Personal Protective Grounding for Electric Utilities

An Online Continuing Education Course for Engineers

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Personal Protective Grounding for Electric Utilities

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Introduction

This course describes general personal protective grounding practices for various electric plant operations. The course describes a set of procedures for temporary grounding of de-energized and isolated high-voltage equipment (over 600 volts) for the purpose of bare hand contact. The procedures described herein are not necessarily appropriate for every utility and each entity must select the best practices for their given situation.

The course includes general information about personal protective grounding practices and then gives application procedures for generating plants, substations, and power lines.

Need for Personal Protective Grounding

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. This is accomplished by grounding and bonding lines and equipment to limit the body contact or exposure voltages at the worksite to a safe value 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)
- Static build-up
- Faulted equipment
- Electromagnetic coupling
- High-voltage testing
- Instrument transformer back-feed

Personal protective grounding should be applied to de-energized lines and equipment having a nominal voltage rating over 600 volts if exposed normally current-carrying parts are to be contacted or approached within the minimum approach distances given in Table 1. Other nearby exposed parts of any electrical equipment rated over 600 volts, which are not associated with the work but may be approached within the minimum distance during the work activities, should either be de-energized and grounded or suitably isolated to prevent contact.

Table 1
AC Minimum Approach Distance for Electrical Workers

Nominal voltage phase-to-phase (kV)	Altitude (ft.)									
	<3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000	12,000	14,000
.301 to .750	1'-4" for all altitudes									
.751 to 15	2'-2"	2'-3	2'-3	2'-4	2'-5"	2'-6"	2'-6"	2'-7"	2'-9'	2'-10"
15.1 to 36	2'-4"	2'-5	2'-5	2'-6	2'-7"	2'-8"	2'-9"	2'-10"	2'-11"	3'-0"
36.1 to 46	2'-7"	2'-8	2'-9	2'-9	2'-10"	2'-11"	3'-0"	3'-1"	3'-3"	3'-4"
46.1 to 72.5	3'-0"	3'-1	3'-2	3'-3	3'-4"	3'-5"	3'-6"	3'-7"	3'-9"	3'-11"
72.6 to 121	3'-2"	3'-3	3'-4	3'-5	3'-6"	3'-7"	3'-9"	3'-10"	4'-0"	4'-1"
138 to 145	3'-7"	3'-8	3'-9	3'-10	4'-0"	4'-1"	4'-2"	4'-4"	4'-6"	4'-8"
161 to 169	4'-0"	4'-1	4'-2	4'-4	4'-5"	4'-7"	4'-8"	4'-10"	5'-0"	5'-2"
230 to 242	5'-3"	5'-4	5'-6	5'-8	5'-10"	6'-0"	6'-2"	6'-4"	6'-7"	6'-10"
345 to 362	8'-6"	8'-8	8'-11	9'-2	9'-5"	9'-8"	9'-11"	10'-2"	10'-8"	11'-1"
500 to 550	11'-3"	11'-6	11'-10	12'-2	12'-6"	12'-10"	13'-2"	13'-6"	14'-1	14'-8"

Note: All distances in feet-inches, phase-to-ground exposure. For phase-to-phase exposure, refer to OSHA CFR 29 1910.269, Table R-6.

Many companies do not require grounding of equipment and circuits rated 600 volts or less. Equipment and circuits operating below 600 volts can be just as deadly under the right conditions as higher voltage equipment. However, application of personal protective grounds on circuits below 600 volts may create unnecessary hazards due to limited approach distances and close proximity between conductors and grounded parts of equipment. If equipment or circuits are not grounded, they should be rendered safe from hazardous energy through clearance, lockout/tagout, personal protective equipment, or other protective measures.

Inappropriate use of Personal Protective Equipment

For de-energized, grounded work on transmission lines, switchyards and substations, personal protective grounds cannot be relied upon to provide adequate safety from a direct or indirect

lightning strike within the line of sight. Therefore, work should not be performed while there is any indication of lightning in the area.

Extreme electromechanical separation forces are developed in ground cables for currents exceeding 50,000 amperes, symmetrical. Mechanical failure of the ground cable assembly is likely. The method of double-isolation grounding using equipment ground switches is recommended in lieu of conventional direct application of protective grounds in power and pumping plants.

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.

Chapter 1: Basic Grounding Practice Criteria

Personal protective grounds must be designed, fabricated, and applied at the worksite in a manner that satisfies the following six basic criteria:

1. Maximize personal safety while working on de-energized high-voltage equipment through the use of appropriate protective grounding equipment, procedure, and training.

2. Limit worksite exposure voltages to a safe level during accidental energization.

3. Promote prompt operation of protective devices.

4. Ensure that protective grounds will not fail under the most severe fault conditions.

5. Provide the final energy barrier in the facility hazardous energy control program under direct control of personnel at the worksite.

6. Meet minimum maintenance performance tests.

The Golden Rule for on the job personal electrical safety around de-energized lines and equipment is:

High-voltage lines and equipment should be considered energized until protective grounds are installed. Until grounded, minimum approach distance applies.

Electric Shock Hazard

It is current through the body that causes electric shock or electrocution. The potential difference a person may contact between conductive parts of equipment or between equipment and ground is important because this voltage forces current through the body according to Ohm's law. Therefore, current through the body increases with lower body resistance and also increases with higher contact voltage. Hazardous conditions may develop that place the worker's body in series or parallel with circuits that can produce a current through the body (Figure 1).

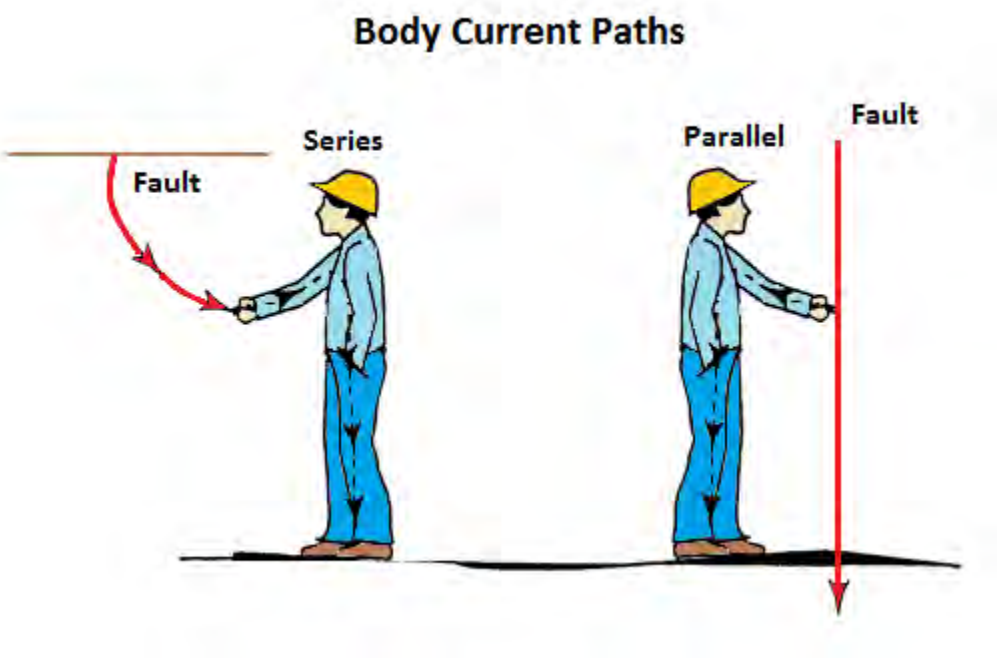

Figure 1

Personal protective grounding is a special case of the parallel circuit where low-resistance grounding cable is in parallel with the worker to shunt current away from the body.

Figure 2 shows the likely effects of different current levels on a 150 lb. male.

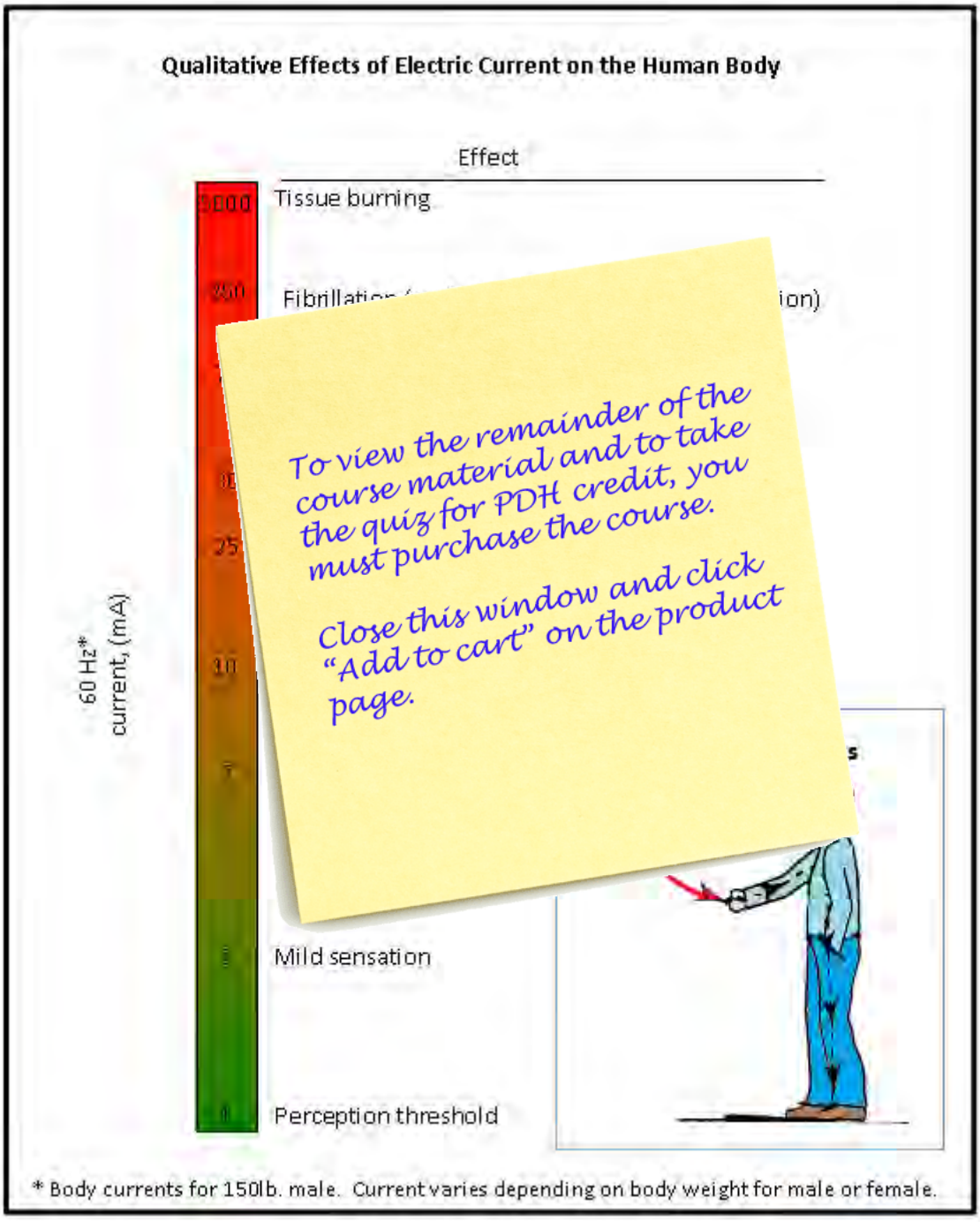

Figure 2

The accepted minimum value of body resistance is 500 ohms for electric shock hazard analysis. Although the resistance between hands with dry skin can range from 5,000 to 50,000 ohms, punctured skin reduces the body resistance to about that of salt water which is very low. Voltages above 240 volts readily penetrate dry skin, leaving a small, deep burn.