

## 2011 NEC Study Guide For “Transformer Installations & Separately Derived System Grounding”

*(This Study Guide was prepared by Gaylord Poe)*

Electrical inspectors receive many questions about transformer installations and how to ground separately derived systems. Most transformer questions are about transformers rated 600V and less. Most generator questions are about grounding. The purpose of this study guide is to address these common questions and how to find the information you need. I think it's more important to know where to *find* the answer than it is to be able to *remember* the answer! It's easy to end up in “the wrong part of the code book” when you're looking for answers about certain items but it's especially easy to do so when researching the rules for these installations. So, let's establish a logical path:

### What is a “Separately Derived System”?

NEC Art. 100 defines a Separately Derived System as “A premises wiring system whose power is derived from a source of electric energy or equipment other than a service. Such systems have no direct connection from circuit conductors of one system to circuit conductors of another system, other than connections through the earth, metal enclosures, metallic raceways, or equipment grounding conductors.”

### Are all Generator & Transformer Installations Separately Derived Systems?

For generator installations, the connections in the transfer switch determine if a generator is a separately derived system. *(If the neutrals from the “normal” and the “emergency” and the “load” all tie together in the transfer switch the generator is not a separately derived system.)* For transformer installations, most premises wiring transformers that you encounter will be separately derived systems. *(The exception being a “Y-Y” transformer where the primary and secondary neutral conductors are tied together.)*

Determining whether or not an installation is a “separately derived system” is extremely important so that proper and safe system grounding can be achieved. For example, if a system is not separately derived, a downstream connection of a circuit conductor to a grounding electrode system will have disastrous results. Separately derived systems require a separate grounding electrode conductor and non-separately derived systems (generators and transformers with a direct neutral-to-neutral connection with the service) do not require a separate grounding electrode conductor because the neutrals **are already connected to a grounding electrode system** through the common neutral connection.

### What exactly are you looking for?

It's logical to have a transformer question and try to find the answer in NEC Art. 450. In fact, that's where one should go for a *transformer* question. The same can be said for generator questions and NEC Art. 445. But many times our questions aren't really *transformer* or *generator* questions. Instead our questions are about overcurrent protection for *conductors* supplied by transformers or generators or about *grounding*.

When you're looking for answers to questions such as these in NEC Arts. 450 and 445, you are looking in the wrong place.

### **Protecting the transformer –**

Transformers require overcurrent protection. These overcurrent protection requirements are found in NEC 450.3. A common installation mistake is to provide overcurrent protection for a transformer and assume that it takes care of the overcurrent protection requirements for the conductors that the transformer supplies. These are two separate issues: you must protect the transformer and you must protect the supplied conductors.

The nice thing about the rules is that with a little “engineering” you can install an overcurrent protective device on the secondary side that will protect both the transformer and the supplied conductors in most cases.

An explanation: NEC Table 450.3(B) provides two “protection methods” for overcurrent protection of transformers 600V and less. One method provides overcurrent protection only on the primary side (primary only protection). The other method provides overcurrent protection on the secondary side when the primary overcurrent protection is limited (primary and secondary protection). Either “scheme” protects the transformer but if you provide overcurrent protection on the secondary side and properly size the secondary conductors, you can often use this one device to protect the transformer and the supplied conductors.

### **Protecting the conductors supplied by the transformer –**

Now that we've got the transformer overcurrent protection out of the way, let's review secondary **conductor** overcurrent protection. A very important code section to study is NEC 240.4(F) which states “Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors **shall not be considered to be protected** by the primary overcurrent protective device.” The section goes on to explain how to accomplish compliance (without overcurrent protection for secondary conductors) for 2-wire and delta-delta transformers. **But** the vast majority of the transformers that you will install in commercial buildings will be 480V delta primary/120-208V wye secondary. These secondary conductors require overcurrent protection.

Once you establish the need for overcurrent protection for the secondary conductors, the next question is “Where do I put it?”

NEC 240.21 states that the overcurrent protection “...shall be located at the point where the conductors receive their supply except as specified in 240.21(A) through (H).” Now before we rush into the rest of NEC 240.21, let's consider three points of understanding. These points are 1.) NEC 240.4 requires overcurrent protection for conductors. 2.) NEC 240.4(F) verifies that the primary overcurrent device does not protect the secondary conductors in most cases. 3.) NEC 240.21 does not “undo” any of the overcurrent protection requirements of 240.4.

NEC 240.21 is about **the location of the overcurrent device, not the need for it.** I bring up these three points because it's easy to become so involved in the "location" rules (240.21) that you may misinterpret them into meaning that secondary conductor overcurrent protection is not required at all!

That being said, a review of NEC 240.21(C) provides the location requirements for secondary conductor overcurrent protection. A good perspective for using 240.21(C) is this: without (C) (1) through (6), the location of the secondary conductors overcurrent protection would have to be at the secondary terminals – where the conductors receive their supply.

### **Grounding Separately Derived Systems –**

The rules for establishing the grounding electrode system for a separately derived system are very similar to the rules for the grounding of services. Some of the applicable code sections are listed at the end of this section.

*Some of the similarities are:* If there is a neutral\* (a *grounded* system) it must be bonded and grounded. It must be connected to a grounding electrode system via a grounding electrode conductor. This connection can be upstream but not downstream of the system overcurrent device. A system having no neutral (an *ungrounded* system), must also be connected to a grounding electrode system in like manner. The grounding electrode conductor for either system must be sized in accordance with the size of the secondary conductors using the same table that is used for sizing grounding electrode conductors for service installations. (\*Note: Be sure and read 250.20(B)...you may have to "ground" a system even if you don't want to!)

*Some issues unique to separately derived systems are:* Using layman's terms, unlike grounding electrode systems for services, there is a "pecking order" of preferred electrodes. You must use **the nearest** one of the following – a metal water pipe or building steel (*Building steel must qualify as a grounding electrode.*). It's important to note that the only portion of a metal water pipe that qualifies for use (in most cases) is the first 5 ft. after it enters the building. What if there is no "building steel" and the metal water pipe enters the opposite end of the building? Can you just drive a ground rod? **No.** A ground rod can only be used when "building steel" and a metal water pipe are not available on the premises. Additionally, **you must install bonding conductors to the metal water piping and other exposed structural metal in the area served by the separately derived system.**

**250.20(B), 250.30(A), 250.30(A)(7), 250.30(B), 250.104(D), 445, 450.**