

### EMD –Machine Diagnostics...

Coverage of various test methods to determine  
Electric Machine condition

1. No Maintenance
2. Preventative Maintenance
3. Predictive Maintenance

EMD - Testing

Tom Blair, P.E.

1

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

Current Signature Analysis (CSA)–

Normal Current –  $F2 = S \cdot F1$

Abnormal current –  $Fsb = F1(1 \pm 2S)$

Detects backward freq due to asymmetry of rotor  
current. – Spectrum analyzer -> freq domain

Online at full load

Cracked rotor bars

Cast rotor windings with voids

Broken bar to short circuit ring connection

Cracked short circuit rings

EMD - Testing

Tom Blair, P.E.

2

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

Growler –

Sets up flux -> induces current in rotor bar

Bar will "Growl" is open

Also, amp meter to detect open bar (reduced  
amp indicate open bar)

Offline – rotor removed

Open (not cracked) rotor bars

EMD - Testing

Tom Blair, P.E.

3

---

---

---

---

---

---

---

---

**EMD –Machine Diagnostics...**  
Insulation Resistance (IR) and Polarization Index (PI)  
-  
IR tests ground wall insulation (not turn to turn)  
PI (using DC) removes effect of temperature  
Offline  
Detects contaminated winding insulation (oil, dirt, water, etc)  
IR – 5Mohm (<1KV), 100Mohm (>1KV)  
PI > 2  
DC Hipot typical values  
Stator (2\*Vs + 1000)\*1.7  
Rotor (10\*Vf) WHY?

---

---

---

---

---

---

---

---

**EMD –Machine Diagnostics...**  
Surge Test –  
Go – no go  
Vdc stepped up. Waveform captured & compared with each step. A sudden change in waveform indicates failure.  
Offline  
Detects turn to turn insulation failure

---

---

---

---

---

---

---

---

**EMD –Machine Diagnostics...**  
Partial discharge (PD) Test –  
Medium voltage – detect void in stator insulation  
Measures directly pulse currents from PD  
Various methods;  
1. Offline on entire stator  
2. Offline corona probe test (locate PD)  
3. Offline ultrasonic probe (locate PD)  
4. Offline UV Imaging to locate PD  
5. Online (RFPT, RFCT, slot coupler)  
Due to electron flow across void  
(Rise time of VSD complicate PD detection)  
Magnitude of PD pulse proportional to void size  
Larger PD pulse more concerning

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

Partial discharge (PD) Test (continued)–  
(SSC) stator slot coupler -

If positive PD pulse > Negative PD pulse = void on or near surface of coil

If negative PD pulse > Positive PD pulse = void on or near conductor of coil

If Positive & negative PD pulse same, void in middle of ground wall insulation

EMD - Testing

Tom Blair, P.E.

7

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

Visual inspections –

Core tightness

Wedge tightness

Air Pressure Decay test – leaks (snooping, ultrasonic probe – helium gas typical tracer gas

Pressure drop in directly cooled coils

Flow test of directly cooled coils

Air Vacuum Decay test – leaks (more sensitive)

(snooping, ultrasonic probe – helium gas typical tracer gas

*Re-wedging in a particular slot is required if:*

1. Less than 75% of the wedges are tight in the slot
2. Three or more adjacent wedges are fully loose
3. Fully loose end-wedges must be re-tightened.

EMD - Testing

Tom Blair, P.E.

8

---

---

---

---

---

---

---

---

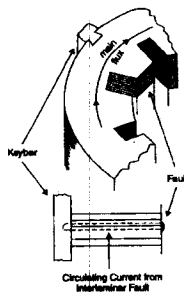
### EMD –Machine Diagnostics...

Detection of failed core insulation

Loop Test, - rated flux in core – look for hot spots with IR camera

EL-CID (Electromagnetic Core Imperfection Detector)

4% flux in core – Detector picks up quadrature current (power loss vs. magnetizing current) 0-20mA, acceptable, > 100mA, damaged core insulation



EMD - Testing

Tom Blair, P.E.

9

---

---

---

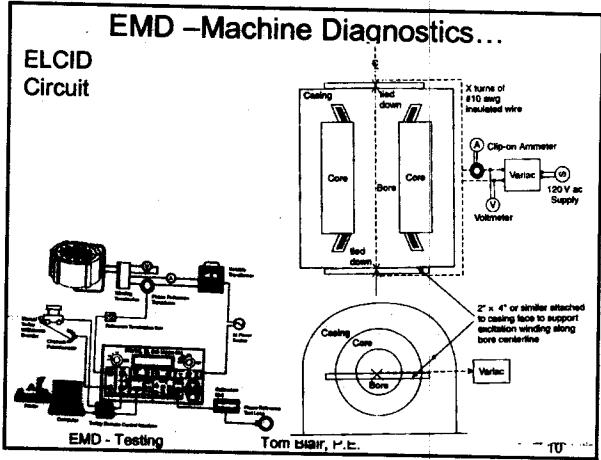
---

---

---

---

---




---

---

---

---

---

---

---

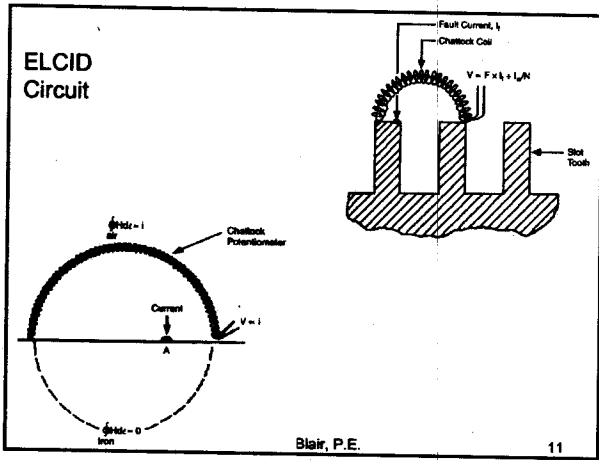
---

---

---

---

---




---

---

---

---

---

---

---

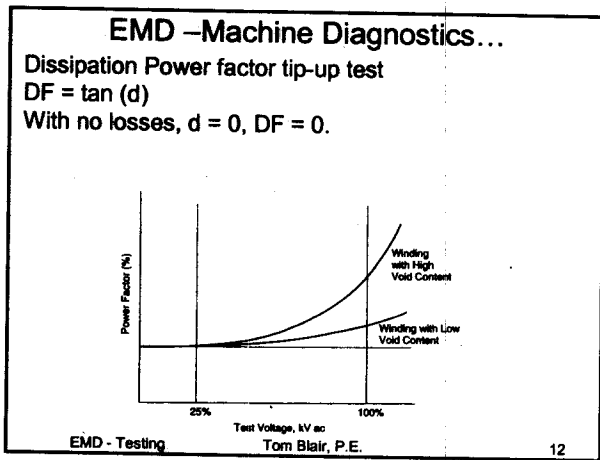
---

---

---

---

---




---

---

---

---

---

---

---

---

---

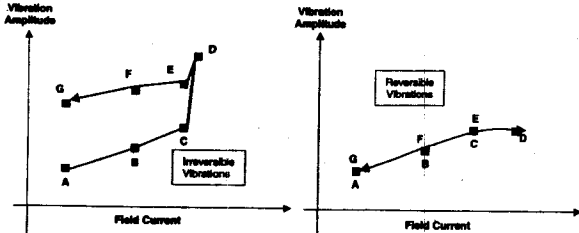
---

---

---

### EMD –Machine Diagnostics...

#### Reversible vs non reversible



EMD - Testing

Tom Blair, P.E.

13

---

---

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

Vibration –

Vibration –

**MACHINE SPEED**

**MAX AMPLITUDE**

0-1000 RPM

3 mils

1000-1500 RPM

2.5 mils

1500-3000 RPM

2 mils

3000 AND ABOVE

1 mil

EMD - Testing

Tom Blair, P.E.

14

---

---

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

Possible causes – (field current dependant)  
shorted rotor coil turns (reversible)

Flux probe possible confirmation.

Ratcheting effect (coil movement) (irreversible)

Gas path blockage (either)

Insulation shift in slot (either)

If not field current dependant, mechanical in nature

Balance weight shift, fan shift, retaining ring

movement, stator uneven heating, bearing

misalignment, H2 seal rub, loose footing or

components.

EMD - Testing

Tom Blair, P.E.

15

---

---

---

---

---

---

---

---

---

---

### EMD –Machine Diagnostics...

- Rotor NDE
- Visual (surface)
- Radiographic (volumetric)
- Magnetic Particle (surface)
- Liquid Penetrant (surface)
- Ultrasonic (volumetric)
- Eddy Current (surface)

EMD - Testing

Tom Blair, P.E.

16

---

---

---

---

---

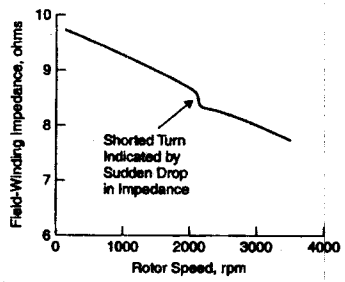
---

---

---

### EMD –Machine Diagnostics...

- Field Ground –
- Split voltage test
- Online field resistance monitoring



EMD - Testing

Tom Blair, P.E.

17

---

---

---

---

---

---

---

---