Recent Experience With Stator Rewinds Of Epoxy Injected Machines

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Generator Stator Epoxy Injection

- Topic Clarification:
  - **Specifically discussing** considerations of Epoxy Injection between the stator Bar / Coil and the stator Core.
  - **NOT** related to Water Cooled Stator Bar water box or bar strand leaking and injecting epoxy to address

Why Epoxy Injection?

- Correct and/or impede Generator Stator Spark Erosion (SE) and to a lesser degree Partial Discharge (PD)
  - Reestablish Bar to Core interface
  - Prevent Bar movement
  - Fill Voids

Origin & Development

- Transition form asphalt mica to polymer Insulation Systems in the late 50’s - 60’s
- 70’s and 80’s growing use of Global Vacuum Pressure Impregnation (GVPI) on new generators
- 1979 GE documents Vibration Sparking in TIL-175 and use of Side Ripple Filler
- Alstom aggressively pursued GVPI in the manufacture of new equipment, as did other OEM’s too
- Late 70’s early 80’s OEM’s using GVPI encounter issues with Slot PD and SE / VS

Origin & Development

- Alstom introduces DVV in 1982
  - DVV – Druck Verfestigungs verfaren
  - English – Pressure Consolidation
- Alstom quickly becomes the leader in Epoxy Injection, stating:
  - Alstom 2013 “ Normal Maintenance Activity”
  - Perform before 24K EOH – 32K EOH
  - Units with higher EOH are not good candidates and risk failure
  - Condition assessment (visual & possibly electrical)
  - Claims of DVV never needing repeated

DVV Visible From Borescope In Cooling Vents

Level 2 Spark Erosion At Area Of DVV injection

Case Study

- ~2003, Alstom expressed to the market that most Alstom generator types WX & WY, and all global VPI'ed stators should have DVV performed

- Case study on a ~300 MVA; 21 KV; Alstom Generator type WY that had the DVV epoxy injection process applied early in life, and then later rewound by NEC

Rewound in 2015 by: NATIONAL ELECTRIC COIL® Columbus, Ohio & Brownsville, Texas, USA

AC Generator Stator Winding

300,000 kVA 255,000 kW 8,248 AMPERES 21,000 VOLTS

3600 RPM 0.85 PF 3 PHASE 60 CYCLES

332 Field Volts 1441 Field Amperes Insulation Class F

Stator Winding Temp Rise: CLASS B

Unit No. 2 OEM Serial No. GM 214947

Winding Mfr. by: NATIONAL ELECTRIC COIL® Columbus, Ohio & Brownsville, Texas, USA

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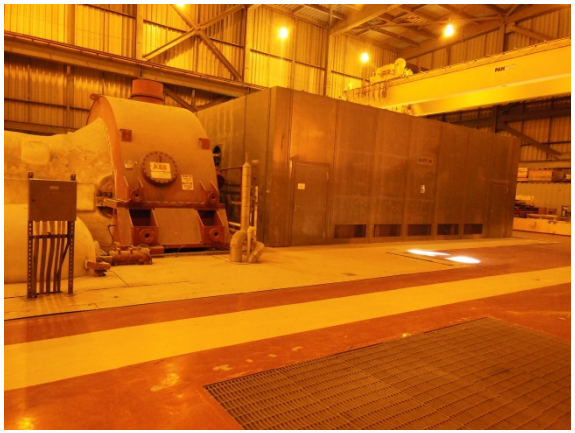
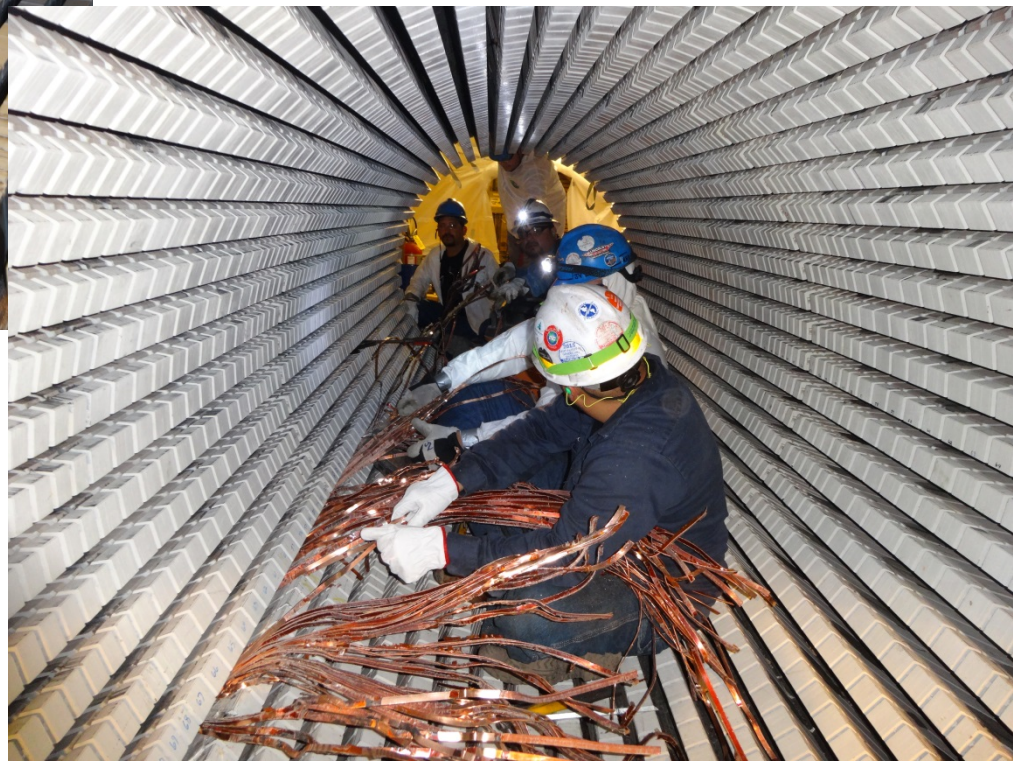


Model Design Weakness

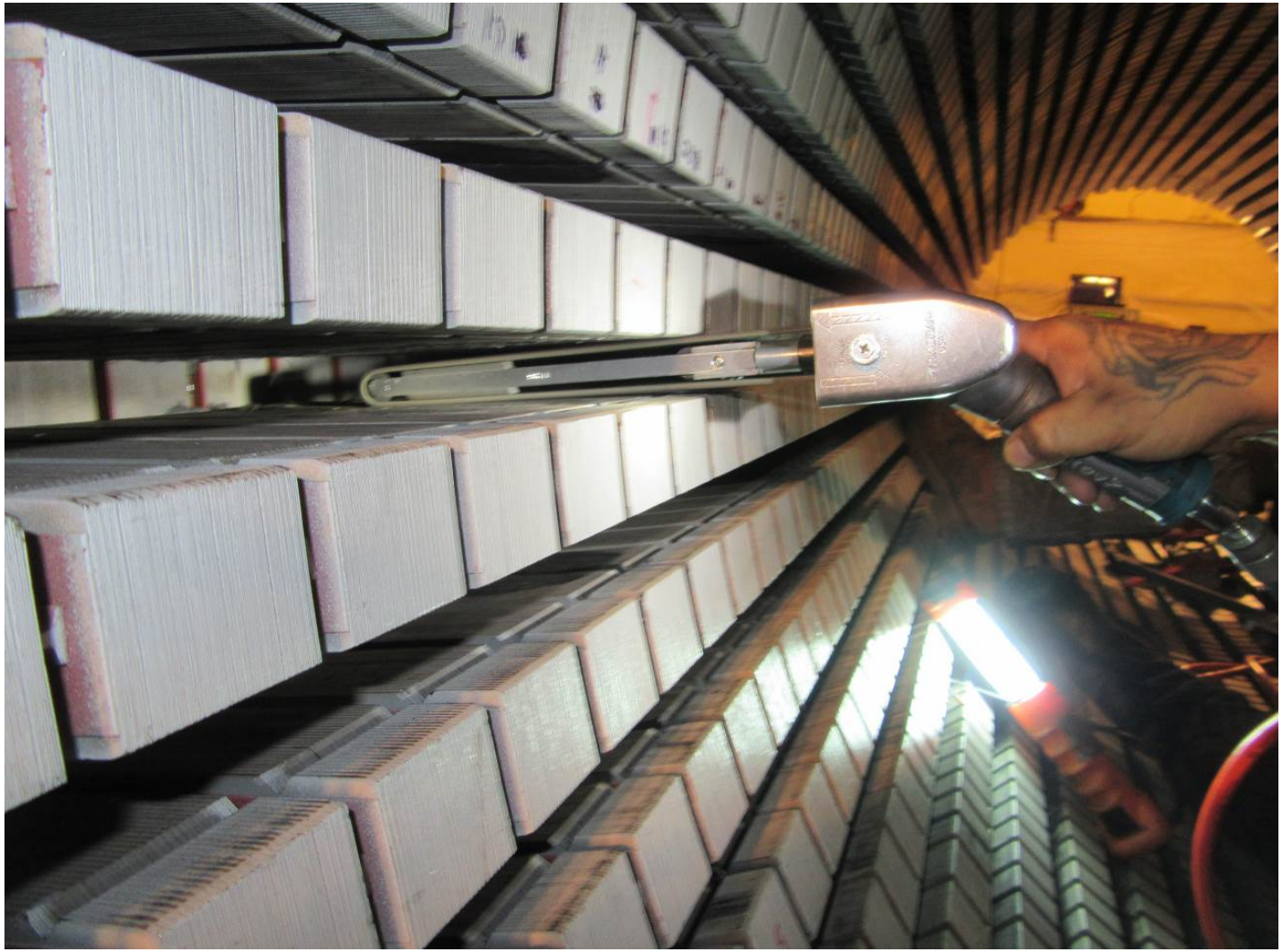
- **Stator Failure due to Spark Erosion**
- Rolled Tape OCP System
- Conventional side packing –Vs.- Side Ripple
- End Winding Support System & Phase Connection Cracking/Failures
- Rotor Pole to Pole Cracking/ Failures
- High VPM ground wall insulation

End Winding Support System

Stripping Coils



Cleaning & Repairing Core



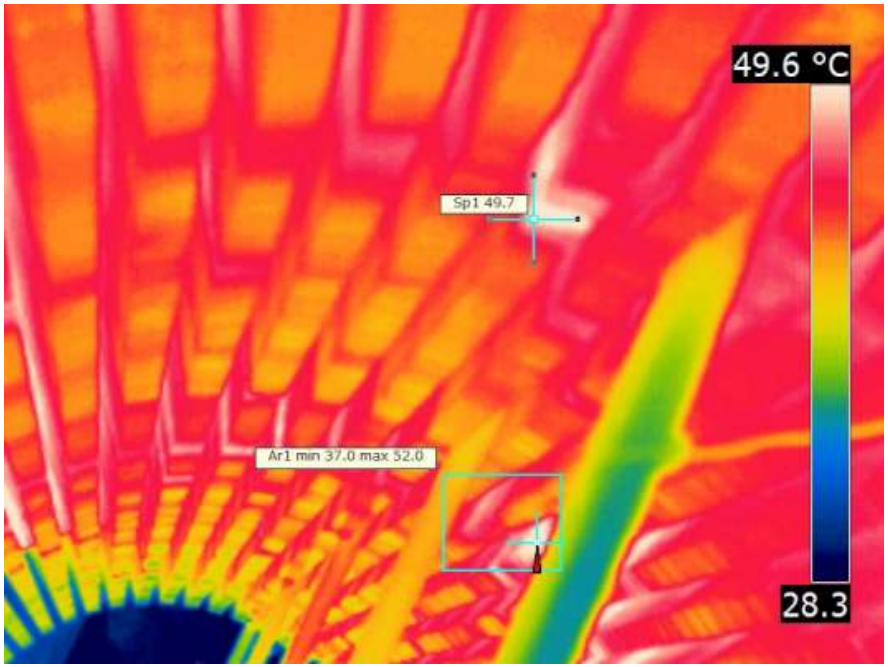
Cleaning & Repairing Core

Stator Core Qualification - Loop Test

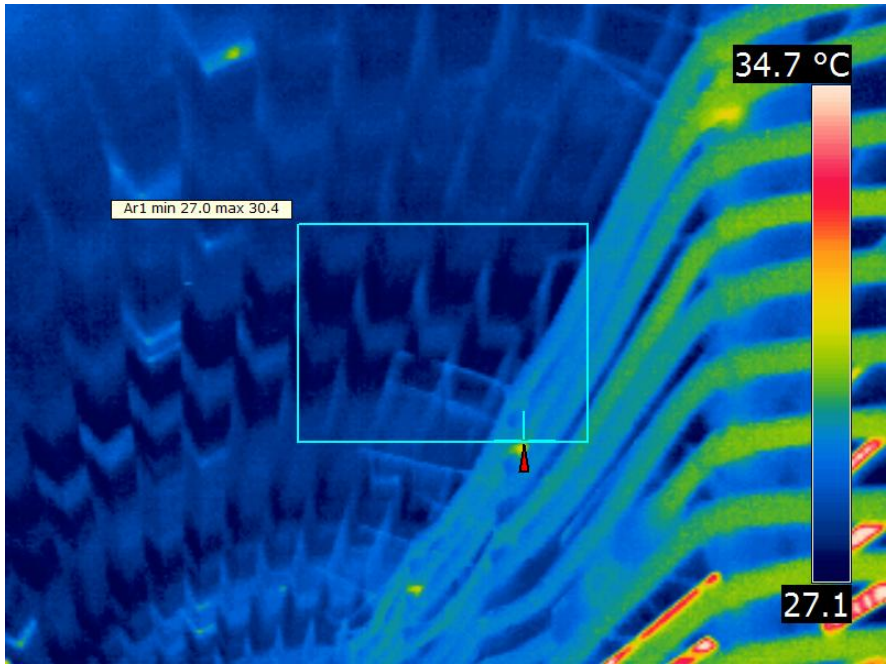
(See IEEE 56 and IEEE 62.2)

Pictures - Before & After Cleaning & Repair

Before



After



DVV Injection Considerations

- Total time and cost to effectively strip coils and clean the core
  - Schedule Impact: 5-6 Days ~1,000 man hours
  - Cost Impact: ~ $280K
- Total time to requalify the stator core
  - Schedule Impact: ~11 days ~2000 man hours
  - Cost Impact: ~550K inc. 9 loop tests
- Advantages of advanced design enhancements to Coil, OCP, & Slot Side Packing – Permanent Solution

Summary

- Epoxy injection (DVV) is an option to prolonging the life of GVPI and some Non- GVPI designed generators.
- However, several decades of experience indicate epoxy injection is not a permanent solution to machines with PD and SE
- If considering epoxy injection it should be done early in the machine life and, prior to performing, be certain a proper evaluation is performed to confirm condition.

Summary

- The choice to perform epoxy injection should be carefully made considering:
  - The EOH at the planned time of injection and overall condition of the insulation system
  - Consider unit planned service duration & future rewind cost and duration
  - Consider other available options based on:
    - Long term reliability
    - Needed machine service life
    - Total ownership cost
    - Risk reduction

Summary

- Despite claims by injection service providers, it is a fact that the time to strip a an epoxy injected stator core is significantly greater than a conventional non-injected machine.
- After stripping an epoxy injected core, due consideration must be given to the technical process, time duration, & cost to confirm the core integrity before proceeding with the rewind.

Rotor Pole To Pole Crossover

Phase Lead Failure

The natural frequency of the remaining phase leads were found to be solidly within the normal 2 pole natural frequency exclusion zone of 115 Hz to 135 Hz. (actual range of ~ 121 to 126 Hz)

Questions

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