

PORTABLE GENERATORS AND OSHA CONSTRUCTION REGULATIONS

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Portable generators used on construction sites have been much misunderstood, at least with respect to the regulatory requirements. There are **three** regulatory references to portable generators used in 29 CFR 1926, OSHA's Construction Standards. The first deals with the **Grounding Electrode** (ground rod or earthing electrode). The second reference lists the criteria for **GFCI (Ground Fault Circuit Interrupter) exemption** and the third addresses the **Neutral Conductor Bonding requirement**.

These requirements are three distinctly separate issues and should not be confused or combined. This monograph addresses and explains each. Where adopted by OSHA, the National Electrical Code[®] (NEC[®]) reference is also listed. The NEC[®] should be referenced directly for additional clarification.

I. Generator Grounding Electrode Exemption (system grounding)

29 CFR 1926.404(f)(3) *Portable and vehicle-mounted generators –*

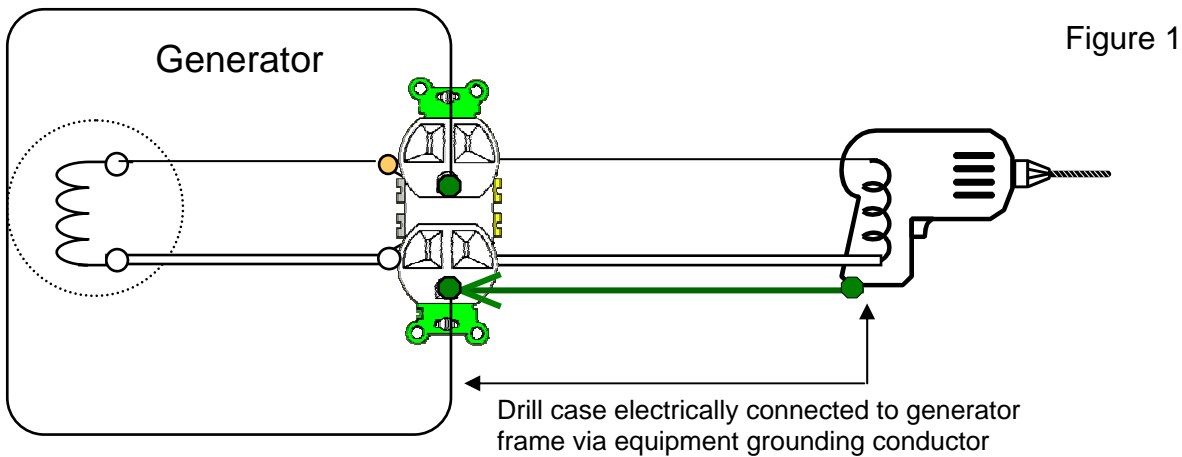
(i) *Portable Generators.* “Under the following conditions, the frame of a portable generator need not be grounded and **may** serve as the grounding electrode...” (NEC[®] Article 250.34 – 2005 Edition). This reference uses the term “grounding electrode”, which is code language for a “system ground” or the intentional connection of an electrical system to the earth or our surroundings. In other words, a ground rod is not required and, in fact, may create a hazard.

The conditions referenced in 1926.404(f)(3)(i) are:

A) The generator supplies only equipment mounted on the generator and/or cord and plug connected equipment (i.e. saws, drills, lights, etc.) through the receptacles mounted on the generator,

AND

B) The **grounding** pin(s) of the generator-mounted receptacles are connected to the generator frame and the equipment **grounding conductors** of the portable equipment plugged into the generator are continuous to the generator frame. (See Figure 1)



The principle function of the **system ground, or grounding electrode (ground rod)**, is lightning protection for equipment (see NEC[®] Article 250.4(A)(1) Electrical System Grounding). The likelihood of lightning striking a portable generator supplying some hand tools on a construction site is unlikely, to say the least. So, aside from the unlikelihood of a lightning strike, why eliminate the ground rod? **Because the ground rod potentially introduces an electrocution hazard!** Depending upon the internal wiring of the generator winding to the frame (see Figure 2), this hazard is introduced by creating an improved path for current to return to its source in the event of short circuits or insulation failure in equipment. So, just treat the generator frame as the ground rod and leave it at that, which this regulation permits.

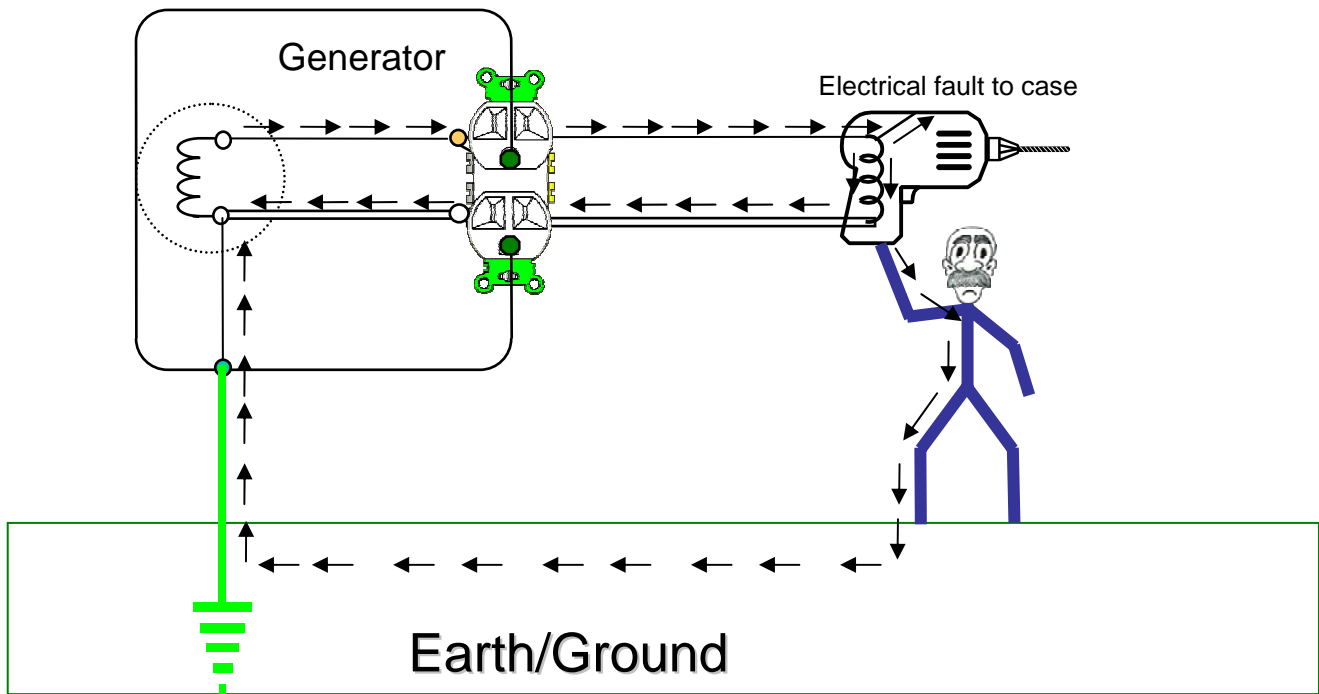


Figure 2

From a historical perspective, the grounding electrode (which is also a system ground) is required for other reasons and was the earliest grounding requirement in the National Electrical Code[®], becoming mandatory in the 1913 edition. The main purpose of grounding (earthing) the system at the neutral of

the transformer secondary was to prevent high (primary) voltages from being applied to premises wiring (homes) due to a breakdown of insulation between the transformer primary winding and secondary winding. A primary-to-secondary short would apply thousands of volts to the premises, whereby causing an insulation failure in the wiring and a subsequent fire. The requirement was precipitated by the insurance companies and their concern about fire loss.

This system ground is different than the equipment grounding requirements which did not appear in the NEC[®] until 1947, and which are for people protection. More specifically, the purpose of the equipment grounding conductor (code language) is to **prevent electrocution** in the event of a fault (short circuit) in the equipment that energizes the frame or enclosure of that equipment.

The grounding requirements in the OSHA regulations are found in 1910.304(f) and 1926.404(f). More specifically, 1910.304(f)(1), (2), (3) and (7) as well as 1926.404(f)(1), (2), (3), (4), (5), (10) and (11) all address **system grounding**. The remaining references, 1910.304(f)(4), (5) and (6), as well as 1926.404(f)(6), (7), (8) and (9) all speak to equipment grounding requirements for the prevention of electrocution.

In summary, the installation of grounding electrodes (ground rods) on portable generators is discouraged because they introduce a potential electrocution hazard, it serves no other purpose and the codes do not require it.

II. Generator GFCI Exemption

The second OSHA regulatory reference on portable generators is the **GFCI exemption**. 29 CFR 1926.404(b)(1)(ii) reads, "Receptacles on a two-wire, single-phase portable or vehicle mounted generator rated not more than 5kW, where the circuit conductors on the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters." This same exemption was formerly in NEC[®] Article 305-6(a) *Exception*, but was removed in the 2002 NEC[®] as well as the 2004 NFPA 70E.

This means that under these conditions, you do not need the normally required GFCI's on a generator. There are three conditions or criteria listed in the regulation and **the generator must meet all three conditions in order to qualify for GFCI exemption**. The criteria are simply these:

1. The generator must be two-wire, single phase. Reference to two wires does not include grounding or equipment grounding conductors. Only the conductors or wires which are normally current-carrying circuit conductors are to be considered. This restriction eliminates three-wire generators which have a neutral conductor. The neutral conductor is the center tap of the output winding, which also allows a reference point for dual voltages such as 120v/240v. In a two-wire supply there can only be **one voltage derived**. Therefore, a 120v/240v generator must be a three-wire generator and cannot meet these criteria. Also, 3Ø (three phase) generators, which are typically four-wire, cannot meet this exemption. Incidentally, a three-wire, or dual voltage (120v/240v) generator must have the neutral wire connected to the frame. This will be covered in more detail in the next section.

Additionally, a two-wire system/generator (see Figure 1) **has no neutral wire**; both wires are normally current carrying. A true neutral would be a center-taped wire on a transformer (such as a 120v/240v single-phase, three-wire system), which carries the unbalanced current in a dual-voltage system.

2. The generator must be not over 5kW (kilo-watts/thousand watts). The size of the generator can be obtained from the manufacturer's nameplate on the generator, which includes the electrical specifications. Reference should be made to 29 CFR 1926.403(g) "*Marking*". Electrical equipment shall not be used unless the manufacturer's name, trademark, or other descriptive marking by which the

organization responsible for the product may be identified is placed on the equipment and unless other markings are provided giving voltage, current, wattage, or other ratings as necessary. The markings shall be of sufficient durability to withstand the environment involved." (NEC® Article 110.21 - 2005 Edition). The purpose of this requirement is to minimize capacitive coupling or capacitive reactance effects where alternating current at 60 Hertz could pass between the case of a generator and the winding, even with no direct electrical connection between the winding and the case. This effect could result in a path for current to flow back to its source, causing an electrocution in the event of a fault or in the equipment or damaged equipment cord plugged into the generator. This electrical effect becomes possible with windings of larger physical magnitude, as is the case when the generator is over 5kW (see Figure 3). The bottom line is that if the generator is over 5kW, then it cannot meet the exemption requirements and must be GFCI protected.

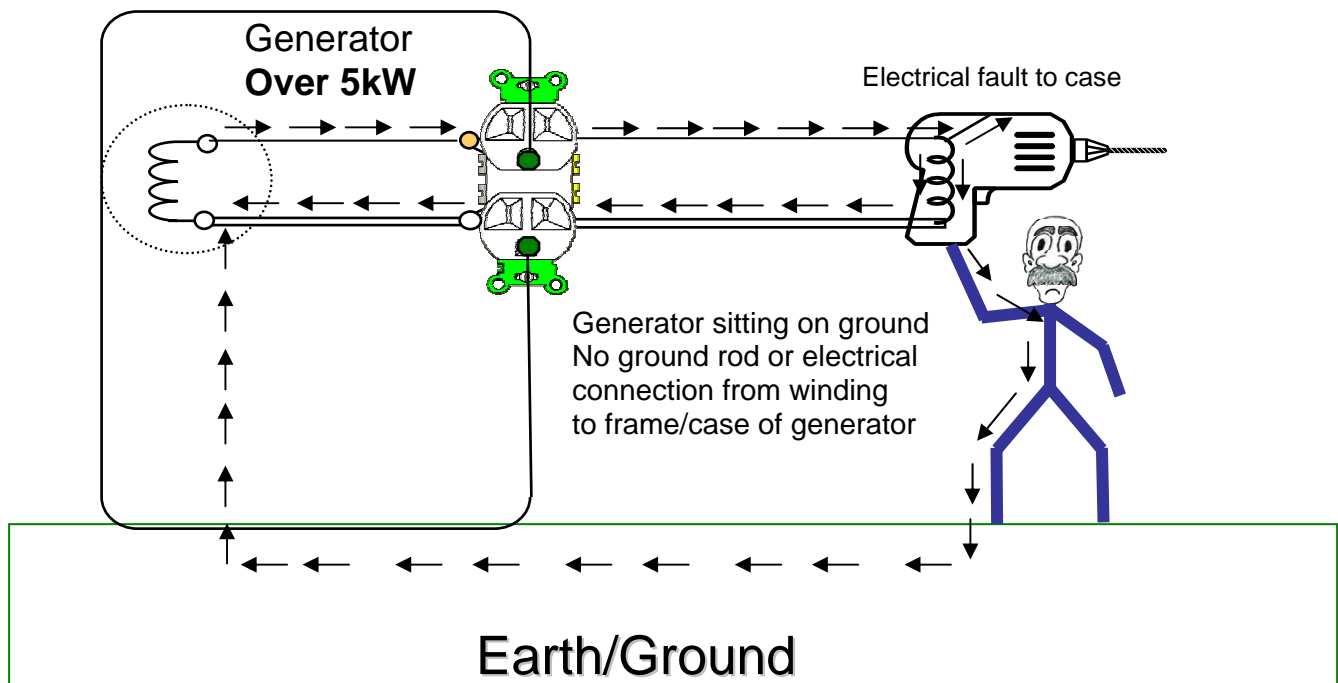


Figure 3

3. The circuit wires must not be connected to the generator frame, case, or other grounded surfaces. The two wires must be insulated or isolated and not electrically connected to the frame or other grounded surfaces. This refers only to the two conductors which are normally current-carrying. This does not refer to the equipment grounding conductor (See Figure 4).

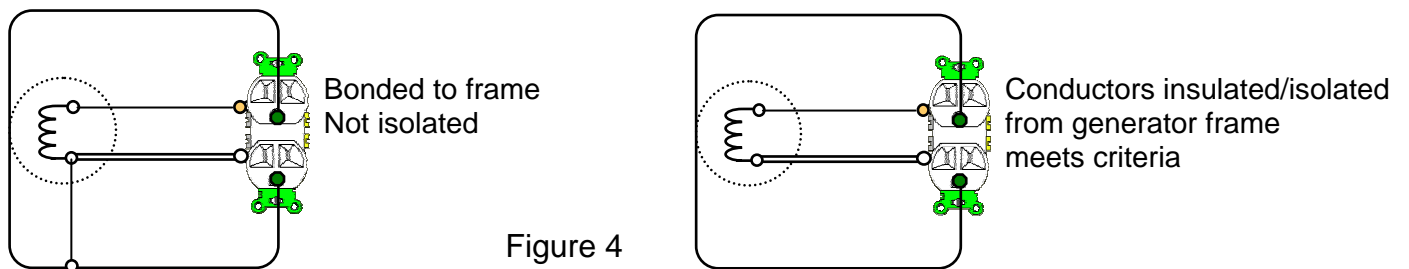


Figure 4

Since these wires or conductors are internal to the generator, the only way to effectively determine if they are, in fact, electrically isolated is to measure their continuity to the frame using an electrical continuity tester, or ohmmeter. These types of tests are **always** made with the generator **off - never** to a live or energized circuit. The continuity test can be made from either blade of the receptacle (not the ground pin) to the case/frame of the generator. Be sure the test lead of the tester is penetrating the paint, rust, and all other contaminants on the generator case when making the measurement. If the test indicates continuity, then the wires are connected to the case and do not meet this third criteria for isolation, therefore the generator must be GFCI protected. It does not matter which receptacle blade is selected to make this measurement. The only difference is that one blade will be connected to the case through the generator windings, while the other blade will be connected directly to the case. Since the resistance of generator windings is typically below 10 ohms, both blades will indicate continuity if they are not isolated, whereby requiring GFCI protection. This requirement eliminates a return current path, preventing an otherwise lethal condition in the event of an equipment short circuit or insulation failure.

The end result is that if the generator meets all three conditions or criteria, then even if one of the normal current-carrying conductors in a portable tool faults and energizes the case of the tool, no current path back to the source (generator winding) will exist to present an electrocution hazard to a person holding the tool. Furthermore, if the generator meets these three conditions, the generator does not need a GFCI.

Remember, the **generator must meet all three conditions** to permit this GFCI exemption.

As previously mentioned, this GFCI exemption was removed for the 2002 Edition of the NEC[®]. As a result, the local electrical inspectors, as the "Authorities Having Jurisdiction" or AHJ's as they are referred to, will no longer accept this exemption and will require the use of GFCI's on portable generators used for temporary wiring such as on construction sites per Article 590 of the 2005 NEC[®]. Although the exemption still appears in the OSHA construction regulations, this author suspects that it will eventually be totally eliminated and the required use of GFCI's will prevail in all cases.

III. Neutral Conductor Bonding Requirements for Generators-

The third and final issue for discussion can be found in 29 CFR 1926.404(f)(3)(iii) "*Neutral conductor bonding*. A neutral conductor **shall** be bonded to the generator frame if the generator is a component of a separately derived system." This reference can be found in 1996 NEC[®] Article 250-6(c) and 250-34 in the 1999 Edition. Although slightly modified for the 2002 Edition the reference is still located in NEC[®] Article 250.34(C). Consider this question. Is a generator on a construction site supplying only cord-and-plug-connected equipment (saws, drills, lights, etc.) through the receptacles mounted on the generator considered a separately derived system? The answer is a resounding "Yes!" It is always a separately derived system under those conditions and consequently the neutral must be bonded (electrically connected) to the frame of the generator.

For a more detailed explanation of why it's a separately derived system, we must examine the NEC[®] in more detail. NEC[®] Article 100 definitions of *Premises Wiring (System)* and *Separately Derived Systems* clarify this. *Premises Wiring Systems* include temporary lighting and power circuits extending from the source to the outlet. This would encompass our generator supplying cord-and-plug lights and tools on a construction site. A *Separately Derived System* is a generator which does not have any electrical connection to any other system. An emergency backup generator with its neutral permanently connected at the panelboard to the neutral supplied from a local utility company, with only the hot or ungrounded conductors being switched in for emergency backup in case of power failure, would not be considered a separately derived system. Further clarification on when a generator is **not a separately derived system** can be found in the 1996 NEC[®], Article 250-5(d), FPN No. 1, or in the 2005 NEC[®], Article 250.20(D), FPN No.1.

Perhaps the most definitive information comes from the CMP (Code Making Panel) recommendations and amendments to the 1974 NEC®. Prior to 1974, this generator issue was addressed in both NEC® Article 250-26(a) and Article 445-8 (Article 445 covers generators) Grounding. Code Making Panel #22 (as well as CMPs #5 and #11) proposed that the frames of generators be bonded to the neutral. The proposed amendments, including justification to the CMP, were not documented very thoroughly in those days. However, extensive research revealed this supporting comment which was the proposal to the 1974 CMP, **"The required bonding (neutral conductor to frame) for portable or cord and cable connected wiring systems supplied from portable generators will provide an assured fault current path to actuate the circuit or system overcurrent device for user protection in the event of multiple faults and insulation failure. Without this bonding (electrical connection of the neutral to the frame of the generator) a multiple fault condition would expose persons to a 240-volt potential."** (See Figure 5) This path will satisfy the intent of NEC® Article 250.2 & 250.4(A)(5), 2005 Edition (previous editions see Article 250-51).

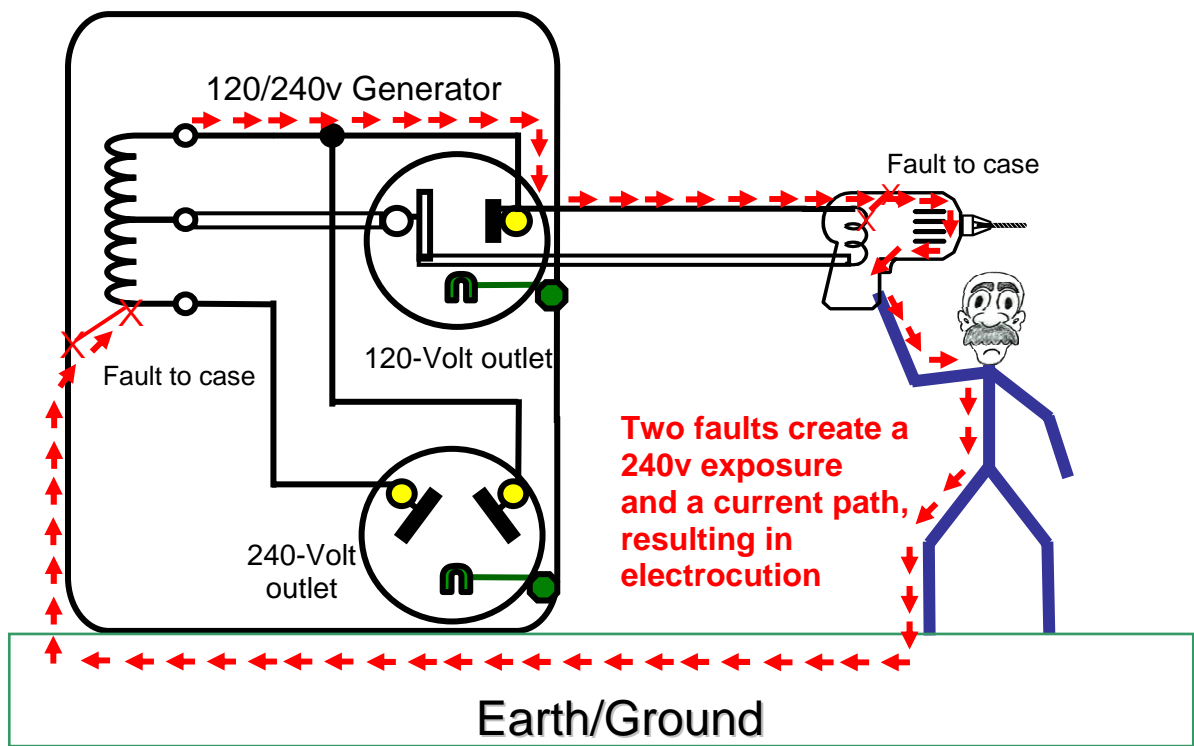


Figure 5

In summary, remember, the Generator Grounding Electrode (system grounding) Exemption (I), the Generator GFCI Exemption (II) and the Neutral Conductor Bonding Requirements for Generators (III) are all mutually exclusive and have nothing whatsoever to do with each other. Each issue needs to be examined one at a time for its applicability with respect to the code requirements, or more simply stated, examine each generator for all three issues to ensure it meets the codes.