Bearing Protection Best Practices

AEGIS®
BEARING PROTECTION RINGS






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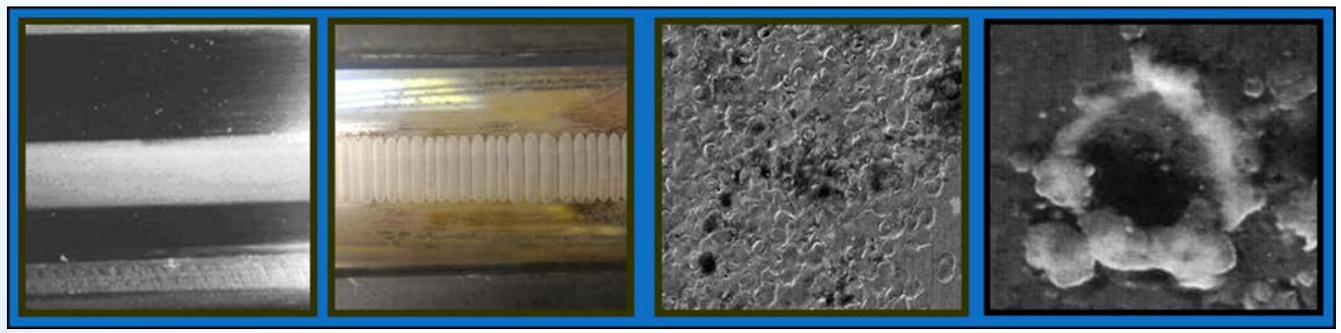
What the experts say…

- **Industry Applications, 1998, Vol. 32, No. 6:** "Pulsewidth modulation (PWM) inverters have recently been found to be a major cause of motor bearing failure in inverter-drive systems." ***Shaotang Chen, Member IEEE et. al.***
- **IEEE 2004, IAS 2004, 0-7803-8486-5/04**: "The surfaces of the bearing races of bearings with operation time greater than 500 h are melted several times at the whole surface due to small craters…..", ***A. Muetze, A.Binder, H.Vogel, J.Hering***,
- **March 2005 Journal of Electrostatics** "Statistical model of electrostatic discharge hazard in bearings of induction motor fed by inverter" ***by Adam Kempski et. al.*** "Electrical Discharge Machining (EDM) bearing currents have been found as the main cause of premature bearing damages in Pulse Width Modulation (PWM) inverter fed drives."



Bearing failures are costly…

Typical Motor Failure:	30 HP (22.5 kW)	300 HP (225 kW)	500 HP (375 kW)
Rigging/Removal and re-installation	$500	$2,000	$5,000
Motor Repair	$1,500	$8,400	$20,200
Production Downtime estimate	$5,000	$10,000	$100,000
Total cost of failed motor on production line	$7,000	$20,400	$125,200
Cost of AEGIS® installed on motor parts plus labor	$465 AEGIS® UKIT	$870 AEGIS® UKIT	$2,340 AEGIS® PROSL
Savings for preventing one motor failure	$6,535	$19,530	$121,860

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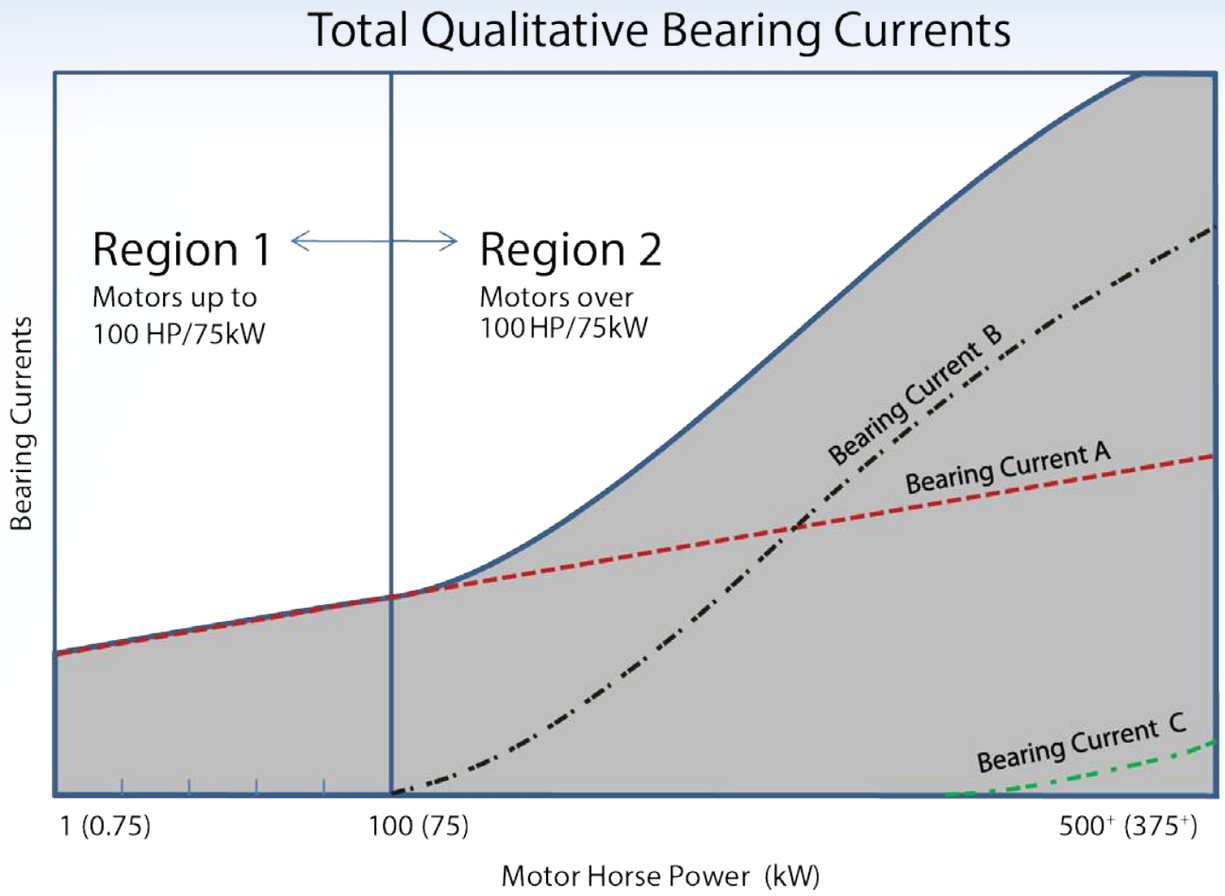
Three Sources of Bearing Currents

1. **Bearing Current A (from VFD):** Is a *capacitive induced voltage* from the pulse width switching waveform produced by the variable frequency drive (VFD).
2. **Bearing Current B (from VFD):** *High Frequency Circulating Currents* may flow due to a high-frequency flux produced by common-mode currents.
3. **Bearing Current C (from line voltage):** 50/60 Hz Sine wave voltage sources in large machines can cause *extremely low frequency circulating currents* because of the motor's asymmetrical design and magnetic asymmetries.



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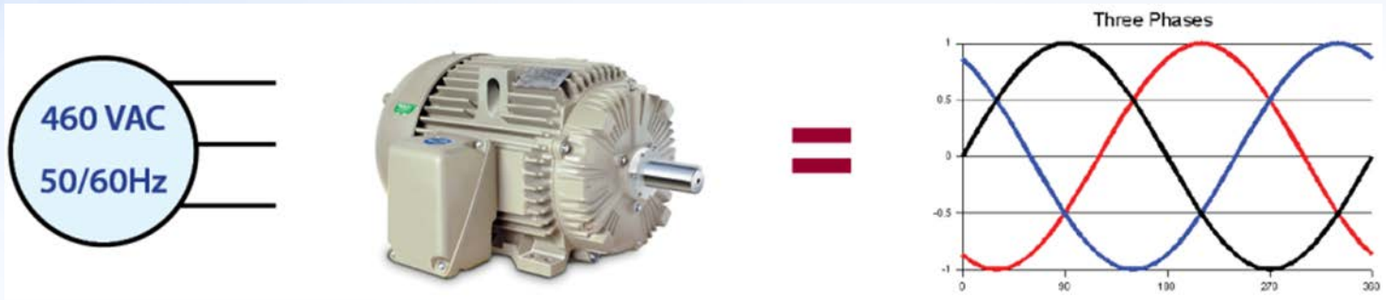
Line Voltage – Balanced Input Voltage Usually no problem for motors

Balanced voltage condition

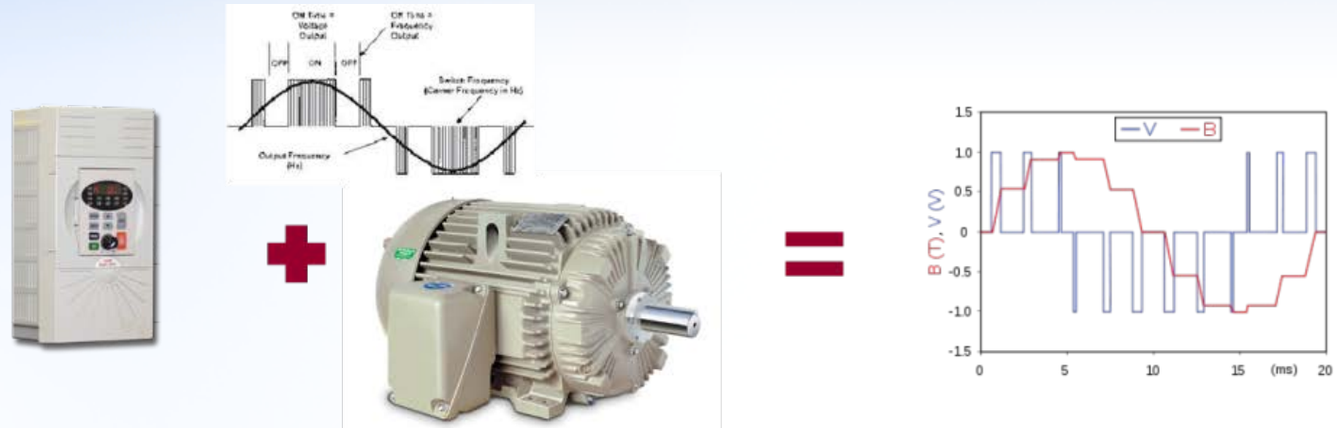


- Electric induction motors are designed for operation on 3 phase sine wave power - either 50 or 60 Hz.
- The input power is balanced in frequency, phase (120 degree phase shift) and in amplitude.
- Common mode voltage - the sum of the 3 phases always equal zero volts when properly balanced.

Note: Bearing protection generally not needed except for large frame motors.

Variable Frequency Drives
PWM Voltage - A Problem for Bearings

Unbalanced voltage condition

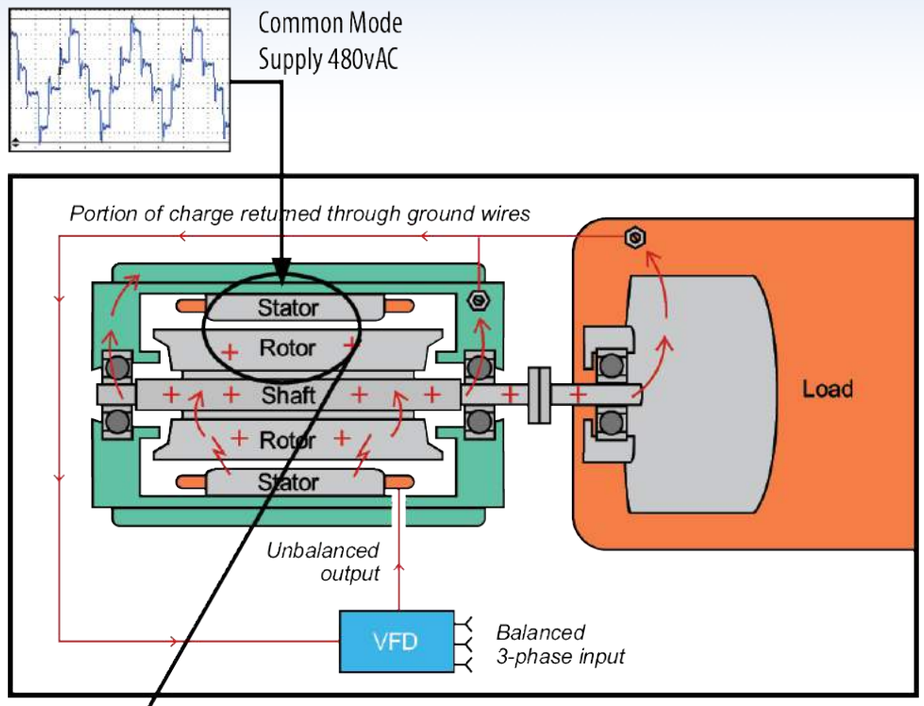


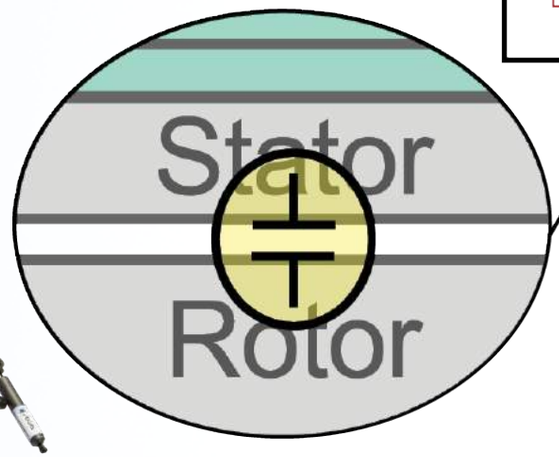
- When operated by VFD, the power to the motor is a series of positive and negative pulses instead of a smooth sine wave.
- The input voltage is never balanced because the voltage is either 0 volts, positive, or negative with rapid switching between pulses in all three phases.
- The common mode voltage is usually a “square wave” or “6 step” voltage wave form.

Bearing protection needed to mitigate electrical discharge machining (EDM) damage in bearings.

An Electric Motor works like a Capacitor (Bearing Current A)

- The pulses to the motor from the VFD create a capacitively coupled common mode voltage on the motors shaft.
- Voltages are measurable with AEGIS® Shaft Voltage Tester™ and specially designed shaft voltage probe tips that can contact a spinning shaft.





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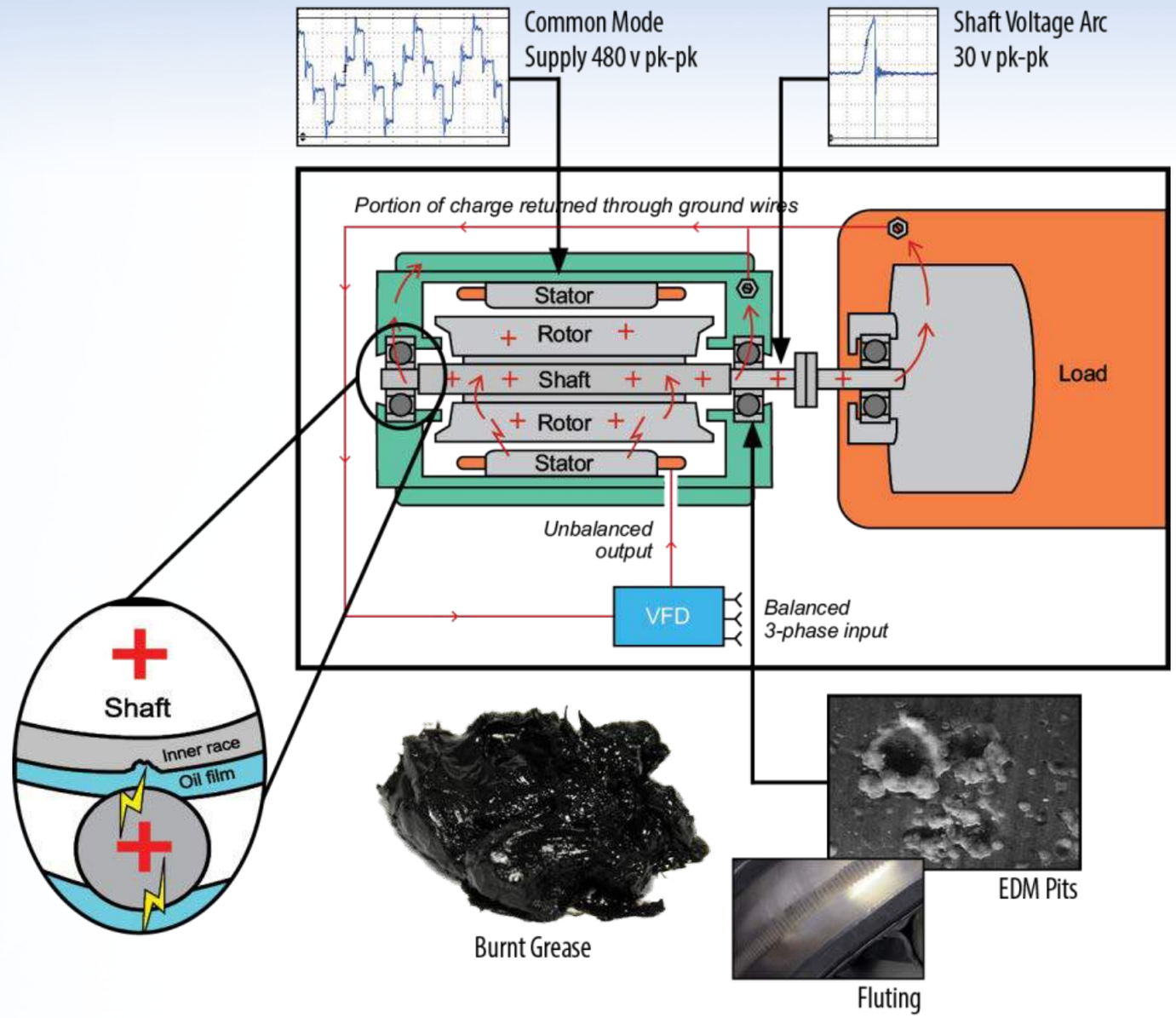
Voltage Arcs through the Bearing

- Electrical discharge machining (EDM) creates thousands of pits
- Bearings degrade, resulting in increased friction and noise
- Eventually, the rolling elements can cause fluting damage to the bearing races
- Bearing lubrication/grease deteriorates/burnt
- Potential for costly unplanned downtime



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Testing for Shaft Voltages

- AEGIS-OSC-9100 Shaft Voltage Tester™ Digital Oscilloscope with 100MHz bandwidth
- AEGIS® Shaft Voltage Probe™ Tips contact the spinning shaft.
- Magnetic base and Probe holder.

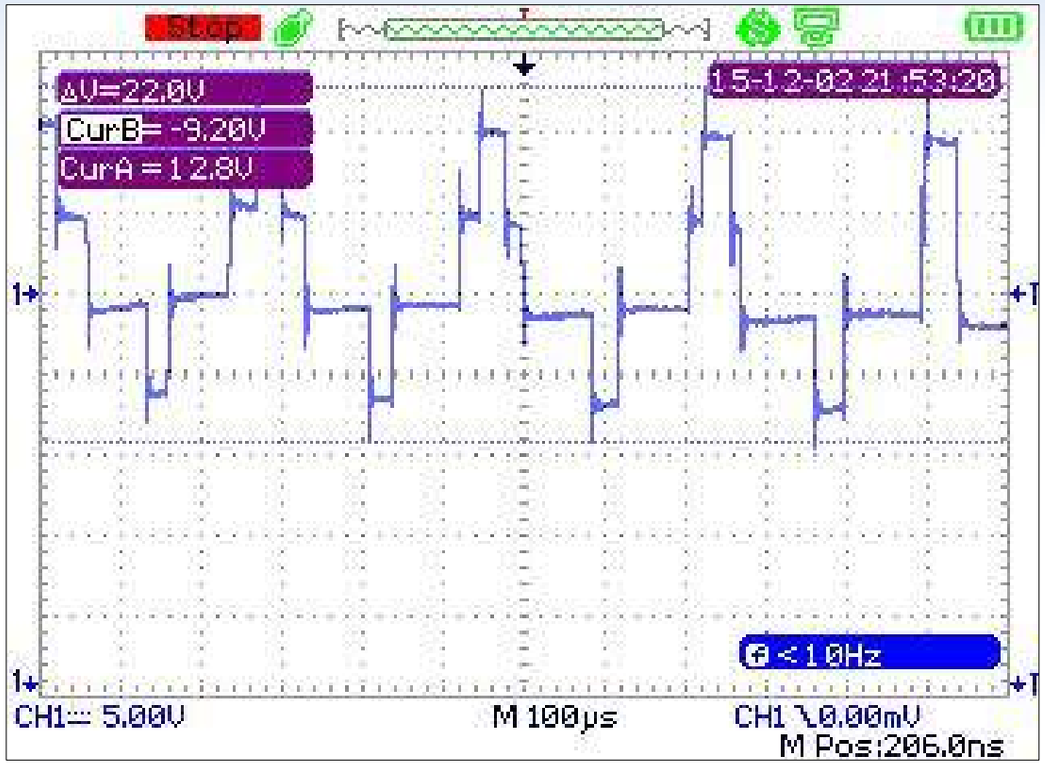
Examples of Shaft Voltage Readings

- Because of the high-speed switching frequencies in PWM inverters, variable frequency drives induce shaft currents in AC motors.

- The switching frequencies of insulated-gate bipolar transistors (IGBT) used in these drives produce voltages on the motor shaft during normal operation through parasitic capacitance between the stator and rotor.

- These voltages, which can register 10-40 volts peak, are easily measured by touching an oscilloscope probe to the shaft while the motor is running.

Reference: NEMA MG1 Section 31.4.4.3



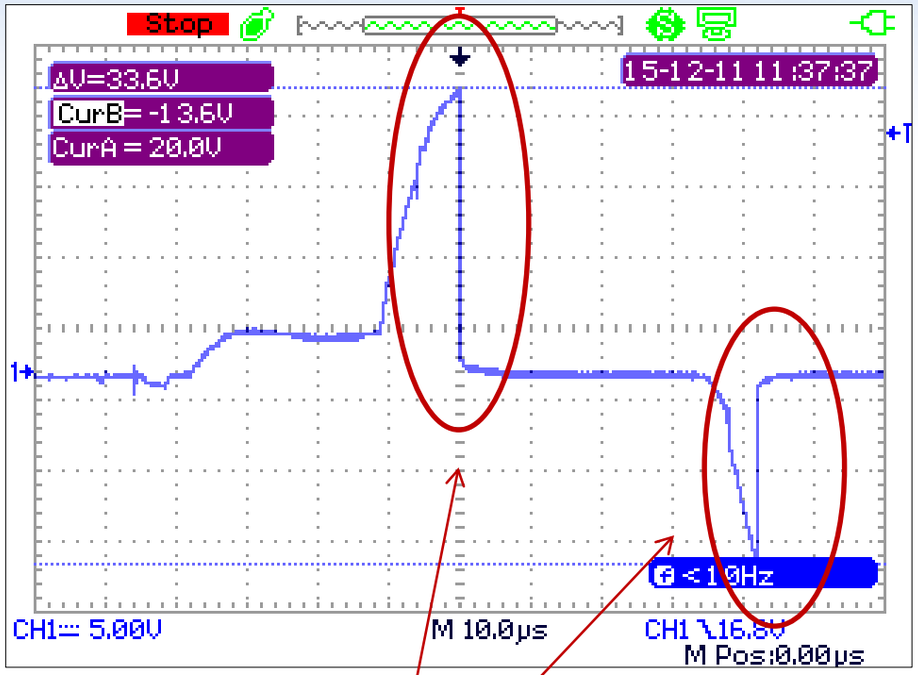
Common Mode Voltage “Six Step” Wave Form

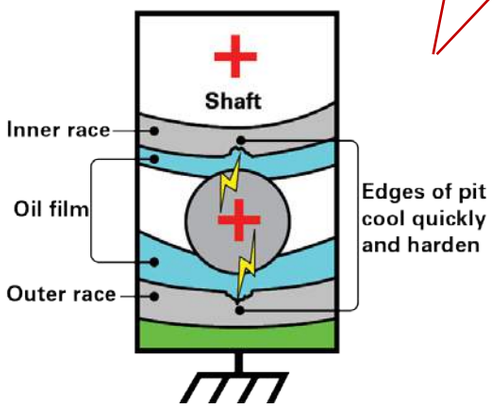
Electrical Discharge Machining (EDM) Wave Form

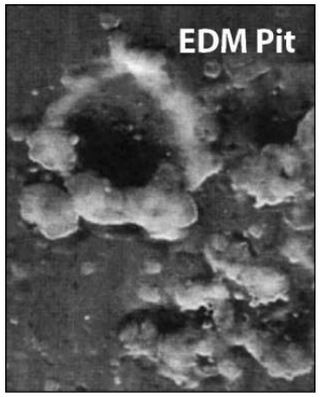
High Peak to Peak common mode voltage discharges

Typically 20 to 120 volts peak to peak. The sharp trailing edge is typical of an EDM pit created in the bearing race.

When the high speed oscilloscope is set up to capture the discharge wave form, one can see the common mode voltage increasing normally and then when the discharge threshold is reached, the high frequency discharge occurs as the current “arcs” through the bearing to ground.







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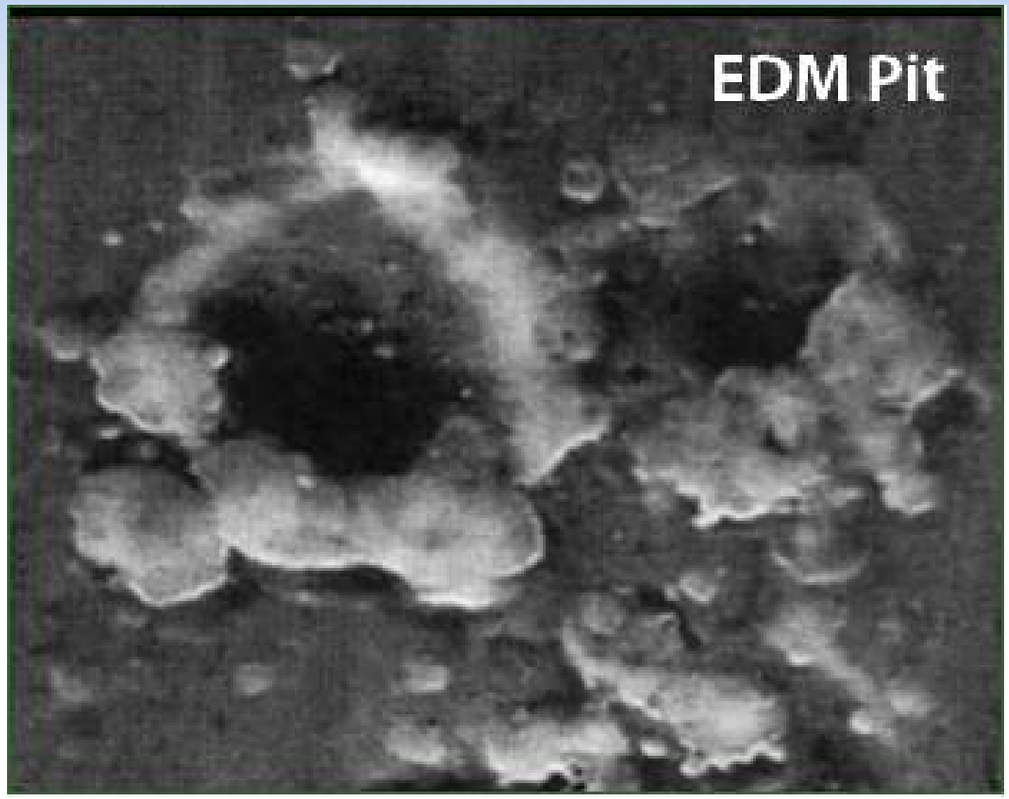
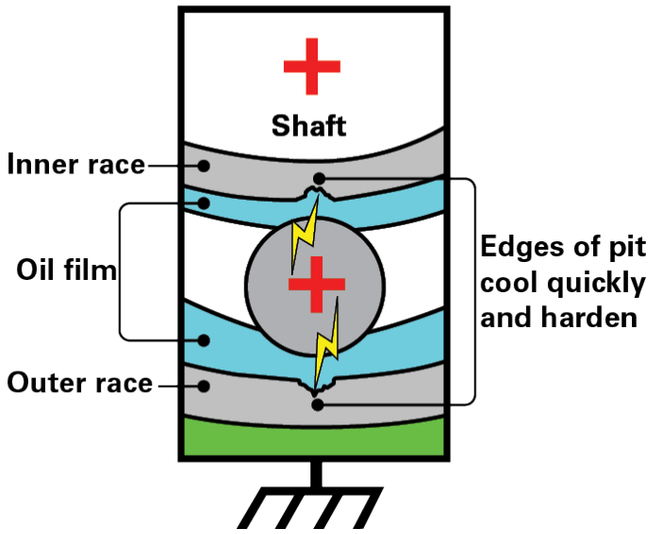
EDM Pit in the Motor's Bearing Race

- These voltages reach a level sufficient to overcome the dielectric properties of the bearing grease, they discharge along the path of least resistance — typically the motor bearings — to the motor housing.
- When this event happens, temperatures are hot enough to melt bearing steel and severely damage the bearing lubrication.
- During virtually every VFD switching cycle, induced shaft voltage discharges from the motor shaft to the frame via the bearings, leaving a small fusion crater (fret) in the bearing race.





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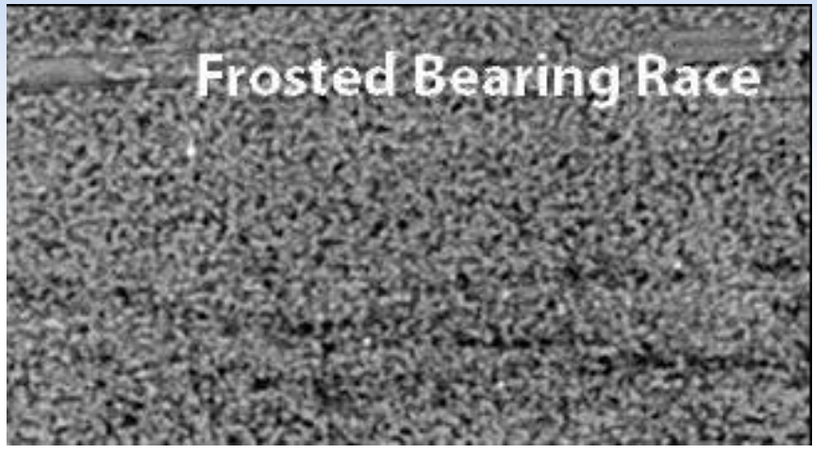
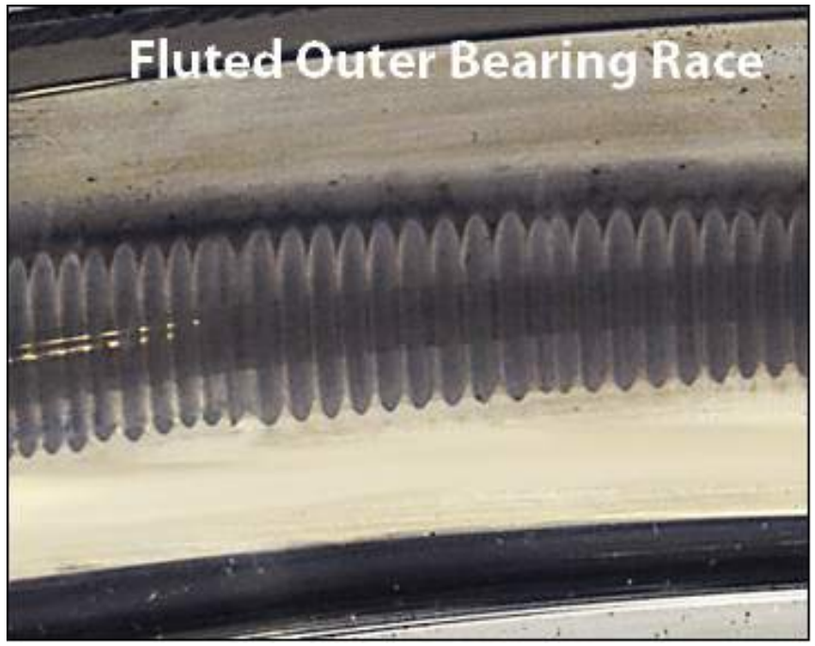
Frosting and Fluting in Bearing Race

- These discharges are so frequent (millions per hour) that before long the entire bearing race becomes marked with countless pits known as frosting.
- A phenomenon known as fluting may occur as well, producing washboard-like ridges across the frosted bearing race.
- Fluting causes excessive noise and vibration and in heating, ventilation, and air-conditioning systems, it is magnified and transmitted by the ducting.



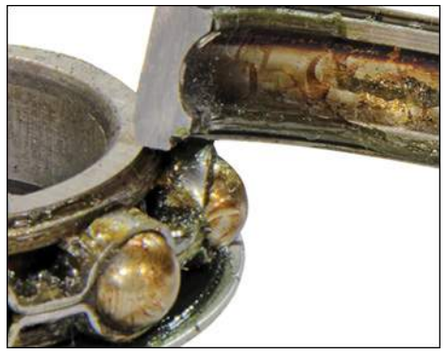


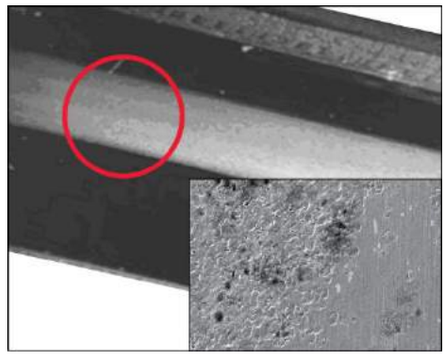
When Bearings Fail, Cut and Inspect

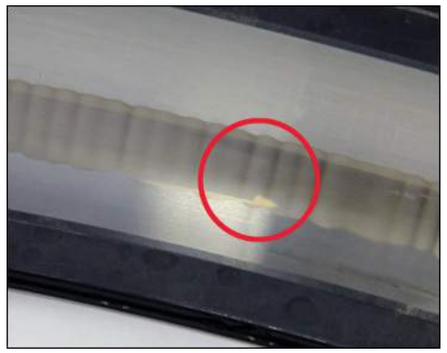
ANSI/EASA Standard AR100-2015, Section 2, Mechanical Repair: *2.2 Bearings*

"Bearings should be inspected for failure modes such as spalling, contamination, fretting, fluting, and scoring."

- Burnt bearing grease is blackened and often times contaminated with metal particles. Compare to new bearing grease - is available in many colors.
- Look for evidence of Electrical Discharge Machining (EDM) in the bearing race and ball
- EDM are millions of microscopic electrical pits created when current discharges through the motor's bearings. The individual pit is usually between 5 and 10 micron diameter.







Bearing Failure – A problem Worth Solving

- Regardless of the type of bearing or race damage that occurs, the resulting motor failure often costs many thousands or even tens of thousands of dollars in downtime and lost production.
- Failure rates vary widely depending on many factors, but evidence suggests that a significant portion of failures occur only 3 to 12 months after system startup.
- Because many of today's AC motors have sealed bearings to keep out dirt and other contaminants, electrical damage has become the most common cause of bearing failure in AC motors with VFDs.

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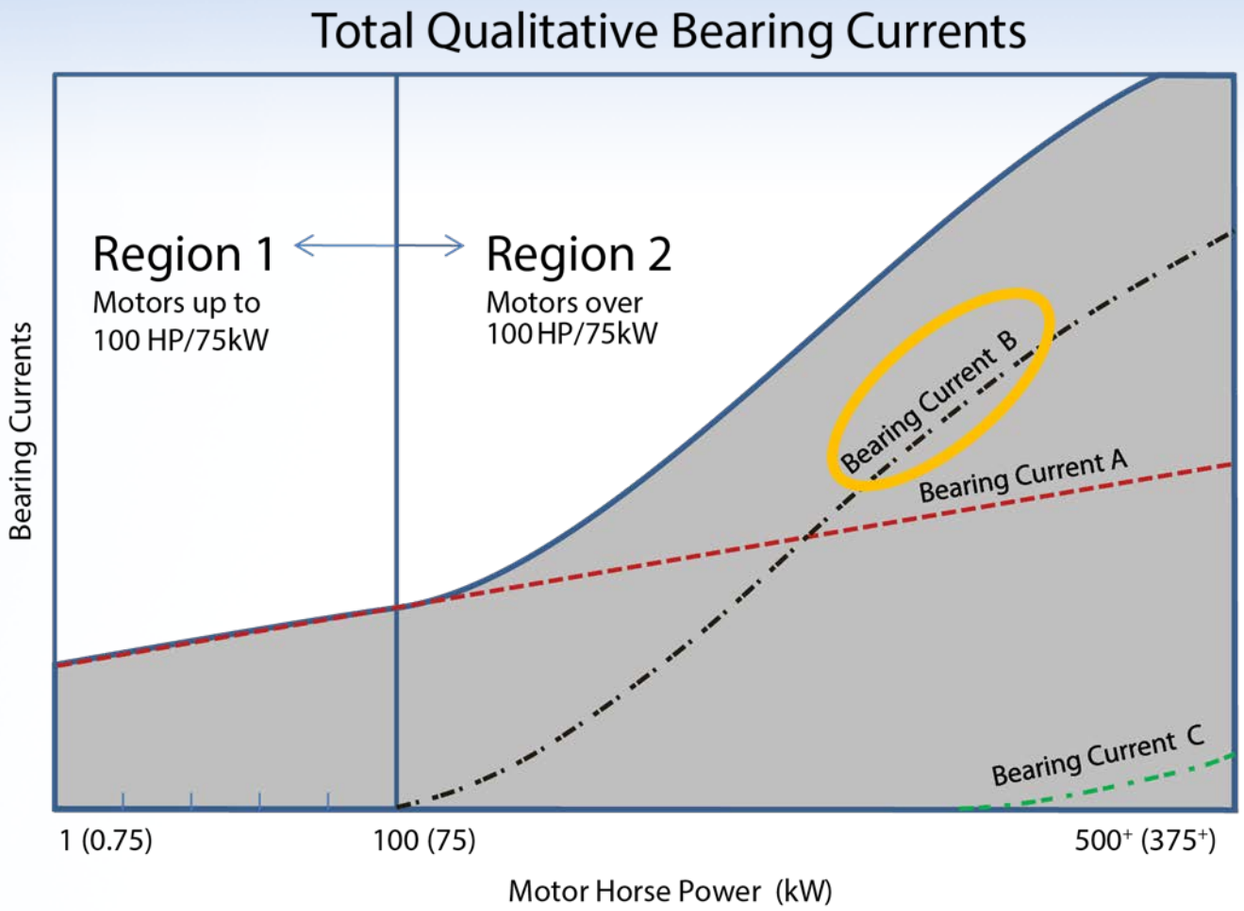
High Frequency Circulating Currents (Bearing Current “B”) in Larger Motors

- High frequency circulating currents may flow due to a high-frequency flux produced by common-mode currents in KHz or MHz frequencies.
- Usually present in motors above 100 HP (75kW).
- Circulate through the motor bearings, shaft to frame



Best Practice: Install AEGIS® Ring for Current A (capacitively induced shaft voltage) on one end and interrupt the high frequency circulating current in the bearing (Current B) by insulating the opposite end.

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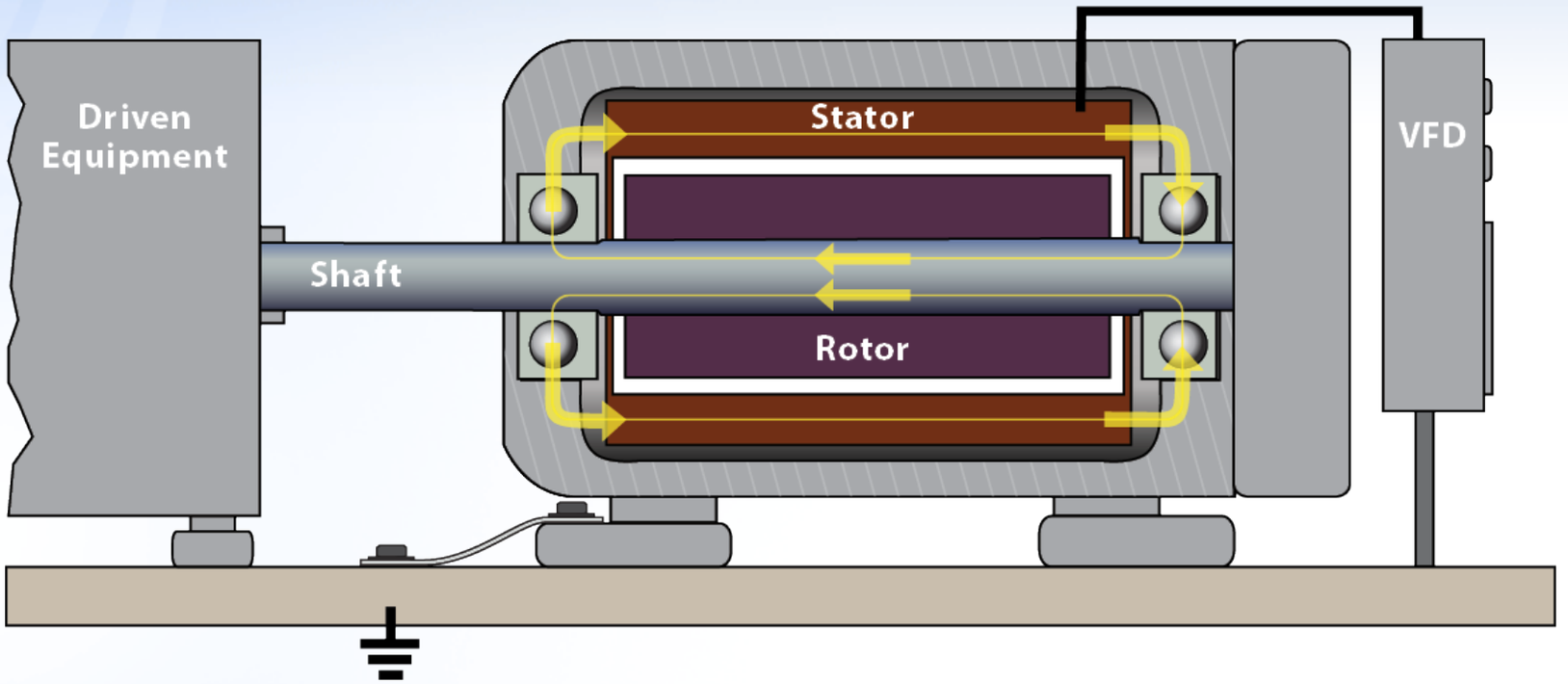
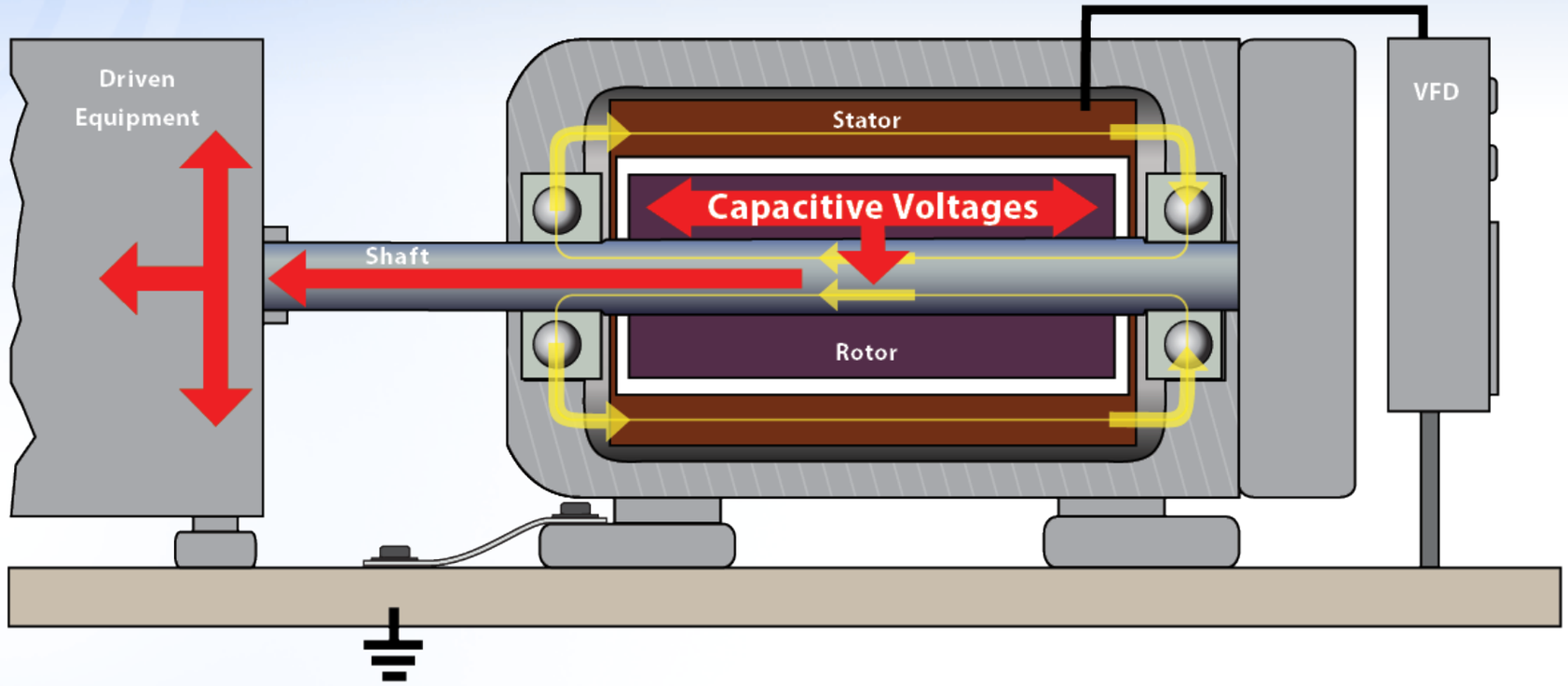
High Frequency Circulating Currents (Bearing Current “B”)



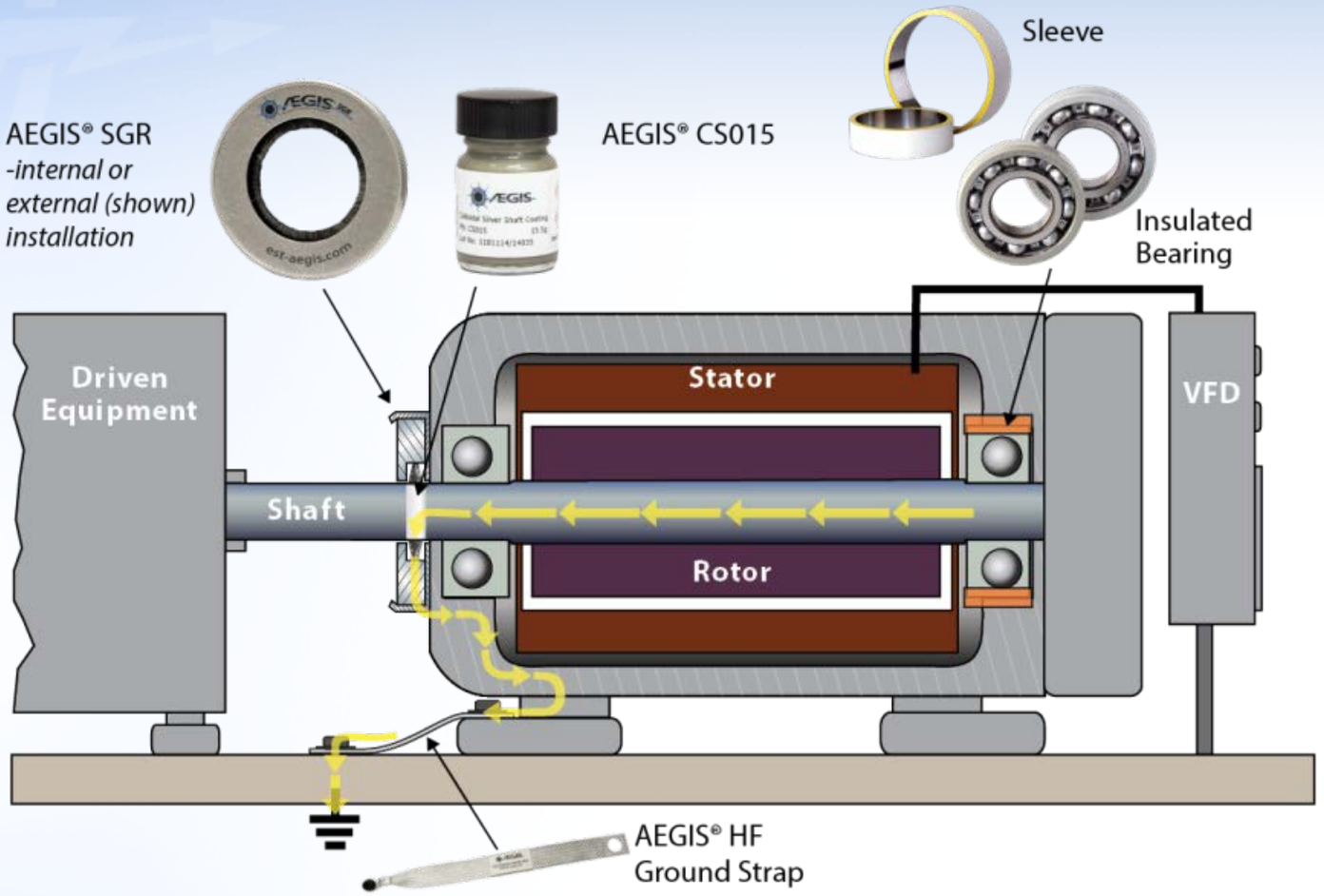
Induced by the magnetic flux imbalance around the motor shaft from the stator windings, these currents circulate through the motor bearings. High Frequency Circulating Currents (HFCC) are a problem in large AC motors of over 100 hp (75kW).

Voltage Discharges in Attached Equipment and Gear Boxes Currents A and B



Along with the High Frequency Circulating Currents you will also have Bearing Current “A” which can travel down the shaft to attached equipment. Therefore it is important when considering HFCC to also mitigate Bearing Current “A” with the AEGIS® Shaft Grounding Ring to divert the voltages away from the drive end motor bearing and/or the attached equipment to ground.

Best Practice to Protect from Both Bearing Currents A and B



Install an AEGIS® Bearing Protection Ring on the drive end (DE) of the motor for bearing current “A” and stop the high frequency circulating currents by insulating the non-drive end (NDE) bearing of the motor to prevent bearing current B. This practice will protect both the motor’s DE bearing and the attached equipment.

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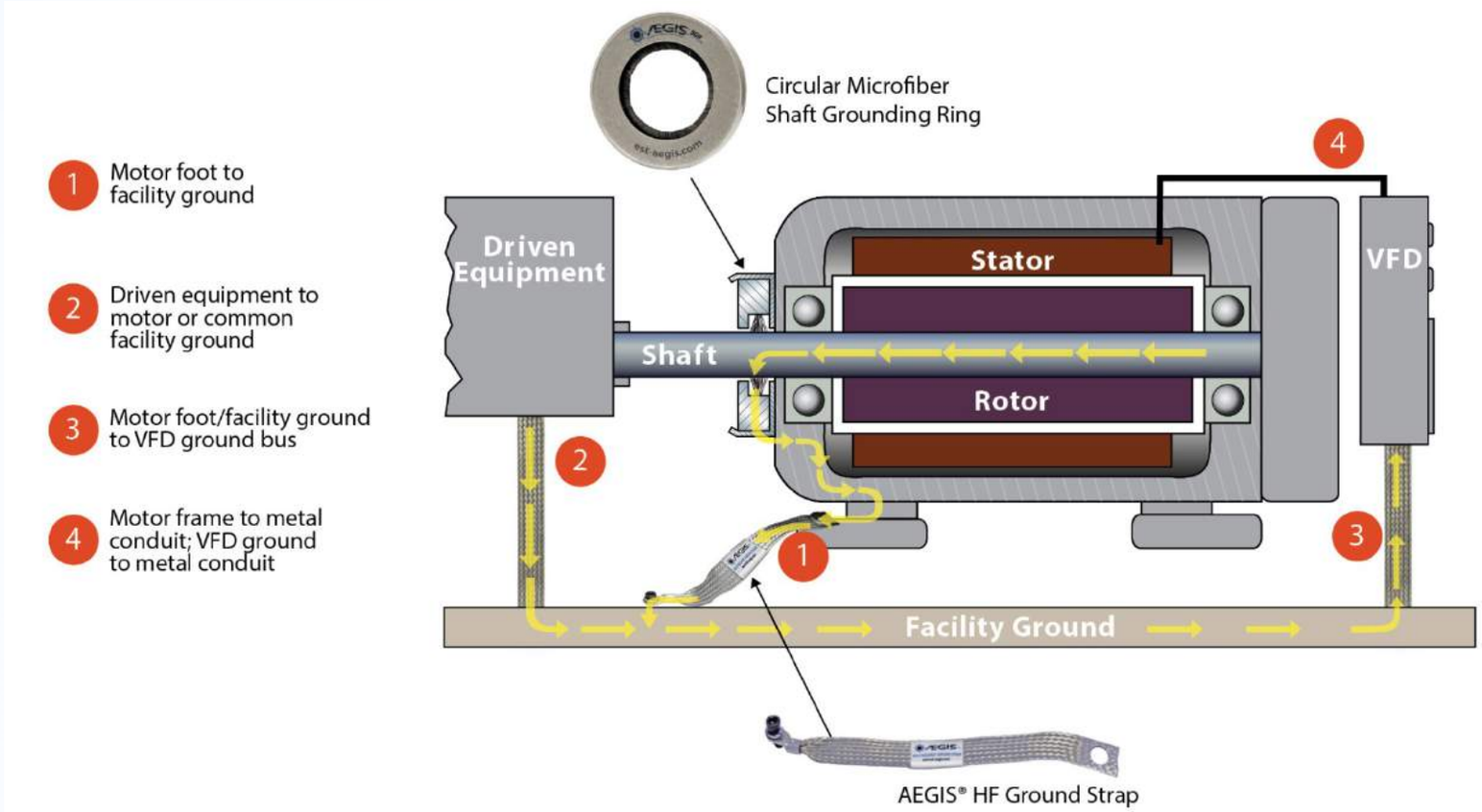
High Frequency Ground Path from Motor

- While the AEGIS® Ring conducts harmful shaft voltages away from the bearings to the motor's frame, it is advisable to also ensure a low impedance path to earth ground.
- Recommended by motor and drive manufacturers, this high frequency grounding path is best accomplished with a braided strap from the motor to ground.
- The AEGIS® HFGS (High-Frequency Ground Strap) is a braided cable used to lower the impedance between the motor's frame and earth ground. Secure one end to motor and the other end to earth ground and from there back to the VFD.



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Best Practices by Motor and Drive Manufacturers

What the experts say…

ABB Technical Guide No. 5

"Add high frequency bonding connections between the installations and known earth reference points to equalize the potential of affected items, using braided straps of copper…"
"This must be made at the points where discontinuity between the earth level of the inverter and that of the motor is suspected. Additionally it may be necessary to equalize the potential between the frames of the motor and the driven machinery to short the current path through the motor and the driven machine bearings."

Allen Bradley Publication 1770-4.1, Application Data, Industrial Automation Wiring and Grounding Guidelines.

"In addition to making good connections through each bolt or stud, use either 1-inch copper braid... to connect each chassis, enclosure and central ground bus mounted on the back-panel."

Nidec Motor Corporation Technical White Paper: Increased Reports of Bearing Damage in AC Motors Operating from Modern PWM VFD's.

"One approach that simplifies the solution is to utilize the following components: Proper grounding connection points, proper grounding cables and bonding straps for high frequency conditions and proper termination devices for high frequencies…"

Best Practices by Motor and Drive Manufacturers

What the experts say…

Danfoss Engineering Guide – HVAC & Refrigeration applications – Facility services design and project engineering of electrical drives

"A large conductor surface area for draining high-frequency currents can be obtained by using fine stranded wire, such as … using special earthing straps or cables. "
"Braided earthing straps are often used nowadays in practice… "
"Note: System earthing has a substantial effect on smooth, trouble-free facility operation. Ground loops must be avoided. Good potential equalization is essential."

Baldor INDUSTRY WHITE PAPER Inverter-Driven Induction Motors Shaft and Bearing Current Solutions

"Proper grounding of the motor frame is also important. … ground straps should also be connected between the motor frame and the driven load equipment frame to allow a low impedance, alternate path for shaft currents."
"High frequency ground strap impedance is lowest for straps with fine conductors and the largest width to length ratio."
"In all cases, ground straps should be connected directly metal to metal (not through a painted surface) to provide the lowest impedance path for high frequency currents."

AEGIS® Bearing Protection Rings

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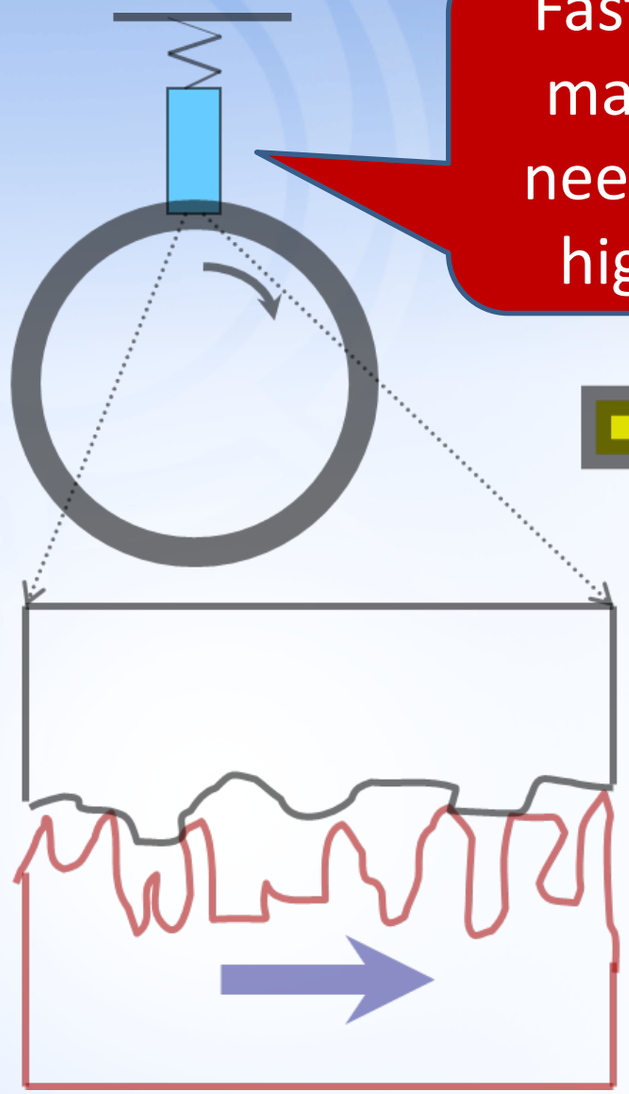
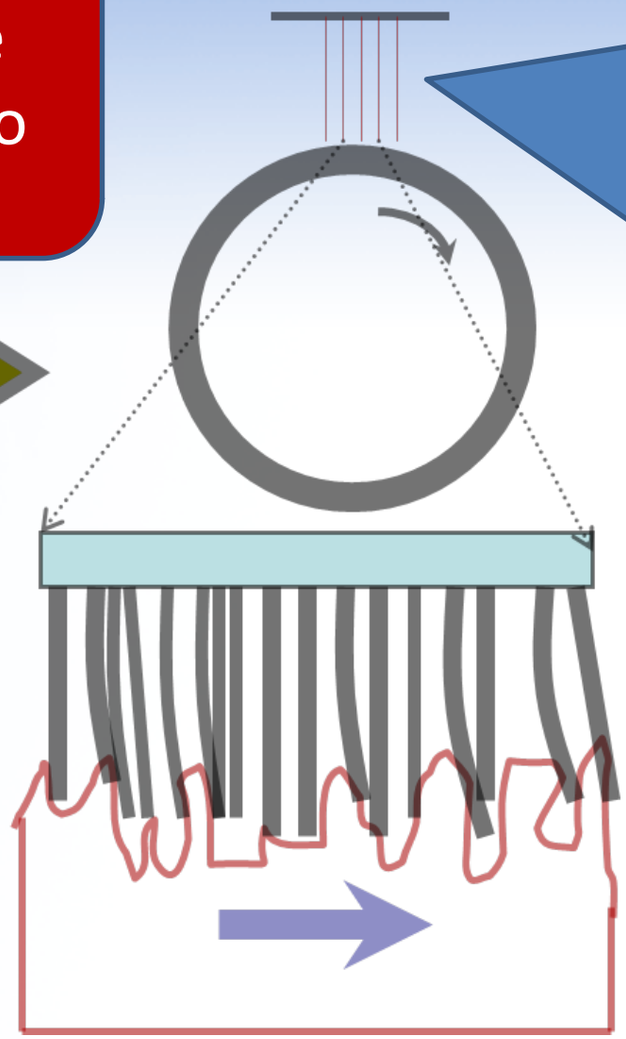
Spring Energized Brush

AEGIS® Conductive Micro Fiber

Fast wear and maintenance needed due to high friction





Virtually zero friction and wear. Uses proprietary “nanogap” conductive micro fiber non-contact and contact technology for 100% electrical shaft grounding

Conventional “Single Point” contact with carbon block – Designed for DC current

AEGIS 100% circumferential Microfiber Contact / Non Contact – Designed for high frequency VFD voltages 10 KHz to 100 MHz

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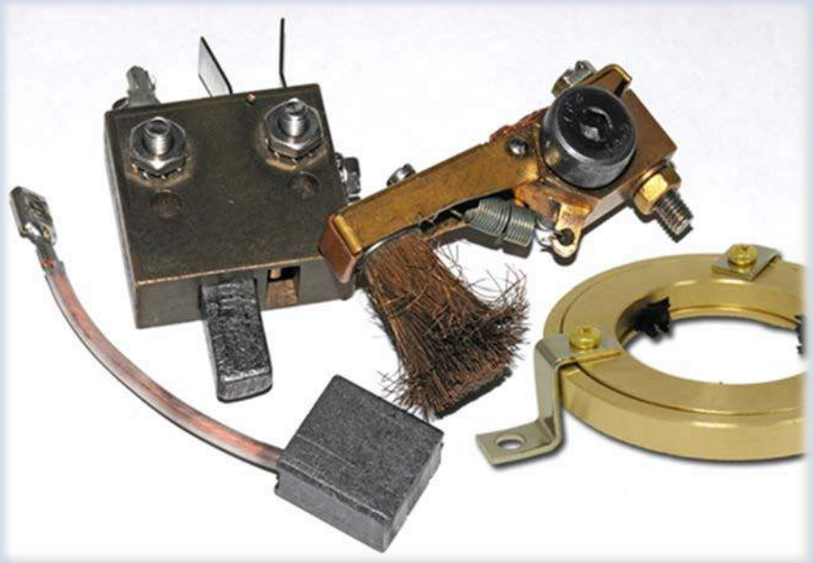
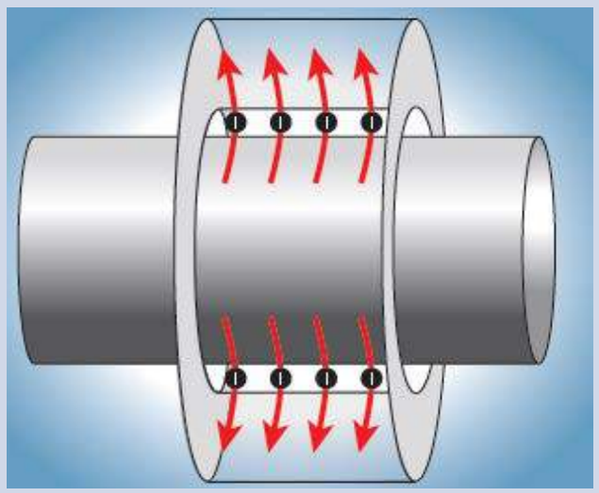
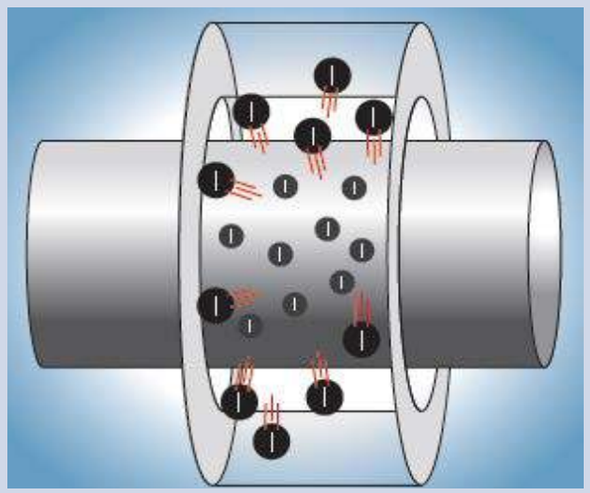
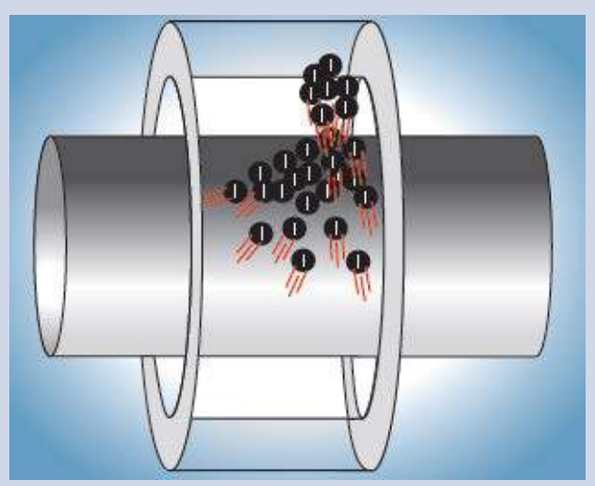
Design Difference

100%	Only 4%
• Full 360º degrees around shaft • Designed for VFD currents • Larger Shaft = more current capability • Contact and Nanogap Contact	• Limited shaft coverage • Small contact area • Friction contact only • Wear and replacement • Not suitable for VFD currents
	

Patented AEGIS® NanoGap Contact Technology

Tunneling of Electrons when Fibers are <2nm	Field Emissions of Electrons when Fibers are 2nm -5um	Townsend Avalanche of Gaseous Ions when Fibers are >5um
		

“NanoGap Electron Transfer”

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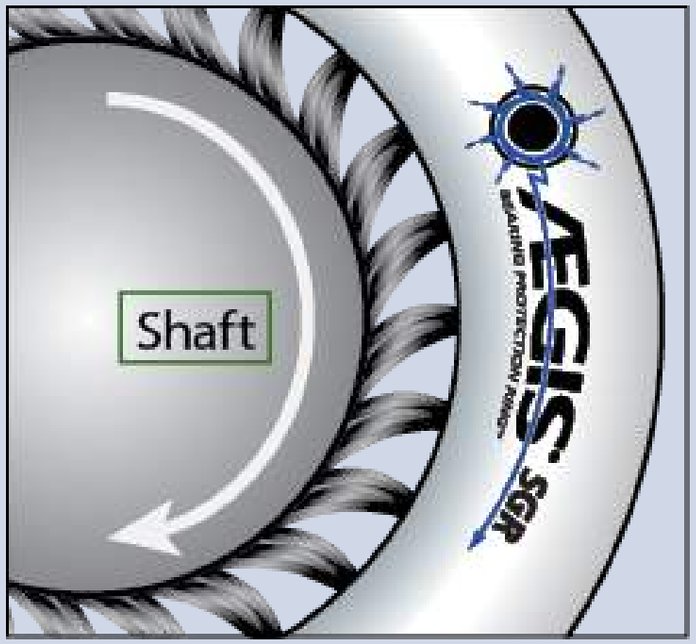
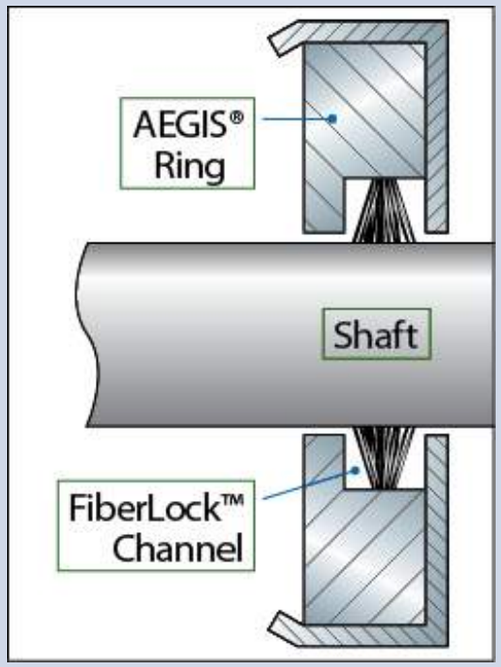
Patented AEGIS® Ring Design

Specially Designed Microfibers Flex Without Breaking – Ultra Low Friction	Patented FiberLock™ Channel Secures and Protects Fibers
	

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2007 IEEE Award – First Prize

2007 First Prize Paper Award

Design Aspects of Conductive Microfiber Rings for Shaft Grounding Purposes

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IEEE

The Industrial Drives Committee
of the
IEEE Industry Applications Society
takes pleasure in presenting the
2007 First Prize Paper Award
to
William Oh

For the manuscript co-authored with Annette Muetze entitled,
"Design Aspects of Conductive Microfiber Rings for Shaft Grounding Purposes"
as presented at the 2007 IEEE Industry Applications Society Annual Conference.

October 2008

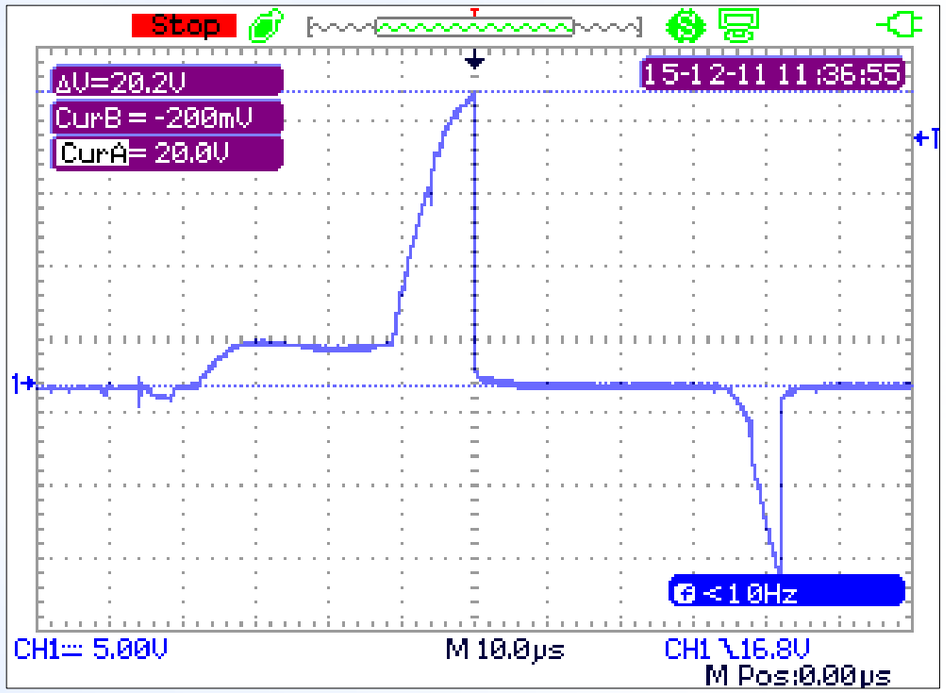
S. Mark Halpin
President
IEEE Industry Applications Society

J.O. Ojo
Vice-Chair, Paper Reviews, IEEE Industry Applications Society
Industrial Drives Committee

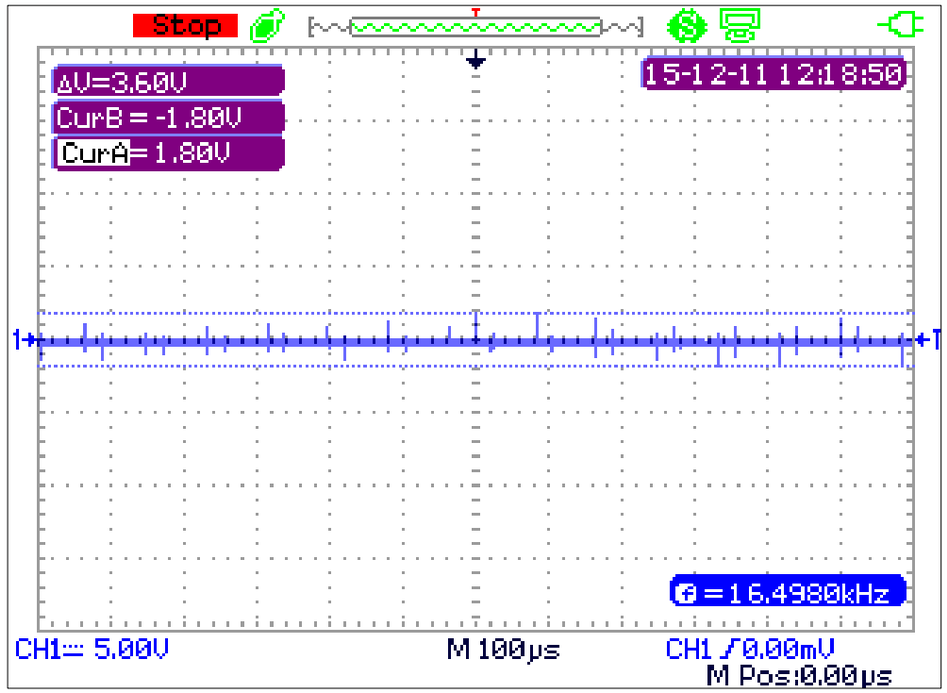
William Oh and Dr. Annette Muetze receive 2007 First Prize Paper Award at IEEE Conference for Scientific Paper on AEGIS Bearing Protection Ring Technology

Before & After

SHAFT VOLTAGE READING WITHOUT AEGIS® RINGS



SHAFT VOLTAGE READING WITH AEGIS® RINGS INSTALLED



PROBLEM

SOLUTION

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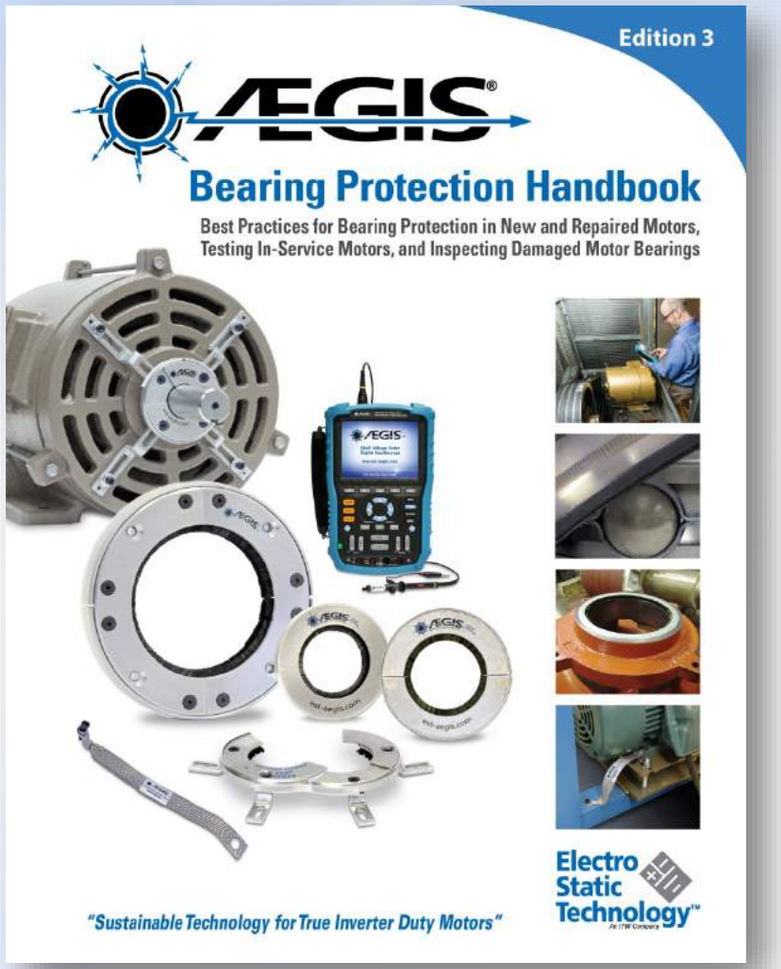
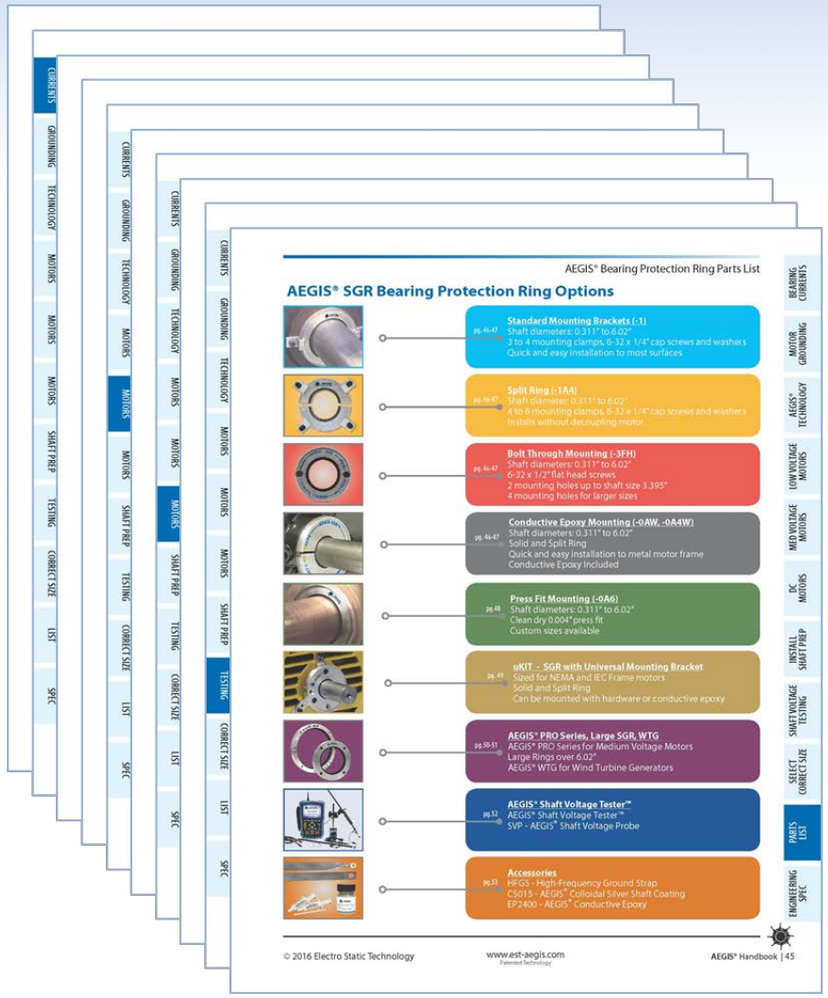
AEGIS® Bearing Protection Handbook





Download at www.est-aegis.com

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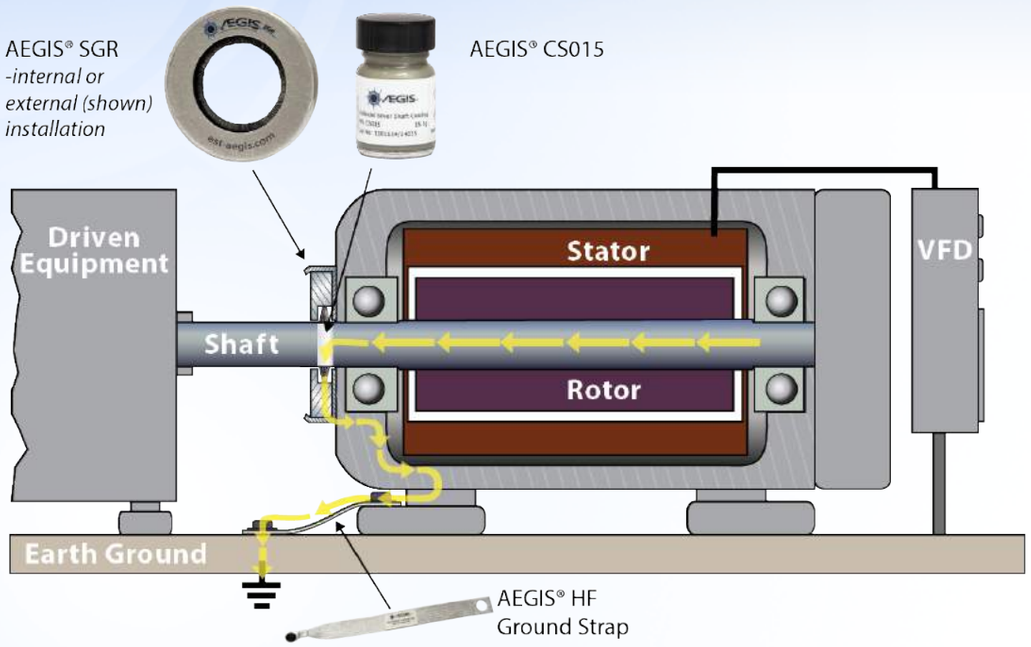
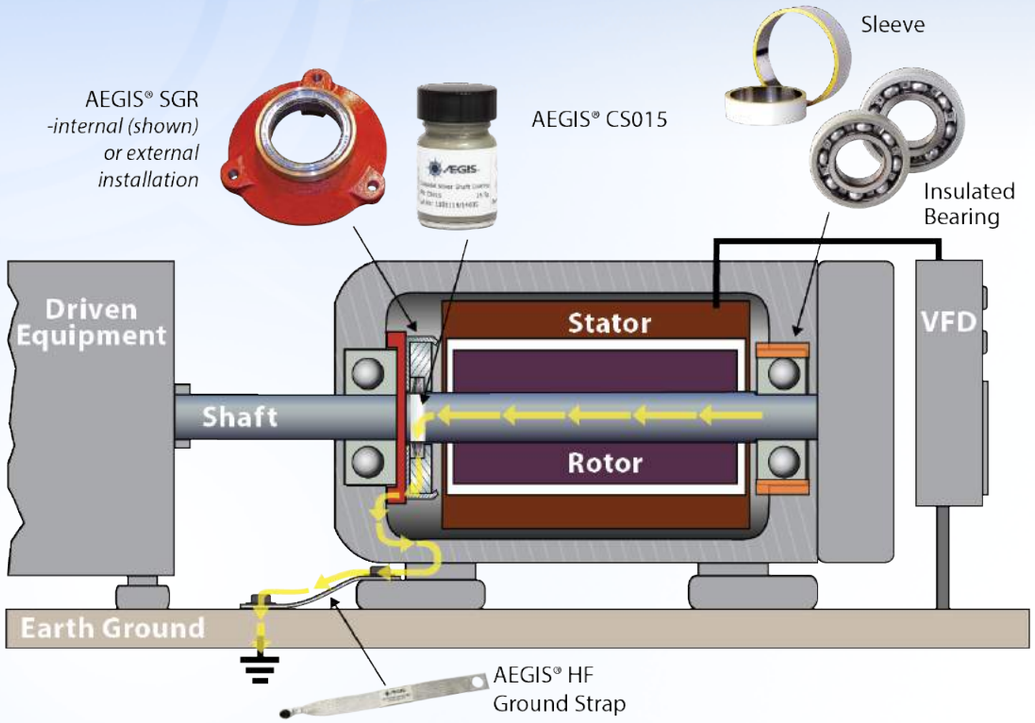
Motors up to and including 100 HP (75 kW) - *Low Voltage*



- Foot mounted, c-face or d-flange mounted motors with single row radial ball bearings on both ends of the motor. Motors may be installed either horizontally or vertically in the customer's application.
- Install one AEGIS® SGR Bearing Protection Ring on either the drive end or the non-drive end of the motor to discharge capacitive induced shaft voltage.
- AEGIS® SGR may be installed either internally or externally.
- Use AEGIS® Colloidal Silver Shaft Coating (PN# CS015) on motor shaft where fibers touch.

Product recommendation: AEGIS® SGR

Motors Greater than 100 HP (75 kW) - *Low Voltage*



Install AEGIS® Ring on opposite end from insulation

Product recommendation:
Motors up to 500HP: AEGIS® SGR
Motors over 500HP: AEGIS® PRO Series

For horizontally mounted motors with single row radial ball bearings on both ends of the motor:

- Non-Drive end: Bearing housing must be isolated with insulated sleeve or coating or use insulated ceramic or hybrid bearing to disrupt circulating currents.
- Drive end: Install one AEGIS® Bearing Protection Ring .
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- Use AEGIS® Colloidal Silver Shaft Coating (PN# CS015) on motor shaft where fibers touch.

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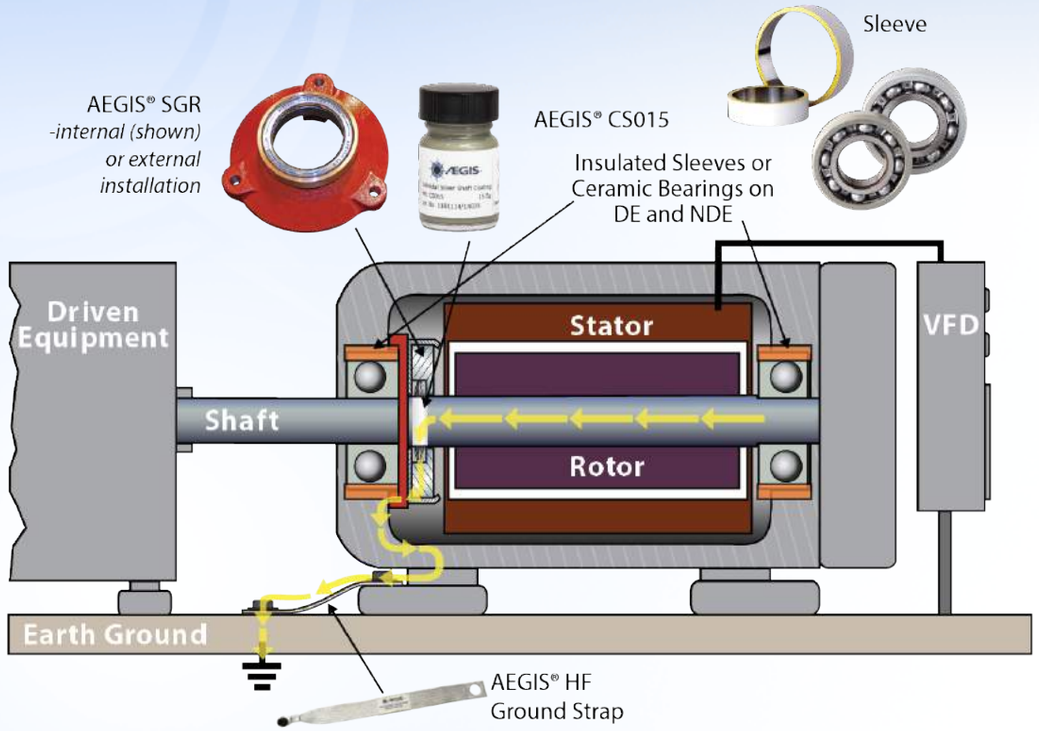
Motors Where Both Bearings are Insulated – Any HP/kW - *Low Voltage*



Install AEGIS® Ring on opposite end from insulation

- Install one AEGIS® Bearing Protection Ring, drive end preferred, to protect bearings in attached equipment (gearbox, pump, fan bearing and encoder, etc…).
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

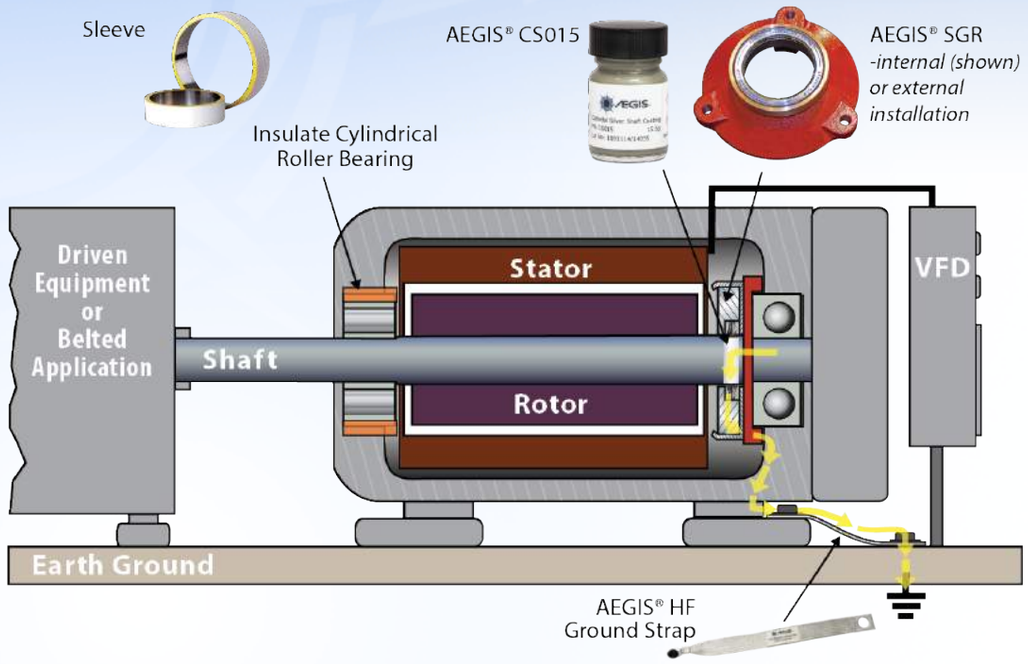
Bearings in attached equipment may be at risk from VFD induced shaft voltage unless AEGIS® Shaft Grounding is installed

Product recommendation:

Motors up to 500HP: AEGIS® SGR

Motors over 500HP: AEGIS® PRO Series

Motors with Cylindrical Roller, Babbit or Sleeve Bearings - *Low Voltage*



Note: Insulating the DE cylindrical roller bearing is preferred. However, if this is not possible, then insulate the NDE bearing instead and install an AEGIS® Ring on the DE (cylindrical roller bearing side).

Install AEGIS® Ring on opposite end from insulation

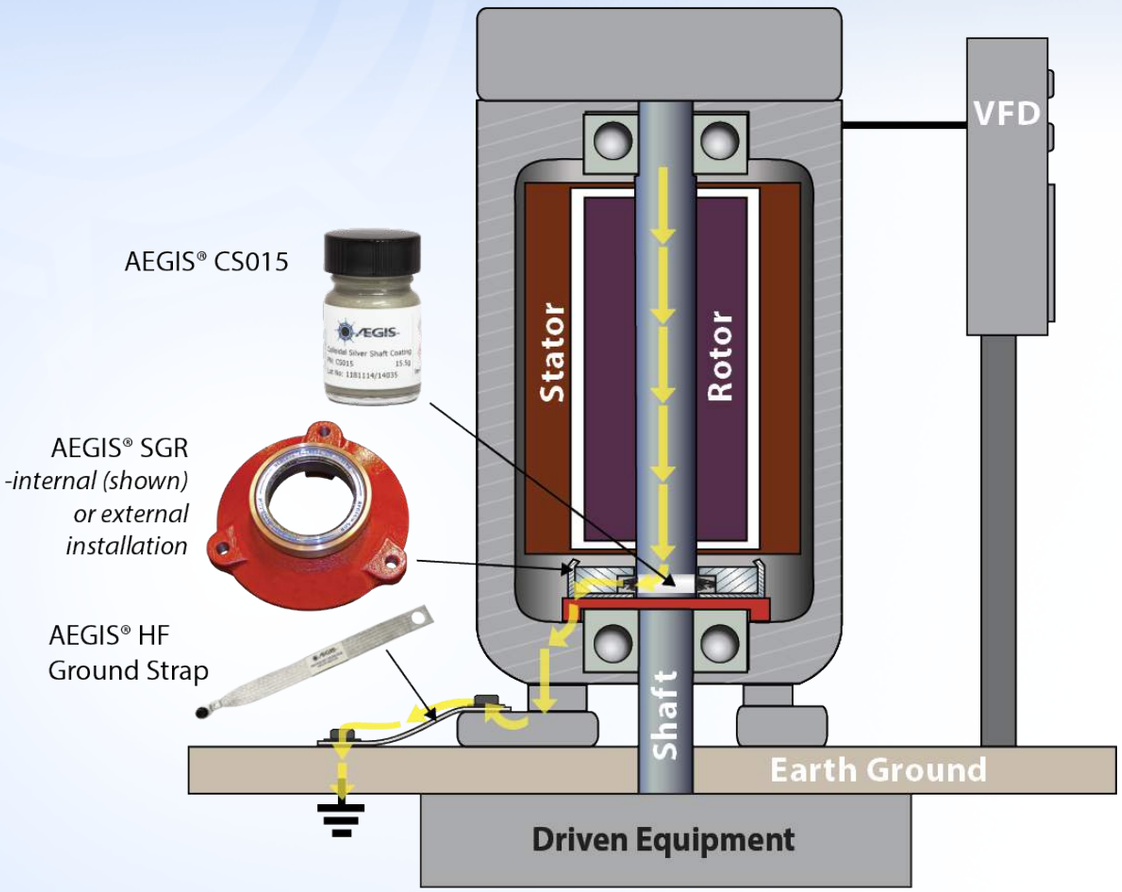
Product recommendation:

Motors up to 500HP: AEGIS® SGR

Motors over 500HP: AEGIS® PRO Series

- Cylindrical Roller Bearing, Babbit, or Sleeve bearing: Bearing housing should be isolated or use insulated bearing.
- Motors with insulated cylindrical roller bearing DE: Install AEGIS® Bearing Protection Ring on opposite drive end (NDE).
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

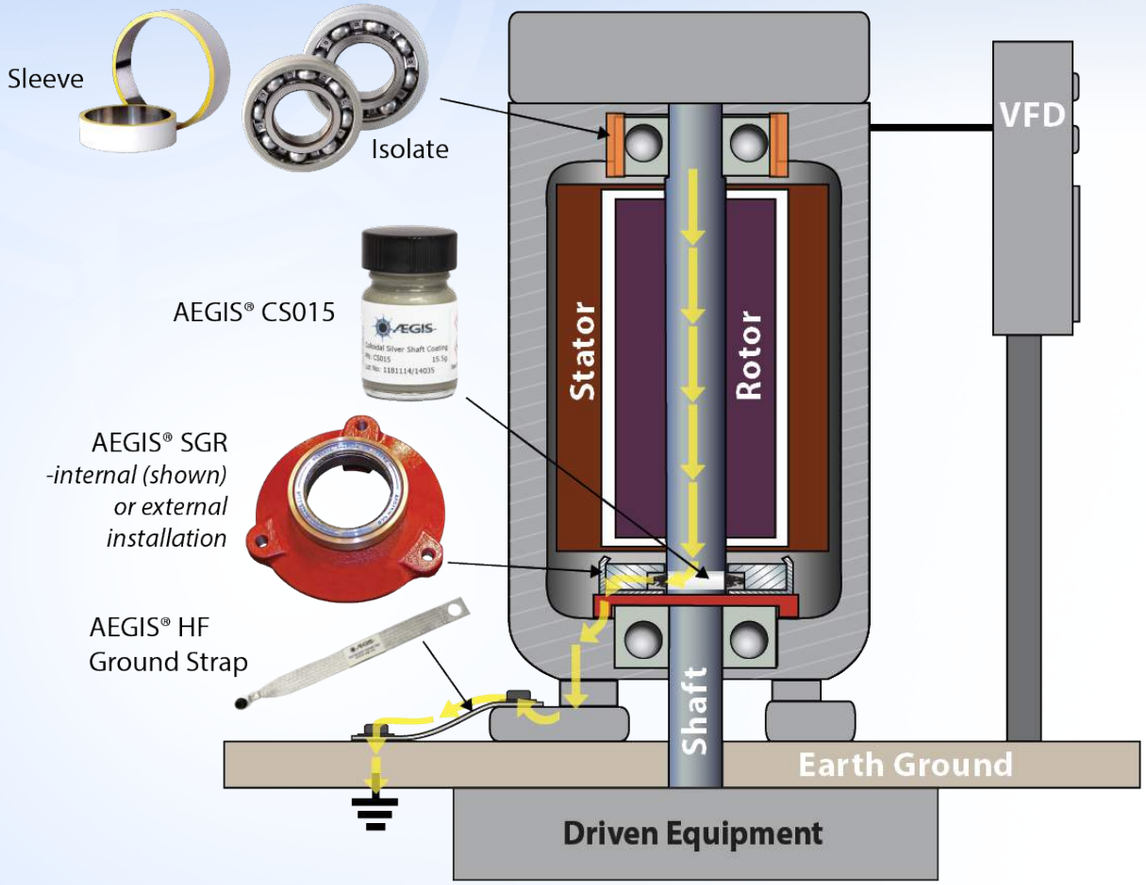
Vertical Solid Shaft Motors up to and including 100 HP (75 kW) - *Low Voltage*



- Lower Bearing: Install one AEGIS® Bearing Protection Ring
- AEGIS® SGR can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Product recommendation: AEGIS® SGR

Vertical Solid Shaft Motors up to and including 100 HP (75 kW) - *Low Voltage*



- Upper Bearing: Bearing journal must be isolated or insulated ceramic or hybrid ceramic bearing installed.
- Bottom Bearing: Install one AEGIS® Bearing Protection Ring.
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Product recommendation:
Motors up to 500HP: AEGIS® SGR
Motors over 500HP: AEGIS® PRO Series

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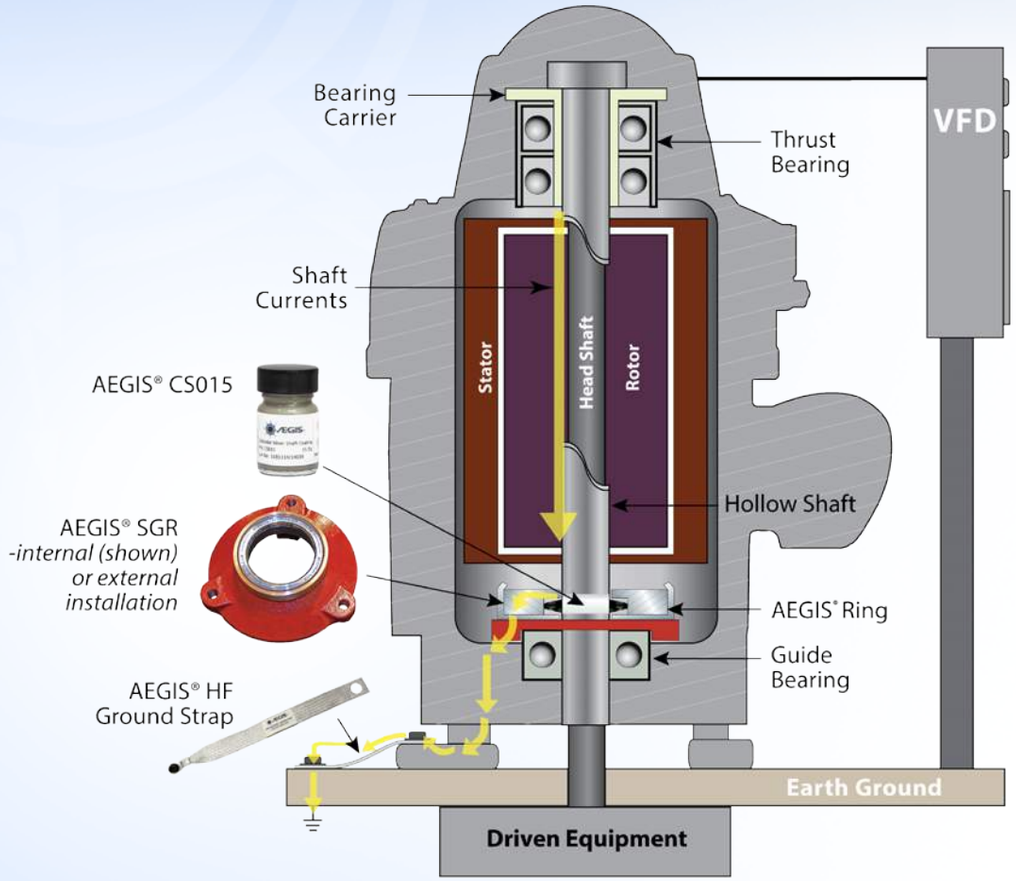
Vertical (Hollow & Solid Shaft) Thrust Handling Motors up to and including 100 HP (75 kW)
Low Voltage



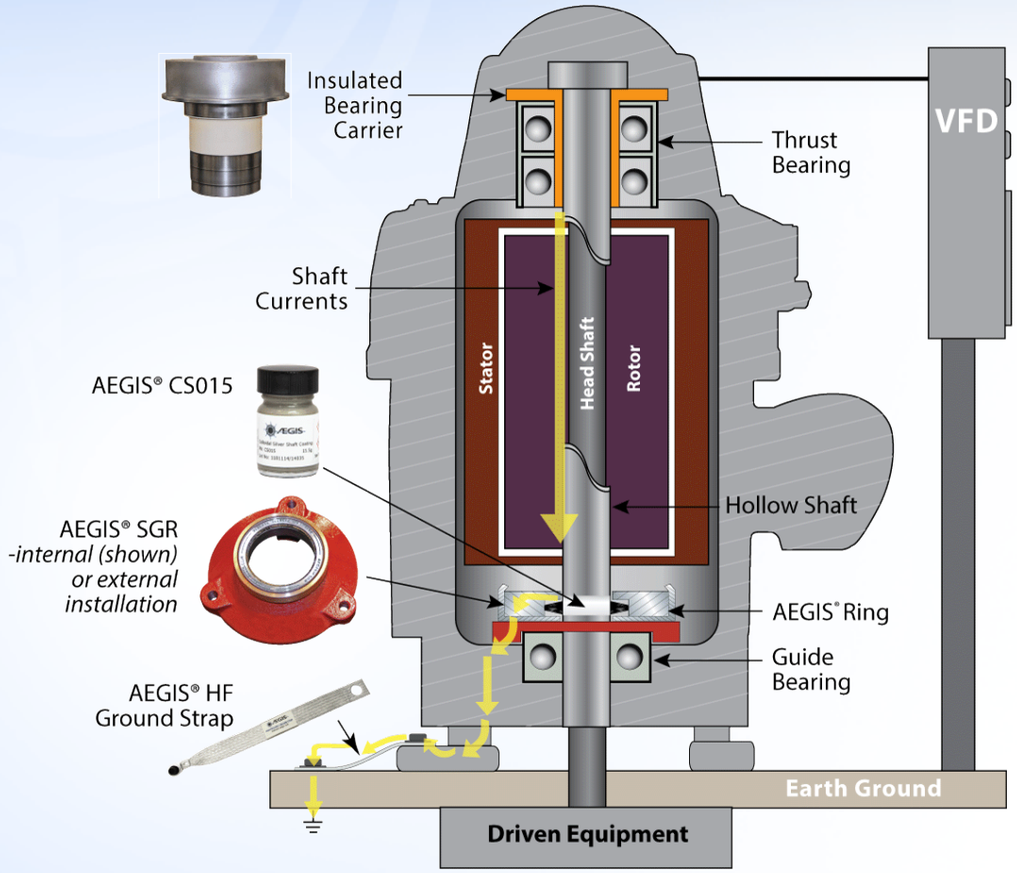
Product recommendation: AEGIS® SGR

- Lower Bearing: Install one AEGIS® SGR Bearing Protection Ring.
- AEGIS® SGR can be installed internally on the back of the bearing cap.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Note: For external installation, the AEGIS® Ring must run on the motor or pump shaft at the lower bearing. Ring must not be mounted around the steady bushing.

Upper bearing may be isolated with insulated bearing carrier for added protection.

Vertical (Hollow & Solid Shaft) Thrust Handling Motors Greater than 100 HP (75 kW)
Low Voltage



- Upper Bearing: Bearing carrier must be isolated or insulated ceramic or hybrid ceramic bearing installed
- Lower Bearing: Install one AEGIS® Bearing Protection Ring.
- AEGIS® SGR can be installed internally on the back of the bearing cap.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Product recommendation:
Motors up to 500HP: AEGIS® SGR
Motors over 500HP: AEGIS® PRO Series

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AEGIS® PRO Series – Shaft Grounding Rings for Maximum Bearing Protection

Designed for:

- Large frame low-voltage motors: 500 HP (375kW) or greater
- Medium-voltage motors
- DC motors: 300 HP or greater

Specifications:

- Available in shaft diameters from 3” to 30” (50mm to 800mm)
- Rows of fiber: 6
- Fiber overlaps shaft 0.030” (.76mm)
- Ships with CS015 Colloidal Silver Shaft Coating
- Available in Aluminum and Stainless Steel

Options:

- Solid and split ring designs
- Monitoring ring option for voltage monitoring
- Stock brackets and stand-off kits
- Custom brackets available

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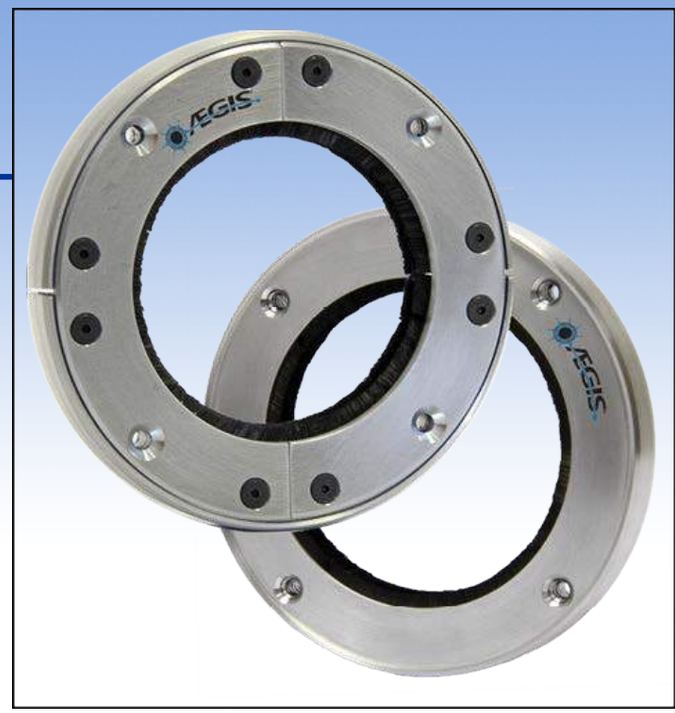
AEGIS® PROSL



The AEGIS® PROSL is a high current capable AEGIS® PRO Series Ring for large motors, generators and turbines operated by VFDs. The slim design and flexible installation options allow for adaptation to virtually all large motors.

Specifications

Designs: Solid, Split and Press Fit

Shaft Dia: 2” to 15.75” [50.80mm to 400mm]

OD: Shaft Dia. + 1.86” [47.24mm]

OAL: 0.650” [16.51mm] MAX assembled with mounting screws

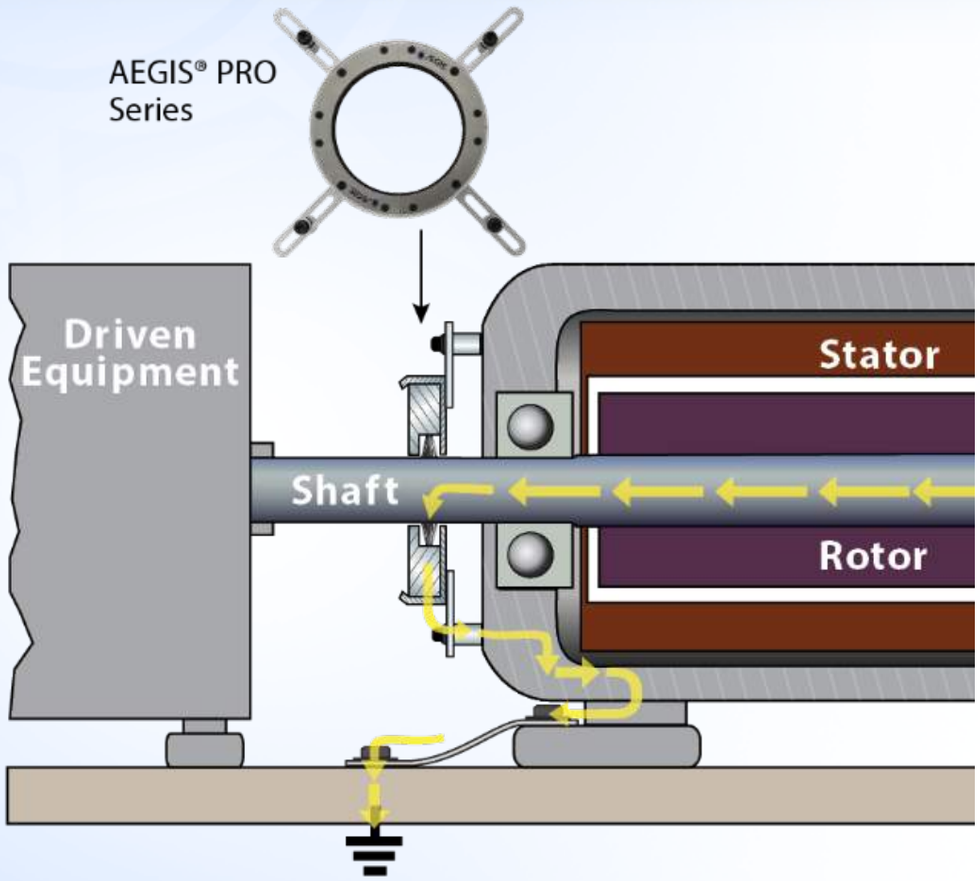
Mounting: Supplied with screws for bolt through mounting

- English: 8-32 x 1” Flat Head Cap Screws
- Metric: M4 x .7 x 25mm Flat Head Cap Screws

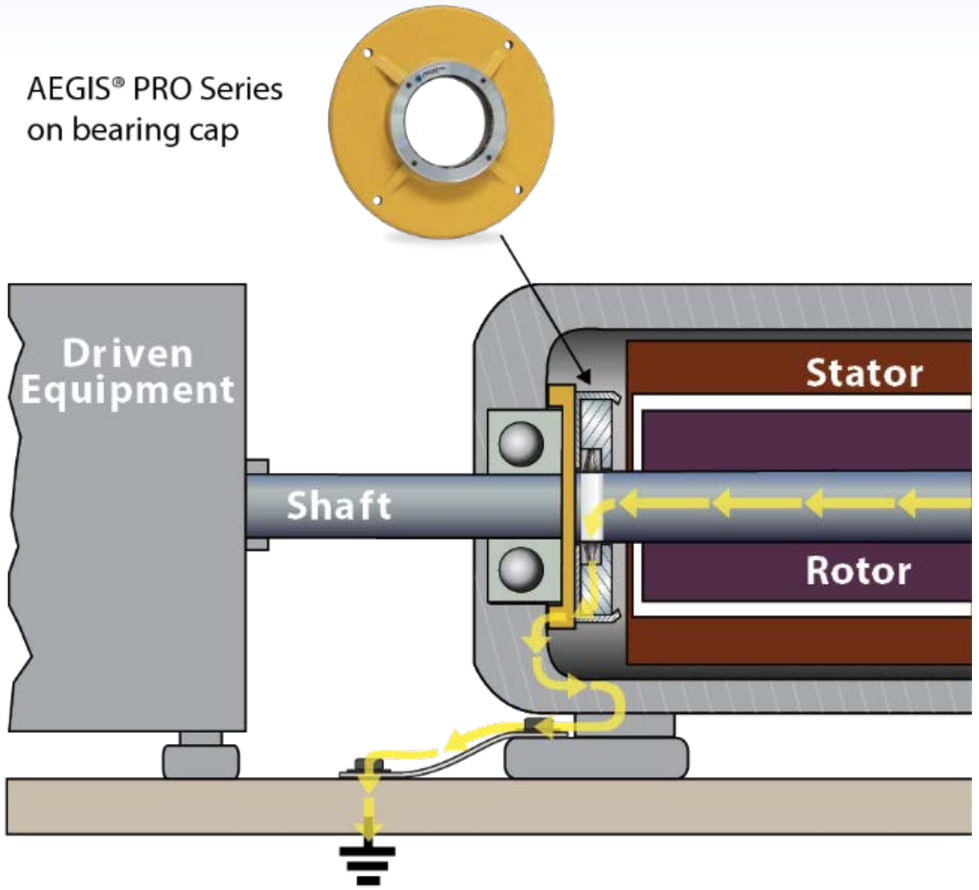
Optional Universal Brackets for easy mounting.

AEGIS® PROSL

External Installation



Internal Installation



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Optional Mounting Brackets for AEGIS® PRO Series

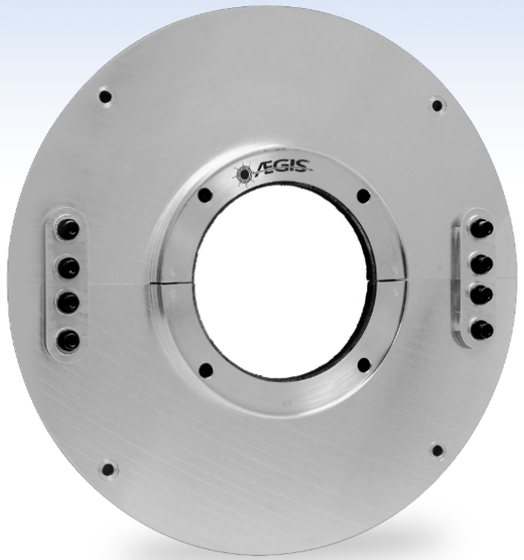
AEGIS® PROSL Universal Brackets

BKT-PRO-1	BKT-PRO-2
English Hardware	Metric Hardware
(4) Universal brackets	(4) Universal brackets
(4) ¾ x ½” spacers	(4) 19mm x 12.7mm spacers
(4) ¾ x 1” spacers	(4) 19mm x 25.4mm spacers
(4) ¾ x 1-1/2” spacers	(4) 19mm x 38.1mm spacers
(4) 5/16-18 x 1.25” SHCS	(4) M8 x 35mm SHCS
(4) 5/16-18 x 1.75” SHCS	(4) M8 x 45mm SHCS
(4) 5/16-18 x 2.25” SHCS	(4) M8 x 60mm SHCS
(4) Flat washers	(4) Flat washers
(4) Lock washers	(4) Lock washers

Mounting the AEGIS® PRO Series

AEGIS® PRO Series Custom Brackets

Contact our Engineering Team for special mounting applications.

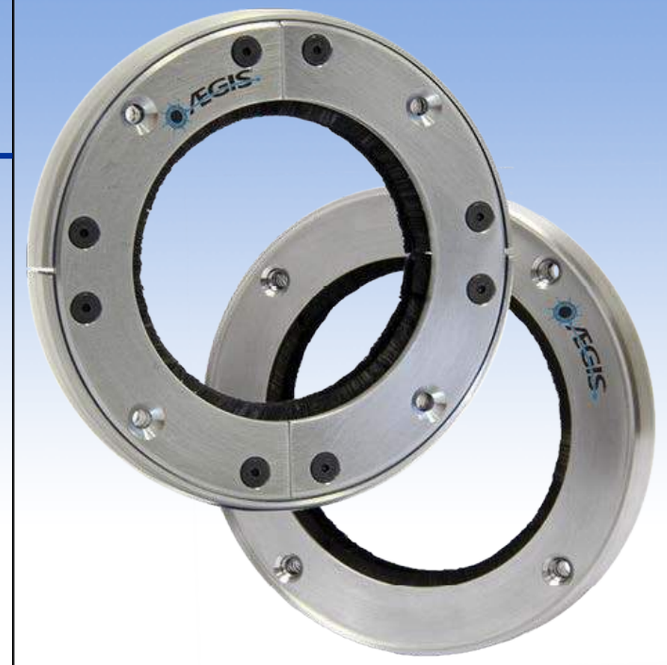


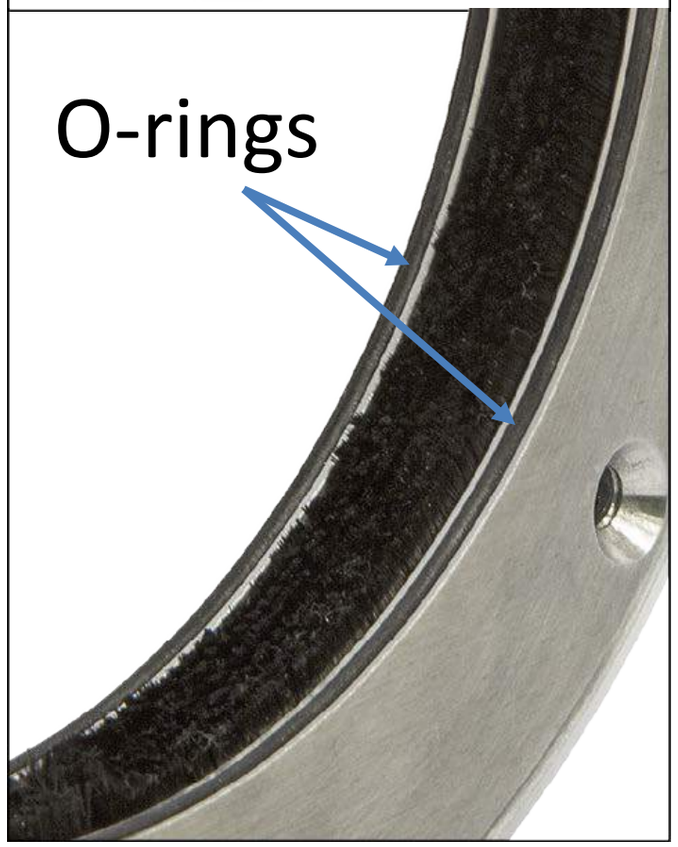
AEGIS® PROSL mounted on a bearing cap for an internal installation.

AEGIS® PROSLR

Severe Duty motors are operated in general processing industry applications requiring protection from severe environmental operating conditions - often where there is debris, powder, dirt, liquids, lubricants or other contaminants. For these applications the AEGIS® PROSLR incorporates an O-ring dust and debris barrier which will prevent ingress of materials that could interfere with the contact of the conductive microfibers to the motor's shaft.

When the AEGIS® PROSLR is installed inside the motor the O-ring barrier will prevent grease from clogging the fibers in an over-lubricated condition.





Specifications

Designs:	Solid and Split
Shaft Dia:	2" to 15.75" [50.80mm to 400mm]
OD:	Shaft Dia + 1.86" [47.24mm]
OAL:	0.650" [16.51mm] MAX assembled with mounting screws
Mounting:	Supplied with screws for bolt through mounting

- English: 8-32 x 1" Flat Head Cap Screws
- Metric: M4 x .7 x 25mm Flat Head Cap Screws

Optional Universal Brackets for easy mounting.

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AEGIS® PROMAX

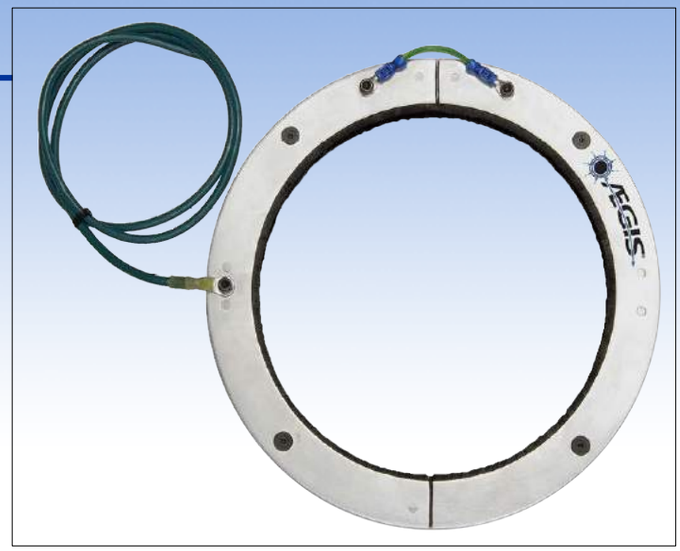
The AEGIS® PROMAX is designed for installation on the most critical and largest motors, generators and turbines. Scalable to any shaft diameter over 15.75” [400mm], this high current capable AEGIS® PROMAX Shaft Grounding Ring is custom engineered for each application to ensure the best bearing protection possible.

Specifications:

Designs:	Split Ring only
Shaft Dia:	15.75” to 30” [400mm to 762mm]
OD:	Shaft Dia + 3.0” [76.2mm]
OAL:	1.875” [47.62mm] assembled with mounting Screws
Mounting:	Supplied with (4) M8 x 1.25 x 50 Socket Head Cap Screws for bolt through mounting

Custom brackets and O-ring barrier available upon request

AEGIS® PROMR



The AEGIS® PROMR "monitoring ring" combines the AEGIS® PROSL with an additional isolated SGR ring that can be used as a monitoring device. The PROSL channels the voltages and currents safely to ground while the monitoring SGR ring measures voltage on the shaft and is not grounded. A phenolic plate between the 2 rings is used to isolate the monitoring ring.

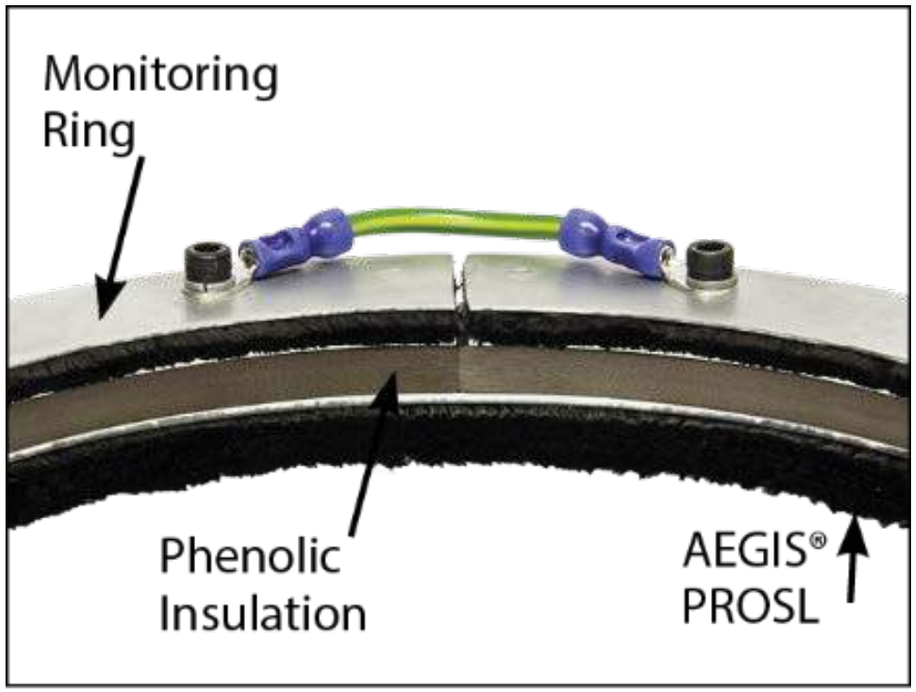
Specifications:

For shaft diameter of 2" to 15.75" [50.80mm to 400mm].

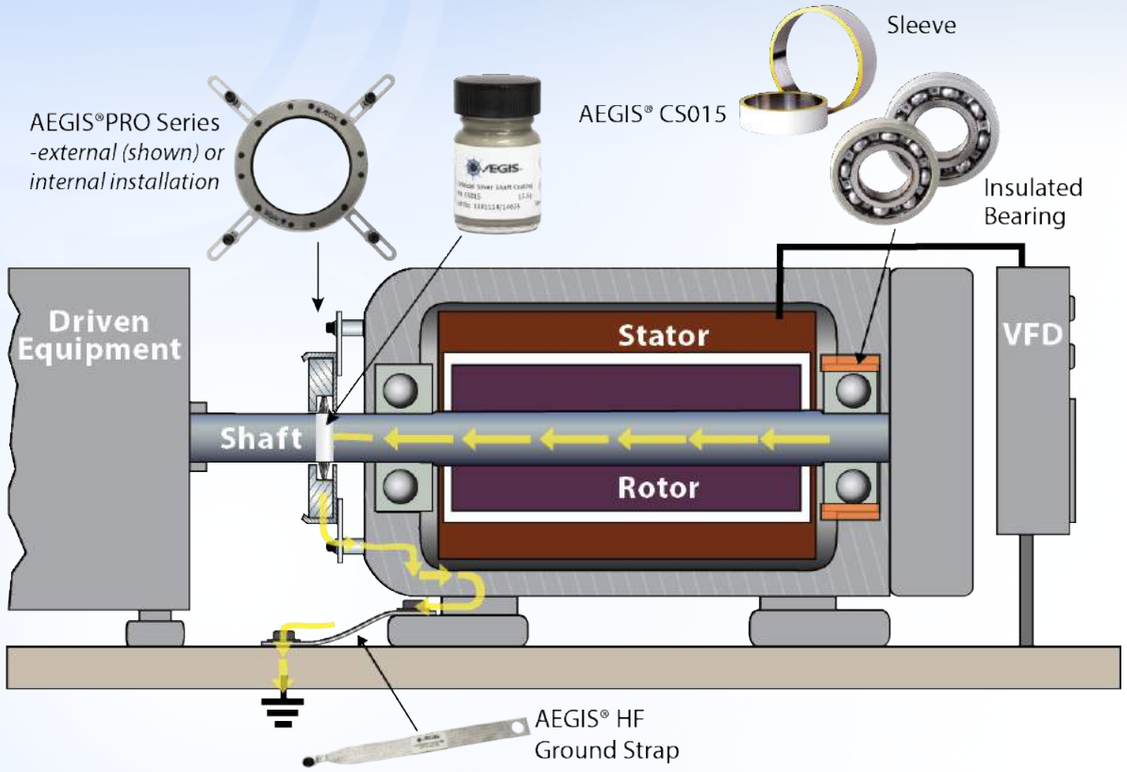
Designs:	Solid and Split
OD:	Shaft Dia + 1.86" [47.24mm]
OAL:	1.312" [33.32mm] assembled with mounting screws
Mounting:	Supplied with screws for bolt through mounting

- English Screws: 8-32 x 1" Flat Head Cap Screws
- Metric Screws: M4 x .7 x 25mm Flat Head Cap Screws

Optional Universal Brackets for easy mounting.



Motors Greater than 100 HP (75 kW) -
Medium Voltage



Install AEGIS® Ring on opposite end from insulation

Product recommendation: AEGIS® PRO Series

For horizontally mounted motors with single row radial ball bearings on both ends of the motor:

- Non-Drive end: Bearing housing must be isolated with insulated sleeve or coating or use insulated ceramic or hybrid bearing to disrupt circulating currents.
- Drive end: Install one AEGIS® Bearing Protection Ring .
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- Use AEGIS® Colloidal Silver Shaft Coating (PN# CS015) on motor shaft where fibers touch.

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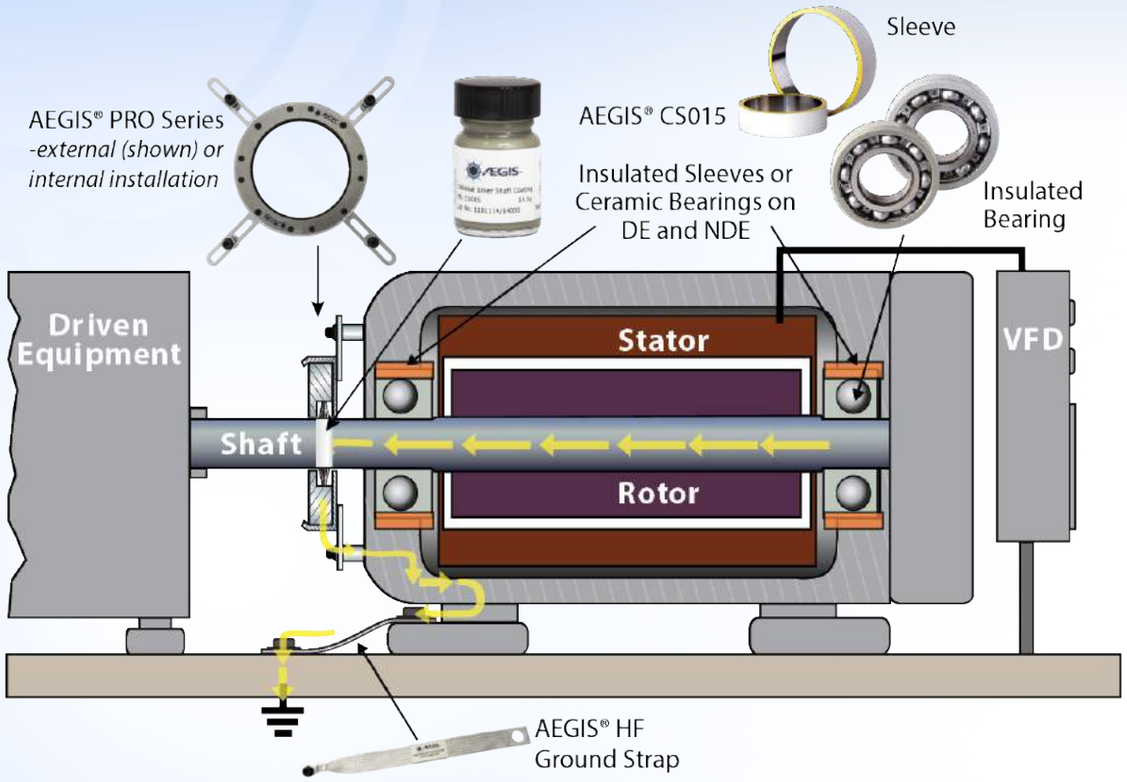
Motors Where Both Bearings are Insulated – Any HP/kW - *Medium Voltage*



Install AEGIS® Ring on opposite end from insulation

- Install one AEGIS® Bearing Protection Ring, drive end preferred, to protect bearings in attached equipment (gearbox, pump, fan bearing and encoder, etc...).
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- Colloidal Silver Shaft Coating PN CS015 is required for this type of application.

Bearings in attached equipment may be at risk from VFD induced shaft voltage unless AEGIS® Shaft Grounding is installed

Product recommendation: AEGIS® PRO Series

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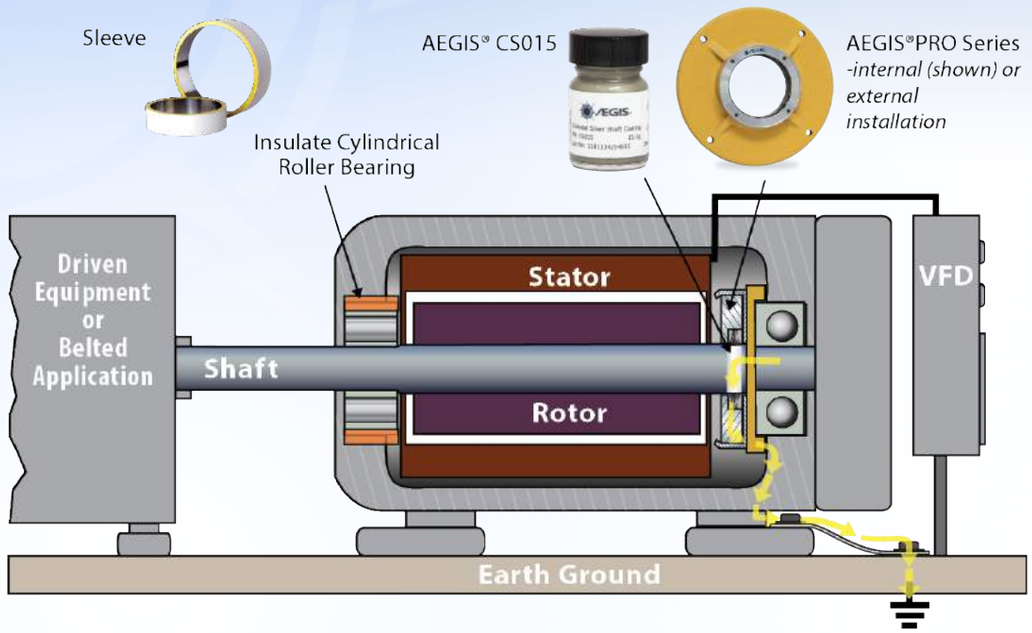
Motors with Cylindrical Roller, Babbit or Sleeve Bearings – *Medium Voltage*



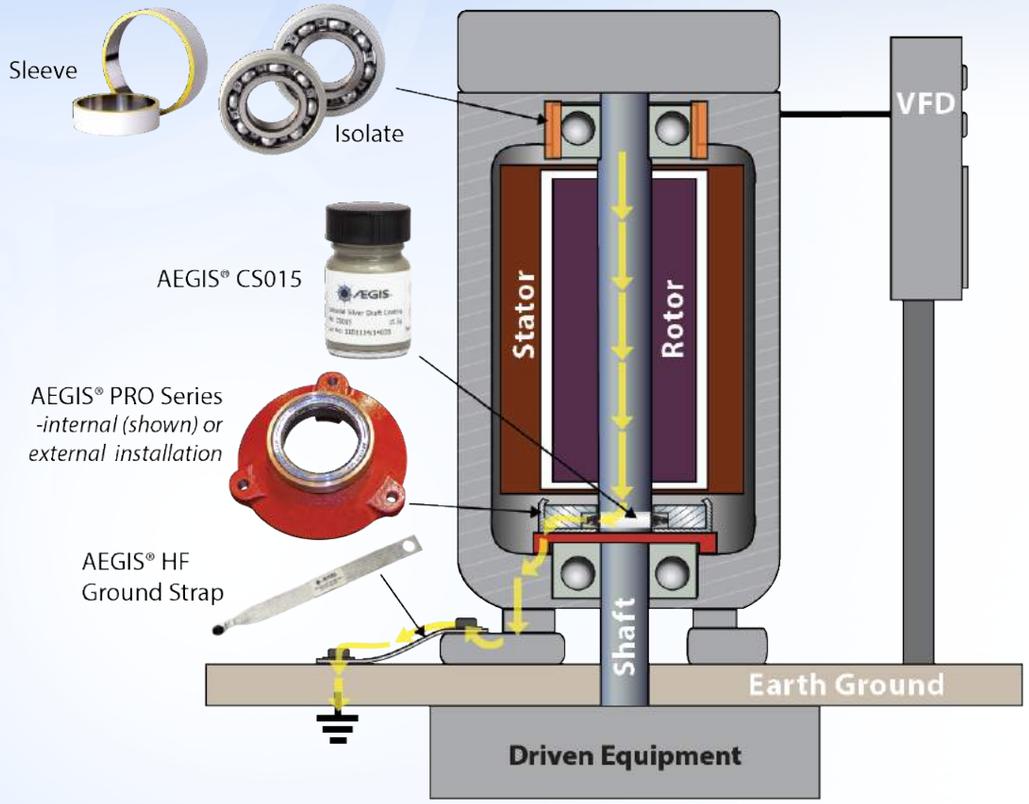
Note: Insulating the DE cylindrical roller bearing is preferred. However, if this is not possible, then insulate the NDE bearing instead and install an AEGIS® Ring on the DE (cylindrical roller bearing side).

Install AEGIS® Ring on opposite end from insulation

- Cylindrical Roller Bearing, Babbit, or Sleeve bearing: Bearing housing should be isolated or use insulated bearing.
- Motors with insulated cylindrical roller bearing DE: Install AEGIS® Bearing Protection Ring on opposite drive end (NDE).
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Product recommendation: AEGIS® PRO Series

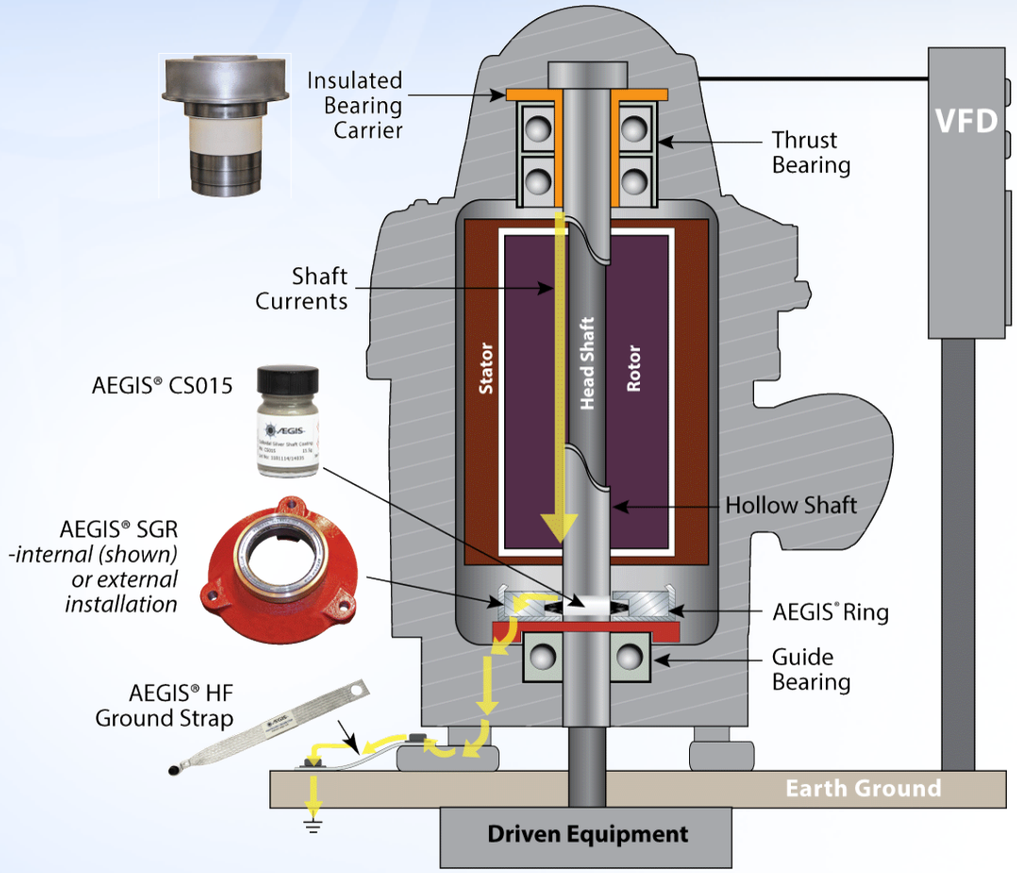
Vertical Solid Shaft Motors Greater than 100 HP (75 kW) – *Medium Voltage*



- Upper Bearing: Bearing journal must be isolated or insulated ceramic or hybrid ceramic bearing installed.
- Bottom Bearing: Install one AEGIS® Bearing Protection Ring.
- AEGIS® Ring can be installed internally on the back of the bearing cap or externally on the motor end bracket.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Product recommendation: AEGIS® PRO Series

Vertical Hollow Shaft Motors Greater than 100 HP (75 kW) - *Medium Voltage*



- Upper Bearing: Bearing carrier must be isolated or insulated ceramic or hybrid ceramic bearing installed
- Lower Bearing: Install one AEGIS® Bearing Protection Ring.
- AEGIS® SGR can be installed internally on the back of the bearing cap.
- AEGIS® Colloidal Silver Shaft Coating (PN# CS015) is required for this type of application.

Product recommendation: AEGIS® PRO Series

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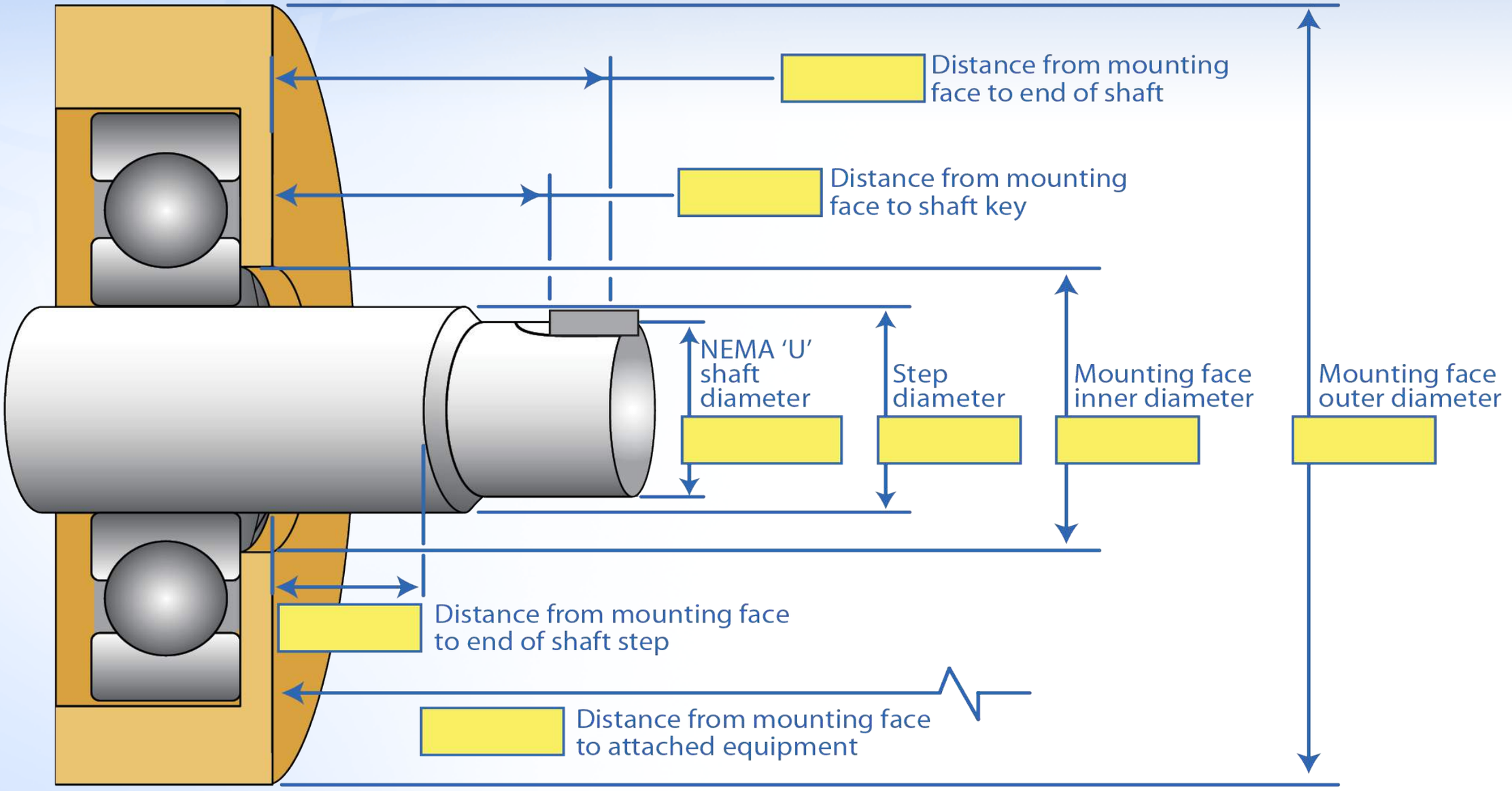
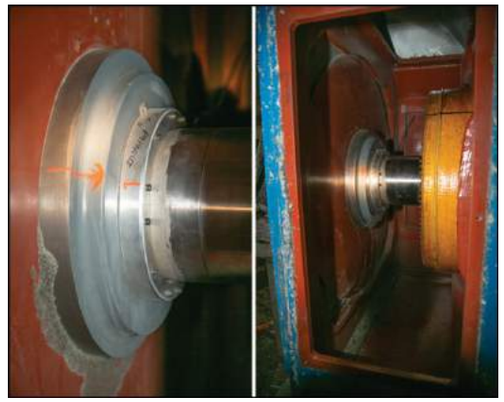
All AEGIS® PRO Series Rings are custom-manufactured to the measurements provided.



Measure dimensions to: Inches: 3 decimal places / Metric: 2 decimal places

AEGIS® Shaft Grounding for DC Motors on Drives

DC motors when operated on drives may also require bearing protection from induced shaft voltages. Capacitive induced shaft voltages may be hundreds of volts peak-to-peak and depending on the drive will increase in amplitude as the speed of the motor is increased.
In addition circulating currents from magnetic dissymmetry may exist on DC motors over 10 HP (7.5 kW)[(1)].



(1) EASA web seminar: Dealing with Shaft and Bearing Currents, Thomas H. Bishop, P.E., Electrical Apparatus Service Association, January 19, 2011

Recommendation: Install AEGIS SGR on the DE of the DC motor for all motors up to 300 HP (225 kW). For DC motors over 10 HP (7.5 kW), also insulate the NDE bearing.

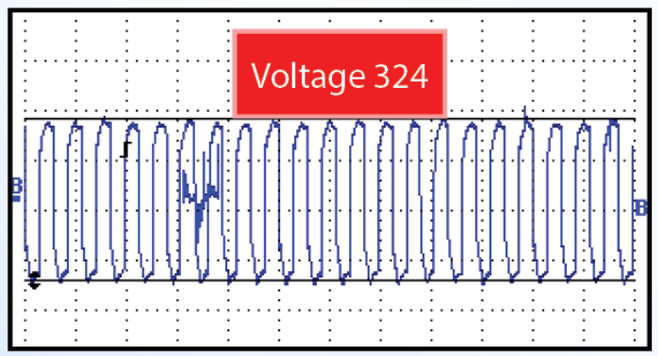
AEGIS® PRO Series for Large DC Motors 300 HP (225 kW) and Greater

Large DC motors over 300 HP (225 kW) have higher shaft voltages and currents and require the AEGIS PRO Series installed on the DE of the motor. In addition, the NDE bearing should have insulation to prevent circulating currents.

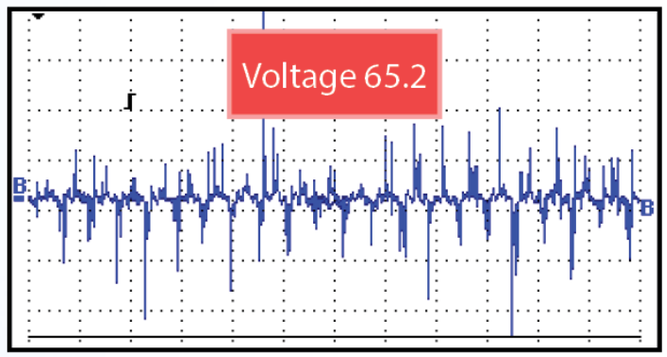
Recommendation: Install AEGIS SGR on the DE of the DC motor for all motors up to 300 HP (225 kW). For DC motors over 10 HP (7.5 kW), also insulate the NDE bearing.

DC Motor Testing Before and After

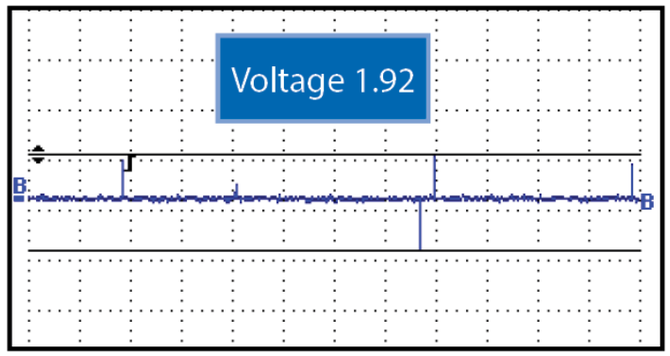
350 HP DC Motor – DC Inverter Drive



Capacitive induced shaft voltage before bearing current discharge through the bearings. Square wave from DC SCR drive.



No Shaft Grounding
Volts: 65.2 V pk-pk
Bearing discharges (EDM)



AEGIS® Shaft Grounding
Volts: 1.92 V pk-pk
Discharge through AEGIS® Shaft Grounding Ring

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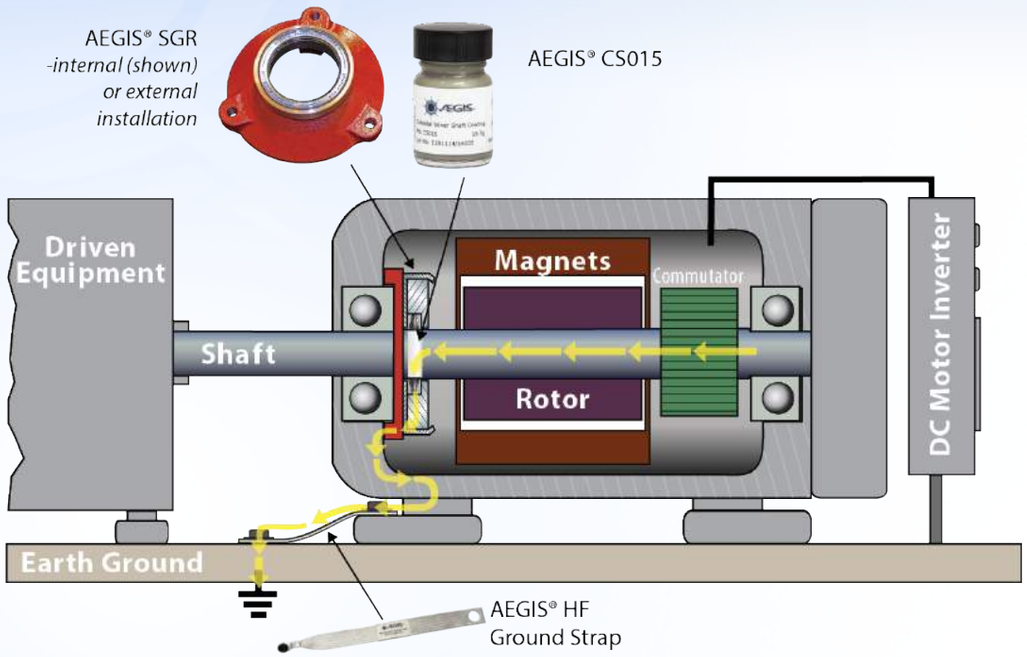
DC Motors up to and including 10 HP (18 kW) Operated on DC Inverter(1)

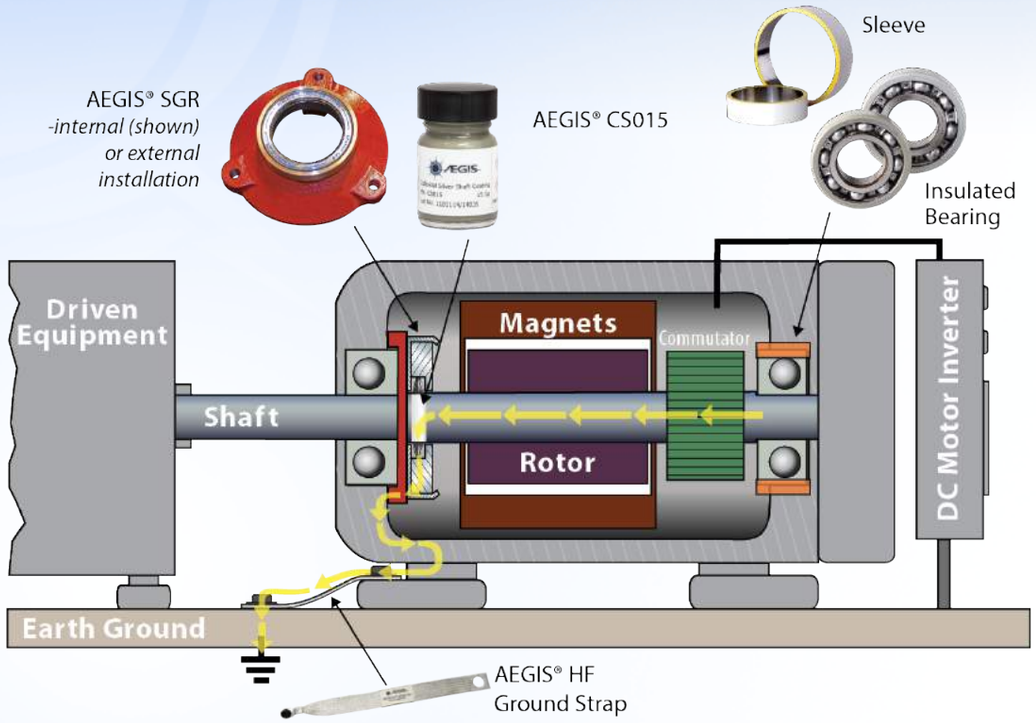


- Install one AEGIS® SGR Bearing Protection Ring on either the drive end or the non-drive end of the motor to discharge induced shaft voltage.
- AEGIS® SGR should be installed internal to the motor if possible but may also be attached externally to the motor's end bracket.
- Use AEGIS® Colloidal Silver Shaft Coating (PN# CS015) on motor shaft where fibers touch.

Product recommendation: AEGIS® SGR

(1) EASA web seminar: Dealing with Shaft and Bearing Currents, Thomas H. Bishop, P.E., Electrical Apparatus Service Association, January 19, 2011

DC Motors Greater than 10 HP (18 kW) Operated on DC Inverter



- Non-Drive end: Bearing housing must be isolated with insulated sleeve or coating or use insulated ceramic or hybrid bearing to disrupt circulating currents.
- Drive end: Install one AEGIS® Bearing Protection Ring to discharge induced shaft voltage.
- AEGIS® Ring should be installed internal to the motor if possible but may also be attached externally to the motor's end bracket.
- Use AEGIS® Colloidal Silver Shaft Coating (PN# CS015) on motor shaft where fibers touch.

Product recommendation:

DC motors from 10 HP to 300 HP: AEGIS® SGR

DC motors over 300HP: AEGIS® PRO Series

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Patented Technology

AEGIS® Award Winning Technology

CONSULTING - SPECIFYING engineer® 2011 PRODUCT OF THE YEAR | Gold

2007 FROST & SULLIVAN
North American Motors & Drives
Product Value Leadership of the Year Award

Plant Engineering PRODUCT of the YEAR Finalist 2015
Plant Engineering PRODUCT of the YEAR Winner 2013
Plant Engineering PRODUCT of the YEAR Finalist 2011
Plant Engineering PRODUCT of the YEAR Finalist 2009
Plant Engineering PRODUCT of the YEAR 2007 Winner
Plant Engineering PRODUCT of the YEAR Finalist 2006

2010 DEALER DESIGN AWARDS
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2006 Product of the Year Silver Winner

CONSULTING - SPECIFYING engineer® 2015 PRODUCT OF THE YEAR | Bronze

CONSULTING - SPECIFYING engineer® 2012 PRODUCT OF THE YEAR FINALIST

2007 design news GOLDEN MOUSETRAP Finalist

CONSULTING - SPECIFYING engineer® 2009 PRODUCT OF THE YEAR | Finalist

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