

# A CASE STUDY OF PARTIAL DISCHARGE AND ELECTRICAL TRACKING IN A 11KV METAL CLAD SWITCHGEAR

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## **ABSTRACT :**

Electrical discharge in the form of corona and tracking has caused many failures in metal-clad switchgear with little warning or understanding of the cause. The fundamental cause of this symptom is an electrical breakdown of air brought on by electrical stress through weak electrical components and poor air quality within the switchgear. Dealing with corona discharge in the case of metal clad switchgear is very unpredictable and caution must be used at all times.

Through this paper we share our learnings to take the mystery out of the occurrence of partial discharge and tracking in metal clad switchgear by discussing its occurrence, what to look for during an inspection and a case study.

## **INTRODUCTION:**

Electrical discharge in the form of 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 through weak electrical components and poor air quality within the switchgear. If not rectified a flashover is imminent, possibly causing enormous damage and injury to personal and equipments.

Because Corona and tracking conditions are voltage problems that rarely produce heat, they remain undetected using a typical infrared inspection.

## **CORONA AND TRACKING:**

Corona refers to the faint glow surrounding an electrical conductor of 3500 volts or greater as a result of the ionization of air as the nitrogen in the air breaks down. When corona occurs, it creates ozone, ultraviolet light, nitric acid, electromagnetic emissions and sound.

Ozone is a strong odorous gas that deteriorates rubber based insulation. If moisture or high humidity exists, then nitric acid can also be formed that attacks copper and other metals. The electromagnetic emissions can be heard as an interference on AM radios and the corona signs and tracking can be heard or detected by the ultrasonic scanning devices.

One important point to consider is that unlike infrared that detects heating due to current flow, partial discharge or tracking indicates voltage problem and can be present without current flow hence it goes undetected using infrared thermography.

Once partial discharge becomes active, it leaves behind a conductive tracking path on surfaces and also creates a conductive cloud of air around itself. A flashover can occur once a tracking pathway is completed from phase to phase or phase to ground. It can also occur from the conductive cloud of surrounding air once it finds a path to ground.

## **WHAT CAUSES PARTIAL DISCHARGE OR TRACKING:**

There are three primary causes for its development:

1.) **Geometric factors:** Geometric factors include sharp edges on conductors, connections and switchgear cabinet components. This may be the results of sharp tapes wrapped in conductor terminations, tag ends on conductors, and corners and points on conductor bracing and support shelves.

2.) **Spatial factors:** Spatial factors include small air gap spaces between the two or more conductors, insulation board and switchgear cabinet components. This may results from:

- conductors being tie wrapped together
- conductors touching insulators, conduit, and edges of cabinet.
- Non shielded cables in contact with grounded surfaces
- Bus bars in close proximity to fiber glass sheet and insulator material.

3.) **Contamination:** Contamination in the forms of dust, oil/fluids, and other particulates including sulphation on conductors and insulators will create partial discharge which further exasperated by humid and wet conditions.

#### **VISIBLE SIGNS OF PARTIAL DISCHARGE AND TRACKING:**

Probably the most noticeable sign of partial discharge is the smell of Ozone, since this is its major byproduct. Early stages of corona may not show any visible signs. Typically the effects of partial discharge on rubber based insulators, tape, and insulation board will leave a white, fibrous powder residue or dust as shown in Figure 1. This dust is the physical breakdown of the material making the material prone to damage as this condition persists.



Figure 1

As the condition worsens, carbon track develops on conductors and insulators as shown in Figure 2.



Figure 2

Other indicators include pitting and discoloration on cable and bus bar as shown in figure 3.



Figure 3

Unusual weathering patterns on copper bus and conductors are also good indicators of partial discharge and tracking. Humid and wet condition inside the switchgear cabinets will allow Nitric acid to form which attacks the copper surface leaving unusual weathering patterns. It can be seen in a sticky droplets form on the conductors and insulators with a bad smell and bitter taste. Litmus test can also be done.

#### **PARTIAL DISCHARGE AND HEATING:**

Tracking conditions produces a very faint heating pattern due to the molecular disturbance of electrons associated with the ionization of air. Depending upon air movement and the intensity of partial discharge, the delta temperature may or may not be detected by the infrared technology. Using Ultrasound technology, we will be able to locate the culprit or affected area where the tracking is occurring.

#### **ULTRASOUND TECHNOLOGY:**

Sounds above the normal range of human hearing(20 Hz-20 kHz),is typically thought of as Ultrasonic. A frequency range between 20 kHz to 40 kHz generally covers all of the ultrasonic applications used for predictive maintenance application and electrical discharge.

The equipment includes a receiver unit, headphones and various modular listening devices that attach to the receiver. Through a process of heterodyning, the ultrasound signal is converted by the receiver unit to a low frequency audible signal that can be heard through the headphones. There is also a read out display that shows the intensity of the received signal. Because corona and tracking problems are occurring in air, it makes senses that the best technique to detect these problems is through air or structure borne ultrasound.

Ultrasonic waves are very directional in their movement making it relatively easy to track problems back to their source. Using common sense and following the strongest received signal we can somehow locate the cubicle where the tracking or discharge taking place.

#### **CASE STUDY:**

In NTPC Singrauli, there is a Siemens make 11kV metal clad Switchgear named as a Colony Switchgear as supply to the colony and NTPC SSTPS township is taken through this switchgear. This switch gear consists of 14 cubicles having VCB including 2 Incomers and one bus coupler units.

After acoustic Ultrasonic test, we found severe tracking phenomena happening in the switchgear in almost all the cubicles, but the severity level of the bus coupler unit was much more compared to the

other cubicles. The test result associated with the bus coupler unit is shown below in Figure 4 . The bus coupler breaker was in test position.

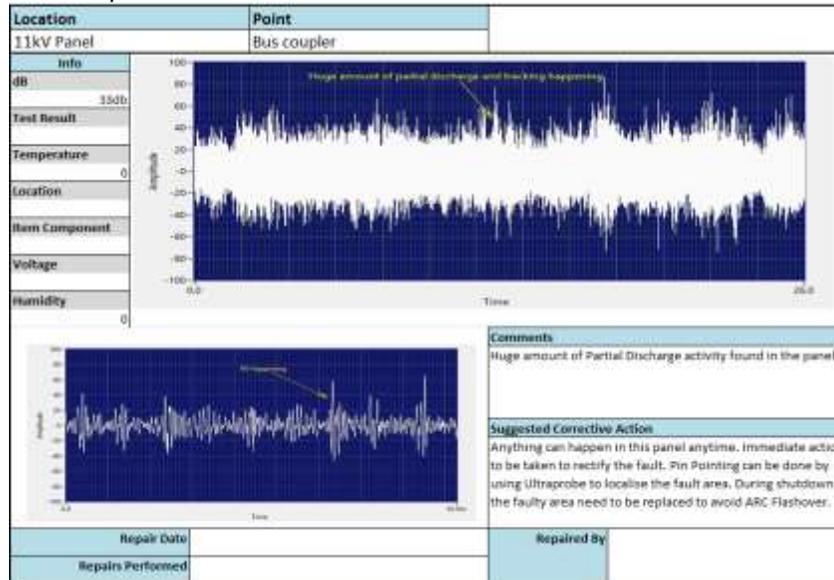


Figure 4

Just a day after ultrasonic test, a flashover occurred in the bus coupler panel causing damage to the breaker unit and associated insulating components. Both the incomers were tripped on earth fault and over current causing disruption to the colony supply and other associated feeders.

#### **ANALYSIS AND CORRECTIVE ACTION :**

Immediately permit was taken and Isolation was done and confirmed. After opening the bus coupler cubicle we found the breaker unit was carbonized and associated support insulators and other insulating materials were also affected badly.

One by one all the 14 panels were opened from the front and back side and the condition of the cubicle units were analyzed. It was observed that a sticky liquid drops with bad smell and bitter taste were present on the bus surface and also white fibrous powder like substance were found on the conductors and insulators. Sulphation was also observed on the bus bar. This switchgear has the bottom opening and cable trench was placed beneath the switchgear.

Cleaning of all the panels were done with acetone and CRC thus removing all the powdered materials and varnishing of bus bar was done. Along with the cleaning, IR values of all the support insulators and spouts were taken. Few insulators and spouts were having low IR values.

After the cleaning process was done, IR value of bus bar with respect to earth and with respect to phases was taken but surprisingly, IR value was coming very low i.e. of the order of kilo-ohms. 11 kV Bus could not be charged with this low I.R value hence a high voltage 6.6 kV ac injection was done. The voltage was increased gradually from 1 kV step by step and leakage current was also observed during every step. When we injected around 5 kV, a corona discharge was seen in the bus coupler cubicle unit around the spouts and glass fiber insulating sheet. The leakage current was also found of the order of 700-800 mA.

Now once again the bus coupler unit was diagnosed and the area where corona was seen was analyzed. It was found that the glass fiber insulating sheet was brittle. The glass fiber insulating sheet was the culprit which aggravated the discharge and tracking phenomena was happening because of this. The sheet was taken out, get varnished properly and then placed. After that, the IR value was taken and found okay i.e. greater than 100 Mega ohms.

The Bus then charged successfully and supply of all the associated feeder was restored.

### LEARNINGS AND SUGGESTIONS:

The presence of electrical discharge /or tracking in the switchgear is a serious problem that should be addressed as soon as possible. Through our recent happening we learnt few things and following points are suggested to avoid flashover:

- During predictive maintenance, the cubicle should be tested through ultrasonic acoustic device if available. It indicates the condition and severity of tracking phenomena (if any). If the switchgear is located in the '0' meter with the bottom opening with the possibility of moisture ingress, the test should be done more often.
- If any sticky liquid is found with bad odor and a bitter taste, it is possibly the formation of nitric acid which can further aggravate the tracking phenomena.
- Any physical sign of breakdown or injury to conductors, insulators or insulation board/sheet should be corrected by repairing/replacing the damaged component.
- Look for the air gap between the conducting units. Air gap can also be increased using porcelain insulators of the required rating.
- Smooth sharp edges if any. Apply semi conductive tape or compound or wrap edges with metallic screening to form round conductive surfaces.
- Replace damaged terminations.

### CONCLUSION:

Unlike resistance problems associated with current flow that can be detected by infrared, corona is a voltage problem that seldom generates heat. Corona and tracking problems can be easily missed by infrared and remain enigmatic until a major fault occurs that destroys switchgear equipment. Hence testing of cubicles during predictive maintenance through ultrasonic acoustic device is advisable. It indicates the condition and severity of tracking phenomena (if any). The location of switchgear should also be taken into account and if the switchgear is located in the '0' meter with the bottom opening together with the possibility of moisture ingress, the test should be done more often.

### BIOGRAPHY



Anil Shrivastava having completed his B.E from NIT Bhopal in 1986 joined NTPC as 11th batch Executive Trainee in the same year. With over 29 years of experience in electrical maintenance, he has worked in diversified areas of switchgear, HT & LT motors, valves, transformers, switchyard, generator and testing. Currently he is the Head of Department of O&M-Electrical in NTPC SSTPS. Prior joining NTPC Singrauli he was working as an Assistant General Manager in NTPC VSTPP, heading the transformer, generator, testing, switchgear and motor sections of NTPC Vindhyaachal.



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