

energy storage shall also be marked with the maximum operating voltage, including any equalization voltage, and the polarity of the grounded circuit conductor.

705.82 Hybrid Systems. Hybrid systems shall be permitted to be interconnected with utility-interactive inverters.

705.95 Ampacity of Neutral Conductor. If a single-phase, 2-wire inverter output is connected to the neutral and one ungrounded conductor (only) of a 3-wire system or of a 3-phase, 4-wire, wye-connected system, the maximum load connected between the neutral and any one ungrounded conductor plus the inverter output rating shall not exceed the ampacity of the neutral conductor.

705.100 Unbalanced Interconnections.

(A) Single Phase. Single-phase inverters for hybrid systems and ac modules in interactive hybrid systems shall not be connected to 3-phase power systems unless the interconnected system is designed so that significant unbalanced voltages cannot result.

(B) Three Phase. Three-phase inverters and 3-phase ac modules in interactive systems shall have all phases automatically de-energized upon loss of, or unbalanced, voltage in one or more phases unless the interconnected system is designed so that significant unbalanced voltages will not result.

III. Generators

705.130 Overcurrent Protection. Conductors shall be protected in accordance with Article 240. Equipment and conductors connected to more than one electrical source shall have overcurrent devices located so as to provide protection from all sources. Generators shall be protected in accordance with 445.12.

705.143 Synchronous Generators. Synchronous generators in a parallel system shall be provided with the necessary equipment to establish and maintain a synchronous condition.

ARTICLE 708 Critical Operations Power Systems (COPS)

FPN: Rules that are followed by a reference in brackets contain text that has been extracted from NFPA 1600-2007, *Standard on Disaster/Emergency Management and Business Continuity Programs*. Only editorial changes were made to the extracted text to make it consistent with this Code.

I. General

708.1 Scope. The provisions of this article apply to the installation, operation, monitoring, control, and maintenance of the portions of the premises wiring system intended to supply, distribute, and control electricity to designated critical operations areas (DCOA) in the event of disruption to elements of the normal system.

Critical operations power systems are those systems so classed by municipal, state, federal, or other codes by any governmental agency having jurisdiction or by facility engineering documentation establishing the necessity for such a system. These systems include but are not limited to power systems, HVAC, fire alarm, security, communications, and signaling for designated critical operations areas.

FPN No. 1: Critical operations power systems are generally installed in vital infrastructure facilities that, if destroyed or incapacitated, would disrupt national security, the economy, public health or safety; and where enhanced electrical infrastructure for continuity of operation has been deemed necessary by governmental authority. ← AHJ?

FPN No. 2: For further information on disaster and emergency management see NFPA 1600-2007, *Standard on Disaster/Emergency Management and Business Continuity Programs*.

FPN No. 3: For further information regarding performance of emergency and standby power systems, see NFPA 110-2005, *Standard for Emergency and Standby Power Systems*.

FPN No. 4: For further information regarding performance and maintenance of emergency systems in health care facilities, see NFPA 99-2005, *Standard for Health Care Facilities*.

FPN No. 5: For specification of locations where emergency lighting is considered essential to life safety, see NFPA 101[®]-2006, *Life Safety Code*[®].

FPN No. 6: For further information on regarding physical security, see NFPA 730-2006, *Guide for Premises Security*.

FPN No. 7: Threats to facilities that may require transfer of operation to the critical systems include both naturally occurring hazards and human-caused events. See also A.5.3.2 of NFPA 1600-2007.

FPN No. 8: See Annex G for information on Supervisory Control and Data Acquisition.

708.2 Definitions.

Commissioning. The acceptance testing, integrated system testing, operational tune-up, and start-up testing is the process by which baseline test results verify the proper operation and sequence of operation of electrical equipment, in addition to developing baseline criteria by which future trend analysis can identify equipment deterioration.

Critical Operations Power Systems (COPS). Power systems for facilities or parts of facilities that require continuous operation for the reasons of public safety, emergency management, national security, or business continuity.

Designated Critical Operations Areas (DCOA). Areas within a facility or site designated as requiring critical operations power.

Supervisory Control and Data Acquisition (SCADA). An electronic system that provides monitoring and controls for the operation of the critical operations power system. This can include the fire alarm system, security system, control of the HVAC, the start/stop/monitoring of the power supplies and electrical distribution system, annunciation and communication equipment to emergency personnel, facility occupants, and remote operators.

708.3 Application of Other Articles. Except as modified by this article, all applicable articles of this Code shall apply.

708.4 Risk Assessment. Risk assessment for critical operations power systems shall be documented and shall be conducted in accordance with 708.4(A) through (C).

FPN: Chapter 5 of NFPA 1600-2007, *Standard on Disaster/Emergency Management and Business Continuity Programs*, provides additional guidance concerning risk assessment and hazard analysis.

(A) Conducting Risk Assessment. In critical operations power systems, risk assessment shall be performed to identify hazards, the likelihood of their occurrence, and the vulnerability of the electrical system to those hazards.

(B) Identification of Hazards. Hazards to be considered at a minimum shall include, but shall not be limited to, the following:

- (1) Naturally occurring hazards (geological, meteorological, and biological)
- (2) Human-caused events (accidental and intentional) [1600:5.3.2]

(C) Developing Mitigation Strategy. Based on the results of the risk assessment, a strategy shall be developed and implemented to mitigate the hazards that have not been sufficiently mitigated by the prescriptive requirements of this Code.

708.5 Physical Security. Physical security shall be provided for critical operations power systems in accordance with 708.5(A) and (B).

(A) Risk Assessment. Based on the results of the risk assessment, a strategy for providing physical security for critical operations power systems shall be developed, documented, and implemented.

(B) Restricted Access. Electrical circuits and equipment for critical operations power systems shall be accessible to qualified personnel only.

708.6 Testing and Maintenance.

(A) Conduct or Witness Test. The authority having jurisdiction shall conduct or witness a test of the complete system upon installation and periodically afterward.

(B) Tested Periodically. Systems shall be tested periodically on a schedule acceptable to the authority having jurisdiction to ensure the systems are maintained in proper operating condition.

(C) Maintenance. The authority having jurisdiction shall require a documented preventive maintenance program for critical operations power systems.

FPN: For testing and maintenance procedures, see NFPA 70B-2006, *Recommended Practice for Electrical Equipment Maintenance*.

(D) Written Record. A written record shall be kept of such tests and maintenance.

(E) Testing Under Load. Means for testing all critical power systems during maximum anticipated load conditions shall be provided.

FPN: For testing and maintenance procedures of emergency power supply systems (EPSSs) that are also applicable to COPS, see NFPA 110-2005, *Standard for Emergency and Standby Power Systems*.

708.8 Commissioning.

(A) Commissioning Plan. A commissioning plan shall be developed and documented.

FPN: For further information on developing a commissioning program see NFPA 70B-2006, *Recommended Practice for Electrical Equipment Maintenance*.

(B) Component and System Tests. The installation of the equipment shall undergo component and system tests to ensure that, when energized, the system will function properly.

(C) Baseline Test Results. A set of baseline test results shall be documented for comparison with future periodic maintenance testing to identify equipment deterioration.

(D) Functional Performance Tests. A functional performance test program shall be established, documented, and executed upon complete installation of the critical system in order to establish a baseline reference for future performance requirements.

FPN: See Annex F for more information on developing and implementing a functional performance test program.

II. Circuit Wiring and Equipment

708.10 Feeder and Branch Circuit Wiring.

(A) Identification.

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(1) Boxes and Enclosures. All boxes and enclosures (including transfer switches, generators, and power panels) for critical operations power system circuits shall be permanently marked so they will be readily identified as a component of the system.

(2) Receptacle Identification. The cover plates for the electrical receptacles or the electrical receptacles themselves supplied from the COPS shall have a distinctive color or marking so as to be readily identifiable.

(B) Wiring. Wiring of two or more COPS circuits supplied from the same source shall be permitted in the same raceway, cable, box, or cabinet. Wiring from a COPS source or COPS source distribution overcurrent protection to critical loads shall be kept entirely independent of all other wiring and equipment.

Exception: Where the COPS feeder is installed in transfer equipment enclosures.

(C) COPS Feeder Wiring Requirements. COPS feeders shall comply with 708.10(C)(1) through (C)(3).

(1) Protection Against Physical Damage. The wiring of the COPS system shall be protected against physical damage. Wiring methods shall be permitted to be installed in accordance with the following:

- (1) Rigid metal conduit, intermediate metal conduit, or Type MI cable.
- (2) Where encased in not less than 50 mm (2 in.) of concrete, any of the following wiring methods shall be permitted:
 - a. Schedule 40 or Schedule 80 rigid polyvinyl chloride conduit (Type PVC)
 - b. Reinforced thermosetting resin conduit (Type RTRC)
 - c. Electrical metallic tubing (Type EMT)
 - d. Flexible nonmetallic or jacketed metallic raceways
 - e. Jacketed metallic cable assemblies listed for installation in concrete
- (3) Where provisions must be made for flexibility at equipment connection, one or more of the following shall also be permitted:
 - a. Flexible metal fittings
 - b. Flexible metal conduit with listed fittings
 - c. Liquidtight flexible metal conduit with listed fittings

(2) Fire Protection for Feeders. Feeders shall meet one of the following conditions:

- (1) Be a listed electrical circuit protective system with a minimum 1-hour fire rating
- (2) Be protected by a fire-rated assembly listed to achieve a minimum fire rating of 1 hour
- (3) Be embedded in not less than 50 mm (2 in.) of concrete

(4) Be a cable listed to maintain circuit integrity for not less than 1 hour when installed in accordance with the listing requirement

(3) Floodplain Protection. Where COPS feeders are installed below the level of the 100-year floodplain, the circuit conductors shall be listed for use in a wet location and be installed in a wiring method that is permitted for use in wet locations.

(D) COPS Branch Circuit Wiring.

(a) *Outside the DCOA.* COPS branch circuits installed outside the DCOA shall comply with the physical and fire protection requirements of 708.10(C)(1) through (C)(3).

(b) *Within the DCOA.* Any of the wiring methods recognized in Chapter 3 of this *Code* shall be permitted within the DCOA.

708.11 Branch Circuit and Feeder Distribution Equipment.

(A) Branch Circuit Distribution Equipment. COPS branch circuit distribution equipment shall be located within the same DCOA as the branch circuits it supplies.

(B) Feeder Distribution Equipment. Equipment for COPS feeder circuits (including transfer equipment, transformers, and panelboards) shall comply with (1) and (2).

- (1) Be located in spaces with a 2-hour fire resistance rating
- (2) Be located above the 100-year floodplain.

708.12 Feeders and Branch Circuits Supplied by COPS. Feeders and branch circuits supplied by the COPS shall supply only equipment specified as required for critical operations use.

708.14 Wiring of HVAC, Fire Alarm, Security, Emergency Communications, and Signaling Systems. All conductors or cables shall be installed using any of the metal wiring methods permitted by 708.10(C)(1) and in addition shall comply with 708.14(1) through 708.14(8) as applicable.

- (1) Signal and communication wires shall use shielded twisted pairs.
- (2) Shields of signal and communication wires shall be continuous.
- (3) Fiber optic cables shall be used for connections between two or more buildings on the property and under single management.
- (4) Listed secondary protectors shall be provided at the terminals of the communication circuits.
- (5) Conductors for all control circuits rated above 50V shall be installed with wire rated not less than 600V.
- (6) Communications, fire alarm, and signaling circuits shall use relays with contact ratings that exceed circuit voltage and current ratings in the controlled circuit.

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- (7) Riser communication cables shall be 2-hour fire-resistive cable or a listed 2-hour electrical circuit protective system.
- (8) Control, monitoring, and power wiring to HVAC systems shall be 2-hour fire-resistive cable or a listed 2-hour electrical circuit protective system.

III. Power Sources and Connection

708.20 Sources of Power.

(A) **General Requirements.** Current supply shall be such that, in the event of failure of the normal supply to the DCOA, critical operations power shall be available within the time required for the application. The supply system for critical operations power, in addition to the normal services to the building and meeting the general requirements of this section, shall be one or more of the types of systems described in 708.20(D) through (H).

FPN: Assignment of degree of reliability of the recognized critical operations power system depends on the careful evaluation in accordance with the risk assessment.

(B) **Fire Protection.** Where located within a building, equipment for sources of power as described in 708.20(D) through (H) shall be installed either in spaces fully protected by approved automatic fire suppression systems (sprinklers, carbon dioxide systems, and so forth) or in spaces with a 1-hour fire rating.

(C) **Grounding.** All sources of power shall be grounded as a separately derived source in accordance with 250.30.

Exception: Where the equipment containing the main bonding jumper or system bonding jumper for the normal source and the feeder wiring to the transfer equipment are installed in accordance with 708.10(C) and 708.11(B).

(D) **Surge Protection Devices.** Surge protection devices shall be provided at all facility distribution voltage levels.

(E) **Storage Battery.** An automatic battery charging means shall be provided. Batteries shall be compatible with the charger for that particular installation. For a sealed battery, the container shall not be required to be transparent. However, for the lead acid battery that requires water additions, transparent or translucent jars shall be furnished. Automotive-type batteries shall not be used.

(F) Generator Set.

(1) **Prime Mover-Driven.** Generator sets driven by a prime mover shall be provided with means for automatically starting the prime mover on failure of the normal service. A time-delay feature permitting a minimum 15-minute setting shall be provided to avoid retransfer in case of short-time reestablishment of the normal source.

(2) **Power for fuel transfer pumps.** Where power is needed for the operation of the fuel transfer pumps to deliver fuel to a generator set day tank, this pump shall be connected to the COPS.

(3) **Dual Supplies.** Prime movers shall not be solely dependent on a public utility gas system for their fuel supply or municipal water supply for their cooling systems. Means shall be provided for automatically transferring from one fuel supply to another where dual fuel supplies are used.

(4) **Battery Power and Dampers.** Where a storage battery is used for control or signal power or as the means of starting the prime mover, it shall be suitable for the purpose and shall be equipped with an automatic charging means independent of the generator set. Where the battery charger is required for the operation of the generator set, it shall be connected to the COPS. Where power is required for the operation of dampers used to ventilate the generator set, the dampers shall be connected to the COPS.

(5) **Outdoor Generator Sets.** Where an outdoor housed generator set is equipped with a readily accessible disconnecting means located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure.

(6) **Means for Connecting Portable or Vehicle-Mounted Generator.** Where the COPS is supplied by a single generator, a means to connect a portable or vehicle-mounted generator shall be provided.

(7) **On-Site Fuel Supply.** Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided. The on-site fuel supply shall be secured and protected in accordance with the risk assessment.

(G) **Uninterruptible Power Supplies.** Uninterruptible power supplies used as the sole source of power for COPS shall comply with the applicable provisions of 708.20(E) and (F).

(H) **Fuel Cell System.** Installation of a fuel cell system shall meet the requirements of Parts II through VIII of Article 692.

708.22 Capacity of Power Sources.

(A) **Capacity and Rating.** A COPS shall have capacity and rating for all loads to be operated simultaneously for continuous operation with variable load for an unlimited number of hours, except for required maintenance of the power source. A portable, temporary, or redundant alternate power source shall be available for use whenever the COPS power source is out of service for maintenance or repair.

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(B) Selective Load Pickup, Load Shedding, and Peak Load Sharing. The alternate power source shall be permitted to supply COPS emergency, legally required standby and optional loads where the source has adequate capacity or where automatic selective load pickup and load shedding is provided as needed to ensure adequate power to (1) the COPS and emergency circuits, (2) the legally required standby circuits, and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided these conditions are met.

Peak load-shaving operation shall be permitted for satisfying the test requirement of 708.6(B), provided all other conditions of 708.6 are met.

(C) Duration of COPS Operation. The alternate power source shall be capable of operating the COPS for a minimum of 72 hours at full load of DCOA with a steady-state voltage within ± 10 percent of nominal utilization voltage.

(D) Ventilation. Adequate ventilation shall be provided for the alternate power source for continued operation under maximum anticipated ambient temperatures.

FPN: NFPA 110-2005, *Standard for Emergency and Standby Power Systems*, and NFPA 111-2005, *Standard for Stored Energy Emergency and Standby Power Systems*, include additional information on ventilation air for combustion and cooling.

708.24 Transfer Equipment.

(A) General. Transfer equipment, including automatic transfer switches, shall be automatic and identified for emergency use. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and critical operations sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.

(B) Bypass Isolation Switches. Means shall be permitted to bypass and isolate the transfer equipment. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.

(C) Automatic Transfer Switches. Where used with sources that are not inherently synchronized, automatic transfer switches shall comply with (C)(1) and (C)(2).

- (1) Automatic transfer switches shall be listed for emergency use.
- (2) Automatic transfer switches shall be electrically operated and mechanically held.

(D) Use. Transfer equipment shall supply only COPS loads.

708.30 Branch Circuits Supplied by COPS. Branch circuits supplied by the COPS shall only supply equipment specified as required for critical operations use.

IV. Overcurrent Protection

708.50 Accessibility. The feeder- and branch-circuit overcurrent devices shall be accessible to authorized persons only.

708.52 Ground-Fault Protection of Equipment.

(A) Applicability. The requirements of 708.52 shall apply to critical operations (including multiple occupancy buildings) with critical operation areas.

(B) Feeders. Where ground-fault protection is provided for operation of the service disconnecting means or feeder disconnecting means as specified by 230.95 or 215.10, an additional step of ground-fault protection shall be provided in all next level feeder disconnecting means downstream toward the load. Such protection shall consist of overcurrent devices and current transformers or other equivalent protective equipment that causes the feeder disconnecting means to open.

The additional levels of ground-fault protection shall not be installed on electrical systems that are not solidly grounded wye systems with greater than 150 volts to ground but not exceeding 600 volts phase-to-phase.

(C) Testing. When equipment ground-fault protection is first installed, each level shall be tested to ensure that ground-fault protection is operational.

FPN: Testing is intended to verify the ground-fault function is operational. The performance test is not intended to verify selectivity in 708.52(D), as this is often coordinated similarly to circuit breakers by reviewing tie and current curves and properly setting the equipment. (Selectivity of fuses and circuit breakers is not performance tested for overload and short circuit.)

(D) Selectivity. Ground-fault protection for operation of the service and feeder disconnecting means shall be fully selective such that the feeder device, but not the service device, shall open on ground faults on the load side of the feeder device. A six-cycle minimum tripping separation between the service and feeder ground-fault tripping bands shall be provided. Operating time of the disconnecting devices shall be considered in selecting the time spread between these two bands to achieve 100 percent selectivity.

FPN: See 230.95, FPN No. 4, for transfer of alternate source where ground-fault protection is applied.

708.54 Coordination. Critical operations power system(s) overcurrent devices shall be selectively coordinated with all supply side overcurrent protective devices.

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V. System Performance and Analysis

708.64 Emergency Operations Plan. A facility with a COPS shall have documented an emergency operations plan. The plan shall consider emergency operations and response, recovery, and continuity of operations.

FPN: NFPA 1600-2007, *Standard on Disaster/Emergency Management and Business Continuity Programs*, Section 5.7, provides guidance for the development and implementation of emergency plans.

ARTICLE 720

Circuits and Equipment Operating at Less Than 50 Volts

720.1 Scope. This article covers installations operating at less than 50 volts, direct current or alternating current.

720.2 Other Articles. Direct current or alternating-current installations operating at less than 50 volts, as covered in 411.1 through 411.7; Part VI of Article 517; Part II of Article 551; Parts II and III and 552.60(B) of Article 552; 650.1 through 650.8; 669.1 through 669.9; Parts I and VIII of Article 690; Parts I and III of Article 725; or Parts I and III of Article 760 shall not be required to comply with this article.

720.3 Hazardous (Classified) Locations. Installations within the scope of this article and installed in hazardous (classified) locations shall also comply with the appropriate provisions for hazardous (classified) locations in other applicable articles of this *Code*.

720.4 Conductors. Conductors shall not be smaller than 12 AWG copper or equivalent. Conductors for appliance branch circuits supplying more than one appliance or appliance receptacle shall not be smaller than 10 AWG copper or equivalent.

720.5 Lampholders. Standard lampholders that have a rating of not less than 660 watts shall be used.

720.6 Receptacle Rating. Receptacles shall have a rating of not less than 15 amperes.

720.7 Receptacles Required. Receptacles of not less than 20-ampere rating shall be provided in kitchens, laundries, and other locations where portable appliances are likely to be used.

720.9 Batteries. Installations of storage batteries shall comply with 480.1 through 480.4 and 480.8 through 480.10.

720.11 Mechanical Execution of Work. Circuits operating at less than 50 volts shall be installed in a neat and workmanlike manner. Cables shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use.

ARTICLE 725

Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits

I. General

725.1 Scope. This article covers remote-control, signaling, and power-limited circuits that are not an integral part of a device or appliance.

FPN: The circuits described herein are characterized by usage and electrical power limitations that differentiate them from electric light and power circuits; therefore, alternative requirements to those of Chapters 1 through 4 are given with regard to minimum wire sizes, derating factors, overcurrent protection, insulation requirements, and wiring methods and materials.

725.2 Definitions.

Abandoned Class 2, Class 3, and PLTC Cable. Installed Class 2, Class 3, and PLTC cable that is not terminated at equipment and not identified for future use with a tag.

Circuit Integrity (CI) Cable. Cable(s) used for remote-control, signaling, or power-limited systems that supply critical circuits to ensure survivability for continued circuit operation for a specified time under fire conditions.

Class 1 Circuit. The portion of the wiring system between the load side of the overcurrent device or power-limited supply and the connected equipment.

FPN: See 725.21 for voltage and power limitations of Class I circuits.

Class 2 Circuit. The portion of the wiring system between the load side of a Class 2 power source and the connected equipment. Due to its power limitations, a Class 2 circuit considers safety from a fire initiation standpoint and provides acceptable protection from electric shock.

Class 3 Circuit. The portion of the wiring system between the load side of a Class 3 power source and the connected equipment. Due to its power limitations, a Class 3 circuit considers safety from a fire initiation standpoint. Since higher levels of voltage and current than for Class 2 are permitted, additional safeguards are specified to provide protection from an electric shock hazard that could be encountered.