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Questions and Answers about Grounding & Bonding in Separate Structures

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Q: When I'm looking at a panel in a detached building, fed by a panel in the primary building, is that panel at the second building to be treated like a subpanel, with grounds and neutrals separated, or is it treated like a service, with the neutral bonded to the enclosure?

A: If there are 4 conductors in the feeder to that panel (2 hot, neutral, + equipment ground) then it is almost the same as any other subpanel, except that it also requires a connection to a grounding electrode system. If there are only 3 conductors (2 hot 1 neutral) then it is treated like a service, with the neutral bonded to the enclosure and to a grounding electrode system.

Q: Which way is the right way – a 3-conductor feeder or 4-conductors?

A: It's partly a matter of when it was done, at least in terms of code compliance, but it mainly depends upon whether there are conductive metal pathways between the two buildings. Examples of that would be a telephone line, metal water or gas piping, cable TV, other communications cables, or steel reinforcement in concrete. If any of those are present and connecting the two buildings, ***a safety hazard exists when the neutral is bonded.*** It is creating a parallel path between the buildings, and current will also travel on that path. In that situation, you must have an insulated neutral that is not bonded, and you also need an equipment grounding conductor to carry fault currents.

Q: If I just have a 3-conductor feeder, can't I just remove the bond in the separate building, install an equipment ground bar in the panel, and connect that to a ground rod?

A: No. An effective fault current path is necessary to trip a breaker in the event of a fault in a circuit in that second building. The earth plays no part in clearing faults – it has too much resistance to make any significant safety contribution in that regard.

Q: If I have a 4-wire feeder, and it connects to the grounding electrode system at the first building, why do I need another grounding electrode system at the second building? And if I do need it, can't it just be a ground rod?

A: Connections to grounding electrodes in the earth have to do with keeping the metal inside the building at the same potential *as the earth that it sits on*. That isn't necessarily the same as the potential of the building at the source of that feeder. Each building with more than one branch circuit requires its own grounding electrode system. That means using everything that is available, such as metal underground water piping, steel in foundations in earth contact, or added electrodes if nothing else is readily available. Water piping must always be supplemented by another type of electrode, usually 2 ground rods.

Q. Why 2 ground rods? Isn't one enough?

A. For reasons no one quite remembers, the earth resistance of a ground rod must be proven (by a fall-of-potential test) to be no more than 25 ohms, or a second rod is required. The second rod is required to be at least 6 feet from the first one; ideally they should be 16 feet apart. They are bonded to each other with a #6 wire to form a grounding electrode system.

Q: If it was installed to code at the time of the construction, does it matter whether I have a 3-conductor or 4-conductor feeder?

A: It won't matter if your electrons are capable of reading the code. If, like most electrons, they prefer to follow the laws of physics, then see the answer to the second question on the previous page and look for the words "safety hazard."

Q: What is the code now for these second buildings?

A: A grounding electrode system at the second building or structure is required except when there is only a single branch circuit (which could be a multiwire circuit) and that single branch circuit contains an equipment grounding conductor. A grounding electrode system is always required when the second building has an electrical panel. The feeder to that panel must include an insulated neutral and an equipment grounding conductor. The subpanel in that second building needs to comply with the rules for a disconnecting means (up to 6 handles). The only differences between it and any other subpanel are (1) that it requires a disconnecting means, and (2) that the enclosure connects to a grounding electrode system. *In existing buildings only*, if there is no parallel metal path connecting the buildings, an existing 3-wire feeder can remain. It is treated like a service, including bonding the enclosure, location, rating of the panel as service equipment, and a grounding electrode system.

Q: Speaking of those parallel paths, what about a cable connection?

A: If that separate building has any sort of communications wiring from outside the building, such as cable TV or a land line phone, it must have an Intersystem Bonding Terminal at the disconnecting means for that building. The communications systems must all be bonded to it and it must connect to the grounding electrode conductor of the building, or directly to the enclosure of the disconnecting means. This rule applies even if the cable TV or other system connects directly from the provider without first going to the primary building.

Q: How did it get this way? Why is this topic so confusing to so many people?

A: The reason for confusion originates with the words we use to describe it, in particular the word "ground." We use the same word when we mean 3 different things. Electrical current does not "go to ground" – it travels in circuits back to its source. In terms of the electrical current in houses, that means it travels to and from the utility transformer. We want that current to travel on insulated paths. When it has other paths it can take, we have a problem. We accompany the current-carrying conductors with spare conductors that are normally not carrying current. We call those spare conductors "equipment grounding conductors" (though in reality they are bonding conductors). We connect (bond) those equipment grounding conductors to the metal enclosures of electrical equipment.

We also connect this whole system, and one of its current carrying conductors, to the earth. The code calls the conductor connected to earth a "grounded conductor" and in everyday parlance we call it a neutral. We connect it to earth to reduce electrical noise, help reduce lightning damage, and to limit the voltage from the utility. And *we only do it once* – at the first place where we can shut off the power that comes to a building from the electrical utility. If we do it a second time, we are inviting current to take other paths that are not insulated.

Early editions of the code used terms like grounds, ground conductors, circuit grounds, grounding, and ground wire without clarifying their meaning. The words "ground wire" no longer appear together in the National Electrical Code® (NEC). The terms that are used now help to explain the specific purpose of the wires: Grounded conductors, grounding electrode conductors, bonding conductors, and equipment grounding conductors.

This topic has confused the authors of the electrical code for a very long time. We have had a rule against re-bonding the neutral after the service since 1918, and we have had a rule against "objectionable currents" since that time. Because other parts of the code were not clear about what might cause these objectionable currents, it took a long time to straighten out. We didn't really get there until the 2008 NEC (effective in California as of January 1, 2011). The history below shows that for many code cycles, the code had inherent contradictions which added to the confusion on this topic.

A Brief Code History of Grounding & Bonding in Separate Structures:

1913 NEC: Grounding of system neutral becomes mandatory.

1918 NEC: Arrange to avoid "objectionable current."

1937 NEC: First modern format of the NEC, no mention of second buildings.

1940 NEC: Second buildings allowed to have grounding electrodes, neutral allowed to bond to it.

1947 NEC: Second buildings required to have grounding electrodes, neutral required to bond to it. An exception is allowed for structures with only one circuit and no equipment that requires grounding.

1971 NEC: Allowed to omit grounding electrodes at 2nd building if equipment ground run to the building and there are no livestock in the building.

1984 NEC: Grounding electrode conductor at 2nd building required again, with exception for building with only one circuit (back to the 1947 edition!). New rule allows the neutral to NOT be bonded if an equipment grounding conductor runs to the building. It doesn't prohibit bonding the neutral in such cases, nor does it require it.

1996: Tom Trainor, Connie Golovko, Chuck Mello, and George Anchales create test setup and publish their findings in the IAEI Journal Article "A Question of Current, Objectionable or Not."

1998: Tom Trainor heads task force to do global re-write of NEC Article 250

1999 NEC: Separate buildings or structures require a grounding electrode system except for those supplied by a single branch circuit that contains an equipment grounding conductor. Systems that have an equipment grounding conductor run with the feeder are not allowed to bond the neutral at the second building. Only the panel enclosure and equipment grounding conductors are bonded to the grounding electrode system. If there are no parallel metal paths between the two buildings, the feeder equipment grounding conductor can be omitted, and in such cases the neutral is bonded to the second building disconnect and to a grounding electrode system.

2008 NEC: The omission of the feeder equipment grounding conductor is no longer allowed in new construction. Existing buildings where no parallel path exists are allowed to continue with a bonded neutral 3-wire feeder only if there are no parallel paths and there is a grounding electrode system at the second structure.

Relevant sections in recent editions of the NEC:

225.30, 225.32, 225.33, 250.6, 250.24(A)(5), 250.32(A), 250.32(B)(1)

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