

2023 NEC Study Guide For “Grounding Electrode Systems”

(This Study Guide was prepared by Gaylord Poe)

Few things are more frustrating for an electrician than trying to figure out how the NEC rules for service grounding and bonding are going to be interpreted and enforced by the local electrical inspector. The purpose of this study guide is to explore and explain “my take” on some of the rules found in NEC Article 250.

1. **Grounding Electrode** – All electrodes that are present on the premises shall be bonded together to form the grounding electrode system. These electrodes include: metal underground water pipes (10’ in the earth or longer), the structural steel frame of the building (when properly connected to earth), concrete encased electrodes (typically re-bar), ground rings, ground rods & pipes, and ground plates. These items, when bonded together, form the grounding electrode system. Size the bonding jumpers for these electrodes from Art. 250.66. Steel beams used to support wood joists (typical residential) or steel joists spanning masonry walls should not be considered as grounding electrodes. The only time that a “made electrode” (rod, pipe or plate) is required is either 1. When there are no other electrodes, or 2. The only electrode present on the premises is a metal underground water pipe (Art. 250.53(D)(2)). If you have a combination of any of the electrodes outlined in Art. 250.52(A)(1)(2)(3)(4)(6)(7) or (8), a “made electrode” is not required. When a “made electrode” is installed it shall comply with Arts. 250.52(A)(5) and 250.53. *(For specific information on “made electrodes” see “Art. 250.53 (A) Rod, Pipe, and Plate Electrodes”. All “made electrodes such as rods pipes or plates shall comply with Art. 250.53(A) and (B))*
2. **Grounding Electrode Conductor** – The grounding electrode conductor shall be installed without splice or joint (except as permitted by Art. 250.64) from the service (see Art. 250.24(A)) to any convenient grounding electrode in the grounding electrode system. For example – if you have a metal underground water pipe, a concrete encased electrode (typically re-bar), and structural steel that qualifies as a grounding electrode (properly connected to earth), they shall be bonded together to form the grounding electrode system. The grounding electrode conductor can be run from the service to whichever electrode is convenient to the installer. (250.64(F)(1)). Because of the reduced conductor sizes to certain electrodes as permitted in 250.66, when determining a “convenient” electrode the main grounding electrode conductor is usually run to either the metal underground water pipe or the steel structure. *(It should be understood that when sizing the conductors for concrete encased electrodes (typically re-bar), ground*

rings, or ground rods that the reduced conductor size permitted by Art. 250.66 only applies when the reduced conductor is used solely for connection to each of these electrodes.).

3. Grounding Connections, General:

- **A metal underground water pipe** (10' in the earth or longer) can only be considered as a grounding electrode for the first 5 ft. of its length within the building. Art. 250.52(A)(1), 250.68(C)(1).
- **A non-metallic underground water pipe is not** a grounding electrode and the interior metal water piping that it supplies **is not** a grounding electrode and cannot be used as a means to connect other grounding electrodes together. However, this interior metal water piping must be bonded to the service in a manner specified in Art. 250.104(A).
- **A water meter** must be jumpered regardless of the location of the system's grounding or bonding connection to the metal water pipe. Art. 250.53(D)(1).
- **Transformers:** Even though a transformer is required to be grounded to a grounding electrode system in accordance with Art. 250.30(A) and 250.30(B), the metal water piping and other exposed structural metal **in the area served by the transformer** must also be **bonded** to the transformer in accordance with Art. 250.104(D)(1) & (2). This **bonding** conductor is a separate conductor from the required grounding electrode conductor.
- **Ungrounded Structural Steel:** Exposed structural steel that is not part of the grounding electrode system must be bonded to the service in a manner specified in Art. 250.104(C).
- **Ground Rods:** See Art. 250.53. "Single ground rod" installations are only acceptable if the resistance to earth of the ground rod is 25 ohms or less. (Art. 250.53(A)(2)(*Exception*) The NEC does not recognize a metal underground water pipe as being suitable for augmenting a single rod. If the resistance of a single ground rod exceeds 25 ohms to ground and the metal underground water line is the only other available electrode, an additional electrode must be installed. If this additional electrode is another ground rod, it must be driven at least 6' away. On jobs where a building or structure containing no available electrodes is supplied by another building, the grounding electrode (usually a ground rod) installed at the "second" building may be considered to be supplemented by the grounding electrode system at the "first" building via the installed equipment grounding conductor (**if of sufficient size**) between the buildings or the bonded neutral (existing

buildings only) at the “second” building. Note that the above rules apply to all “made electrodes” (rods, pipes, or plates - Art. 250.53).