

Rockwell Automation
Shreveport Service Center
Robert L. Stokes - Preserv Mng.

Elect./Mech. Root Cause Analysis-
Synch. & DC Motors

Background:

- Pilot program to compare time based maint. versus condition based maint.
- Target Synch & DC Motors/Generators
- Sample Systems Quarterly
- Down-day required
- Correlate to operational records
- Correlate to historical repairs

Test Equipment Utilized:

- Preserv Technology - in the field = PdMA Corp. Motor Circuit Evaluation (MCE - Static model)
- Interpretation based on historical data
- Test procedures developed by Rockwell Automation
- Confirmation by I.R., core loss, surge test, Meggar, & current application

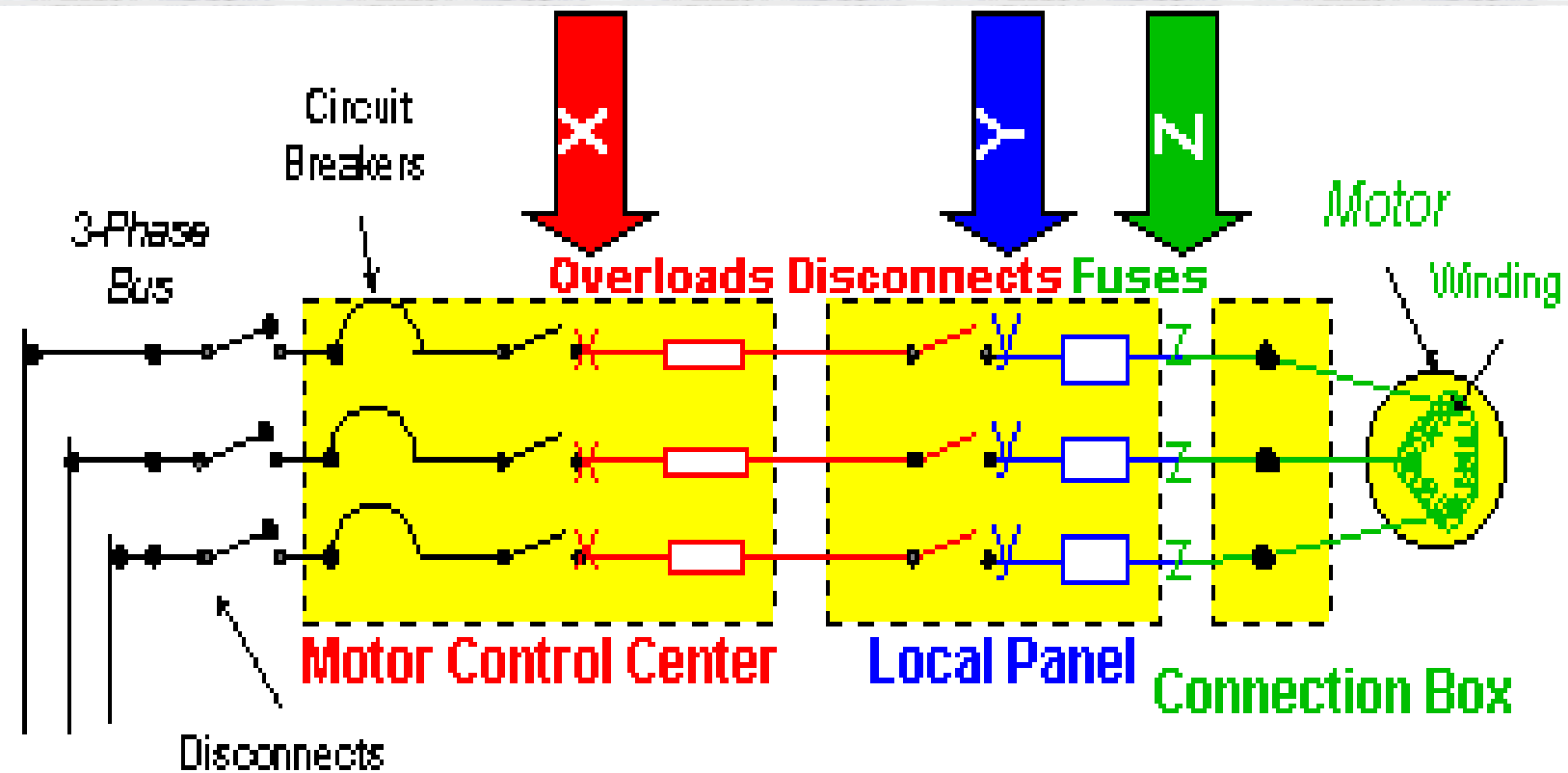
MOTOR CIRCUIT EVALUATION

- *Non Intrusive, Non Destructive* motor electrical circuit testing.
- *Low Voltage, Computer Precision* test measurements.
- *OEM comparison* for root cause analysis
- *Proprietary test method* to isolate fault to stator or rotor

Measures the following Motor Circuit Characteristics:

- Resistance to ground.
- Capacitance to ground.
- Phase to phase resistance.
- Phase to phase inductance.
- Magnetic centering effect

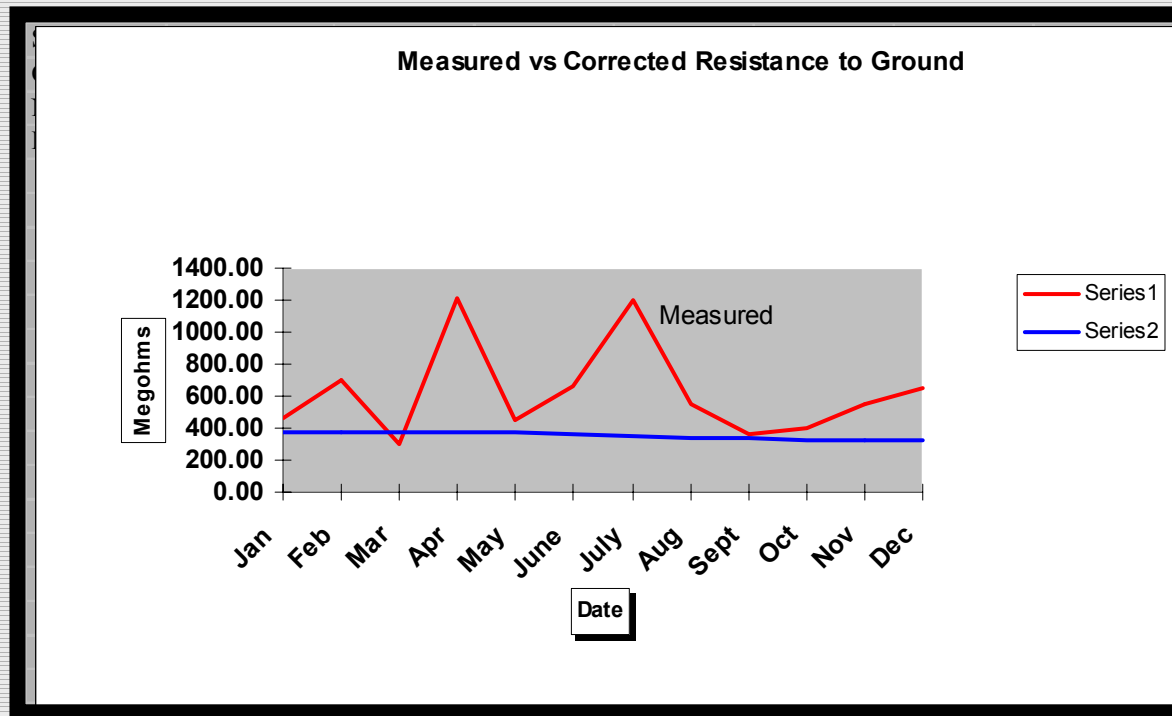
Poly Phase Motor Testing



Resistance to Ground

- Test Motor and cabling ground wall integrity.
- 500 or 1000 VDC.
- Temperature corrected.
- Trend for change
- Determine cause of pending failure

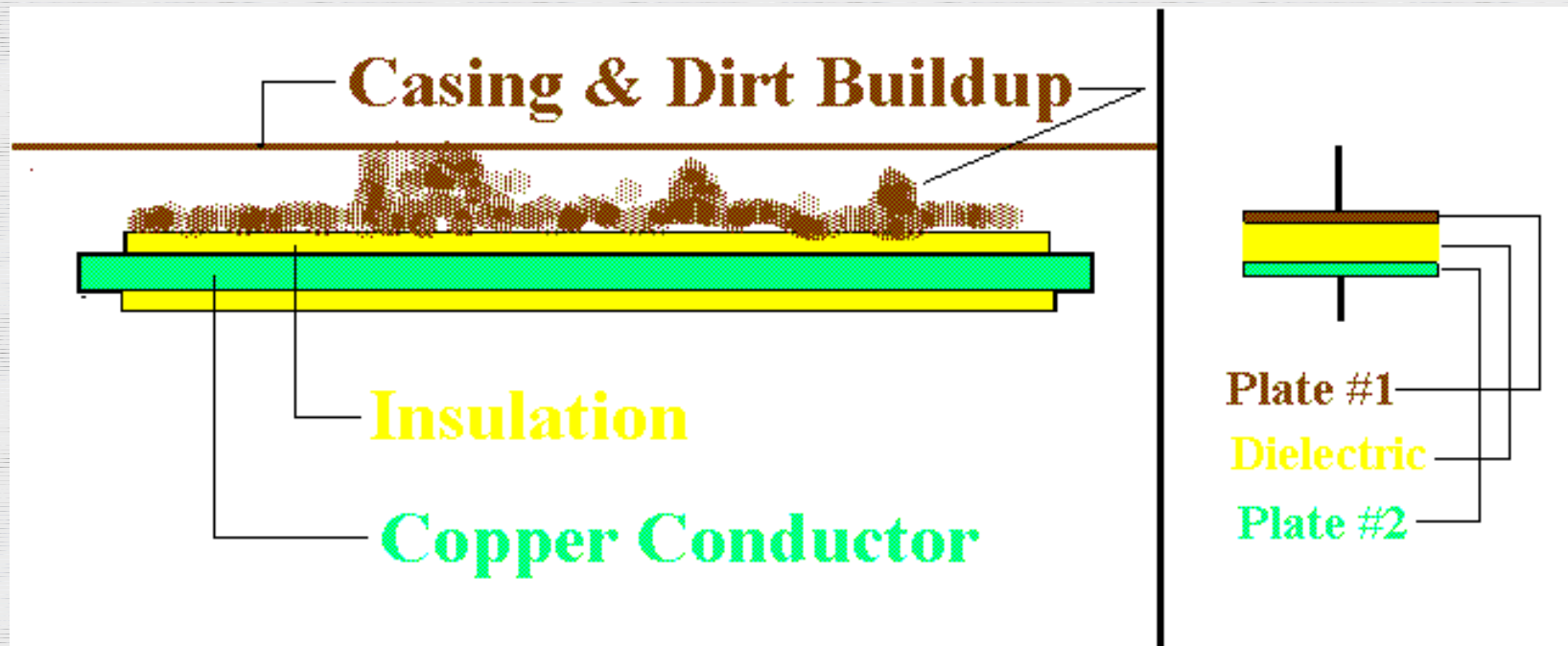
Resistance to Ground



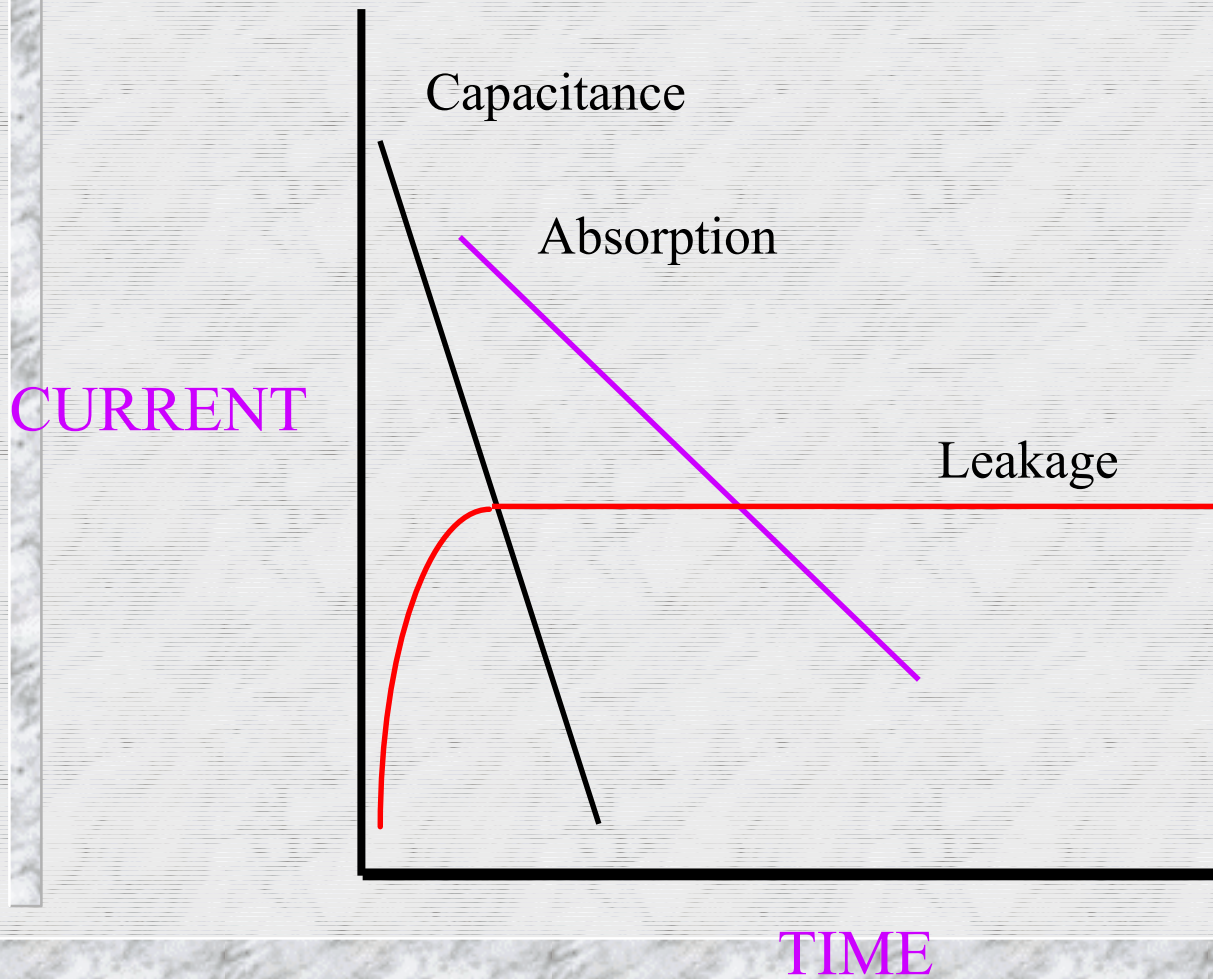
Resistance to Ground

Test Date	6/22/97	12/19/97	1/12/98	2/26/98
Test ID:	13	79	152	255
Frequency	1200	1200	1200	1200
	BASELINE	BASELINE	BASELINE	BASELINE
Charge Time	30	30	30	30
Voltage	1000	1000	1000	1000
Motor Temp	30	20	40	30
Measured Mohm	820.0	630.0	221.0	149.0
Corrected Mohm	410.0	236.5	221.0	74.5

Capacitance to Ground

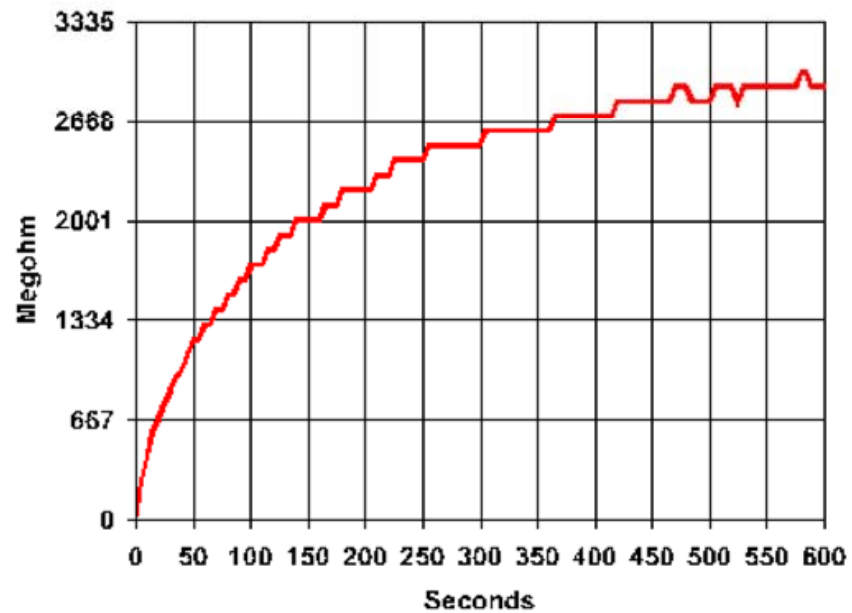


Polarization Index



Polarization Index

PI Test (#3 Jordan Drive Motor - Stator) Ratio: PI 2.23 DA 1.49



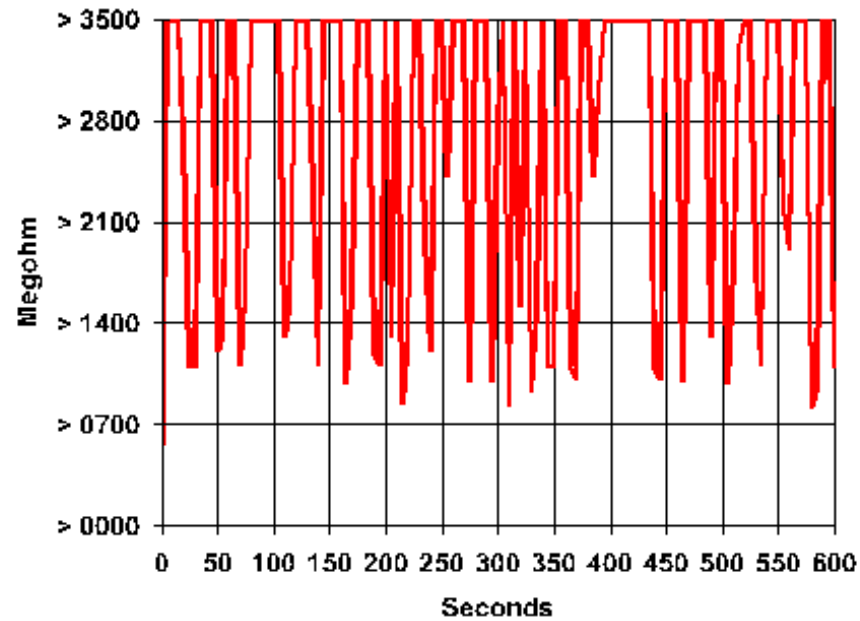
PI Raw Data

Test ID: 2

Test Date: 1/23/1996

Polarization Index

PI Test (Inboard Rewind - Field) Ratio: PI .11 DA N/C



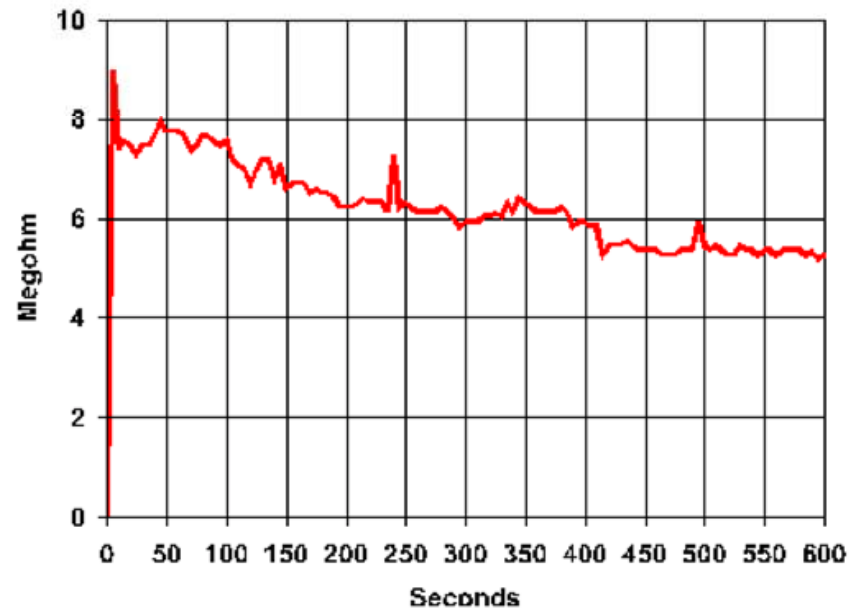
Raw Data

Test ID: 675

Test Date: 12/12/1991

Polarization Index

PI Test (#3 Main DC Generator - Field) Ratio: PI .68 DA 1.04



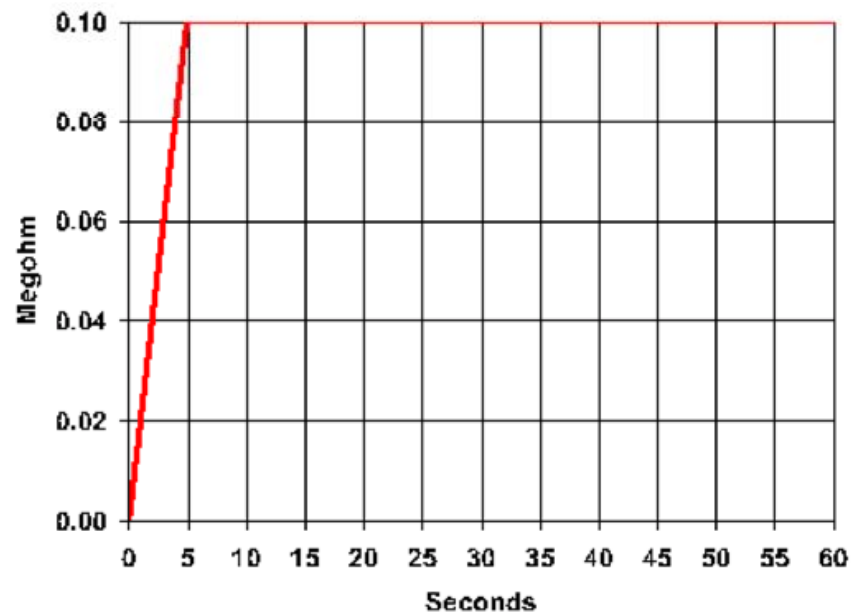
PI Raw Data

Test ID: 194

Test Date: 6/17/1996

Polarization Index

PI Test (E0071 - Stator) Ratio: PI N/A DA 1



PI Raw Data

Test ID: 24

Test Date: 1/23/1998

Causes of Motor Failures

- 1985 EPRI Study.
 - Funded GE
 - 6000 Motor Test Group
- Study results indicated the necessity for motor and motor circuit electrical testing.
- 7 year root cause analysis Study
- Study indicated 25% of failures were repeat

EPRI Study Results

■ Failures

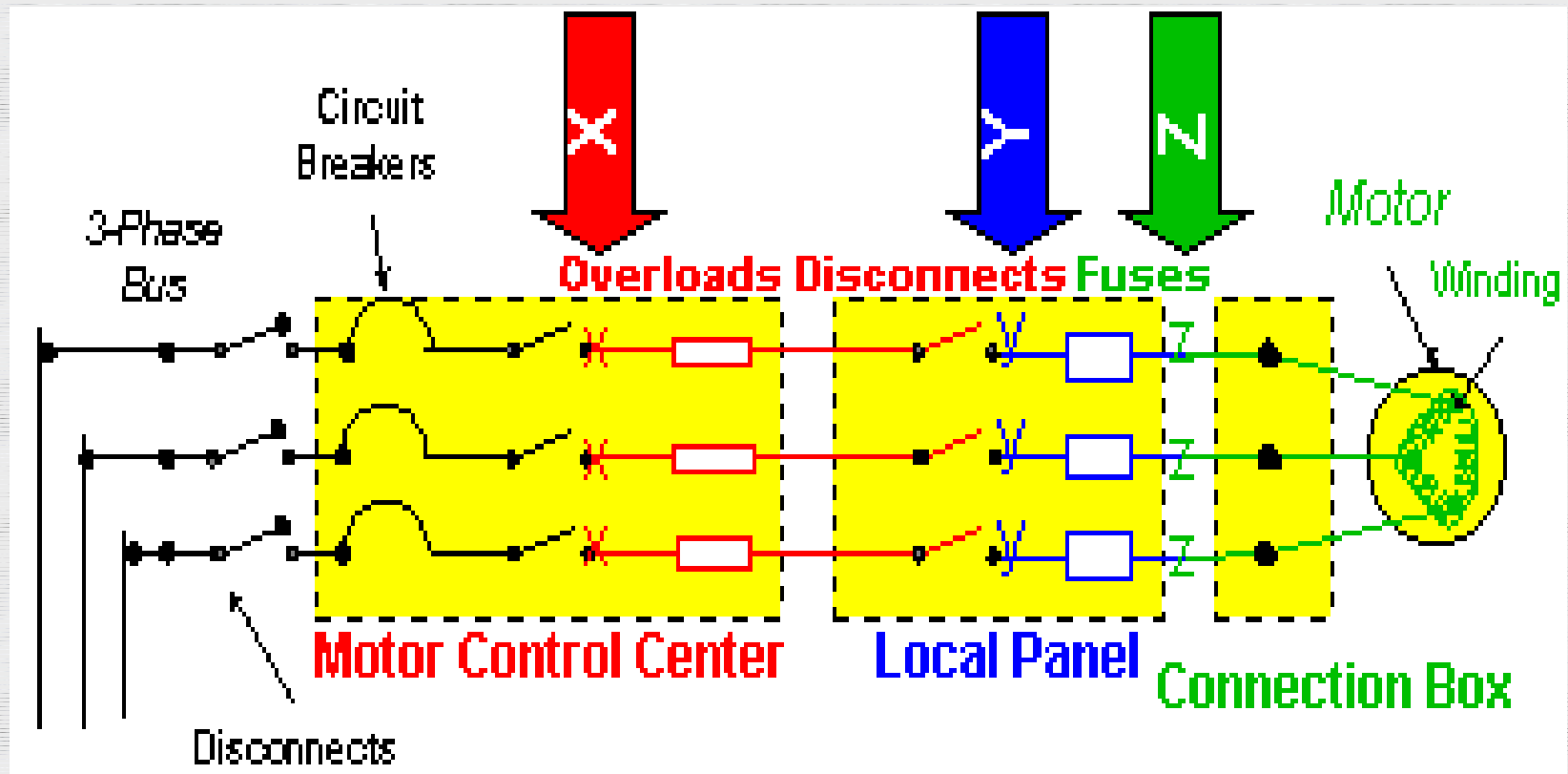
- 41% Bearings
- 37% Stator Related
- 10% Rotor Related
- 12% Miscellaneous

- No research conducted to determine number of mechanical failures attributed to electrical defects.

Phase to Phase Resistance

- Determines the resistive balance.
- Identifies High resistance connections.
- Correlates data to isolate fault to:
 - Rotor Anomalies
 - Stator Anomalies / Power Circuit
- Provides “\$” loss calculation.
- 3% voltage imbalance halves motor life expectancy.

Phase to Phase Resistance



Normal = Phase - Phase Resist./Ind. 6.9 KV 2500hp

Test Date	12/8/99
Test ID:	1660
Frequency	1200
	BASELINE
Ph 1 to 2	0.243 @ 16.6 mH
Ph 1 to 3	0.243 @ 16.3 mH
Ph 2 to 3	0.244 @ 16.3 mH
% Res. Imbalance	0.21
\$ Power Loss	46.83

Predicted Coil Failure - Phase - Phase Resist./Ind. 6.9 KV 2500 hp

Test Date	9/22/98
Test ID:	1394
Frequency	1200
	BASELINE
Ph 1 to 2	0.239 @ 16.2 mH
Ph 1 to 3	0.246 @ 16.2 mH
Ph 2 to 3	0.249 @ 16.4 mH
% Res. Imbalance	2.38
\$ Power Loss	468.36

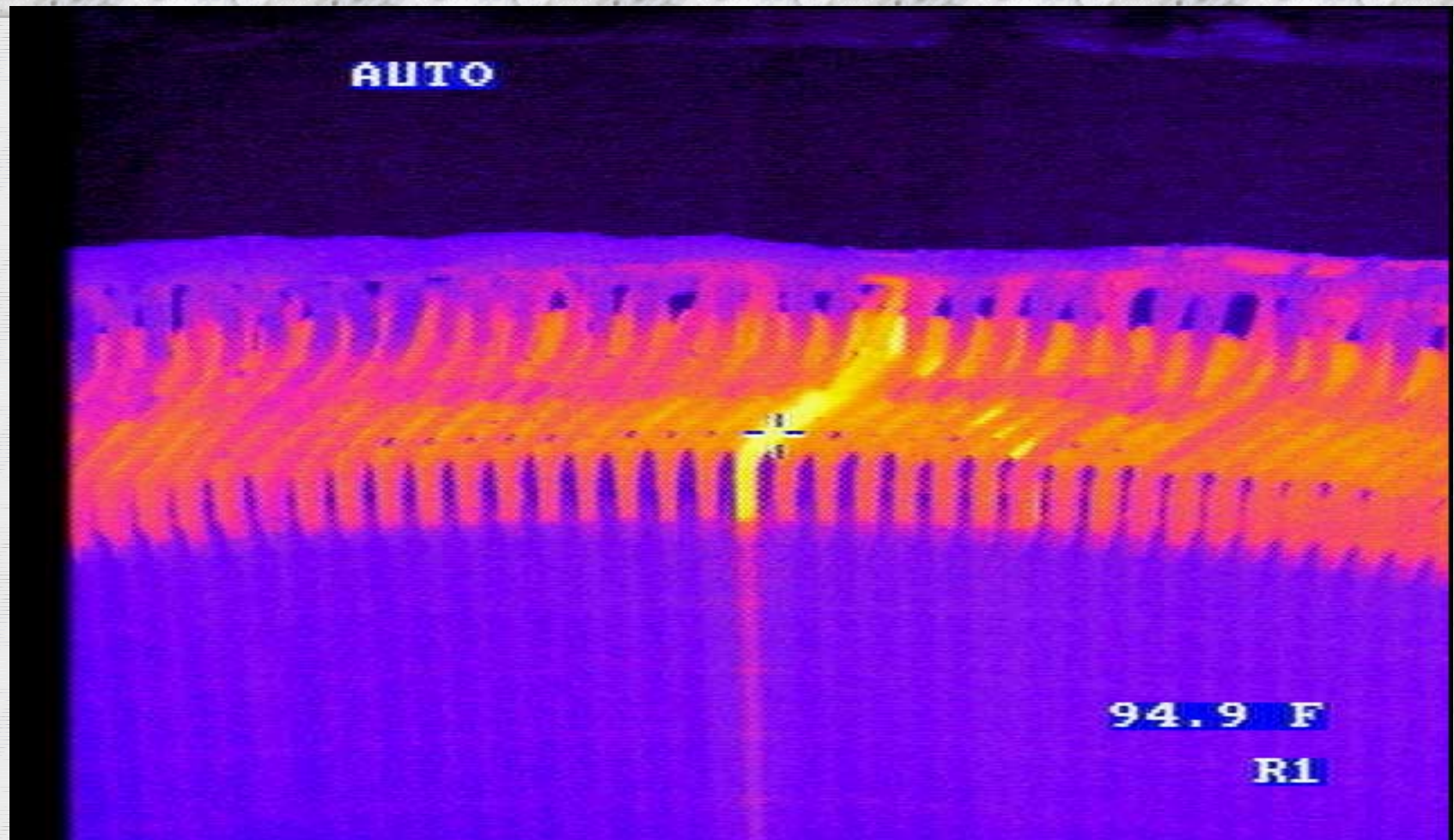
Coil Failure - No Rotor, Phase - Phase Resist./Ind. 6.9 KV 2500 hp

Test Date	2/23/99
Test ID:	1570
Frequency	1200
	Failure in service
Ph 1 to 2	0.228 @ 19.8 mH
Ph 1 to 3	0.229 @ 19.5 mH
Ph 2 to 3	0.229 @ 19.8 mH
% Res./Ind.Unba	0.22% & 1.2%
Corrected Mohm	0.00 Meg.

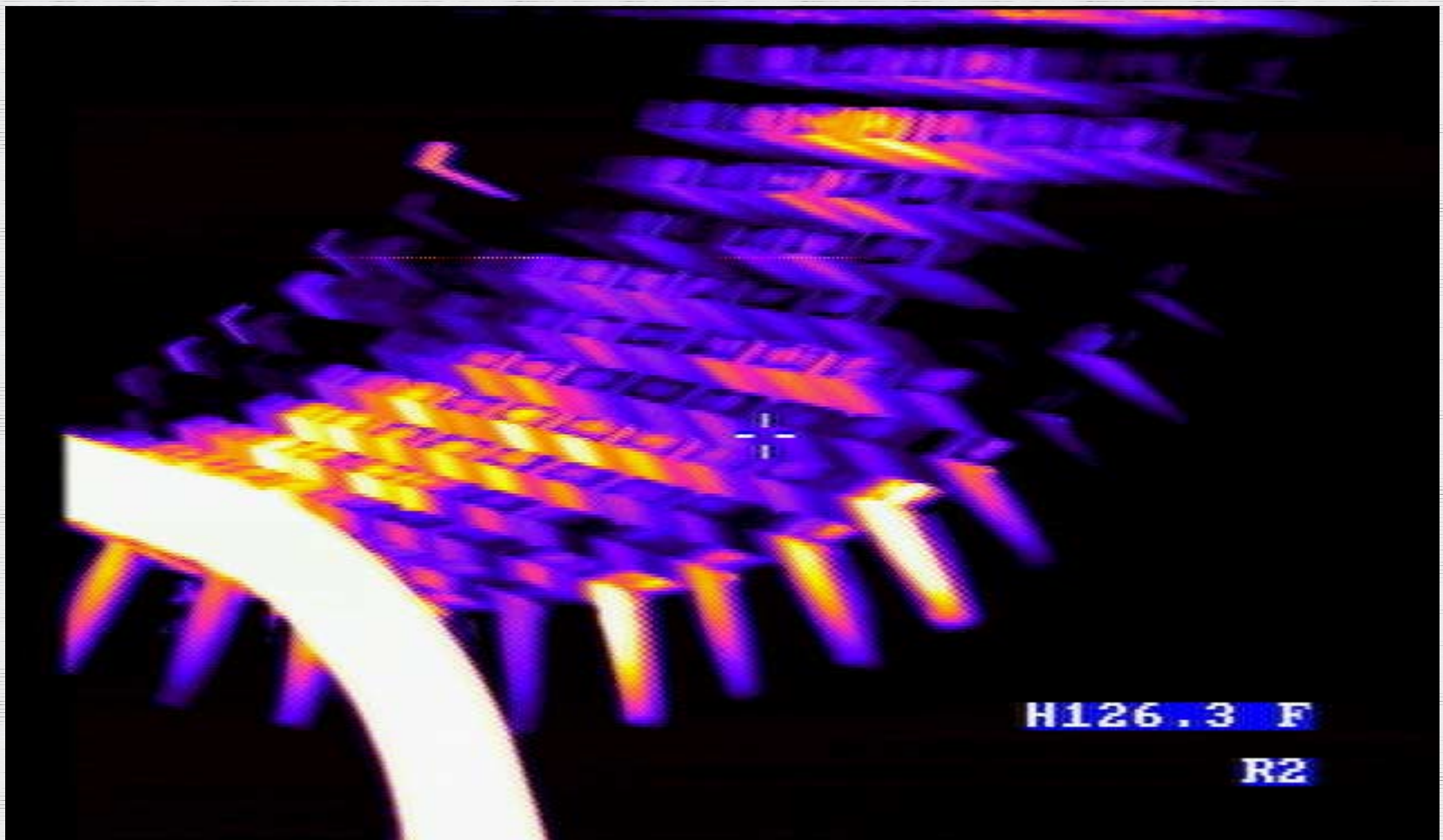
Suspect Coil Failure by Inductive Heating - Synch. 15KV 2500hp



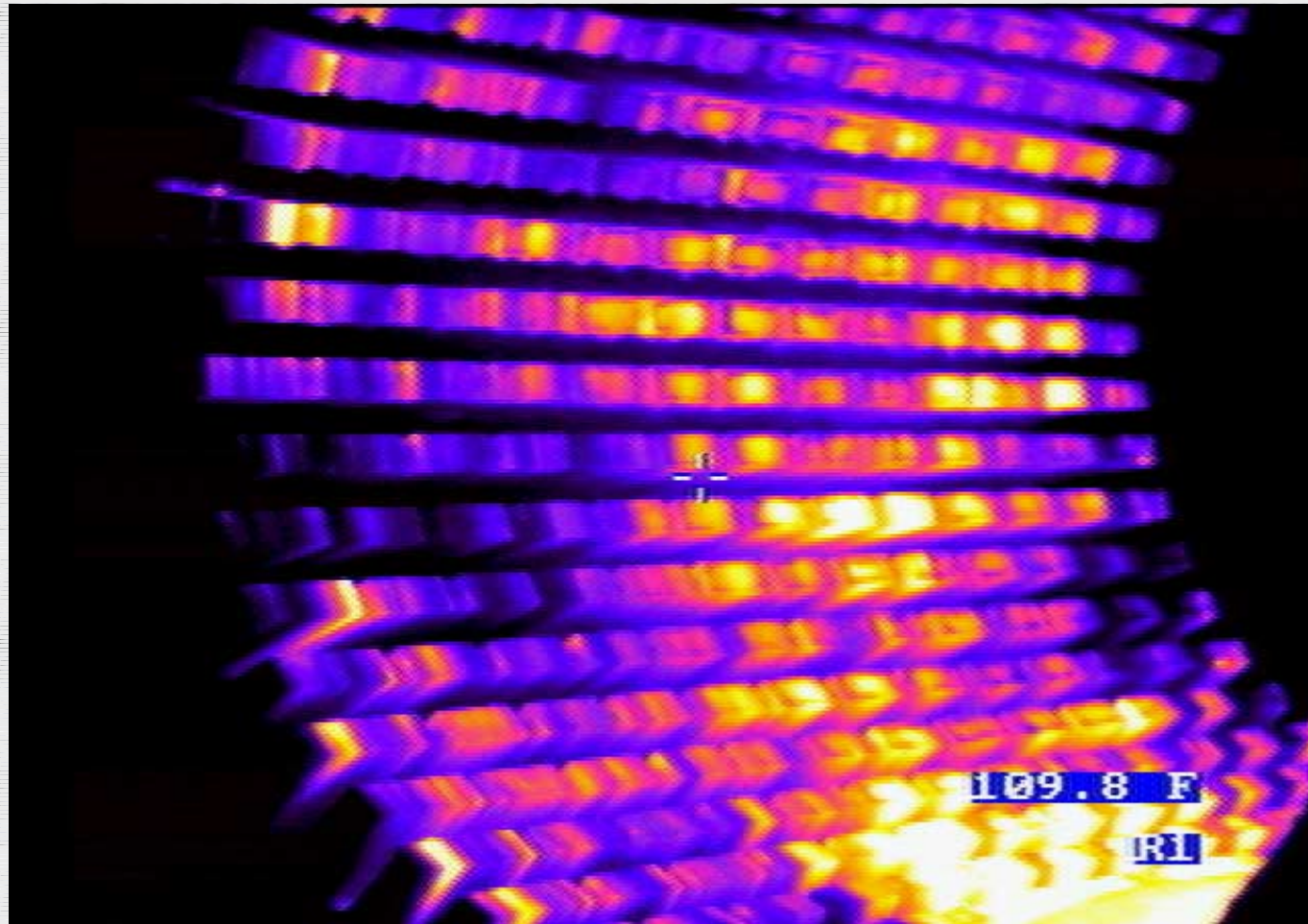
MCE, Current, & I.R. combination



MCE data suspect, rotor/stator contact, repeat insulation defect



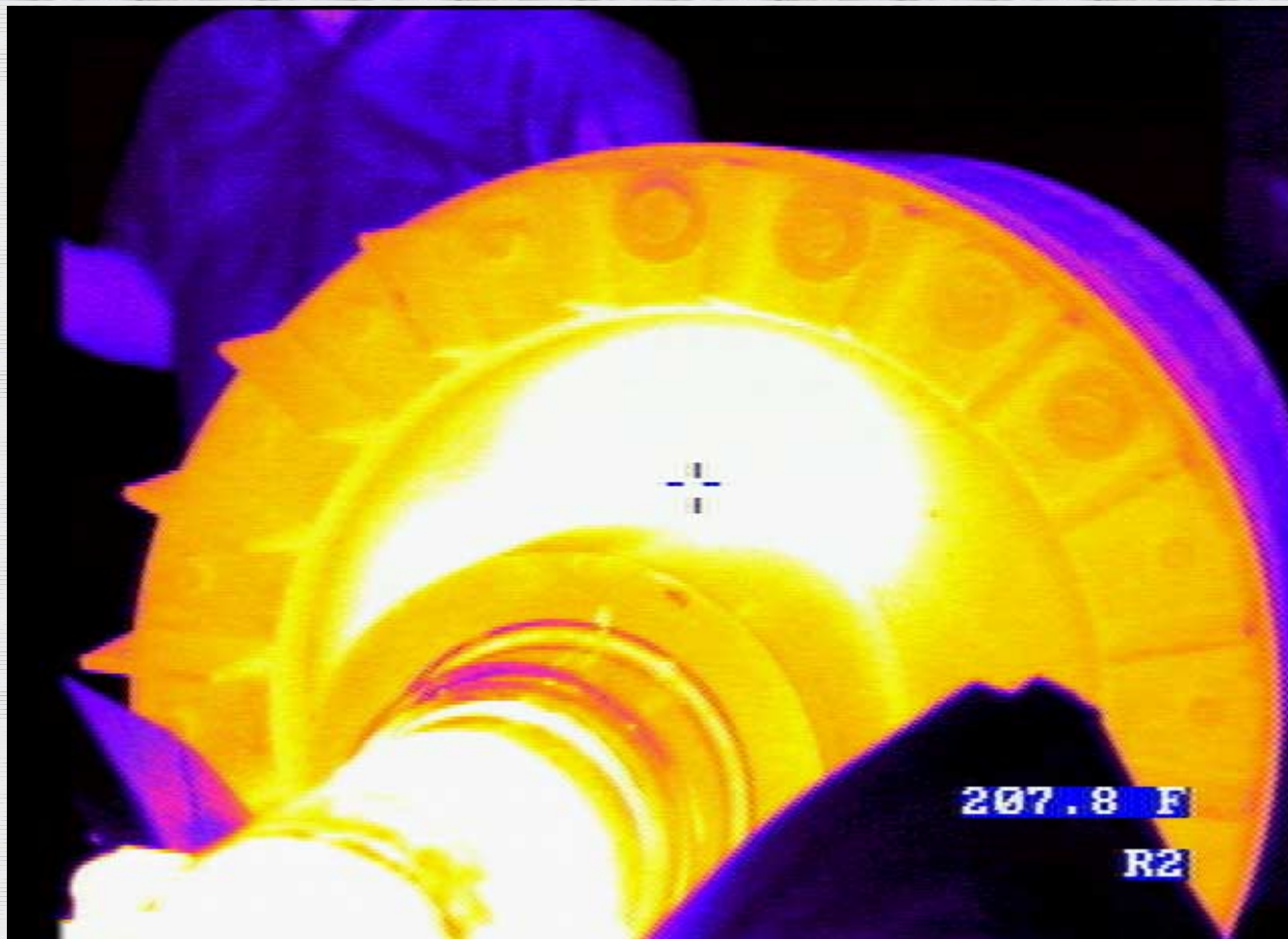
MCE data suspect, coil failure in slots, vibration with El. Freq.



MCE data suspect, rotor thermal bowing possible - ODE results



MCE data suspect, thermal bowing possible, repeat bearing failure - DE



Predicted Cage Fault : Phase - Phase Resist./Ind. 6.9 KV 2500 hp

Test Date	3/4/99
Test ID:	47
Frequency	1200
	BASELINE
Ph 1 to 2	0.243 @ 15.4 mH
Ph 1 to 3	0.238 @ 15.3 mH
Ph 2 to 3	0.247 @ 15.8 mH
% Res. Imbalance	1.78
\$ Power Loss	398.11

Predicted Cage Fault : Phase - Phase Resist./Ind. 6.9 KV 2500 hp Field

Test Date	3/4/99
Test ID:	3 Identical motors
Frequency	300
	BASELINE
ohm Ph 1 to 2	.79 - .76 - .77
mH Ph 1 to 2	1248 - 700 - 800
Normal range	.78 ohm @ 750mH
Corrected Mohm	all fields @ Infinity
Correlation=	<i>Iron/Core Loss</i>

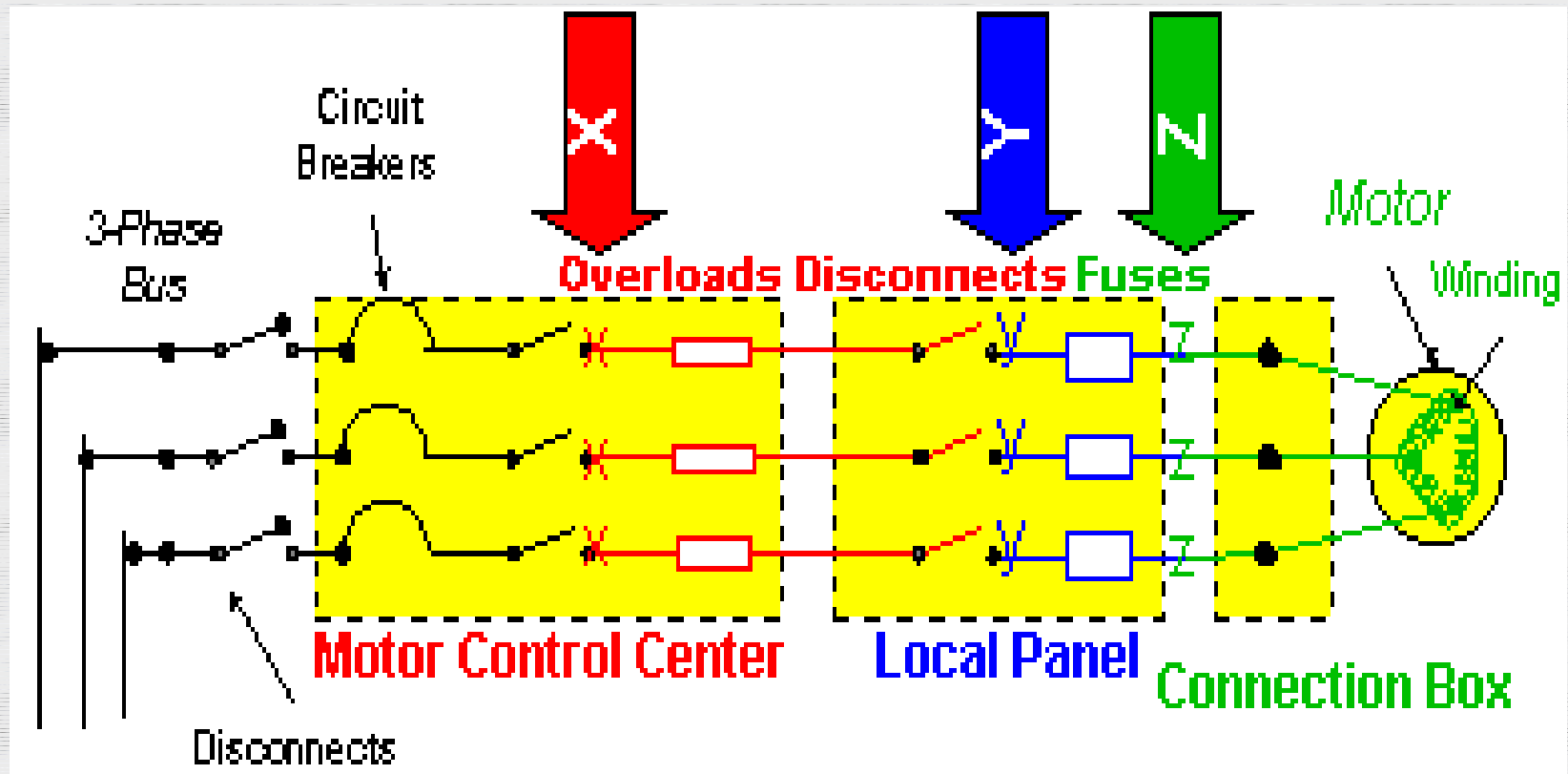
Results: R/R detected 4 splices broken in cage assembly. Cost avoidance!



Phase to Phase Inductance

- Inductance is affected by:
 - Number of turns in coils
 - Air gap between rotor / stator
 - Stator core
 - Rotor bars / core
 - Core area (length & diameter)
 - Material composition

Phase to Phase Inductance



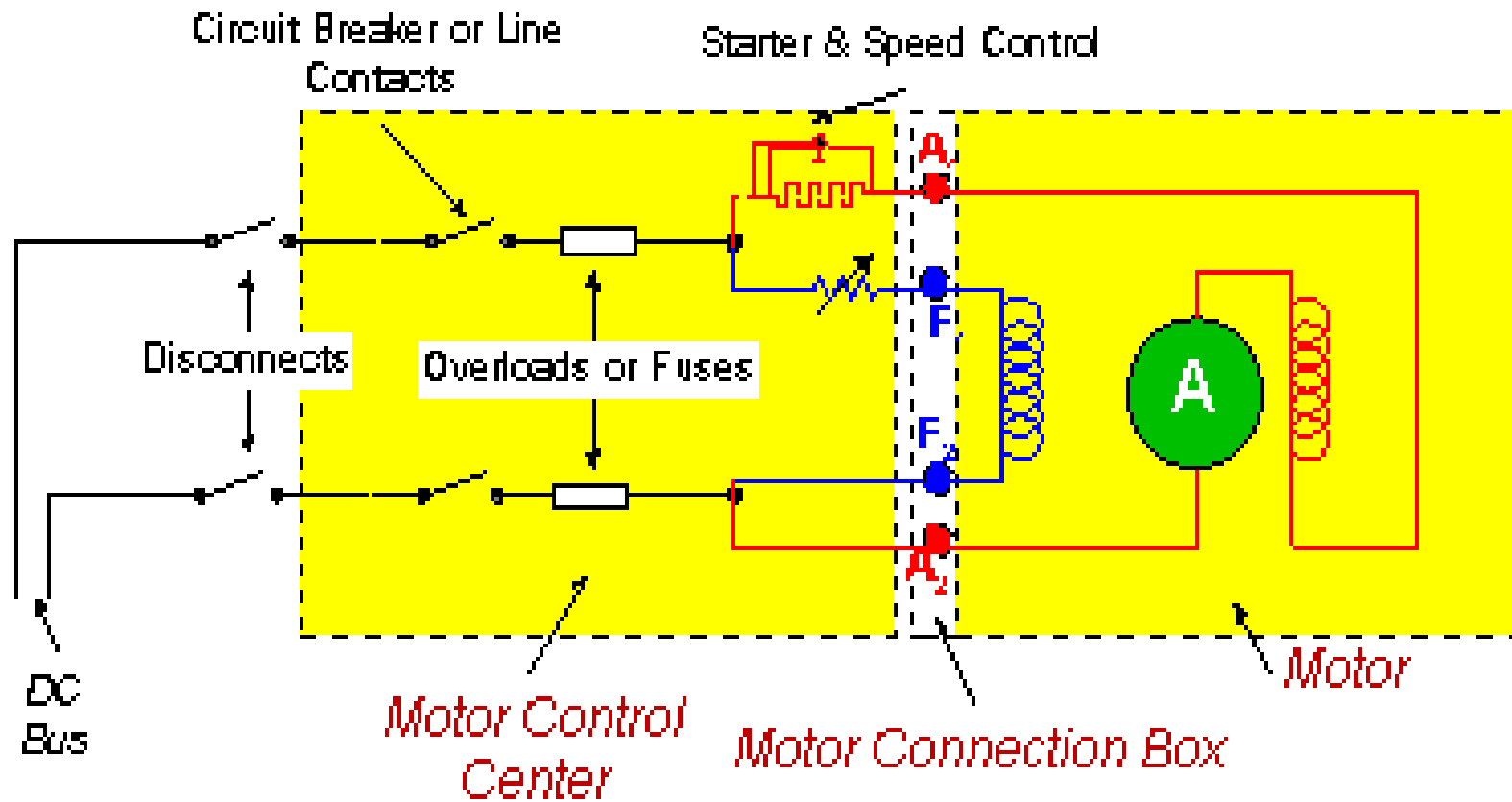
Phase to Phase Inductance Rotor Installed

Test Date	9/22/98
Test ID:	1398
Frequency	1200
	BAS ELINE
mH Ph 1 to 2	16.200
mH Ph 1 to 3	16.200
mH Ph 2 to 3	16.400
% Ind. Imbalance	0.90

Phase to Phase Inductance Rotor Removed with coil defect

Test Date	2/23/99
Test ID:	1570
Frequency	1200
mH Ph 1 to 2	19.800
mH Ph 1 to 3	19.400
mH Ph 2 to 3	19.800
% Ind. Imbalance	1.2 should be 0.0

DC Motor Testing



DC Armature - No faults

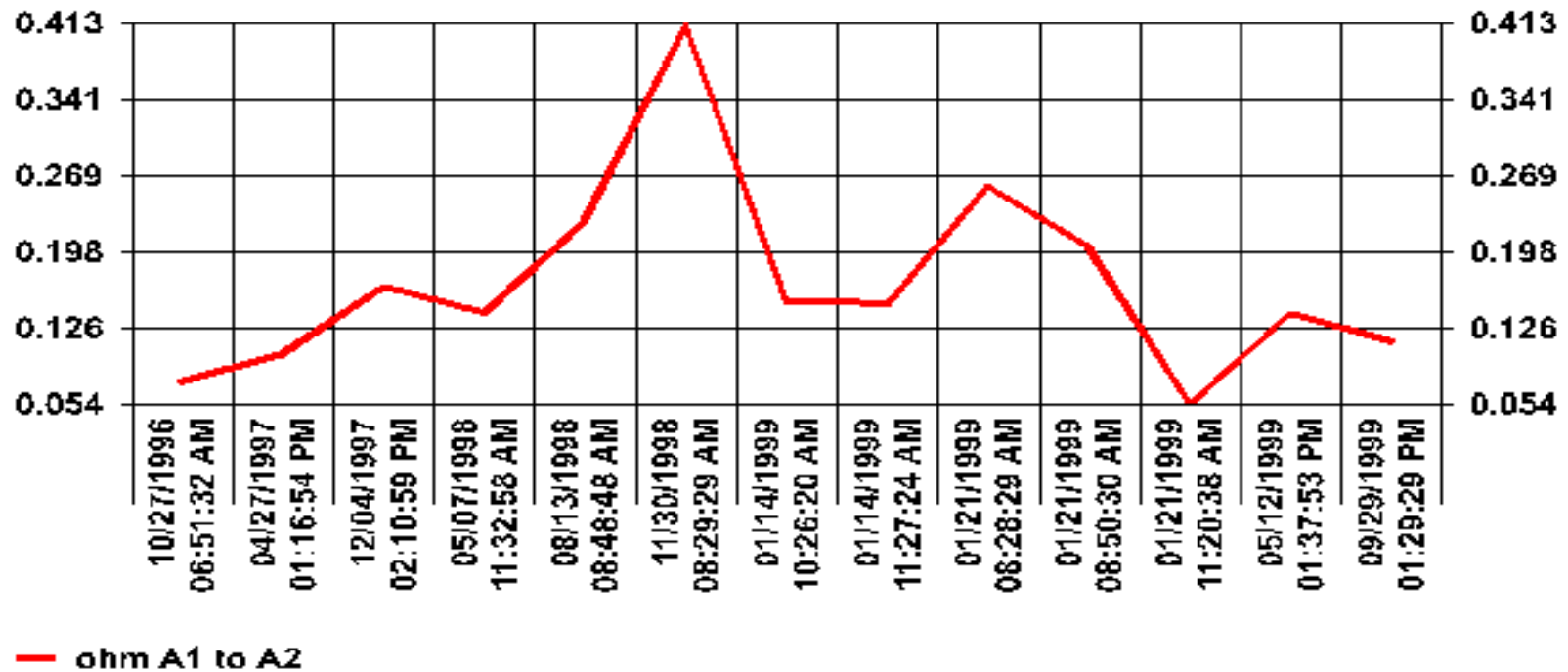
Test Date	10/27/96
Test ID:	876
Frequency	1200
	BASELINE
Charge Time	30
Voltage	500
Motor Temp	30
Measured Mohm	1200.0
Corrected Mohm	600.0
pF A1 to Gnd	202750
ohm A1 to A2	0.07650
mH A1 to A2	0.940

DC Armature - Improper turn & Undercut

Test Date	11/30/98
Test ID:	1400
Frequency	1200
Charge Time	30
Voltage	500
Motor Temp	25
Measured Mohm	109.0
Corrected Mohm	38.0
pF A1 to Gnd	226000
ohm A1 to A2	0.49000
mH A1 to A2	0.960

Trend of Change in Resistance

DC Standard Test (East (Entry) Reel #2 - Armature)



Resistance (A1 to A2) 11-13-2000

Preserv MCE Additional Test Capabilities

- Synchronous Motors
- Wound Rotor Motors
- Single Phase Motors
- AC & DC Generators*
- Transformers*
- Capacitor Banks
- Surge and Arrestor Circuitry
- Bus Connections

Preserv MCE Advantages & Benefits

- Non-destructive, Non -invasive
- Determine root cause without removal
- Correlate cause to cost effective repairs
- Compare data to OEM specifications
- Increase mean time to failure
- Condition assessment versus time
- Increase equipment availability

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