

**CORONA (PARTIAL DISCHARGE)
REHABILITATION CASE STUDY
HIGH-VOLTAGE STATOR WINDINGS**

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Respond. Rethink. Resolve.



PARTIAL DISCHARGE (CORONA)

Partial Discharge: Often used interchangeably with Corona

- Electrical discharges that occur across voids in high voltage insulation systems
- Voids or separations can occur due to manufacturing process defects, thermal deterioration, mechanical movement during operation, and other factors
- A transient gaseous ionization and carbonization occurs in an insulation system when the electric stress exceeds a critical value
- This ionization in the void produces partial discharges (Paschen's Law)

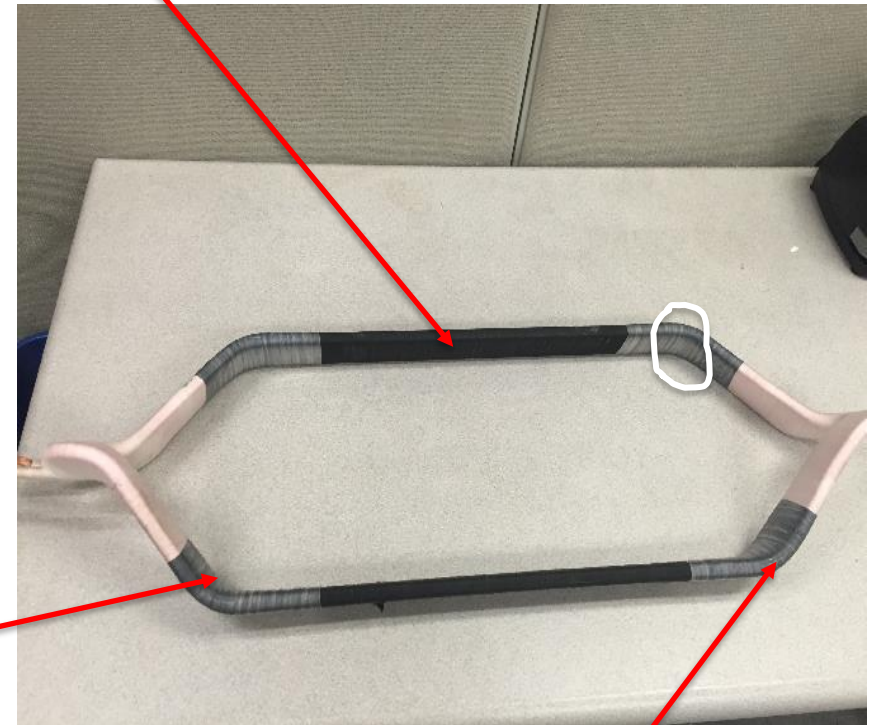


B STAGE OR GREEN COIL WITH CORONA SUPPRESSION SYSTEM (TYPICALLY FOR 6KV AND UP)

Conductive Corona Paint or Tape



Grading Paint or Tape
(4 Corners)



Overlap Region
(4 corners)

- **Conductive Tape (aka Corona suppression tape) is used to eliminate partial discharge along the coil surface to core, which typically occurs in the ground wall of coils rated 6 kV and above.**

PARTIAL DISCHARGE COMMON CAUSES

Manufacturing Defects

- Coil manufacturing defects and winding techniques
- Deficiencies with conductive packing materials
- Inadequate resin distribution and curing during press cycle
- Old or poor-quality resins rich tapes for B stage windings
- Voids in the insulation or delamination of the insulation tapes
- Lacking space between coils and parallel rings

Electrical Slot Discharge

- Poor contact of semi-conductive layer of coil with conductive packing and stator core slot iron
- Thermal aging and coil shrinkage
- Mechanical coil movement into the slot



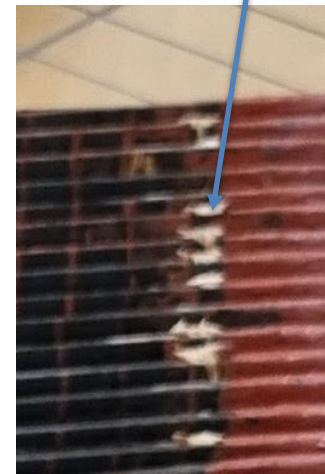
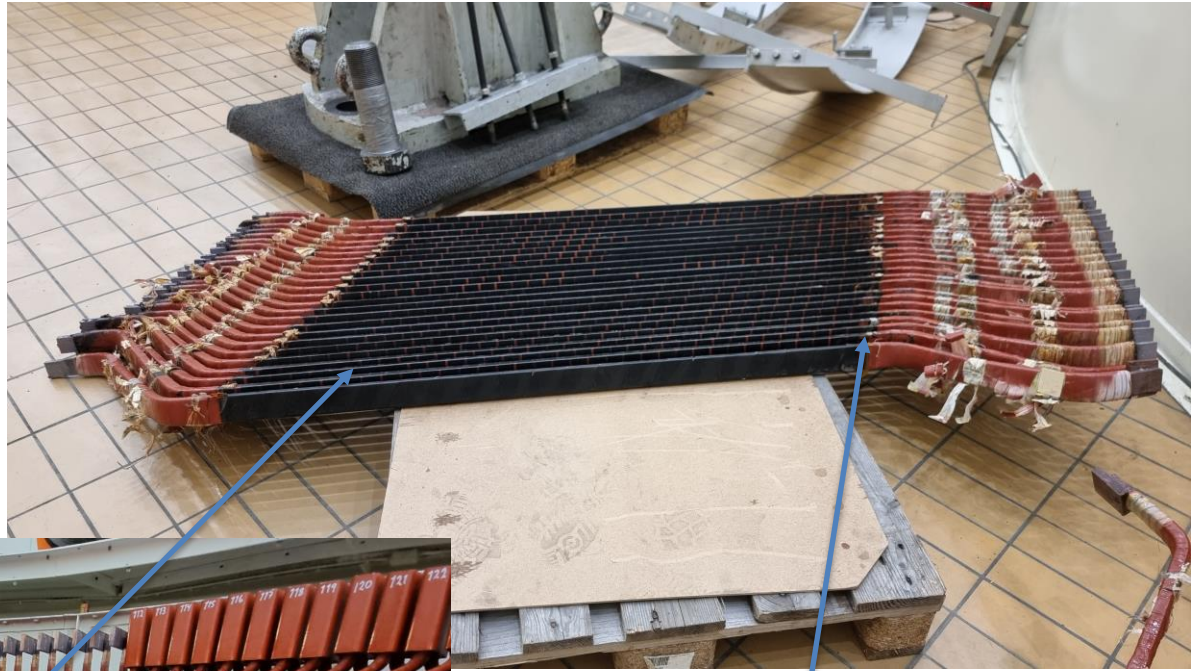
PARTIAL DISCHARGE (SOME VISIBLE / SOME NOT)



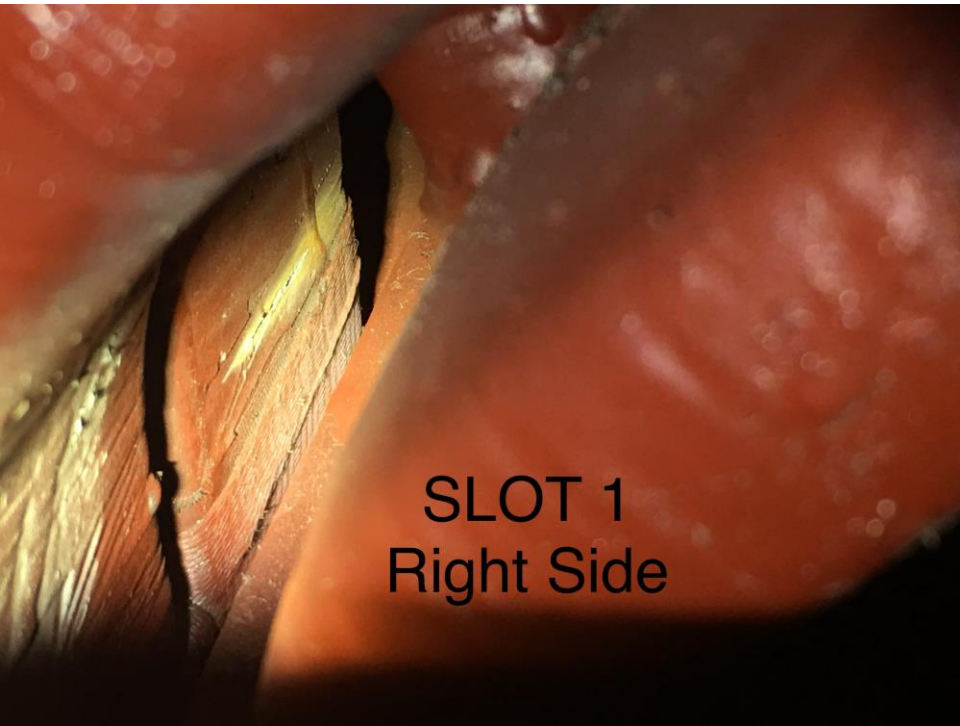
Using a borescope (through cooling vents)



PARTIAL DISCHARGE VISIBLE - 46 MVA, 300 RPM, 13800V



PARTIAL DISCHARGE VISIBLE - 36 MVA, 144 RPM, 13800V



CORONA MAINTENANCE REHABILITATION CASE STUDY

Determining When Corona Maintenance is Required

- Identification/Confirmation of partial discharge (Trending)
- Visual Inspection
- Partial Discharge Testing in the field
- Bus Couplers PD Test using single phase offline test method
- UV Camera Test

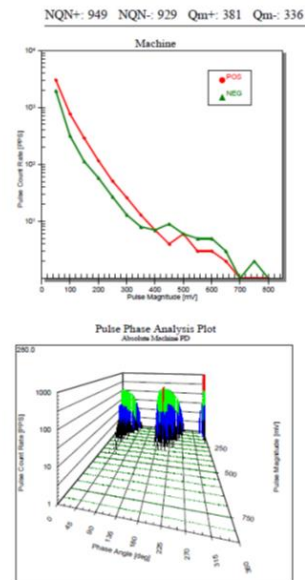


PD Bus Couplers
Epoxy Mica Capacitors

PD Test Equipment

Corona Camera

HV Resonator



30000 HP, 13800 V – FIELD EVALUATION

- Elevated PD trending results with PD detectors
- Visual inspection and UV camera test revealed several coils with advanced Partial Discharge activity

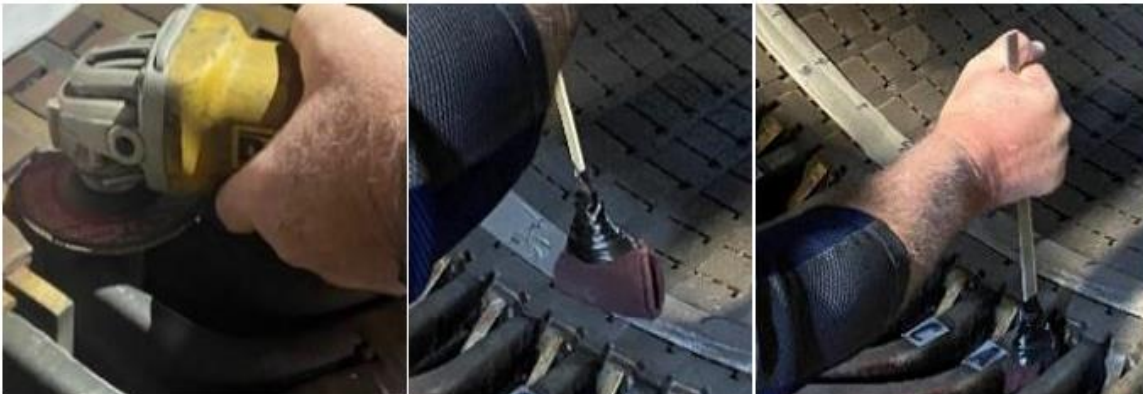


ACCESSING STATOR WINDINGS

Remove covers and rotor or rehabilitate with rotor in place if possible



- If rotor cannot be removed completely wrap rotor and shaft extension



- Prepare Stator Core
- Buff stator core to obtain fresh iron
- Scrub and clean coil extensions
- Mask 1" or first service pack back into the bore of the stator core

STATOR PREPARATION FOR RE-ESTABLISHING CORONA SUPPRESSION SYSTEM



- Clean stator bore and coils with white rags and alcohol
- Vacuum all debris out of stator bore
- Prepare semiconductor treatment area
- Apply 1" painters tape band around the perimeter of top and bottom legs
- Tape should be applied a minimum of 1" beyond finger plates

REAPPLICATION OF SEMICON AND STRESS GRADIENT SYSTEMS



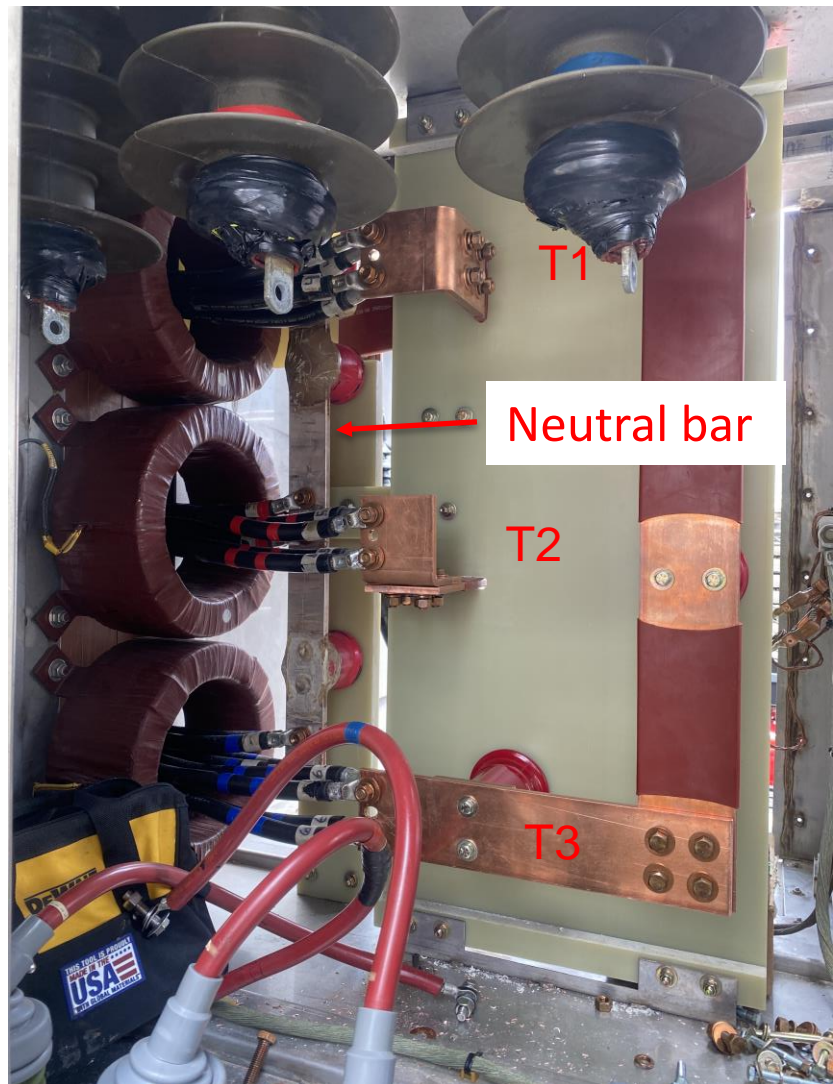
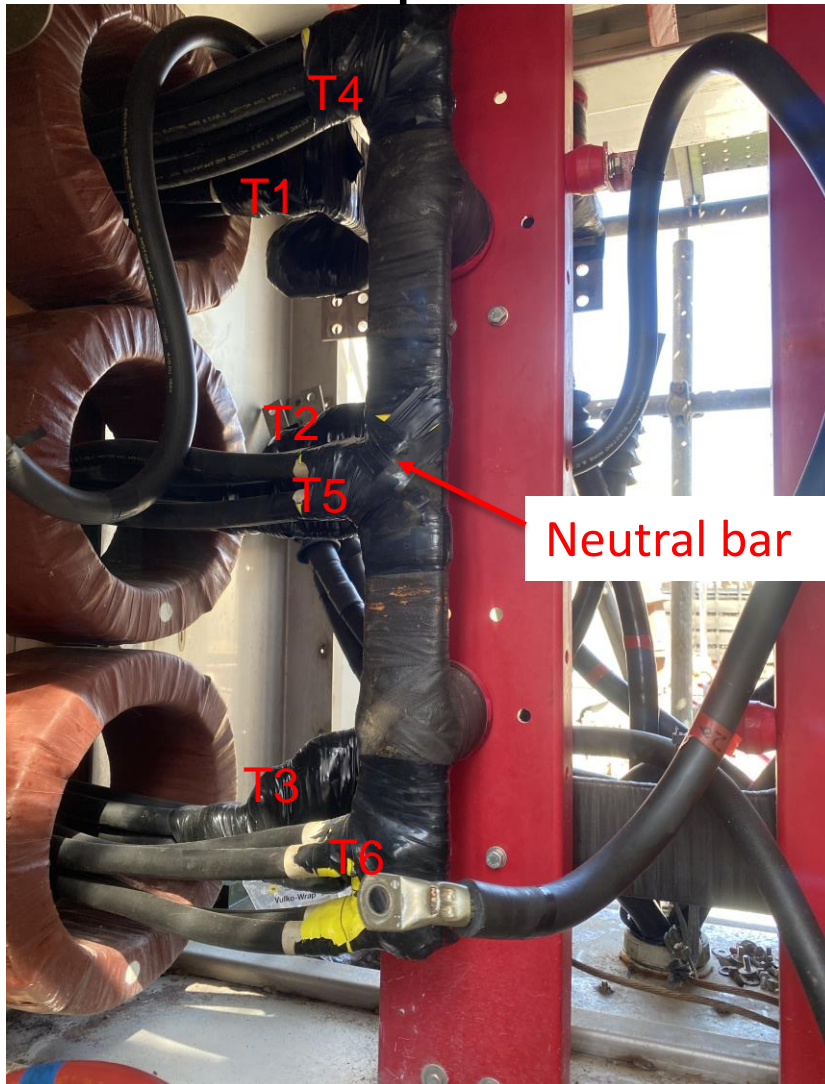
- Apply semiconductor paint and allow to dry
- Tape off coil region for application of the stress gradient paint
- Stress gradient region should over-lap semiconductor region by a minimum of 1"
- Allow stress gradient paint to dry and remove tape
- Apply RTV layer between top and bottom coils legs in crossover
- Completely overspray end turns with two-part topical epoxy overcoat

RESULTS AFTER RE-ESTABLISHING CORONA SUPPRESSION SYSTEM



REVERSE MACHINE TERMINALS IF REQUIRED

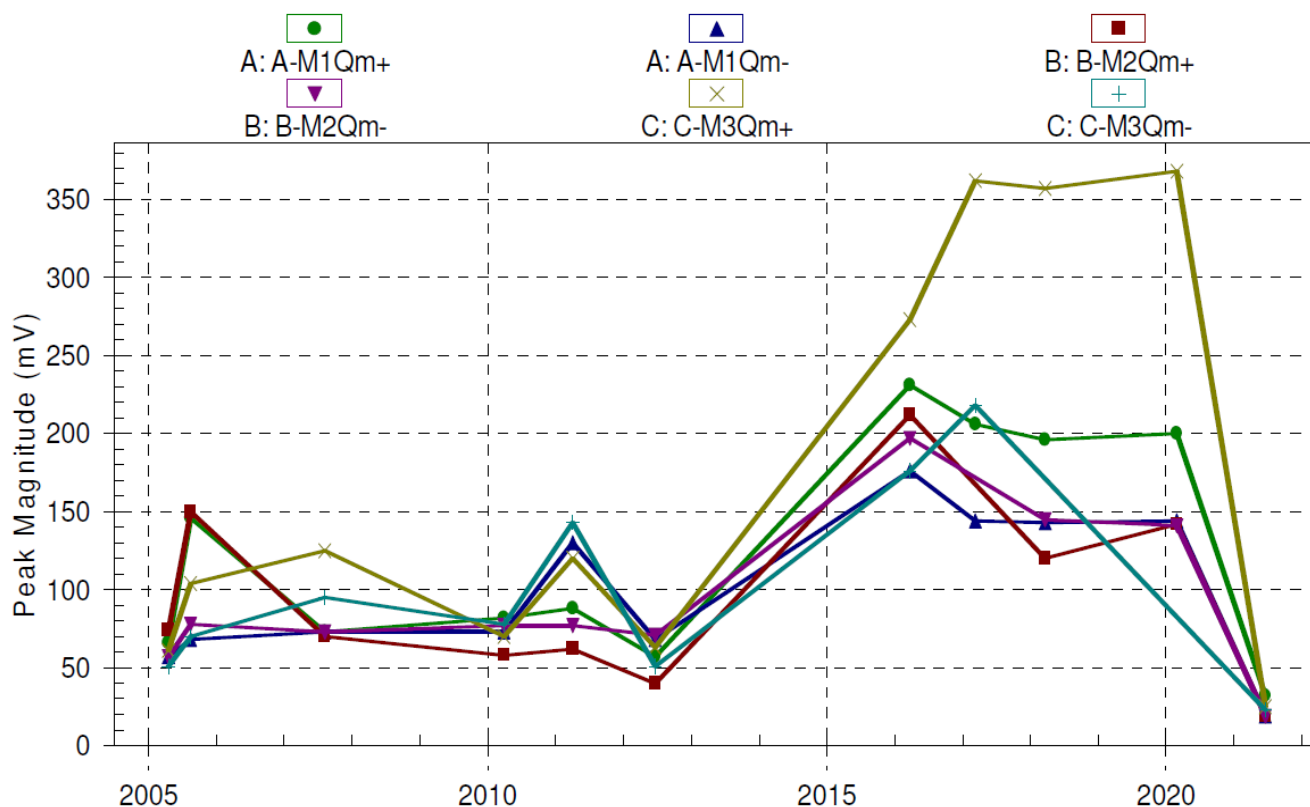
Neutral Lead Swap



PARTIAL DISCHARGE RESULTS (OFFLINE) AFTER RE-ESTABLISHING CORONA SUPPRESSION SYSTEM

All three Phases

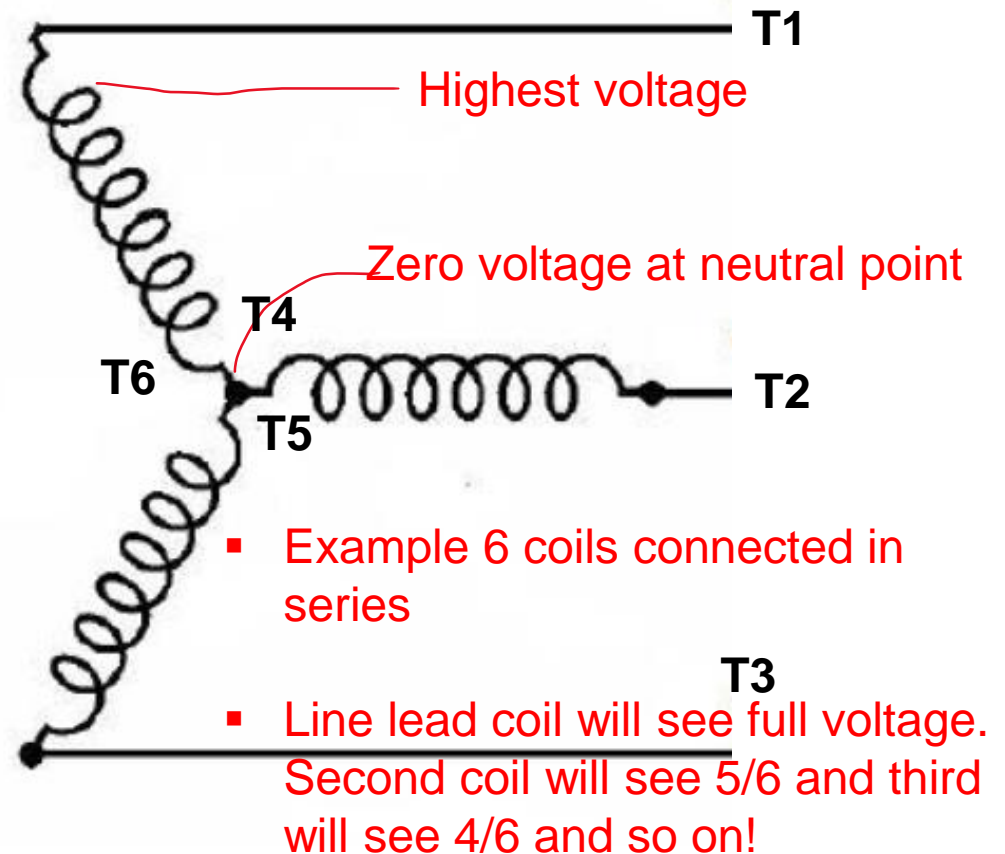
The Partial Discharge is stable (no more than 25% difference in Peak Magnitudes (+/-Qm), so there is no evidence of a change in winding condition. The Qm values recorded between 2016 and 2020 were an artefact of testing at lower sensitivity ranges.



WHAT DOES A LEAD SWAP MEAN DIELECTRICALLY FOR THE STATOR WINDING?

$$L-L = 13800V$$

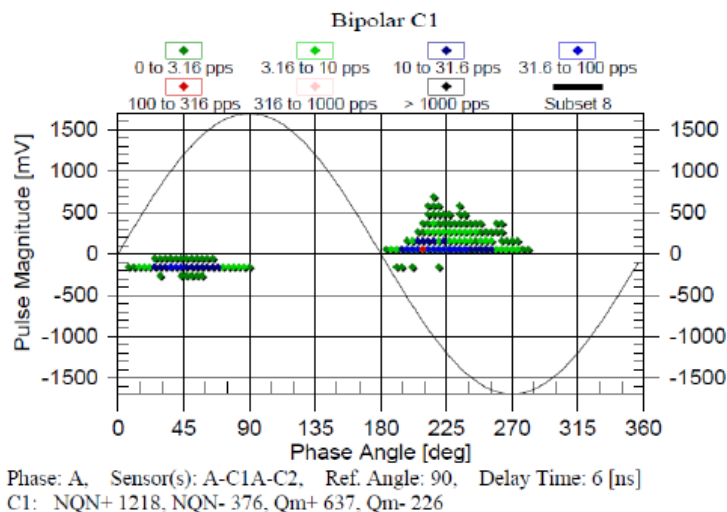
$$L-G = 13800/1.732 = 7967V$$



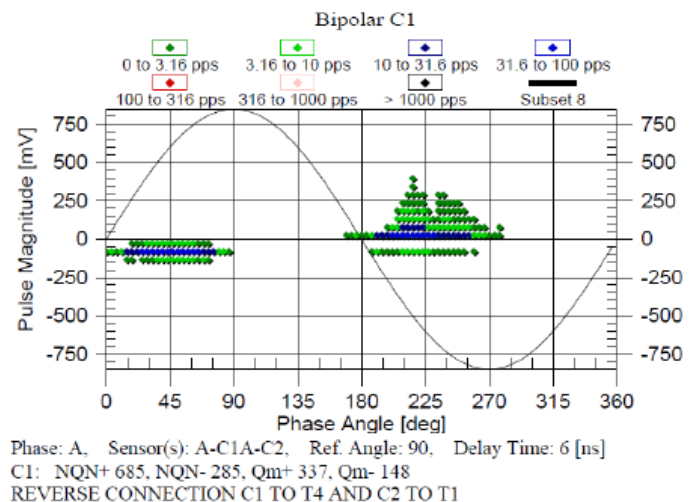
EFFECT OF REVERSING WINDING MACHINE TERMINALS



- In machines with 6 leads out , we can swap T1,T2 & T3 with T4,T5 & T6
- The coils at the tail end of the phase are subjected to less stress than the lead coil



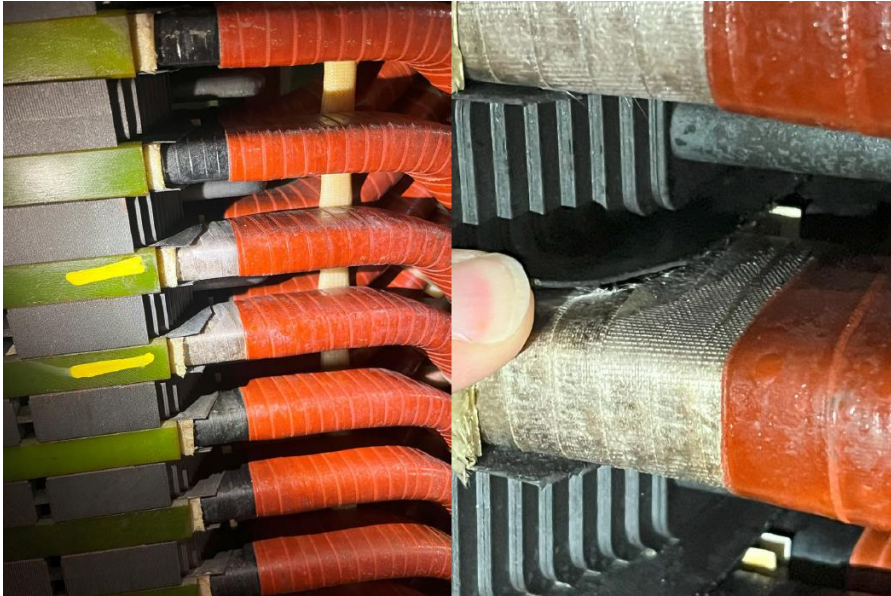
Normal Connection



Reverse Connection

22.5MVA , 4P, 12470V SYNC GENERATOR (PARTIAL DISCHARGE)

Before

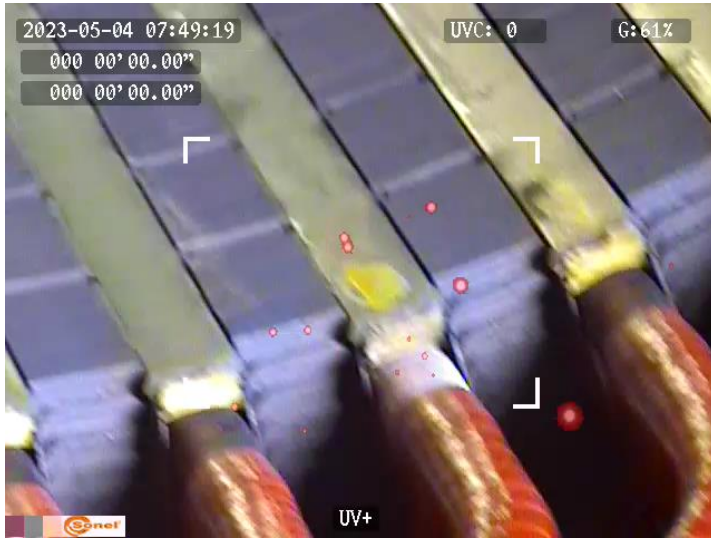


After



22.5MVA , 4P, 12470V SYNC GENERATOR (UV CAMERA TEST)

Before



After



REDUCE WINDING PD DURING OUTAGES

Re-establishing the corona suppression system reduces partial discharge if found outside the slot.



CASE STUDY CONCLUSIONS

- In many cases a high voltage machine with advancing PD can be rehabilitated to extend the operating life
- Identifying machines with partial discharge can be accomplished by utilizing PD test equipment, UV cameras, and Visual Inspection performed during machinery Preventive Maintenance outage
- Re-establishing corona suppression systems can be accomplished in the field in many cases especially for large machines during PM's
- It is beneficial for a neutral swap to be performed when the majority of the PD is determined to be associated with line lead coils
- All rehabilitation materials are catalyzed including weeping epoxies and do not require supplemental heat for curing
- Typically, the rehabilitation effort can be completed in 2 to 3 weeks depending on the size of the machine

QUESTIONS??

THANK YOU!!!

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