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Field Test Report

UW Health, American Family Children's Hospital
Shaft Voltage Testing

AEGIS SGR NEMA kit

Shaft Voltage Testing for application of:

AEGIS Bearing Protection Ring:

Purpose: Protect VFD/Inverter Driven Motor Systems from Bearing Failure and Induced Shaft Voltages and Electrical Discharge in Bearings

Applicable to all PWM Inverter Driven AC motors

Test Date: Nov 20, 2008

Location: UW Health
American Family Children's Hospital
Madison, WI

System: Return Fans #5 and #6

Application:

(1) #5 Return Fan; NEMA 256T Frame Baldor Super E Model EM2515T, 20 HP, ABB Drive

(2) #6 Return Fan; NEMA 256T Frame Baldor Super E Model EM2515T, 20 HP, ABB Drive

History:

#5 and #6 Return Fan Systems were installed in September 2008 and within the first 2 months of operation the bearings became extremely noisy. The system was installed with ABB drives and Baldor Super E motors.

Electro Static Technology™
An ITW Company

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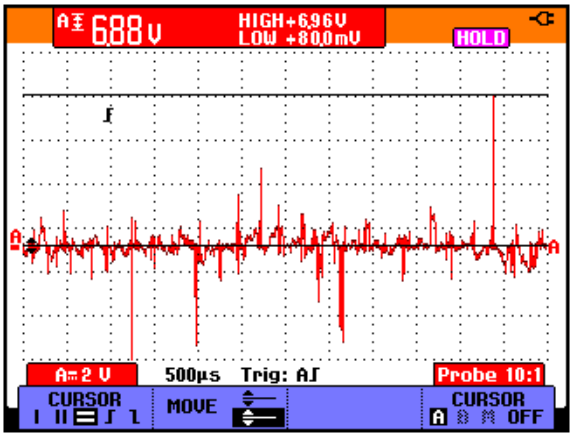
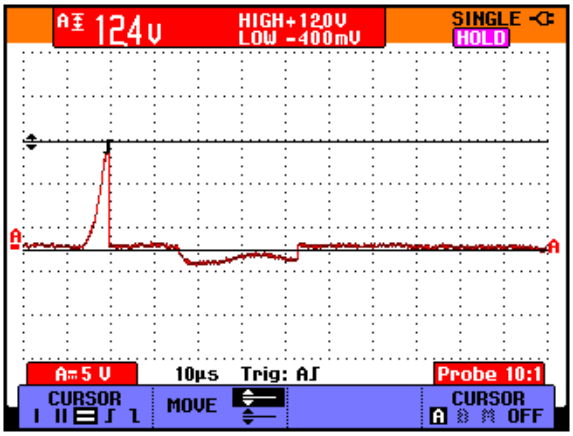
Test Measurement Objective: Measure shaft voltage using AEGIS SVP - Shaft Voltage Measuring Probe to determine induced voltage on the motor shaft. These VFD induced voltages are likely to cause motor bearing currents and bearing fluting failure.

System 1 Test: Return Fan #5 – Shaft Voltage Readings



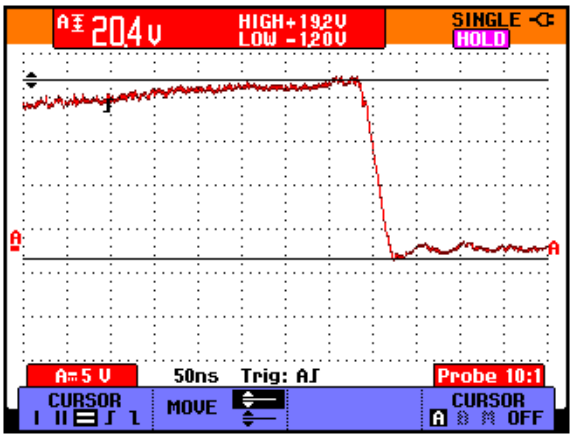
Reading 1: Shaft Voltage Reading DE
Fluke 199C Setting: 2 v/div; 500usec/div

Observations: 12 v pk – pk with numerous positive and negative voltage spikes present of 4-7v pk indicating potential bearing currents. Max spike is 6.88 v pk.



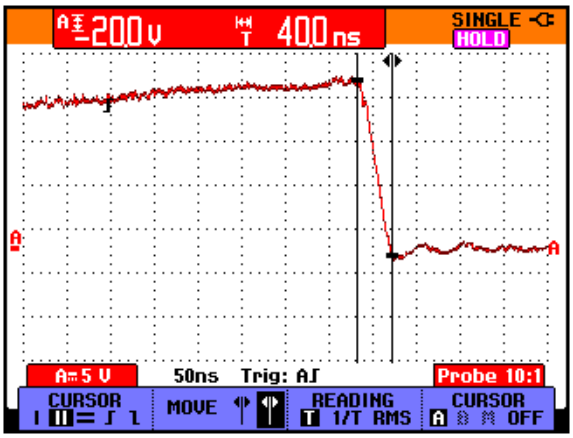
Reading 2: Shaft Voltage Reading DE
Fluke 199C Setting: 5 v/div; 10 usec/div

Observations: Isolated a single 12.4 v pk with wave form indicating a gradual rise time and sharp trailing edge voltage drop indicative of EDM bearing current.



Reading 3: Shaft Voltage Reading DE
Fluke 199C Setting: 5 v/div; 50 nsec/div

Observations: Isolated a single 20.4 v pk with typical EDM discharge pattern. The rapid voltage discharge is indicative of bearing oil film breakdown and voltage discharge in the motor bearing.



Reading 3: Shaft Voltage Reading DE
Fluke 199C Setting: 5 v/div; 50 nsec/div

Observations: Same 20.0 volt discharge. Discharge time is a 40 nano seconds. This is a discharge frequency of 25 MHz.

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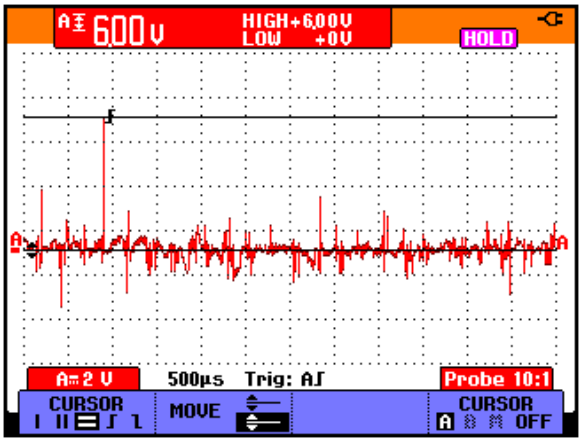
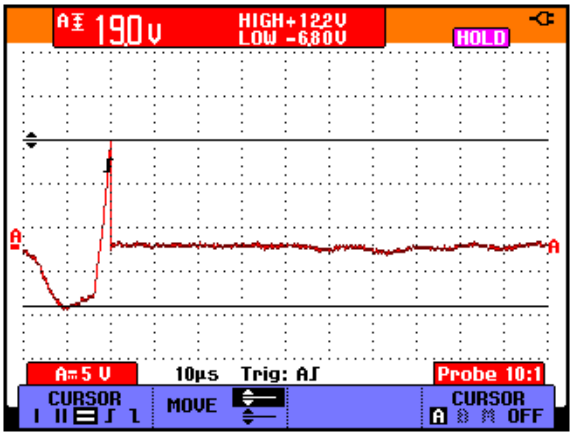
System 2 Test: Return Fan #6 – Shaft Voltage Readings



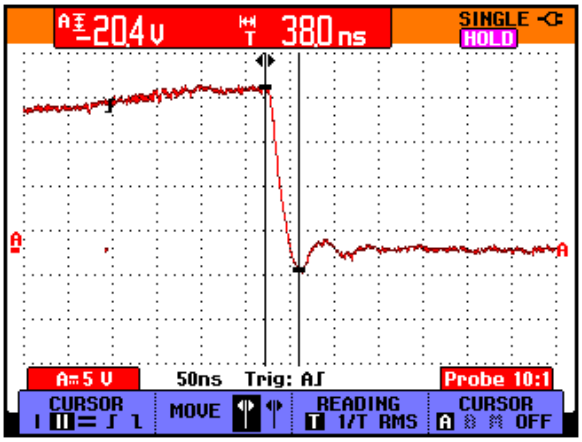
Reading 1: Shaft Voltage Reading DE
Fluke 199C Setting: 2 v/div; 500usec/div

Observations: 8 v pk – pk with numerous positive and negative voltage spikes present of 3-6 v pk indicating potential bearing currents. Highest voltage spike is 6.00 v pk.



Reading 2: Shaft Voltage Reading DE
Fluke 199C Setting: 5 v/div; 10 usec/div

Observations: Isolated a single 19.0 v pk with wave form indicating a gradual rise time and sharp trailing edge voltage drop indicative of EDM bearing current.



Reading 3: Shaft Voltage Reading DE
Fluke 199C Setting: 5 v/div; 50 nsec/div

Observations: Isolated a single 20.4 v pk with typical EDM discharge pattern. The rapid voltage discharge of 38 nano seconds is indicative of bearing oil film breakdown and voltage discharge in the motor bearing. This is a discharge frequency of 26.3 MHz.

Test Equipment used:

Fluke 199C Scopemeter
200MHz / 2.5GS/s

Fluke 10:1 200MHz probe
AEGIS SVP Shaft Voltage Probe Tip

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Test results:

System 1 Test, Shaft Voltage Measurement: #5 Return Fan; NEMA 256T Frame Baldor Super E Model EM2515T, 20 HP, ABB Drive. No shaft grounding/bearing protection installed.

Reading 1: 12 v pk – pk; max peak measured 6.88 v

Reading 2: 12.4 v pk

Reading 3: 20.4 v pk, 40 nsec discharge time (25 MHz)

Note: Wave forms in readings 2 and 3 clearly show typical EDM bearing current discharge pattern.

System 2 Test, Shaft Voltage Measurement: #6 Return Fan; NEMA 256T Frame Baldor Super E Model EM2515T, 20 HP, ABB Drive. No shaft grounding/bearing protection installed.

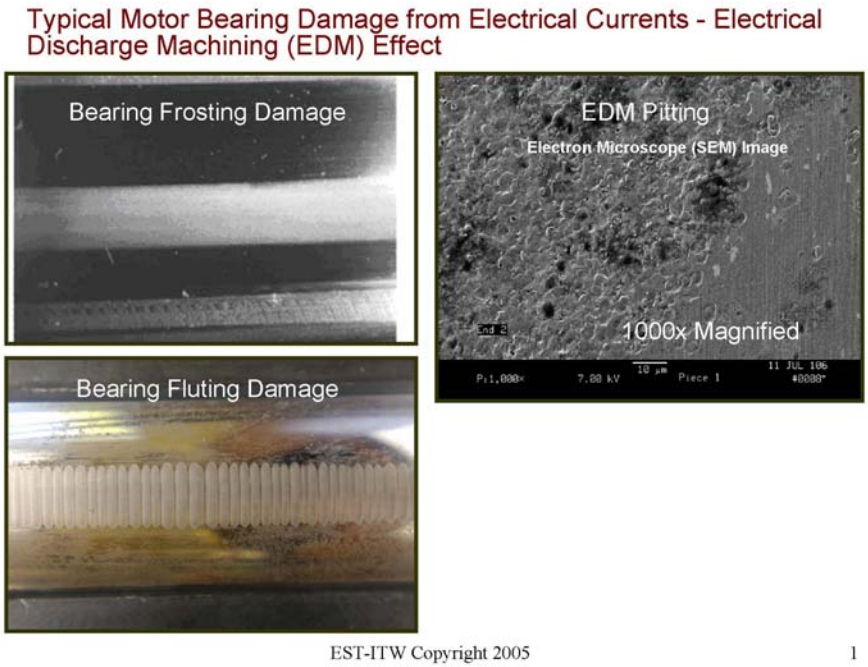
Reading 1: 8 v pk – pk; max peak measured 6.00 v

Reading 2: 19.0 v pk

Reading 3: 20.4 v pk, 38 nsec discharge time (26.3 MHz)

Note: Wave forms in readings 2 and 3 clearly show typical EDM bearing current discharge pattern.

Observation: Both #5 and #6 return fan motors exhibited extremely high audible bearing noise which is typical of fluting damage in motor bearings.



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Conclusions:

A. **System 1:** #5 Return Fan; NEMA 256T Frame Baldor Super E Model EM2515T, 20 HP, ABB Drive.

B. **System 2:** #6 Return Fan; NEMA 256T Frame Baldor Super E Model EM2515T, 20 HP, ABB Drive.

(1) Conclusions apply to both System 1 and 2 (#5 and #6 return fans) at the UW Children's Hospital.

(2) Inverter pulse width modulation (PWM) technology in variable frequency drives (VFD) will typically induce voltages on the shaft of motors they control because of the parasitic capacitance in the motor. These VFD induced shaft voltages may discharge through the motor bearings by breaking down the oil film between the rolling elements and the bearing race. This voltage discharge damages the bearing by pitting and eventual fluting in the bearing race. Virtually all VFD driven motors can be damaged in this way.

(3) Based on the voltage measurements and wave form analysis, it is clear that this bearing damage has occurred in the #5 and #6 return fans at UW Childrens.

(4) Bearing damage occurred within 2 months of operating the motors.

(5) No voltage discharge or bearing protection was installed on the motors.

(6) Bearings are in a critical failure mode.

(7) A vibration analysis further confirmed the critical damage to the return fans.

Recommendations:

1. **Shaft Grounding for VFD driven AC Motors:** All VFD driven AC motors should incorporate AEGIS shaft grounding as a standard to protect motor bearings. Voltages present on shaft will then have a discharge path to ground to prevent bearing discharges.

   (1) **System 1**: #5 Return Fan; Replace motor bearing and install AEGIS SGR conductive micro fiber Bearing Protection Ring on DE or NDE

   (2) **System 2**: #6 Return Fan; Replace motor bearing and install AEGIS SGR conductive micro fiber Bearing Protection Ring on DE or NDE

2. **AEGIS Conductive Microfiber Shaft Grounding:** Installing a ring of conductive micro fibers around the shaft provides the most effective solution for:

   (1) Voltage discharge
   (2) Reliable operation
   (3) Maintenance free operation
   (4) Longest life

3. Use an authorized AEGIS installer

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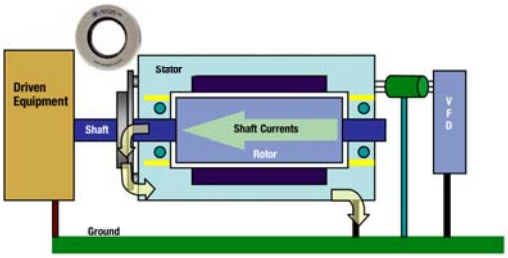
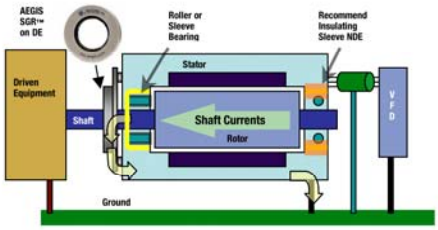
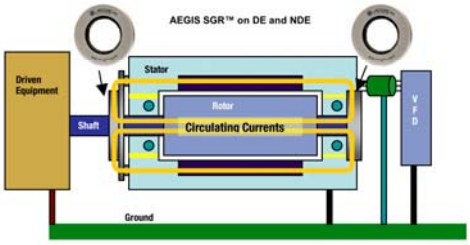
General recommendations for other applications:

Motors up to 100 HP (75kW): Install one AEGIS SGR Bearing Protection Ring on either the drive end or the non-drive end of the motor.



Motors 100 HP to 1000 HP (75 kW to 750 kW): Install AEGIS SGR on DE of motor and insulated bearing on NDE or if one bearing is not insulated then install AEGIS SGR on DE and NDE of motor.





or

Refer to application notes at www.est-aegis.com

For more information please contact:

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