

## **GROUNDING - NEC 250**

Grounding is provided as a safety precaution. Nevertheless, it is not a guarantee that no electrical shock will occur. Sensation of electrical shock may occur with as little as 1 to 3 ma. Women and children are sensitive to values as low as three-fourths that amount.

### **Grounded - Neutral**

A current carrying conductor for alternating current systems is grounded under the noted conditions. The conductor is identified by white insulation.

1. Ground the neutral conductor to assure the maximum voltage on the ungrounded conductors does not exceed 150 volts.
2. Ground the neutral if the system is nominally rated 277 / 480Y, 3 phase, 4-wire.
3. Ground the mid-point of one phase used as a circuit conductor for a 120 / 240 volt, 3-phase, 4-wire system.

### **Grounded - Locations**

The current carrying conductor is grounded at the point of origin.

1. Separately derived systems (transformers, generators, converters ) must be grounded at the origin.
2. A single source supplying multiple systems must be grounded at the supply side of the disconnects.
3. Do not bond the neutral of a second breaker box or panel. Ground loops would result.

### **Grounding - Safety**

The grounding system does not carry current under normal operating conditions. It is a low impedance path for the flow of current to earth under extraordinary conditions. Non-current carrying metal parts must be bonded to ground if

1. Within 8' vertically or 5' horizontally of ground or grounded metal objects subject to contact.
2. Located in damp or wet locations and not isolated.
3. In electrical contact with metal.
4. Located in hazardous (classified) locations.
5. Operated with any line over 150 volts to ground.
6. Constructed with metal frames.
7. Connected by cord and plug.
8. Uses metal raceways and enclosures.

### **Equipment Grounding Conductor**

An equipment grounding conductor provides the bond between the metal and the ground. It may be one of these

1. Metal conduit, raceway, or enclosure.
2. Bare or insulated (green) wire contained in same raceway. Conduit enclosing a grounding conductor must be bonded.
3. The neutral when 2 hot lines are used in 3-wire non-metallic sheathed (NM) cable supplying appliances (ranges and dryers).
4. Liquid-tight flex in sizes of 1 1/4" or smaller, if less than 6 feet total length and if the circuit is protected for 20 amps or less.
5. Type MC metal clad cable.
6. Note: Structural steel is not permitted for use as an equipment grounding conductor.

### **Grounding Electrode Conductor**

The conductor bonds the service equipment enclosure, the system grounded circuit conductor (neutral), and the equipment grounding conductors (safety) to all the grounding electrodes.

### **Grounding Electrode - Acceptable**

A grounding electrode is the electrical point of contact with earth. Acceptable electrodes have a priority of selection.

1. Bond to a metal cold water pipe in direct contact with the earth for at least 10 feet. If available, this must be used. Additional electrodes may be required.
2. Bond to the nearest available grounded structural steel imbedded in earth or in buried concrete.
3. Construct concrete encased electrode(s) consisting of at least 20' of 1/2" steel rebar or #4 AWG copper or larger.
4. Construct a ground ring at least 2-1/2 feet down using at least 20 feet of #2 AWG copper.

### **Grounding Electrode - Made**

Made electrodes are constructed for electrical contact with the earth.

1. Use underground bare metal gas pipe, tanks, and casings.
2. Use non-corrosive rod (5/8"+) and pipe (3/4"+) electrodes at least 8' long. Drive the electrode. If rock is encountered at less than 4 feet, bury the rod below permanent moisture level.
3. Plate electrodes must have at least two square feet of exposed surface.

### **Resistance - NEC**

Made electrodes for power circuits must have a resistance to ground of less than 25 ohms. Use additional electrodes to reduce the resistance. Separate the electrodes by at least 6 feet. The desired distance is 2.2 times the length of the electrode. A triad arrangement is one of the preferred configurations.

Lightning rod grounds are not used in lieu of other made electrodes.

### **Resistance - Lower Concerns**

A 25 ohm ground circuit is *inadequate* for most personnel and electronic protection systems. As an example, assume a 120 volt circuit comes in contact with a ground path of 25 ohms. The current flow will be  $I = 120 \text{ V} / 25 \text{ ohm} = 4.8 \text{ amp}$ . This will not trip a 20 Amp circuit breaker. So the line and the ground will be continuously energized.

Many personnel safety guidelines suggest a resistance of less than 5 Ohms. Lower than 2 Ohms is preferred.

For protection of electronics and other sensitive devices, the goal for the ground systems is near 1 ohm or less.