by Jim White, Shermco Industries, Inc.

How Not to Feel Like a Biscuit

Medium-voltage, metal-clad switchgear presents a number of unique safety issues for maintenance personnel who often must operate and service them on a regular basis. Their higher operating voltage and relatively high available short-circuit current combined with tripping delays due to protective relay coordination and the possible use of auxiliary relays can make them very hazardous if they should fail.

Two operations that expose workers to elevated risk from an arc flash are inserting and removing a circuit breaker (racking) and the application of personal protective grounds. This article will discuss racking circuit breakers. Applying personal protective grounds can wait for a future article. There are several factors outside the control of workers who are required to operate medium-voltage switchgear:

- Age
- Loading
- Environment
- Condition
- Original installation
- Maintenance
- Equipment design

Most facility maintenance personnel are familiar with their installed equipment, so they have some idea as to which equipment presents a greater risk. When NETA technicians respond to a trouble call they often walk in with no knowledge of the equipment's history or condition. To make matters worse, often there isn't anyone who can supply that information, and the customer is always in a rush to restore power so production can resume. This can result in pressuring the technician to rush also. When all of these factors are added up it can create a perfect arc-flash storm, one for which we may not be prepared.

Racking Breakers

This is a task that is successfully performed thousands of times daily. It is the rare exception from which we need to learn. I often say, "If we knew there was going to be an accident, we'd be someplace else." No one purposely subjects himself to injury or death, but some people seem to think that all will be fine if only they maintain positive thoughts. Here's a positive thought – I'm positive you will have major problems if you assume all is well. My dad would tell me, "Don't trust your life to a mechanical device." He was talking about me being under a car supported by a hydraulic jack, but it's good advice for anyone working on mechanical or electrical equipment. Circuit breakers are primarily mechanical devices. They will fail – we know that. What we cannot know is when they will fail. Proper engineering, installation, and maintenance will delay that failure for many, many years. If all three of these conditions are met, that failure will probably not occur during the equipment's installed life. Do we really know, though, if these three functions have been done correctly?

The Case of Paul Bunyan

Well, that wasn't his name, but it could have been. Tall, 6'3", maybe 6'4", big, but not fat at all. Paul seemed like a good-natured guy, at least during the short time I knew him and he seemed to get along with people. Paul worked for a company that, at the time, had no electrical safety program, no procedures and no arc-flash PPE. When the NETA technicians racked his company's 5 kV vacuum circuit breakers, they wore 65 cal/cm² arc-flash suits. Paul and his coworkers asked them why they wore such heavy, and obviously uncomfortable, PPE when the equipment was virtually brand new (only five years old). The technicians took the ribbing in good nature, because Paul, like many others, just didn't understand the arc-flash hazard. One day, Paul and a coworker were assigned to rack one of the 5 kV breakers back into its cubicle, the bottom of a two-high lineup. Paul had plenty of experience at doing this, and it was fairly routine.

Paul closed the enclosure door and proceeded to rack in the breaker. Like many people, Paul was wearing a cotton t-shirt, jeans, tennis shoes, and nothing by way of PPE. As Paul racked the breaker in it began to bind up. Paul had experienced this several times in the past and knew the racking screws on this type of breaker could be balky. Paul racked the breaker out a bit and then racked it back in and it started to bind up at the same spot. Paul told me that he then really cranked down on it. What Paul did not know was that some wires connected to an add-on transducer looped across the path of the circuit breaker and were the cause of the binding. When Paul cranked it in the wires were pulled from the transducer, Figure 1, and landed on the energized 5 kV bus. The resulting arc flash was estimated at 33 cal/cm².

Figure 2 — Damaged 5 kV Circuit Breaker Enclosure

Figure 1 — Transducer Wiring

Figure 3 — Damage to Upper Enclosure

Paul was stooped down on one knee as he racked the breaker in. His coworker was standing next to him, with one hand on the door of the cubicle above the one where the breaker was being racked in and the other in his pocket. The pressure wave created by the arc blew the door open, but the door, which was solid and had no vents or openings, diverted most of the arc-flash heat and blast away from Paul and his coworker. Paul told me that even with the door deflecting the heat, he felt like he was being cooked. Paul's coworker received second-degree burns on the palm of his hand, because the door of the upper cubicle heated up so fast that he was burned before he could reflexively withdraw it. The arc flash and blast blew open the upper cubicle door, also, and that cubicle and breaker were also damaged. Figure 2 shows the aftermath of the incident. Figure 3 shows the damage to the upper cubicle door. It is hard to imagine the amount of pressure that caused the door to deform like it did (see Figure 3).

The handle on the enclosure door struck Paul in the side of the head, knocking out a quarter-sized piece of his skull, but Paul did not suffer any serious burn injuries. Paul was rushed to the emergency room, where they operated to remove the bone fragments and to reduce the swelling. He was out of work for several months. When I met Paul he was back to work and seemed pretty much okay. He had some difficulty putting sentences together, but would only pause briefly while he sorted things out. Paul became emotional when describing the incident. It was obvious that the accident had left some very deep scars in him. Not long after the accident, Paul's marriage fell apart. People who suffer serious injuries often require long-term counseling to cope with their "new" life. As sad as this story is, the ending is even worse. Paul took his own life shortly after the beginning of the year. This will never appear in OSHA's statistics, but I am certain that Paul's final gesture was due to his injuries and his frustrations and losses.

What Could Have Been Done Differently?

OSHA defines electrical safety as "being aware of the hazards associated with the use of electricity and taking precautions so those hazards do not cause injury or death." That's a pretty good definition. If we break that statement down, it means we must be aware of the hazards and know how to avoid them. That works for all workers, both qualified and unqualified. Since I do training for a living, my first recommendation is to train your workers, particularly to train them to properly assess the risks and the hazards associated with a specific task. If Paul had been properly trained, he would have been aware of the arc-flash hazard and would have had on appropriate PPE. His company now supplies that PPE, as required by OHSA. Just as important, though, Paul should have been trained on the specifics concerning the equipment he was about to work on and the hazards associated with the task he was about to do. Paul was trained in the mechanics of the task (racking the breaker), but not trained as to what can cause binding and what actions he should have taken. His experience was just not adequate to protect him, and that is true for most of us in one situation or another.

A Hazard/Risk Analysis could have looked like this:

- What is the incident energy available?
- If that information is lacking, what is the short circuit available current and the operating time of the overcurrent protective device (OCPD)?
- What is the Arc Flash Protection Boundary? (See article 130.3(A) in NFPA 70E. The word "protection" will probably be dropped for the 2012 edition of the 70E. Then again, maybe not. We still have the Report on Comments (ROC) meeting ahead).
- What is the nominal voltage of the circuits?
- What are the shock approach boundaries? Will there be exposed, energized parts?
- Where will the safety zone be established?
- What PPE and equipment are necessary to perform the task safely? Is it available? Is it in good condition and tested recently?
- What precautions are being taken or are needed for unqualified persons?
- Is a safety backup required? What training and PPE does the safety backup need?
- Is the safety backup's CPR certification renewed annually?
- What is the phone number for emergency rescue personnel? Where are they located and how long does it take them to respond?
- What is the condition of the equipment that is to be worked on? Are there known or obvious issues that could affect the performance or safety of the task?
- If there are no exposed, energized components or circuit parts, does the task involve interacting with the equipment in a manner that could cause failure such as racking breakers, inserting or removing MCC compartments, or inserting or removing bus plugs?
- When was the last maintenance performed on the equipment? Is there a calibration sticker on the OCPD? Is it within a three-year window?
- What are the risks associated with the task to be performed? Are personnel qualified to perform this task? Do they understand what is supposed to occur during the task and the signs that something is not working properly?
- What would be the result of an accident?
- Does the technician believe the OCPD will function as the manufacturer designed it to?
- Is the residual risk low enough to allow the performance of the task?
- Does the technician believe the task can be done safely?

Summary

There's more that could be added to this list, but this is a good start. Many people seem to have a tendency to focus on the hazard. Knowing the hazard is important, but being able to assess risk is equally important, which is why the NFPA 70E uses the phrase hazard/risk instead of just hazard. Being able to assess risk, especially when racking circuit breakers, requires good judgment, experience, and safety training. That training does not have to be by way of classroom, but can be done in the field as on-the-job training (OJT). If OJT is the way training is conducted, be certain to document it.

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