of the opening that the plate is intended to close; or
- c) Overlap as specified in 10.8(a) on one, two, or three sides and shall have a flange or the equivalent as described in 10.8(b) on the remaining side or sides.

10.9 A filler plate shall close the opening to at least the same extent as the unit, such as a switch or circuit breaker, in place of which the filler plate is mounted.

10.10 The amount of overlap at a formed ear intended to secure a filler plate in place is not specified, but with the plate in place a resulting opening at such point shall not be longer than the thickness of the cabinet front or the dead-front shield.

11 Current-Carrying Parts

11.1 General

11.1.1 A current-carrying part shall be of silver, a silver alloy, copper, a copper alloy, aluminum, an aluminum alloy, or other metal investigated and found to be acceptable for the application, and shall be rigid.

11.1.2 Iron or steel shall not be used for a part that is depended upon to carry current.

11.1.3 Plated steel screws, nuts, and studs may be used to secure pressure wire connectors and bus bars. A No. 10 and larger plated-steel wire-binding screw may be used at a terminal, in connection with a nonferrous terminal plate. Bolts, washers, and nuts at the hinges of knife switches are considered to be parts that are not depended upon to carry current.

11.1.4 Copper and brass are not acceptable for plating wire-binding screws, nuts, and stud terminals, but a plating of cadmium, zinc, tin, or silver is acceptable.

11.1.5 Each bus bar shall be plated at each joint with tin, silver, nickel, or cadmium.

Exception No. 1: Welded or brazed joints need not be plated.

Exception No. 2: Copper bus bars need not be plated if the current at the joints is 600 amperes or less.

Exception No. 3: Other coatings may be used for aluminum bus bars if investigated for the application in accordance with the requirements in 21.1.1 and 21.6.1.

11.1.6 Among the factors taken into consideration when the acceptability of other coatings as mentioned in Exception No. 3 to 11.1.5 is being determined are its adherence to aluminum and resistance to corrosive environment. These factors are considered with respect to conductivity and thermal aging.

11.1.7 Each riveted connection involving current-carrying parts shall have a spring washer at one end and either a spring washer or a flat washer at the other end.

Exception No. 1: A construction that has been tested in accordance with 21.5.1.

Exception No. 2: A connection rated 225 amperes or less employing copper bus bars only.

11.1.8 A spring washer shall be used at one end of a bolt securing current-carrying parts together.

Exception No. 1: A construction that has been tested in accordance with 21.5.1.

Exception No. 2: A spring washer may be replaced with a split ring lock washer and flat washer if each aluminum bus in the joint has a tensile yield strength of at least 20,000 pounds per square inch (138 MPa).

Exception No. 3: A flat washer, a split-ring lock washer, or a bolthead that complies with 11.1.10(b) may be used in place of a spring washer if the joint does not include any aluminum or if aluminum bolts are used with aluminum bus bars.

Exception No. 4: A type of fastening equivalent to that used for evaluating the suitability of a wire connector used as a component in accordance with the requirements for wire connectors.

Exception No. 5: A spring washer is not required at a bolted contact of an aluminum alloy conductor used in the grounding circuit for an application such as the service-grounding electrode, a neutral-bonding conductor, or an equipment-grounding conductor.

11.1.9 A spring washer as mentioned in 11.1.7 and 11.1.8 shall:

- a) Be a dished washer of stainless, or hardened and tempered steel,
- b) Have an outer diameter not less than 150 percent of the bolt diameter and a thickness not less than one-eighth of the bolt diameter, and
- c) Be dished not less than 3-1/2 percent of the bolt diameter.

11.1.10 A flat washer as mentioned in 11.1.7 and 11.1.8 shall have:

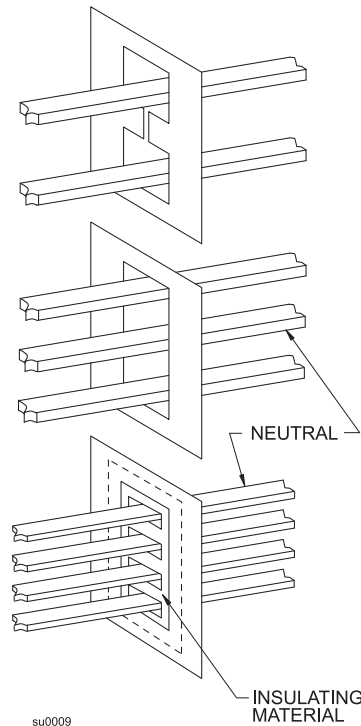
- a) A thickness at least one-sixth the diameter of the rivet shank or bolt, and
- b) An outer diameter at least 150 percent of that of the rivet shank or bolt, but not less than the outer diameter of the spring washer.

11.1.11 All conductors of an alternating-current circuit that pass through a wall or partition of metal having magnetic properties, including the neutral, shall be run through the same opening.

Exception: Internal wiring of panelboards subjected to the Temperature Test, Section 21, with temperatures recorded in the area of the metal wall or partition to determine compliance with Table 21.1, are not required to include all conductors in the same opening.

11.1.12 With reference to the requirement in 11.1.11, and to Figure 11.1, the conductors may pass through individual openings in a wall or partition if the openings are connected by slots cut in the metal wall. The conductors may be run through individual openings in an insulating block used to cover an opening in the metal wall sufficiently large for all the conductors of the circuit if no metal bracket, brace, or the like, is placed across the insulating material between the conductors.

Figure 11.1
Conductors through openings



11.2 Bus bars, supports

11.2.1 A bus bar or uninsulated live part, other than a pressure wire connector as mentioned in 16.1.15, shall be reliably secured so that ordinary vibration will not loosen the securing means, and shall be prevented from turning or shifting in position if any spacings less than half those specified in Table 16.1 would result from such turning or shifting. A bus bar provided with one or more insulators that must be removed when the unit is installed shall be prevented from any turning or shifting that would result in spacings less than half those specified in Table 16.1 with all insulators in place, or that would result in a spacing less than 1/8 inch (3.2 mm) for any voltage up to 250 volts, or 1/4 inch (6.4 mm) for any voltage from 251 to 1000 volts, with any insulators omitted.

11.2.2 A neutral bus bar shall be mounted on an insulating base that complies with the requirements in 8.1.

Exception: A neutral need not be mounted on an insulating base when the panelboard is marked to indicate that it is suitable only for use as service equipment in accordance with 34.9.1 and 34.9.2.

11.2.3 A bolted connection between two bus bars or between a bus bar and another current-carrying part shall not depend on polymeric insulation to maintain the clamping force unless investigated for such use as specified in 21.7.1, and shall not depend on thermoplastic material in any case.

Exception: This requirement does not apply to a joint intended to carry 30 amperes or less, or to a meter socket base.

11.2.4 A bus bar shall be supported independently of any switch, circuit breaker, or the like that is connected to it unless such switch, or the like is reliably supported independently of the bus bar and is factory-installed.

11.2.5 The phase arrangement of main and submain bus bars in a 3-phase panelboard, not including the connections to metering equipment, shall be A, B, C, from front to back, top to bottom, or left to right as viewed from the front of the panelboard. The neutral in a 3-phase, 4-wire panelboard may be in any location in the sequence (for example: A, N, B, C) if it is identified as such by a marking on the neutral or on a wiring diagram. The B-phase shall be that phase having the higher voltage to ground on 3-phase, 4-wire, delta-connected systems (see 34.4.4 and 34.4.5).

Exception No. 1: Other bus bar arrangements may be used for a panelboard manufactured for an existing installation if the arrangement of the bus bars is indicated by marking.

Exception No. 2: The phase arrangement in a 240-volt, 3-phase, 3-wire panelboard intended for use on a grounded B-phase system is to be A, C with the neutral as the B-phase.

Exception No. 3: Other bus bar arrangements may be used for a panelboard if access to the bus bars is limited or field connection of cables is not required, and the arrangement of bus bars is indicated by marking.

Exception No. 4: Equipment within a panelboard with provision for a watt-hour meter, intended for 3-phase, 4-wire delta connected systems only may have the same phase configuration as the metering equipment (C-phase at the higher voltage to ground). See 34.4.5.

Exception No. 5: Equipment within a panelboard with provision for a watt-hour meter, and having a combination voltage rating that includes a 3-phase, 4-wire delta system rating, may be marked to show the C-phase at the higher voltage to ground.

11.2.6 If a branch bus bar is not prevented from turning by being secured to a circuit breaker, a switch, a fuseholder, or the like when the panelboard is shipped from the factory:

- a) The branch bus bar shall be prevented from turning. Friction alone is not acceptable for this purpose; or
- b) Any part of the branch bus bar to which spacings may be reduced to values less than the minimum acceptable if the bus bar rotates shall be insulated. The insulation shall be securely held in place.

11.2.7 A panelboard in which branch bus bars may be mounted in the field – see 6.6.3 – shall be such that reliable support will be provided for such bus bars. A base for supporting a bus bar shall be assembled in place in the panelboard before it is shipped from the factory. See 34.12.4.

11.2.8 Friction between surfaces is not acceptable as a means to prevent turning or shifting of an uninsulated live part. Turning or shifting may be prevented by the use of two screws or rivets, by noncircular shoulders or mortises, by a dowel pin, lug, or offset, by a connecting strap or clip fitted into an adjacent part, or by an equivalent method. No reliance is to be placed on a single branch circuit fuseholder, circuit breaker or switch unit for preventing turning of the branch bus bar feeding such unit, if such turning would reduce spacings to less than those specified in 11.2.1 or Table 16.1.

11.2.9 In determining the adequacy of means to prevent turning or shifting in regard to 11.2.8, any screw or nut is to be loosened and retightened finger-tight without a tool. The bus bar is then to be pushed to the extent limited by the screws or other means and the resulting spacings measured.

11.2.10 If a branch-circuit unit, such as a circuit breaker, switch unit, or plug fuseholder, rated 600 amperes or less is removable from the front of the panel, the replacement or removal of such unit shall not result in the likelihood of a short circuit from turning or dropping of parts.

11.2.11 Bolts, nuts, or washers used in securing a branch circuit unit are not considered likely to fall if they are visible and readily reached. A branch bus bar will usually be considered likely to fall if the same bolts that secure the branch-circuit unit to the branch bus bar also serve to secure the branch bus bar to the bus bar on its line side.

11.2.12 If parts are held together by screws, a threaded part shall not have fewer than two full, clean-cut threads. If the screw does not extend all the way through a threaded part, the taper or lead thread and the first full thread are to be disregarded in determining the number of threads engaged.

11.3 Ampacity General

11.3.1 Except as indicated in 11.3.2, a panelboard shall comply with the requirements specified in Section 21, Temperature Test. See 12.1.10.

11.3.2 A panelboard rated 400 amperes or less with aluminum bus bars or 1600 amperes or less with copper bus bars need not be subjected to the tests in Section 21, Temperature Test, if it complies with all of the following:

- a) A factory- or field-installed insulated conductor connected between parts of a panelboard shall have an ampacity not less than the maximum current rating of the circuit in which it is connected, in accordance with Table 11.1.
- b) Other than as noted in 11.3.3, 11.3.4, and 11.3.5 the current density shall not be more than:
 - 1) One thousand amperes per square inch (155 A/cm^2) of cross section for solid copper.
 - 2) Seven hundred fifty amperes per square inch (116 A/cm^2) of cross section for solid aluminum having a conductivity of at least 55 percent that of the International Annealed Copper Standard.
 - 3) Two hundred amperes per square inch (31 A/cm^2) of contact area at bolted contacts between copper or aluminum bus bars and connecting straps or connectors. In determining the contact area of a bolted or riveted connection, no additions or subtractions shall be made for the area of screws, bolts, or rivets.
 - 4) Seventy-five amperes per square inch (11.6 A/cm^2) of contact area at contact surfaces of copper switch blades and jaws.
- c) The panelboard shall not be rated for a frequency of more than 60 hertz.
- d) The panelboard is rated 110 amperes or less or having any circuits rated 110 amperes or less and is marked to indicate use of 60°C conductors only for circuits rated 110 amperes or less and 75°C conductors for circuits rated more than 110 amperes. See 12.1.10(c).

Table 11.1
Ampacities of insulated conductors

Wire size,		Temperature rating of conductor			
		60°C (140°F)		75°C (167°F)	
AWG or kcmil	mm ²	Copper	Aluminum	Copper	Aluminum
14	2.1	20 (15) ^a	—	20 (15) ^a	—
12	3.3	25 (20) ^a	20 (15) ^a	25 (20) ^a	20 (15) ^a
10	5.3	30	25	35 (30) ^a	30 (25) ^a
8	8.4	40	30	50 ^b	40 ^b
6	13.3	55	40	65 ^b	50 ^b
4	21.2	70	55	85 ^b (100) ^c	65 ^b
3	26.7	85	65	100 ^b (110) ^c	75 ^b
2	33.6	95	75	115 ^b (125) ^c	90 ^b (100) ^c
1	42.4	110	85	130 ^b (150) ^c	100 ^b (110) ^c
1/0	53.5	d	d	150 (175) ^c	120 (125) ^c
2/0	67.4	d	d	175 (200) ^c	135 (150) ^c
3/0	85.0	d	d	200 (225) ^c	155 (175) ^c
4/0	107.2	d	d	230 (250) ^c	180 (200) ^c
250	127	d	d	255 (300) ^c	205 (225) ^c
300	152	d	d	285	230 (250) ^c
350	177	d	d	310 (350) ^c	250 (300) ^c
400	203	d	d	335 (400) ^c	270
500	253	d	d	380	310 (350) ^c
600	304	d	d	420	340 (400) ^c
700	355	d	d	460	375
750	380	d	d	475	385
800	405	d	d	490	395
900	456	d	d	520	425
1000	506	d	d	545	445
1250	633	d	d	590	485
1500	760	d	d	625	520
1750	887	d	d	650	545
2000	1013	d	d	665	560

NOTES

1 For a multiple conductor connector at a terminal, the ampacity value is to be multiplied by the number of conductors that the terminal is capable of accommodating [1/0 AWG (53.5 mm²) and larger].

2 These values of ampacity apply only when a maximum of 3 current carrying conductors are to be field installed in a single conduit. When four or more conductors other than a grounding conductor or a neutral that carries the unbalanced current from other conductors of the same circuit are to be installed in conduit, the allowable ampacity of each of these conductors is reduced as shown in the following table. These reduced values do not apply to internal wiring of a panelboard unless enclosed in conduit.

Number of Conductors	Percent of Value in Table
4 – 6	80
7 – 9	70
10 – 20	50
21 – 30	45
31 – 40	40
41 or more	35

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Table 11.1 Continued

Wire size,		Temperature rating of conductor			
		60°C (140°F)		75°C (167°F)	
AWG or kcmil	mm ²	Copper	Aluminum	Copper	Aluminum
^a Values in parentheses are to be used if wire is connected to an overcurrent protective device. The other values are applicable in accordance with 11.3.2. ^b The ampacity of these sizes shall be the same as for 60°C (140°F) wire when connected to a molded case circuit breaker unless the breaker is marked 75°C (167°F). ^c The values in parentheses are capable of being used at the main terminals of a single-phase, 3-wire, panelboard intended for use as residential service equipment, when the panelboard is marked in accordance with 34.1.14. ^d For wire sizes 1/0 AWG and larger, it is assumed that wire with at least a 75°C temperature rating is being used.					

11.3.3 The limitations on current density mentioned in 11.3.2(b) do not apply:

- a) To a connecting strap, bus bar, or the like comprising a part of a circuit breaker, switch, or fuseholder employed in the panelboard.
- b) To a part of a strap, bus bar, jumper, and the like, adjacent to and connected to a terminal of a switch, circuit breaker, or fuseholder – but for not more than 1 inch (25.4 mm) from the terminal – if a reduced cross section in that part is necessary because the terminal is recessed or barriers are adjacent to it.
- c) At a connector if the entire normal contact surface is in contact with the bus bar, terminal, or other surface to which it is connected. The normal contact surface of a pressure wire connector is considered to be that area resulting when two identical connectors are positioned back-to-back with the major axes of the wire barrels at 90 degrees or 180 degrees from each other, whichever position results in the smaller contact surface.
- d) At the connection of a bus bar to a terminal of a switch, circuit breaker, or fuseholder if the contact area at the point at which the bus bar is connected to such a terminal is:
 - 1) The full contact area available on the circuit breaker, switch, or fuseholder, or
 - 2) Not less than the contact area between the terminal and the pressure wire connector normally supplied with such a unit.

11.3.4 The cross section of a bus as covered in 11.3.2(b) may be reduced by not more than 5 percent due to rounding, shaping, or dimensional tolerances.

11.3.5 Part of the bus material may be removed for slots or holes – whether used or not – provided the remaining material at any cross section along the length of the bus bar has at least 70 percent of the required ampacity and the remaining metal in any 6 inch (152.4 mm) length of bus is at least 93 percent of the metal of a bus having the required ampacity in accordance with 11.3.2(b); for example, a 1 inch (25.4 mm) wide bus may have 9/32 inch (7.1 mm) holes on 1 inch centers or a 4 inch (101.6 mm) wide bus may have 13/32 inch (10.4 mm) wide slots 3.2 inch (80.9 mm) long every 6 inches.

11.3.6 Table 11.2 gives the ampacities of some of the more common sizes of copper bus bars.

Table 11.2
Ampacities of common size copper bus bar

Width of bus bar,		Bus-bar thickness, inches (mm)											
		3/64	0.051	1/16	0.064	5/64	0.081	3/32	1/8	5/32	3/16	7/32	1/4
inches	(mm)	(1.2)	(1.30)	(1.6)	(1.63)	(2.0)	(2.06)	(2.4)	(3.2)	(4.0)	(4.8)	(5.6)	(6.4)
3/8	(9.5)	18	19	23	24	29	30	35	47	59	70	82	94
7/16	(11.1)	21	22	27	28	34	35	41	55	68	82	96	109
1/2	(12.7)	23	26	31	32	39	41	47	63	78	94	109	125
9/16	(14.3)	26	29	35	36	44	46	53	70	88	105	123	141
5/8	(15.9)	29	32	39	40	49	51	59	78	98	117	137	156
11/16	(17.5)	32	35	43	44	54	56	64	86	108	129	150	172
3/4	(19.1)	35	38	47	48	59	61	70	94	117	141	164	188
7/8	(22.2)	41	45	55	56	68	71	82	109	137	164	191	219
1	(25.4)	47	51	63	64	78	81	94	125	156	188	219	250
1-1/8	(28.6)	53	57	70	72	88	91	105	141	176	211	246	281
1-1/4	(31.8)	59	64	78	80	98	101	117	156	195	234	273	313
1-3/8	(34.9)	64	70	86	88	102	111	129	172	205	258	301	344
1-1/2	(38.1)	70	77	94	96	117	122	141	188	235	281	328	375
1-3/4	(44.5)	82	89	109	112	137	142	164	219	273	328	383	438
2	(50.8)	94	102	125	128	156	162	188	250	313	375	438	500
2-1/4	(57.2)	105	115	141	144	176	182	211	281	352	422	492	563
2-1/2	(63.5)	117	128	156	160	185	203	234	313	391	469	547	625

11.4 Main unit ratings

11.4.1 The current rating of a main switch, a main fuseholder, and a main circuit breaker – trip-unit rating of a breaker having interchangeable trip units – shall be in accordance with Table 11.3.

Table 11.3
Main switch, fuseholder, and circuit breaker ratings

Rated ampacity of main bus bar	Maximum main switch and fuseholder rating, amperes	Maximum main circuit breaker rating, amperes
0 – 30	30	30
31 – 40	60	40
41 – 50	60	50
51 – 60	60	60
61 – 70	100	70
71 – 90	100	90
91 – 100	100	100
101 – 125	200	125
126 – 150	200	150
151 – 175	200	175
176 – 200	200	200
201 – 225	400	225
226 – 250	400	250
251 – 275	400	275
276 – 300	400	300

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Table 11.3 Continued

Rated ampacity of main bus bar	Maximum main switch and fuseholder rating, amperes	Maximum main circuit breaker rating, amperes
301 – 350	400	350
351 – 400	400	400
401 – 450	600	450
451 – 500	600	500
501 – 600	600	600

11.5 Neutral

11.5.1 The neutral bus bar shall have an ampacity not less than that of the other bus bars, except that the neutral in a 3-wire d-c or single-phase a-c panelboard or in a 3-phase, 4-wire panelboard, rated more than 200 amperes, shall not have an ampacity less than 200 amperes. See 34.1.12.

11.5.2 A neutral bus bar intended for use in a panelboard with increased neutral ampacity shall have an ampacity of 125%, 150%, 175%, or 200% of the other phase bus bars.

11.5.3 When the main neutral terminal is located at the electrical center of the neutral bus bar, the ampacity of each half of the bus bar shall not be less than half the value specified in 11.5.1. The electrical center is identified as the point at which the neutral current to one side of the bus bar is equal to that to the other side, taking into consideration the total number of terminals located on the neutral bus bar and the current associated with each.

11.5.4 The ampacity of a section of a neutral bus bar that consists of two or more sections shall not be less than the greater of the following:

a) The ampacity required for the part of the neutral current that is expected to flow in that section taking into consideration the relationship between:

- 1) The number of terminals in that section and the current associated with each, and
- 2) The total number of terminals in the entire neutral and the currents associated with each.

b) The ampacity required for the current associated with the largest ampacity terminal located in that section.

11.5.5 With reference to 11.5.3 and 11.5.4, the neutral current associated with a given terminal is determined in accordance with Table 11.1, based on the wire of maximum size for which the terminal is capable of supporting; except that the assumed size of wire is not determined to be larger than that required to provide an ampacity not less than the maximum current rating of any overcurrent-protective device to be used in the panelboard. A terminal employing a wire-binding screw is identified as a 30 ampere terminal.

11.5.6 When the service phase conductors are paralleled, the size of the neutral conductor shall be based on the equivalent area of the parallel conductors.

Exception: The neutral conductor shall not be required to be larger than the largest ungrounded service conductor or equivalent area for parallel conductors.

11.6 Fuseholders and circuit breakers

11.6.1 Other than as indicated in 34.1.9, a wire or bus bar leading to a fuseholder shall have an ampacity not less than the maximum current rating of any fuse that the fuseholder will accommodate.

11.6.2 A wire or bus bar leading to a noninterchangeable-trip circuit breaker shall have an ampacity not less than the current rating of the breaker, and not less than 20 amperes in any case. See 34.1.10.

11.6.3 A wire or bus bar leading to an adjustable trip circuit breaker shall have an ampacity not less than the maximum current rating of the adjustable trip circuit breaker, and not less than 20 amperes in any case. See 34.1.10.

11.6.4 Other than as indicated in 34.1.9, a wire or bus bar leading to a circuit-breaker frame designed for use with interchangeable-trip units shall have an ampacity not less than the maximum current rating of the frame.

12 Wiring Terminals

12.1 General

12.1.1 A terminal, such as a pressure wire connector or wire-binding screw, shall be provided for connection of each conductor intended to be field-installed in the panelboard and shall be the same type as used during the short-circuit test. Connections may be provided for cord-connected equipment, see Cord-Connectors, Section 13. See 18.2, Equipment-grounding terminals.

Exception No. 1: Terminals are not required in a panelboard intended for connection to bus bars.

Exception No. 2: Terminals are not required to be factory installed in the panelboard if component terminal kits are available from the equipment manufacturer or one or more acceptable pressure terminal connectors are specified for field installation on the equipment, and the construction complies with requirements in 6.7.3.

Exception No. 3: An alternative wire connector, such as crimp for crimp, mechanical for mechanical, or crimp for mechanical that complies with the Standard for Wire Connectors, UL 486A-486B, may be used in a panelboard without conducting a short-circuit test under the following conditions:

- a) The short-circuit current rating of the panelboard is less than 100,000 amperes, or 100,000 amperes maximum if the panelboard is protected by an overcurrent protective device, and*
- b) The panelboard short-circuit current rating divided by the number of conductors per phase results in a current of 50,000 amperes per conductor or less.*

Exception No. 4: An alternative wire connector, such as crimp for crimp, mechanical for mechanical, or crimp for mechanical that complies with UL 486A-486B, may be used in a panelboard under the following conditions: