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.

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

Informational Note: 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 time 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. Separation of ground-fault protection time-current characteristics shall conform to the manufacturer's recommendations and shall consider all required tolerances and disconnect operating time to achieve 100 percent selectivity.

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

Δ **708.54 Selective Coordination.**

*N* **(A) General.** Critical operations power system(s) overcurrent protective devices (OCPDs) shall be selectively coordinated with all supply-side and load-side OCPDs.

Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

*N* **(B) Replacements.** Where critical operations power system(s) OCPDs are replaced, they shall be reevaluated to ensure selective coordination is maintained with all supply-side and load-side OCPDs.

*N* **(C) Modifications.** If modifications, additions, or deletions to the critical operations power system(s) occur, selective coordination of the critical operations power system(s) OCPDs with all supply-side and load-side OCPDs shall be reevaluated.

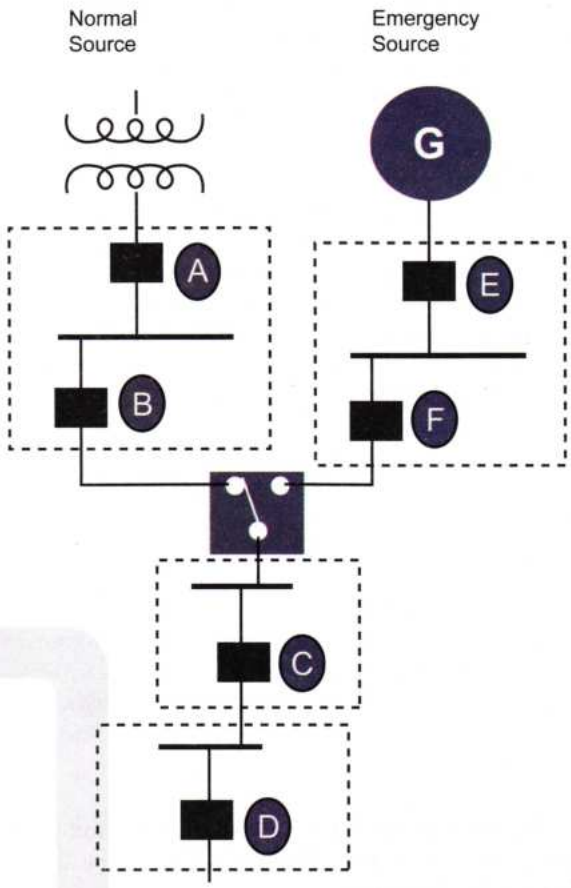
*Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.*

Informational Note: See Informational Note Figure 708.54(C) for an example of how critical operations power system OCPDs selectively coordinate with all supply-side OCPDs.

OCPD D selectively coordinates with OCPDs C, F, E, B, and A.

OCPD C selectively coordinates with OCPDs F, E, B, and A.

OCPD F selectively coordinates with OCPD E.




***INFORMATIONAL NOTE FIGURE 708.54(C)*** *Critical Operations Power System Selective Coordination.*

OCPD B is not required to selectively coordinate with OCPD A because OCPD B is not a critical operations power system OCPD.

## Part V. System Performance and Analysis

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

Informational Note: See *NFPA 1600*-2019, *Standard on Continuity, Emergency, and Crisis Management*, Section 5.7, which provides guidance for the development and implementation of emergency plans.

# ARTICLE 710 Stand-Alone Systems

Δ **710.1 Scope.** This article covers electric power production systems that operate in island mode not connected to an electric utility or other electric power production and distribution network.

Informational Note: These systems operate independently from an electric utility and include isolated microgrid systems. Stand-alone systems often include a single or a compatible interconnection of sources such as engine generators, solar PV, wind, ESS, or batteries.

This article addresses the operating parameters for electric power production sources in stand-alone mode. If a stand-alone system is interconnected with the alternating-current (ac) system, the requirements of Article 705 apply. Power production sources such as a generator, photovoltaic (PV) system, fuel cell, and wind electric system supplying a sign, lights, irrigation system, or remote facilities such as a cabin are a few examples of stand-alone systems. These systems can include energy storage or backup power supplies.

Article 710, which covers stand-alone systems, and Article 702, which covers optional standby systems, are not mutually exclusive. In respect to how the two articles interact, a stand-alone system operating in island mode (such as a generator or a solar PV system) serves as the alternate electric power production source for the optional standby system loads covered by Article 702. The connection of the stand-alone system to the optional standby system loads can be done automatically or manually using transfer equipment or multimode inverters. The capacity of the stand-alone source is affected by whether the optional standby system loads are connected automatically or manually as specified in 702.4(A)(1) and (2).

Δ **710.6 Equipment Approval.** All power production equipment or systems shall be approved for use in island mode and comply with one of the following:

(1) Be listed
(2) Be evaluated for the application and have a field label applied

Δ **710.10 Identification of Power Sources.** A permanent plaque, label, or directory shall be installed at a building supplied by a stand-alone system at the power source disconnecting means location, or at an approved readily visible location. The plaque, label, or directory shall denote the location of each power source disconnecting means for the building or be grouped with other plaques or directories for other on-site sources. Where multiple sources supply the building, markings shall comply with 705.10.

**710.12 Stand-Alone Inverter Input Circuit Current.** The maximum current shall be the stand-alone continuous inverter input current rating when the inverter is producing rated power at the lowest input voltage.

**710.15 General.** Premises wiring systems shall be adequate to meet the requirements of this *Code* for similar installations supplied by a feeder or service. The wiring on the supply side of the building or structure disconnecting means shall comply with the requirements of this *Code*, except as modified by 710.15(A) through (G).

**(A) Supply Output.** Power supply to premises wiring systems fed by stand-alone or isolated microgrid power sources shall be permitted to have less capacity than the calculated load. The capacity of the sum of all sources of the stand-alone supply shall be equal to or greater than the load posed by the largest single utilization equipment connected to the system. Calculated general lighting loads shall not be considered as a single load.

Informational Note: For general-use loads the system capacity can be calculated using the sum of the capacity of the firm sources, such as generators and ESS inverters. For specialty loads intended to be powered directly from a variable source, the capacity can be calculated using the sum of the variable sources, such as PV or wind inverters, or the combined capacity of both firm and variable sources.

Even though a stand-alone installation may have disconnecting means rated at 100 or 200 amperes at 120/240 volts, the PV source is not required to provide either the full current rating or the dual voltages of the service equipment. A PV installation usually is designed so that the actual ac demands on the system are sized to the output rating of the PV system. The inverter output is required to have sufficient capacity to power the largest single piece of utilization equipment to be supplied by the PV system, but the inverter output does not have to be rated for potential multiple loads to be simultaneously connected to it.

**(B) Sizing and Protection.** The circuit conductors between a stand-alone source and a building or structure disconnecting means shall be sized based on the sum of the output ratings of the stand-alone source(s). For three-phase interconnections, the phase loads shall be controlled or balanced to be compatible with specifications of the sum of the power supply capacities.

Δ **(C) Single 120-Volt Supply.** Stand-alone and isolated microgrid systems shall be permitted to supply 120 volts to single-phase, 3-wire, 120/240-volt service equipment or distribution panels where there are no 240-volt outlets and where there are no multiwire branch circuits. In all installations, the sum of the ratings of the power sources shall be less than the rating of the neutral bus in the service equipment. This equipment shall be marked with the following words or equivalent:

WARNING:
SINGLE 120-VOLT SUPPLY.
DO NOT CONNECT MULTIWIRE
BRANCH CIRCUITS!

The warning sign(s) or label(s) shall comply with 110.21(B).

If multiwire branch circuits are connected to a normal 120/240-volt ac service, the currents in the neutral conductors subtract or are at most no larger than the rating of the branch-circuit overcurrent device. If the electrical system consists of a single 120-volt electrical system supplying the two buses in the panelboard, the currents in the grounded conductor for each multiwire branch circuit add rather than subtract. Because the two buses are in phase, there is no neutral conductor. The currents in these conductors can be as high as twice the rating of the branch-circuit overcurrent device, and overloading is possible.

**(D) Three-phase Supply.** Stand-alone and microgrid systems shall be permitted to supply three-phase, 3-wire or 4-wire systems.