Handout of additional information for
Lesson 7 and 8 Review
Lesson Basic Grounding
Based on the NEC 2014
The Temporary Service Inspection
Underground feed to meter

Neutral to service

Bonding screw in meter

Neutral

Line

Load

Meter enclosure not considered to be service equipment

Sch. 80 PVC
Photo 1. Here is a very small sampling of some of the devices designed for grounding connections. Please note the bottom right device will bond the grounding electrode conductor to an enclosure or raceway.

Photo 2. This shows a sampling of bonding jumpers that are provided by the factory for main bonding jumpers in panels.
RMC nipple from bottom of meter enclosure

2/0 Copper

200-amp over-current device and disconnect

N

Grounding electrode system

#6

#4

2 ground rods 6” apart
Q 1 NEC 250.52 and 250.104C

Bonding Exposed Structural Metal Section 250.104(C)

Structural metal that forms the building frame must be bonded to one of the following:

1. Service enclosure
2. Grounded service conductor
3. Grounding electrode conductor
4. Grounding electrode

Rule does not apply to metal framing members or metal skin of building.
Q 2  NEC 250.104C
In the early years of the *NEC*, concerns over the effect of electric current on metal water piping created some uncertainty as to whether metal water piping systems should be used as grounding electrodes. To address those concerns, the electrical industry and the waterworks industry formed a committee to evaluate the use of metal underground water piping systems as grounding electrodes. Based on its findings, the committee issued an authoritative report on the subject. The International Association of Electrical Inspectors published the report, *Interim Report of the American Research Committee on Grounding*, in January 1944 (reprinted March 1949). This report serves as part of the basis for the continuation of the practice of using metal water pipes as part of the grounding electrode system.
Q 11    Tossed Out-all answers could be right under certain installations
Is where we find the details on the installation of the grounding electrode conductor. Covered is how to secure and protect it, and depending on the size, it may need some physical protection such as a raceway. Please note that if protected by a metallic raceway, and the raceway isn’t continuous from the equipment to the grounding electrode, then the raceway must be bonded at each end to the grounding electrode, see 250.64(E). The reason for this is really pretty simple: the impedance of the conductor and the raceway are different and the current will travel at different speeds from one end to the other, so if they are not bonded and there is an air gap at one end or the other, it will arc. Repeated arcing will cause damage to the electrode conductor. It must be securely fastened to the surface on which it is carried and can be run through framing members. It shall be installed in one continuous length without a splice or joint; however, if it absolutely has to be spliced, there are four very specific ways to do it in 250.64(C). Remember this is a crucial element to the safety of the electrical system, and anytime we have a splice or connection we have created a possible failure point, so we try to avoid any conditions which may create a weak point.
Also please note 250.64(D), which has allowances for a single electrode and conductor to be tapped to serve several service-entrance enclosures located in close proximity to one another. Now for one of the key elements of the grounding electrode conductor — how do we size it? In Article 250.64(D)(2) we find that each electrode conductor is to be sized according to 250.66, and there we find that generally it is sized according to Table 250.66, which lists the size of the service conductors on the line side of a service and then shows us the size of the grounding electrode conductor. The sizing is based on the size of the conductors feeding the service, since we don’t have an overcurrent device on the service conductors. Refer to Table 250.66 and also review the notes, which cover the methods for multiple sets of conductors.
Now for three applications where we don’t need to use the table and that are covered in 250.66(A), (B) and (C): these deal with conditions where we have a single conductor which is the sole connection to the grounding electrode for rod, pipe, plate, concrete-encased and ground-ring electrodes. In these sections we find a new maximum size conductor requirement for each of these types of electrodes. For example, on a concrete-encased electrode you are not required to use a conductor larger than a 4 AWG copper conductor, no matter what the size of the service. I must caution you that if the design professional has designated a larger conductor, you would be obligated to follow his requirements. Remember that the code is a minimum and can always be exceeded.
(1) Bonding a metal water piping system is not the same as using the metal water piping system as a grounding electrode. Bonding to the grounding electrode system places the bonded components at the same voltage level. For example, a current of 2000 amperes through 25 feet of 6 AWG copper conductor produces a voltage differential of approximately 26 volts.

Where it is not certain that the hot and cold water pipes are reliably bonded through mechanical connections, an electrical bonding jumper is required to ensure that this connection is made. Judgment must be exercised for each installation. Isolated sections of metal water piping (such as may be used for a plumbing fixture connection) that are connected to an overall nonmetallic water piping system are not subject to the requirements of 250.104(A). The isolated sections are not a metal water piping system. The special installation requirements provided in 250.64(A), (B), and (E) also apply to the water piping bonding jumper.
NEC 250.104 (A)(2)

Due to increasing use of nonmetallic piping, such as plastic, metal water piping in multiple occupancy buildings may be isolated by plastic fittings and lengths of plastic pipe. Therefore, the metal water pipe of an occupancy is permitted to be bonded to the panel board or switchboard that serves only that particular occupancy. The bonding jumper, in this case, is permitted to be sized according to Table 250.122, based on the size of the main overcurrent device supplying the occupancy.
EXHIBIT 250.35 Grounding bushings used to connect a copper bonding or grounding wire to conduits. (Courtesy of Thomas & Betts Corp.)
**TABLE 250.66 Grounding Electrode Conductor for Alternating-Current Systems**

<table>
<thead>
<tr>
<th>Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors</th>
<th>Size of Grounding Electrode Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Copper (AWG/kcmil)</td>
</tr>
<tr>
<td>Copper</td>
<td>Aluminum or Copper-Clad Aluminum</td>
</tr>
<tr>
<td>2 or smaller</td>
<td>1/0 or smaller</td>
</tr>
<tr>
<td>1 or 1/0</td>
<td>2/0 or 3/0</td>
</tr>
<tr>
<td>2/0 or 3/0</td>
<td>4/0 or 250</td>
</tr>
<tr>
<td>Over 3/0</td>
<td>Over 250</td>
</tr>
<tr>
<td>through 350</td>
<td>through 500</td>
</tr>
<tr>
<td>Over 350</td>
<td>Over 500</td>
</tr>
<tr>
<td>through 600</td>
<td>through 900</td>
</tr>
<tr>
<td>Over 600</td>
<td>Over 900</td>
</tr>
<tr>
<td>through 1100</td>
<td>through 1750</td>
</tr>
<tr>
<td>Over 1100</td>
<td>Over 1750</td>
</tr>
</tbody>
</table>

Notes:
1. If multiple sets of service-entrance conductors connect directly to a service drop, set of overhead service conductors, set of underground service conductors, or service lateral, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.
2. Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.
3. This table also applies to the derived conductors of separately derived ac systems.
4. See installation restrictions in 250.64(A).
EXHIBIT 250.2 Use of a grounding screw to attach equipment bonding jumper to a metal box.
Section 250.50 introduces the important concept of a *grounding electrode system*, in which all electrodes that are present at a building or structure are bonded together, as illustrated in **Exhibit 250.22**. Rather than total reliance on a single grounding electrode to perform its function over the life of the electrical installation, the *NEC* requires the formation of a system of electrodes where multiple grounding electrodes are at the building being served. Metal structural members, metal water pipe, and concrete footings or foundations are found in many buildings and structures and are required to be integrated into the grounding electrode system if they qualify under the conditions specified in 250.52(A). The *Code* does not specify that metal water pipe, structural metal frame, or concrete-encased–type electrodes have to be installed, only that where they have been installed as part of the building construction they are to be used as components of the grounding electrode system. A system of electrodes adds a level of reliability and helps ensure system performance over a long period of time.