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Ground Fault Protection for Electrical Tools

Effective electrical tool and equipment grounding are extremely important on construction sites. Injuries and deaths can result from the improper grounding of tools or from ground fault currents. Ground fault circuit interrupters have been developed to protect users from the hazards of poorly insulated or defective electrical tools. This report outlines suggestions on safeguarding against potential electrical hazards when using tools.

As a source of power, electricity is accepted without much thought to the potential hazards one can encounter. Electric shock is the chief hazard from electrically powered tools. Types of injuries include electrical flesh burns, minor shock that may cause falls, and shock that results in death. It is possible for a tool to operate with a defect or short in the wiring. The use of a ground wire helps protect the operator from a defect or short and is mandatory for all but double-insulated electrical power tools. A ground fault circuit interrupter (GFCI) should be used with all electrical power tools.

The primary peril when using an electrical tool is exposure to a flow of current. The principal hazard is defective insulation. A voltage difference across the human body is necessary for shock to occur; however, the resultant current flow causes bodily injury. A GFCI does not prevent shock, it limits the duration of the shock so the heart is not affected. There are three types of body reactions to current flow. [1]

- Below one milliampere (.001 ampere)—This level may be felt as a slight tingle and normally causes no injury. However, a sick person, particularly one with a coronary condition, may be injured by a current 1/100 of this value.
- "Let-go" current is the maximum current at which an individual grasping a conductor or tool can release it by using the muscles directly affected by the current. "Let-go" current is about 16 milliamperes for men and about 10 milliamperes for women. This level of current does not normally damage human tissue.
- Lethal currents for healthy persons may be as low as 18 milliamperes. When current at this level, or higher, flows through the chest cavity, the chest muscles may contract and could cause breathing to stop. If the current is maintained, unconsciousness and death will result. Ventricular fibrillation is another potentially lethal result of shock. In this case, the heart ceases its rhythmical pumping action and feebly quivers to effectively stop blood circulation.

Ground Fault Circuit Interrupters

Ground fault circuit interrupters (GFCIs) were developed to provide protection for users of electrical equipment, and have become an integral part of many electrical tools. They are similar in function to circuit breakers (both interrupt the flow of power), but there is one

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very significant difference; circuit breakers are designed primarily to protect property while GFCIs are used to protect people.

A typical circuit breaker or fuse is normally set to open a circuit when the current in the circuit exceeds 15, 20, or more amperes. Circuit breakers are set at values that prevent an electrical device from overheating, thereby preventing fires and protecting property. They are not intended to protect the operator of the device from electrical shock. A person exposed to as little as 0.018 amperes of current may be seriously injured, and such a current would not cause the circuit breaker to open.

Types of Exposures

When an electrical tool is functioning properly, all the current that flows into it should also flow out of it through intended paths. When an electrical fault or "leak" develops, the return current is less than the current supplied. The difference is "leakage current" that flows to ground through some unintended path.

Output Current = Input Current Minus Leakage Current.

Ideally, leakage current should always be zero, but a small fraction of a milliampere is permitted by most electrical standards.

A GFCI is used to open a circuit (within as little as 1/40 of a second) when a relatively small amount (five milliamperes) of current strays from its intended path. A typical electric circuit consists of a "hot" conductor that supplies power to the electrical device, the electrical device itself, and a return conductor. Ideally, all the current that enters the "hot" conductor should flow through the electrical device and then into the return conductor. However, if some of the current "leaks" out of either of the conductors or the device, and makes contact with the user, it can cause serious injury. The cause of the "leak" is usually defective insulation. The GFCI detects this "leakage" and de-energizes the circuit.

However, the GFCI will not protect the worker from line-to-line contact hazards such as a worker holding two "hot" wires or a hot wire in one hand and a neutral wire in the other hand. It does provide protection against the most common form of electrical shock hazards—the ground fault. It also provides protection against fires, overheating, and destruction of insulation on wiring.

GFCI Types/Usage

The common types of ground fault circuit-interrupters that are available are as follows:

Circuit Breaker/GFCI Type

Located at the power supply or in a circuit breaker panel controlling all outlets in a circuit. The circuit breaker GFCI serves a dual purpose—not only will it shut off electricity in the event of a "ground fault," but it will also trip when a short circuit or an overload occurs. Protection by the GFCI covers the wiring and each outlet, served by the branch circuit.

Receptacle Type

This type of GFCI is used in place of a standard duplex receptacle. It fits into the standard outlet box and protects against "ground faults" whenever an electrical tool is plugged into the outlet. Receptacle-type GFCIs can be installed so that they also protect other electrical outlets in the branch circuit. All GFCI circuitry is contained in the unit.

Portable Type

Where permanent GFCIs are not practical, portable GFCIs can be used. One type contains the GFCI circuitry in a plastic enclosure with plug and receptacle slots in the front. It can be plugged into a standard receptacle; then, the electrical tool is plugged into the GFCI. Another type of portable GFCI is an extension cord combined with a GFCI. It adds flexibility in using receptacles that are not protected by GFCIs.

The most convenient GFCIs used on construction sites are the portable type. It allows protection and ease of movement for workers going from one location to another. All GFCIs should be checked and returned to their proper storage location at the end of the day.

Preventing and Eliminating Hazards

GFCIs can be used successfully to help protect against electrical hazards on construction sites. Tripping of GFCIs—interruption of current flow—is sometimes caused by wet connectors and tools. It is good practice to limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors. Providing additional GFCIs with shorter cords can prevent tripping caused by the cumulative leakage from several tools or by leakages from extremely long circuits.

Safety and Testing Standards

OSHA construction industry standards 29 CFR 1926/1910 Subpart K (1926.400-408) [7] states that all electrical work installation and wire capacities should be in accordance with the National Fire Protection Association, *National Electrical Code*, (ANSI/NFPA 70) [4], and the *Standard for Electrical Safety Requirements for Employee Workplaces*, (NFPA 70E) [5], unless otherwise noted.

General

OSHA ground fault protection rules and regulations are mandatory. [7] The contractor must provide either: (a) ground fault circuit interrupters on construction sites for receptacle outlets in use and not part of the permanent wiring; or (b) a scheduled and recorded assured equipment grounding conductor program (AEGCP).To assure maximum job site protection, the contractor should provide both. These requirements are in addition to any other requirements for tools or equipment grounding conductors. Some recommendations are as follows:

Ground Fault Circuit Interrupters–All 120-volt, single phase, 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring and that are used by workers, should have approved ground fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the frame and all other grounded surfaces, need not be protected with ground fault circuit interrupters.

Assured Equipment Ground Conductor Program (AEGCP)–Contractors are responsible for establishing and implementing an assured equipment grounding conductor program on construction sites. The AEGCP covers all cord sets, and receptacles which are not part of the permanent wiring, and equipment connected by cord and plug which are available or used by workers. This program should comply with the following minimum requirements:

- The program must be in writing and include the specific procedures adopted by the contractor. It must be available at the job site for inspection and copying by regulatory compliance officers and any affected worker.
- There must be at least one competent person assigned to implement and be responsible for the program (29 CFR 1926.32(f)). [7]
- Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, (except cord sets and receptacles which are fixed and not exposed to damage) should be visually inspected before each day's use. They are to be checked for external defects, such as deformed or missing ground pins or insulation damage, and for indication of possible internal damage. Plugs should be of the heavy duty type, and approved for use in damp conditions. Cords can only be used in continuous lengths without splices. When different voltages, frequencies, or types of current (ac or dc) are supplied, receptacle and plug configurations should also be designed so they are not interchangeable. Equipment found damaged or defective must not be used until repaired, and should be tagged as unusable before removal from the construction site.
- All equipment grounding conductors must be tested to assure continuity, and each receptacle and attachment cap or plug should be tested for its correct attachment on all cord sets and receptacles which are not part of the permanent wiring, and on cord and plug connected equipment required to be grounded.
- All required tests should be performed: before first use; before equipment is returned to service, following any repairs; after any incident that could reasonably be suspected of having caused damage; and at intervals not greater than 3 months. Cord sets and receptacles that are fixed and not exposed to damage are to be tested at least every 6 months.
- The contractor should prohibit the use by workers of any equipment that does not meet the requirements of the AEGCP.
- The tests that are required by the AEGCP must be recorded. This record should include and identify each receptacle, cord set, cord- and plug-connected equipment that passed the test, and should indicate the date of the test or the interval for which it was tested. This record should be kept by means of logs, color coding, or other means, and kept up to date. The record should be available on the job site for inspection.

It should be noted that OSHA recognized the important role of NFPA's *National Electrical Code* (NEC) in defining electrical safety requirements and has updated, simplified, and clarified *Subpart K–Electrical 29 CFR 1926/1910*. [7] The revisions serve these purposes:

- NEC requirements that directly affect workers in construction have been placed in the text of the OSHA standard, eliminating the need for the NEC to be incorporated by reference.
- Certain requirements that supplemented the NEC have been integrated in the new format.
- Performance language is utilized, superfluous specifications omitted, and changes in technology accommodated.

The most widely used standards for testing GFCIs are published by Underwriters Laboratories Inc (UL): UL 943, *Ground Fault Circuit Interrupters* and UL 943A, *Leakage Current Protection Devices*. [9,10] The standards list two classes of units:

- Class A—Units that will function when the leakage (fault) current is 6 milliamperes or more.
- Class B—Units that will function when the leakage current is 20 milliamperes or more.

This standard requires that a GFCI must be provided with a test circuit that will allow for periodic, convenient testing of the ability of the device to trip in response to a ground fault.

Suggested Safety Procedures/Guidelines

The following selected items are guidelines for electrical safety procedures:

- All tools and equipment should be kept clean and in good repair. Manufacturer's instructions for use and maintenance of electrical power tools should be followed. When electrical defects are noted, they should be corrected promptly.
- Follow the manufacturer's instructions regarding the testing of a GFCI. Any unit found to be defective, should be immediately replaced.
- The non-circuit metal parts of portable and/or plug-connected equipment should be grounded.
- Portable tools and appliances protected by an approved system of double insulation, or its equivalent, need not be grounded. However, such equipment should be distinctively marked.
- The electrical grounding path from the metal parts of circuit enclosures, equipment, and structures to ground should be permanent and continuous.
- Extension cords should be carefully selected (never spliced or frayed) so they are capable of handling the intended load. They should also be located so that they are not a tripping hazard to workers.
- When an electrical tool functions intermittently, the cause may be due to a defect in the tool or a problem in the electrical system. When this occurs, the tool should be brought to a qualified electrical technician for repairs. Only qualified technicians should work on the electrical system and the circuit should be de-energized before repairs are attempted.

References

1. American Insurance Services Group. Engineering and Safety Service. *Ground Fault Circuit Interrupters*. Product Safety Report PS-45-10. New York, NY: AISG, 1998.
2. —. Engineering and Safety Service. *Hand and Portable Power Tools*. Construction Management Report CM-60-02. New York, NY: AISG, 1995.
3. —. Engineering and Safety Service. *Temporary Electrical Wiring*. Construction Management Report CM-70-03. New York, NY: AISG, 1995.
4. National Fire Protection Association. *National Electrical Code*. NFPA-70. Quincy, MA: NFPA, 1997.
5. —. *Standard for Electrical Safety Requirements for Employee Workplaces*. NFPA 70E. Quincy, MA: NFPA, 1997.
6. National Safety Council. *Accident Prevention Manual for Business and Industry*. 10th Ed. Chicago, IL: NSC, 1992.

7. Occupational Safety and Health Standards, OSHA. *Construction Industry*. Washington DC: The Administration, 1993, *OSHA 29 CFR 1926/1910, Subpart C–General Safety and Health Provisions (1926.20–1926.32) and Subpart K–Electrical GPO (29 CFR 1926.400 through 408)*.

8. —. *Ground Fault Protection on Construction Sites*. OSHA-3007. Washington, DC: GPO, 1989.

9. Underwriters Laboratories Inc. *Ground Fault Circuit Interrupters*. UL 943. Northbrook, IL: UL, 1996.

10. —. *Leakage Current Protection Devices*. UL 693A. Northbrook, IL: UL, 1996.

11. United States Consumer Product Safety Commission. *Ground Fault Circuit Interruption (GFCI)*. Product Safety Fact Sheet No. 99. Washington, DC: CPSC, 1991.

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