

Avoiding Flashover in Medium Voltage Switchgear

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Abstract: This paper describes some of our experiences over the last 20 years related to damage from corona discharge in 5kv and 15kv indoor/outdoor Metal Clad Switchgear . Tracking it down and verifying our findings, using IR Imaging, UV Imaging, Ultrasonic Detection and visual inspection.

Corona is a serious issue in metal clad switchgear because of its highly destructive nature and is the cause of most flashovers in medium voltage metal clad electrical equipment. The fundamental cause of this symptom is an electrical breakdown of air brought on by electrical stress and poor air quality within the switchgear. If not rectified a flashover is imminent, possibly causing enormous damage and injury to personal.

Tests have proven that when a flashover occurs the temperature is in excess of 20,000 degrees, with a bulk of the damage being caused by secondary explosions from a build up of compressed unburned gases within the enclosure. Dealing with corona discharge in the case of metal clad switchgear is very unpredictable and caution must be used at all times.

With today's instruments used for condition monitoring and predictive maintenance, we are able to help combat and verify this problem and do it successfully.

Introduction We at Highvec take extra precautions to prevent serious potential hazards such as electrical shock and severe burns which are the two main Safety issues in the business. Most of our customers have a million dollar price tag if their plant goes off line and that is why we are there in the first place. The other serious issue is making sure we are part of the solution and not part of the problem. i.e.: Causing a power outage.

All experienced electrical maintenance personnel are familiar with the various surprises when entering any electrical equipment. Always expect the unexpected. So prior to opening any equipment a visual inspection, Ultrasound detection and sometimes IR Imaging are necessary.

Corona damage is one of the problems that we find on a regular basis. Because of the by-products, nitric acid and carbon produced from the corona discharge a continuous decay of insulation is taking place, which makes the situation highly unpredictable. With corona being the cause of most flashovers in metal clad switchgear you can predict that flashover is imminent in all cases. There are various signs that identify corona, some with no indication of corona using nondestructive testing, but with closer visual inspection we find that corona discharge had been present, but is not active as shown in fig. #1 and fig. #2.



fig. #1

fig. #2

In both these images, flashover was imminent if the problem was not rectified. Even though the corona was dormant at the time of inspection, it would have started discharging again with the appropriate relative air density, temperature, moisture and lack of air movement. Fig. #1 shows insulation decay phase to phase on a 5kv feeder. Figure. #2 shows actual air flow in the dust during corona activity on a 4160v conductor. In this case the deterioration is on the conductor insulation and corrosion on the metal clad.

In other cases we find the corona discharge extremely active. This is when extra caution is taken because a flashover could occur at any time. Corona also produces airborne ultrasound, ultraviolet light and if advanced into arcing it will sometimes show a thermal signature. This is a perfect opportunity for Ultrasonic detection, UV/Corona Imaging, IR/Thermal Imaging to find out where and why the corona is discharging as shown in fig. #3

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CORONA ACTIVITY REPORT

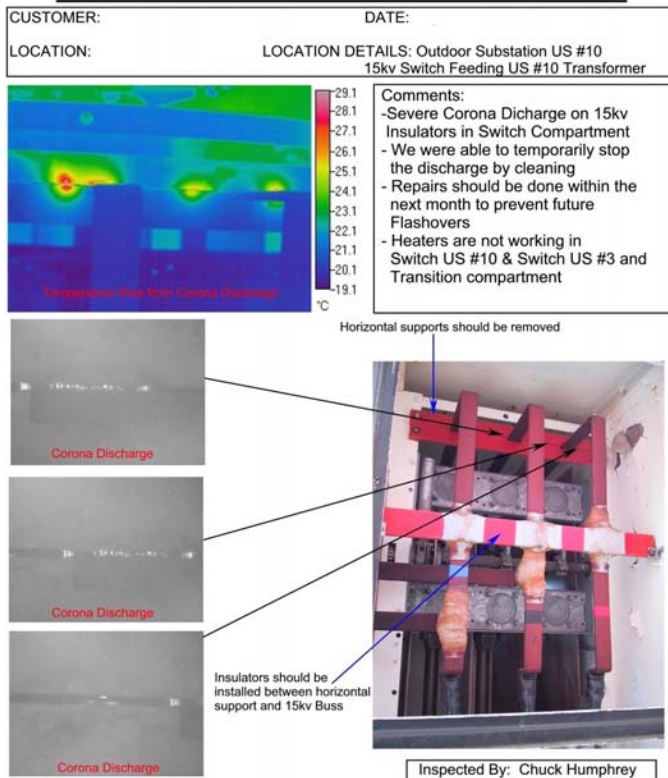


fig. #3

In the case of fig. #3 a thermogram was able to show a temperature rise on the 15kv buss insulators, verified by the ultraviolet corona images. The problem in this case is decay in the horizontal insulators causing electrical stress to initiate the corona. This all started with contamination entering the switchgear, trapping moisture and then under the right conditions started producing corona. Then with nitric acid, ultraviolet light, ozone and carbon deteriorating the insulation the corona eventually spreads on it's own.

Corona at anytime is extremely serious and should be dealt with and eliminated as soon as possible. In our case we can stop the corona with our cleaning equipment. Sometimes permanent and sometimes temporarily, depending on the situation.

At times when entering equipment the environment changes inside the metal clad compartment when you open a door or remove a cover. This, on occasion stops the corona discharge which makes it a little tougher to verify. Another byproduct of corona is ozone and the odor can be identified. Also there may be a chance of a thermal signature as shown in fig. #4 & fig. #5

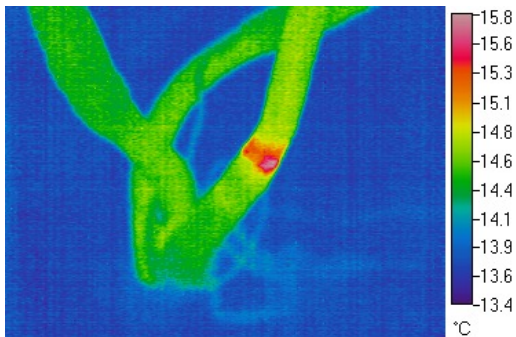


fig. #4

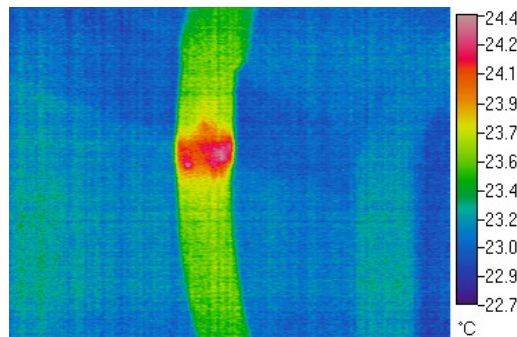


fig. #5

These thermograms represent two different cases of defective stress cones. Fig #4 shows a 5kv shielded cable with a stress cone and fig #5 shows a 15kv shielded cable with stress cone. The temperature rise is minimal, but the problems are very serious. Both stress cones were developing corona underneath the insulation and will eventually flash to ground. I have talked to different electrical thermographers and some believe that if the temperature rise is less than 10 degrees, not to worry about it. As you can see from images #4 and #5 that the temperature rise is less than 2 degrees C .

During the course of our duties we have found that some corona discharge events sometimes show up well in a thermal image as shown in fig. #6 and fig. #7



fig. #6

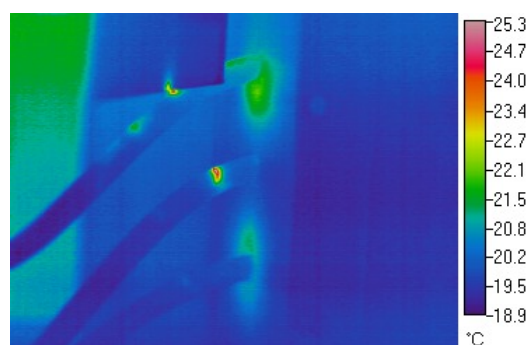


fig. #7

Active corona in fig. #6 shows a 4,160v junction box which is very close to flashover on three phases and had to be rebuilt because the corona damage was too extensive. We were able to temporarily stop the

activity with cleaning which kept it energized until they had a scheduled shutdown. Fig. #7 shows 13,800v conductors and insulators developing a temperature rise from corona discharge.

Corona discharge is always caused by a deficiency which in turn creates electrical stress on the components i.e. Contamination, design defect, or poor installation. Corona is not always easy to find, but with the use of UV/Corona Imaging, IR/Thermal Imaging, Ultrasonic detection and visual inspection to verify your findings, it is getting easier.

The corona camera that we use is an excellent tool to find, verify and know exactly where the discharge is and what the corona discharge is doing.

When our customers are burdened with high costs for downtime, it is necessary to be as accurate as possible with our findings.

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UV / CORONA IMAGING REPORT

CUSTOMER: Porcupine Joint Venture

DATE: Sept. 16 / 02

LOCATION: Hoyle Pond

LOCATION DETAILS: 440m Level Shaft Station
5kv Junction Box Feeder #1

Inspected By: Chuck Humphrey

Comments:
Corona is active in JB
We were able to temporarily stop the corona.
A heater should be installed in both Feeder #1 & Feeder #2

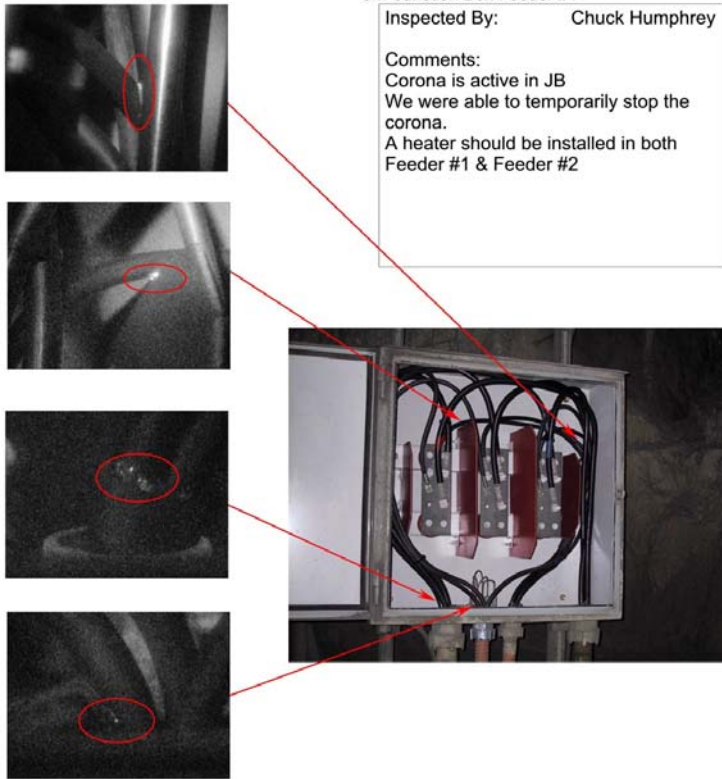


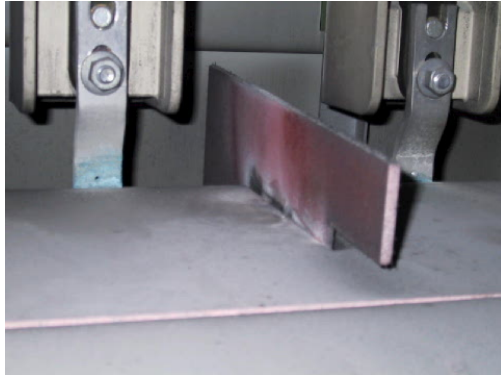
fig. #8

Fig. #8 shows a 5kv main feeder for an underground mine. No outage was needed for this corona problem. After we cleaned the junction box and separated the leads, a heater was installed to keep the moisture out.

Corona is an electrical breakdown of air phenomenon that results from the ionizing of gasses due to a high electrical stress. This stress is often caused by the reasons mentioned earlier, i.e. contamination and poor insulation values.

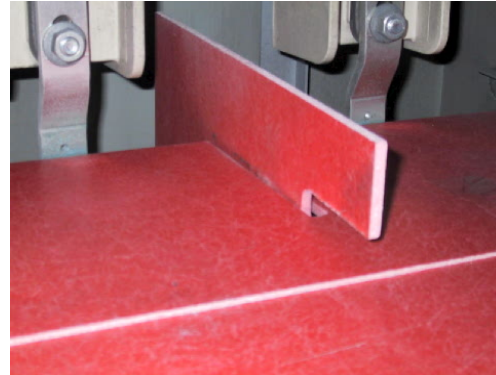
After continually working in live metal clad electrical equipment, Highvec has grown to take the corona situation very seriously. By wearing fire retardant clothing, knowing your surroundings and exits at all times and using proper tools, we have been able to extinguish a lot of corona problems for the sake of everybody's safety and to insure the integrity of the equipment to prevent costly outages.

There are times when corona is quite obvious. Without using any test equipment. Again we use extreme caution to investigate. Example in fig. #9.



Before Cleaning

fig. #9



After Cleaning

fig. #10

Figure #9 shows severe corona in a 15kv interrupter switch. The green material on the buss bar is corrosion from active corona and the black material on the bakelite insulation is carbon residue from active corona and arcing. This particular switch was very close to flashover.

Figure #10 shows what fig. #9 was like after it was cleaned. We were able to stop the corona activity temporarily, to buy time for a scheduled power outage. The problem in this case was the red bakelite insulating divider was tight against the 15kv buss and was starting to short out. The problem was resolved by cutting the insulating divider a couple of inches back from the buss.

There is no one tool that will verify all corona problems all the time because the corona discharge is erratic and unpredictable, especially in the early stages. Ultrasound detector is used to verify if air born ultrasound is present from the corona discharge. The IR camera is used to verify if there is any temperature rise from corona discharge. The UV/corona camera is the ultimate tool for verifying corona discharge. If the discharge is dormant, then none of this equipment will indicate or verify anything. That's when a visual inspection may indicate there was discharge previously as shown in this paper. Which will tell you, it will return.

When tracking down corona we have found that it does not always leave a thermal signature. Corona by nature creates little or no heat, but as it progresses into arcing and tracking a thermal signature can sometimes be found. Corona is most intense in the 300 nanometer to 400 nanometer range in the ultraviolet spectrum. When it exceeds the 400nm range corona can be seen in the visual spectrum if there is no interference from background light. Similar to heat coming into the visual spectrum at approximately 585deg. C. at the 700nm level. As shown in fig. #11

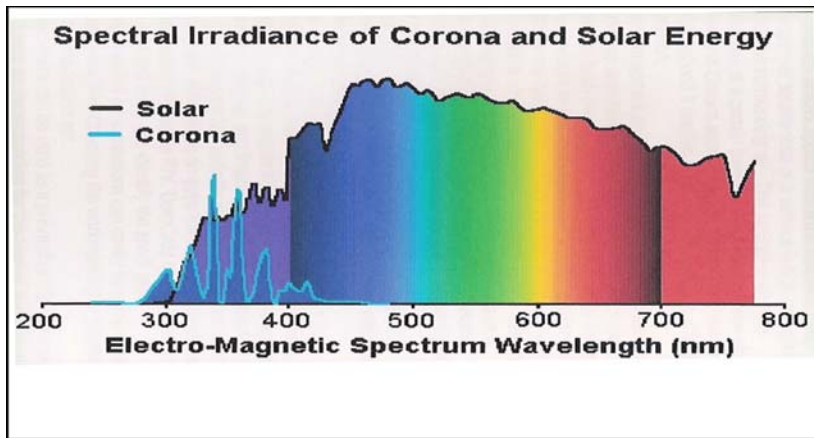


fig. #11

We performed a small corona experiment using the three different spectrums. As shown in fig. #12

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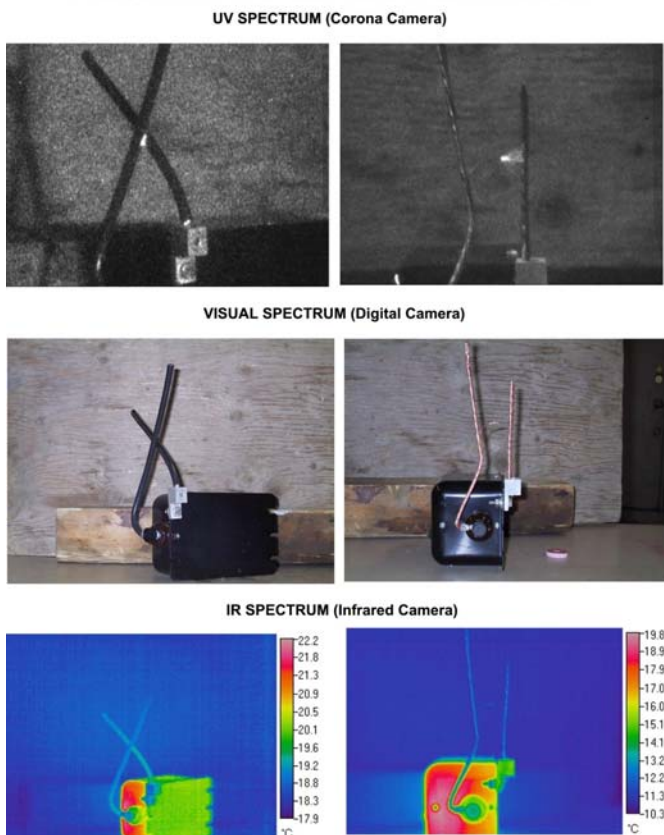


fig. #12

In fig. #12 we show two different scenarios of active corona at 5kv. In the left and right columns we see the three different spectrums all at the same time. At the top we have the UV spectrum using the corona camera and corona is evident. In the middle nothing can be seen in the visual spectrum. At the bottom in the IR spectrum using thermal imaging there is no thermal signature where the corona activity is present.

Summary:

Over the years Highvec has gone through an enormous learning curve to improve safety for others, and ourselves while performing on live line electrical cleaning and maintenance up to 230 kv. With the use of infrared imaging, corona imaging and ultrasound detection, we are able to find problem areas before they become a health and safety risk along with serious financial burdens to our customers. To clean and maintain electrical equipment under live conditions has proven to be very beneficial to everyone.