AEGIS® SHAFT GROUNDING RING

Best Practices for Bearing Protection

- AEGIS Technology
- About VFD Induced Shaft Voltages and Bearing Currents
- Bearing Frosting & Fluting
- AEGIS® Shaft Grounding Best Practices

www.est-aegis.com
COMPANY INFORMATION

Electro Static Technology, An ITW Company, is a global manufacturer and inventor of AEGIS® Bearing Protection Rings used in electric motors and other rotating equipment to safely discharge variable frequency drive (VFD) voltages to ground. AEGIS® Shaft Grounding Ring technology is installed in all ranges of motors from fractional horse power to large medium voltage motors used in virtually all commercial and industrial applications.

AEGIS® Shaft Grounding Ring technology is the only technology that combines both contact and non-contact nanogap technology to reliably protect bearings from electrical discharges that cause pitting, frosting and fluting damage. AEGIS® Ring Technology uses proprietary conductive micro fibers arranged circumferentially around the motor shaft and secured in our patented AEGIS® FiberLock™ channel which protects them during operation. The following patents apply: 8199453, 8169766, 7193836, 7136271, 7528513, 7339777, and other patents pending.

WARRANTY

Units are guaranteed for one year from date of purchase against defective materials and workmanship. Replacement will be made except for defects caused by abnormal use or mishandling. All statements and technical information contained herein, or presented by the manufacturer or their representative are rendered in good faith. User must assume responsibility to determine suitability of the product for intended use. The manufacturer shall not be liable for any injury, loss or damage, direct or consequential arising out of the use, or attempt to use the product.

SAFETY

Follow all workplace safety policies and procedures applicable to electric motor repair and for all hazardous operations. Wear all applicable personal protective equipment (PPE) required by the applicable law. Employees should be informed of the relevant safety rules and employers should enforce compliance. The manufacturer shall not be liable for any injury, loss or damage, direct or consequential arising out of the use, or attempt to use the product or procedures described in this manual.
**AEGIS® Shaft Grounding Rings Provide Both Contact and Noncontact Grounding**

*The Only Product of its Kind*

**AEGIS® Bearing Protection Ring uses Revolutionary Nanogap Technology**

- Unique contact/non-contact design
- 360 degrees circumferential conductive micro fiber ring
- Multiple row design – greatest reliability
- Ensures unmatched shaft grounding and performance

The AEGIS® Bearing Protection Ring's patented Nanogap Technology ensures effective electrical contact even when physical contact is broken. Only AEGIS® Nanogap Technology provides both maintenance-free contact and noncontact bearing protection for the normal service life of the motor’s bearings as well as the most reliable operation of any shaft grounding technology.

**Proprietary Conductive Microfibers Last for the Service Life of the Motor**

The AEGIS® Bearing Protection Ring’s unique design features hundreds of thousands to millions of specially engineered conductive microfibers that encircle the motor shaft. With so many electrical transfer points the ring provides continuous electrical contact, whether its fibers are physically touching the shaft or not. This patented “nanogap” technology enables both contact and noncontact shaft grounding — 100% of the time.

**Specially Designed Microfibers Flex Without Breaking**

Designed with specific mechanical and electrical characteristics that minimize wear and maintain conductivity, AEGIS® microfibers will last for the life of the motor. Based on wear of less than 0.001” (0.025mm) during 10,000 hours of testing, proven to withstand over 200,000 hours of continuous operation.

Through our patented design, AEGIS® conductive microfibers exhibit minimal wear and the ability to flex without breaking. In testing, they were proven to withstand 2 million direction reversals (to 1800 RPM) with no fiber fatigue or breakage.

AEGIS® Rings are designed with an optimal fiber overlap to the shaft of 0.030” (0.76mm).

**Patented FiberLock™ Channel Secures and Protects Fibers**

AEGIS’s patented, protective FiberLock™ channel locks the ring’s conductive microfibers securely in place around the motor shaft, allowing them to flex without breaking. The channel also helps protect the fibers from excessive dirt, oil, grease, and other contaminants.
Electric Motors Operating on Line Voltage

- 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.

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Electric Motors Operated by Variable Frequency Drives (VFD)

- 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.
There are two primary sources of bearing currents in VFD driven AC motors (*Bearing Currents A and B*):

**Bearing Current A**: is a capacitive induced shaft voltage that discharges in the motor bearings. The VFD induced shaft voltages are capacitively coupled from stator to rotor through parasitic capacitance and create the possibility of bearing currents.

- Virtually any motor from fractional HP to large motors may have bearing currents from this source.
- Voltages can discharge through the motor bearings resulting in EDM pitting and fluting failure.

*Best Practice:* Ground the motor shaft with the AEGIS® Shaft Grounding Ring to provide a path of least resistance to ground and divert current away from the motor’s bearings.

Ref: NEMA MG1 Part 31.4.4.3

An Electric Motor behaves like a Capacitor (*Bearing Current A*)

- The pulses to the motor from the VFD create a capacitively coupled common mode voltage on the motor shaft.
- Voltages are measurable with a Fluke 190 series portable oscilloscope and AEGIS® SVP Shaft Voltage Probe Tip.
- Creates electrical bearing discharge currents.
Voltage arcs through the bearing

- Voltages arc through the bearings, and 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, is burnt and fails
- Potential for costly unplanned downtime

High Frequency Circulating Currents

**Bearing Current B**: High frequency circulating currents may flow due to a high-frequency flux produced by common-mode currents. High frequency inductive circulating currents from VFDs are in the KHz or MHz frequencies.

a. May be present in motors above 100 HP.
   a. Circulate through the motor bearings, shaft to frame.

**Best Practice**: Interrupting the high frequency circulating current in the bearing is the best approach to mitigating potential bearing damage. Also, motors subject to Current B (high frequency circulating currents) will also be subject to Current A (capacitively induced shaft voltage) and therefore need an AEGIS® Shaft Grounding Ring.
A third source of bearing currents are circulating currents from 60Hz/50Hz Line Voltage (motors over 500 Frame):

**Bearing Current C:** Sinusoidal voltage sources can cause circulating currents in large machines due to the motor’s asymmetrical design. 50/60Hz operation can result in circulating currents due to motor magnetic asymmetries.

  a. Usually present in very large machines only.
  a. Circulate through the motor bearings, shaft to frame.

**Best Practice:** Interrupting the circulating current is the best approach to mitigating potential bearing damage.

Ref: NEMA MG1 Part 31.4.4.3

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**AC Induction Motors**

<table>
<thead>
<tr>
<th>VFD OPERATION</th>
<th>NO VFD-Sinusoidal Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motors up to and including 100hp (Low Voltage)</td>
<td>Motors over 500 Frame (Medium Voltage)</td>
</tr>
<tr>
<td>Bearing Current A</td>
<td>Bearing Current C</td>
</tr>
<tr>
<td>AEGIS® SGR</td>
<td>AEGIS® iPRO (may not be needed)</td>
</tr>
<tr>
<td>n/a</td>
<td>Isolate one bearing, usually the NDE to break the circulating current path</td>
</tr>
<tr>
<td>Install AEGIS® SGR on DE or NDE</td>
<td>Install AEGIS® iPRO opposite side of bearing insulation; usually DE</td>
</tr>
<tr>
<td>Motors over 100hp to 500hp (Low Voltage-600 volts AC)</td>
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<tr>
<td>Motors over 500hp (Medium Voltage-greater than 600 volts AC)</td>
<td>Isolate one bearing, usually the NDE to break the circulating current path</td>
</tr>
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</table>
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

Once 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. 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. When this event happens, temperatures are hot enough to melt bearing steel and severely damage the bearing lubrication.

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. 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.
AEGIS® SGR for Low Voltage and iPRO for Medium Voltage Motors

Low Voltage Motors
Supply voltage: 600 VAC or less
Recommended Technology: AEGIS® SGR

- Motors over 100 HP - recommend isolation of one bearing and AEGIS® SGR on the opposite bearing.

Medium Voltage Motors
Supply voltage: greater than 600 VAC
Recommended Technology: AEGIS® iPRO

- Recommend isolation of one bearing and AEGIS® iPRO on the opposite bearing.

Description:
- Design Type: AEGIS® SGR
- Circumferential Conductive MicroFiber rows in FiberLock™Channel
- Rows of fiber: 2
- Fiber overlaps shaft 0.030” (.76mm)
- OAL: 0.295” (7.5mm)
- OD: listed in AEGIS® Catalog

Mounting:
- Internal or External
- Select based on shaft diameter
- Split or Solid versions available
- Custom brackets optional

AEGIS® SGR Current Capability Chart

AEGIS® iPRO for Low Voltage and iPRO for Medium Voltage Motors

Low Voltage Motors
Supply voltage: 600 VAC or less
Recommended Technology: AEGIS® SGR

- Motors over 100 HP - recommend isolation of one bearing and AEGIS® SGR on the opposite bearing.

Medium Voltage Motors
Supply voltage: greater than 600 VAC
Recommended Technology: AEGIS® iPRO

- Recommend isolation of one bearing and AEGIS® iPRO on the opposite bearing.

Description:
- Design Type: AEGIS® iPRO
- Circumferential Conductive MicroFiber rows in FiberLock™Channel
- Rows of fiber: 6
- Fiber overlaps shaft 0.030” (.76mm)
- OAL: 0.625” (15.875mm)
- OD: Shaft + (refer to drawing)

Mounting:
- Internal or External
- Select based on shaft diameter
- Split or Solid versions available
- Custom brackets optional

AEGIS® iPRO Current Capability Chart

AEGIS® SGR for Low Voltage and iPRO for Medium Voltage Motors

Low Voltage Motors
Supply voltage: 600 VAC or less
Recommended Technology: AEGIS® SGR

- Motors over 100 HP - recommend isolation of one bearing and AEGIS® SGR on the opposite bearing.

Medium Voltage Motors
Supply voltage: greater than 600 VAC
Recommended Technology: AEGIS® iPRO

- Recommend isolation of one bearing and AEGIS® iPRO on the opposite bearing.

Description:
- Design Type: AEGIS® SGR
- Circumferential Conductive MicroFiber rows in FiberLock™Channel
- Rows of fiber: 2
- Fiber overlaps shaft 0.030” (.76mm)
- OAL: 0.295” (7.5mm)
- OD: listed in AEGIS® Catalog

Mounting:
- Internal or External
- Select based on shaft diameter
- Split or Solid versions available
- Custom brackets optional

AEGIS® SGR Current Capability Chart

AEGIS® iPRO for Low Voltage and iPRO for Medium Voltage Motors

Low Voltage Motors
Supply voltage: 600 VAC or less
Recommended Technology: AEGIS® SGR

- Motors over 100 HP - recommend isolation of one bearing and AEGIS® SGR on the opposite bearing.

Medium Voltage Motors
Supply voltage: greater than 600 VAC
Recommended Technology: AEGIS® iPRO

- Recommend isolation of one bearing and AEGIS® iPRO on the opposite bearing.

Description:
- Design Type: AEGIS® iPRO
- Circumferential Conductive MicroFiber rows in FiberLock™Channel
- Rows of fiber: 6
- Fiber overlaps shaft 0.030” (.76mm)
- OAL: 0.625” (15.875mm)
- OD: Shaft + (refer to drawing)

Mounting:
- Internal or External
- Select based on shaft diameter
- Split or Solid versions available
- Custom brackets optional

AEGIS® iPRO Current Capability Chart
Motors up to and including 100 HP (75 kW) - Low Voltage

General recommendations: For induction motors either 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

⚠️ Follow all safety precautions. MSDS available for download at www.est-aegis.com

Motors Greater than 100 HP (75 kW)

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.

⚠️ Product recommendation:
  - Low Voltage Motors up to 500HP: AEGIS® SGR
  - Low Voltage Motors over 500HP: AEGIS® iPRO
  - Medium Voltage Motors: AEGIS® iPRO

For Technical Support: sales@est-aegis.com or call 1-866-738-1857
Motors Where Both Bearings are Insulated - Any HP/kW Low Voltage or Medium Voltage Motors:

- 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.

**Product recommendation:**
- Low Voltage Motors: AEGIS® SGR
- Medium Voltage Motors: AEGIS® iPRO

Motors with Cylindrical Roller, Babbitt or Sleeve Bearings:

- Cylindrical Roller Bearing, Babbitt, or Sleeve bearing: Bearing housing should be isolated or use insulated bearing.
- Motors with isolated 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.
- Colloidal Silver Shaft Coating PN CS015 is required for this type of application.

**Product recommendation:**
- Low Voltage Motors: AEGIS® SGR
- Medium Voltage Motors: AEGIS® iPRO

Note: If an isolated cylindrical roller bearing or sleeve is not possible, then isolate the opposite roller bearing and install an AEGIS® Ring at the cylindrical roller bearing side.
Vertical Solid Shaft Motors up to and including 100 HP (75 kW) - Low Voltage:

- Lower Bearing: Install one AEGIS® SGR Bearing Protection Ring.
- AEGIS® SGR 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.

⚠️ Product recommendation: AEGIS® SGR

Follow all safety precautions. MSDS available for download at www.est-aegis.com

Vertical Solid Shaft Motors Greater than 100 HP (75 kW):

- 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.
- Colloidal Silver Shaft Coating PN CS015 is required for this type of application.

⚠️ Product recommendation:
- Low Voltage Motors: AEGIS® SGR
- Medium Voltage Motors: AEGIS® iPRO
Vertical Hollow Shaft Motors up to and including 100 HP (75 kW) - Low Voltage:

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

**Product recommendation:** AEGIS® SGR

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 Shaft Motors Greater than 100 HP (75 kW):

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

**Product recommendation:**
- Low Voltage Motors: AEGIS® SGR
- Medium Voltage Motors: AEGIS® iPRO

Application notes are intended as general guidance to assist with proper application of AEGIS® Bearing Protection Ring to protect motor bearings. All statements and technical information contained in the application notes are rendered in good faith. User must assume responsibility to determine suitability of the product for its intended use.
Grounding

The AEGIS® Ring conducts harmful shaft voltages away from the bearings to ground. Voltage travels from the shaft, through the conductive microfibers, through the housing of the ring, through the hardware (or conductive epoxy) used to attach the ring to the motor, to ground. All paths must be conductive.

Note: Overspray on end bracket must be removed to ensure a conductive path to ground. Clean all fits.

Shaft Preparation for Internal and External Installation

AEGIS® Rings should not operate over a keyway because the edges are very sharp. For proper performance:

Adjust or change spacer and screw lengths to avoid the keyway; or

Fill the keyway (in the area where the AEGIS® microfibers will be in contact with the shaft) with a fast-curing epoxy putty such as Devcon® Plastic Steel® 5 Minute® Putty(SF).

Motor shaft must be conductive:

Shaft must be clean and free of any coatings, paint, or other nonconductive material (clean to bare metal). Depending on the condition of the shaft, it may require using emery cloth or Scotch-Brite™. If the shaft is visibly clean, a non petroleum based solvent may be used to remove any residue. If possible, check the conductivity of the shaft using an ohm meter.

Ohms test:

Place the positive and negative meter leads on the shaft at a place where the microfibers will contact the shaft. Each motor will have a different reading but in general you should have a maximum reading of less than 2 ohms. If the reading is higher, clean the shaft again and retest.
Shaft Preparation continued

Colloidal Silver Shaft Coating (CS015) is recommended for all applications. The silver coating enhances the conductivity of the shaft and also lessens the amount of corrosion that can impede the grounding path.

Treating the shaft of the motor prior to installing the AEGIS® Ring:

1. Shaft must be clean and free of any coatings, paint, or other nonconductive material. The shaft must be clean to bare metal.
2. Thoroughly stir the silver coating.
3. Apply a light coat of the AEGIS® Colloidal Silver Shaft Coating to the area where the AEGIS® microfibers are in contact with the motor shaft. Apply evenly all around the shaft.
4. Allow to dry before installing the AEGIS® Shaft Grounding Ring. Coating will cure at room temperature in 16-20 hours or in 30 minutes at 120-200°C. A heat gun will cure the materials in seconds.

Follow all safety precautions. MSDS for CS015 available for download at www.est-aegis.com

Install the AEGIS® SGR so that the aluminum frame maintains an even clearance around the shaft. AEGIS® conductive microfibers must be in contact with conductive metal surface of the shaft.

Do not use thread lock to secure the mounting screws as it may compromise the conductive path to ground.

If thread lock is required, use a small amount of EP2400 AEGIS® Conductive Epoxy to secure the screws in place.

After installation, test for a conductive path to ground using an Ohm meter. Place one probe on metal frame of AEGIS® SGR and one probe on motor frame.

Motor must be grounded to common earth ground with drive according to applicable standards.

Where AEGIS® SGR is exposed to excessive debris, additional protection of the AEGIS® SGR fibers may be necessary.

Install an o-ring or v-slinger against the ring.

Contact AEGIS® Customer Service/Engineering for assistance with specific applications.
Motors Controlled by PWM Drives (VFD)
Electrical Bearing Damage Protection

Engineering Specification:
Construction Specification Institute Section 23 05 13

MOTORS
23 05 13

2.1 Motors

A. General Requirements:

1. All motors operated on variable frequency drives shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring with a minimum of two rows of circumferential micro fibers to discharge electrical shaft currents within the motor and/or its bearings.

2. Application Note: Motors up to 100HP shall be provided with one shaft grounding ring installed either on the drive end or non-drive end. Motors over 100HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the manufacturer's recommendations.

Recommended part: AEGIS® Bearing Protection Ring
Recommended source: Electro Static Technology-ITW
Manufacturer of AEGIS® Bearing Protection Ring
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