Using Personal Protective Grounds in Industrial Facilities

You are sitting around waiting for the outage to begin. Your task is to perform preventive maintenance on the 15 kV class switchgear lineup feeding a large industrial facility. As seems typical of the situation, an argument is in full force over the need and adequacy of the personal protective grounds being applied. The local contractor intends to use what looks like a modified set of automobile jumper cables. Your supervisor is requiring use of a much more substantial configuration of cables with fancy connectors on each end. He is also requiring that two ground sets be attached so that his workers are working between the ground sets. The customer is trying to resolve the situation. He just wants to start the outage. This is when one of the contractor’s men offers a statement like, “We used to just throw a logging chain across the bus. If it came back out at you, it wasn’t dead.” During times such as those described above, it is nice to know the requirements associated with use and selection of personal protective grounds.

The primary purpose of personal protective grounding is to provide adequate protection against electrical shock causing death or injury to personnel while working on de-energized lines or equipment. For medium- and high-voltage applications, protective grounds are required as part of the lockout/tagout program. This is accomplished by grounding and bonding lines and equipment to limit contact or exposure to voltages at the work site to a safe level if the lines or equipment are accidentally energized from any source of hazardous energy. The greatest source of hazardous energy in most cases is direct energization of lines or equipment from the power system. Other sources of hazardous energy may include:

- Stored energy (capacitors and cables)
- Static build-up
- Electromagnetic coupling
- High-voltage testing
- Back-feed from atypical power sources

Personal protective grounding is intended for temporary grounding during installation, maintenance, and repair or modification of lines and equipment. It is not intended to substitute for a prolonged or permanent plant or station equipment grounding connection which should be provided by permanent grounding and wiring methods. Any employee working on de-energized medium- and high-voltage equipment is responsible for understanding protective grounding requirements and procedures. Further, facility managers and supervisors are responsible for ensuring that workers are knowledgeable of and comply with grounding procedures. Only trained and qualified workers shall apply and remove temporary personal protective grounds.

OSHA requirements for personal protective grounding at an industrial facility is actually found in 29 CFR 1910.269, the standard typically associated with utility systems. As it states in the note from 1910.269(a)(1)(i)(A), “(t)he types of installations covered … include the generation, transmission, and distribution installations of electric utilities, as well as equivalent installations of industrial establishments.” Medium-voltage electrical
infrastructure within an industrial facility is an equivalent installation. In accordance with 1910.269(n)(2), “For the employee to work lines or equipment as de-energized, the lines or equipment shall be de-energized … and shall be grounded as specified in paragraphs (n)(3) through (n)(9) of this section.”

**Protective Grounds — Sizing and Selection**

Protective ground cables and associated grounding equipment shall meet the following requirements:

- Personal protective grounds shall be capable of conducting the maximum fault current that could flow at the point of grounding for the time necessary to clear the fault. This equipment shall have an ampacity greater than or equal to that of No. 2 AWG copper.
- Personal protective grounds shall have an impedance low enough to cause immediate operation of protective devices in case of accidental energizing of the lines or equipment. This translates into being capable of carrying the maximum available fault current, including dc offset current due to waveform asymmetry, for high values of fault circuit impedance X/R ratio.

The guidelines for determining the adequacy of personal protective grounds are contained in ASTM F855-2004, *Standard Specifications for Temporary Grounding Systems to Be Used on De-Energized Electric Power Lines and Equipment*. Based on information in ASTM F855, the following table is what we are using in the field for evaluating the adequacy of protective grounds:

<table>
<thead>
<tr>
<th>Cable Size</th>
<th>ASTM Grade</th>
<th>Withstand Rating kA (60Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15 Cycles</td>
</tr>
<tr>
<td>#2</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>1/0</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>2/0</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>3/0</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>4/0</td>
<td>5</td>
<td>43</td>
</tr>
</tbody>
</table>

Select protective ground sets which are easy to apply. This includes considerations associated with the field application conditions and minimizing preparation and installation time. Standardized ground set configuration, to the extent practical, is desirable at each location to keep the number of sizes and types to a minimum. The ground sets should be fabricated as an assembly of suitably rated components (conductor, ferrules, and clamps) to withstand thermal and electromechanical stresses imposed while conducting fault current.

It is also recommended that the ground sets be stored and transported properly to avoid damage and ensure that the ground sets are maintained in good working order.

**Protective Grounds — Location**

The guiding principle for protective grounding in facilities is that the grounds should be installed as close to the workers as practical in order to provide an effective current shunt around the body and to limit exposure voltage. Keep in mind that the conductor-end and ground-end clamps of protective grounds should be connected near the locations where workers will likely contact parts of equipment that may inadvertently become energized. The protective grounds should be connected directly to the equipment, bus, or conductors to be grounded. No impedance or device (circuit breaker, disconnect switch, transformer, line trap, etc.) shall be permitted between the point of connection of the protective grounds and the location of contact by the workers. Additionally, avoid connecting the ground-end clamps to a grounding point (plant grounding conductor) that is not bonded directly to permanently grounded parts of the equipment to be worked on. Otherwise, ground loops may be formed with embedded ground mat conductors in plant concrete which can significantly increase the exposure voltage.

**Protective Grounds — Application and Removal**

Before any personal protective grounds are installed, the applicable lines and equipment shall be tested and found absent of nominal voltage. This typically involves measuring the voltage with a voltage sensor on the end of a hot stick. Appropriate personnel protective equipment and safety precautions consistent with the circuits being energized should be utilized when testing for voltage and while applying the grounds. When attaching the grounds, the ground-end...
connection shall be attached first, and then the other ends shall be attached by means of a live-line tool. When removing protective grounds, the connections shall be removed from the line or equipment using a live-line tool before the ground-end connection is removed.

Protective grounds may be removed temporarily to accommodate tests. During those tests, it is the responsibility of the tester and owner to ensure that workers use insulating equipment and are isolated from any hazards. Also, the tester and owner should institute any additional measures as may be necessary to protect each exposed worker from the previously grounded lines and equipment becoming energized.

The general rule for on the job personal electrical safety around de-energized lines and equipment is the lines and equipment shall be considered energized until protective grounds are installed. Until grounded, minimum approach distances apply with regard to the use and application of personnel protective equipment and procedures.

Further, personal protective grounds must be designed, fabricated, and applied in a manner that satisfies the following basic criteria:

- Maximize personal safety while working on de-energized high voltage equipment through the use of appropriate protective grounding equipment, procedures, and training.
- Limit work site exposure voltages to a safe level during accidental energization.
- Ensure that protective grounds will not fail under the most severe fault conditions.
- Provide the final energy barrier in the facility lockout/tagout (LOTO) program under direct control of personnel at the worksite.

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