



Eugene Water & Electric Board

Generator Inspection and Testing



Northwest Hydro Operators Forum

May 19th, 2015

Generator Testing, Inspection and Maintenance Program Development

- Training and experience
- References and resources
- Visual inspection
- Testing
- Trending and documentation



Training and Experience

- Step 1: Participate in regular/annual outage inspections with O&M Staff – observe existing practices
- Step 1a: Learning--- generator design, component names, testing procedures/analysis (Year 1 & 2)
- Step 2: Inspection checklists, Test data sheets, Find issues (Year 3 & 4)
- Step 3: Gather and trend data, find and repair issues (Year 5 & 6)

References

- Visual Inspection:

Inspection of Large Synchronous Machines
(Kerszenbaum)

CEATI Generator Inspection Guide

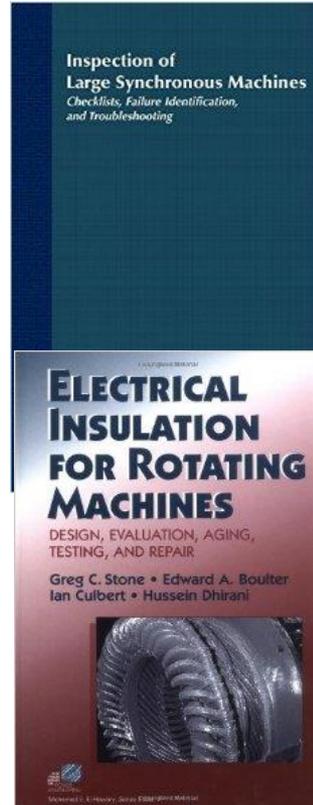
- Testing:

Electrical Insulation for Rotating Machines
(Stone/Boutler/Culbert/Dhirani)

- IEEE:

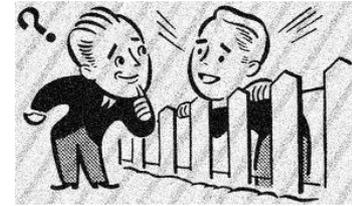
43 – Recommended Practice for Testing Insulation
Resistance of Rotating Machinery

115 – Guide for Test Procedures for Synchronous
Machines



Resources

- Internal O&M & Engineering Staff
- Neighboring Hydro Owners
- Technical Organizations/Forums (CEATI, NWhA, etc)
- Training/Conferences (IRIS --> IRMC, Hydrogen Maint)
- Online: IGTC (International Generator Technical Community)
www.generatortechnicalforum.com (free)





2014 Generator Testing and Inspection Report

Station	Carmen Power Plant	Engineer	Tyler Nice
Unit	1	Date	1/28/15

Executive Summary

Inspection and testing of Carmen Generator 1 was completed during the 2014 annual outage. Minor repairs based on visual inspection were completed during the outage with no extension to schedule and at minimal cost. Based on testing and inspection, the unit was fit for continued operation with no operational restrictions and was restored to service. Analysis of testing and inspection findings shows the unit condition is degrading.

Testing

Stator:

- Testing showed minimal signs of degradation based on IEEE standard acceptance values.

Rotor:

- Testing showed signs of degradation or excessive contamination.

Visual Inspection

Stator:

- Wedging system is showing signs of looseness; evident by slipping fillers and packing. No wedges have been found migrated.
- Coil to core fretting found in few locations on bottom side of core.
- All high voltage coils show signs of partial discharge at end winding.
- Contamination of oil and carbon dust prevalent in air gap and lower end winding.

Rotor:

- Insulation resistance testing results of passing value, however lower than preferred.
- Contamination on rotor is present comprised of oil and carbon dust.

Repairs

Stator:

- End winding partial discharge damaged areas were painted over.
- Unit end winding was cleaned.
- Migrated fillers were repaired.

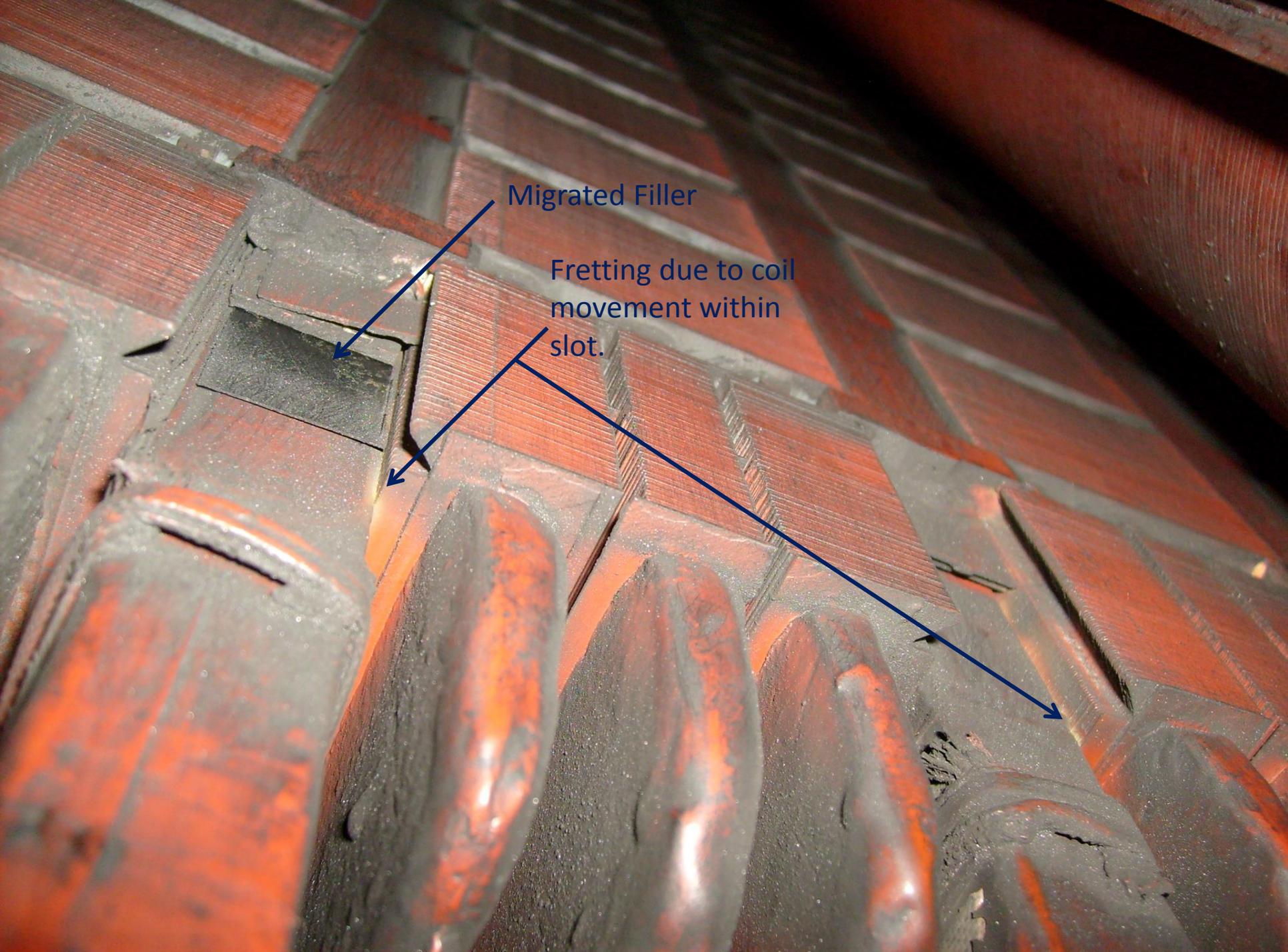
Rotor:

- No repair work was completed on rotor.
- Cleaning of rotor completed.

Recommendations

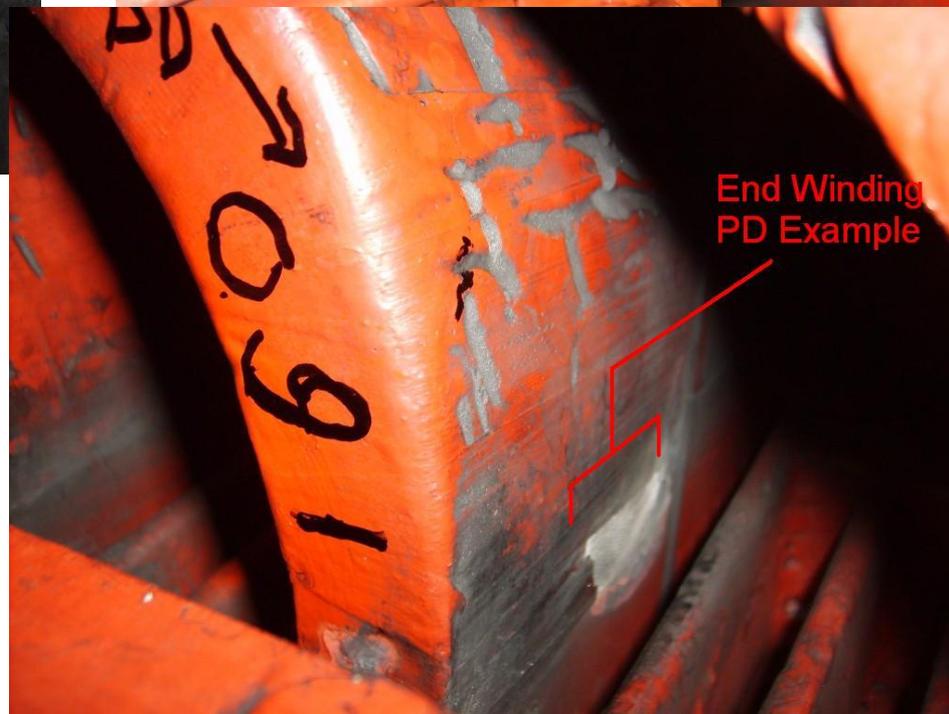
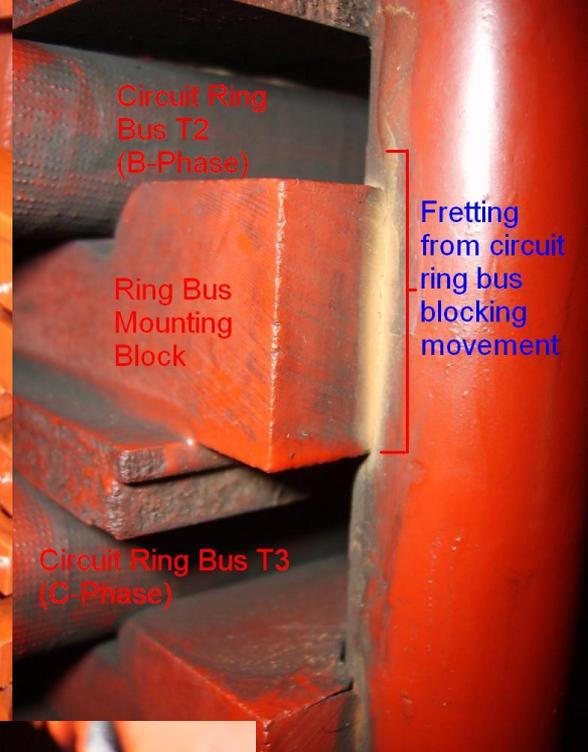
Unit is showing signs of age as evident by testing results and visual inspection. Continued testing and inspection should be completed at annual outages. Planning for re-wedging in or rewind should be considered.

- Develop a checklist
- Collect photograph
- Document Finding
- Trend indications a
- Don't forget auxilia
- Summary Sheet

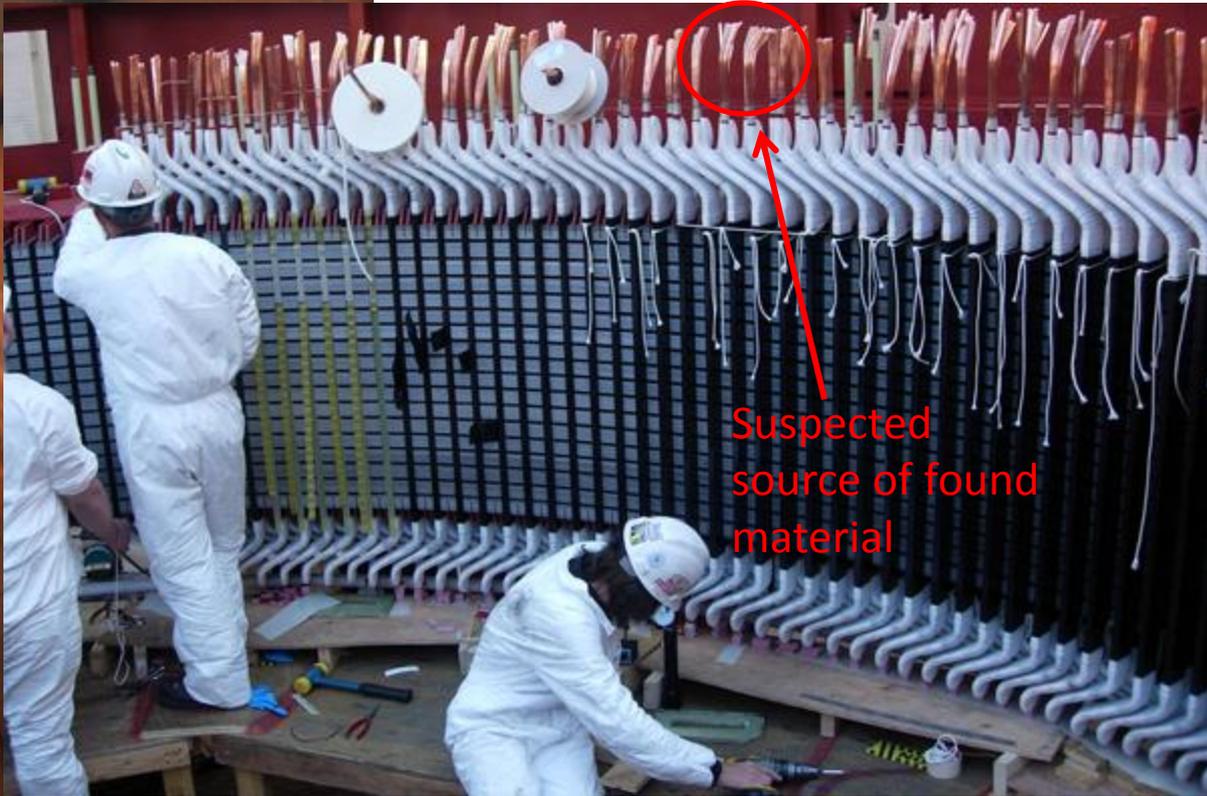


Migrated Filler

Fretting due to coil
movement within
slot.



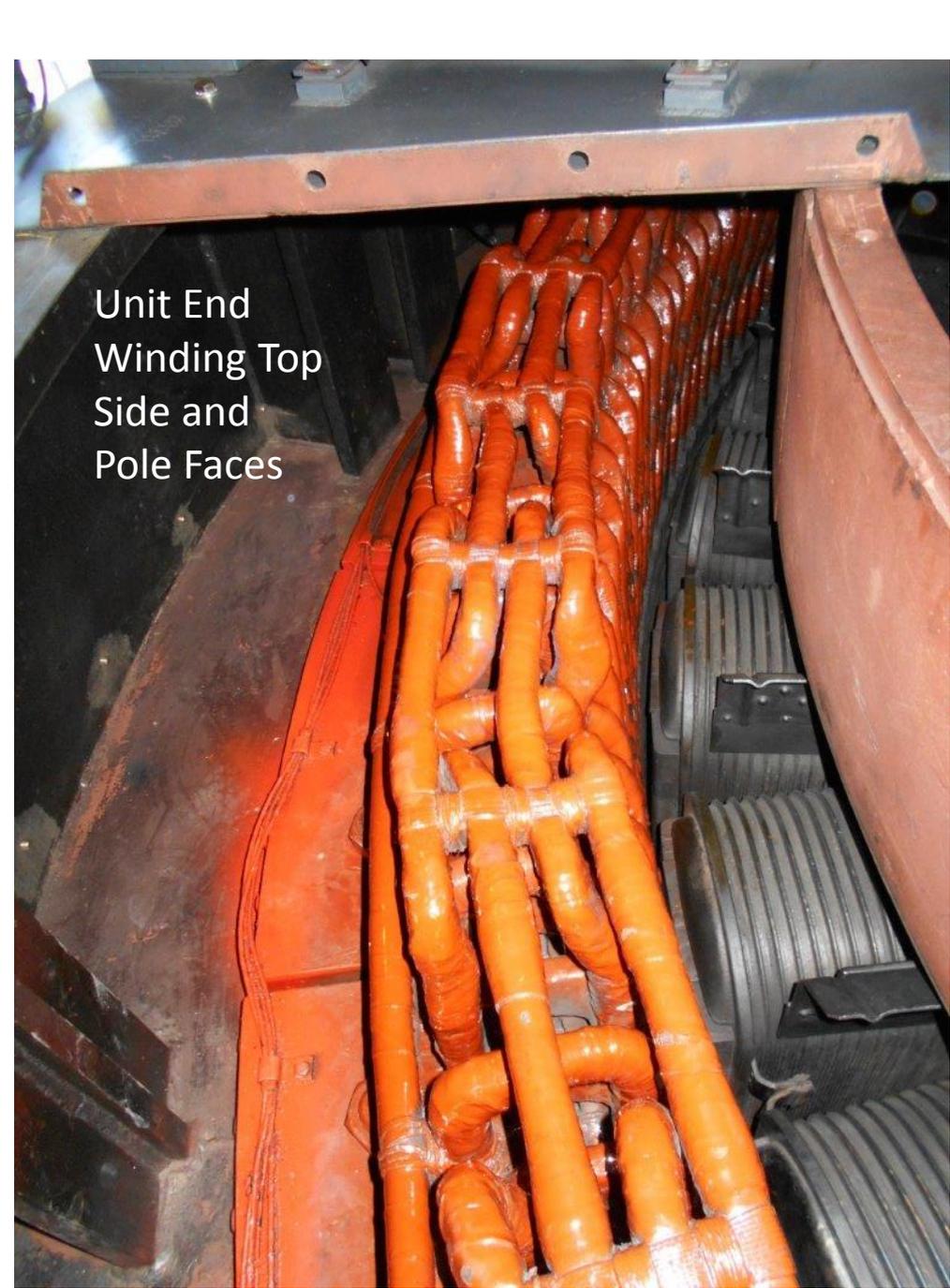
Stator Coil End Winding



Suspected source of found material

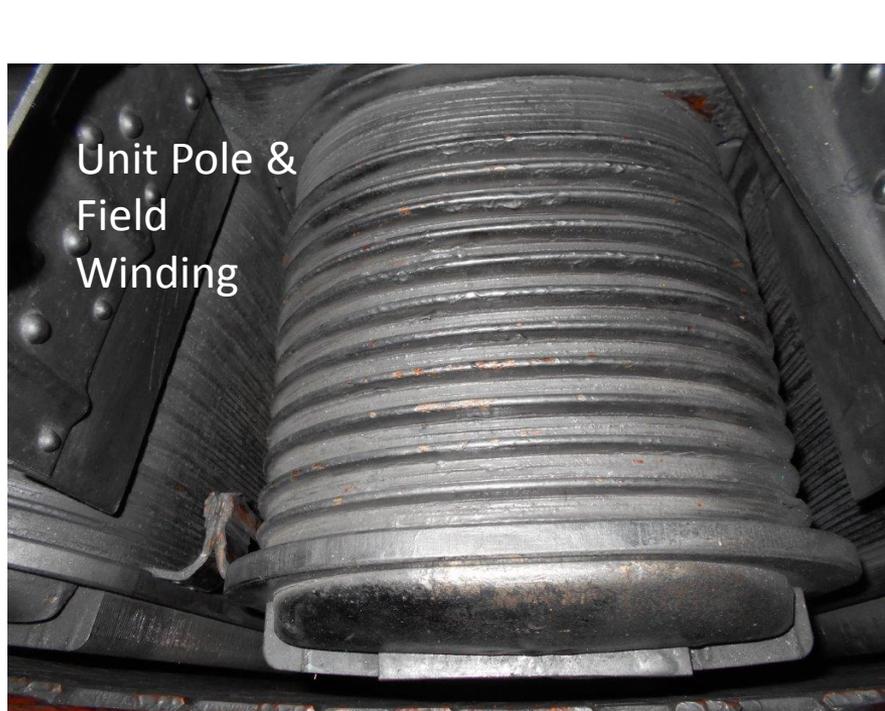
Copper coil
final braze
winding jumpers.





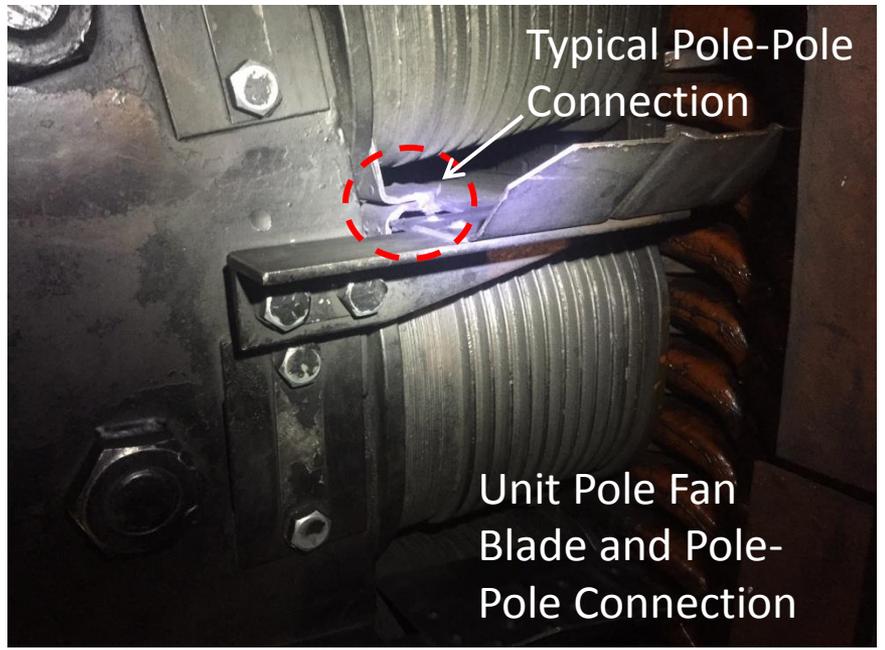
Unit End
Winding Top
Side and
Pole Faces

This photograph shows the end view of a large electrical machine's stator. Numerous thick, orange-insulated copper windings are arranged in a dense, parallel pattern. The windings are held in place by metal brackets and are situated between large, dark metal pole faces. The overall appearance is that of a well-maintained industrial component.



Unit Pole &
Field
Winding

This image provides a close-up view of a single pole of the machine. The pole is a large, cylindrical metal structure with a series of horizontal cooling fins. It is surrounded by a complex arrangement of field windings, which are also cylindrical and stacked together. The metal surfaces show some signs of wear and discoloration.



Typical Pole-Pole
Connection

This photograph shows the electrical connection between two adjacent poles. A metal pole fan blade is visible, which is used to cool the windings. The connection point is highlighted with a red dashed circle and a white arrow, showing the intricate wiring and insulation that connect the two poles.

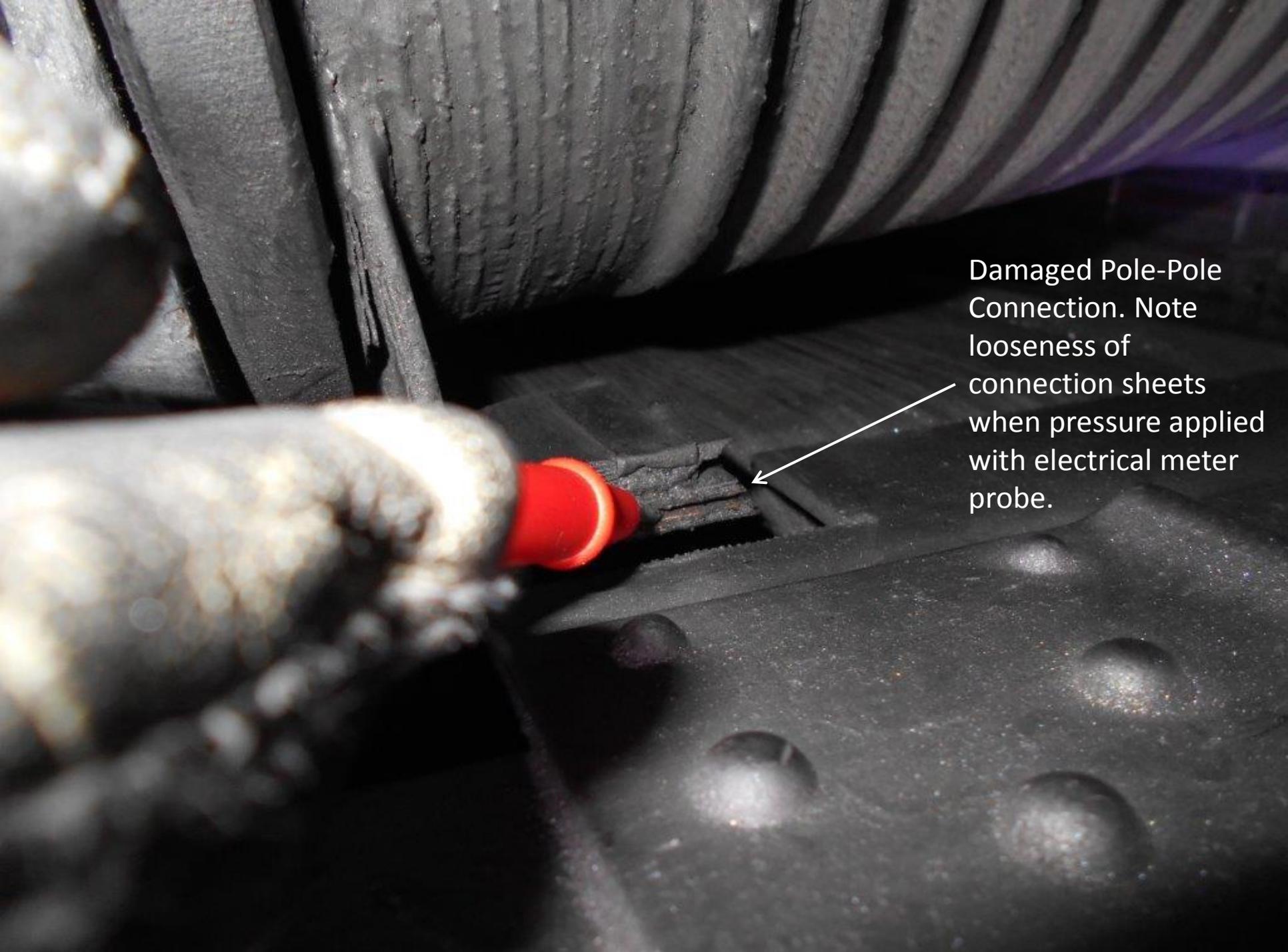
Unit Pole Fan
Blade and Pole-
Pole Connection

Close Up View Of Damaged Field Pole-Pole Connection

Braze cap of copper sheets on connection.



Damaged Pole-Pole Connection. Note brazed end cap on this portion is missing.



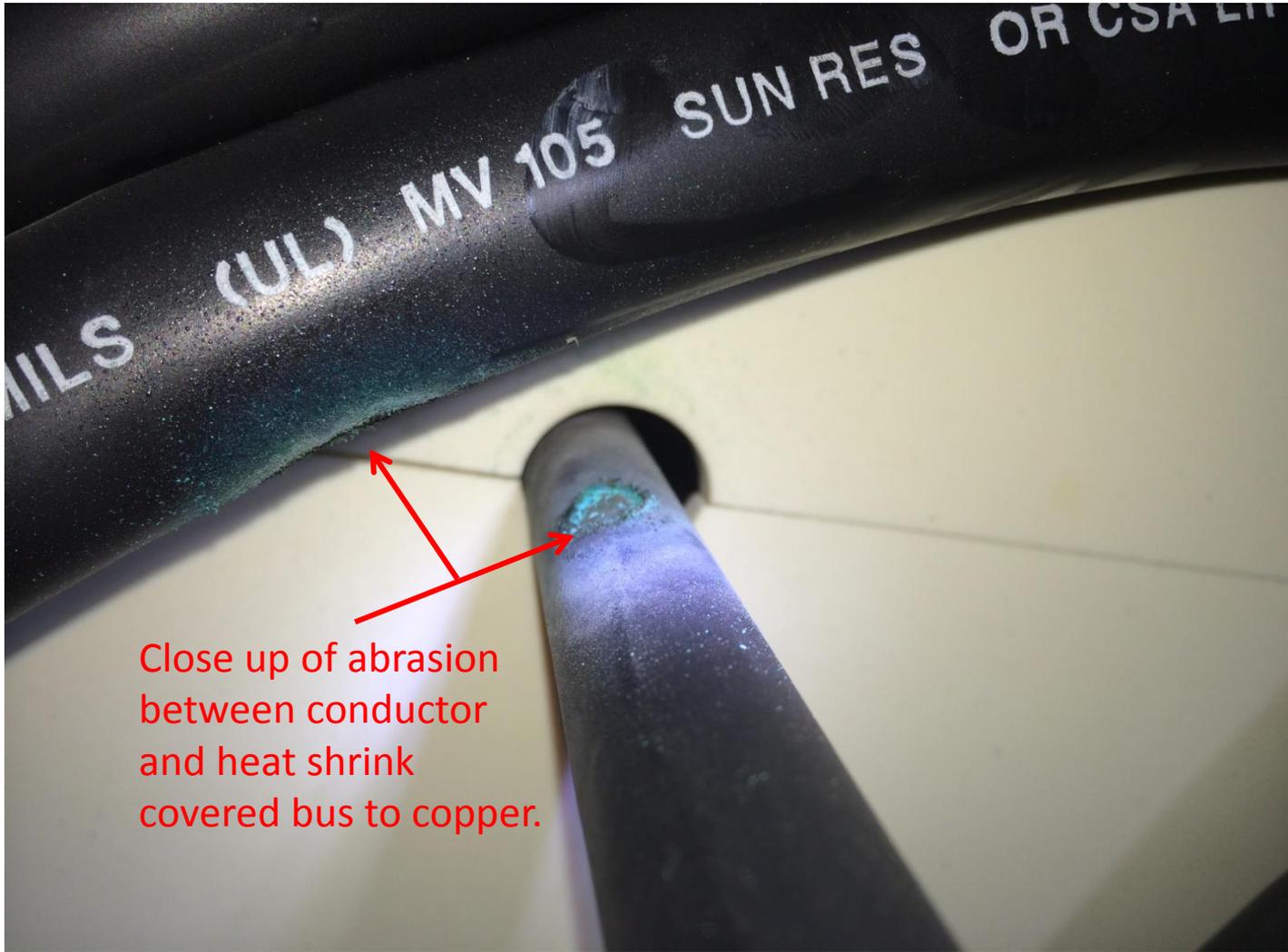
Damaged Pole-Pole Connection. Note looseness of connection sheets when pressure applied with electrical meter probe.

Location of
insulation abrasion
due to contact and
vibration

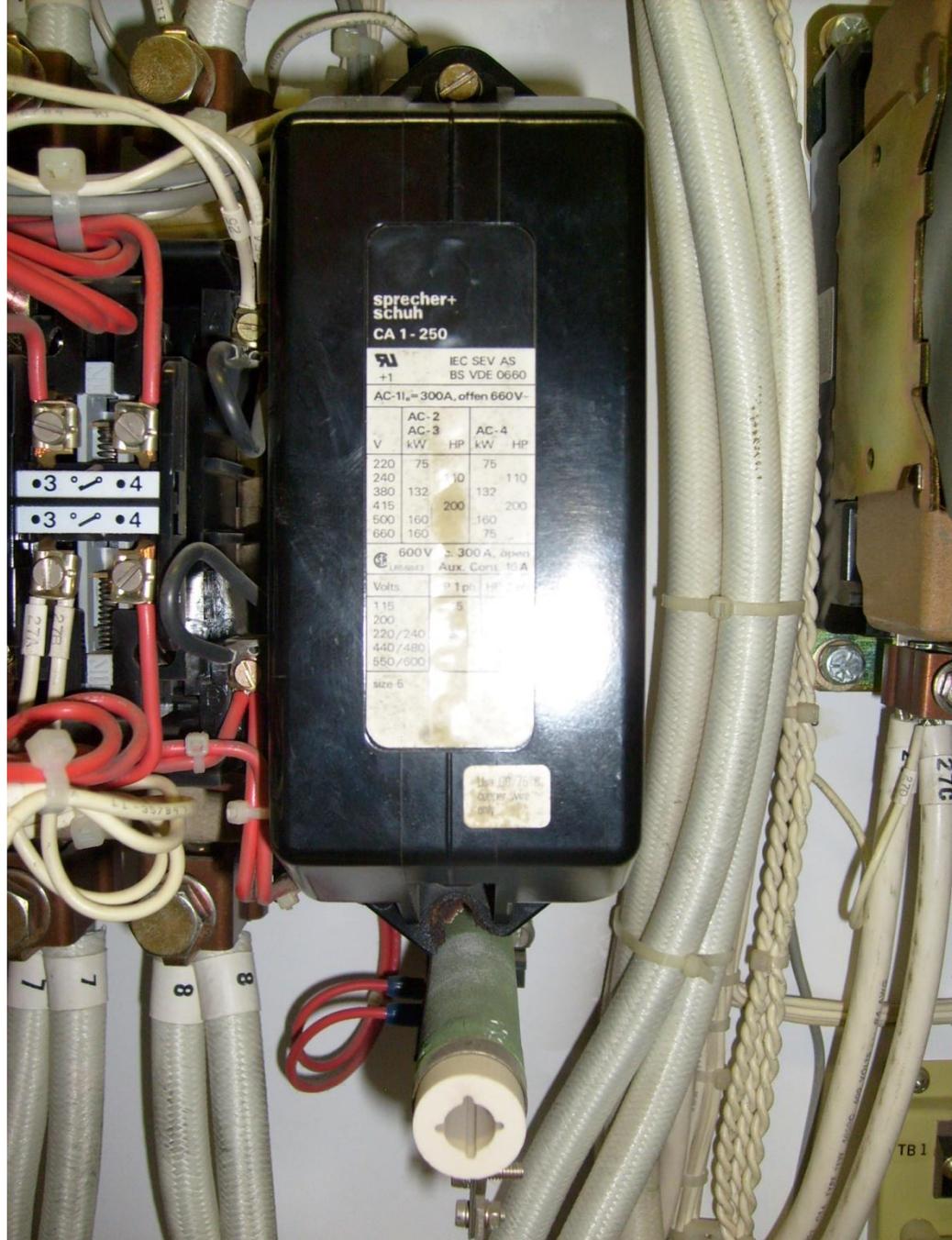
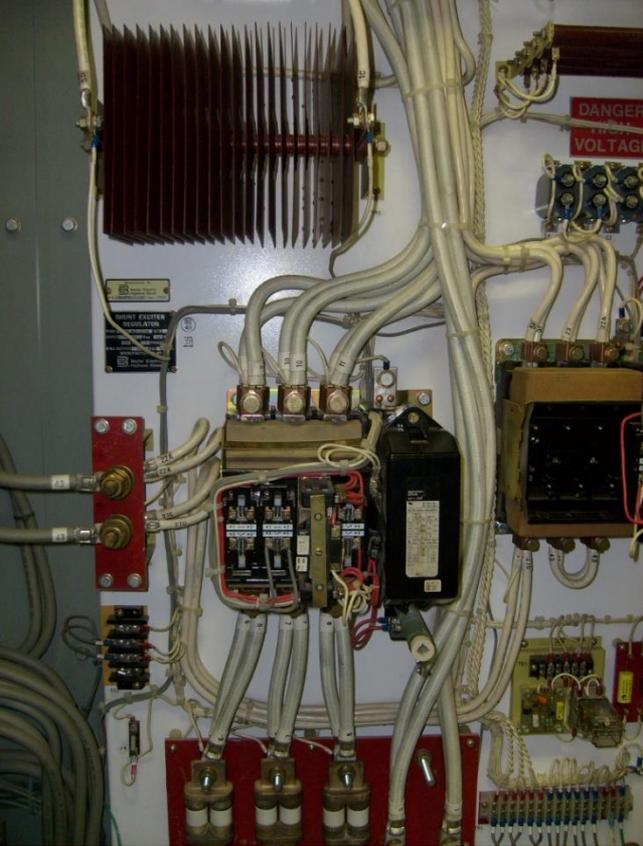
Green coating
on fuses

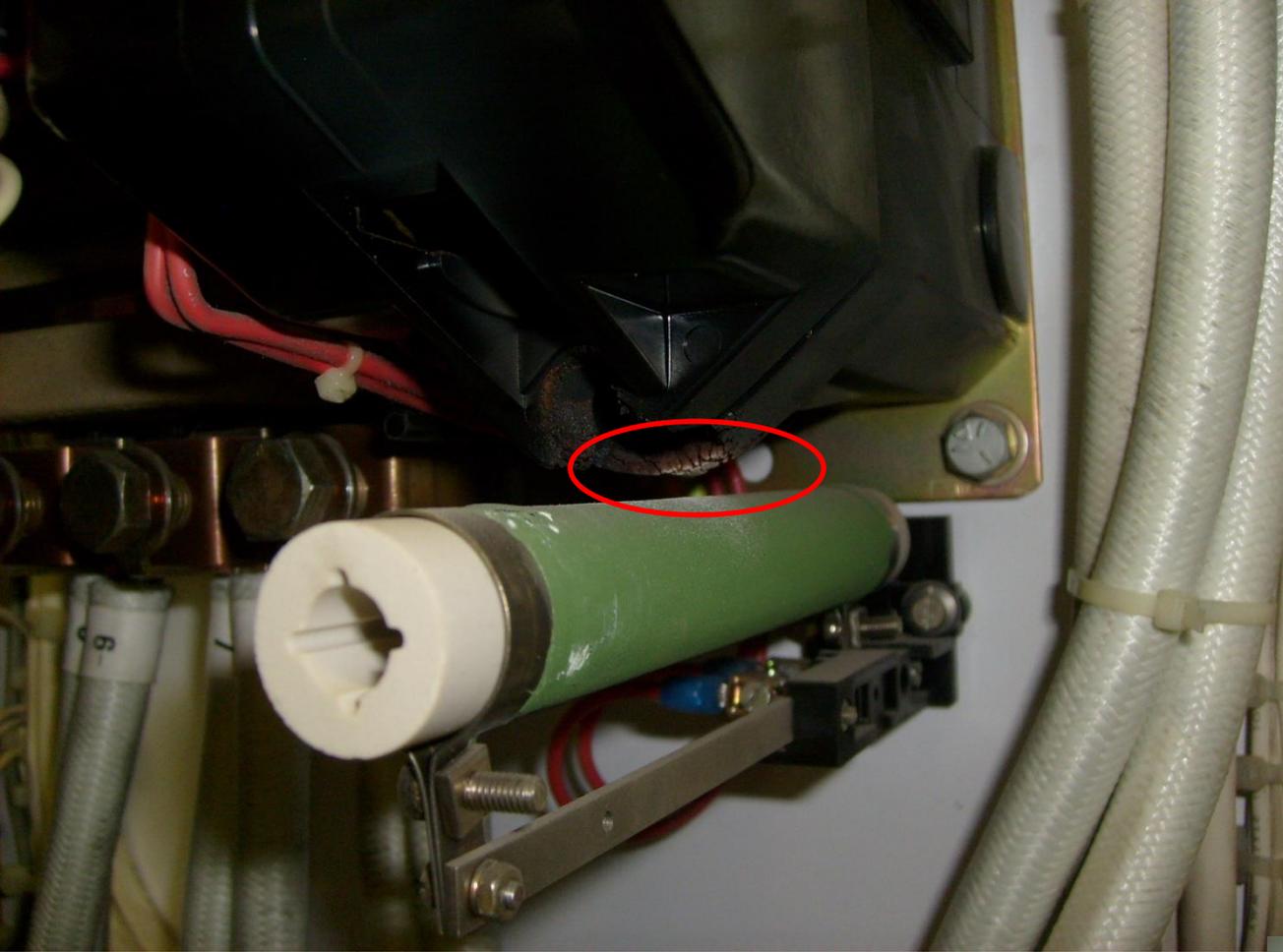
Leads from
generator
terminals.





Close up of abrasion
between conductor
and heat shrink
covered bus to copper.



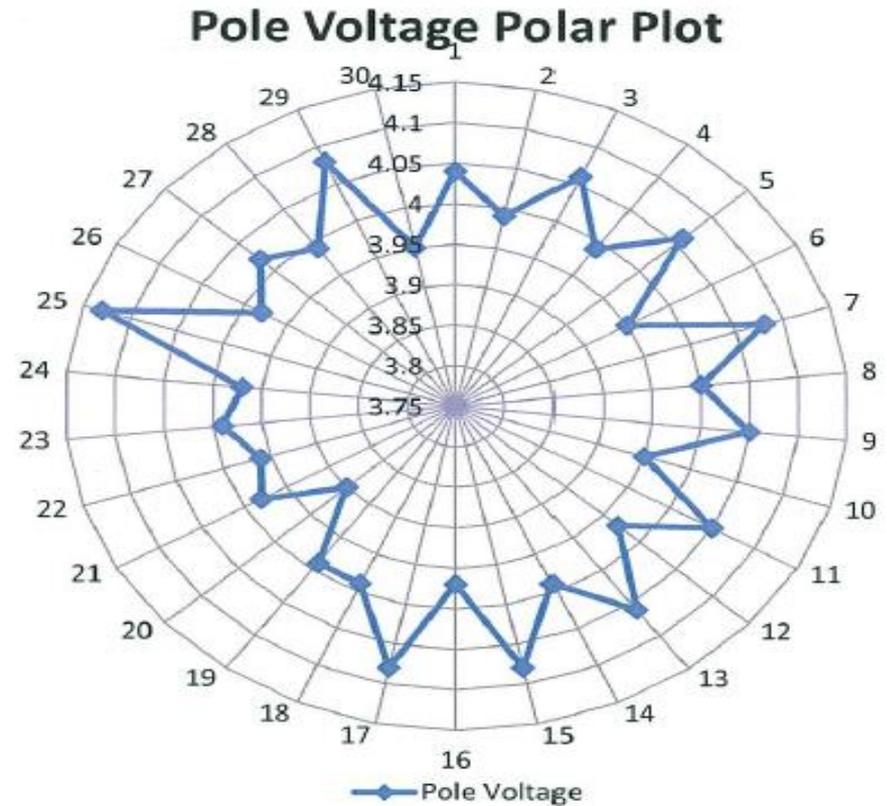


- Procedures
- Data Sheets
- Trend...(graphs and chart
- Data Summary Sheet

Generator Testing As Left Data Summary						rev 1/13/15
				(As-found)	(As-left)	
Station	Carmen			Date	10/14/2014	11/3/2014
Unit	1					
Insulation Resistance & Polarization Index (corrected to 40 deg C)						Remarks
Stator		Test Voltage:		5,000 VDC		All testing show minimal signs of degradation. Resistance value is historically low; shows signs of degradation or contamination.
Phase	R (1min)	R (10min)	PI	DAR		
A	3,412	14,925	4.37	1.89		
B	3,233	14,641	4.53	1.55		
C	3,591	16,552	4.61	1.82		
Rotor		Test Voltage:		500 VDC		
Field	4	4	0.99	0.99		
Winding Resistance (corrected to 25 deg C)						
Stator						As left testing not completed; as found data used. All test results show minimal signs of degradation.
Phase	R (@ 25 deg C)	% Diff From Ave	% Diff From Factory	Factory Resistance	Factory Resistance @ 25 deg C	
A	0.0066	0.2%	3.5%	0.00633	0.00655	
B	0.0065	0.3%	3.2%	0.00634	0.00656	
C	0.0066	0.5%	4.0%	0.00634	0.00656	
Average	0.0066	0.3%	3.5%	0.00634	0.00655	
Rotor				Stator Factory Resistance Temp (C):		16.5
Field				Rotor Factory Resistance Temp (C):		16.5
Field	0.284	NA	0.7%	0.286	0.29584	
Stepped Voltage (corrected to 40 deg C)						
Stator		End Test Voltage:		5,000 VDC		As left testing not completed; as found used. Field test shows signs of insulation degradation or contamination. Continue testing; consider cleaning.
Phase	R (1min)	R (2min)	R (3min)	R (4min)	R (5min)	
A	4,848	5,381	5,817	6,094	6,372	
B	4,488	5,234	5,724	6,054	6,321	
C	4,668	5,351	5,789	6,163	6,409	
Rotor		End Test Voltage:		0 VDC		
Field	378	41	15	6	4	
Pole Drop						
Applied Field Voltage:		120 VAC				Testing shows no signs of detectable shorted turns within pole windings.
Applied Field Current:		0.293 Amps				
No. of Poles:		30				
Expected Voltage/Pole:		4.00		Expected PF/Pole:	0.069%	
Ave. Measured Voltage/pole:		4.00		Ave. Measured PF/pole:	0.069%	
Highest % Voltage Change:		2.08%		Highest % PF Change:	2.11%	
No. of poles Volt change 5%-10%:		0				
No. of poles Volt change >10%:		0				
PASS	Test results exhibit no degradation.					
MONITOR	Test results exhibit some degradation.					
FAIL	Test results exhibit degradation.					
	Calculation or reference from testing sheet.					
	User input.					

EWEB's Testing Regime

- Stator and Rotor:
 - Insulation Resistance/Polarization Index
 - Stepped Voltage Test
 - Winding Resistance
- Rotor Only:
 - Impedance Test
 - Pole Drop Test
- Stator Only:
 - Online Partial Discharge



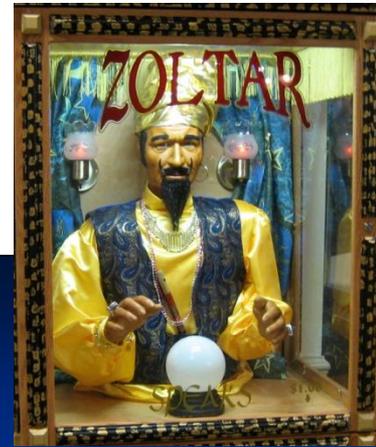
EWEB's Testing Regime Future Additions...

- Rotor Roundness
- Stator Roundness
- Heat Runs
- Infrared
- Wedge Tap Tester
- DC Ramp
- Power Factor



Generator Testing/Inspection/Maintenance Summary

- It takes time to develop the program
- It needs staff support and drive
- Documentation is key
- Goal is to get to preventative and condition based maintenance program



Questions?

- Comments?
- Tips & Tricks?
- Who wants to share?



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