Application Note

Stand-By Generator Panels

Introduction

Homeowners are dependent on electricity for heat, water, sump pumps, cooking and lighting. Temporary electrical outages, whatever the cause, can result in hardship for those affected. Computerization has lead many to believe that whole generating stations may shut down if there is an incident with a single computer in a critical function.

Need for electricity and fear of availability has created a demand by consumers for a system in which they can generate electricity to operate essential loads during temporary utility outages. Availability of low cost portable generators has created a need to develop a method to safely connect these generators to residential electrical systems via some sort of generator panel. This paper, although referring to residential applications, is equally valid for small commercial or industrial applications.

Essential Loads

Essential loads are defined as those loads which are required to maintain a minimum level of convenience and safety to a homeowner — heat, pumps, lighting, refrigeration and cooking circuits. Some may argue that computers, stereos, TV's and VCR's are also essential loads.

Since the essential loads must operate under normal supply and under stand-by supply, there is a requirement to provide electricity from two or more distinct sources. This will require a transfer switching mechanism to be installed.

Stand-by Generator Panels

The Canadian Electrical Code (CEC) Rules 6-106 and 14-612 require that any wiring system connected to a stand-by generator be connected through a transfer mechanism. The transfer mechanism will 1) ensure that it is impossible for the generator to feed back onto the utility power lines and 2) prevent the two sources, utility and generator, from feeding the loads simultaneously, **in any operation of the transfer mechanism**. In other words, both loads **CANNOT** be feeding the loads at the same time, even momentarily during switching. These Rules protect the homeowner and their equipment and ensure the safety of anyone working on the utility system upstream from the service entrance panel.

What is a Generator Panel?

We will define a generator panel as a device that incorporates a manual transfer mechanism (breakers or switches) and branch breakers into one enclosure. This generator panel is located on the load side of a service entrance panel and is sub-fed from the service entrance panel.

For generators providing 1∅, 120/240Vac power the manual transfer portion of the panel will be either a 2-pole or 3-pole mechanism.

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This transfer mechanism allows the user to switch between normal utility power and a stand-by generator to provide electricity to the essential loads. **The type of generator used determines the use of a 2-pole or 3-pole generator panel.** (For 3∅ generators, the switching mechanism will need to be a 3-pole or 4-pole device.)

Types of Portable Generators

Portable generators can be categorized in many ways - by the type of fuel used, output wattage, 1∅ or 3∅, brand name, country of origin etc. For the purpose of this paper, the generators we will be considering are 1∅ and sub-grouped as **"Neutral Bonded to the Frame"** and **"Neutral Floating"**. As per CSA Standard 22.2 No 100-95, the status of the neutral must be indicated on the nameplate of the generator.

Generator Panel Selection — Neutral Bonding Issue

The most important factor when selecting a generator panel is to determine if the generator to be used has a neutral **bonded** to the frame or a **floating** neutral.

Why does the neutral bonding in the generator determine the type of generator panel used? For an answer we refer to the CEC. Rule 10-400 requires that equipment (generator frames) be bonded to ground. Rule 10-106 requires AC systems to be grounded. Rule 10-204 requires the ground to be located at the service entrance switch or panel. And finally, Rule 10-204(1)(d) does not allow a connection between the neutral conductor and the grounding electrode on the load side of the service entrance panel, effectively this does not allow bonding of the neutral to the ground electrode in more than one location.

Therefore if the generator has a **bonded** neutral, we would be **required to switch the neutral conductor**. This prevents a system where the neutral is bonded to ground in two locations, once at the service entrance and once at the generator.

If the generator has a **floating** neutral, we would be required to carry the generator neutral though to the service entrance panel to provide neutral to ground bonding per Rule 10-106 of the CEC.

Bonded Neutral Application — 3-Pole Transfer Switching Required

Diagrams 1 and 2 show the circuit for a generator with a bonded neutral used with a generator panel that switches the neutral (To simplify the diagram only L1 is shown). In normal conditions (Diagram 1) the load is powered from the utility and the neutral is connected through the generator panel and bonded to ground in the service entrance panel. The simplified circuits show the current path and bonding location.

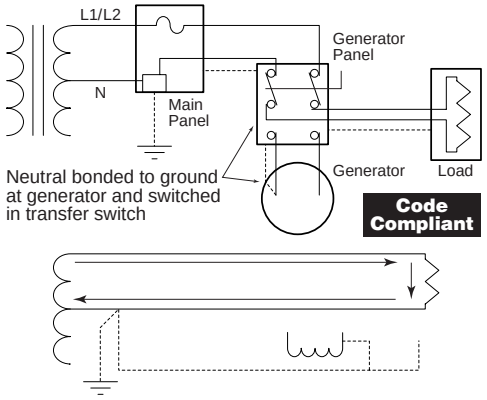

Diagram 1

In stand-by power mode (Diagram 2), the load is fed from the generator and generator neutral is bonded to the ground electrode in a single location at the service entrance panel.

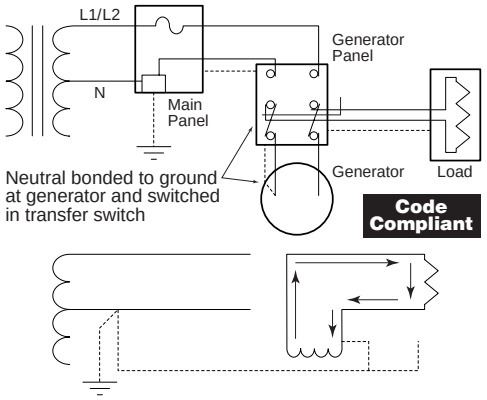

Diagram 2

Therefore it is clear to see that a 3-pole transfer mechanism, switching Line 1, Line 2 and the neutral conductors is required to provide this code compliant installation as per Rule 10-204 (1)(d).

If we try to perform the same installation with a 2-pole transfer mechanism with a generator panel in which the neutral is solidly connected then Diagrams 3 and 4 show this circuit. As the simplified diagrams show, in both cases the neutral is effectively bonded to ground in two locations, a clear **VIOLATION** of Rule 10-204 (1)(d). This would cause a current to

flow in the ground circuit, which would cause the generator panel to be “hot” and creates a safety hazard.

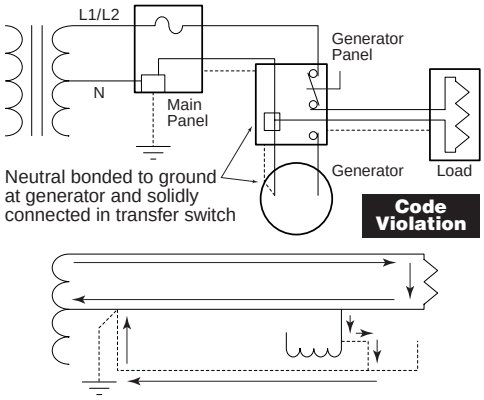

Diagram 3

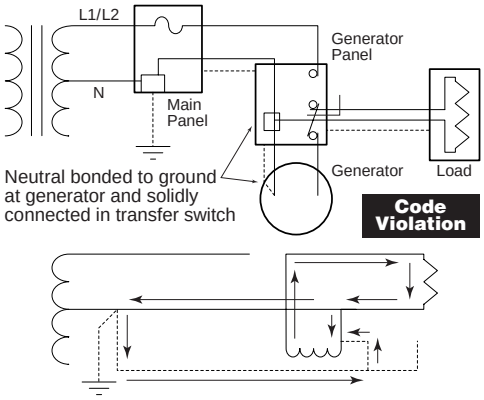

Diagram 4

These Diagrams show that a 2-pole transfer mechanism, switching Line 1 and Line 2 only, would allow circulating currents to flow in the parallel ground circuit when the installation includes a generator with a bonded neutral.

Floating Neutral Applications

Diagrams 5 and 6 show the circuit for a generator with a floating neutral used with a generator panel that solidly connects the neutral. In normal conditions (Diagram 5) the load is powered from the utility and the neutral is connected through the generator panel neutral and bonded in the service entrance panel. The simplified circuits show the current path and bonding locations.

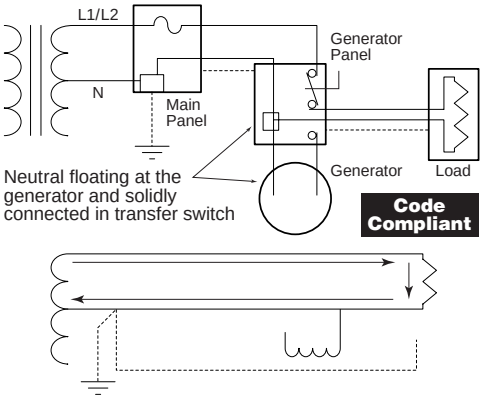

Diagram 5

In stand-by power mode (Diagram 6) the load is fed from the generator and the generator neutral is again connected through the generator panel neutral and bonded to the ground electrode in a single location at the service entrance panel.

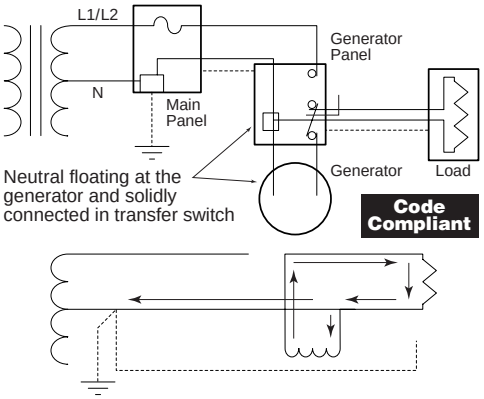

Diagram 6

Therefore it is clear to see that a 2-pole transfer mechanism, switching Line 1 and Line 2 conductors only and solidly connecting the neutral conductors is required to provide this code compliant installation for a floating neutral generator.

If we try to connect a generator with a floating neutral using a 3-pole transfer mechanism and switch the neutral conductor, Diagrams 7 and 8 show this circuit. In normal conditions (Diagram 7) the load is powered from the utility and the neutral is connected through the generator panel neutral and bonded in the service entrance panel. Everything looks okay.

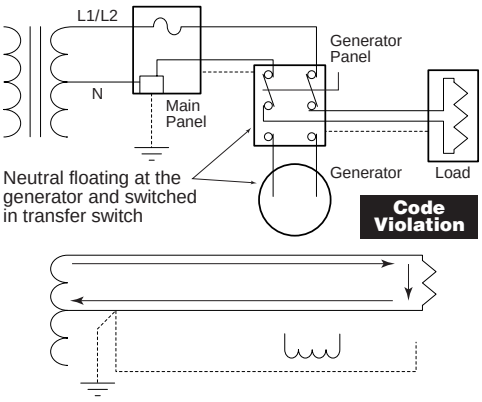

Diagram 7

But in stand-by power mode (Diagram 8) the load is fed from the generator and the generator neutral has been switched. Therefore the neutral bond has been removed from the system. This would be a violation of CEC Rule 10-106 that requires AC systems to be bonded to ground.

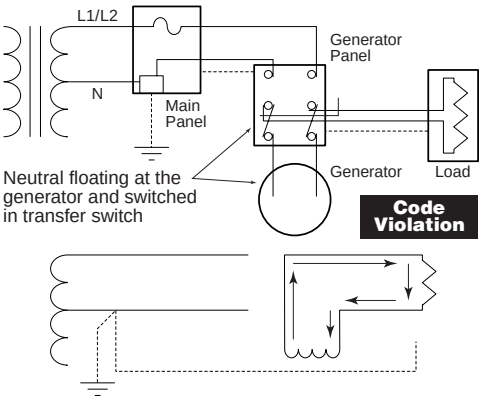

Diagram 8

These Diagrams show that a 3-pole transfer mechanism switching Line 1, Line 2 and the neutral conductors would result in a circuit that does not comply with the rules of the CEC. In stand-by power mode, a circuit exists in which the system voltage from the generator could float on each phase. In the most extreme case 240Vac would appear on one phase and 0Vac on the second phase, potentially resulting in damage to any 120Vac equipment operated in the home.

Other Selection Criteria

Once it has been determined that a generator with a bonded or floating neutral will be used a generator panel with the appropriate transfer mechanism can be selected. Then other considerations must be taken into effect such as;

- Voltage requirements (120Vac only or 120/240Vac)
- Total amperage of the loads to be operated simultaneously
- Generator output in Amperes
- Short circuit requirements
- Number of circuits to be fed

Then the appropriate generator panel may be selected and installed for a worry free future.

Final Installation Considerations

After the installation is complete the generator transfer panel and generator inlet connection point must be permanently labeled to clearly indicate the type of generator to be used (neutral bonded to frame or floating neutral) as per Rule 2-100(1)(e) of the CEC.

Finally, all installations of electrical equipment are subject to the inspection requirements contained in the CEC. Contact your local inspection authority for details.

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