Electrical Tech Note — 601

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Grounding Standby Generators

Rules concerning standby generators are found in *NEC Article 445* and *Article 702.* The major concerns deal with safety with respect to shock prevention, generator grounding, and proper connection to a building's electrical system. This tech note deals primarily with generators, both portable and permanently installed, used for standby operation for dwellings and small business buildings. Only single-phase 120 volt or 120/240 volt generators are discussed in this document. *(National Electrical Code, NEC)*

Portable generators usually have one or more receptacles supplying 15- or 20-ampere power at 120 volts. These outlets are required to be provided with ground-fault circuit-interrupter (GFCI) protection. These same portable generators are usually provided with a 3-wire, 30 ampere outlet that can provide power at both 120 volts and 240 volts. This 30 ampere outlet is often used to supply power to a panel in a dwelling that supplies only essential circuits. (See *Figure 601.5* & *Figure 601.6*) Standby generators that are intended to supply circuits in an entire dwelling or building are connected ahead of the service panel by means of a transfer switch that must be rated to act as the building disconnect. (See *Figures 601.4A* & *4601.4B*). The major purpose of this tech note is to explain grounding issues with respect to installation of these generators.

The 30 ampere outlet of a portable generator is supplied by two ungrounded (hot) conductors, a neutral conductor, and an equipment grounding conductor. If this outlet is used to supply 120 volt and 240 volt loads directly the output is required to be GFCI protected. If used to supply a building electrical system this GFCI protection must be capable of being deactivated. A portable generator with both 120 volt outlets and a 30 ampere outlet is shown in *Figure 601.1.* When a stand-alone portable generator is used for power tools or other electrical appliances or lighting the generator must be one that has a bonded neutral. In the case of a floating generator neutral a complete circuit cannot will not occur in the event a person touches an appliance that has a ground fault.

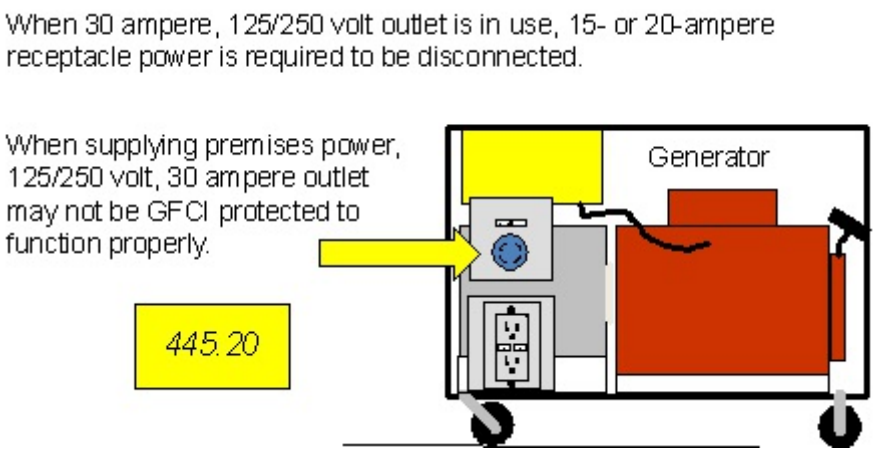

Figure 601.1 *The arrow points to a typical 30 ampere 120/240 volt generator output. On some*

generators the 120 volt receptacles my be deactivated while the 30 ampere output is in use.

To connect a portable generator to a selected emergency load in a dwelling or other building the generator can be connected by means of a 30 ampere power cord to an outlet that supplies a transfer switch that supplies power to a panel containing only the selected emergency circuits. The transfer switch lever is switched to emergency use and the portable generator supplies power to those emergency circuits through the transfer switch. This is illustrated in *Figure 601.2.* When utility power is restored the portable generator is shut off and the transfer switch is changed back to normal power. Standby generators used in this manner must be supplied with an electrical power disconnect switch which in this case the cord connection serves as the disconnect.

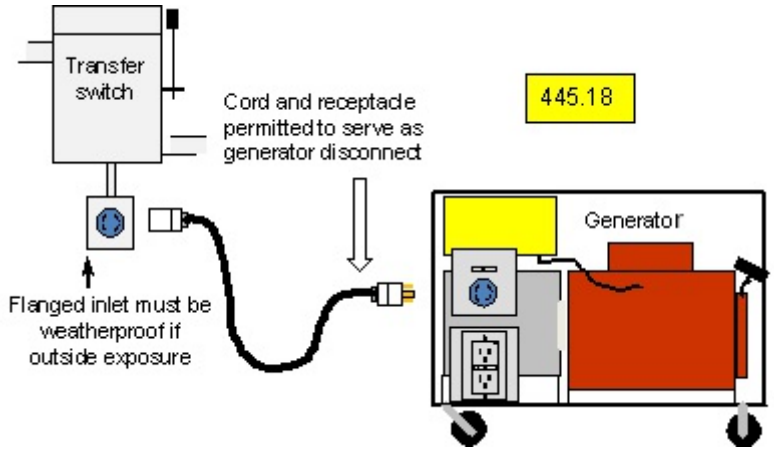

Figure 601.2 *Here a portable generator is connected to a building emergency circuit panel by means of a power cord connected to a transfer switch in the building. Power cord is permitted to act as the power disconnecting means for a portable generator rated not over 15 kW.*

In recent years the electrical code requires that all generators intended for standby use must indicate if the output neutral wire is connected or bonded to the generator metal frame. It is preferred that this bonding or connection point is accessible to the generator system installer.

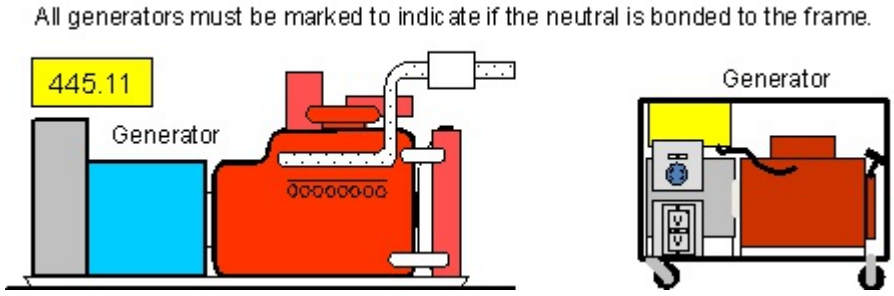

Figure 601.3 *All generators intended for use as a standby power source to a dwelling or building are required to indicate if the generator output neutral conductor is bonded to the generator metal frame.*

Sometimes generators both portable or fixed-in-place need to have the generator output neutral wire bonded to the generator metal frame and sometimes this bond connection needs to be removed. Installers need to understand what it means by a generator with a "bonded neutral" or a "**floating neutral.**" This issue is illustrated in *Figure 601.4A & 4B.* The

illustrations indicate a portable generator connection to the transfer switch, with the generator supplying power to the entire dwelling or building with a permanent wiring connection.

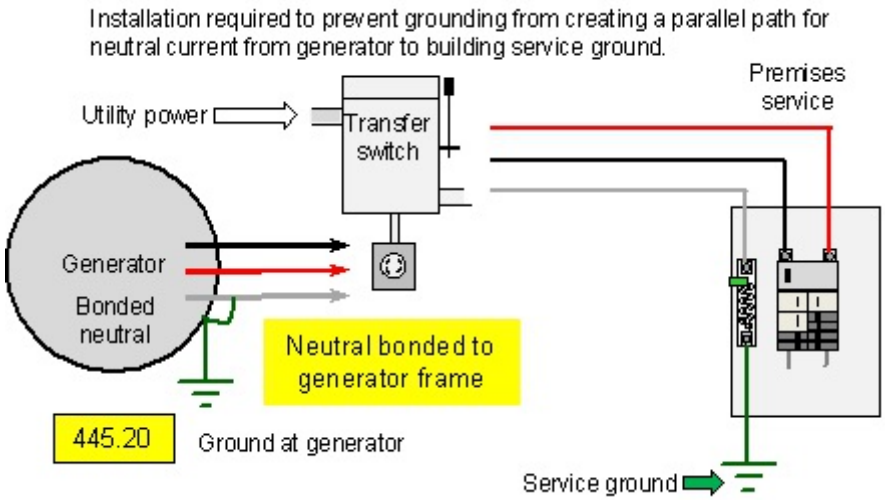

Figure 601.4A *In this illustration the generator output is two ungrounded (hot) conductors and a neutral. The generator output neutral bonded to the generator metal frame ,"Bonded neutral."*

Note in the previous illustration and the next illustration the transfer switch is acting as the electrical disconnecting means for the dwelling or building. Note that a grounding electrode is located is required at the transfer switch.

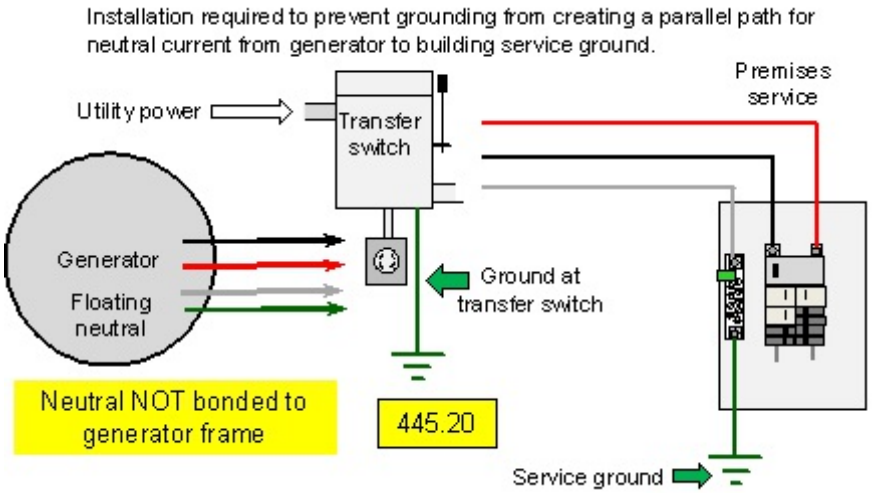

Figure 601.4B *Note in the case of a "Floating Neutral" generator the neutral is* ***not*** *bonded to the generator frame so a separate insulated grounding wire must be bonded to the generator output neutral and run to the transfer switch.*

Serving Necessary Circuits Only: A more practical approach to providing standby power to a dwelling or a building is to install a separate panel adjacent to the main service panel and move all necessary circuits that need to operate in the case of a power outage to the separate

emergency panel. In the case of a **"*bonded neutral*"** generator the transfer switch is required to switch the neutral conductor. This is illustrated in *Figure 601.5.* A grounding electrode is also required at the generator.

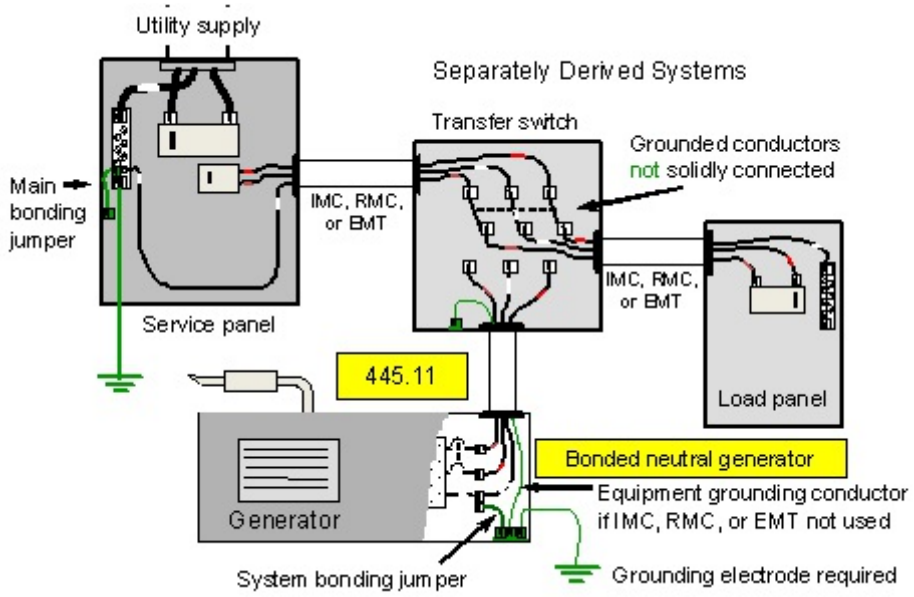

Figure 601.5 *When the generator output neutral is connected to the generator metal frame a "bonded neutral" system is the result and a grounding electrode is required at the generator [See 250.28(D)(3)]*

In the case of a "**floating neutral"** generator the output grounding conductor is not bonded to the generator metal frame. Also note that the transfer switch only switches the two ungrounded (hot) conductors. The generator neutral is solidly connected to the transfer switch neutral terminal block which is insulated from the metal transfer switch enclosure. In this case the neutrals and the equipment grounding conductors are only connected together at the main service panel. This type of installation is shown in *Figure 601.6.*

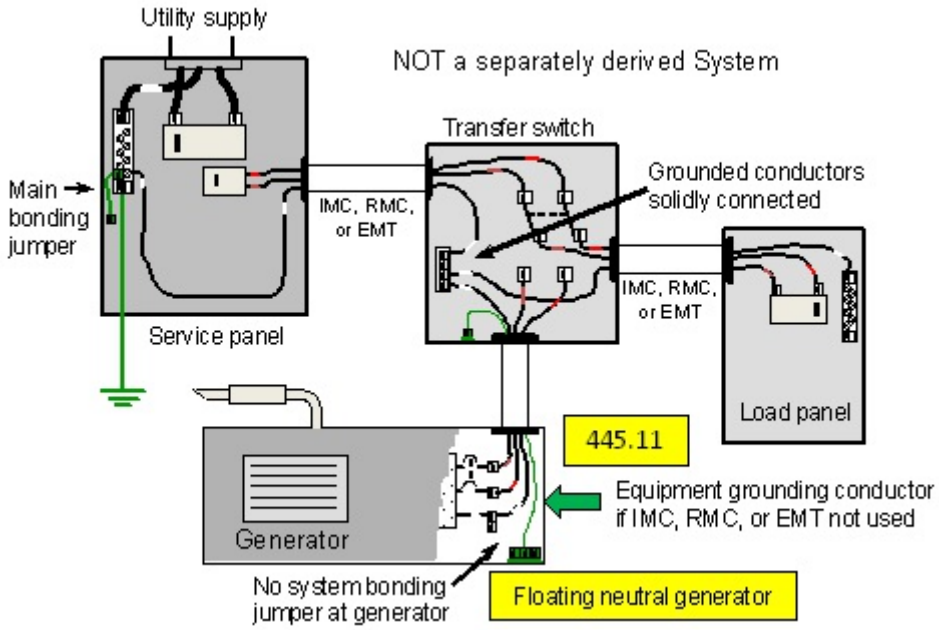

Figure 601.6 *For this "floating neutral" generator output the neutral conductor is not bonded to the generator output neutral. It is bonded to the other neutral conductors at the transfer switch.*

Other Requirements: To protect service personnel, a generator set that is controlled automatically or remotely requires a disconnect switch that can be locked in the off position. An example is illustrated in *Figure 601.7.*

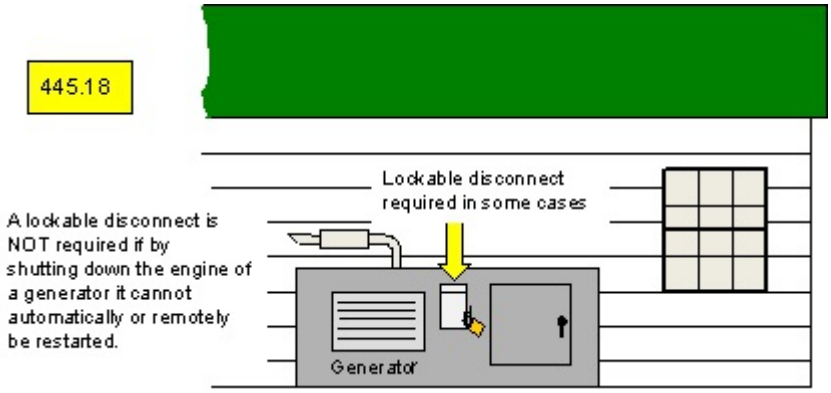

Figure 601.7 *An exterior power disconnect is required to prevent a generator from starting if automatically or remotely controlled. This disconnect must be of a type that has a lock in the off position.*

The issue of a floating neutral or a bonded neutral applies in cases other than generator systems. *Figure 601.8* shows an autotransformer where the neutral is continuous through the transformer from the primary to the secondary circuits. Also shown is a insulating single-phase two winding transformer where the secondary is a completely new electrical system that is "floating" with respect to the primary system.

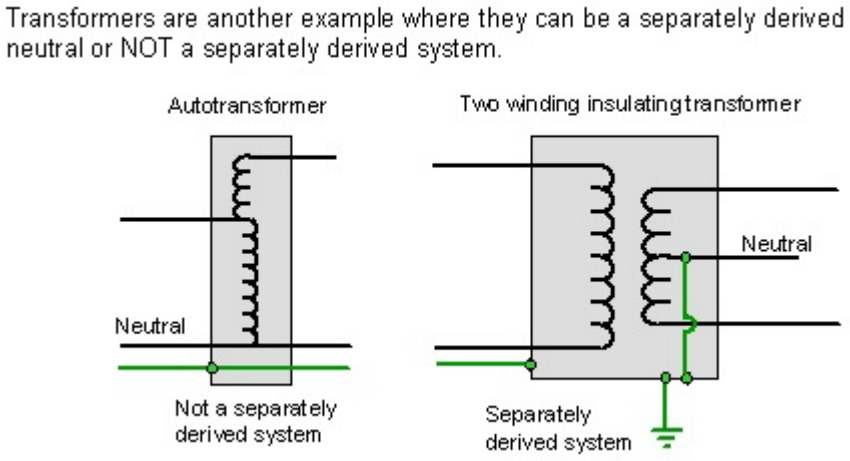

Figure 601.8 *The autotransformer on the left is an example of a bonded neutral system. On the right is an example of a commonly used two winding transformer that creates a neutral that is not bonded to the primary system. The installing electrician must install the grounding to create a bonded system.*