Office of Compliance

fast facts

advancing safety, health, and workplace rights in the legislative branch

Electrical Impedance Hazards

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Impedance, in very simple terms, is resistance occurring in AC (as opposed to DC) electrical circuits. The degree of resistance is measured in units called ohms. The lower the impedance, the easier it is for electricity to flow through an object. If electricity can follow either a path with low impedance, such as a ground circuit, or high impedance, such as a person with dry hands, then the majority of the electricity will follow the path with low impedance. Electrical circuits are made up of several different parts. Impedance can occur in the hot wire portion of a circuit, the neutral side of a circuit, or in the ground conductor wiring portion of a circuit. This Fast Facts focuses on ground wiring circuits typically found in wall outlets (namely circuits that are 115 volts AC with between 15 and 20 amps of current). More specifically, it will examine the grounding conductor, located inside an electrical outlet, and the portion of the circuit between the outlet and the panel board or breaker box.

Grounding Conductors

Grounding conductors have very low impedance. Many electrical devices such as motors, ovens, and computers are designed so that if a fault (short) occurs and energizes something that is not meant to be energized, such as the frame of a computer monitor, then an employee would not be shocked by touching the energized object. To prevent electrical shocks or electrocutions, electrical equipment designers install ground circuits in products. The grounding circuit (or "third wire" on electrical plugs) safely conducts the unwanted fault current to ground. Instead of shocking the person touching the energized object, most of the current follows the low resistance path to ground.

Figure 1: Impedance Tester

The Path of Least Resistance

The cliché about electricity following the path of least resistance is incorrect. Electricity will follow all paths back to the source, but it will follow paths proportionally according to the conductivity of each path. When wall outlet ground circuits have very low impedance compared to a person in contact with an energized object, they can safely convey high current away from a faulty electrical device and trip the circuit breaker or fuse in most instances (See figure 1). However, when impedance increases even slightly, the electrical current seeks other paths to ground other than the path contained in the grounding circuit of a wall outlet, such as through a person in contact with an energized surface. Different factors can influence whether an employee may receive a serious shock when touching an energized device. Wet hands can lower a body's impedance. As a result, a person's body can become a better electrical conductor than a wall outlet ground circuit with higher impedance, and the person could receive an electrical shock. As the current going through a person's body increases, so does the potential for serious harm. Studies have shown that as few as 10 milliamps on a 115 volt system can stop a person's heart.

Causes of Impedance

What causes impedance problems on a grounding circuit? On Capitol Hill, we have found that a poor contact between two electrical conductors is usually to blame. This occurs most often at the outlet itself. Sometimes the screw fastening the ground wire conductor in the receptacle needs to be tightened. Sometimes the outlet itself is broken or worn so much that it needs to be replaced (See figure 2). Sometimes the screw fastening the ground wire in the breaker box needs to be tightened. In rare cases, the distance between the breaker box and the outlet is too great and needs to be shortened by re-wiring the outlet to a closer box. Aluminum wiring, as opposed to copper wiring, can readily lead to impedance problems. Fortunately, aluminum wiring is no longer used in Legislative Branch buildings.

OSHA's electrical regulations require that circuits that could be used on sensitive electrical equipment, such as computers, should have an effective ground with sufficiently low impedance. *See* 29 CFR 1910.304(b)(2)(ii); *see also* 29 CFR 1910.399 (defining same). The most recent National Electrical Code defines "effectively grounded" as "connections of sufficiently low impedance and having sufficient current carrying-capacity to prevent the building up of voltages that may result in undue hazards to connected equipment or to persons." OSHA uses the same definition. Electrical safety engineers have calculated that impedance levels in ground circuits must remain less than 1 ohm. Commercial testing equipment is available for measuring the amount of impedance in electrical receptacles. Inspections identify outlets with ground impedance levels higher than 1 ohm as potential safety hazards that need attention from a qualified electrical technician.

Figure 2: Broken Outlet

fast stats

- In 2007, the Bureau of Labor Statistics reported that 1,100 people in the US suffered burn injuries due to electrical hazards.
- During 2007, the Bureau of Labor Statistics also reported that 1,480 people suffered electrical shock injuries.
- The National Institute for Occupational Safety and Health (NIOSH) reports that electrocution is the third leading cause of worker fatalities in the United States.

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