

Corrective Measures to Arc-Flash Problems *Is It that Simple?*

Introduction

With all the talk about the NFPA 70E, Hazard Risk Analysis, IEEE 1584, and all of the associated elements related to arc-flash hazards, what do you do when you discover an arc-flash hazard within your facility? Hint: Run like the wind.....

While at times it can be a very complicated (read: expensive) solution to solving your problem, more often than not it is, or can be, a simple solution. The following case studies are examples of how some arc-flash hazards can be corrected without too much effort, and heck, you might even impress your boss (doubtful).

Background

One of the first, and most basic, principles of an electrical safety program is to identify and minimize hazards in an electrical system. One of the key elements to identifying these hazards is to quantify the electrical arc energy in the system, both magnitude and distance. An arc-flash engineering study will get you these values, but it won't buy you a new pair of shoes.

If a worker is to work on or near exposed conductors that will not be in an *electrically safe work condition**, a shock hazard analysis and flash hazard analysis are required.

*Electrically Safe Work Condition; Per NFPA 70E, *Standard for Electrical Safety in the Workplace*, 2004 Edition:

A state in which the conductor or circuit part to be worked on or near has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.



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While personal protective equipment (PPE) manufacturers make flash suits with arc ratings up to 100 cal/cm², NFPA 70E does not have a Hazard Risk Category for incident energies above 40 cal/cm². Working on energized circuits with energy levels in excess of 40 cal/cm² should be avoided by all means necessary. If energized work must be performed on these circuits, steps should be taken to reduce the hazard before the work is to be performed. Although it would seem as though a 100 calorie Hazard Risk Category level might be one you could easily classify as the BOD, or "Big 'Ol Dufus" category.

So if you have determined that a hazard exists, and have performed an arc-flash study, you are on your way to protecting your workers from the hazards. But now that you know the hazards exist along with the quantifiable data, what's next? Happy Hour! OK, I digress — a few examples with solutions are outlined below.

Case Study Examples

Case Study No. 1

2000 kVA Transformer With No Main Breaker

Invariably, just about any 1500 — 3000 kVA 480-volt unit substation transformer will have a high incident energy level between the transformer secondary bushings and the main breaker line side bus. In this example, a 480-volt outdoor substation is fed from a 2000 kVA transformer. The transformer primary is protected with a 15 kV vacuum circuit breaker. The substation does not have a main breaker, only feeder breakers. For a diagram of this design, read "Engineering 101 — What NOT to do."

After analysis, it was determined that the incident energy on the main bus was approximately 109 cal/cm². At this level of incident energy and because the feeder breakers were not protected by a main breaker, none of the feeder breakers could be racked in or out without being in violation of the requirements as established in NFPA 70E. And, one of the most prevalent comments from the owner of the equipment was, "Why, after 25 years, do you now tell me I cannot operate those same breakers that I have been operating (racking in and out) for the last 25 years?"

The answer is, obviously, "Because."

OK, that may not be exactly the right answer, but *because* we now know what the incident energies are, and *because* we now know we have to do something about it, and *because* we care about our employees (well, maybe the first shift employees) — it is because of these items that we need to fix it. So what's the solution? The owner can't change his substation out without going through a time intensive capital spending request with corporate, and he can't just all-of-a-sudden stop racking breakers in and out. So, what is he to do?

Call the Coordination Police, Batman! This particular transformer was coordinated with the system to maintain maximum uptime without damaging the transformer, with a relay time-dial setting of 5.0. After analyzing the data, it was determined that a time-dial setting of 2.0 will still maintain system stability, allow for proper coordination, and will reduce the incident energy on the low-voltage bus from 109 cal/cm² to about 40 cal/cm². Viola! We are now down to a level at which we can get burned just enough to live and tell about it! Mission accomplished.

Case Study No. 2

Racking In (or Out) A Main Breaker on a 2500 kVA Unit Substation

In this example, take the same situation as above, only now insert a main breaker on the 480-volt bus in a double-ended substation. You have now solved one of the two problems. The solution to one of the problems is that now you have put an overcurrent device between the transformer secondary and the feeder breaker main bus (with the main breaker). Problem number two, the incident energy on the line side of the main breaker to the transformer secondary bushings is still high. So now what?

Call the Coordination Police Batman! What?! Phone's busy? Then call the electrical department! So what can the electrical department do for you? Let's take a look at the situation:

- You have a 13.8 kV fused switch in front of a 2500 kVA transformer
- The transformer feeds a main breaker on one side of the substation

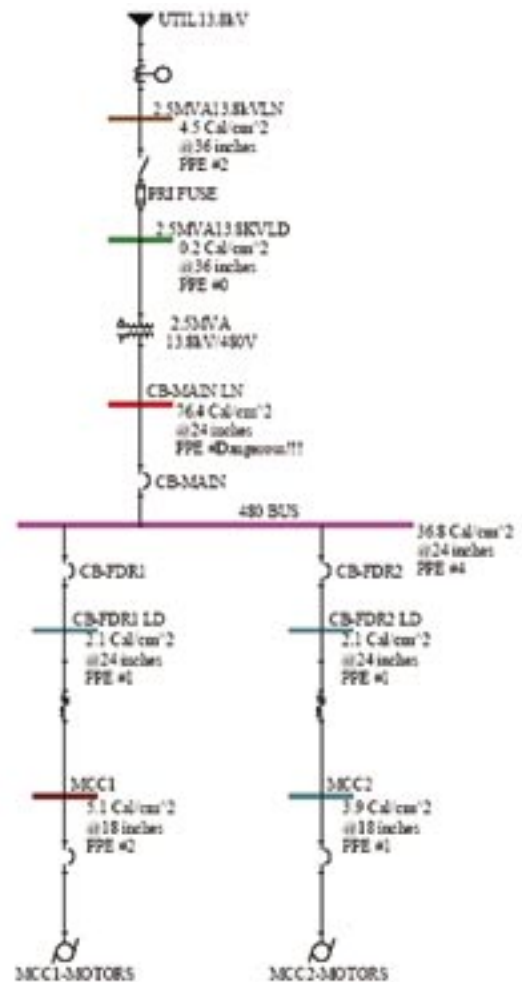


Diagram 1

- The main breaker must be closed to get power to the substation
- The double-ended substation is configured for open-transition operation

Got it? Now think about the operation of the substation — is there any reason to have the transformer energized before racking the breaker in or out? (insert Jeopardy theme here) No? Well good, because you have just changed one simple plant procedure and reduced your exposure to the hazard. Because after all, if there is no electricity, there is no hazard, right? Almost.... It is not exactly “electrically safe,” but it is in a much safer condition than if you had it energized, yes?

As you can see from Diagram 1, at a distance of 36 inches the incident energy at the 13.8 kV switch primary is 4.5 cal/cm², and on the load side of the switch it is 0.2 cal/cm²! Now jump to the 480-volt side of the transformer, line side of the main breaker, and it becomes 76.4 cal/cm² at 24 inches — again a situation that you do not want any part of, unless you like to tan very quickly.

The lesson for Case No. 2? Turn it off, Einstein.

Case Study No. 3

The Case of the Slow Fuse — or How I Spent my Summer Vacation

In this example, check out Diagram 2, where there is a 10,000 kVA transformer fed from a 13.8 kV fused switch, which then feeds a medium-voltage main breaker, and ultimately feeds a medium-voltage motor control center (Em-cee, See?) The MCC feeds another fused switch, which then feeds a 1000 kVA transformer, reactor, and variable frequency drive (VFD-Big Money) for a 900 hp motor. Simple, right?

With all of those overcurrent devices, including switches, breakers, fuses, reactors, and lengths of cable you would think the power system would owe you a few incident energies. Sorry, it is not to be. Initially there was a s-l-o-w speed

fuse in the 4.16 kV main switch for the VFD. How did we know it was slow fuse? It had a degree from Texas A&M (bad Texas joke).

Actually, when the application was changed to a standard speed fuse, it was apparent that there was no room in Bryan-College Station for no slow-speed fuse. Check out the incident energies before and after the fuses were changed:

Slow Fuse (Diagram 2)	Standard Fuse (Diagram 3)
Reactor Line Side 51.9 cal/cm ²	Reactor Line Side 24.7 cal/cm ²
Reactor Load Side 52.7 cal/cm ²	Reactor Load Side 25.3 cal/cm ²

As Top Gun Maverick says “I feel the need, the need for speed.” Another interesting point of discovery, the incident energy is higher on the load side of the reactor than it is on the line side of the reactor. Hmmm. That doesn’t sound right. I thought reactors were supposed to limit current, thereby limit the amount of incident energy. Not on my watch, soldier!

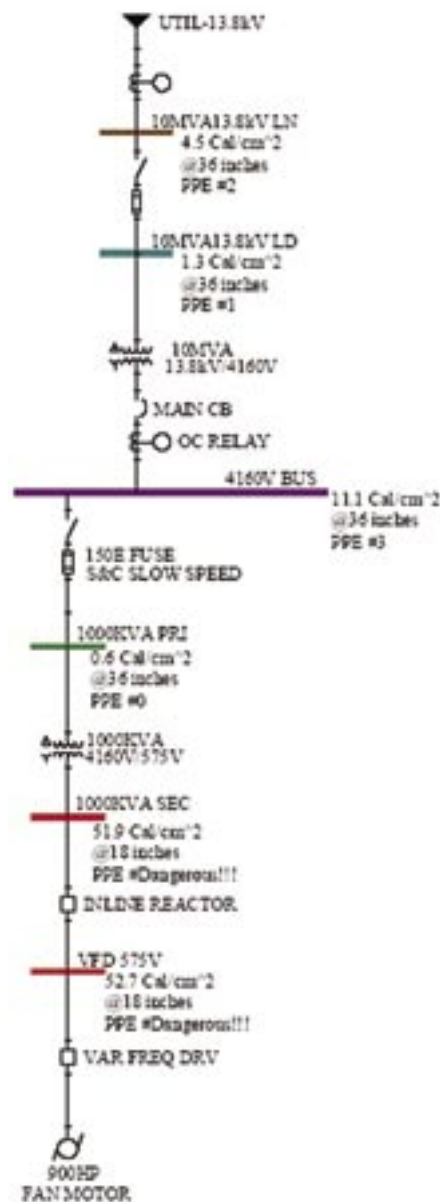


Diagram 2

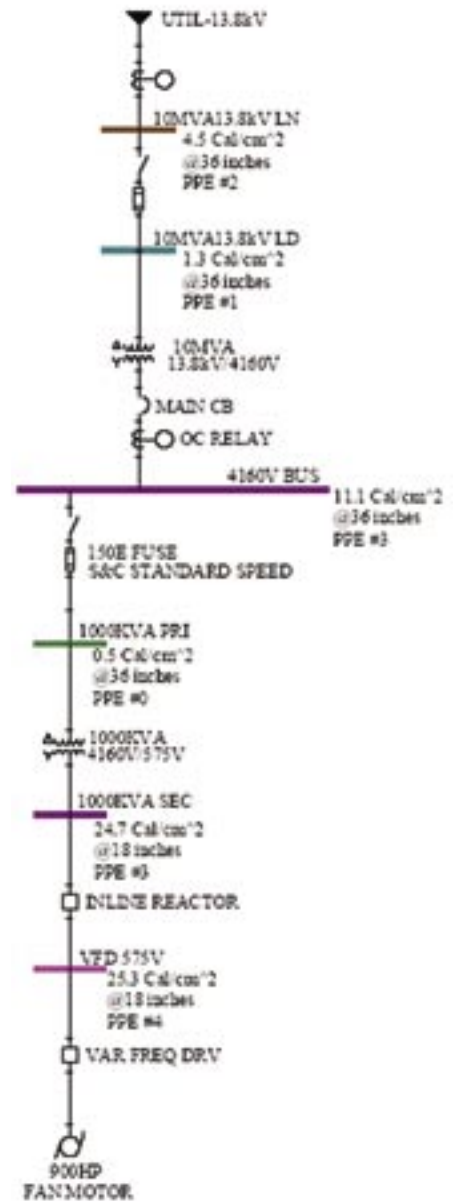


Diagram 3

While these case studies are but a few of the thousands of possibilities that occur when performing an arc-flash study, it shows that the issues don't necessarily always involve expensive solutions. The answer to protecting your workers from the hazards of the electric arc may just be a simple one. Which, after all, is what it is all about....

Be Safe! 

References:

1. *NFPA 70E, Standard for Electrical Safety in the Workplace*. Quincy, MA: National Fire Protection Association, 2004
 2. *Safety Basics, Handbook for Electrical Safety*. St. Louis, MO: Cooper Bussman, Inc., Edition 2
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Ron. A. Widup, Executive Vice President/General Manager of Shermco Industries, Inc. has over 20 years of experience in the low-, medium-, and high-voltage switchgear and substation market. He is a principal member of NFPA technical committee 70E (Standard for Electrical Safety in the Workplace) and a member of NEC Code Panel 11. He is past president of NETA and currently a member of the Board of Directors and Standards Review Council. He is certified as a NETA Level IV Senior Test Technician.