31 Winterbrook Road
Mechanic Falls, ME 04256-5724
Toll free: 1-866-738-1857
Ph: 207-998-5140
Fax: 207-998-5143
sales@est-aegis.com
www.est-aegis.com

Rooftop HVAC Sustainability Test Report

Shaft Voltage Testing: Inverter Driven HVAC motors.

Application: Bearing Protection for PWM Inverter Driven AC electric motors commonly used in HVAC Systems

Purpose: Protect VFD/Inverter Driven Motors from Electrical Bearing Failure

AEGIS SGR Bearing Protection Ring

System: VFD driven Fan Motor

Application: Inverter Driven 15 HP Motor 460 v three phase

Test 1: Cold start shaft voltage – No AEGIS
1800 RPM

Test 2: Motor – No AEGIS
a. 900 RPM
b. 1800 RPM
c. 3600 RPM

Test 3: Motor with AEGIS SGR Shaft Grounding Ring Installed.
a. 900 RPM
b. 1800 RPM
c. 3600 RPM

Test Measurement Objective: Measure shaft voltage to determine induced voltage on the motor shaft which could result in electrical EDM discharges in the bearings.

VFD induced voltages are likely to cause motor bearing currents and bearing fluting failure.

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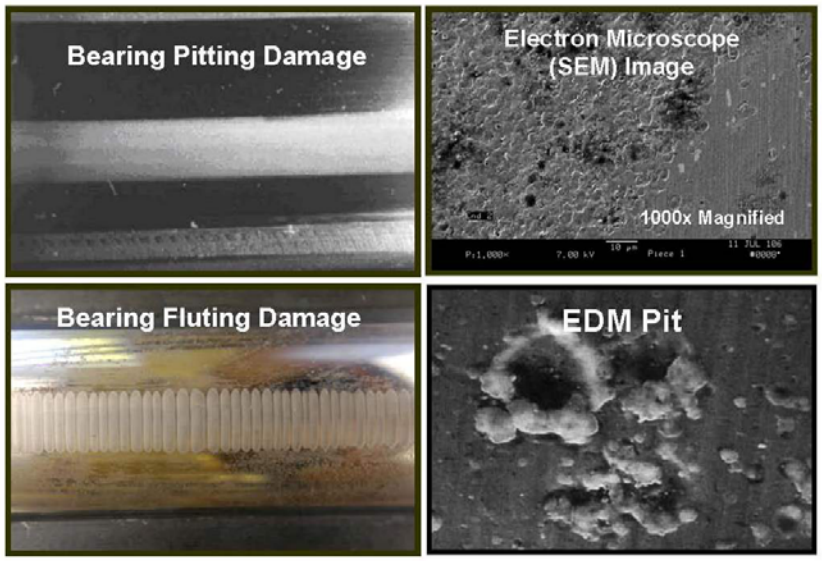
Test Equipment Used:
Fluke 199C Scope Meter
200MHz / 2.5GS/s
Fluke 10:1 200MHz probe
AEGIS SVP Shaft Voltage Probe Tip

Shaft Preparation: Cleaned paint from motor shaft surface and coated shaft with conductive colloidal silver shaft coating prior to taking voltage readings.

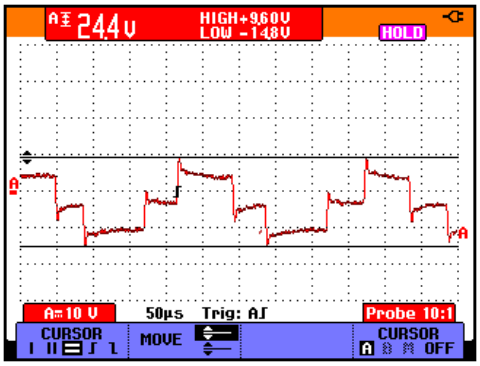
Colloidal Silver Shaft Coating: Enhances shaft surface conductivity and helps to prevent potential rust and oxidation.

Typical Motor Bearing Damage from Electrical Currents – Electrical Discharge Machining (EDM) Effect



Test 1: No AEGIS
Cold Start Shaft Voltage Reading – Motor running at 1800 RPM

Settings: 10v/div, 50 µsec/div



Cold Start:
Reading taken at initial start-up prior to bearing discharges. Common mode voltage present on shaft of motor.

Reading 1: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 50 µsec/div
24.4 v pk – pk

Observations: Typical pre-discharge common mode voltage. Six step waveform is result of VFD PWM three phase pulse algorithm capacitive voltages induced onto the motor shaft.

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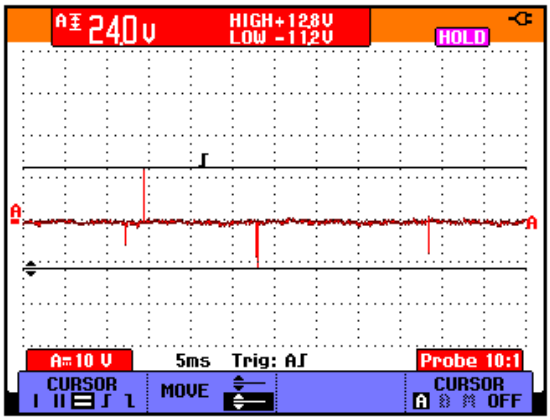
Test 2a: Shaft Voltage with NO AEGIS
Motor running at 900 RPM

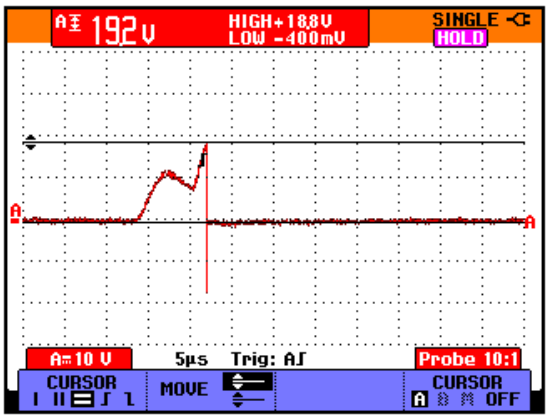


Reading 1: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 5msec/div

Observations: 24 v pk-pk.

Four distinct discharge events in 60 msec trace. Note lack of common mode square wave.

Voltage is breaking down with EDM currents discharging in bearings

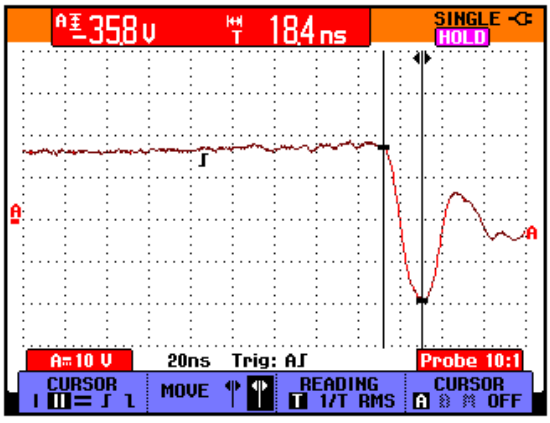


Reading 2: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 5µsec/div

Observations: Single 19.2 v pk discharge event.

Observe voltage climb until oil film breakdown occurs in bearing resulting in the sharp decline in voltage on trailing edge.

This is a typical bearing discharge voltage wave form indicating EDM in bearing.



Reading 3: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 20 nsec/div

Observations: Trailing edge of wave form; detail look at the EDM voltage discharge event.

The 35.8 v discharge occurs in a 18 nano second time frame.

This is a discharge frequency of 53 MHz.

Electro Static Technology™
An ITW Company

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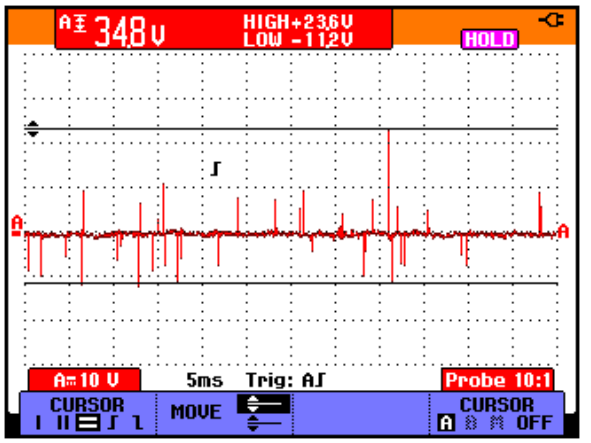
Test 2b: Shaft Voltage with NO AEGIS
Motor running at 1800 RPM



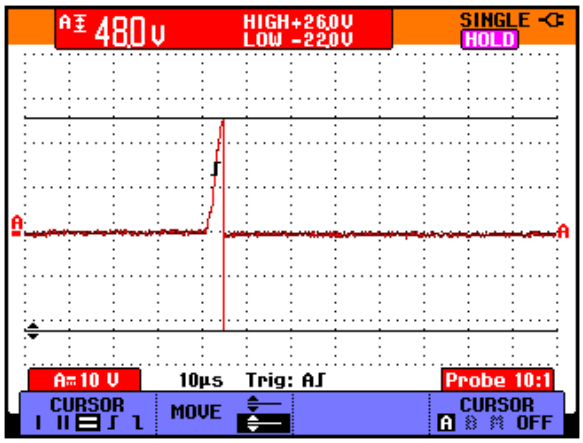
Reading 1: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 5msec/div

Observations: 34.8 v pk-pk.

30+ discharge events in 60 msec trace.

Voltage is breaking down with EDM currents discharging in bearings.

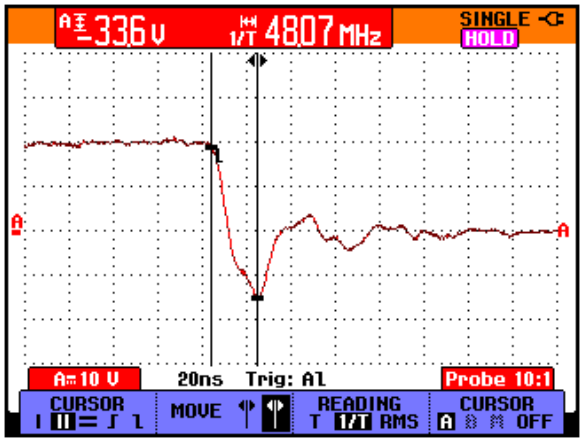
Note lack of common mode voltage square wave form.



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

Observations: Single 48 v pk – pk discharge event.

Higher voltage peak with typical discharge event on trailing edge breaking down the oil film.



Reading 3: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 20 nsec/div

Observations: Trailing edge of wave form; detail look at the EDM voltage discharge event.

The 33.6 v discharge occurs in a 20.8 nano second time frame.

This is a discharge frequency of 48.07 MHz.

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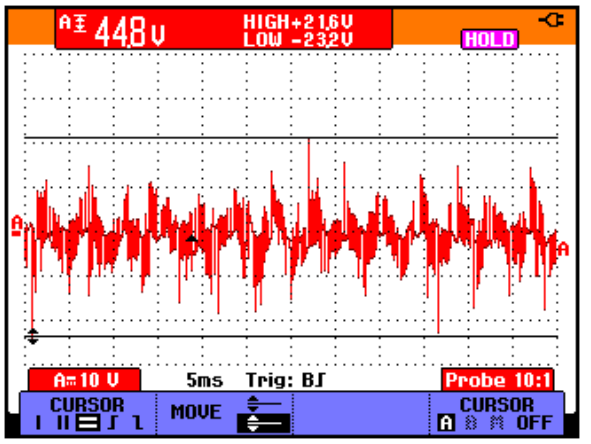
Test 2c: Shaft Voltage with NO AEGIS
Motor running at 3600 RPM



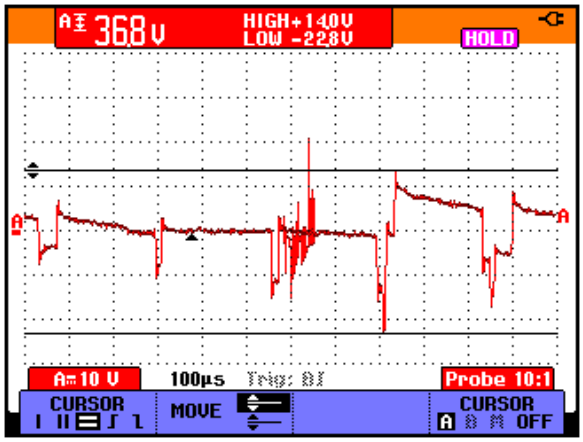
Reading 1: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 5msec/div

Observations: 44.8 v pk-pk.

Continuous discharge events in 60 msec trace.

Voltage is breaking down with EDM currents discharging in bearings.

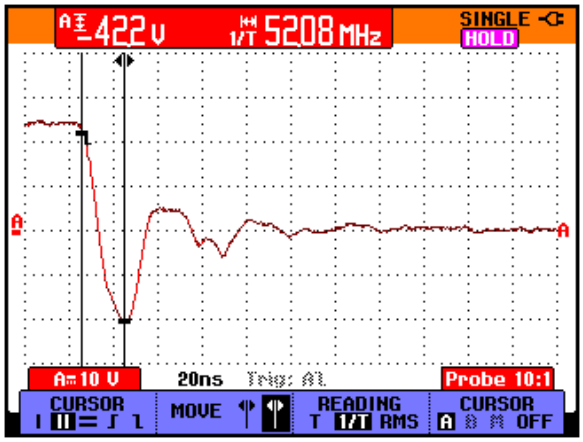
The higher speed at 80 Hz create both higher pk-pk voltage and much greater number of discharges during the same time frame.



Reading 2: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 100µsec/div

Observations: Single 36.8 v pk discharge event.

Higher voltages present with several discharge events breaking down the oil film during the 12 msec trace.



Reading 3: Shaft Voltage Reading DE
Fluke 199C Setting: 10 v/div; 20 nsec/div

Observations: Trailing edge of wave form; detail look at the EDM voltage discharge event.

The 42.2 v discharge occurs in a 19.2 nano second time frame.

This is a discharge frequency of 52.08 MHz.

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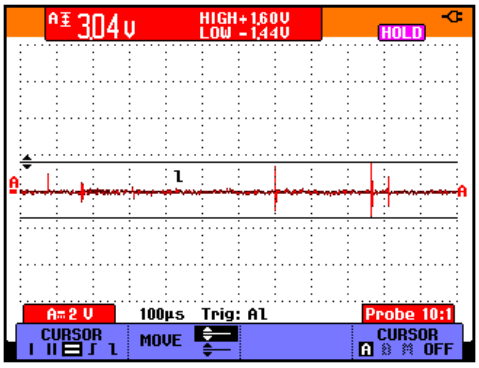
Test 3: Shaft Voltage Readings with AEGIS SGR
Motor tested at 900, 1800, and 3600 RPM

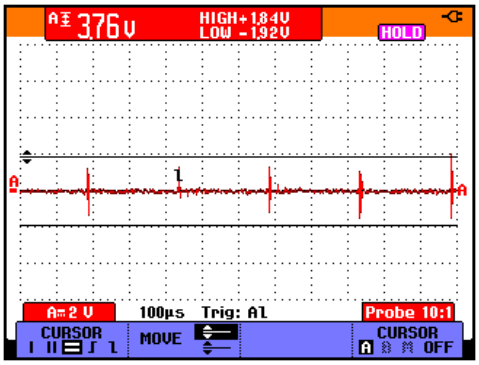


Test 3a:

Motor running at 900 RPM
Shaft Voltage Reading DE

Fluke 199C Setting: 2 v/div; 100µsec/div.

Observations: 3.04 v pk-pk. Low voltage discharges at fiber tips. No EDM in bearings.

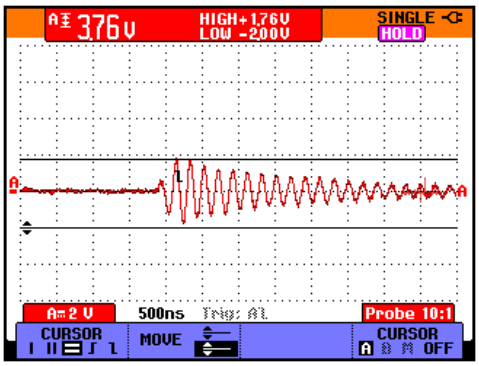


Test 3b Reading 1:

Motor running at 1800 RPM
Shaft Voltage Reading DE

Fluke 199C Setting: 2 v/div; 100µsec/div

Observations: 3.76 v pk-pk. Low voltage discharges at fiber tips. No EDM in bearings.

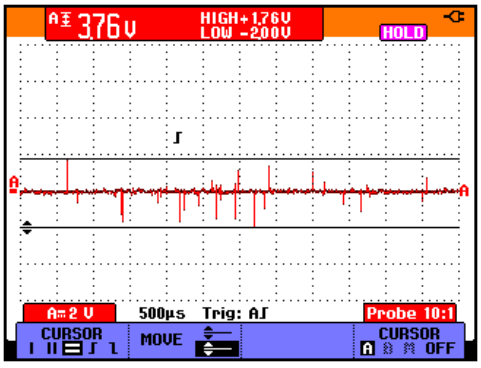


Test 3b Reading 2:

Motor running at 1800 RPM
Shaft Voltage Reading DE

Fluke 199C Setting: 2 v/div; 500µsec/div

Observations: 3.76 v pk-pk. Note ringing effect of voltage wave form. This waveform is typical of VFD ground noise. Voltage discharge takes place at fiber tips.



Test 3c:

Motor running at 3600 RPM
Shaft Voltage Reading DE

Fluke 199C Setting: 2 v/div; 500µsec/div

Observations: 3.76 v pk-pk. Low voltage discharges at fiber tips. No EDM in bearings.

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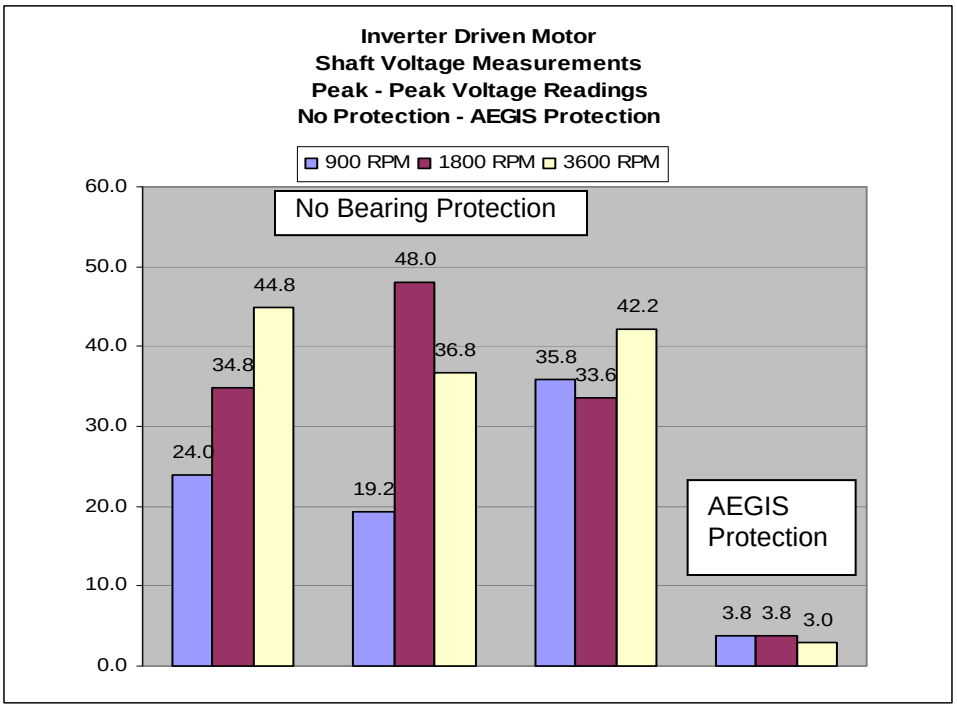
Test results:

Test 1. Cold Start Shaft Voltage Reading (No Bearing Protection): Measured 24.4 v pk-pk common mode voltage 6 step wave form. No Bearing Discharges.

Test 2. Shaft voltage testing at 900, 1800, and 3600 RPM (No Bearing Protection): EDM discharges present at all speeds within 10 minutes of motor operation. Peak to peak voltage readings ranged from 19.2 to 48.0 volts. Trailing edge discharge frequency was between 48 and 53 MHz; discharge times were 18 to 20.8 nano seconds.

Rooftop System	**No Protection**				**AEGIS SGR Bearing Protection Ring**	
15 HP VFD Driven Motor Speed	EDM Yes/No	Reading 1 long time base	Reading 2 short time base	Reading 3 discharge slope	Reading	EDM Yes/No
900 RPM	Yes	24.0	19.2	35.8	3.0	No
1800 RPM	Yes	34.8	48.0	33.6	3.8	No
3600 RPM	Yes	44.8	36.8	42.2	3.8	No

Test 3. Shaft voltage testing at 900, 1800, and 3600 RPM with AEGIS installed: Peak to Peak shaft voltage readings were between 3.0 to 3.8 volts. There were no EDM discharges. Some ground noise was present from VFD.



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Conclusions:

A. PWM inverter driven 15 HP motor on belt driven fan exhibited continuous bearing discharges within less than 30 minutes of operation from cold start. Typical EDM voltages were between 19 and 48 volts pk-pk present at 900, 1800 and 3600 RPM.

B. The same system with AEGIS Bearing Protection Ring installed eliminated EDM in bearings and reduced shaft voltages to a range of 3.0 to 3.8 v pk-pk.

Note: 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.

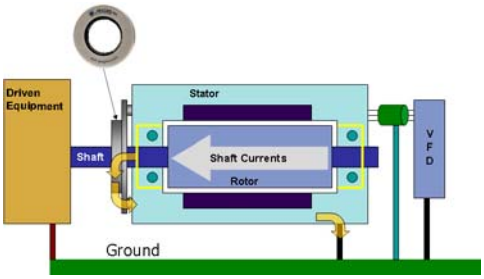
Recommendations:

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

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

   a. Voltage discharge
   b. Reliable operation
   c. Maintenance free operation
   d. Longest life

2. **Application Notes:**



Install one AEGIS SGR™ Bearing Protection Ring™ on either the drive end or the non-drive end of the motor. The simplest installation is to slide the AEGIS SGR™ over the drive end and fasten it to the motor end bell with the easy to install mounting hardware included with each AEGIS SGR™

★ Recommend Colloidal Silver Shaft Coating PN CS015

For more information please contact:

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