Overhaul and repair management of a strategic generator in Western Australia

Vikas Bhandari

Machinemonitor, Australia

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Co-author: Ron Scollay, Principal Engineer CPEng, Machinemonitor

Generator Overview

Generator in-situ

Nameplate details

Shinko 6970kW

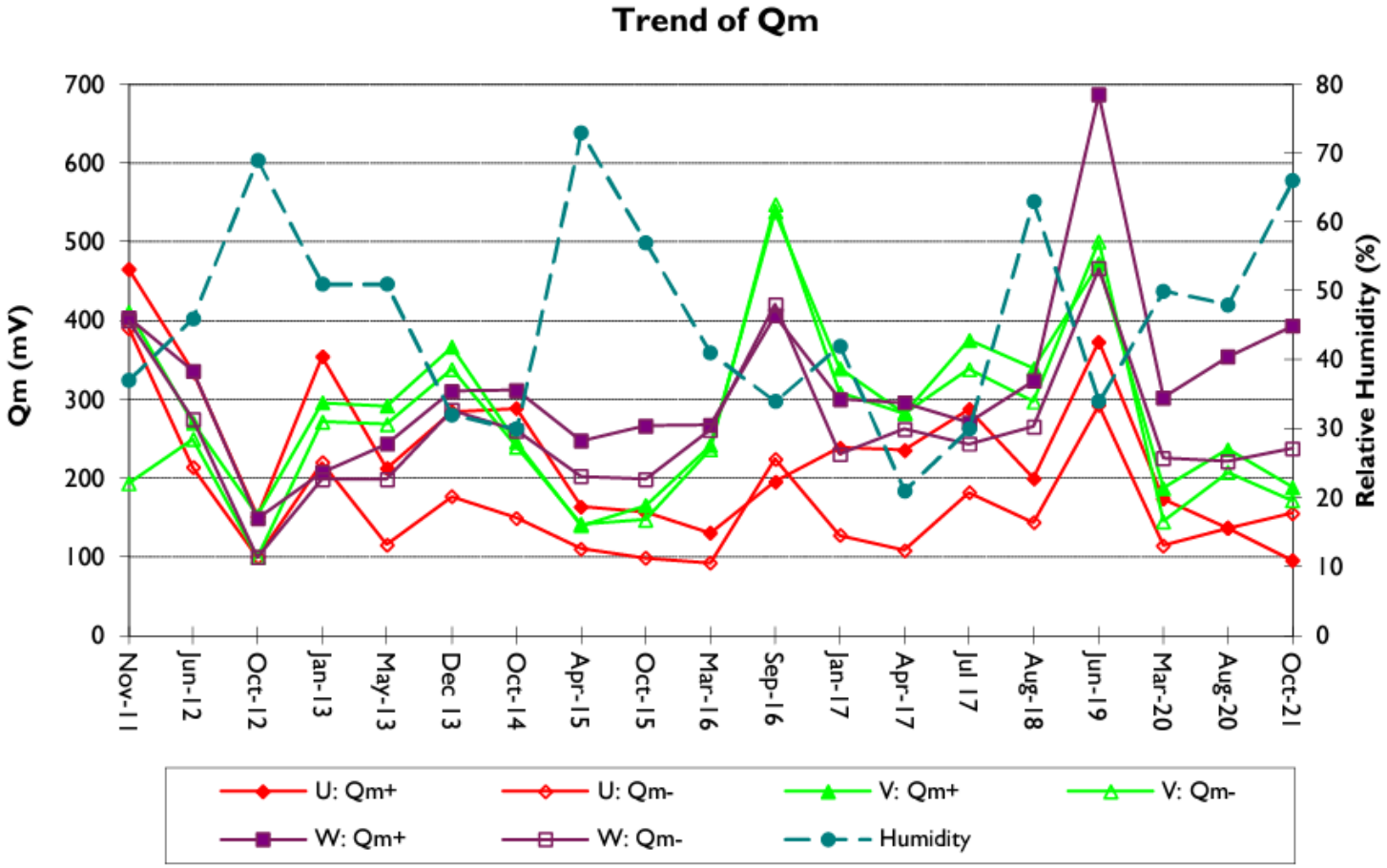
7600kVA 6.6kV

831A 50HZ 4P

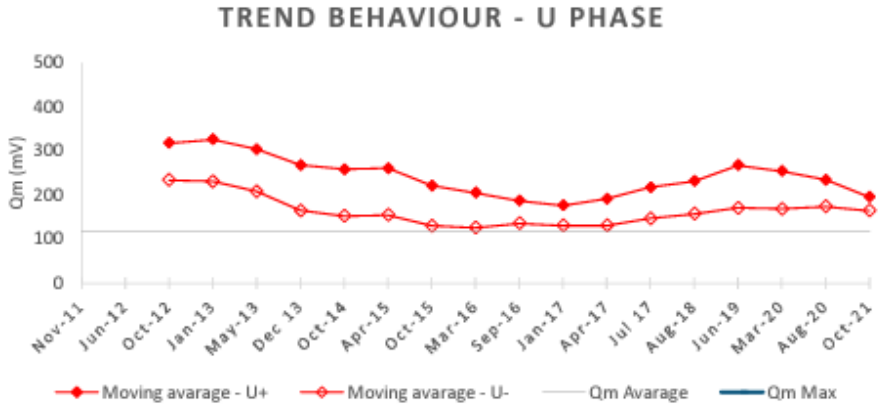
1500RPM 0.80PF

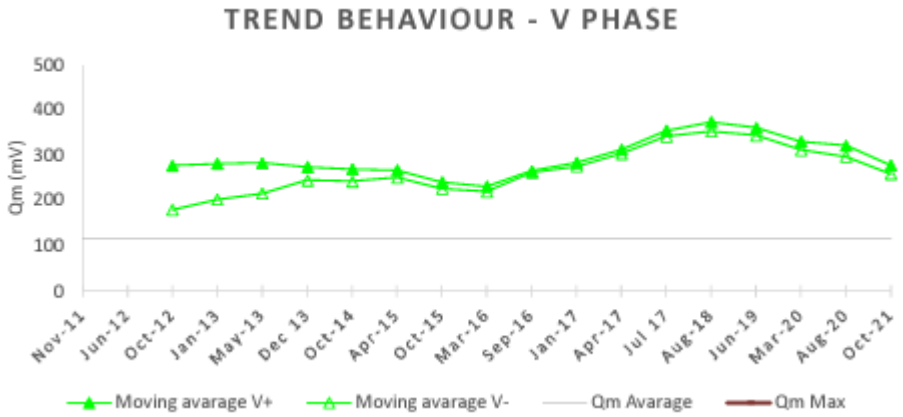
EX 60V 7.2A

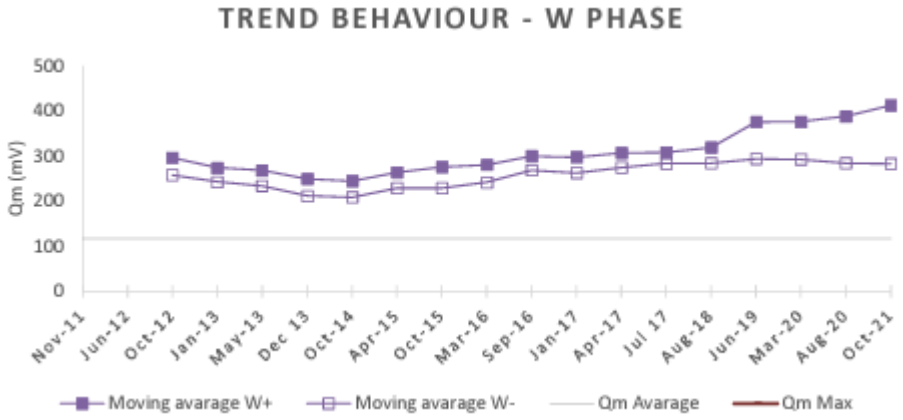
Condition-based Assessment – Online PD Testing



Condition-based Assessment – Average Trending







Five sessions-moving average trends show an increasing behaviour of PD amplitudes for phases W, while phase U and V shows a stable behaviour.
Qm average exceeds the Qm average of similar machines

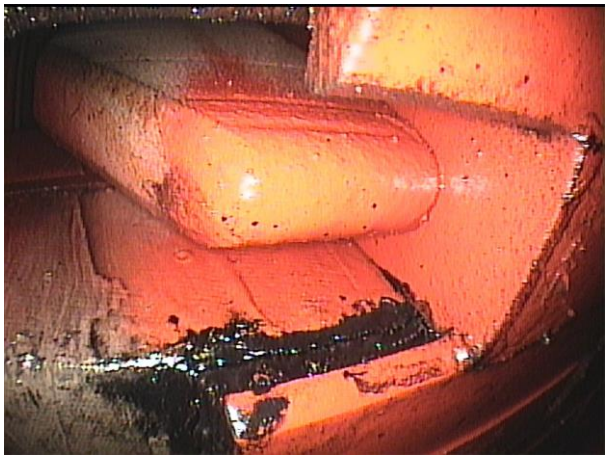
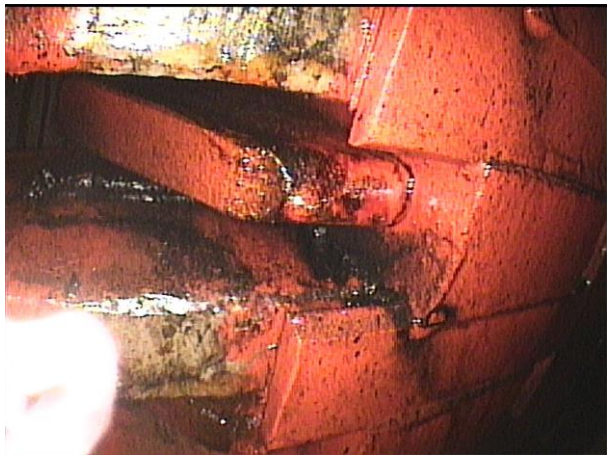
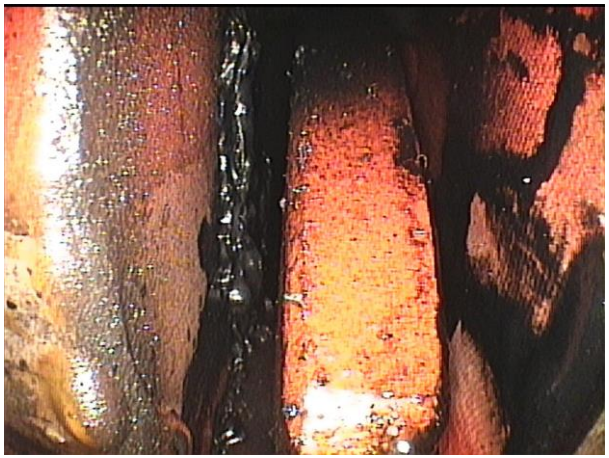
Roof removal to lift out generator

Risk-based Assessment

- *Risk based Maintenance (RbM) uses risk for decision making and continuously improving the asset performance. It is used to select which assets a maintenance program should target.*
- *Visual inspection and suite of electrical testing was performed to identified the condition of stator winding insulation system.*

Visual Inspection



Offline Electrical Testing in-situ

- Insulation Resistance and Polarisation Index
- Step Voltage Test
- Dielectric Dissipation Test up to 125% Phase to Ground Voltage
- Offline Partial Discharge Test
- Stator Winding Resistance Test
- Machine Risk Assessment

Risk Assessment

Component	**Failure Mechanism identified**	**Evidence derived from**	Contribution to overall risk assigned	Risk vs Consequence
Stator winding	Abrasive material attack	On line PD	51%	Medium
		VI Slot		
	Slot discharge	On line PD	24%	
	Contamination	On line PD	12%	
Rotor Winding	Contamination	Visual inspection	100%	Medium
	Chemical attack			
	Abrasive Material Attack			
Stator Core	No significant failure mechanism			

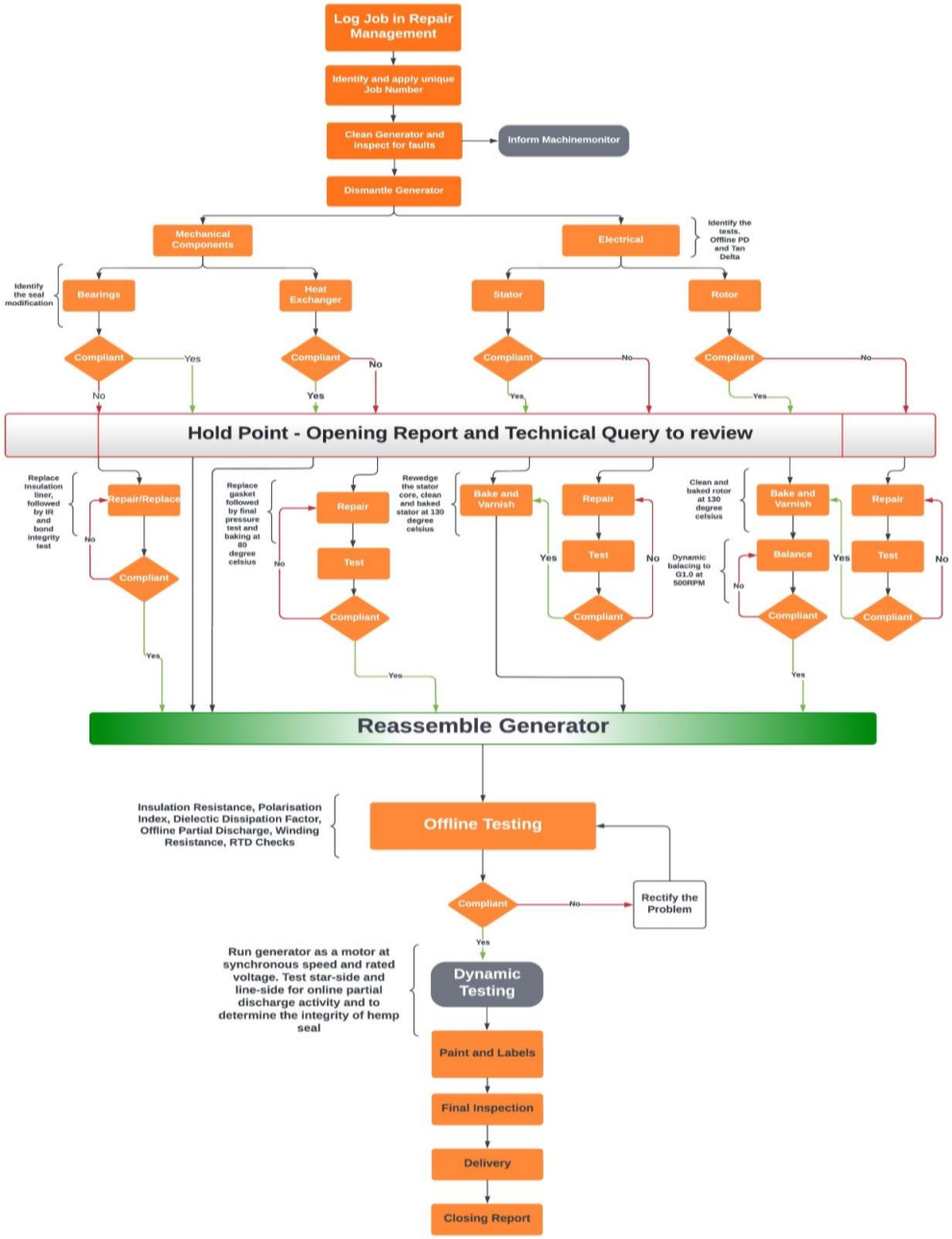
The on-line PD measurement analysis suggested end winding discharges on the W phase supported by visual evidence of grease deposits and discolouration seen on the coils at the slot exits and between the phase groups. The risk rank is medium, with internal surface contamination as the major contribution to the operational risk.

Issues to be addressed

High level PD activity	• Discoloration at the stress-grading junction indicating surface discharge • Indicative of endwinding discharge
Oil Migration	• Oil leakage and pooling inside bearing housing • Ineffective machine sealing
Surface contamination	• Grease deposit at slot exits and between HV coils in endwinding • Dirt and grease contamination on wedges

14-Days Overhaul

Specification



Audit Plan

Prior to Decommission

- Online PD Testing
- Vibration Analysis

Electrical and Mechanical Survey

- Electrical Testing and Mechanical Checks

Repair and Assembly

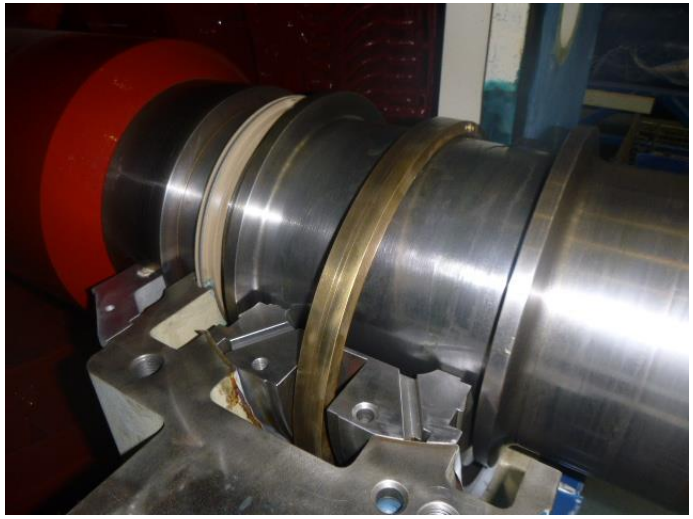
- Detailed cleaning and repair as per the specification after an opening report

Static and Dynamic Testing

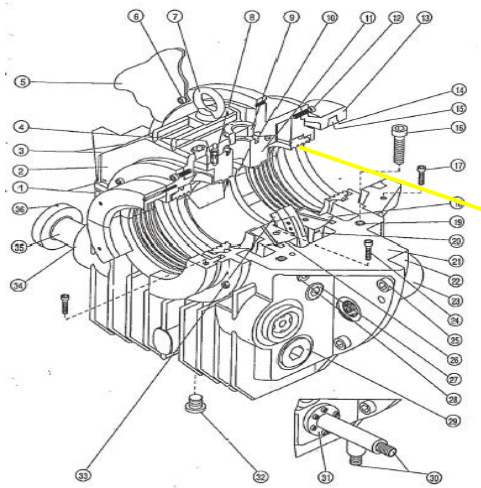
- Final testing and test run to qualify the overhaul

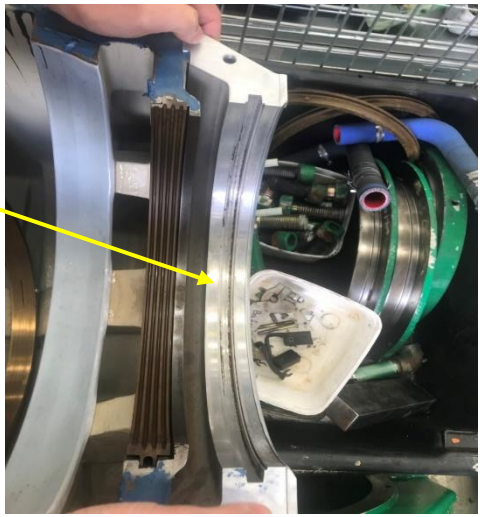
Liaison with OEM

- SINFONIA to involve to provide instruction on machine seal installation.
- Assembly of machine and bearing seals as per OEM.
- Instruction to qualify the sealing, torque setting and pressure equalising hoses.



Repair Assessment - Bearing





Insulated liner on DE bearing was found damage.

Missing hemp packing to create a pressure differential to stop oil migration from bearing to the machine chamber

Repair Assessment – Stator Winding

Moderate dirt contamination between two different phase coils on the stator endwinding, causing endwinding discharge.

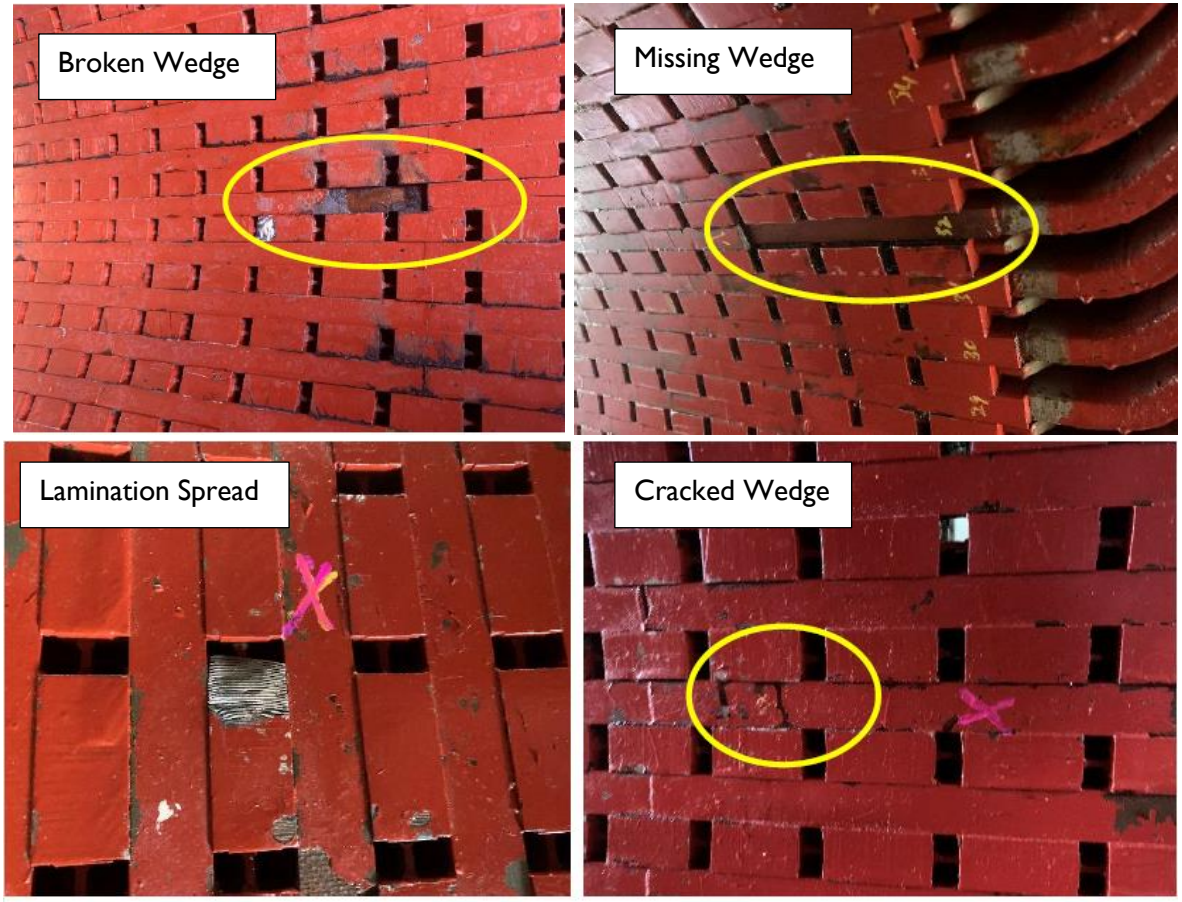
Grease build up near stress grading junction (creating arcing, resulting on discolouration).
Vaseline looks like black substance was also an indicator of loose wedges.

Repair Assessment – Stator Core

Dirt and grease contamination on the surface of stator wedges and inside the radial ventilation duct.
Greasing was identified at the slot exits where wedges were found loose, broken and missing.

Oil strains dripping from the back iron core and on the keybars.
Oil pooling at the bottom of stator housing.

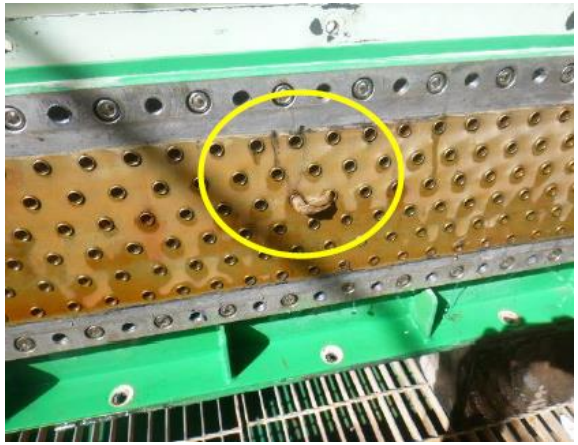
Repair Assessment – Stator Core



Repair Assessment – Heat Exchanger

Compressed gasket causing leakage.
New gasket was installed during the overhaul.

Tubes were partially blocked with plastic bags and foreign materials.
All tubes were water pressure tested and cleaned.



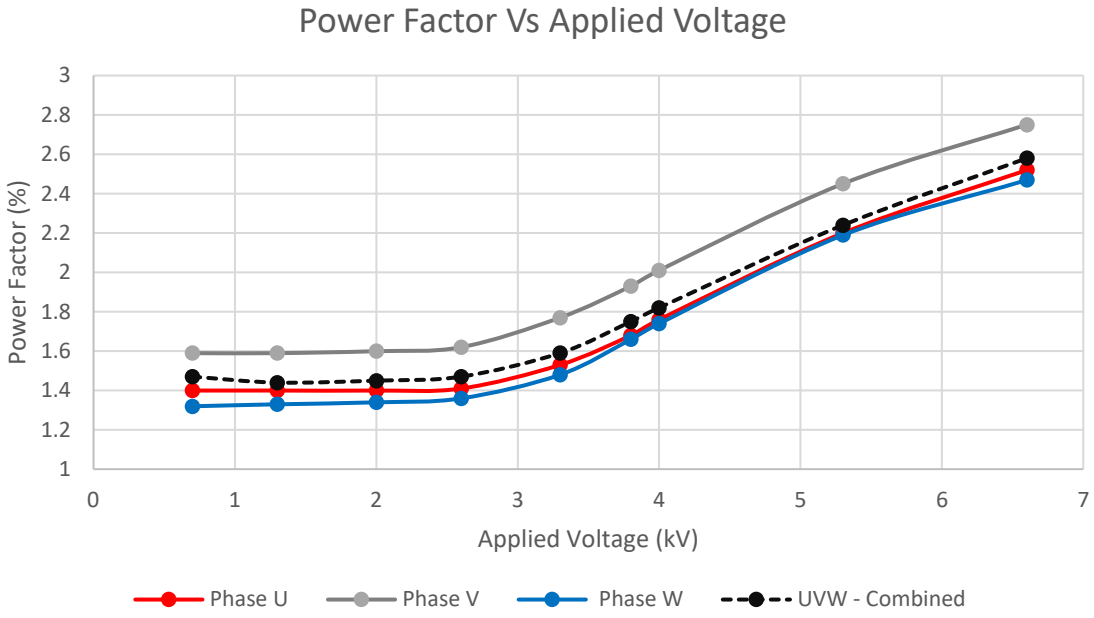
Test during the Repair

- Insulation Resistance and Polarisation Index
  - Stator Winding: Minimum IR = 16.350GΩ, PI = 5.57
  - Rotor Winding: IR = 5.0GΩ, PI = 1.75
  - Field Winding: IR = 12.6GΩ
  - Exciter Rotor: IR = 6.43GΩ

The test was conducted as stated in IEEE43 to meet the minimum requirement to identify any insulation damaged caused by the cleaning prior HV testing and followed by generator assembly.

Test during the Repair

- Dielectric Dissipation Factor Test (Tan Delta)



The test was conducted as stated in IEEE286 power factor and tip-up were improved.

Test during the Repair

- Stator Corona Probe (TVA Probe) Test

Each slot was scanned with the PPM-97 Corona Probe. Most of the slots were qualified as having low readings at 5-10mA. The average reading was 11mA with 4 slots had areas measured up to 45mA. The maximum reading recorded was 90mA at slot 43.

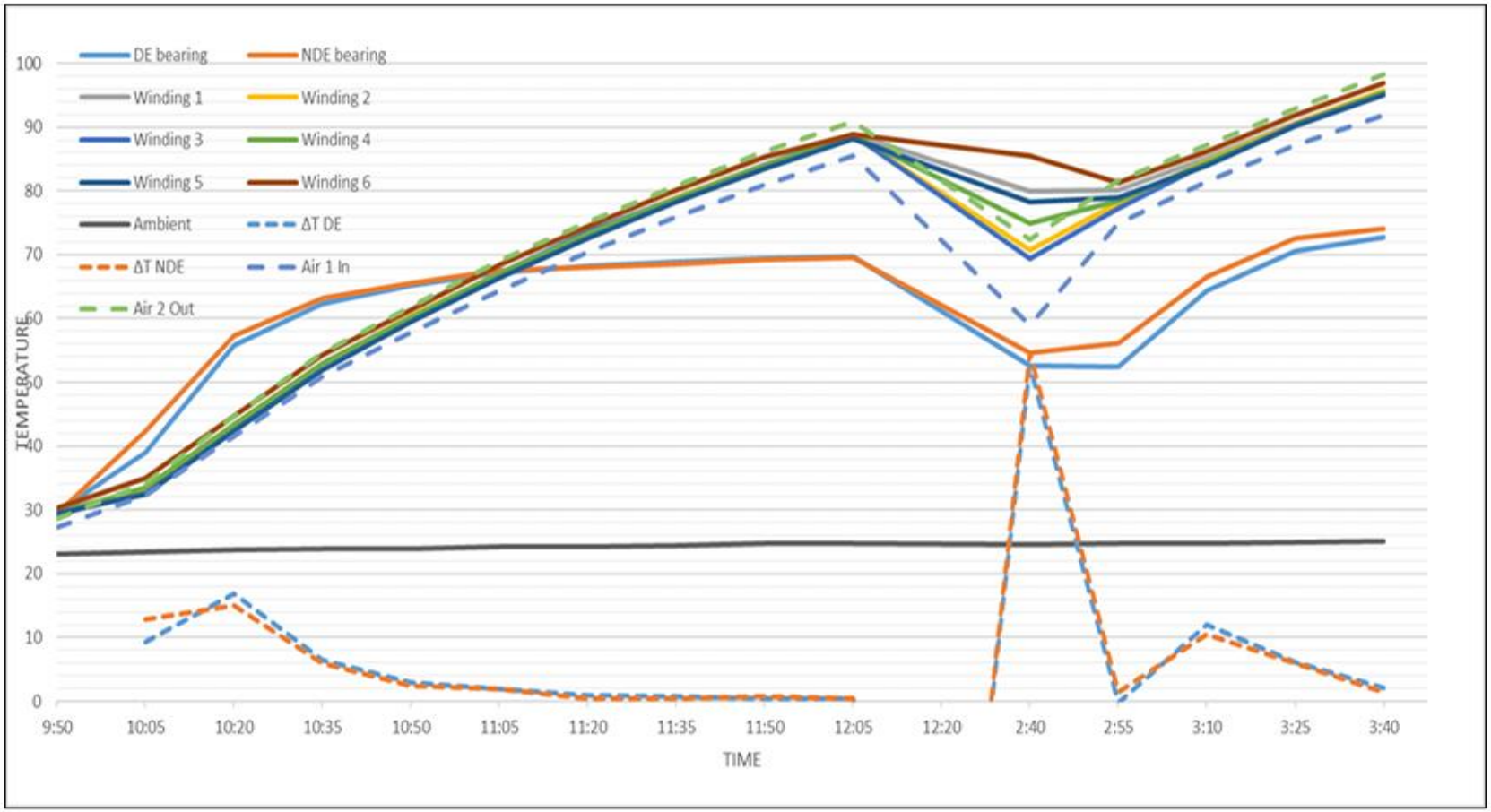
Test during the Repair

- Rotor dynamic balancing at G1.0 after Cleaned and baked at 130°C

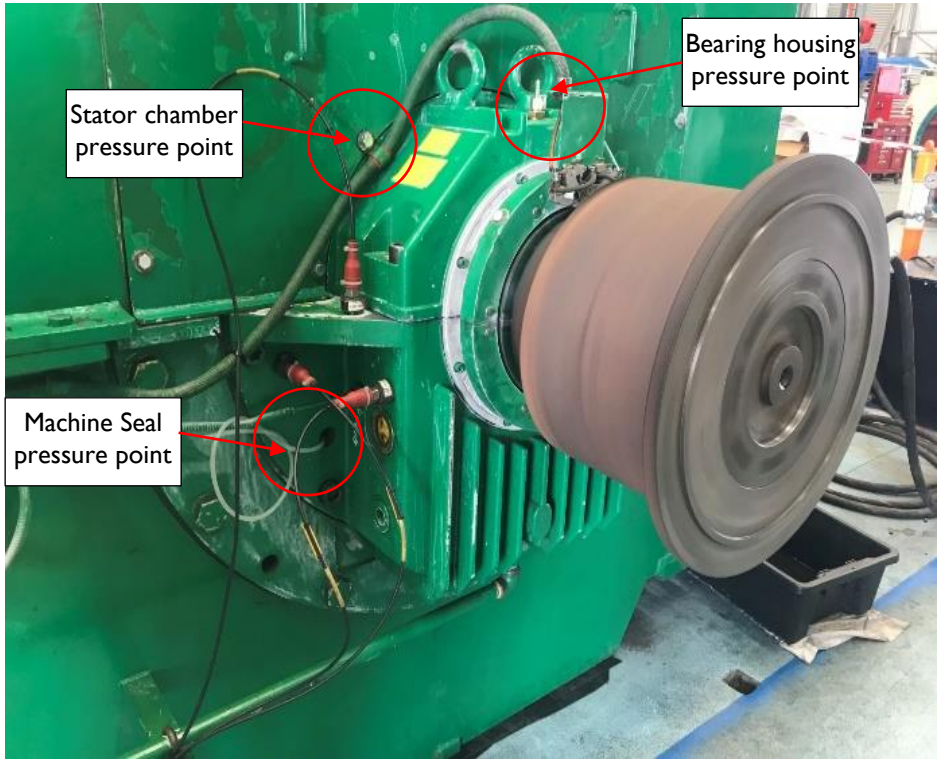
Run test as motor

Run test as motor

Run test as motor



Oil Seal Evaluation

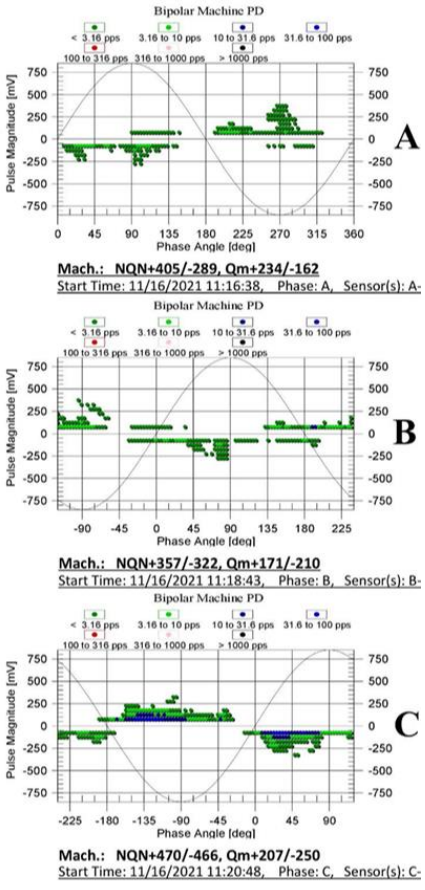


3 pressure point to record the differential pressure while machine was running to qualify the sealing.

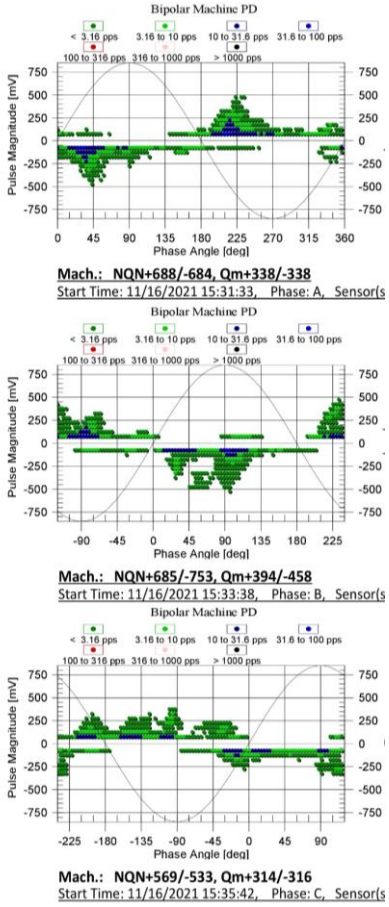
No oil leakage or migration identified inside the housing

Online Partial Discharge Testing

IRIS couplers on line side



IRIS couplers on star side



During the PD assessment, the partial discharge activity after the overhaul was improved and found relatively lower on the original line side of the stator windings.

Final Assembly

Conclusion

- Generator was successfully commissioned and coupled both sides on-site.
- Hemp packing qualified the machine seal
- Online Partial Discharge Activity was reduced.
- Broken and missing wedges were fixed.
- Grease and dirt contamination was cleaned.

Going Forward !

- Machinemonitor to perform following condition-based assessment:
  - Online partial discharge testing
  - Measure differential pressure on bearing
  - Internal Visual Inspection