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| ***REPLACE WITH YOUR MASTHEAD*** |
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| **ABC Fire Department General Operating Guideline** |

**Electrical Surge Protection – Grounding**

***This is a sample of a standard operating guideline (SOG) on this topic. You should review the content, modify as appropriate for your organization, have it reviewed by your leadership team and if appropriate your legal counsel. Once adopted, make sure the SOG is communicated to members, implemented and performance monitored for effective implementation.***

**Policy:**

To establish a best practice for electrical surge protection (grounding) to protect critical facility infrastructure.

**Background:**

From dispatching and radio equipment, to computers and smart phones, electronics and electrical equipment are becoming more critical to an emergency service organization’s (ESO) ability to provide service to their community.

Many organizations have upgraded their training and recreation rooms to include state-of-the-art audio-visual equipment and incorporated computers, printers, copiers, radio equipment and other sensitive electronic equipment in to their stations. Shorelines are common for keeping electrical equipment on apparatus charged and ready to go. This connection makes the equipment and other on-board electronics (i.e. computer circuitry) susceptible to damage from electrical surges within the station.

Over the years, many ESOs have made significant upgrades to electronic equipment. However, many ESOs may overlook evaluating their grounding systems when systems are enhanced. Properly designed grounding systems help to protect personnel and equipment from electrical surges. This guideline addresses three key areas of grounding: Earth-Ground Systems; Interior Grounding Systems; and Single-Point Grounding.

**Procedure:**

**Grounding Basics**

The term “ground” may be confusing, as it is used to describe not only a connection to a grounding system, but also the earth-ground itself. For purposes of this communiqué, the term earth-ground will be used when referring to the system of conductive elements placed in direct contact with the earth. An earth-ground provides a means to dissipate fault currents or transient voltage (surges). The term ground, will be used when referring to components of the system above grade (noun) or connecting to that system (verb). A typical grounding system includes conductors above grade with connections to transmit excess current to the earth-ground. Properly designed, installed and maintained, a grounding system helps protect sensitive electronic equipment from electrical surges.

A key concept in this process is effective transmission of unwanted electricity to ground. For a grounding system to be of value, a desirable (to the electric current), easy path for the fault or excess current to follow is necessary. In electrical terms, the desirability of a path is described in terms of resistance (Ohms). A desirable path has low resistance. The higher the resistance, the less desirable the path becomes.

Resistance is a function of the material, its diameter and length and shape. Good conductors are materials with low resistance while poor conductors (insulators) are materials with high resistance. Sharp bends (less than an eight-inch radius) may also increase resistance. Electricity flow causes heat generation and the higher the resistance the greater the heat generation.

A good grounding system uses suitably sized conductors (for the distance the current needs to be transmitted) and avoids sharp bends. Long runs, small wiring size, sharp bends and poor connections make for a poor grounding system. Not only could this put sensitive equipment at risk but it may also allow for heat buildup that can damage wiring and pose a fire hazard.

**The Earth-Ground System**

The earth-ground system is the interconnected (bonded) grounding electrodes in contact with the earth. This system may be as basic as a single-driven rod at the electrical service entrance. In other cases, it may be a complex configuration with ground rods and wiring with radials that spread out from the building and nearby structures (such as a communication tower). If the earth-ground system does not have sufficiently low resistance, then other surge protection efforts related to it will be severely limited or fail. The National Electrical Code (NEC) specifies that a building’s power service entrance should have an earth-ground connection (ground rod) with a resistance to ground of 25 Ohms or less. The Institute of Electrical and Electronics Engineers (IEEE) Green Book recommends that the ground resistance be less than 5 Ohms, as do most standards used by equipment companies/installers such as AT&T and Motorola.

The resistance of the earth-ground system is dependent on the resistance of the soil from the electrode out. Soil resistance can vary greatly. It is a function of the electrolytes (minerals and dissolved salts), moisture level and particle size of the soil. Moisture content assists in electrolyte exchanges and while electrolyte levels generally take a long time to change, moisture levels can change rapidly and the effect on resistance levels can be dramatic. It is recommended to use qualified electrical, telecommunication or surge protection companies to complete soil resistance level testing. Where an earth-ground system is already in place, measuring the resistance level of the system is recommended. An evaluation of the soil may aid in finding a way to lower the resistance where high resistance levels are found.

Potential solutions for high resistance levels include:

* Digging deeper (moisture levels are more stable at greater depths).
* Enhancing the soil electrolyte level with a chemical leaching system.
* Adding conductive filler material around the electrodes and wiring.
* Increasing the amount of surface contact with the soil (through use of more ground rods, grounding plates and/or wiring).

An evaluation of the soil type and resistance levels will help provide important information for developing or improving a low-resistance earth-ground system. Making use of a qualified company with experience in surge protection may help prevent additional costs associated with random, unsuccessful efforts to reduce the resistance.

**Interior Grounding Systems**

In most structures there are two types of grounding systems connected to the earth-ground. The first is the power distribution ground and the second is the telecommunication equipment (T/E) ground.

The power distribution ground helps provide protection for the incoming AC power service, service entrance equipment, sub-panels and conductors that supply power to the machinery and equipment within the facility. The main function of this ground is to provide an alternate means for current to return to the neutral in the event of a short. This allows the fuse to blow or circuit breaker to trip, thereby protecting property and personnel. A secondary function of this ground is to provide a path to the earth-ground system for excess current, such as from a lightning strike or utility switching (power surge).

The National Electrical Code (NEC) provides guidance on power distribution ground systems. Per the NEC, the neutral and ground wire must be bonded at the service entrance. It specifies that the building’s service entrance should have an earth- ground connection (ground rod) with a resistance to ground of 25 Ohms or less. The NEC allows for driving a second ground rod if the 25-Ohm level cannot be reached with a single rod. Testing or confirmation of the 25-Ohm level is not required in this situation. Although not required by the NEC, it is strongly recommended to perform testing in order to confirm the earth-ground resistance is 25 Ohms or less when sensitive electrical equipment is present.

The telecommunication/equipment (T/E) ground provides protection for signal transmission lines (phone, coax and Ethernet cable) and conductive equipment components (radio and computer housings, equipment racks and cable trays, etc.), which may enclose or are located adjacent to energized conductors. The main function of this ground is to protect the equipment from electrical surges due to lightning or surges. It may reduce the negative effects of electromagnetic noise on equipment performance. It is suggested that, for optimal performance, use single connections from signal line-surge protection devices (SPDs), components, racks and cable trays to the T/E ground, avoiding “daisy-chaining” between equipment.

Unlike power distribution grounding systems, regulation relating to T/E grounding systems is spotty. T/E grounding may not even be part of the installation process unless required by the equipment manufacturer or installer. Motorola’s R56 Standard provides guidelines for T/E grounding. This standard calls for ground resistance levels of 5 Ohms or less.

**Single-Point Grounding**

The NEC requires single point earth-ground systems. The reason: the use of multiple earth-ground systems can lead to electrical current flowing through the grounding system and into the building, putting people, property and equipment at risk. Typically, the grounding connection at the electrical service entrance is the one used for the single point connection to the earth-ground system.

One reason for single-point grounding with an effective earth-ground system is the danger of ground potential rise (GPR) with multiple earth-grounds. GPR is a rise in the electrical potential of the grounding system usually related to a lightning strike or other high voltage event at or near the facility. When an effective single-point earth- grounding system is in place, this change in electrical potential rises and falls uniformly (there is no current flow). If there are remote grounds on a signal line (e.g., cable TV or other coax lines, telephone, supervisory control and data acquisition) or multiple earth-ground connections, then electrical current may flow through the ground line into and out of the building toward the other earth-grounds. This could damage or destroy any equipment on the path the current follows.

This type of damage may occur even where surge protection devices (SPDs) protect equipment. Most SPDs are shunt devices. By design, shunt devices protect equipment and personnel from incoming electrical surges on normal conductors by sending it out through the grounding system. They are not effective against surges coming in through the grounding system, which is what occurs with GPR.

**Summary**

Electronic equipment plays a critical role in the operations. Loss or failure of radio equipment, electronic equipment on rigs connected to station power via a shoreline or other sensitive equipment, can negatively affect the ability to provide service to a community.

The key to protecting this equipment and personnel from electrical surges is an effective, low-resistance grounding system.

***This is a sample guideline furnished to you by VFIS. Your organization should review this guideline and make the necessary modifications to meet your organization’s needs. The intent of this guideline is to assist you in reducing exposure to the risk of injury, harm or damage to personnel, property and the general public. For additional information on this topic, contact your VFIS Risk Control representative.***

**References:**

VFIS Communique – “Electrical Surge Protection – Grounding”

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169

NFPA 70-National Electrical Code, 2011 Edition.

IEEE Standards Association, 445 Hoes Lane, Piscataway, NJ 08854

IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems, 2007 Edition.

Motorola, 600 North U.S. Highway 45, Libertyville, IL 60048

Motorola R56 –Standards and Guidelines for Communications Sites