

# GROUND CLAMPS

*critical*  
*safety components*

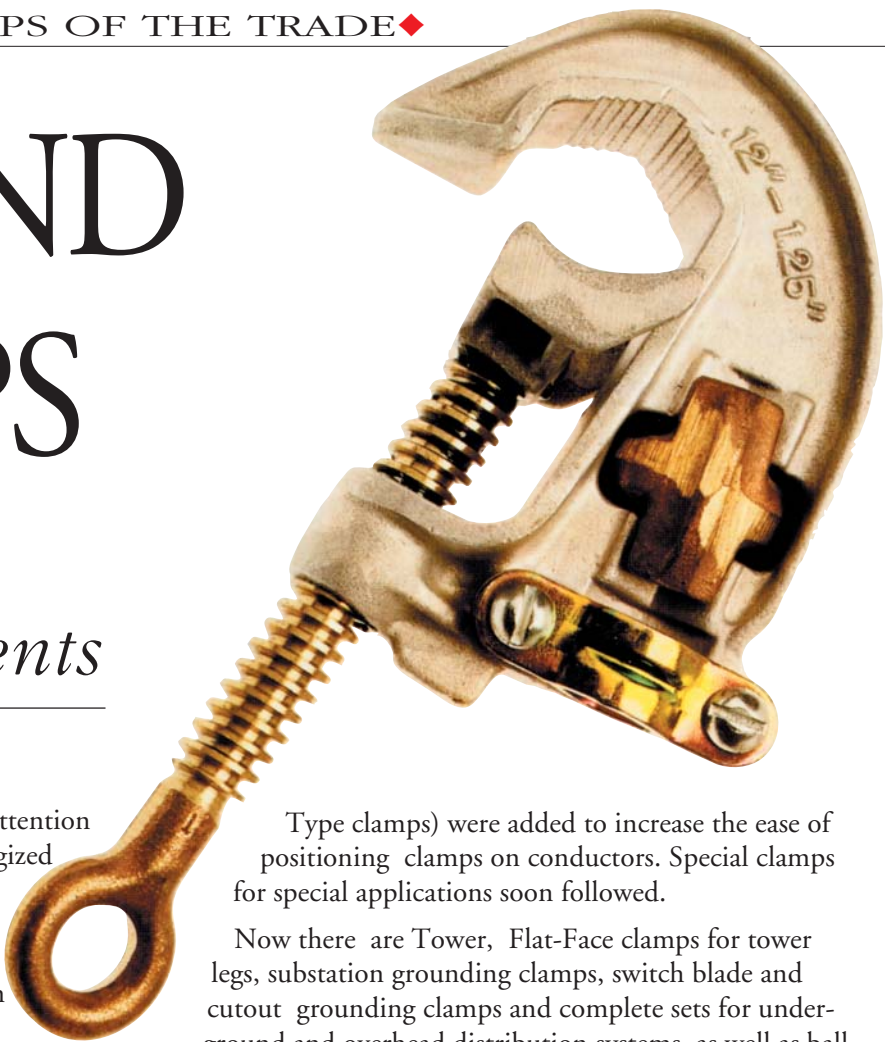
Utilities have been paying increased attention to protective grounding on de-energized lines to maximize worker safety. Stringent laws and regulations, industry standards and product liability litigation have all contributed to the attention safe grounding is receiving.

January 31, 1994, the Occupational Safety and Health Administration (OSHA) issued the document 29 CFR 1910.269 Subpart R. This all-encompassing document covers all aspects of work on or near power lines. The Institute of Electrical and Electronic Engineers (IEEE) has also undertaken the preparation of several new documents dealing with the application of grounds and to provide recommended procedures for their use. In parallel action the American Society of Testing and Materials (ASTM) is revising the ASTM F855 standard which specifies the minimum performance of the equipment used in grounding. At utilities, work practices and requirements are being reviewed to ensure conformance with the actions of OSHA, IEEE and ASTM. In short, grounding safety is getting plenty of attention across the board.

## PURPOSE AND DESCRIPTION OF GROUNDING CLAMPS

Grounding clamps form the interface or connection between the parallel installed low resistance grounding cable, and the conductor being serviced. They are an integral part of the worker's safety equipment.

Clamps for protective grounds come in several styles and sizes for a variety of uses. Originally the form was the basic C-Type clamp. Later spring-loaded (Duck Bill-



Type clamps) were added to increase the ease of positioning clamps on conductors. Special clamps for special applications soon followed.

Now there are Tower, Flat-Face clamps for tower legs, substation grounding clamps, switch blade and cutout grounding clamps and complete sets for underground and overhead distribution systems, as well as ball and socket clamps (a ball and socket stud can replace a ½" bolt in the NEMA pad of a switch to provide a permanent grounding attachment, or to a truck body). Some clamps come with threaded eyescrews for installation by hot line Grip-All hot sticks. Others have threaded T-handles for hand application to towers.

Other components forming this protective system include flexible grounding cable, a pair of crimp ferrules and a conductive pole cluster.

Typically, a worker forms a near equipotential zone in which to work by connecting one clamp to the conductor overhead, and another clamp to a conducting pole band below the worker's feet. Sufficient grounds are needed to connect all de-energized conductors at the work site.

Clamps and associated hardware are divided into grades based upon maximum fault-current duty. For example, a grade 5 clamp with AWG 4/0 cable must withstand 43,000 amperes for 15 cycles without losing its conductive protection of the worker. Maximum mechanical requirements are also specified.

Clamps with ferrules are highly recommended when protective grounding is used. Cable directly placed under pressure terminals works well when new, but as corrosion

builds up on individual strands, the resistance increases. The heat from a high-current fault is sufficient to burn the cable and separate it from the clamp thereby eliminating worker protection. That's why the extra protection given by crimped ferrules is important to safety.

#### THEORY OF OPERATION

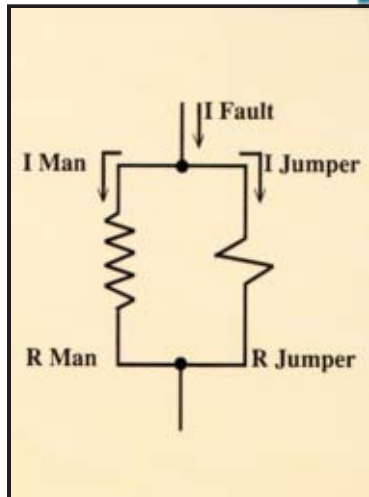
Charles Dalziel, a prominent researcher, statistically determined that the smallest current detectable by the human body was 1.2 milliamperes. The threshold of pain begins about 9 milliamperes and the let-go threshold at 16 milliamperes. He further determined that the threshold of heart fibrillation was dependent not only on current amplitude, but also on the duration of current flow and body weight. He found that 99.5 % of the workers receiving shocks would not go into heart fibrillation if the current was below the level determined by the equation:

$$I = k / \sqrt{t}$$

When a line worker faces fault current in the thousands of amperes at a work site, maintaining a flow in the milliampere range through the worker presents a major challenge.

Only two methods exist to maintain a safe current level in the normal work situation. One is to prevent the passage of current through the body. This means insulating or isolating the worker from the line. But, this is usually impractical for a worker on a pole.

The second option is to provide a parallel path around the worker with such low resistance that all but a minor amount of current passes through the parallel path. A frequently used value of body resistance is 1,000 ohms. This requires the parallel path to have a resistance measured in milliohms.



## USER RESPONSIBILITIES

Get the guidance you need for selecting and using protective equipment by consulting the various standards provided. Documents are available for equipment selection (ASTM F855), substations (IEEE 80), line construction (IEEE 524A), line maintenance (IEEE 516), application of grounds (IEEE 1048), protective grounds for use in substations (IEEE 1246).

At this time, there is some confusion within the industry because there is no universally accepted or mandated maximum allowable body current, amount of time current can flow and level of protection to give workers. These values must be chosen by each utility. The utility must then decide upon the style, grade and work rules for the use of protective equipment. Based upon these decisions, proper equipment can be selected and a workable grounding protection plan established.

## PROCEDURE

Before beginning work, test to see if the de-energized line is truly "dead". Once it is determined the line is dead, begin by installing a ground end clamp to an appropriate ground using an insulated Grip-All clampstick or with rubber gloves. The line-end clamp should then be installed on a conductive pole band. The pole band provides a conductive connection point for use with multiple clamps and a convenient parking location for clamps during installation. Additional protective grounds are then installed from the pole band to each conductor beginning with the closest one. The worker must remain clear of the conductors during this in-



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stallation. If the pole has a down wire present, it may provide an alternate low resistance path through the worker's body until all the safety equipment is installed. Metal poles or towers can be grounded directly to the conductor without the pole band. Steel poles may require a pole band.

Neutral conductors provide excellent low resistance return paths for fault current. Both the neutral and static wires should be involved in the protective procedure when they are available. The more return current paths provided, the less current available to flow through the worker in case of an accidental energization. Removal of the grounding equipment is done by reversing the installation procedure always remaining clear of conductors.

Procedures must be altered slightly for different work methods. For example, working from an insulated bucket truck, or from a metal boom digger derrick-type vehicle requires that protective jumpers be used also. Bonding all the phases together and to the bucket develops the needed equipotential zone. For work from the bucket on a metal boom digger-derrick type vehicle, the conductor must be bonded to the metal at the boom tip, otherwise the main current path may be through the worker and truck to ground.

In each situation the key to safety is to provide a parallel path of sufficiently low resistance so most of the current flows around the man. The maximum voltage that can be developed across the man is the product of current through the parallel protective ground multiplied by its resistance. (Ohm's law).

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## SUMMARY

A key element, sometimes overlooked in grounding, is the need to regularly inspect and test protective ground equipment. Loose ferrules and corrosion in the contact points can result in high resistance points that increase the resistance of the grounding set. When dealing with currents measured in thousands of amperes, a few milliohms resistance may make the difference between protection and injury or death.

For example, if it is desired to maintain a maximum of 100 volts across a worker whose body resistance is 1,000 ohms during a fault with 10,000 amperes available, a parallel protective ground resistance of 10 milliohms or less is required. A loose or corroded connection between the crimp ferrule and the clamp body may increase the ground's resistance to 50 milliohms. This small increase in resistance allows the voltage across the worker to reach 500 volts during the same fault condition.

Fortunately, resistance of the set can be measured. If there is a problem, the set can be disassembled, cleaned, and the ferrules reapplied. Broken cable strands at the point where the cable exits, the ferrules are a common problem. A manual inspection can usually detect if significant strand breakage is present there or elsewhere in the cable.

With stringent binding regulations governing worker safety now in place, correct selection and training in the use of and maintenance of protective grounds takes on new significance for each utility, contractor and tree-trimming operation. ■



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