EWEB

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

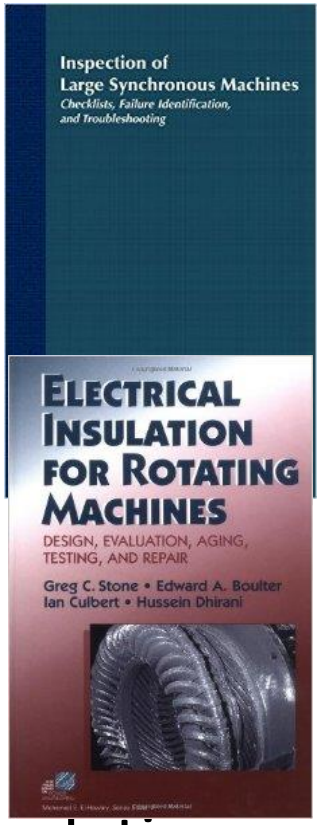
- Step 1: Participate in regular/annual outage inspections with O&M Staff – observe existing practices

- 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

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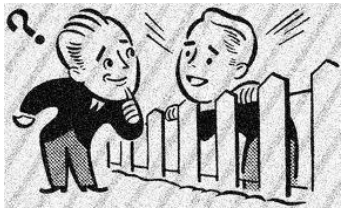
Resources



- 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)

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

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Eugene Water & Electric Board
Generation Engineering

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.

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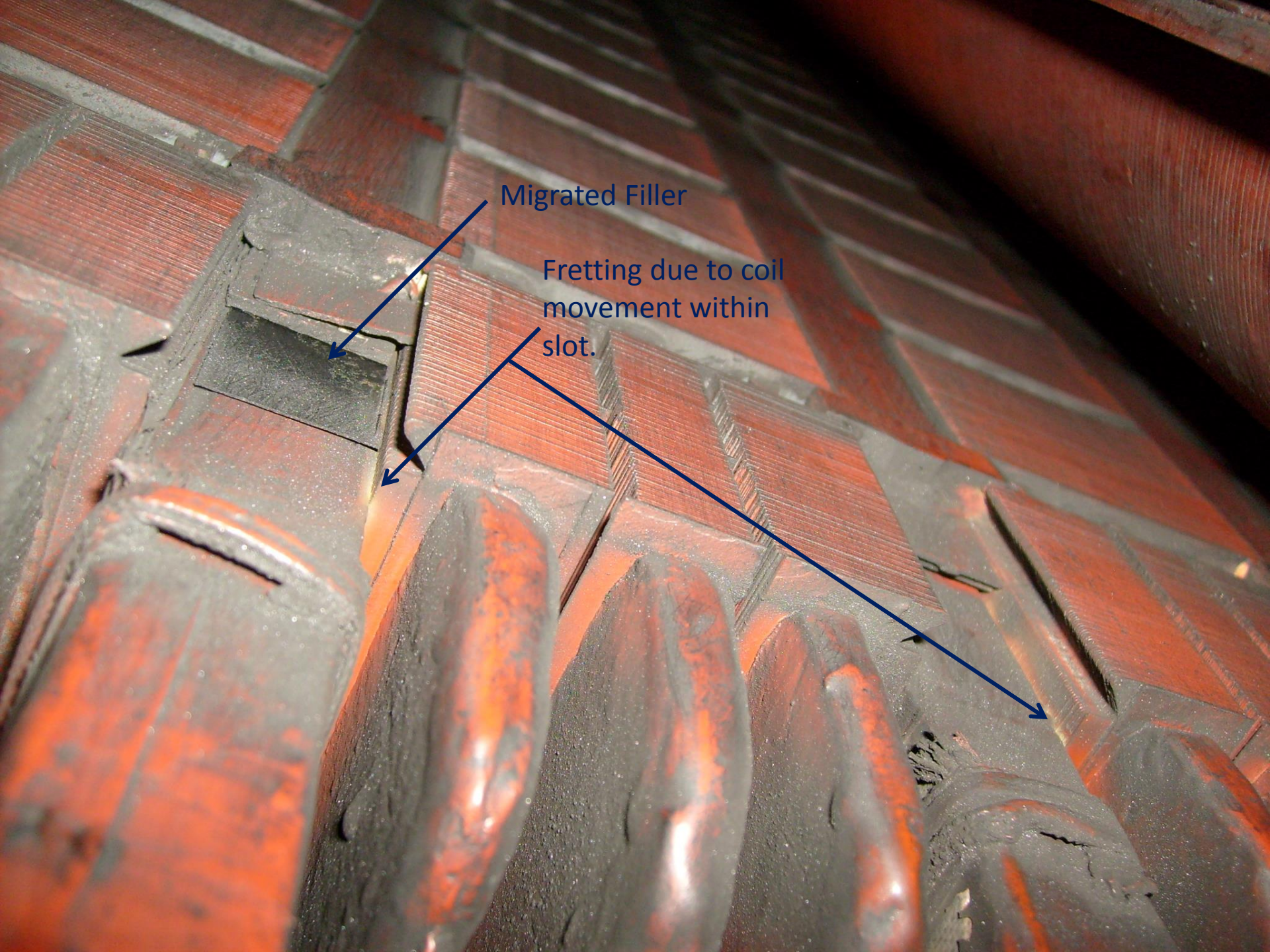
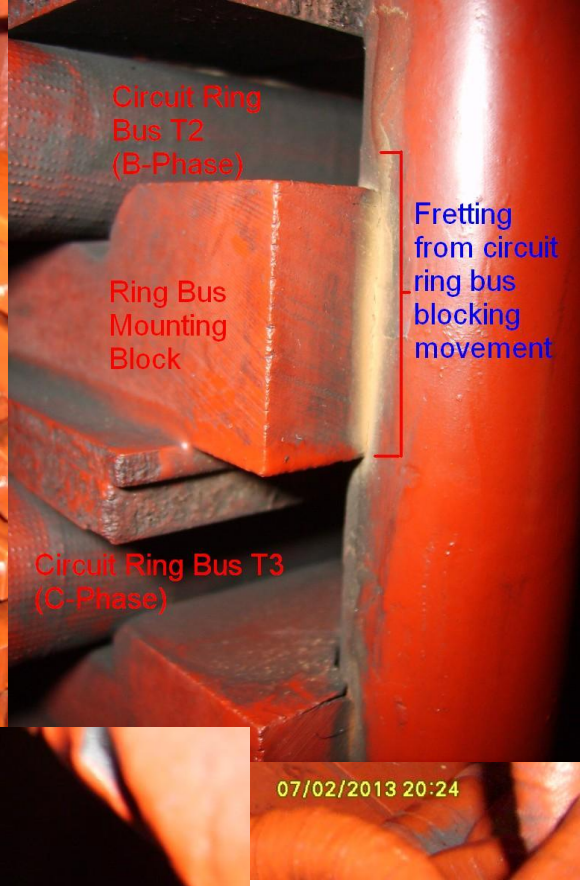
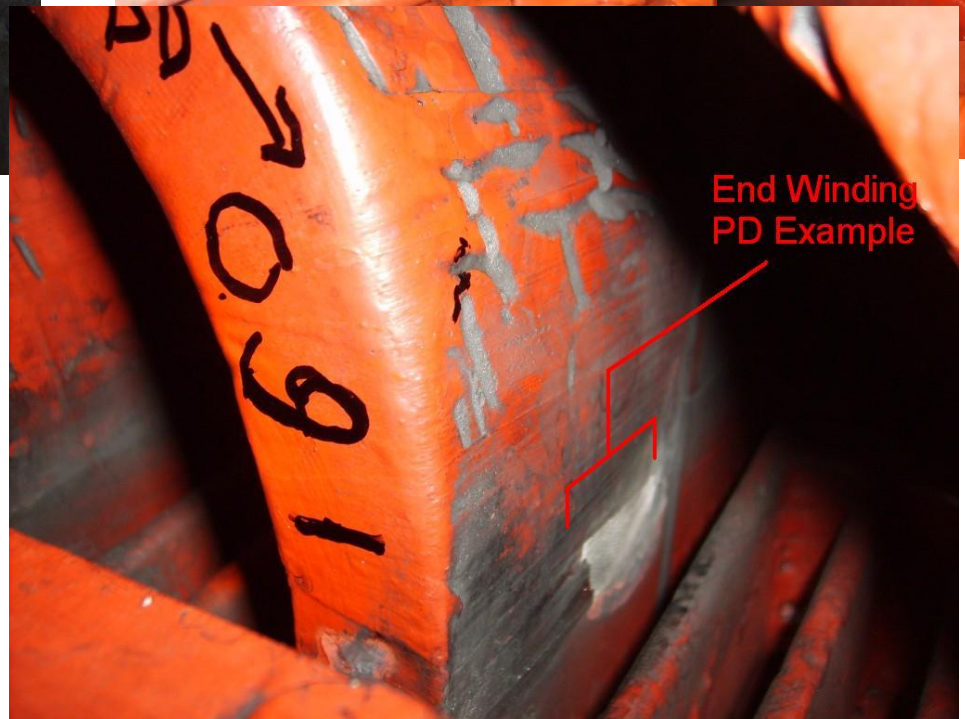
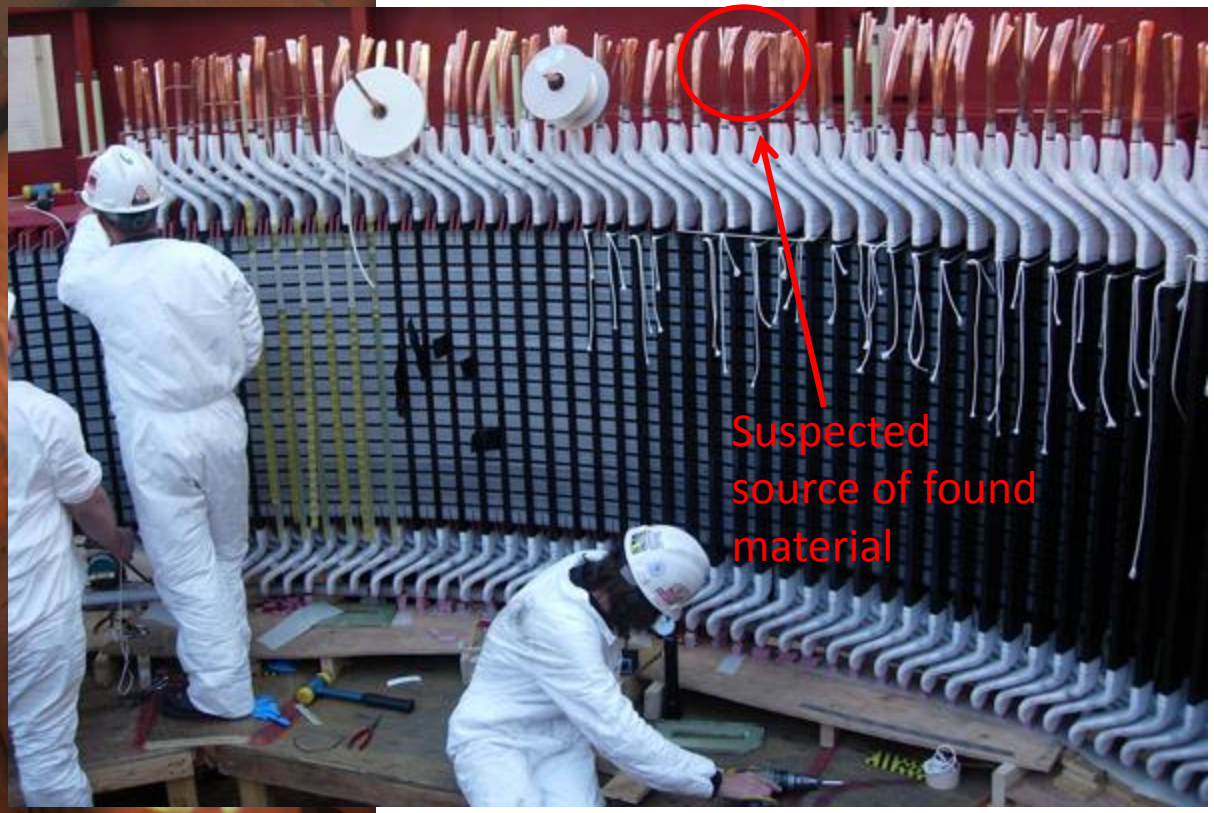

Migrated Filler
Fretting due to coil movement within slot.


Clean air duct
bracing width
Dirty Air Duct
width

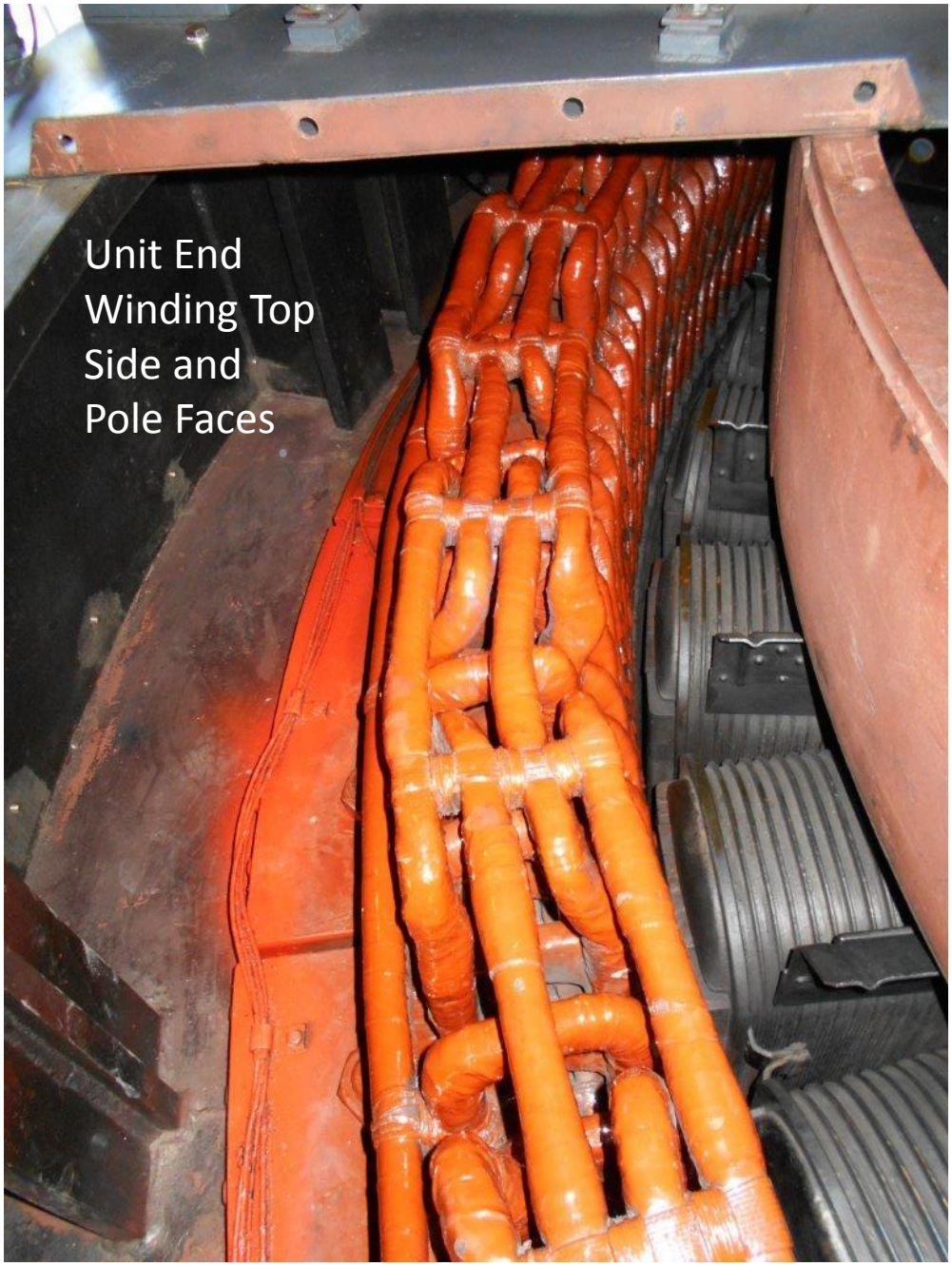

Circuit Ring
Bus T2
(B-Phase)
Fretting
from circuit
ring bus
blocking
movement
Ring Bus
Mounting
Block
Circuit Ring Bus T3
(C-Phase)
07/02/2013 20:24


End Winding
PD Example

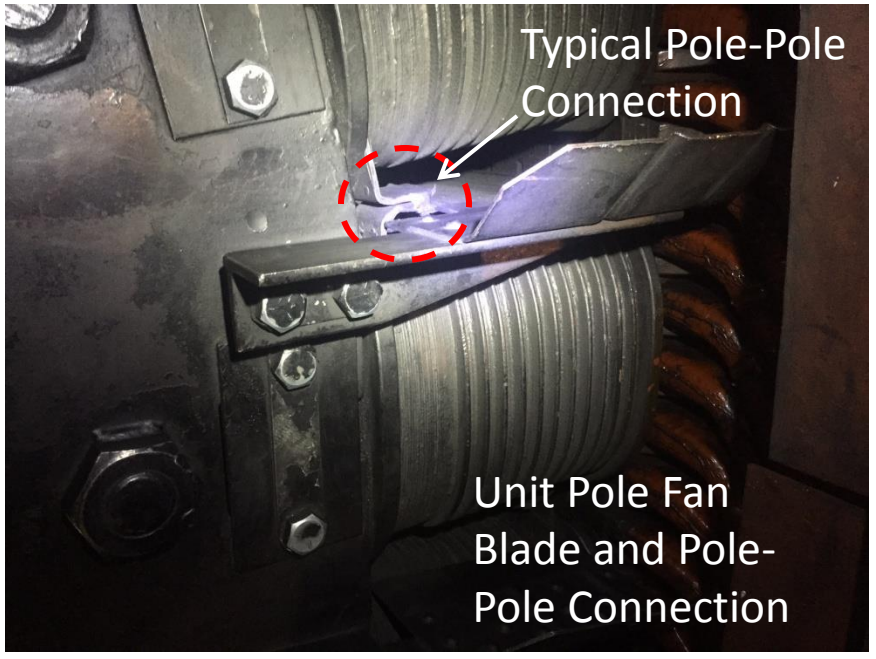
Stator Coil End Winding

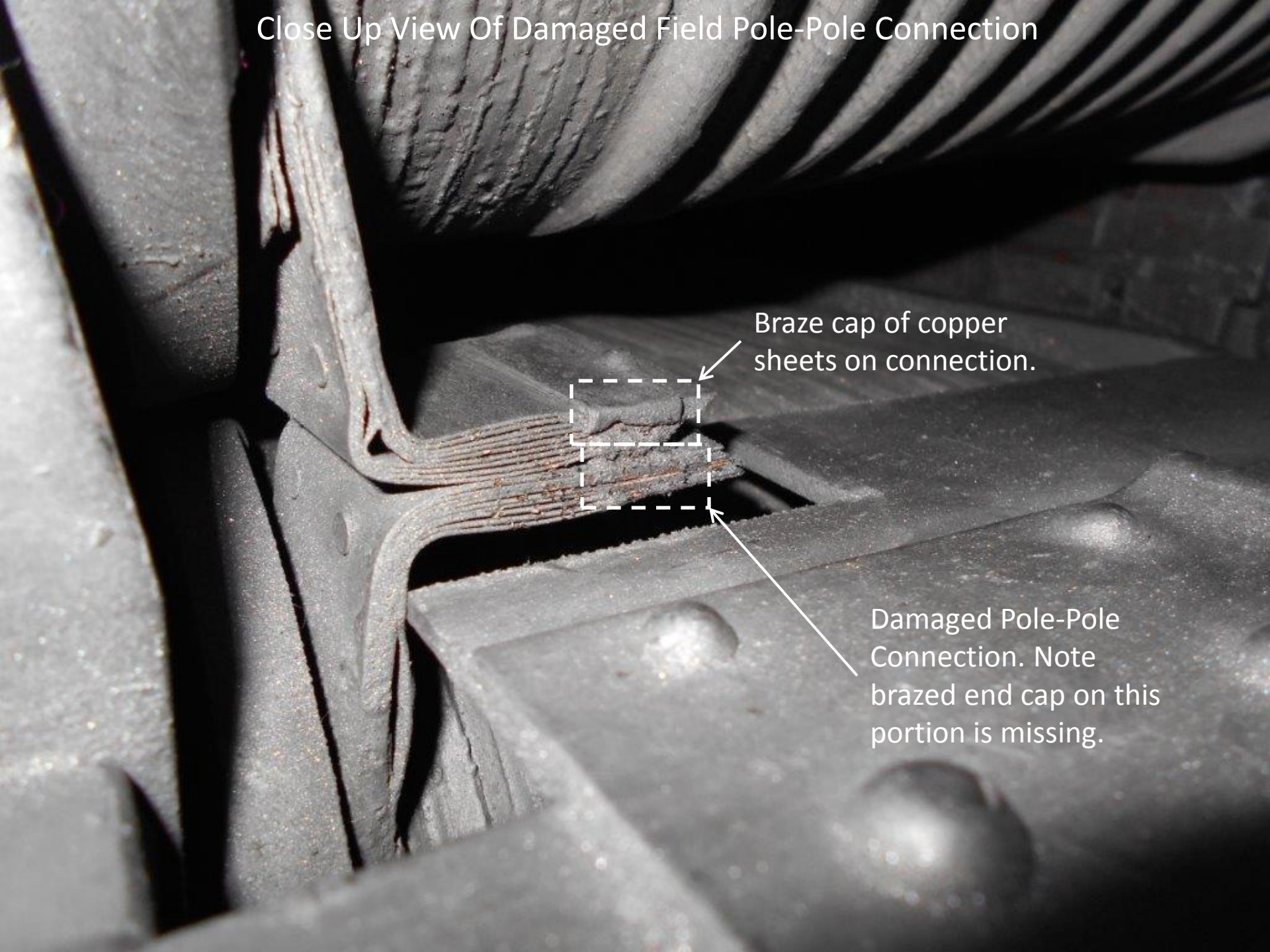


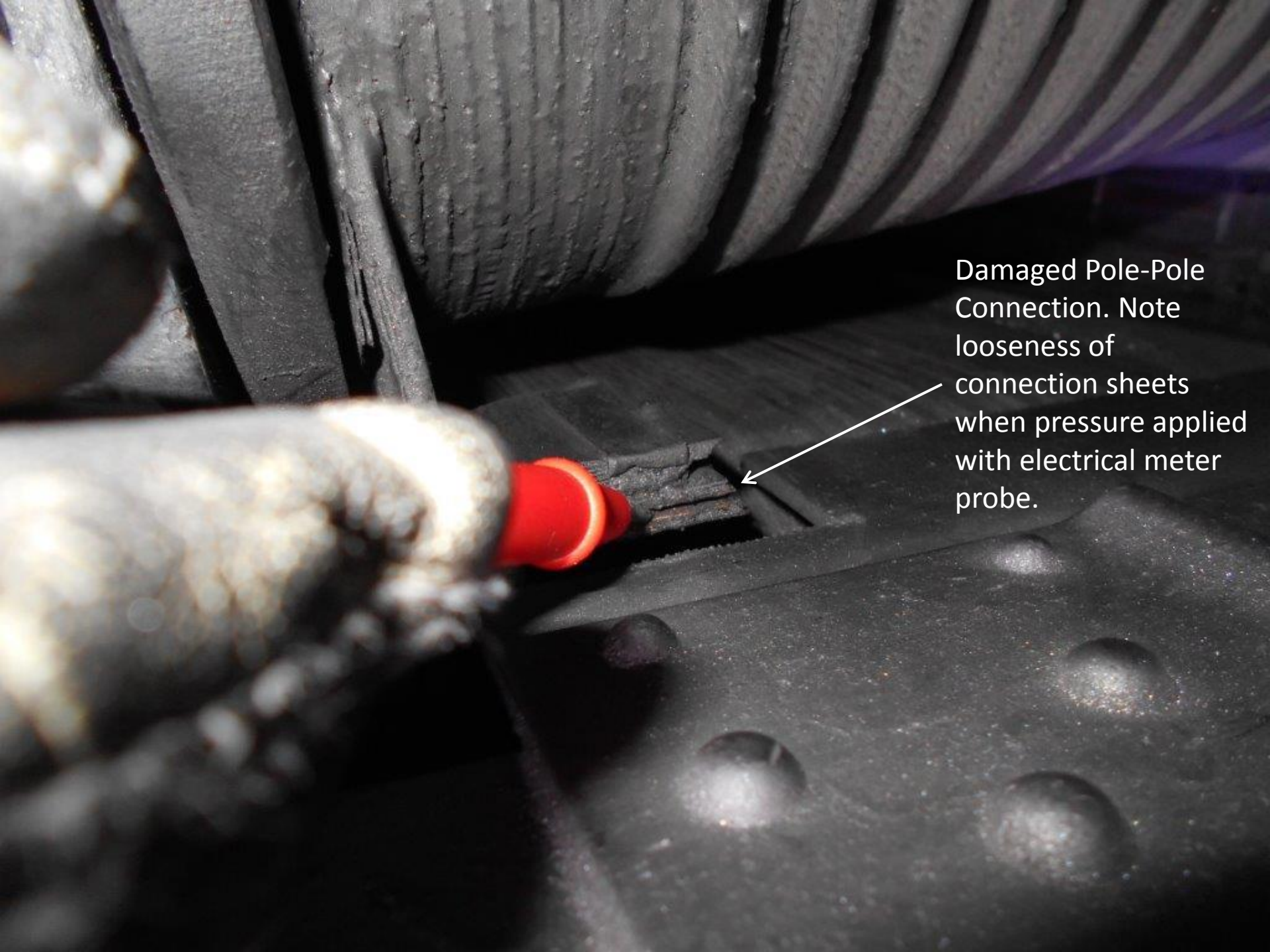
Copper co
final brazi
winding ju


Unit End
Winding Top
Side and
Pole Faces

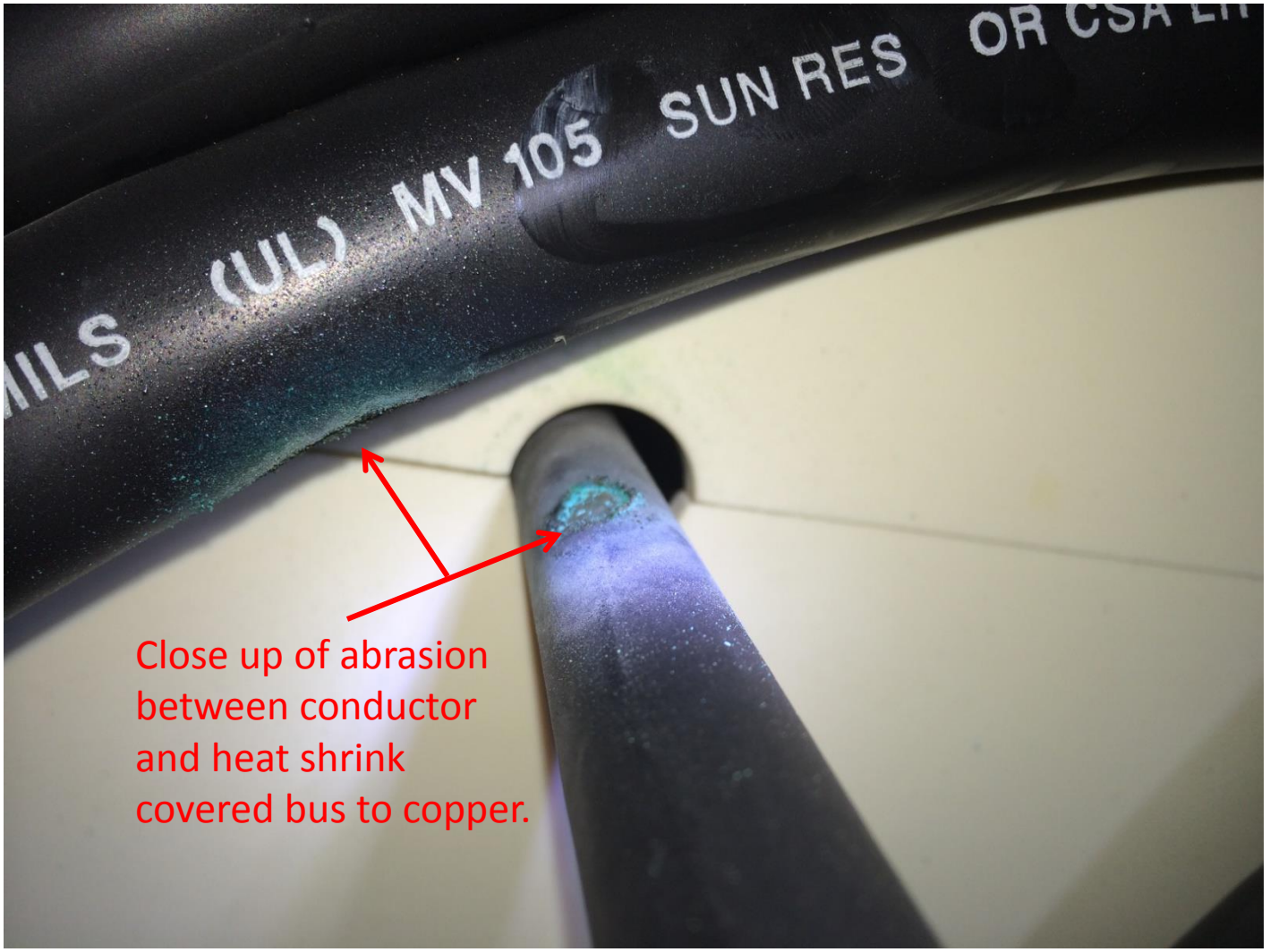

Unit Pole &
Field
Winding

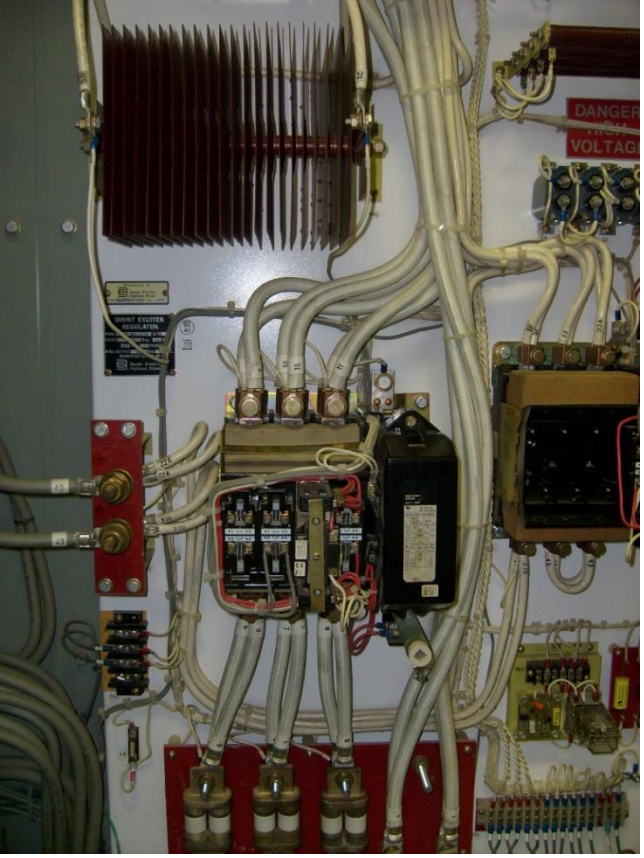

Typical Pole-Pole
Connection
Unit Pole Fan
Blade and Pole-
Pole Connection

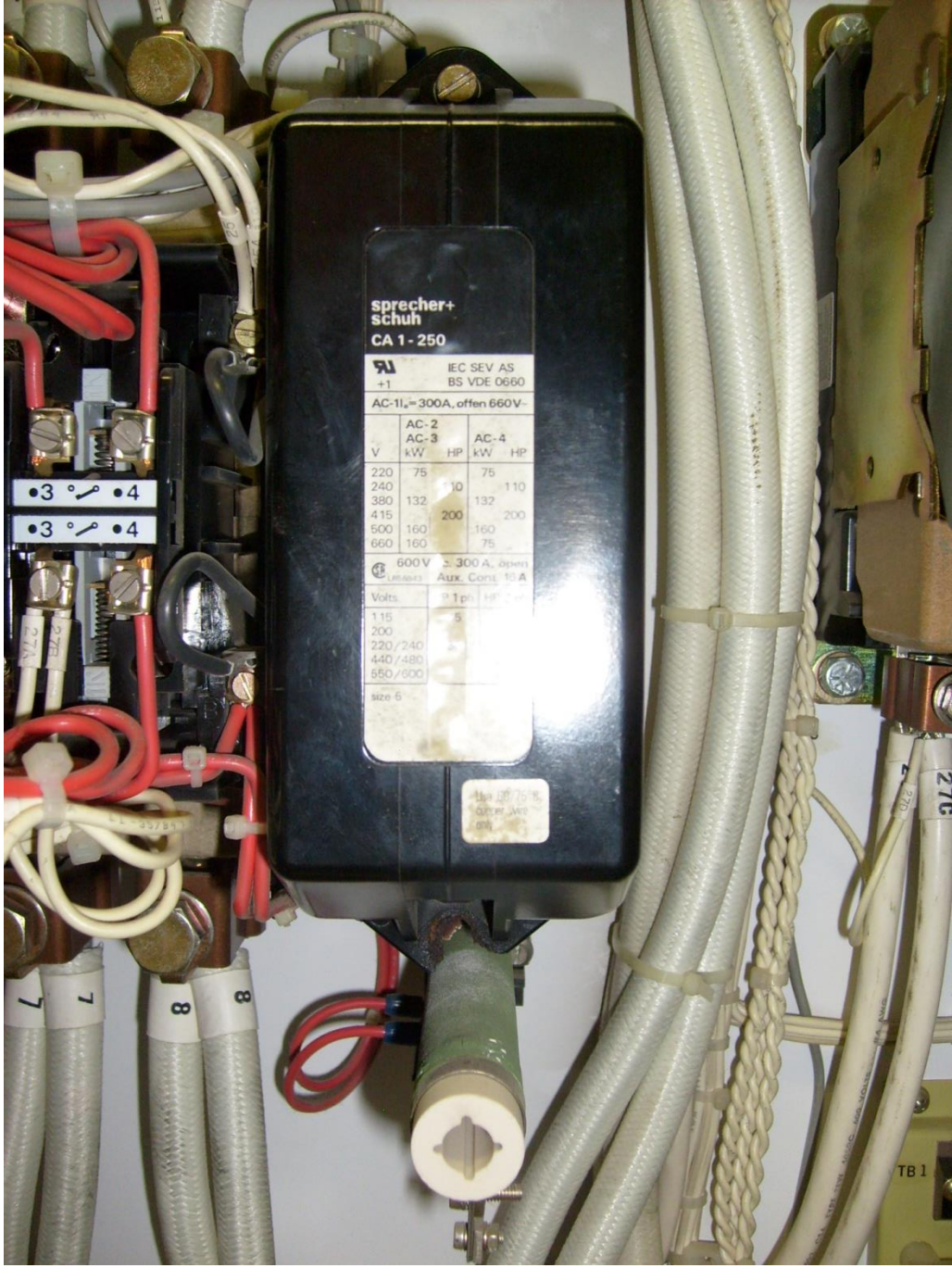

Close Up View Of Damaged Field Pole-Pole Connection
Braze cap of copper sheets on connection.
Damaged Pole-Pole Connection. Note brazed end cap on this portion is missing.

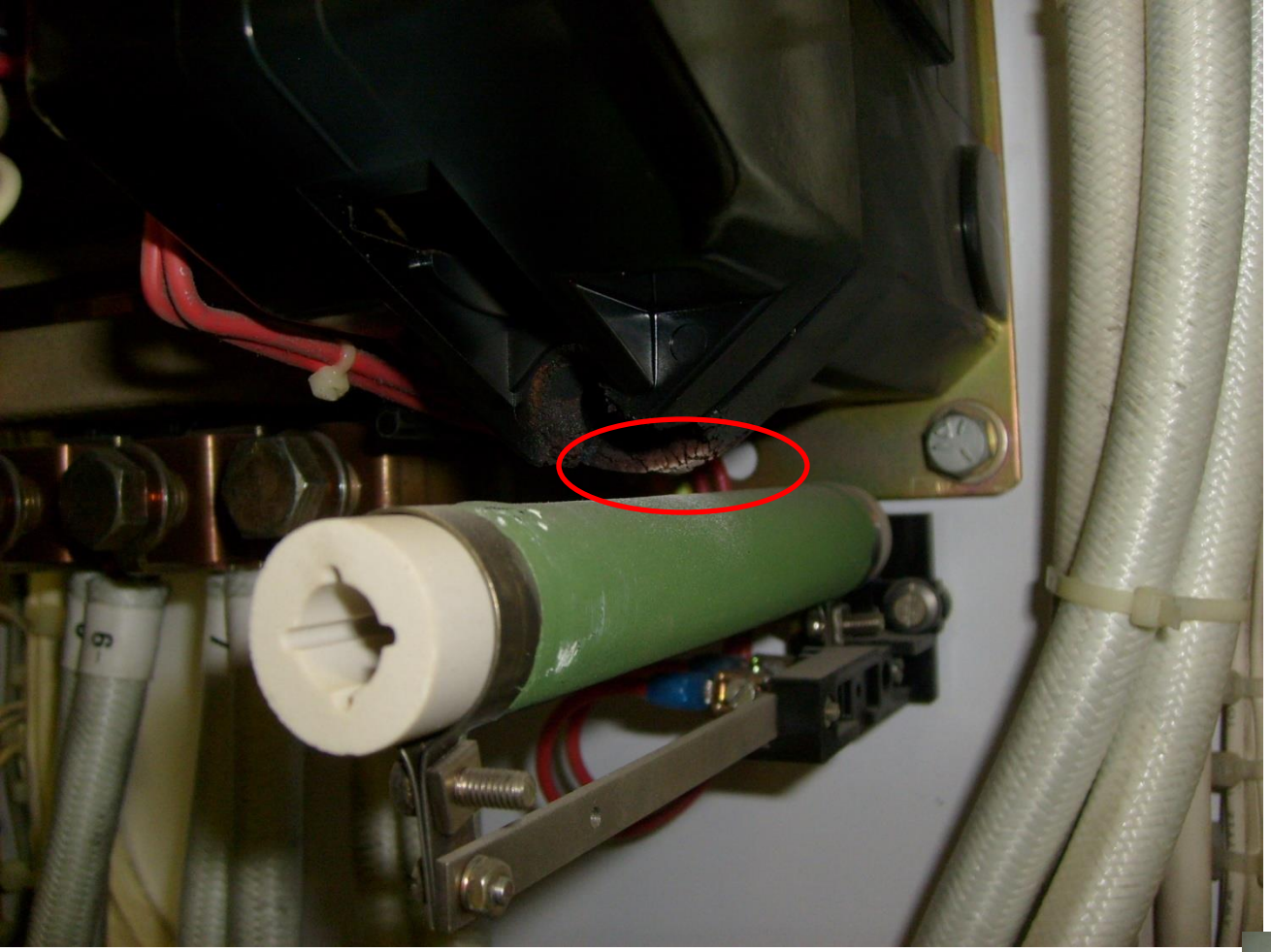

Damaged Pole-Pole Connection. Note looseness of connection sheets when pressure applied with electrical meter probe.


Location of insulation abrasion due to contact and vibration
Green coating on fuses
Leads from generator terminals.


MILS (UL) MV 105 SUN RES OR CSA
Close up of abrasion between conductor and heat shrink covered bus to copper.


DANGER
VOLTAGE
SHUNT EXCITER REGULATOR


sprecher+schuh
CA 1 - 250
IEC SEV AS
BS VDE 0660
AC-1 I_e = 300A, offen 660V~
AC-2
AC-3
AC-4
V kW HP kW HP
220 75 75
240 110 110
380 132 132
415 200 200
500 160 160
660 160 75
600V 300 A, open
Aux. Cont. 10 A
Volts
115
200
220/240
440/480
550/600
size 6
•3 •4
•3 •4
TB 1



- 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)

Stator		Test Voltage:	5,000	VDC
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

Remarks

All testing show minimal signs of degredation.

Resistance value is historically low; shows signs of degredation or contamination.

Winding Resistance (corrected to 25 deg C)

Stator					
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
			Stator Factory Resistance Temp (C):		16.5
Rotor			Rotor Factory Resistance Temp (C):		16.5
Field	0.284	NA	0.7%	0.286	0.29584

As left testing not completed; as found data used.

All test results show minimal signs of degredation.

Stepped Voltage (corrected to 40 deg C)

Stator		End Test Voltage:		5,000	VDC
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

As left testing not completed; as found used.

Field test shows signs of insulation degredation or contamination. Continue testing; consider cleaning.

Pole Drop

Applied Field Voltage:	120	VAC	
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		

Testing shows no signs of detectable shorted turns within pole windings.

PASS	Test results exhibit no degredation.
MONITOR	Test results exhibit some degredation.
FAIL	Test results exhibit degredation.

	Calculation or reference from testing sheet.
	User input.

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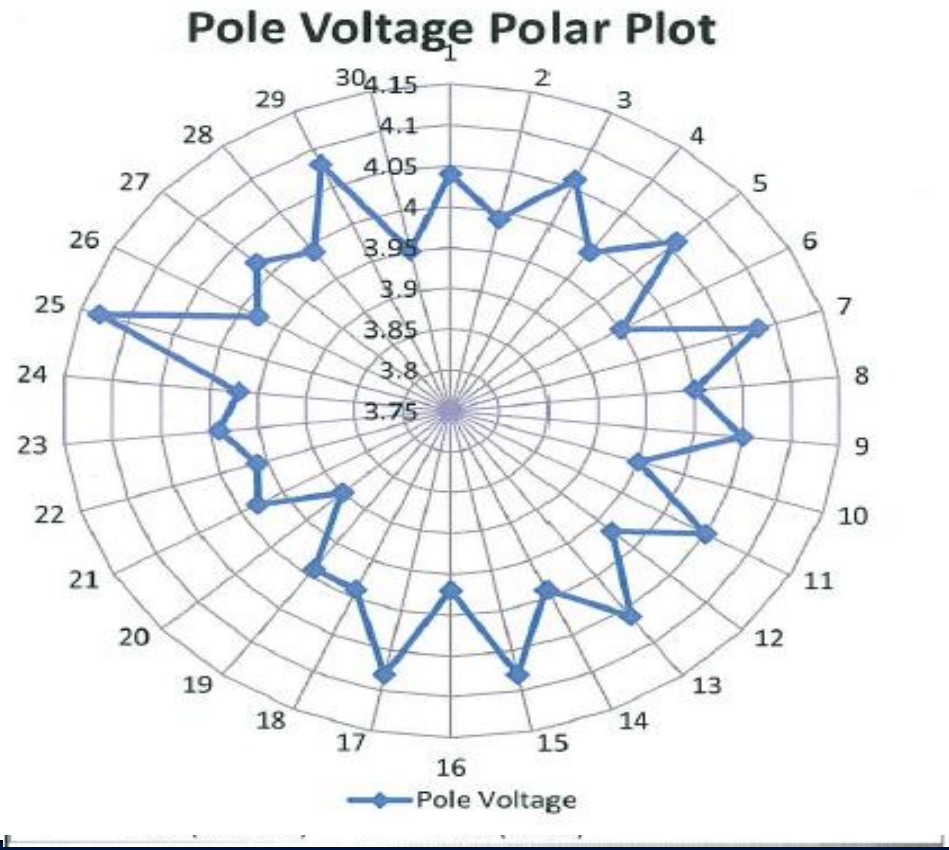
EWEB's Testing Regime

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

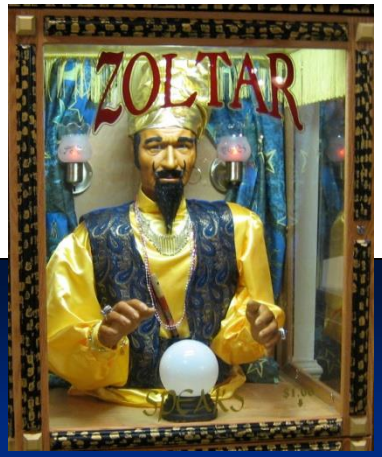


EWEB's Testing Regime Future Additions…

- 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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