HAZARDS OF ESTABLISHING AN ELECTRICALLY SAFE WORK CONDITION

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When working around electrical equipment, the preferred working condition includes the equipment being put in an electrically safe work condition or turned off, locked out, and tagged out. This is stated in both OSHA and NFPA 70E requirements. Unfortunately, there are electrical hazards which must be dealt with while achieving this electrically safe work condition. These hazards could involve switching, equipment racking, voltage testing, and applying grounds to assure an electrically safe work condition. This paper will focus on the safety requirements associated with placing equipment in an electrically safe work condition.

COMMON SENSE

As a precursor to this discussion, it has been noted by some that OSHA and NFPA 70E requirements can be confusing and cumbersome. It has been said that "Common sense is the knack of seeing things as they are, and doing things as they ought to be done." It is time to apply some common sense to electrical hazards. Here are some common sense ideas for electrical safety that are unfortunately, not so common.

1. Distance is your friend. The farther you are away from the hazard, the safer you will be and the less PPE you will be required to wear.
2. Bigger equipment is usually more dangerous.
3. When removing equipment covers, removing a household light switch does not typically require an arc-flash suit for protection but removing the cover from an industrial substation typically does.
4. Shock–related PPE requirements and arc-flash related PPE requirements should be determined separately and added together.

With regard to electrical safety, to do things as they ought to be done means distancing yourself, and others, from the shock and arc-flash hazards while establishing an electrically safe work condition. In order to do this, the whole process needs to be thought through and planned ahead of time. Before equipment is turned off, check the condition of the gear. Are there any panel meters or voltage indicators present? Do they appear to be working properly? Are the correct panel lights lit? In what order should the equipment be shut down? Can the loads be turned off remotely or further upstream or downstream where the hazards may be lower? Are there any additional hazards that could be introduced by turning this equipment off? If an action is likely to cause an arc-flash event, then how do you avoid injury?

Frequently, many people use the last method that should be applied. That method is to suit up in arc-flash protective clothing including leather gloves and face shield or flash-suit hood. PPE should always be a last resort when implementing a safety policy. In any unsafe situation, the goal is to remove the hazard so that the use of PPE is minimized.

DISTANCE

When turning equipment on or off, there are several options. There are engineered options such as using computer control to operate breakers from a distant operations center. Mimic panels can be used to operate the equipment from outside of the protection boundaries or outside of the room. There are aftermarket options that attach onto the front of the switchgear and will operate switches while allowing the operator to stand away from the switchgear.

When none of these options are available, there is also an old tried and true rope-and-pulley system (See Figure 1). This is not known or used by many people. It does not work for all applications but excels in switching load interrupter switches, many medium-voltage starters, and many older style OCBs. Using the rope and pulley system, a rope is attached to the operating handle or pull ring and run through a pulley(s), if necessary. In this way the operator can stand away from, and to the side of, the equipment while operating the equipment. This method is inexpensive, easy to set up, and available to everybody. This can be seen being demonstrated on a motor starter in the Fall 2010 issue of NETA World Magazine in Tony Demaria's article, *Safety and Medium Voltage Starters.*

If you must stand in front of the equipment to operate it, there are a few other things you can do to mitigate being injured. Stand to one side of the equipment being operated and always wear protective gloves. When wearing a face shield and balaclava instead of a full hood, face the equipment to avoid collecting a fireball inside the shield. Arc-rated blankets can be used to redirect the blast as well.

Figure 1: *Medium-Voltage Load Interrupter Switch Operation with Rope and Pulley System*

Racking out a breaker before you work on it is strongly advised and usually the only way to provide adequate separation from a hazard and establish an electrically safe work condition. Unfortunately, racking out equipment can be very hazardous. Again, there are many methods that can be used to distance yourself from the hazards. Some equipment may have built-in, electrically-operated racking mechanisms that will allow the operator to rack-in or rack-out the equipment while maintaining a safe distance. There are also many aftermarket products or robots which may be employed to rack breakers either at the end of a long control cord, or remotely via wireless control. Some of the remote racking devices come with a remote camera, or may be fitted with one at a later date.

If you must rack the breaker out locally, there are additional things to remember. Use closed door racking whenever possible. Wear the proper arc-flash rated PPE and stand to the side, if at all possible. If using a hand crank, use an extension on the crank handle to increase your distance from the equipment and possible arcing location. You can weld an additional section onto your factory-furnished crank handle (See Figure 2). Even an additional few feet can drastically reduce the incident energy exposure. As an example, a 42 cal/cm^2 exposure at 36 inches on medium-voltage switchgear can be reduced to 21 cal/cm^2 at 72 inches.

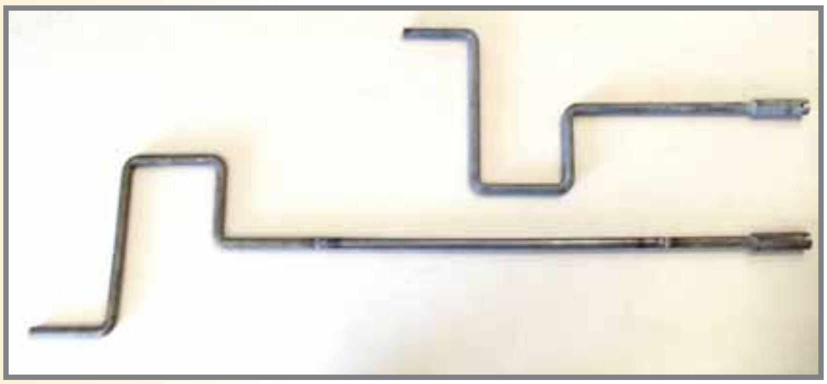


Figure 2: *Factory Racking Handle With Two Foot Extension Welded On*

SHOCK BOUNDARIES

The next task that must be accomplished is to open covers in order to test for absence of voltage. This seemingly easy task can introduce additional hazards. The cover can slip and fall into the gear. There may be loose hardware that is leaning against the cover that could fall when the cover is moved. PPE will be necessary for this task when crossing the shock or arc-flash boundaries.

First, a determination of the shock-related PPE requirements should be performed. This involves identifying the voltage to be worked on and the shock boundary to be applied. The shock boundaries are voltage dependent boundaries and vary by system nominal voltage. They are outlined in NFPA 70E, Table 130.2(C) and in IEEE C2, Table 441-1. These are defined as the Limited, Restricted, and Prohibited Approach Boundaries and are considered the distance from exposed, energized conductors. The distances stated in these tables are irregular and may be difficult to memorize. NFPA 70E, Table 130.2(C) lists 14 voltage ranges in five columns, or up to 70 distances. We believe that over 90 percent of the electrical workers in the U.S. and Canada have not studied these standards and could not tell you these distances from memory for every voltage level presented in these tables. Further, they could not tell you the definitions of Limited, Restricted and Prohibited Boundaries. The following is an example of a way that your company can create a safety policy that will cover the great majority of electrical workers for shock protection. It uses common sense, and promotes an easy way to memorize the distances. Keep in mind that this is an example of a safety policy for shock protection only.

1. When working on or near exposed, energized, fixed circuits up to 750 volts, you should wear voltage-rated gloves and use voltage-rated tools, if you are going to get closer than three feet six inches. If there is a possibility that you might fall into the hazard, you should also wear voltage-rated sleeves. No part of the unprotected body should get closer than your arms can reach. A hard hat and electrical face shield should also be used to prevent contact in tight areas.
2. When working on or near exposed, energized circuits over 750 volts to 15 kV, you should wear voltage-rated gloves, voltage-rated sleeves and voltage-rated tools if you are going to get closer than five feet. No part of the unprotected body may get closer than your arms can reach. A hard hat with an electrical face shield must be worn.
3. Any other voltages or situations should require specialized personnel who are qualified for the higher voltages.

These distances should apply when the covers are off and before the circuits have been de-energized, locked out, tested, and grounded, if necessary. The arc-flash boundary applies any time there are exposed, energized conductors as well as any time anyone is interacting with the equipment in such a manner that could cause an electric arc. This interaction includes operating and racking breakers, removing covers, voltage testing, and applying grounds.

OPENING DOORS & COVERS

When opening hinged covers, care should be taken not to position yourself so that you are in the path of the arc flash or blast. Keep the door between yourself and the exposed conductors until the cover has been fully opened with no incident. When removing a cover without hinges, get some help to remove the cover. Suction cups can be very helpful when removing covers without handles. Make sure the suction cups are placed on a clean, dry, flat surface. These cups are very inexpensive and can be used to avoid dropping the cover into the equipment. Lean the cover out slowly at first and listen for any unexpected noises. Any scraping against the cover from loose parts, or the hissing or crackling of ionized air is a warning sign that more trouble could be coming. This should be investigated before continuing with the task.

VOLTAGE TESTING

In order to test for voltage, the live-dead-live method should always be employed. Panel meters or auxiliary voltage indicators may be used as additional verification. Do the panel meters that you looked at before de-energizing the equipment show an absence of voltage now? Have the voltage indicators that were lit beforehand been extinguished? Even with these checks, it is necessary to use a tested meter to check the circuit. Shock-related PPE and arc-flash related PPE are necessary if crossing the shock or arc-flash boundaries, respectively.

When testing medium-voltage equipment, the meter should be attached to a hot stick. As a general recommendation, use a measuring device designed for the job and the voltage level. Do not select test equipment based on price alone. Using a hot stick will allow you to distance yourself from the hazard while performing the test. Always extend the hot stick to the fullest length that is practical. Always test all three phases. Start with the voltage range setting for the expected voltage, then gradually lower the voltage range setting to the minimum range to confirm that there is no voltage present. A contact-making meter should be used even after a proximity tester has indicated an absence of voltage in order to test for trapped charge, since proximity testers do not respond to dc voltage. Always use gloves rated for the full system voltage for this task when crossing either the restricted or prohibited approach boundaries. Test all three phases-to-ground as well as phase-to-phase.

GROUNDING

Now that absence of voltage has been verified, grounds may be applied. Grounds should always be used when working on equipment that has high fault current capacity., once again, the goal is to protect yourself and others from the hazard.

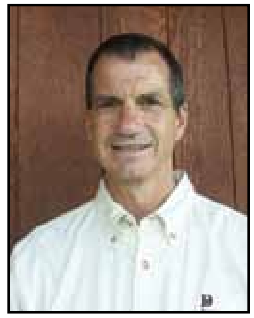
With this in mind, there is another way to apply grounds remotely. Grounding and test devices have been around for some time, but they are not in common use. They are a common sense approach to applying grounds safely. However, it is imperative that the grounding and test device be tested for insulation integrity and the correct stab position chosen for the ground cables. Some cubicles may be energized on the top stabs and others on the bottom stabs. This is especially typical in tie breakers. Using a grounding device with the wrong side grounded could lead to catastrophic damage.

The grounding device may be inserted into a cubicle and then operated remotely from system controls or mimic panels or, if necessary, from a robot operator. Keep in mind, if it needs to be racked into the cubicle, this should also be done remotely, if possible. If not, follow the same precautions as discussed earlier for racking equipment out.

If grounding cables or clusters must be applied manually, use a hot stick. Remember again, distance is your friend. When applying ground sets, assume the circuit is energized even after the circuit has been voltage tested and verified to be de-energized. This means wear the appropriate PPE for the hazard. This is common sense as many an experienced electrician can relate a story of applying grounds and having the unfortunate experience of touching an energized conductor with the ground cluster. Not a pretty picture! The good news is, if the grounding cluster has been sized properly and is being installed correctly, it usually trips the upstream breaker with possible damage to equipment. Once again, use hot sticks at the longest practical lengths and position your body so that you are not in the line of fire. Don't stand in the path of the hazard!

SUMMARY

By thinking through and planning each step, the process of establishing an electrically safe work condition can be done safely and without exposing yourself to unnecessary hazards. Once the equipment is de-energized, locked out, tagged out, tested for voltage, and grounded, if necessary, an electrically safe work condition has been established. Now that this has been done safely and the electrical hazards have been removed, the original work task(s) may begin.



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