Is Electrical Switchgear Safe?

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ABSTRACT

In today's infrared community, we talk a great deal about "What is safe?" when it comes to electrical equipment and internal-arc flash. Thermographers generally assume that with the covers and doors closed, the switchgear is in a totally safe work condition. This paper explores the differences in switchgear with respect to internal-arc flash and how this affects the safety of the thermographer. The presentation incorporates a worked example of an internal-arc flash test on a piece of 15kV switchgear incorporating infrared windows, including actual video footage of an arc-flash test occurring.

Keywords: infrared windows, electrical, switchgear, arc flash, arc fault, bolted fault, medium voltage, high voltage, low voltage

INTRODUCTION

Infrared thermography of electrical switchgear is a well-known and accepted predictive maintenance technique. Working with any kind of live, electrical equipment incorporates an element of risk, but how does this risk manifest itself in relation to arc-flash and infrared thermography? Is our electrical switchgear totally safe?

RECOGNISING THE FAULT TYPE: BOLTED FAULTS OR ARCING FAULTS?

Today, the infrared community talks a great deal about "arc fault" or "arc flash," but to understand what an arc fault actually is and how it affects switchgear, one must first appreciate the difference between an arc fault and another, albeit less common, occurrence known as a "bolted fault."

A bolted fault is basically a dead short via a highly conductive medium between two different phases or between a phase and Earth conductor. Figure 1 shows a diagrammatic example of a bolted fault situation.

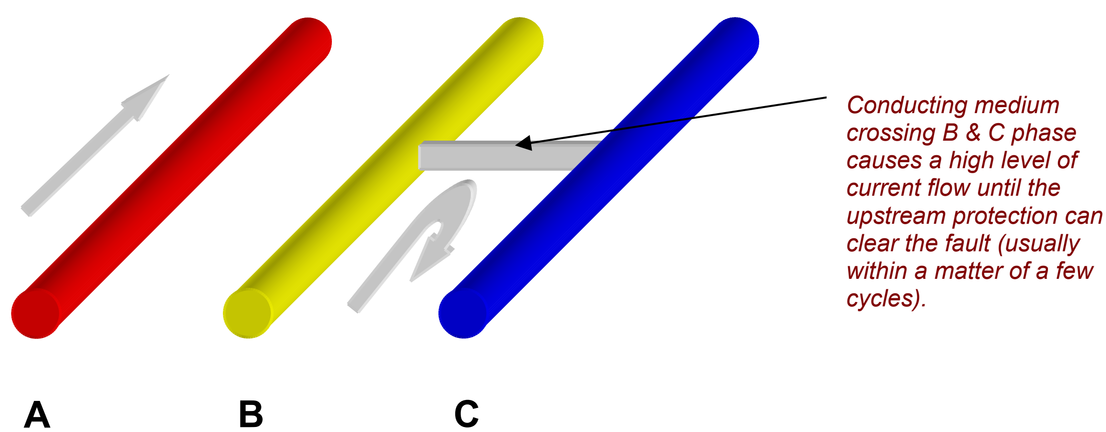

Figure 1. Diagrammatic representation of a bolted fault

Since the fault current is confined to the relevant conductor, there is usually no energy release outside of the system's conductive path.

As is commonly known, an arcing fault is very dangerous and, as we shall see, quite different from a bolted fault. An arcing fault is also a short circuit between phases or between phase and Earth, but this time the short circuit current flows through the air, rather than through an actual conducting material such, as copper. When an arc fault occurs, temperatures at the fault location increase instantly to over 5000ºF (the melting point of copper is 1983ºF). Vaporization of internal components resulting from this massive temperature increase, along with the superheated ball of gas, causes an explosive blast that bombards the switchgear with high intensity pressure waves.

Figure 2 shows a diagrammatic example of an arc fault.

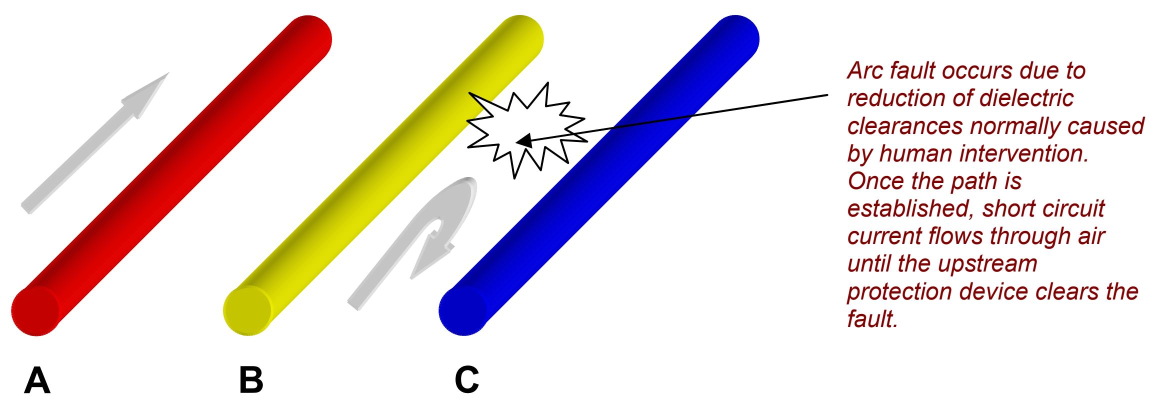

Figure 2. Diagrammatic representation of an arc fault

Under arc fault conditions, a huge amount of damage is caused to the equipment, and a significant injury hazard is posed to any personnel in the vicinity at the time of the fault.

Arc faults are usually caused by one of the following dynamic interventions into an otherwise static system:

Dropped tools
Induced airflow
Dielectric breakdown of insulation
Mechanical failure

So, now that we understand the difference between the two fault occurrences, we can look at the switchgear design in relation to them.

HOW DOES THIS AFFECT THE SWITCHGEAR?

Traditionally, switchgear was designed, tested, and rated to withstand the bolted fault current level that could occur, as this is always higher than the arc fault level, due to the lower current impedance of the cross phase conductor in comparison to air. The switchgear was designed to such an extent that the bolted fault current did not exceed the maximum current-carrying capacity of the conductors, and as such, the equipment was not damaged due to the fault.

NB. This current level is called AIC, which stands for "Amps Interrupt Capacity" and can be found on a metal plate on the switchgear that has been type tested against this type of fault occurrence. The designation will show the bolted fault level tested (xxkA) for a time period commensurate with the anticipated cycle time of the upstream interrupter, be it a fuse or a breaker.

However, as we have seen, there is a vast difference between the effects of a bolted fault and an arc fault, and a successful bolted fault type test does not mean that the switchgear can subsequently withstand an arc fault - even at a lower short circuit current level - which is much more violent.

Today, arc-resistant switchgear undergo arc fault type tests in order to satisfy the market that the equipment is indeed safe, should either fault occur at the tested ENERGY LEVEL or less.

NB. It is not correct to associate arc flash danger solely with voltage. Energy = Voltage x Current x Time. So, it is quite possible for the arc flash energy level on 480V equipment to be as high as or higher than on 4160V or 15kV equipment.

See Figure 3 for a fault-tested piece of medium voltage equipment.

Figure 3. Arc-Resistant Switchgear, GE Power/VAC.

It is important to realize that arc-resistant switchgear is designed to contain the arc by-products and vent the gases in a safe manner. Protection should include against flying objects, flash burn, escaped hot gases, and glowing particles whether the person is outside the enclosure or inside the adjacent live compartment during maintenance. In order to maintain the arc-resistant protection of the switchgear during operation, all doors and covers must be closed and latched or bolted, while energized.

IS OUR INSTALLED SWITCHGEAR ARC-RESISTANT?

The straight answer is most probably no. Arc-resistant switchgear is expensive due to its construction and certification requirements, and as such, this type of equipment is in the minority in today's workplace. It is a recognized fact that should a fault occur in a non-arc-resistant switchgear, then not only will the equipment be destroyed beyond repair, but it is normal for such explosions to cause covers/doors to become forcibly detached from the equipment.

What this means is that, regardless of whether you remove the covers to perform an infrared survey, should an arc fault occur, the cover will be ejected from the cubicle, and the operator will be exposed to the residual fault condition plus the impact from the flying cover.

Figure 4 shows the result of an arc fault explosion in a 4kV starter cubicle.

Figure 4. 4kV starter cell

Explosion caused due to a failure of the leads feeding the motor.

This panel is not arc-resistant and as can be seen, the rear panel was blown completely off.

This is the image that every electrical thermographer must have in their mind BEFORE entering a live, operating switch room. **Just because the covers are closed does NOT mean you are safe.**

WHERE DO WE GO FROM HERE?

There are a number of points the infrared thermographer needs to remember when dealing with potential arc fault occurrences:

1. Arc faults do not simply happen. They are the result of a change in the static nature of the switchgear.
2. If possible, check the operating schedule of the equipment you will be surveying. If a fault is to occur other than from human intervention, then it is likely to happen when a circuit closes and/or load increases.
3. Ensure that predictive maintenance is carried out regularly to reduce the potential for mechanical failure.
4. Do NOT remove covers or doors to perform the infrared inspection, as this is more likely to cause an arc fault than prevent one.

SUMMARY

With run-to-failure being an unacceptable option, electrical infrared thermography must continue. However, it must be executed in a manner that is as safe as possible, and operators performing the inspections must be trained to understand the dangers and risks associated with the work.

Ultimately, live electrical equipment is extremely dangerous, regardless of whether the covers are removed or not, and it is important that the infrared community not become blasé about the safety requirements needed to carry out infrared thermography on such equipment. The recent high-profile coverage relating to arc fault incidents can only serve us well; however, we need to be careful that we do not fall into the trap of “a little knowledge is a dangerous thing.” There are standards such as NFPA70E in the workplace today to assist not only the thermographer, but all personnel working on live electrical equipment. However, care needs to be taken when applying such standards to your facility. This manuscript has shown that:

1. We dare not assume that, if covers are in place, the thermographer is totally safe. This needs to be addressed in the facilities infrared inspection procedures.
2. Low voltage systems can have higher incident energy than medium voltage systems, and as such, it is not sufficient to distinguish between such systems, safety-wise, on voltage alone.
3. In order to reduce the potential for arc fault, we must continue with infrared thermography, but in a manner that does NOT contribute to such a fault occurring.