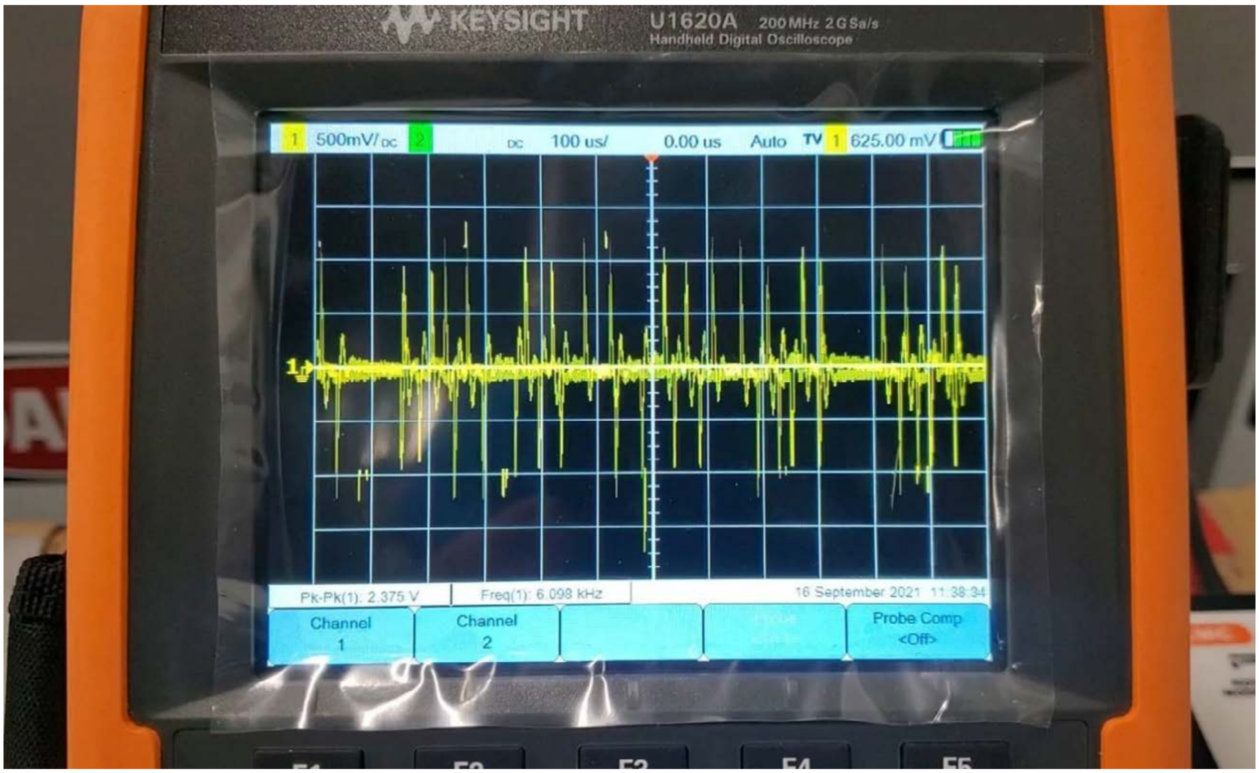
SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)

VIBES Corp®
Est. 1967
Vibration Industrial Balancing & Equipment Services, Corporation
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Electrically Induced Bearing Damage (EIBD) aka Shaft Currents aka Electrical Discharge Machining (EDM)

Identification, Cause, Effect, Prevention, and Solutions



Electrical discharge levels seen on an Oscilloscope using Rogowski Coil helps determine potential shaft current issues

This article contains information about, and offers explanations for, the electrical phenomenon that causes motor bearing defects due to micro-arcing (also referred to as shaft currents). Shaft currents leads to Electrically Induced Bearing Damage (EIBD) and has been found on 600V and 460V VFD applications. EIBD has been confirmed using vibration analysis, metallurgical testing and electrical engineering studies. EIBD is not present everywhere and on all motors; but the potential exists, and it has been found at numerous locations from 1992 to last night on a motor bearing replacement project.

Written by: Garrett Sandwell, MET, CVA, ASNT 3
CEO
Original article: 2002 with revisions up to 2022

SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)

VIBES Corp®
Est. 1967

Vibration **I**ndustrial **B**alancing & **E**quipment **S**ervices, Corporation

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

Introduction to VIBES Corp®

Why work with us? Serving Canadian Industry for over 50 Years.

VIBES Corp's reputation was built and established on thousands of promises fulfilled over 50 years in business across Canada. Superior quality service, sales and training courses provided on the intelligent specialist level has been the standard and always will be since our vibration and balancing business was formed in Calgary, AB, in 1982. (Formerly Industrial Balancing Ltd. Est. 1967) In the final real-time analysis VIBES Corp will deliver more value and peace of mind.

What do we do? Expert technical services and preventative maintenance programs using advanced instruments and tools to solve various vibration, balance and mechanical noise related problems.

Factory trained and repair specialists on HVAC, fans, blowers, cooling towers, pumps, motors, industrial rotors. FlaktWoods Varofoils and Aerofoils, Sheldons Axico, Aerovent, Novenco, New York Blower, Chicago Blower, Canadian/Buffalo Blower, CML Northern Blower, Joy Axivane, Twin City, Alphair, Allied Blower, Markhot Varivane, Loren Cook, BAC, Evapco, Marley, Hoffman, Spencer, Baldor, Reliance, Trane, Carrier, Eng.Air, Haakon, WEG, Leeson, GEC, GE, Emerson, Westinghouse, Toshiba, Siemens, US Electric, Delhi, PennBarry, Armstrong, Westcan, Bell & Gossett, and most types of rotating, diesel engines & reciprocating machinery.

What do we sell, supply, install & service?

- WEG Electric Motors
- Canada Support - Symphony Industrial AI - Engineered Vibration Solutions & Client Training
- COOLBLUE - Inductive Absorbers & Chokes = VFD any motor shaft current bearing damage protection
- DRIVE SYSTEM PARTS: Fans, Bearings, Sheaves, Couplings, Belts, Shafts, Misc.
- VIBRATION CONTROL, Isolation & thrust spring mounts, monitoring, trending, alarm/trip switch 24/7 machine protection

The machinery under our professional health care program = **VIBES-GUARD PdM Program®** are treated as if our own. We use proven technologies and methodologies along with our multi-technical and electro-mechanical (VIV, ASD, VPM, CPM, VFD, EIBD, EDM, Shaft Currents, etc.) training, skills, and experiences for total overall analysis and evaluations. When the total analyzed facts about a machine, motor or engine are known we formulate an accurate condition report and recommend the best possible solutions. We work with clients to organize necessary actions in order of urgency or budgets.

Where do we work? (Commercial Towers, Infrastructure Facilities, Industrial Plants, Lumber Processing & Marine Ports, etc.)

Our service area is mainly BC Lower Mainland and Vancouver Island. If requested we can service other areas.

Who have we worked with?

VIBES Corp service capabilities have been used and accepted by high-ranking officials in:

- other service companies
- manufacturing and processing
- engineering firms
- universities
- colleges
- hospitals
- cold storage
- power plants and dams
- sewage and water treatment plants
- government infrastructure facilities
- oil and gas
- biogas energy systems
- transportation and construction
- commercial towers
- agricultural
- mining
- ski hills
- marine-terminals and ships
- asphalt and cement
- saw mills
- pulp and paper
- research and development
- machining / fabrication
- chemical plants
- restaurants
- skytrain and railway tunnels

VIBES Corp accepts: EFT, VISA, Mastercard, Discovery, Debit & SWIFT

Vendor Compliant for Property Owners, Management Firms of Commercial Buildings, Hospitals, Industrial Sites, & Infra-Structure Facilities

SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)

VIBES Corp®

Est. 1967

Vibration **I**ndustrial **B**alancing & **E**quipment **S**ervices, Corporation

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

We take due diligence to the highest level on all projects regardless of size or budget.

Learn About Articles

You can download educational articles from our home page at www.vibescorp.ca. Here are five:

1. Learn About Vibration Volume 1: Basic Understanding Of Machinery Vibration
2. Learn About Vibration Volume 2: Advanced Vibration Analysis
3. Learn About Electrically Induced Bearing Damage & Shaft Currents
4. Failure Prevention Of Variable Pitch in Motion Axial Fans and Controllable Pitch In Motion Axial Fans
5. Learn About Agricultural Machinery Vibration Solutions

The photos below show typical projects that we have completed.

Fig 1. The failure was due to defective bearing.
Fig 2. The stainless steel guard helps prevent moisture contamination in cooling tower fan bearings (a very common problem).
Fig 3. A new fan was installed due to a complete failure of the original.
Fig 4. Shows a 200HP motor and fan repair/replacement.

Fig. 1

Fig. 3

Solution to Fig. 1 Replaced both Fan Bearings & New Motor Required.

Solution to Fig. 3 Installed Brand New Controllable Pitch Fan & Repaired Motor.

Solution to Fig. 2 The Guard has prolonged the Life Span of the Fan Bearings from 3 years to over 14 years.

Solution to Fig. 4 Replaced the Old Motor based on 20 years of running time and Completed Variable Pitch in Motion Fan Maintenance.

Fig. 2

Fig. 4

Vibration Industrial Balancing & Equipment Services, Corporation
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Electrically Induced Bearing Damage & Shaft Currents

Preface

The purpose of this report is to provide the reader with an introductory knowledge of the phenomenon of Electrically Induced Bearing Damage (coined "EIBD" from 1992) also known as Shaft Currents, and/or Electrical Discharge Machining, which situations it occurs, how to identify it, and how to remedy the problem. VIBES Corp have repaired, replaced, and analyzed various bearings used in numerous VFD applications and in motors from 5 HP to 350 HP. The problem started showing up in about 1992 (or earlier) and is still present in 2020. This major problem pertained to rapid defects in motor bearings that suddenly developed very loud noise and erratic vibration acceleration spectrum data necessitating immediate solutions and further studies.

Solutions and studies to answer these questions:

1) Why this happened so quickly on any VFD applications.
2) How to prevent the problem from reoccurring once new bearings are replaced.
3) How to prevent the problem on new VFD installations.

This report is meant to provide the reader with accurate facts and knowledge on EIBD so that you can solve problems on your own or have VIBES Corp assist.

Summary

EIBD (Electrically Induced Bearing Damage) is the result of an induced voltage in the rotor and shaft of a motor. The IGBT's (Insulated Gate Bipolar Transistors) used in some PWM (Pulse Width Modulation) and VF (Variable Frequency) drives act as high frequency switches. Their switching can cause bearing discharge current which, when coupled with the fast rise times of the IGBT inverter output, causes an induced voltage in a motor's rotor. Bearing grease has a certain dielectric strength to it, but when the voltage induced in the rotor capacitive couples to the shaft, it may exceed this strength and then current flows from the shaft through the lubricated bearing into the motor frame. The current causes arcing through the lubricant, which results in pitting on the bearings and fluting on the bearing races, leading to premature failure of the complete bearings. All it takes is a shaft voltage of 6V to cause arcing through a bearing lubricant, and in some (lab experiments) cases with VFD's, voltage peaks have been seen to reach 70 to 370V on the shaft, clearly above any acceptable level. A conductive coupling between the driven and drive shaft can result in damage to the driven equipment's bearings as well. Recommendations for this problem in most economical order are, firstly, to use electro conductive grease in sealed bearings, which acts as a partial insulator and will help re-direct a percentage of the

induced current from conducting through the bearing. Electro conductive grease inside sealed ball bearings has proven to avoid EIBD problems for over 5 years and on motors ranging from 10 HP to 125 HP. After 5 years or more and/or depending on vibration and noise analysis the process of having to replace the motor bearings with electro conductive grease would be repeated.

Installing a shaft grounding system can also be considered. The rotor grounding seals or brushes come in two arrangements. The first is external and the other is internal. The rotor grounding seals require machining (internal) or drill and tapping (external) for the assembly to accurately fit onto the shaft and are typically mounted on the drive end bell of a motor. In some cases both ends of the motor shaft are grounded using the seals. The rotor grounding seals and brushes have carbon fibres that contact the shaft and create a path to take the micro electrical current back to the stator – avoiding the path through the ball bearings.

In two of the most unusual cases of serious EIBD ever discovered by this writer, the problem required an electrical engineering study that recommended the installation of Inversine Advanced Universal Sinewave Filter (AUSF). See sections of one study completed by Tony Hoevenaars, P. Eng. Mirus International [mirusinternational.com], on pages 20 – 25.

Introduction

Electrically Induced Bearing Damage (EIBD) is a widespread problem that has been overlooked and/or avoided since 1992. The reason the word "avoided" has been used is due to the unknown issue regarding whether or not EIBD was a motor or VFD manufacturer warranty problem. In the end the client usually accepts the problem and costs to resolve EIBD. Therefore, another reason for writing this article is to make the end users aware of the issue so they can take the necessary steps or ask questions related to avoiding EIBD at the design or installation stage of a VFD retrofit or newer projects. Over the last few years some VFD manufacturers are installing protective parts to avoid EIBD but as an optional cost. See information "CoolBlue™ Inductive Absorbers" at vibescorp.ca/coolblue.

EIBD has been found on 600 and 460 V and possibly higher service voltages.

Regardless of the make or model of the motor or variable frequency drive equipment studies have proven that EIBD can occur within one week, six months or longer from the day of repairs or new start up. The extent of motor bearing electrical damage on many motors and at numerous locations resulted in rapidly increasing noise levels and erratic high frequency acceleration vibration spectrum data. In all studies done to date the bearing defects are similar as follows: bearing balls are frosted or dull grey in appearance; raceways have deep, irregular wear all around (fluting); and grease may be discoloured and have a burned odour.

Metallurgical studies called SEM (scanning electron microscope) have also been completed on several bearings that were found with EIBD defects. See SEM photos attached on pages 14 and 15.

Variable Frequency Drives – VFD/AFD/VSD

To understand Electrically Induced Bearing Damage, a good understanding of VFD's (Variable Frequency Drives) must first be attained. When VFD's started to become popular (since the late 80's) one of the major issues was shaft current. For quite a while the problem was treated in the usual manner: insulating the motor ODE (Opposite Drive End) bearing, or adding a grounding brush on the motor drive end (DE) Driven end. The problem was that each of these proven solutions yielded mixed results. Many people disagreed on which solution was the best and many reported less-than-satisfactory results with either method. Higher switching frequencies of around 20 kHz caused more bearing problems than slower drive settings of around 5 kHz but there is no clear line above which problems are expected. The VFD works by rectifying AC (Alternating Current) to DC (Direct Current), and chopping the DC into positive and negative pulses to simulate an AC sine wave. Varying the DC pulse width simulates a variable AC sine wave and changes the frequency, thereby changing the motor speed. One problem with that is the common voltage (the voltage common to both input terminals of a device). When a 3-phase motor operates from a true sine wave, the common mode voltage is always zero, but with the VFD, the balance no longer exists.

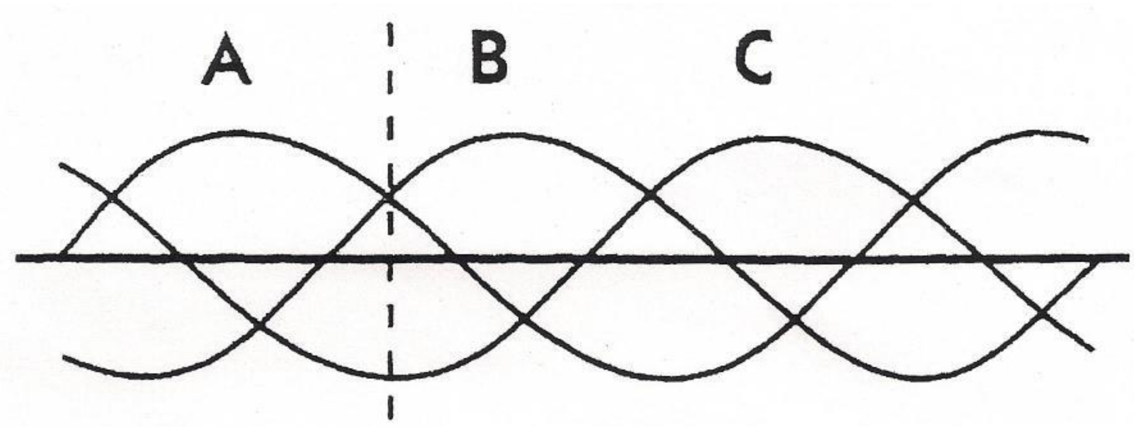


Figure 1: 3 phases 120 degrees apart from each other

Draw a vertical line (that's a point in time) at any point on the graph. Sum the voltages (above the horizontal axis is positive, below is negative), and the common mode voltage is always zero.

DC is either positive or negative, so at any point in time the three phases are either plus, plus, minus or plus, minus, minus. Common mode voltage is essentially line voltage, which, if not zero, as in the three-phase motor case, induces a current on the motor shaft. With the introduction of VFD's, shaft currents became a significant problem for motors, even ones much smaller than had previously experienced problems.

The Cause of EIBD

The earliest known in-depth study dealing with EIBD (Electrically Induced Bearing Damage) was completed in 1994 by Hugh Boyanton. His study took six years to complete and involved testing and evaluating data from hundreds of DC and AC motors running on VFD's. The root cause of EIBD was found to be shaft-to-frame voltage or, simply, shaft voltage. Low shaft voltage between 3 to 5 volts is considered normal and, according to motor manufacturers, will not cause a problem with bearings. Using a battery powered digital oscilloscope the shaft to frame voltage on a working motor experiencing EIBD can present ranges from 8 to 19 volts. In some lab tests, voltage spikes can even be in the order of 70 to 370 volts, much higher than what is considered a normal voltage. These high frequency voltage pulses result in capacitive coupled currents which can flow through paths within the motor that are normally considered to be electrical insulators. In systems with a conductive shaft coupling, currents can also flow from the motor through the driven equipment, potentially putting the driven-equipment bearings at risk as well. Over time this current flow through the bearings and the frame causes arcing and pitting in the raceways of the ball bearing, rapid increase in noise and erratic vibrations, higher temperatures, and ultimately, premature failure can occur. Pictures of defective bearing races and roller-balls can be seen on the photo below (Figure 2) and on pages 12 – 15. The current flow can also result in fluting, which is when material properties in the bearing races are altered through re-hardening after arcing, which is almost as if it has been welded. This creates brittle areas in load zones of the race, which results in fracturing, causing a fluted pattern as shown in Figure 2.

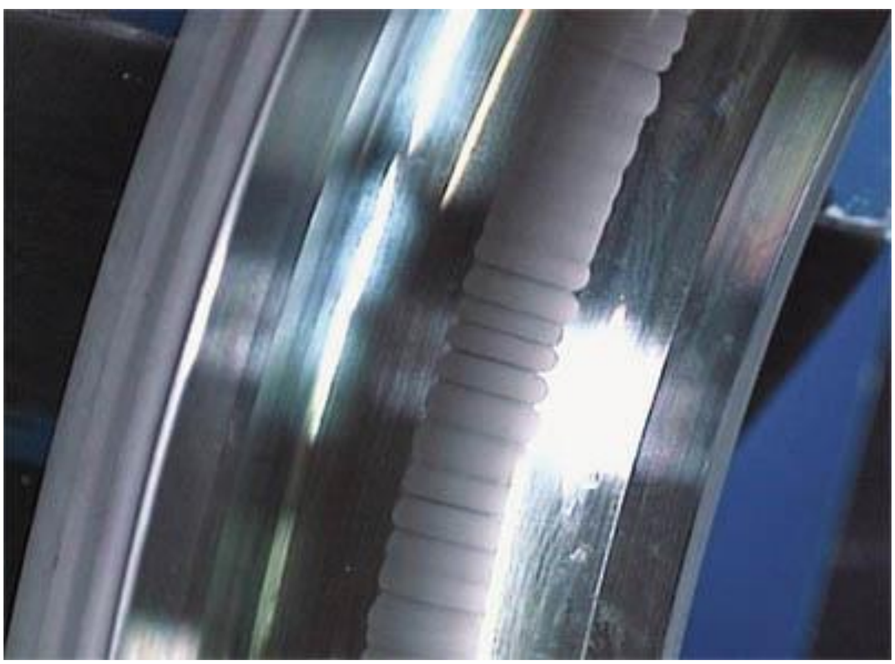


Figure 2: Fluting pattern in an outer bearing race. Vibration levels for the bearing of a motor that is experiencing these defects due to EIBD can be seen on pages 16 – 19.

Bearing Current Paths

The most common bearing current paths in an inverter-driven motor system are shown in Figure 3.

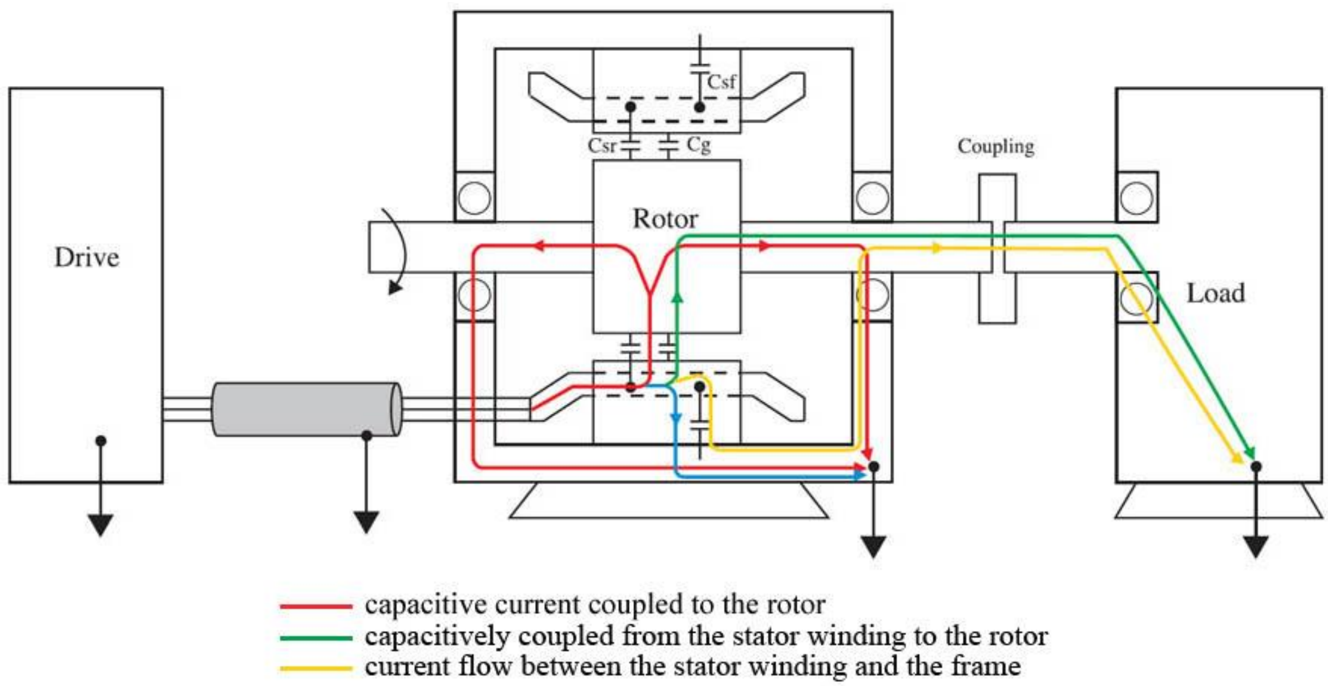


Figure 3: Common bearing current paths in an inverter-driven motor system

The red current path is capacitive current coupled to the rotor, with a return path through the motor bearings, ground connection, and finally to the drive ground. This path is most important in applications where the motor shaft is not electrically connected to a load or where there are no driven-load bearings. The green path in Figure 3 represents current that is capacitively coupled from the stator winding to the rotor with a return path to the drive ground through the driven load. A conductive coupling is required, and the driven load must have its own bearings to support the shaft. The green current flow has the potential to create damage in the load bearing or possibly the coupling itself. The gold current path in Figure 3 represents current flow between the stator winding and the frame. This current flows through the stator winding insulation, which is conductive at high frequencies. With a non-ideal motor to drive high-frequency ground connection, this current flows back to the drive ground through the motor frame, the motor bearing, the motor shaft, the conductive coupling, the load bearing, and the load ground. Current through this path has the potential to damage the motor and load bearings, as well as the motor-to-load coupling. This current only exists if the motor-to-load coupling is electrically conductive.

SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)

VIBES Corp®
Est. 1967
Vibration Industrial Balancing & Equipment Services, Corporation
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Conclusions

1. VFD's present in motor applications do cause an induced current on the motor shaft as well as the rotor. Normally in 3-phase motors the sine wave is true and the common mode voltage is zero; but with a VFD, that balance is lost, and the common mode voltage, which is essentially a line voltage, needs to dissipate, so it does this through the motor frame, rotor or the shaft, inducing a current.

2. Motor bearings are not the only things subject to premature failure when experiencing EIBD due to a VFD. If a flexible coupling which connects the motor drive-end shaft to the driven shaft is conductive, a capacitively coupled current may travel down the shaft, damaging the bearings on the driven component and possibly even the coupling itself.

3. Arcing, pitting and fluting are what cause the damage to the bearing due to the current flow through it. The arcing heats up the bearing race or roller-ball material and results in either pitting (which is when the bearings chemical properties change and it condenses, making the roller-balls no longer flush with the inside and outside races), or fluting (which is when the bearing material re-hardens after arcing but now has brittle areas in load zones of the race, which results in fracturing and the fluting pattern).

Recommendations

The first (and least costly) solution to combat EIBD is to replace the defective motor ball bearings with new sealed ball bearings that have been cleaned out and repacked with electro conductive grease. The electro conductive grease acts as an insulator and helps prevent or reduce micro arcing through the bearing.

In motors that have a roller bearing in the drive end repack the opposite end (sealed) ball bearing with electro conductive grease. Replacement of the defective motor bearings would require a few hours work depending on motor arrangement in the system. First remove the motor end bells and clean thoroughly. Check the shaft journals for any defects and clean up. Remove seals from the new ball bearing one at a time to clean out the factory grease, then pack the bearing with electro conductive grease about 50% full and install the seals tight. Heat the new motor ball bearings to exactly 110°C then install onto shaft journals. The standard for all new motor bearings inner race is a shrink fit to the shaft. Re-assemble the motor and rotate by hand. If free then run the motor under no load for a few minutes.

This method has been proven to prolong the lifespan of bearings from 5 to 16 years from 10 HP to 125 HP VFD driven motors. Note: Vibes Corp still uses this method when budget is a factor and/or convenience (no other logical solutions) = time issues. There is no knowledge of using electro conductive grease in ball bearings above 125 HP (6318 C3) based on our experience or from any other articles so if considering to do so please confirm or google if it's been done and worked on higher HP motors or larger bearings.

Vibration analysis and bearing noise vs acceleration data can be trusted to trend and confirm if the problem has been solved for a few years and/or when new bearings are required again. Fact: When motor bearings develop shaft current wear damage there will always be a noticeable increase in the noise levels near the motor. When bearings are in serious condition due to shaft current damage it sounds like a skill saw cutting wood.

The second (more costly than the first) solution is to install motor shaft grounding rings or brushes. The motor shaft is grounded with a system of carbon brushes that create a low impedance path to ground that the current will follow – instead of going through the bearings. Two types of motor shaft grounding rings are available:

1. External (Shaft Grounding Rings = AEGIS SGR) or (external carbon brush = Baldor SGB) are installed around the shaft and the bracket is fastened to the motor end bell by drilling and tapping holes for mounting bolts. A ground wire should be connected between the seal ring and the stator for best results. The external ring or brush will wear and be subjected to dirt or moisture that will require some maintenance and future replacement.
2. Internal (Shaft Grounding Rings = AEGIS SGR) or (Inpro-Seal MGR) are installed at the machine shop. The drive end bell is machined out and a seal ring is pressed in. The internal ring is a better technology, hence more costly than the external ring. It requires more downtime and exact detailed measurements but requires no further maintenance. Note: on some jobs a new end bell was ordered and modified with the internal ring (SGR or MGR) then installed.

The third solution is to install a sine wave filter system. To date this solution has been used on two projects where the EIBD problem was uncontrolled using all other solutions mentioned previously.

The technology using this system is called Inversine Advanced Universal Sine wave Filter. Mr. Tony Hoevenaars, P. Eng. of Mirus International [mirusinternational.com], has kindly offered a few pages of his product technology for this EIBD article (find this information on pages 20 – 25).

The fourth solution, which has been tried with mixed results, is ceramic sleeves to isolate bearings from the shaft or ceramic bearings. Ceramic alternatives are expensive and may have a special application, but according to electrical engineers' feedback from Europe, the rotor must still be grounded on either end. This is due to the fact that, on a large horsepower motor rotor, it could develop much higher voltage if the shaft is not grounded so that arcing between the rotor and stator may occur which could cause an arc flash from rotor to stator thus complete motor failure.

A fifth solution to avoiding shaft currents / EIBD altogether is by converting to Magnetic Adjustable Speed Drives. (Cost to retrofit or covert VFD to ASD may be an issue on smaller HP motors.) This technology has been used at several major facilities in Vancouver, Canada for over 10 years. Our experience and site visits where Fluxdrive ASD are used shows the product and technology are well built and engineered to last. A very popular Vancouver attraction had no other alternatives but Fluxdrive ASD for controlling EIBD/Shaft currents due to the water treatment salt contamination in the spaces and moisture environment where VFD and other solutions would never survive. Fluxdrives are garden or pressure hose washable. Other large ASD or magnetic drive alternatives (couplings) are used on heavy machinery as a soft start or torque control device. Also Google "MagnaDrive". For more detailed information about variable speed magnetic drives see pages 35 – 38.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Electrical Discharge Measurement Tool: SKF TKED 1 Meter, Can help you discover if your motor has a problem before costly failures occur. It's called EDD (Electrical Discharge Detector) Pen (Model # TKED 1). This is a tool for detecting electrical discharges (or pulses) and erosion in bearings of electrical motors. It's easy to use and cost-effective. Learn more about this tool on pages 65 – 74, or contact SKF.

See page 23 for various other solutions.

The sixth solution = (on many VFD in Vancouver, Canada) at several facilities has proven smart and very effective where EIBD would have otherwise developed within one year or less. CoolBlue™ products have been installed inside VFD cabinets from 5 HP to 350 HP with excellent results. CoolBlue™ Inductive Absorbers are installed around the three phase wires inside the VFD compartment or a CSA enclosure nearby. The CoolBlue™ technology reduces (harmful) electrical discharge levels (pulses) that travel through the wires to the motor so they don't reach the motors. Note: Electrical discharge levels is the actual main source of shaft current buildup in VFD motors. Rogowski Coil tests (see photos and graphs on page 30) are used before and after installation to confirm electrical discharge levels have been reduced below harmful levels. See more information about CoolBlue™ on pages 26 – 34. Also you can review a major CoolBlue™ case study at a Geo Thermal Pump Station located on our home page at www.vibescorp.ca

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Electrically Induced Bearing Damage (EIBD) on a Bearing Race

Figure 4: The bearing race shown in this photo was found in the advanced stage of fluting. Vibration spectrum data for this bearing can be reviewed on pages 16 – 19. See scanning electron microscope (SEM) images for the above bearing race on pages 14 and 15.

EIBD / Shaft Current bearing defects have been found at numerous locations on 600Volt (Canada) and 460Volt (USA) VFD motor applications.

Electrically Induced Bearing Damage (EIBD) on a Bearing Race

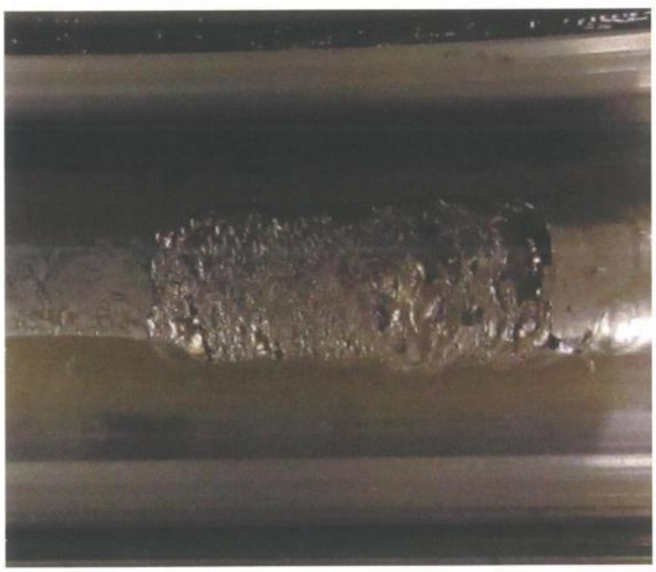


Figure 5: These two photos of the same bearing outer raceway show advanced shaft current / electrically induced bearing damage just prior to failure. Taken September 2011.

Electrically Induced Bearing Damage (EIBD) on a Bearing Race

This SEM image is from page 12 bearing race

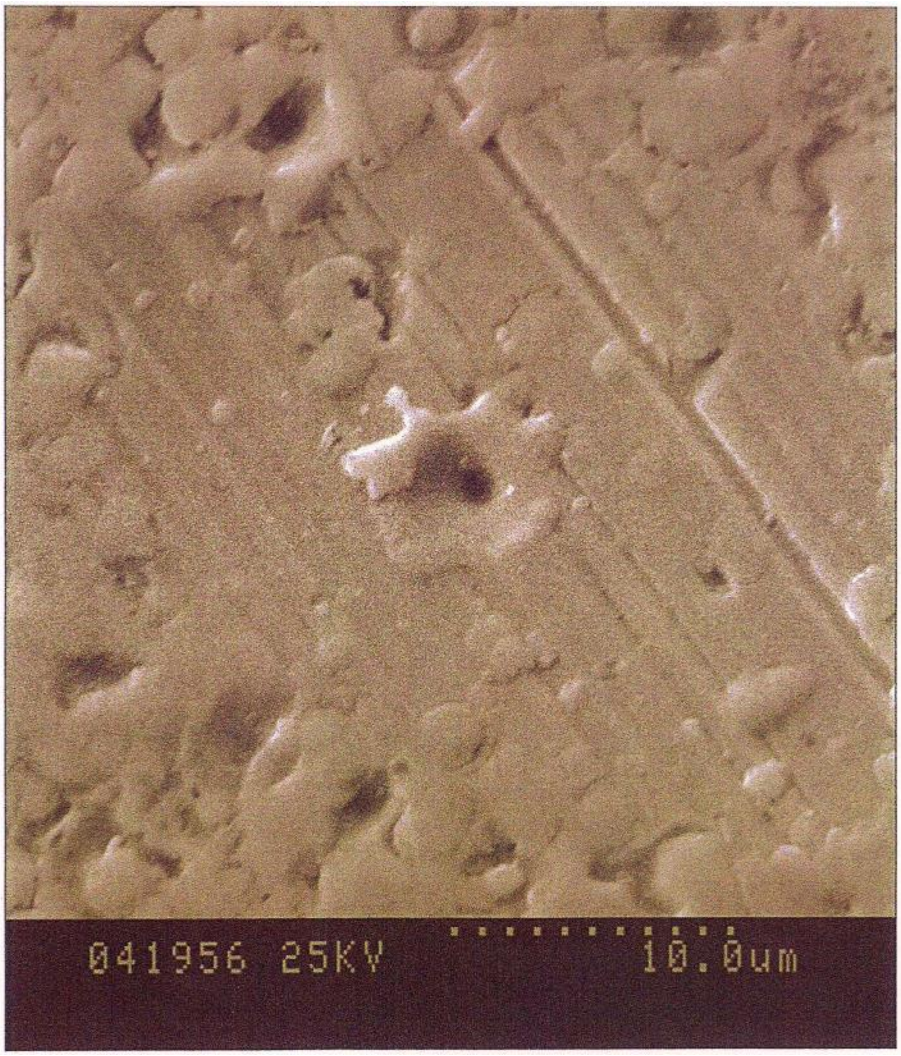


Figure 6: High magnification SEM view of particles flattened onto drive end outer raceway running surface showing variety of particle sizes. Material has clearly been molten at the time of deposit. Magnification 4,500X.

EIBD / Shaft Current bearing defects have been found at numerous locations on 600Volt (Canada) and 460Volt (USA) VFD motor applications.

Electrically Induced Bearing Damage (EIBD) on a Bearing Race

This SEM image is from page 12 bearing race

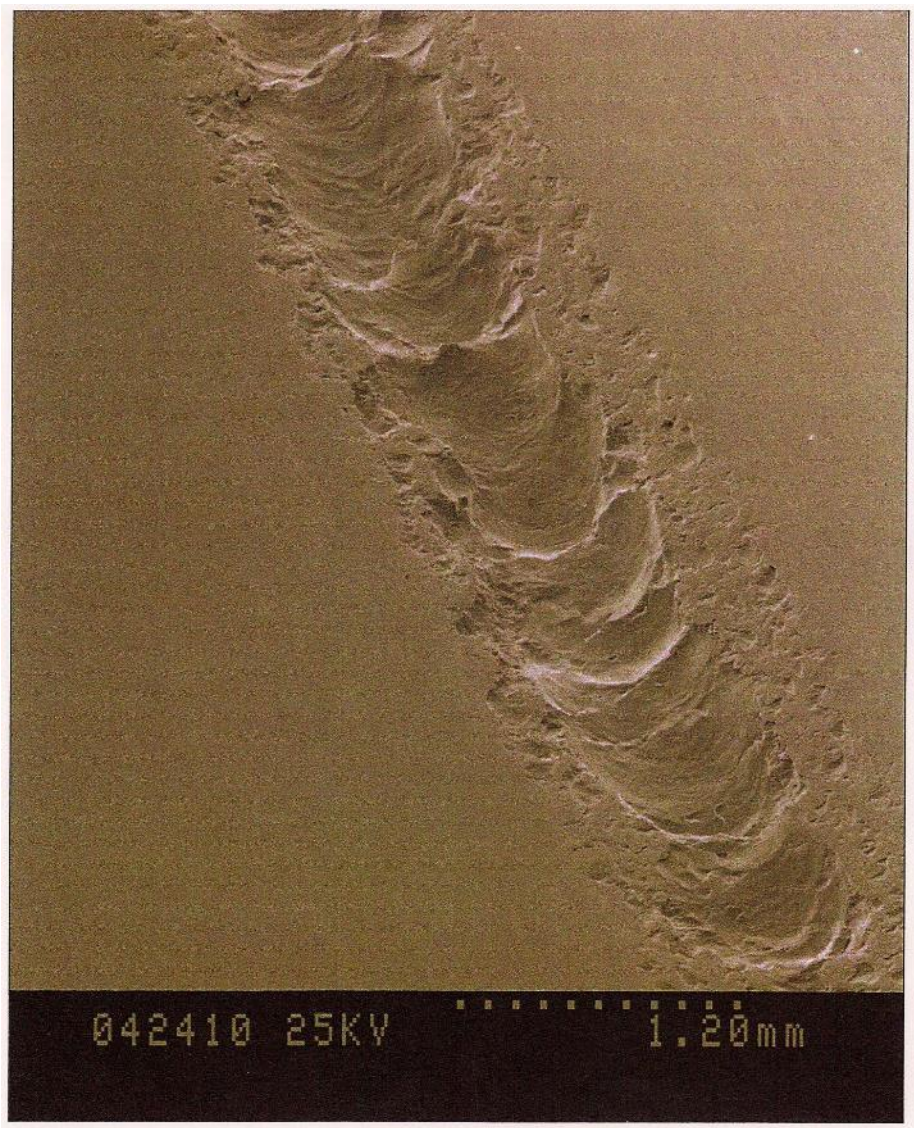


Figure 7: SEM image of the spalling observed on the inside surface of the outer raceway. Magnification 37.5X.

EIBD / Shaft Current bearing defects have been found at numerous locations on 600Volt (Canada) and 460Volt (USA) VFD motor applications.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Electrically Induced Bearing Damage & Shaft Current Issue @ 39 Hz (VFD) Motor ODE Sensor Location 1. Acceleration g rms High Frequency Range.

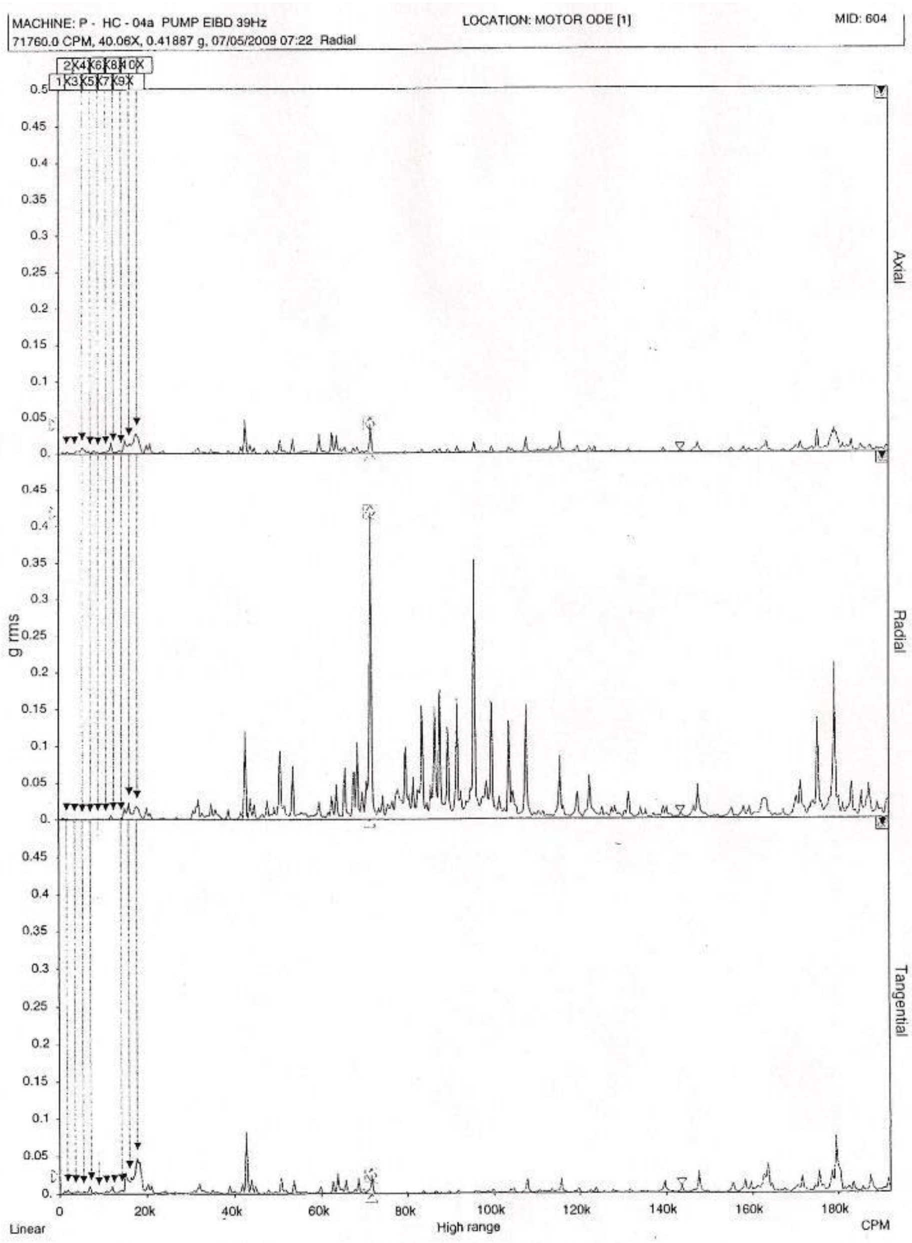


Figure 8: Electrically Induced Bearing Damage @ 39 Hz. The vibration spectrum data shown above was recorded from the bearing (photo) on page 12.

Electrically Induced Bearing Damage & Shaft Current Issue @ 39 Hz (VFD) Motor DE Sensor Location 2. Acceleration g rms High Frequency Range.

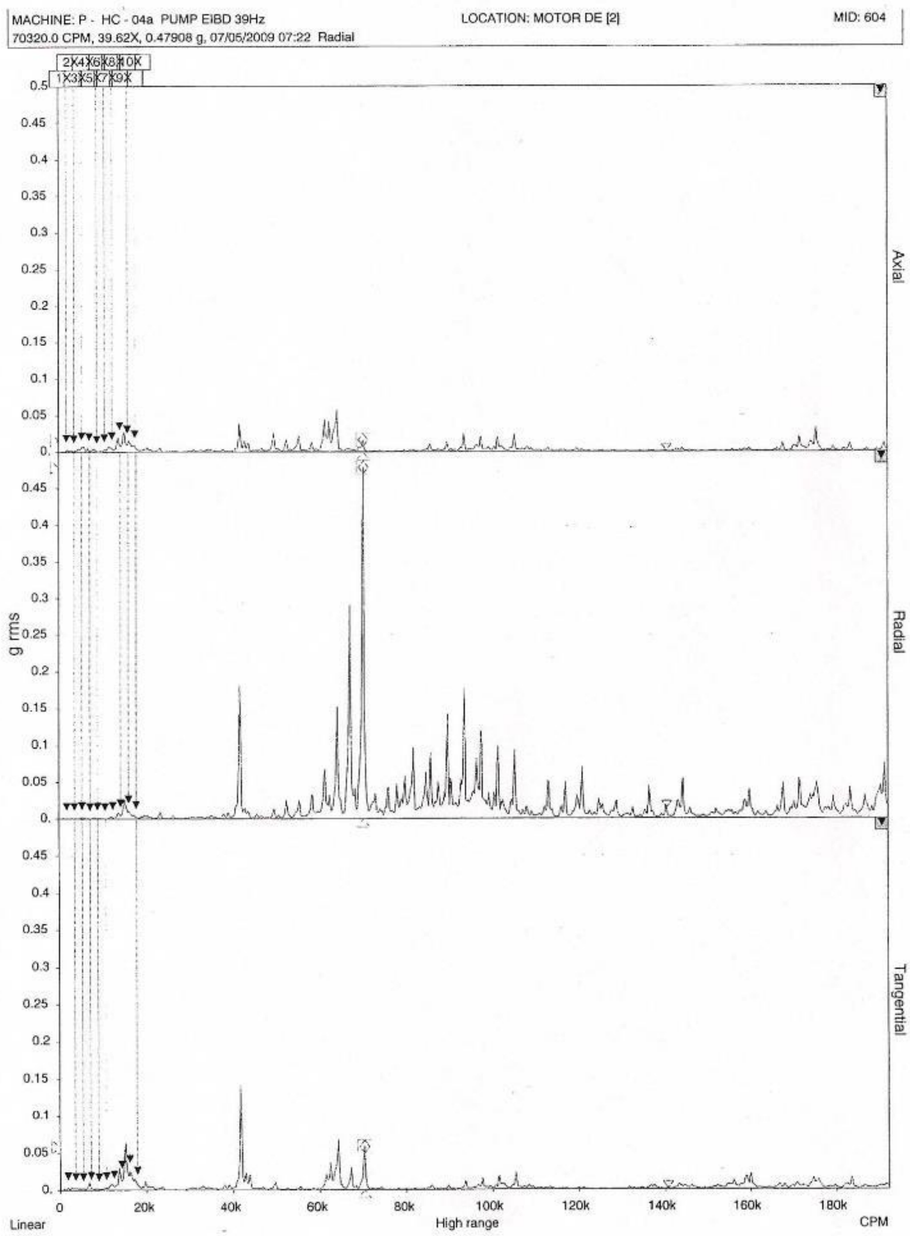


Figure 9: Electrically Induced Bearing Damage @ 39 Hz. The vibration spectrum data shown above was recorded from the bearing (photo) on page 12.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Electrically Induced Bearing Damage & Shaft Current Issue @ 60 Hz (VFD) Motor ODE Sensor Location 1. Acceleration g rms High Frequency Range.

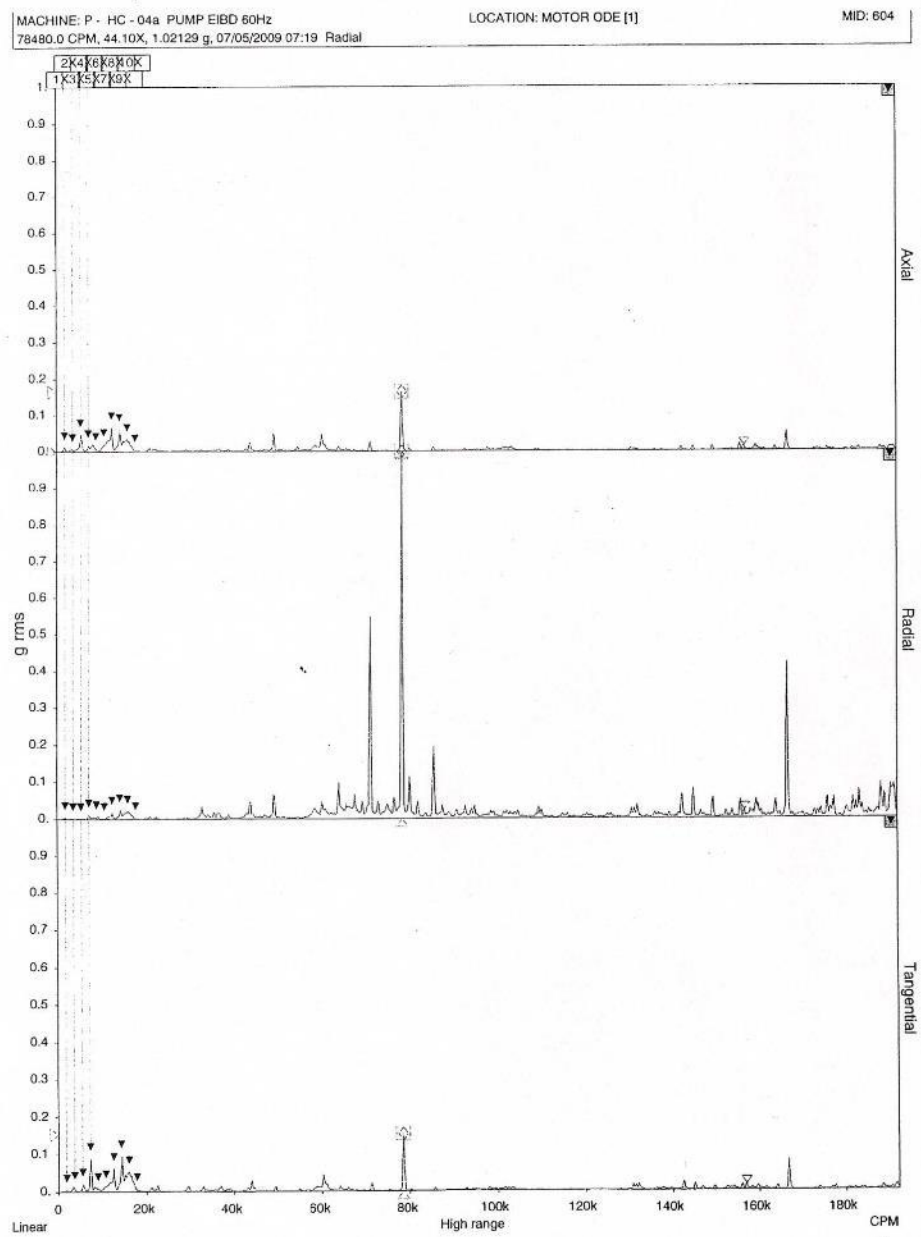


Figure 10: Electrically Induced Bearing Damage @ 60 Hz. The vibration spectrum data shown above was recorded from the bearing (photo) on page 12.

Electrically Induced Bearing Damage & Shaft Current Issue @ 60 Hz (VFD) Motor DE Sensor Location 2. Acceleration g rms High Frequency Range.

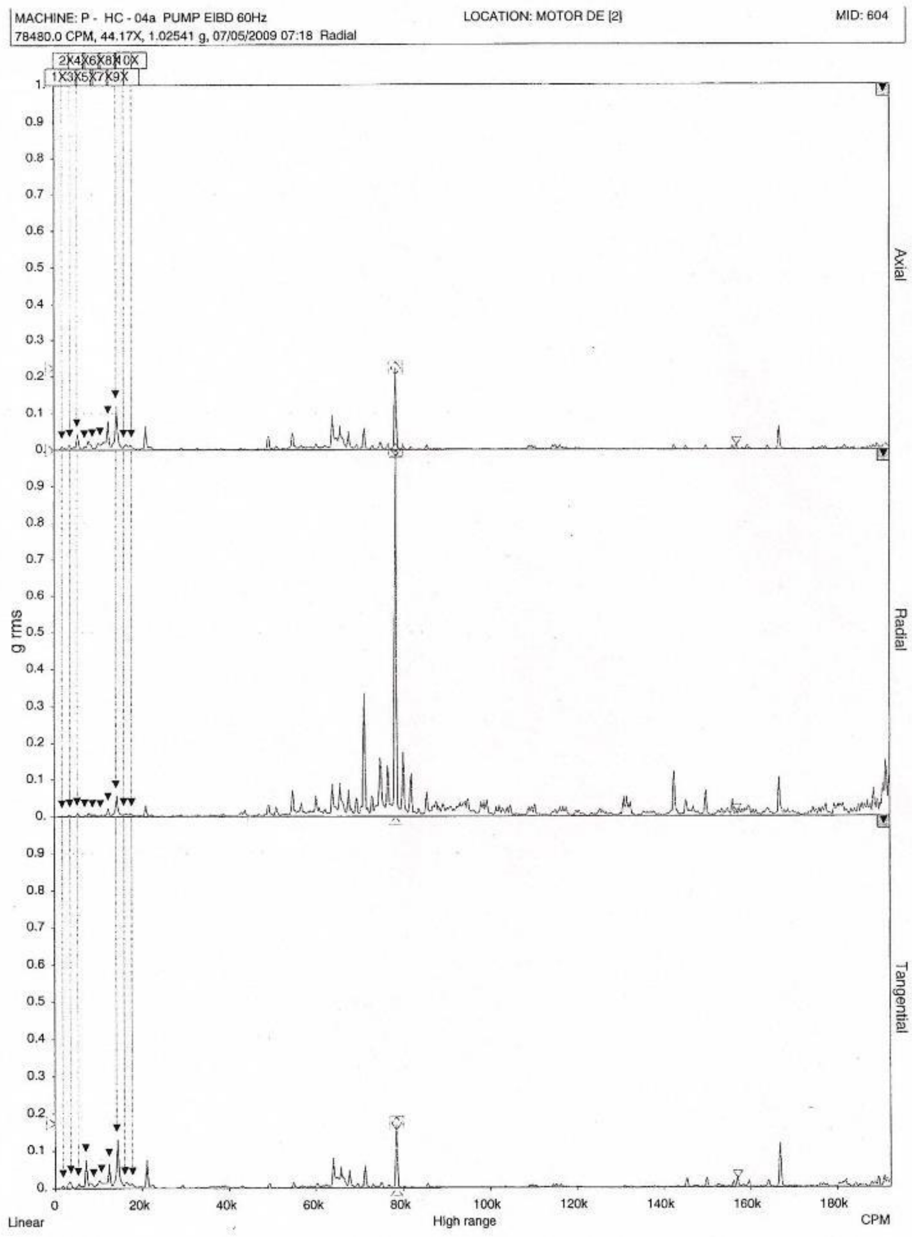


Figure 11: Electrically Induced Bearing Damage @ 60 Hz. The vibration spectrum data shown above was recorded from the bearing (photo) on page 12.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Resolving Inverter Driven Motor Issues (*Ref: Mirus International Study*)

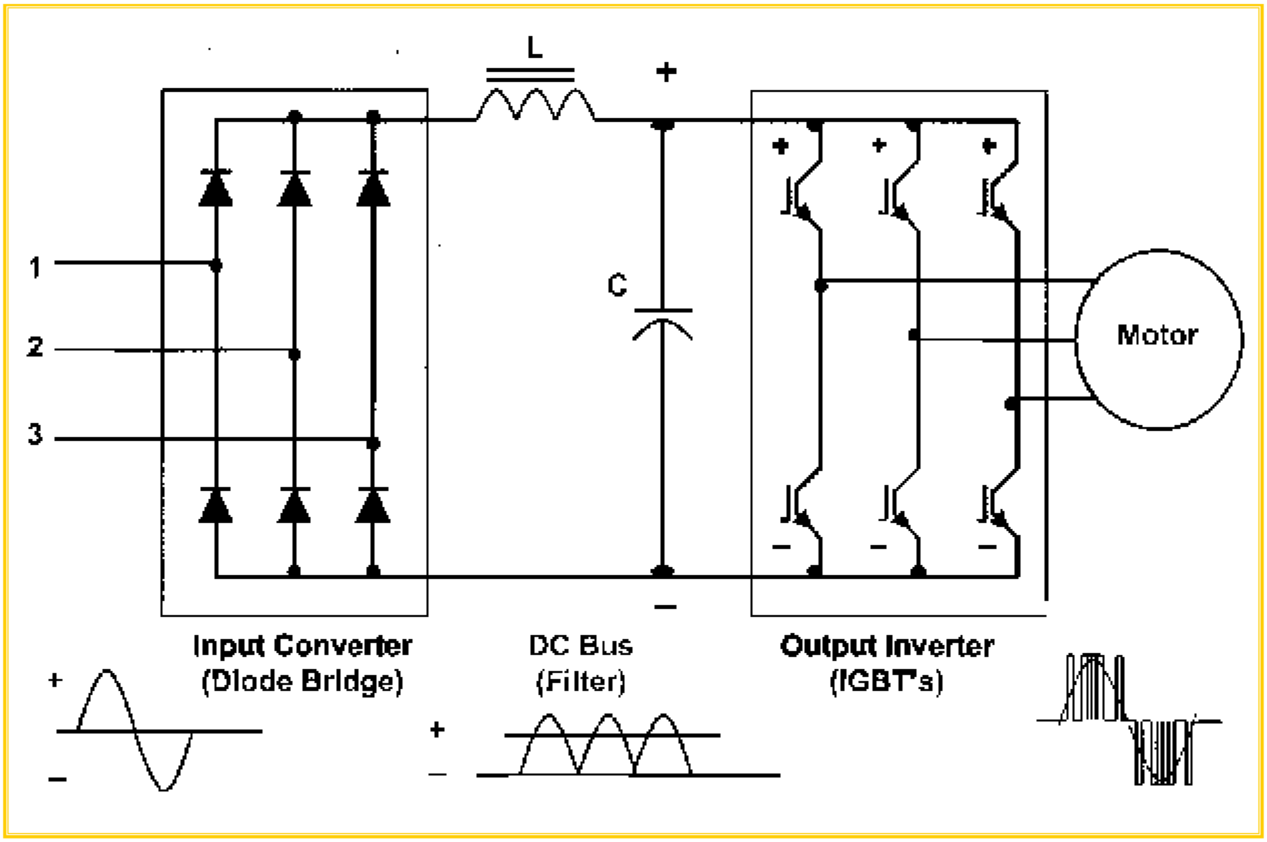


Figure 12: PWM Adjustable Speed Drive Inverters

Adjustable Speed Drives utilize Pulsewidth Modulated (PWM) Inverters equipped with:

- High speed switching insulated gate bipolar transistors
  - 2 to 8 kHz switching frequencies typical
    - Up to 20 kHz in some small sizes
  - Voltage rise (dV/dT) rates of up to 6000 V/µs

Reference: 'An Evaluation of Mitigation Techniques for Bearing Currents, EMI and Overvoltages in ASD Applications, Sept/Oct. 1998'

Resolving Inverter Driven Motor Issues (*Ref: Mirus International Study*)

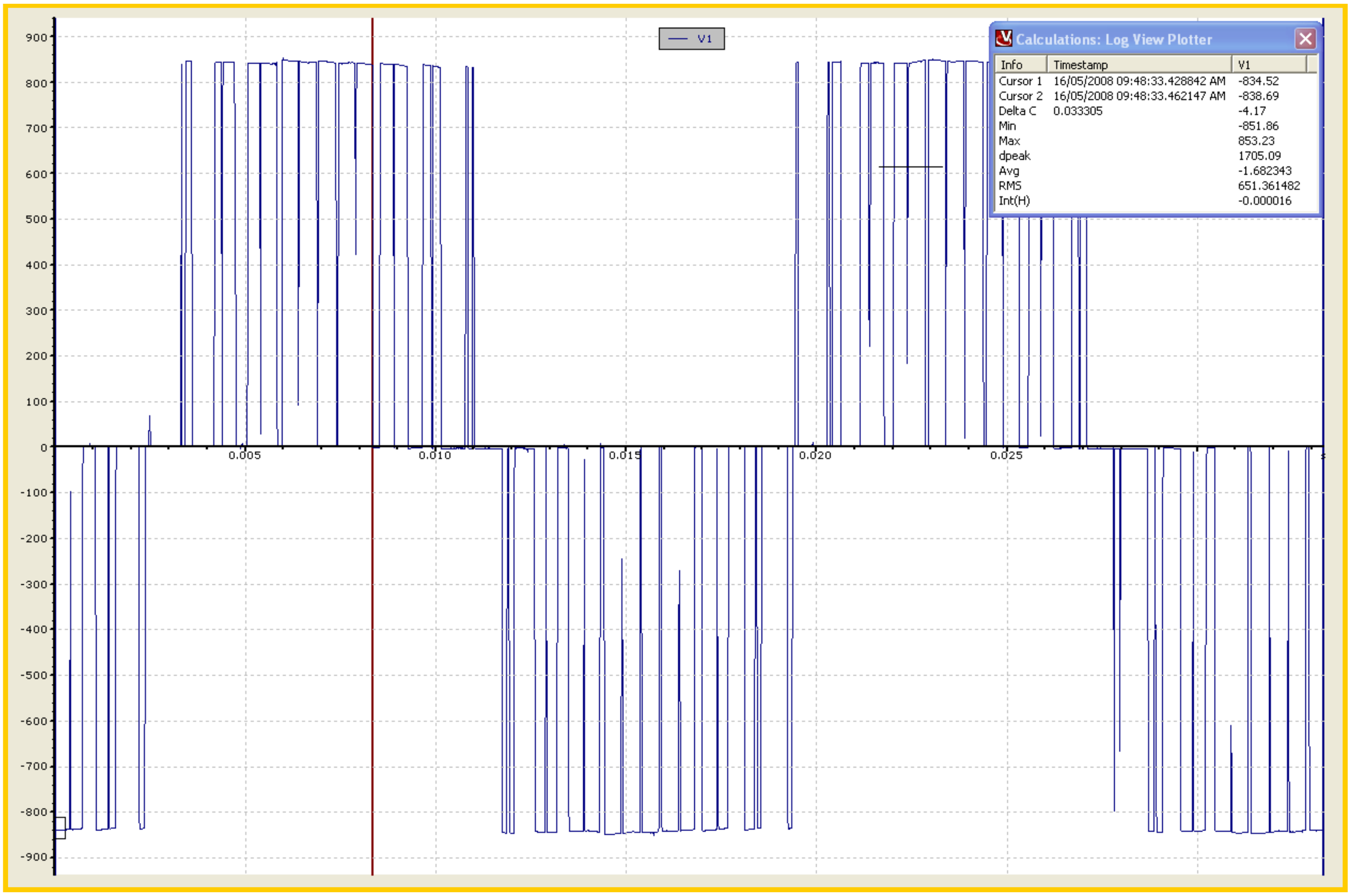


Figure 13: Typical PWM Output Voltage: 600V at 2 kHz

- Voltage rise (dV/dT) = 4400 V/µs
- Peak voltage = 853V

Resolving Inverter Driven Motor Issues (*Ref: Mirus International Study*)

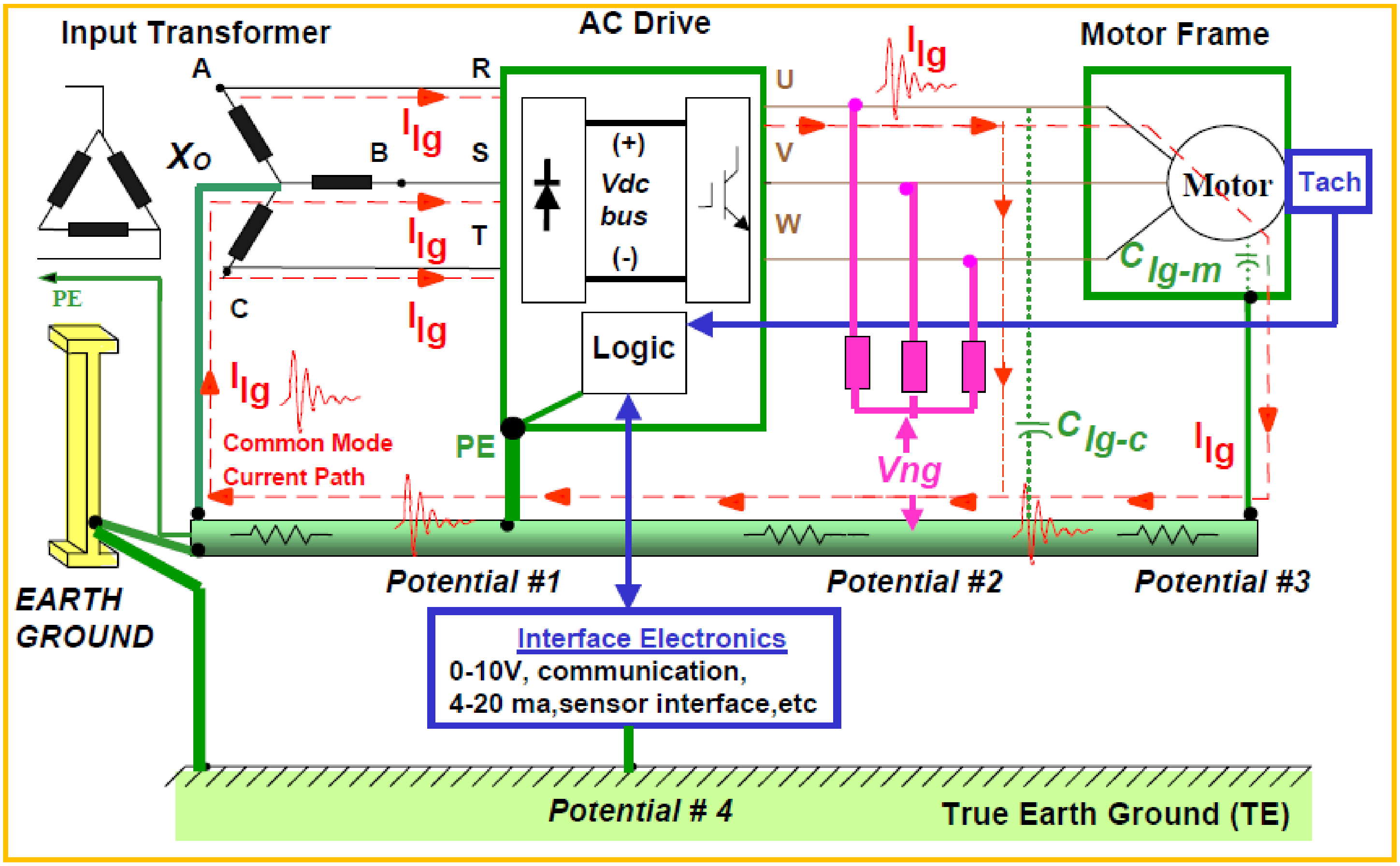


Figure 14: Common-mode Path

- PWM operation produces common-mode voltages
- Common-mode currents flow through parasitic capacitance of cables, motor bearings, etc.

Reference: 'EMI Emissions of Modern PWM AC Drives', IAS Magazine, Nov./Dec. 1999

Resolving Inverter Driven Motor Issues (*Ref: Mirus International Study*)

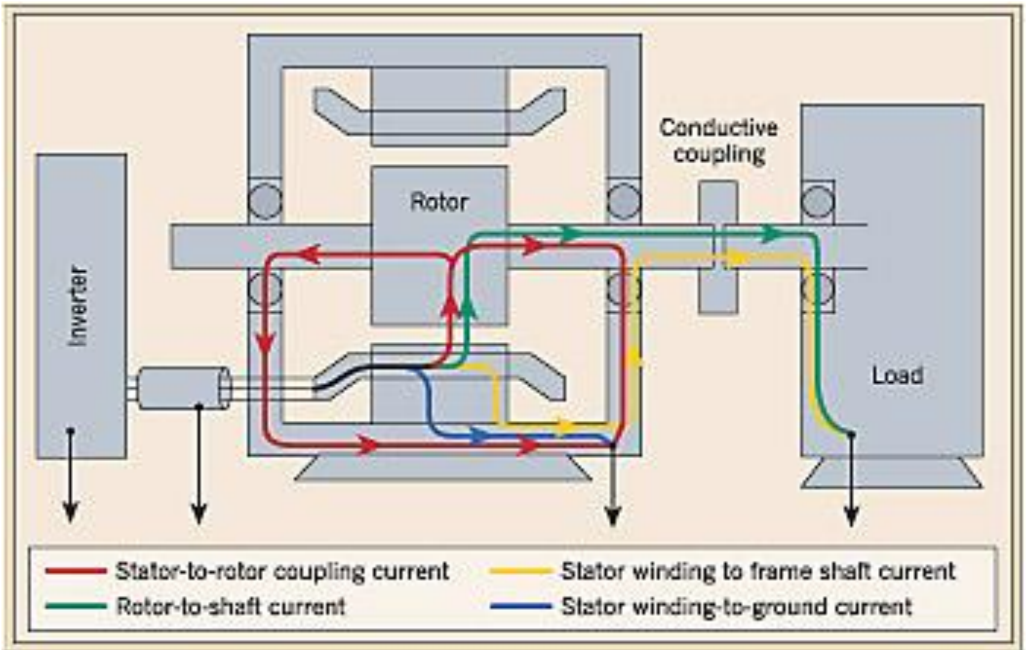


Figure 15: Motor Bearing Currents

Capacitive coupling results in multiple paths for common-mode current

- Stator-to-rotor: Coupled through air gap
- Rotor-to-shaft: Coupled through air gap
- Stator Winding-to-gnd: Coupled through stator winding insulation
- Stator Winding-to-Frame/Shaft: Coupled through stator winding insulation

Methods for Reducing Bearing Currents

- Improve high frequency grounding connection from motor to drive and from motor to driven equipment
  - special inverter cables
- Install one insulated bearing on non-drive end of motor
- Install two insulated bearings on motor
- Install a shaft grounding brush across one motor bearing
- Install a Faraday shielded motor
- Install an insulated coupling between motor and driven equipment, or
- Reduce the common mode voltages

Reference: 'Bearing Current Problems: Causes, Symptoms and Solutions', EC&M Sept. 2005

Resolving Inverter Driven Motor Issues (*Ref: Mirus International Study*)

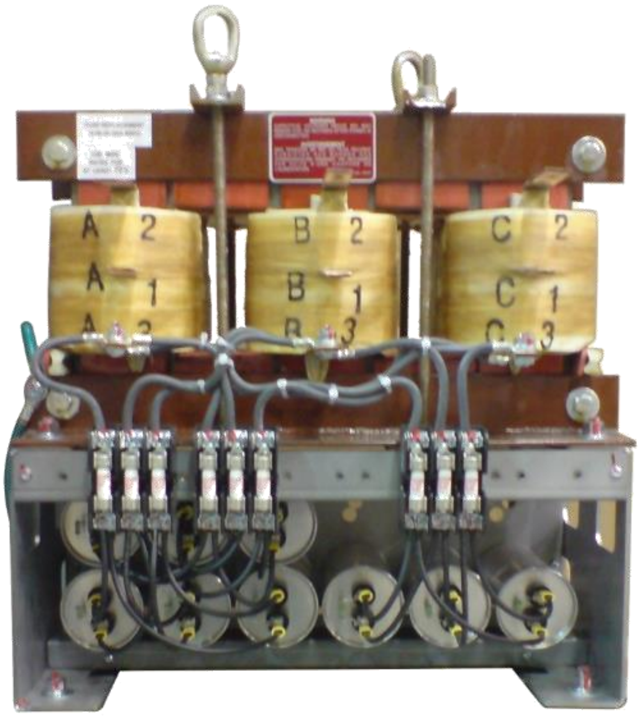


Figure 16: INVERSINE Advanced Universal Sinewave Filter (AUSF)

- Low pass filter with cutoff freq. below switching freq.
    - Filters out high frequency currents while allowing lower frequency fundamental currents to pass
- < 3% VTHD
- No damping resistors required
    - Cooler operation & much higher efficiency than competitor's filters
- Prevents
    - Transient overvoltages at motor
    - Additional motor losses
    - Excessive motor noise

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Resolving Inverter Driven Motor Issues (*Ref: Mirus International Study*)

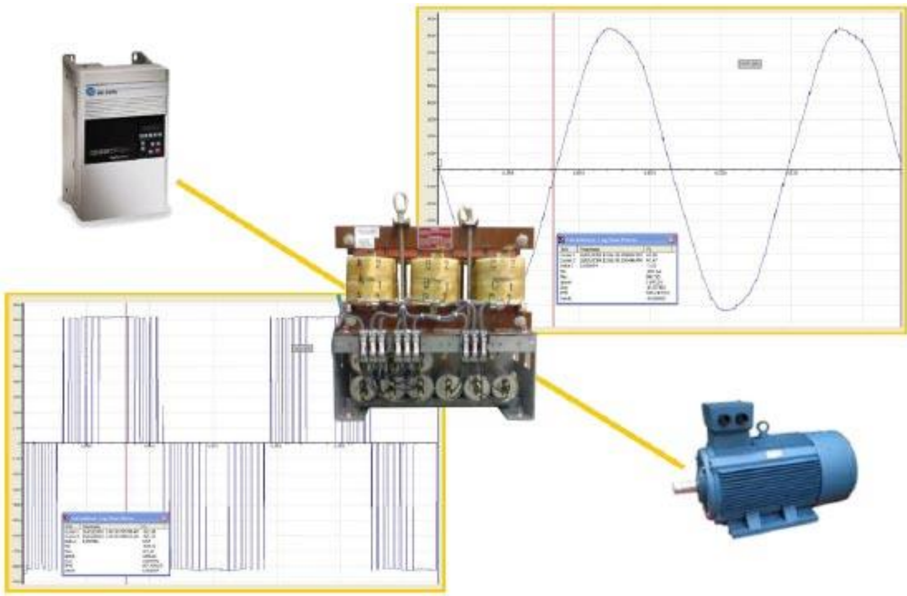


Figure 17: INVERSINE AUSF Performance (Voltage)

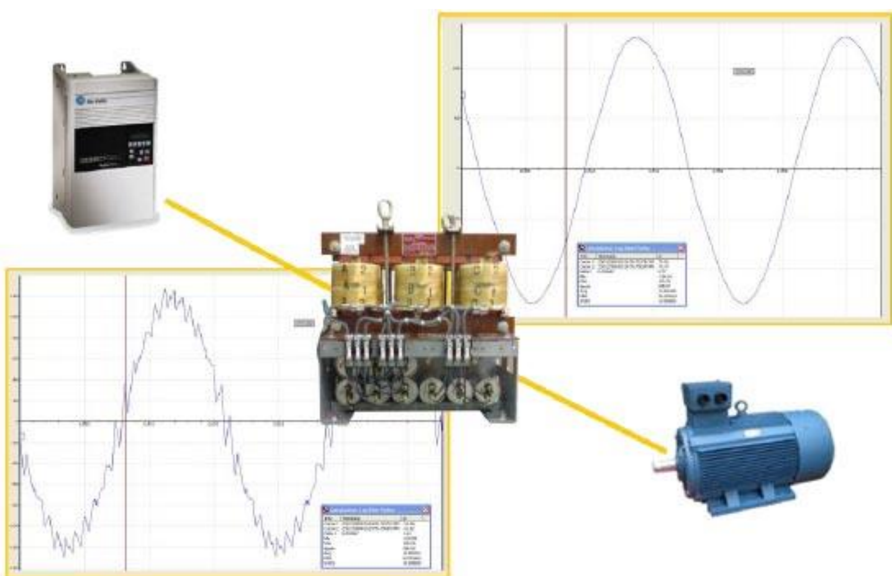


Figure 18: INVERSINE AUSF Performance (Current)

CoolBLUE® and NaLA®

A *MORE* Powerful Solution

Filter Design Guide for Motor Bearing and Stray Ground Currents

MH&W presents CoolBLUE® inductive absorbers, and NaLA® differential mode line absorbers for the highest reliability and longevity of your motor!

Variable frequency drive (VFD) systems create damaging motor bearing currents. If these currents aren't filtered or "choked" – bearing fluting, frosting, breakdown of lubrication, electrical discharge machining (EDM), and motor bearing failure will result. CoolBLUE® with NaLA® absorbs this damaging current before it gets to the motor.

High frequency noise generated by VFD

Fluting from CM Currents

What is a common mode choke?

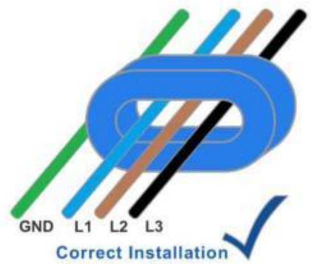
A common mode choke is an inductor that is used to prevent unwanted high frequency electric signals, and energy, from being transmitted along undesired paths or into inappropriate parts of an electric circuit or system.

CoolBLUE® cores act as a common mode choke by absorbing the high frequency noise, so you can maximize equipment reliability, reduce maintenance costs, and avoid unscheduled downtime.

What is a differential mode line absorber?

NaLA® differential mode line absorbers further reduce the current and slow the frequency down to even lower levels for the highest reliability of your system!

CoolBLUE® and NaLA® are easy to choose, with fast installation, in all VFD applications!



Product Features

- Common Mode Choke
- All power ranges in oval or round shape
- Simple selection
- Easy installation
- Lasts a lifetime
- No maintenance.

CoolBLUE® and NaLA® solutions are used in:

- OEM manufacturers of HVAC equipment
- All International VFD manufacturers
- Paper manufacturing
- Hospital, office, and commercial buildings
- Automotive manufacturing
- All types of pumps and fans
- Wind, solar, and other renewable energies

No Maintenance...unlike motor shaft products. Not subject to rust, dirt, grease, worn grounding brushes.

CoolBLUE® Cores have already saved millions of **$$** in the world's industrial plants, wind turbines, hospitals, paper mills, silicon fabrication, and office buildings by avoiding down time and equipment failures.

In order to achieve an effective reduction in high frequency destructive currents, CoolBLUE® cores have to be placed in series over the line power cables at the inverter output. In this configuration, the cores operate as a common mode choke.

This method significantly increases the service life of the motor bearings and thus reduces maintenance costs and standstill periods.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

CoolBlue®

VFD Application Guide - CoolBLUE® cores per horsepower and cable length

CoolBLUE® Round	*M-367*	*M-367*	*M-113*	*M-116*	*M-117*	Round Ver. N/A
CoolBLUE® Oval	*M-049*	*M-049*	*M-283*	*M-302*	*M-111*	*M-248*
Power Range (hp)	*1/4-10 (Use with NaLA®)	11-50 (Use with NaLA®)	51-100	101-428	429-1632	1632+
Cable Length	**# Cores**	**# Cores**	**# Cores**	**# Cores**	**# Cores**	**# Cores**
150ft/50m	2	4	4	4	4	4
300ft/100m	2	4	4	4	4	4
450ft/150m	2	4	6	6	6	6
900ft/300m	4	8	8	8	8	8

Note 1 – CoolBLUE normal operation is below 158°F/70°C. It is important to use the correct number of cores to avoid saturation.
***Note 2** – On motors up to **10hp**, two turns are needed through the cores (pass cable through cores twice).*
Note 3 – Data above is for information and guideline purposes. Please contact MH&W Engineering for detailed information.
Note 4 – Round and oval shaped cores are for ease of installation and mechanical functionality. Round and oval cores have same basic electrical absorption.
Note 5– Cores must be installed on the load side of the drive only. If possible, installing cores in a drive cabinet is preferred.
Note 6 – Do not place conductive wires through the cores for holding cores in place. MH&W offers brackets, and cable ties to hold cores in place.

NaLA®

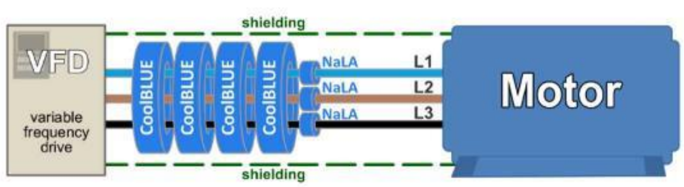
VFD Application Guide - NaLA® cores per horsepower and cable length

In applications where high reliability is needed, or 10hp motors and below, the use of NaLA® differential mode line absorber is necessary. The use of NaLA® increases the reliability of these systems by further reducing the noise and peak values. These cores must be placed around each individual cable.

Below is a simple application chart to be used in conjunction with CoolBLUE® common mode choke cores.

NaLA® Part number	*M-053*	*M-102*	*M-381*	*M-613*	*M-614*	*M-616*
Power Range (hp)	1/4-10	11-40	41-102	103-428	429-1631	over 1631
Cable Length	**# Cores**	**# Cores**	**# Cores**	**# Cores**	**# Cores**	**# Cores**
150ft/50m	2	1	1	1	1	1
300ft/100m	3	2	2	2	2	2
450ft/150m	4	3	3	3	3	3
900ft/300m	5	4	4	4	4	4

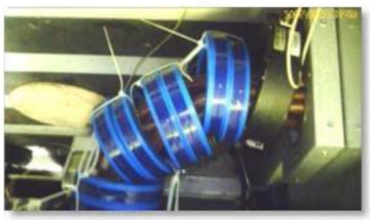
It is important to use the correct number of cores to prevent the cores from getting too hot.



Installation Examples

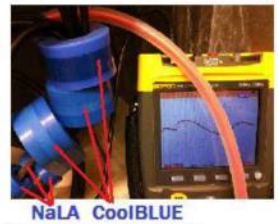
Installation – High Voltage (HV)

Installation Example



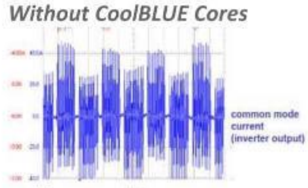
Installation Example – Flat Wire

More Installation Examples

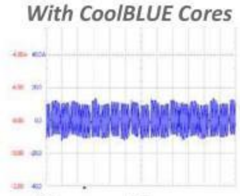


common mode current *(inverter output)*

Without CoolBLUE Cores



With CoolBLUE Cores



Current OEM customers of CoolBLUE®

GRUNDFOS · ABB · BOSCH · SEW EURODRIVE
Electrolux · Rockwell Automation · SIEMENS · Danfoss · VACON®

CoolBlue™ Technology Installed at four sites

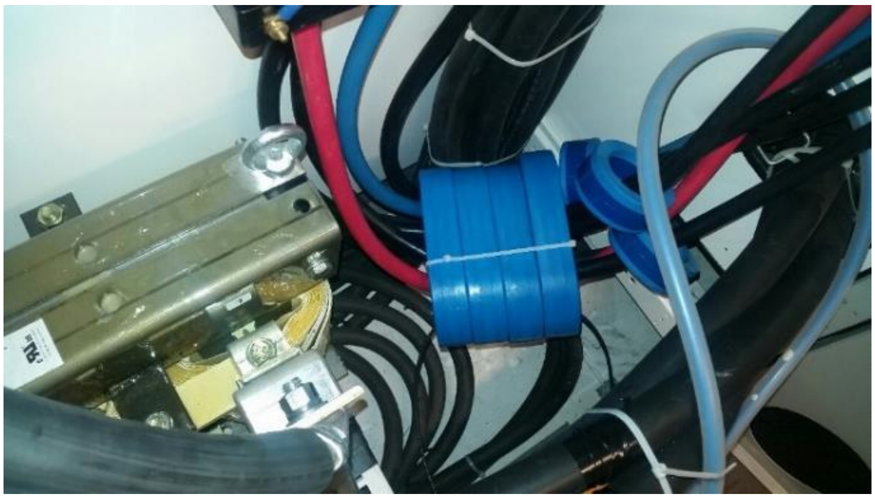


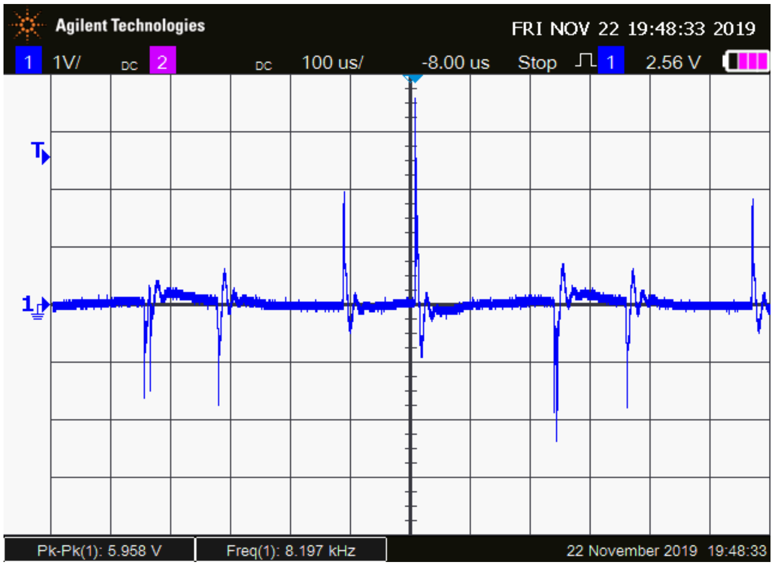
Figure 1 = 350 HP VFD - Rotary Screw Compressor

Figure 2 = 125 HPVFD - Supply Fan

Figure 3 = 10 HP VFD/Junction Box - AHU

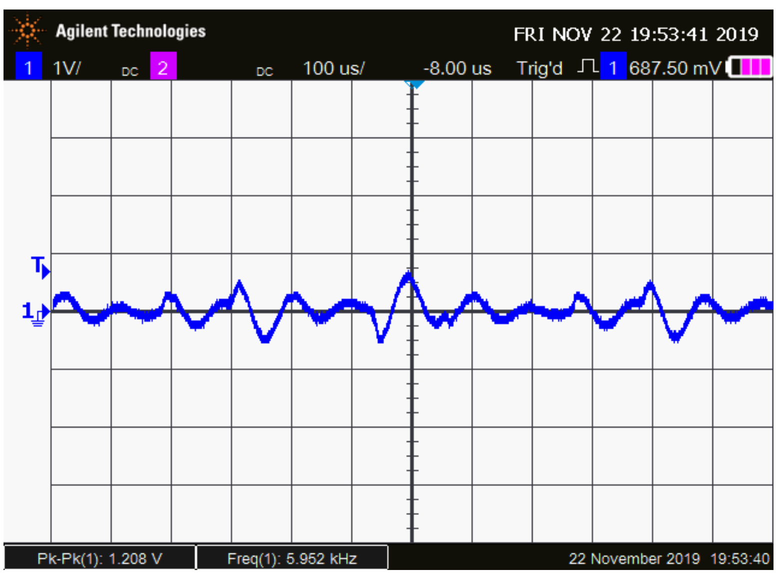
Figure 4 = 10 HP VFD / Junction Box (Typical Rogowski Coil - Electrical Discharge Testing) - AHU

ACTUAL VFD – ROGOWSKI COIL TEST
ELECTRICAL DISCHARGE RECORDED



BEFORE COOLBLUE

ACTUAL VFD – ROGOWSKI COIL TEST
ELECTRICAL DISCHARGE RECORDED



AFTER ADDING COOLBLUE

TWMC (TECO Westinghouse Motor Company) Suggestions for the Application and Protection of Small VFD Duty Induction Motors

Note:

The following suggestions are applicable to small random wound motors 600V and below, and are intended to suggest steps to protect motors operated on (VFD's) variable frequency drives.

Product Statement:

TECO Westinghouse Small VFD duty rated motors have winding insulation that meet or exceed NEMA MG-1 Part 31 voltage level requirements.

Product Application:

TECO motors are purchased and utilized on other manufactured brands of variable frequency drives, and are suitable for such, as long as proper application, setup, and protection are provided to prevent VFD related failures, from possible harmonics, caused by non-sinusoidal wave shapes, and voltage spikes, resulting in increased heating, decreased torque capability, and excessive shaft voltages if application, setup and protection methods suggested by both the VFD drive and motor manufacturers are not carefully followed. TWMC has a considerable number of customers that are successfully operating motors in the field were IGBT type VFD applications are applied. Many of these applications are TECO motor and drive packages that are specifically tuned to provide problem free operation.

Warranty:

TWMC standard stock motor warranty coverage is three years from the date of manufacture. IEEE/841 motor warranty coverage is 5 years from the date of manufacture. TECO motors packaged with TECO brand VFD drives are covered under warranty for three years after the date of packaged sale. Motors that fail under the control of a VFD sourced from another manufacturer that were not applied, setup, or properly protected per the VFD drive and motor manufacturer's suggestions, will not be covered under warranty.

Inverter VFD Compatibility with Motors

Many variables must be considered when determining the suitability of certain types of motors. The variables are as follows:

- Torque requirements (Constant or Variable)
- Speed range
- Line/System Voltage
- Cable length between VFD & Motor
- Drive switching (Carrier) frequency
- Motor configuration
- Grounding

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

Vertical Motors on VFD's

The following require consideration by the end user or installation engineer:

- Slowest rpm that can be utilized and not cause the non-reversing ratchet assembly to not operate properly 4:1 /15 Hz (in the range of 200-300 rpm)
- Noise and or vibration levels caused by the torque pulsation characteristics of the PWM waveform, a system critical frequency falling inside the variable speed range of the process or the added harmonic content of the PWM waveform exciting the system components.
- Application related problems related to the controlled acceleration/deceleration and torque of the motor on VFD power and the building of system pressure load.
- The impact the reduction of pump speed has on the down thrust reflected to the pump motor and any minimum thrust requirements of the motor bearings.
- Water hammer during shutdown damaging the non-reversing ratchet.

Grounding and Cable Installation Guidelines

Proper output winding and grounding practices can be instrumental in minimizing motor related failures cause by PWM waveform characteristic and installation factors. The VFD manufacturer's installation instructions should be consulted regarding the acceptable cable lengths for use with their VFD's voltage rise time. VFD drive manufacturers should also be consulted concerning proper system grounding and protective devices (low pass filters, and voltage clippers and snubbers) needed to prevent voltage overshoot.

Electrical Failure from (Line Ringing – Reflective Wave – Voltage Overshoot) is a function of the voltage rise time, (dV/dT), and of the length of the motor cables which behave as a transmission line. Insulated-gate bipolar transistors (IGBT's) are used in nearly all modern low and medium voltage drives. They produce a carrier upon which is contained the useful fundamental voltage and frequency required to drive a motor. IGBT's have extremely fast on-off switching times some in the range of 100 – 200 nanoseconds (ns). The rate of change of voltage with respect to time (dV/dT), can exceed 7500 volts per microsecond. Impedance mismatch at both ends of the cable, (cable-to-inverter and cable-to-motor), cause some portion of the waveform high frequency leading edge to reflect back in the direction it arrived. Reflected leading edges encounter other waveform leading edges, and their values begin to add causing voltage overshoot. As the carrier frequency is increased more leading edges are added resulting in higher voltage overshoots.

System resonance - VFD cables, no matter their length, have a natural self resonant frequency and can be influenced by the carrier frequency of the drive. The self-resonant frequency ranges can be at, or below the high frequency components of the voltage waveform produced by the IGBT inverter. When the self-resonant frequency of the conductor (cable unit) approximate the frequency range of the IGBT voltage waveform, the conductors themselves go into resonance, which creates a "Gain" or an amplification of the voltage components at, or near, the conductor's natural resonant frequency. This produces voltage spikes at the waveform transition points, recalling that these voltage spikes can have a rise time in excess of 7500 volts per microsecond. This stresses the motor winding and insulation system, (insulation punch through) or (partial discharge – Corona), and if it not corrected will result in motor failure.

If the motor/stator frame is grounded back to the drive with low impedance (at high frequency) ground conductor then most current will bypass bearings.

Best Methods: VFD Cables

- Symmetrical 3 phase power cables
- 3 Ground Conductors (grounded in both boxes)
- 100% Coverage Shield (grounded to cable glands)

If the high frequency impedance cannot be measured, then a ground conductor and/or shield DC resistance of a maximum of 2 time the power conductor's DC resistance should be sufficient. These ground conductors must be properly grounded to both the motor and the VFD ground bus.

Bearing Fluting from Common Mode Voltage

VFD's can generate a "common mode voltage", which raises the three phase winding neutral potential significantly above ground potential. The sum of the 3-phases equal zero for sinusoidal power. For VFD's each phase is rectified and the common mode voltage is the instantaneous sum of the three phases. When the 3-phase output from the drive is rectified, DC is either positive or negative; and the common mode voltage is approximately equal to the RMS voltage. The inherent magnetic dissymmetry (capacitive coupling) can produce shaft and bearing currents. Common mode voltage oscillates at high frequency and is capacitive coupled to the rotor. The result can be pulses as high as 25 volts from shaft to ground, with the path being through either of both bearings to ground.

It is important to check the frame to shaft voltage. One test method based on NEMA MG-1, is to measure the shaft voltage from end to end of the shaft. NEMA uses 300 mill volts AC limit for any type bearing. The higher the common mode voltage and VFD switching frequency, the greater is the possibility of damaging bearing currents. Motor and drive unit must be effectively grounded to each other and to the electrical system ground. The VFD manufacturer's installation instructions should be consulted to determine the proper grounding setup and necessary filtering required to mitigate common mode voltage and bearing currents.

TWMC Suggestions for Preventing Bearing Fluting

The following recommendations are for cases where the purchasers have indicated that the motor will be operated on a VFD:

- For 444/449 (11 inch shaft height) and larger motors being operated on a VFD, TWMC should suggest the following two options to the customer. Install 2 insulated bearings (except roller bearings) and a shaft ground brush on the drive end of the motor. Option two instead of installing insulated bearings and shaft grounding brush install CoolBlue Inductive Absorbers to reduce or remove shaft current and prevent electrical discharging in the bearings

- For 320 frame up to (not including) 444 frame, TWMC should suggests the following two options to the customer. Install 1 insulated bearing on the NDE and a ground brush on the DE. Option two instead of installing insulated bearing and shaft grounding brush install CoolBlue Inductive Absorbers to reduce or remove shaft current and prevent electrical discharging in the bearings

- For frames below 320, TWMC should suggest the following two options to the customer. Install a ground brush. Option two instead a shaft grounding brush install CoolBlue Inductive Absorbers to reduce or remove shaft current and prevent electrical discharging in the bearings

- Note: SGR's (Shaft ground rings) or CDR's (current diverter rings) are considered wear items and must be serviced and/or replaced once it is detected that the device can no longer reduces shaft current and prevents electrical discharging. Installing CoolBlue Inductive Absorbers are simple to install, They do not wear, and are very effective at reducing or removing shaft current and prevent electrical discharging in the bearings. It is the recommended option.

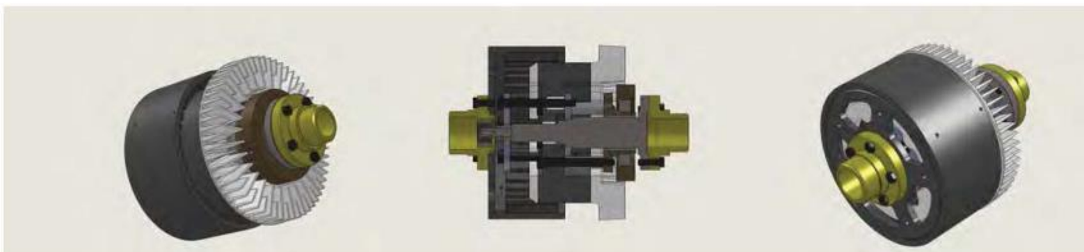
- For hazardous locations, grounding brushes are not allowed. For such conditions, TWMC should suggest 1 insulated bearing on the NDE for frames 444/449 and larger (and no bearing insulation for smaller frames) and TWMC should inform the end user that it is their responsibility to install common mode voltage mitigation devices, such as CoolBLUE Inductive Absorbers, to reduce or remove shaft current and prevent electrical discharging in the bearings.

It is recommended that a comparison be made between the max operating speeds & over speed for our catalog motors with the chart given in NEMA MG-1 Part 31 to verify compliance.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

FLUX DRIVE ADJUSTABLE SPEED DRIVE
BREAK-THRU TORQUE TRANSFER TECHNOLOGY

The Flux Drive® technology utilizes portions of induction motor theory and combines it with recent improvements in permanent magnets to develop a simple but unique mechanical adjustable speed drive that is cheaper to install, maintain and operate without introducing damaging harmonic frequencies to the system.



VARIABLE SPEED WITH NO PERIPHERAL COST

Adjustable speed is achieved by controlling the overlap of the Can and Rotor. As the Can and Rotor are disengaged, the slip increases allowing the output speed to decrease proportionally.
The Flux Drive ASD creates no harmonics and therefore requires no complex filtering systems, no air conditioning nor other devices needed by variable frequency drives to operate efficiently.

ENERGY SAVINGS

In centrifugal applications, system power requirements vary with the cube of the pump speed. Small decreases in speed or flow can significantly reduce energy use. For example, reducing the speed (flow) by 20% can reduce input power requirements by approximately 50%.

HIGH PERFORMANCE IN A SMALL PACKAGE

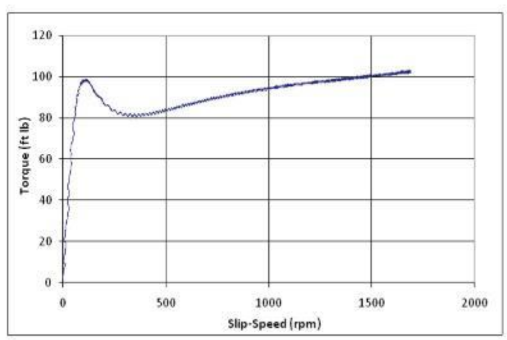
The Flux Drive Adjustable Speed Drive utilizes a closed circuit high performance magnetic array which allows for high torque transfer in a small foot print.

EQUIPMENT PROTECTION. NO HARMONICS.

Torque transfers by means of magnetic induction across an air gap. With no touching parts vibration is reduced and there are no parts to wear out or replace. And with no electrical windings, there are no harmonics to damage sensitive equipment.

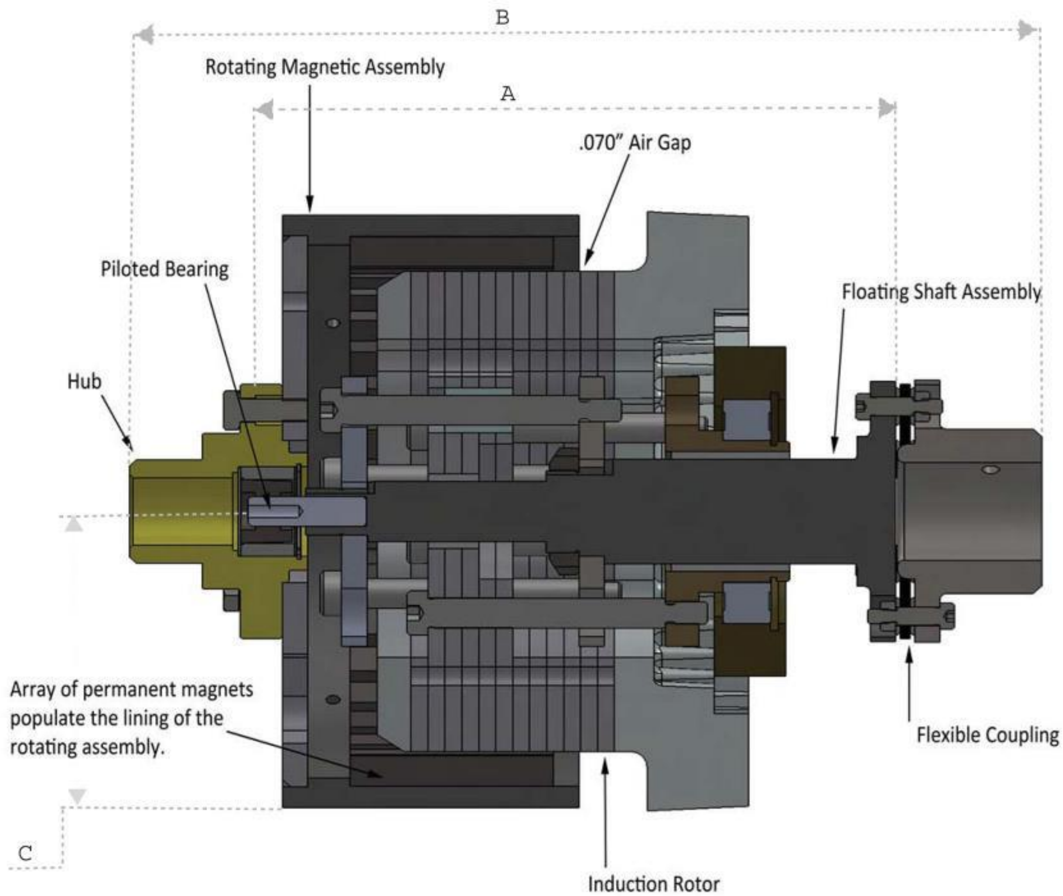
ELIMINATES LOCKED ROTOR CONDITIONS AND DAMAGE FROM LOAD SHAFT SEIZURES

The Flux Drive® Adjustable Speed Drive can be used to soft start a motor's load and substantially reduce start-up current limiting it to the safe value of 134% of full load rating. The ASD's air-gap allows the motor to fully breakaway from the load and accelerate to full motor speed without 'locked rotor' current. This feature also reduces torque 'spikes' and torsional vibration.



Speed / torque characteristics of a 25 HP rated Flux Drive® ASD

VIBES Corp®
Est. 1967
SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)
Vibration Industrial Balancing & Equipment Services, Corporation
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)



Constant magnetic flux is provided by the magnetic circuit via a circular array of alternate polarity permanent magnets supported inside a steel can assembly that rotates with the devices output shaft. The induction rotor on the input shafting is then moved into (to increase speed) or out of (to decrease speed) the high strength magnetic flux of the output magnet assembly. The overlap of the magnetic flux onto the Induction rotor induces current in the rotor's array of electro -conductive material. This inductive interaction closely follows motor theory and scaling.

FluxDrive Model	Dimensions in / (mm)			Horse Power Range (Torque)					
	A (DBSE)	B (DB Hubs)	C (Working Rad.)	15 HP (45 lb-ft)	20 HP (60 lb-ft)	25 HP (75 lb-ft)	30 HP (45 lb-ft)	40 HP (60 lb-ft)	50 HP (75 lb-ft)
08ASD (1800 RPM)	9.58 / (243.4)	13.25 / (336.4)	4.95 / (125.6)	X	X	X			
08ASD (3600 RPM)	9.58 / (243.4)	13.25 / (336.4)	4.95 / (125.6)				X	X	X

SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)

VIBES Corp®
Est. 1967

Vibration **I**ndustrial **B**alancing & **E**quipment **S**ervices, Corporation

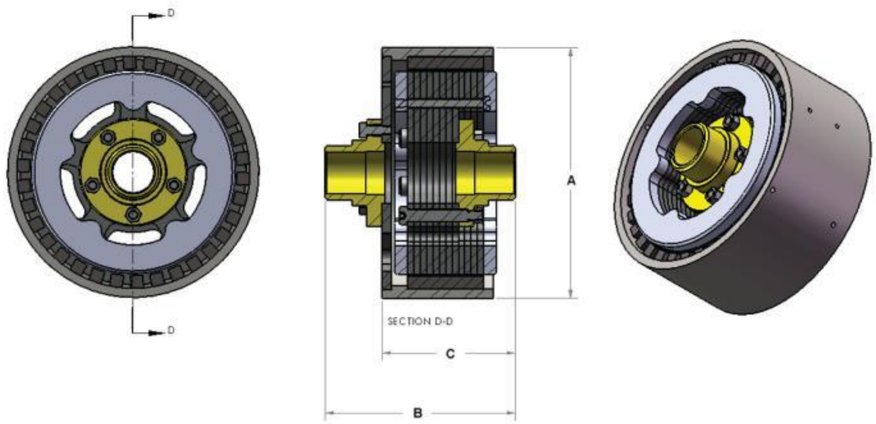
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

FLUX DRIVE FLEXIBLE SOFT START COUPLING

The Flux Drive® technology utilizes portions of induction motor theory and combines it with recent improvements in permanent magnets to develop a simple but unique flexible soft-start coupling that is cheaper to install, maintain and operate without introducing damaging harmonic frequencies to the system.



ELIMINATES LOCKED ROTOR CONDITIONS AND DAMAGE FROM LOAD SHAFT SEIZURES

Flux Drive® coupling can be used to soft start a motor's load and substantially reduce start-up current limiting it to the safe value of 134% of full load rating. The couplings air-gap allows the motor to fully breakaway from the load and accelerate to full motor speed without 'locked rotor' current. This feature also reduces torque 'spikes' and torsional vibration.

HIGH PERFORMANCE IN A SMALL PACKAGE

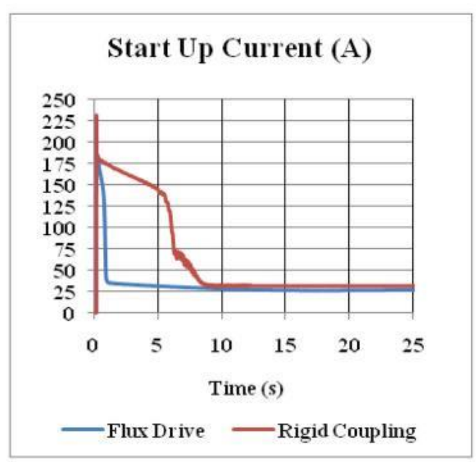
The Flux Drive coupling utilizes a closed circuit high performance magnetic array which allows for high torque transfer in a small foot print. All couplings meet ANSI standards.

EQUIPMENT PROTECTION. NO HARMONICS

Torque transfers by means of magnetic induction across an air gap. With no touching parts vibration is reduced and there are no parts to wear out or replace. And with no electrical windings, there are no harmon ics to damage sensitive equipment.

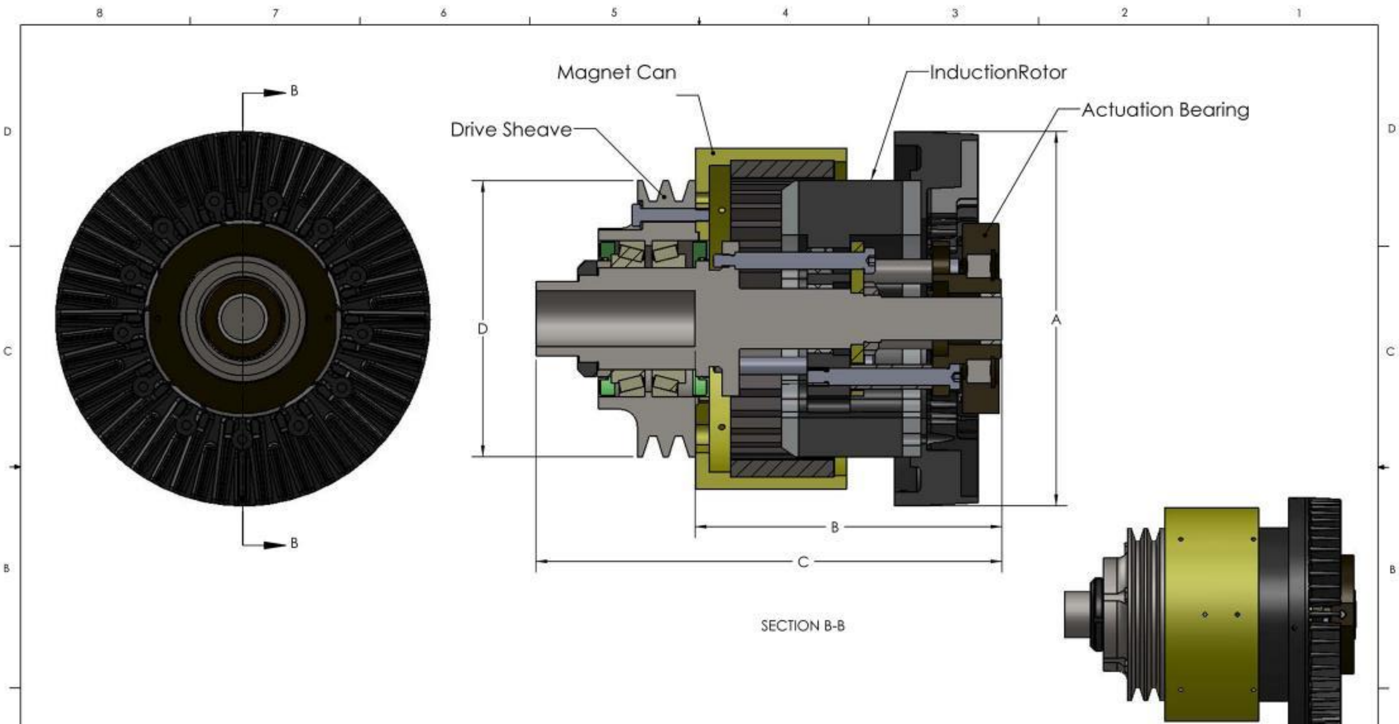
COST EFFECTIVE SOLUTION

Couplings are sized to transfer 100% of the motors torque with less than 2% slip. The couplings are simple mechanical devices that are easy to install and require no electrical training like other soft start solutions that use sensitive electronics. Ongoing operation and maintenance is affordable with no touching parts or sensitive electrical windings to replace.sensitive electri cal windings to replace.



Start-up current for a 25 HP rated coupling

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)



Sheave ASD Model	Rated Torque	Diameter (A)	Length Past Motor Shaft (B)	Overall Length (C)	Sheave Diameter (D)	Type and Number of Belt	Unit Weight
	Lbft (Nm)	in (cm)	in (cm)	in (cm)	in (cm)		Lbs (Kg)
SHASD 08-45	45 (61)	10.85 (27.55)	8.9 (22.6)	13.52 (34.34)	8.0 (20.3)	Size B / 2Groove	100 (45)
SHASD 08-60	60 (81)	10.85 (27.55)	8.9 (22.6)	13.52 (34.34)	8.0 (20.3)	Size B / 2Groove	101(46)
SHASD 08-75	75 (102)	10.85 (27.55)	8.9 (22.6)	13.52 (34.34)	8.0 (20.3)	Size B / 2Groove	102 (46.2)
SHASD 08-90	90 (122)	10.85 (27.55)	8.9 (22.6)	13.52 (34.34)	8.0 (20.3)	Size B / 2Groove	102 (46.2)
SHASD10-120	120 (163)	12.85 (32.60)	9.55 (24.25)	14.20 (36.00)	9.25 (23.49)	Size 5V / 3Groove	130 (59)
SHASD 10-150	150 (203)	12.85 (32.60)	9.55 (24.25)	14.20 (36.00)	9.25 (23.49)	Size 5V / 3Groove	135 (61)
SHASD 10-180	180 (244)	12.85 (32.60)	10.80 (27.43)	16.58 (42.11)	9.25 (23.49)	Size 5v / 3Groove	160 (72.5)

FLUX DRIVE INC.

08&10 Sheave ASD Specifications

Klüberlectric® BE 44-152

Electroconductive rolling bearing grease

Benefits for your application

- **Longer component life**
  - **due to long-term and for-life lubrication of rolling bearings subject to static electricity**
  - **Due to excellent wear protection based on special additives and solid lubricants**

Description

Klüberlectric BE 44-152 is a fully synthetic lubricating grease based on a synthetic hydrocarbon oil, lithium soap and dark solid lubricants. Due to its special composition, static electricity in rolling bearings is conducted through the grease, thus preventing local voltage discharge, which would severely damage the bearing raceways and rolling elements.

Application

Klüberlectric BE 44-152 has been designed for the long-term lubrication of rolling bearings in which static electricity may occur, such as electric motors, paper-making machines, copying machines, film-stretching stenters, guides in conveyors and fans.
Klüberlectric BE 44-152 has proven efficient for ball and roller bearings subject to a current intensity of approx. 1 Ampere. The electric conductivity of Klüberlectric BE 44-152 has been determined in tests based on DIN 53 482 (withdrawn). On the rolling bearing test rig FAG-FE9 acc. to DIN 51 821 and on FAG-FE8 acc. to DIN 51 819, the product showed very good service life and wear protection.

Application notes

Klüberlectric BE 44-152 can be applied by spatula, brush or grease gun. If central lubrication systems are to be used, please check pumpability beforehand.
Owing to the many different elastomer and plastic compositions their compatibility has to be checked prior to series applications.

Minimum shelf life

The minimum shelf life is approx. 36 months if the product is stored in its unopened original container in a dry, frost-free place.

Pack sizes

1 kg can
25 kg bucket

Material Safety Data Sheets

Material safety data sheets can be downloaded or requested via our website www.klueber.com. You may also obtain them through your contact person at Klüber Lubrication.

Vibration Industrial Balancing & Equipment Services, Corporation
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Klüberlectric® BE 44-152

Electroconductive rolling bearing grease

Product data	Klüberlectric BE 44-152
Base oil / thickener	synthetic hydrocarbon, lithium soap; solid lubricant
Colour / Texture	black, homogeneous
Service temperature range*, DIN 51 825, 51 821/2, [°C], approx.	-40 to 150
Worked penetration, DIN ISO 2137, 25°C, [0.1 mm]	265-295
Mechanical stability, Shell-Roller, 130°C, 50 h, [0.1 mm]	≤ +50
Oil separation, DIN 51 817, 7 days, 40°C, [% by wt.]	≤ 4
Oil separation acc. to FTMS 791, 30 h, 140°C, [% by wt.]	≤ 10
Corrosion protection (Emcor test), DIN 51 802, 1 week, distilled water, corrosion rating	≤ 1
Base oil viscosity, DIN 51 562 at 40°C, [mm²/s], approx. at 100°C, [mm²/s], approx.	 150 19
Water resistance, DIN 51 807, pt. 1, 3h/90°C, rating	0-90
FAG-FE9 test run, DIN 51 821, pt. 2, F_a = 1.500 N, n = 6.000 rpm, 140°C, [h]	> 100
Electric resistance acc. to DIN 53 482 (withdrawn), electrode spacing 1 cm, electrode surface 1 cm², [Ω x cm]	≤ 10,000
Speed factor for deep-groove ball bearings**, nxd_m, [mm x min-1], approx.	1,000,000
FAG-FE8 test run***, DIN 51 819, tapered roller bearings 31312 A, Fa = 50 kN, N = 75 rpm Wear [mg] Cage Rolling element	 12 34

* Service temperatures are guide values which depend on the lubricant's composition, the intended use and the application method. Lubricants change their consistency, apparent dynamic viscosity or viscosity depending on the mechano-dynamical loads, time, pressure and temperature. These changes in product characteristics may affect the function of a component.

** Speed factors are guide values which depend on the type and size of the rolling bearing type and the local operating conditions, which is why they have to be confirmed in tests carried out by the user in each individual case.

*** Values are results of one-time measurement and serve for information only. They do not constitute an assurance of values/properties of the series-produced product.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

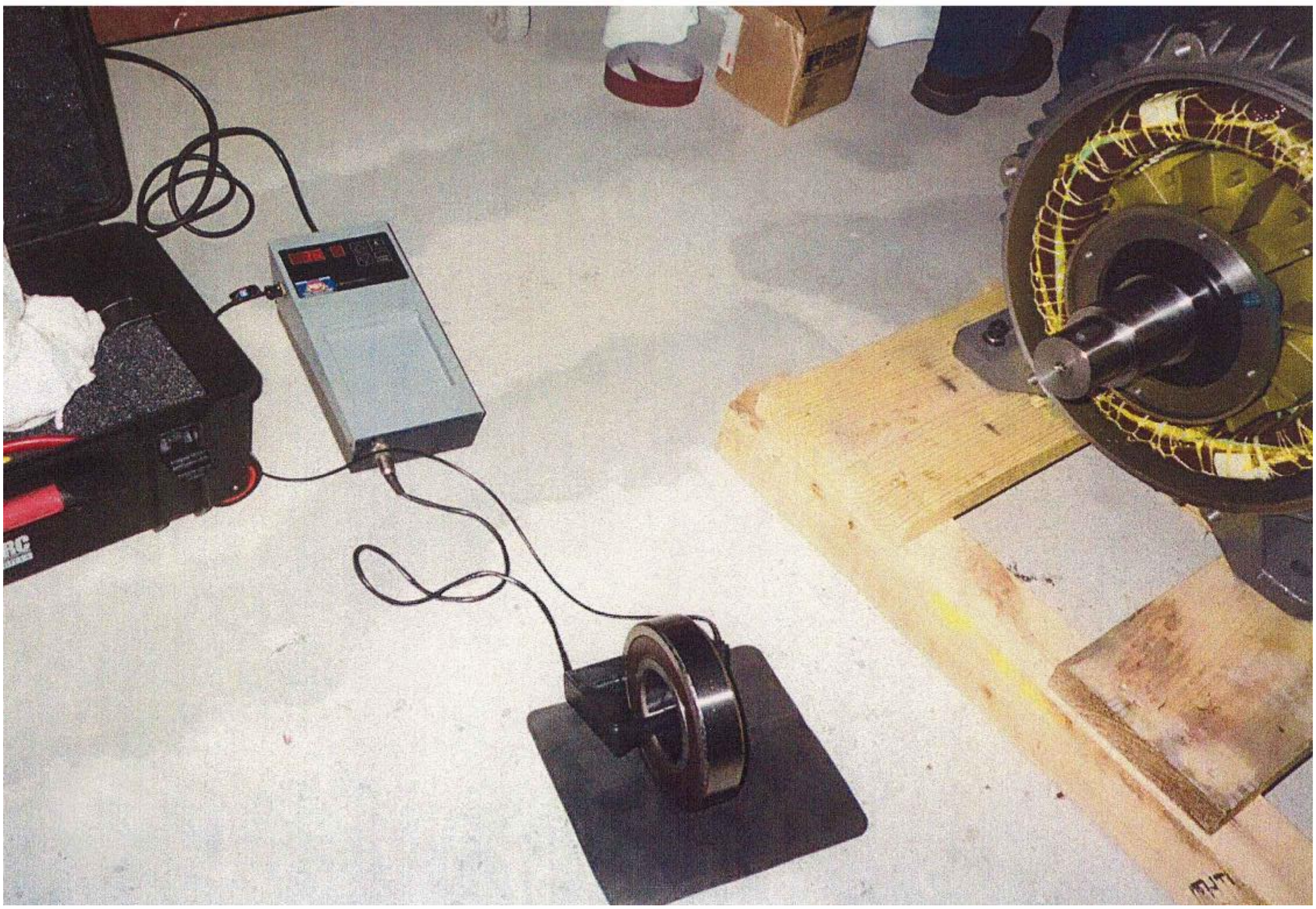
Phone: 604 - 619 - 9381 (24/7)

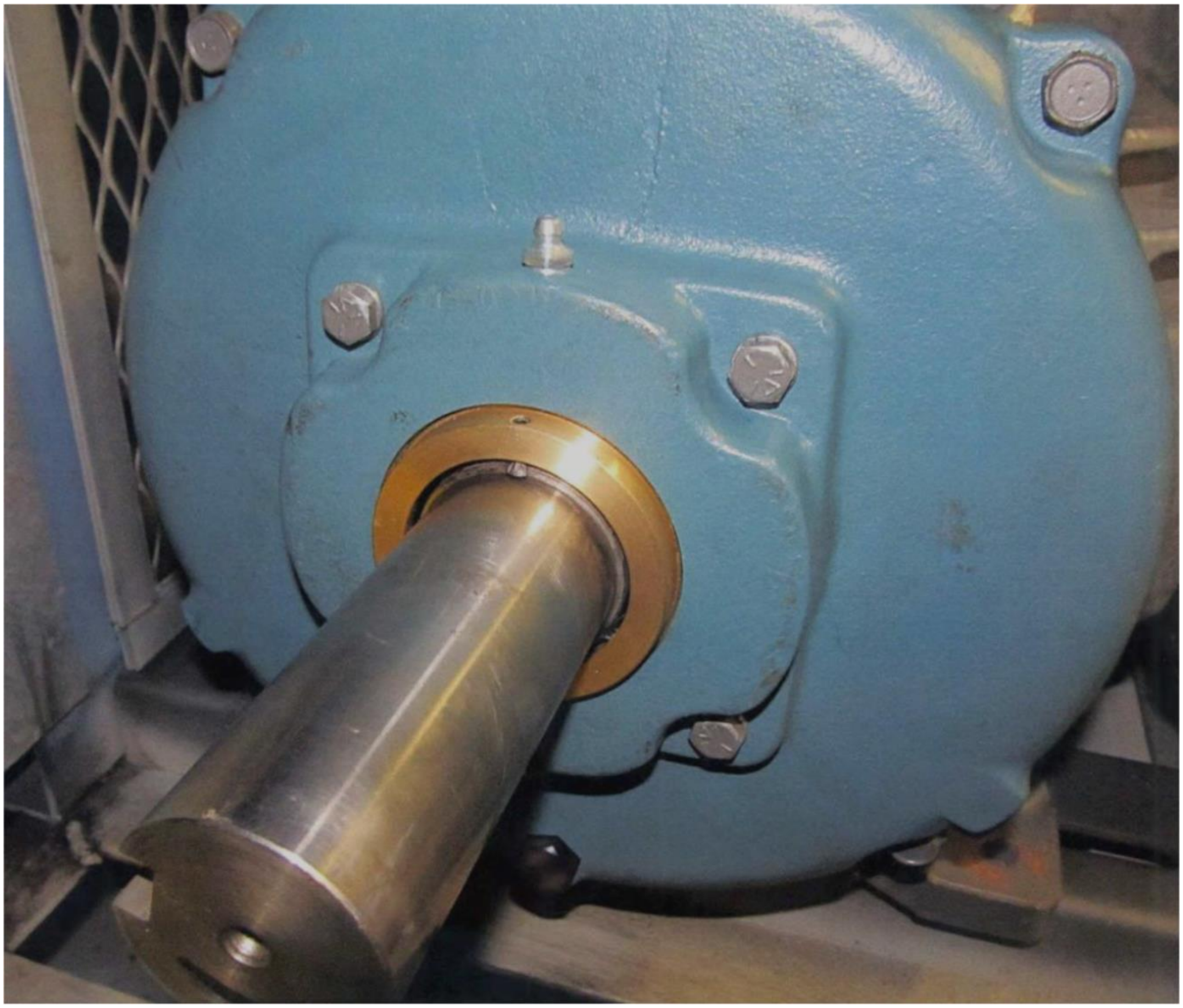
"EIBD" – One Solution Applied = Use Sealed Bearings, clean out factory grease and pack with Electro conductive Grease.

Electro Conductive Grease has proven to prevent EIBD for over ten years at various locations. VFD applications ranging from 10HP to 125HP.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Always use an electronic bearing heater to heat bearing inner race to 110C prior to installation on a motor shaft.



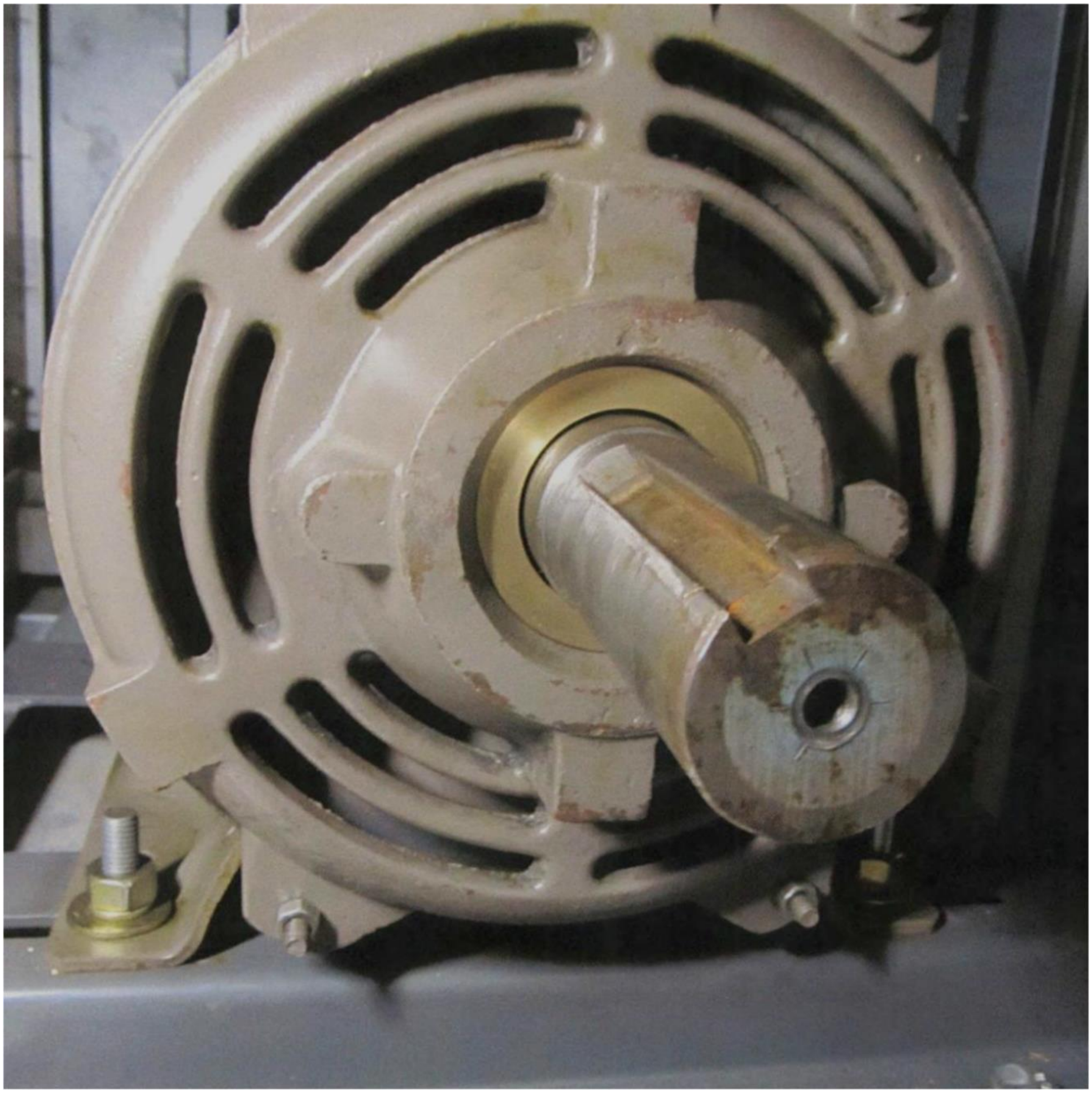


INPRO-SEAL MGS SEAL INSTALLED ON A MOTOR DRIVE END

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)



INPRO-SEAL MGS SEAL INSTALLED ON A MOTOR DRIVE END

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

AEGIS SGR SEAL INSTALLED ON A MOTOR DRIVE END

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

Protecting VFD-Driven Motors:

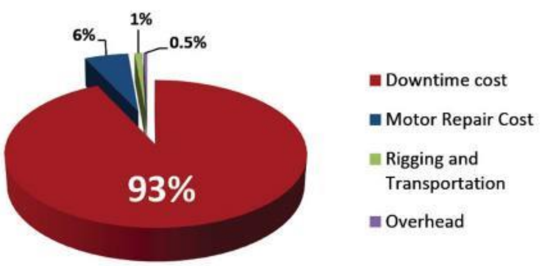
Bearing Protection Best Practices

VFD-Driven Motors Are at Risk of Electrical Bearing Damage!

Motors operated by variable frequency drives (VFD) are vulnerable to VFD-induced shaft voltages and bearing currents that can cause premature bearing failure - often in as little as 3 months!

VFDs induce destructive shaft voltages and high frequency currents which can discharge through motor bearings, burning bearing grease and reducing its effectiveness. Through electrical discharge machining (EDM), these discharges can also cause pitting, frosting, and fluting damage to the motor's bearings and eventual bearing failure. The result is costly repairs, downtime, and lost production.

Prevent EDM Pitting and Fluting Damage



Test Motors with AEGIS® Shaft Voltage Tester™ Oscilloscope

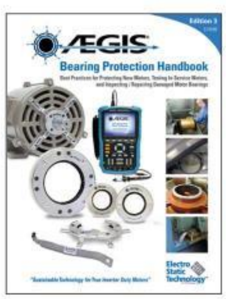
Protect Motor Bearings With AEGIS® Rings

By channeling harmful VFD-induced shaft voltages away from bearings and safely to ground, AEGIS® Shaft Grounding Rings protect motors from costly bearing damage.

Protect Motors with AEGIS® Rings or uKITs

Bearing Protection Best Practices

The AEGIS® Motor Repair Handbook details best practices for protecting VFD-driven motors from electrical bearing damage and preventing costly repairs, downtime and lost production.



Learn about:

- Bearing currents and shaft voltages
- AEGIS® technology
- Shaft voltage testing
- Installation best practices

For detailed recommendations, refer to the AEGIS® Bearing Protection Handbook. An essential reference, the Handbook is available free at www.est-aegis.com/handbook

SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)

VIBES Corp®

Est. 1967

Vibration **I**ndustrial **B**alancing & **E**quipment **S**ervices, Corporation

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

Standard Mounting Clamps (-1)
Shaft diameters: 0.311" to 6.02"
3 to 4 mounting clamps, 6-32 x 1/4" cap screws and washers

Split Ring (-1A4)
Shaft diameter: 0.311" to 6.02"
4 to 6 mounting clamps, 6-32 x 1/4" cap screws and washers
Installs without decoupling motor

Bolt Through Mounting (-3FH)
Shaft diameters: 0.311" to 6.02"
6-32 x 1/2" flat head screws
2 mounting holes up to shaft size 3.395"
4 mounting holes for larger sizes

Conductive Epoxy Mounting (-0AW, -0A4W)
Shaft diameters: 0.311" to 6.02"
Solid and Split Ring
Conductive Epoxy Included

Press Fit Mounting (-0A6)
Shaft diameters: 0.311" to 6.02"
Clean dry 0.004" press fit
Custom sizes available

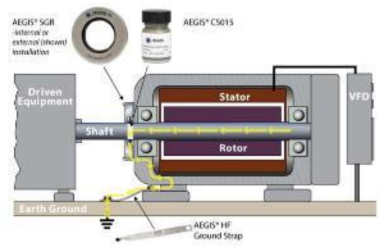
uKIT - SGR with Universal Mounting Bracket
Sized for NEMA and IEC frame motors
Solid and Split Ring
Can be mounted with hardware or conductive epoxy

AEGIS® PRO Series, Large SGR, WTG
AEGIS® PROSL, PROSLR, PROMAX, PROMR
Large SGR Rings over 6.02"
AEGIS® WTG for Wind Turbine Generators

AEGIS® Shaft Voltage Tester™ Oscilloscope
100 MHz Digital Oscilloscope
10:1 probe with SVP tip for measuring voltages on a rotating shaft
AEGIS® One-Touch™ instant image capture

Accessories
HFGS - AEGIS® High-Frequency Ground Strap
CS015 - AEGIS® Colloidal Silver Shaft Coating
EP2400 - AEGIS® Conductive Epoxy

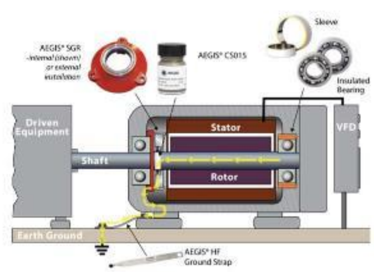
Motors up to and including 100 HP (75 kW) Low Voltage



- Install AEGIS® Bearing Protection Ring – either internally or externally – on drive end or the non-drive end of motor. 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)



- Drive End: Install AEGIS® Bearing Protection Ring - Internally on the back of the bearing cap or externally on the motor end bracket. Use AEGIS® Colloidal Silver Shaft Coating on motor shaft
- Non-Drive End: Isolate bearing housing with insulated sleeve or coating or use insulated ceramic or hybrid bearing to disrupt circulating currents.

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

Download the AEGIS® Best Practices Handbook:
www.est-aegis.com/handbook

COMPLYWORKS ContractorCheck Alcumus® Avetta

Vendor Compliant for Property Owners, Management Firms of Commercial Buildings, Hospitals, Industrial Sites, & Infra-Structure Facilities

Vibration **I**ndustrial **B**alancing & **E**quipment **S**ervices, Corporation

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

THE PHOTOS ATTACHED ARE AN ACTUAL APPLICATION EXAMPLE OF INSULATING A MOTOR BEARING.

THE INSULATED BEARING AND SHAFT JOURNAL IS ON THE OPPOSITE DRIVE END OF THE MOTOR. NOTE - ON THE SAME MOTOR A GROUNDING SEAL (Inpro-Seal MGS - Photo) WAS ALSO SPECIFIED ON THE DRIVE END.

REFERENCE - Frequently asked questions & answers: www.usmotors.com/default_service.htm

THE PHOTOS ATTACHED ARE AN ACTUAL APPLICATION EXAMPLE OF INSULATING A MOTOR BEARING.

THE INSULATED BEARING AND SHAFT JOURNAL IS ON THE OPPOSITE DRIVE END OF THE MOTOR. NOTE - ON THE SAME MOTOR A GROUNDING SEAL (Inpro-Seal MGS - Photo) WAS ALSO SPECIFIED ON THE DRIVE END.

REFERENCE - Frequently asked questions & answers: www.usmotors.com/default_service.htm

THE PHOTOS ATTACHED ARE AN ACTUAL APPLICATION EXAMPLE OF INSULATING A MOTOR BEARING.

THE INSULATED BEARING AND SHAFT JOURNAL IS ON THE OPPOSITE DRIVE END OF THE MOTOR. NOTE - ON THE SAME MOTOR A GROUNDING SEAL (Inpro-Seal MGS - Photo) WAS ALSO SPECIFIED ON THE DRIVE END.

REFERENCE - Frequently asked questions & answers: www.usmotors.com/default_service.htm

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

THE PHOTOS ATTACHED ARE AN ACTUAL APPLICATION EXAMPLE OF INSULATING A MOTOR BEARING.

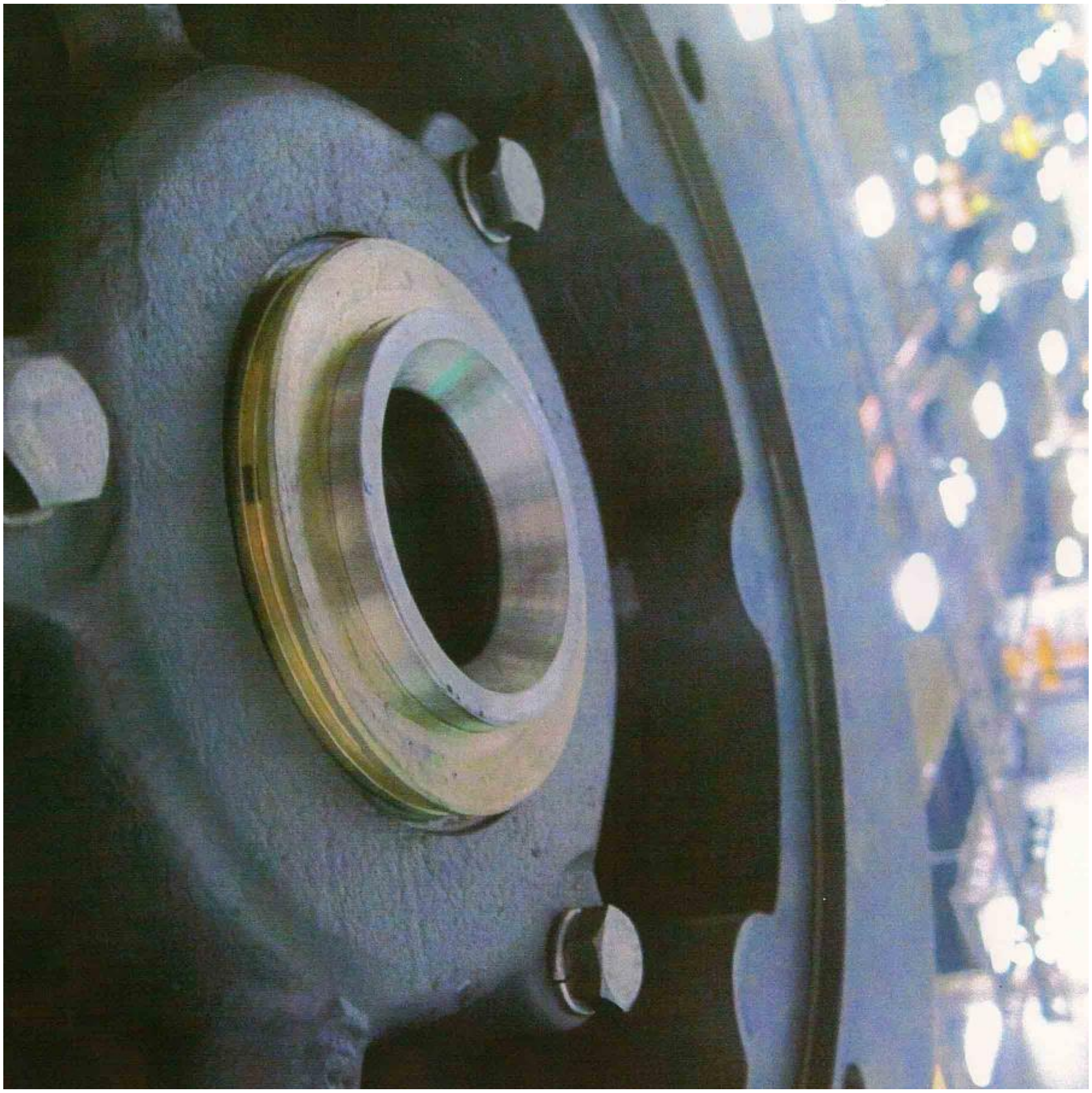
THE INSULATED BEARING AND SHAFT JOURNAL IS ON THE OPPOSITE DRIVE END OF THE MOTOR. NOTE - ON THE SAME MOTOR A GROUNDING SEAL (Inpro-Seal MGS - Photo) WAS ALSO SPECIFIED ON THE DRIVE END.

REFERENCE - Frequently asked questions & answers: www.usmotors.com/default_service.htm

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

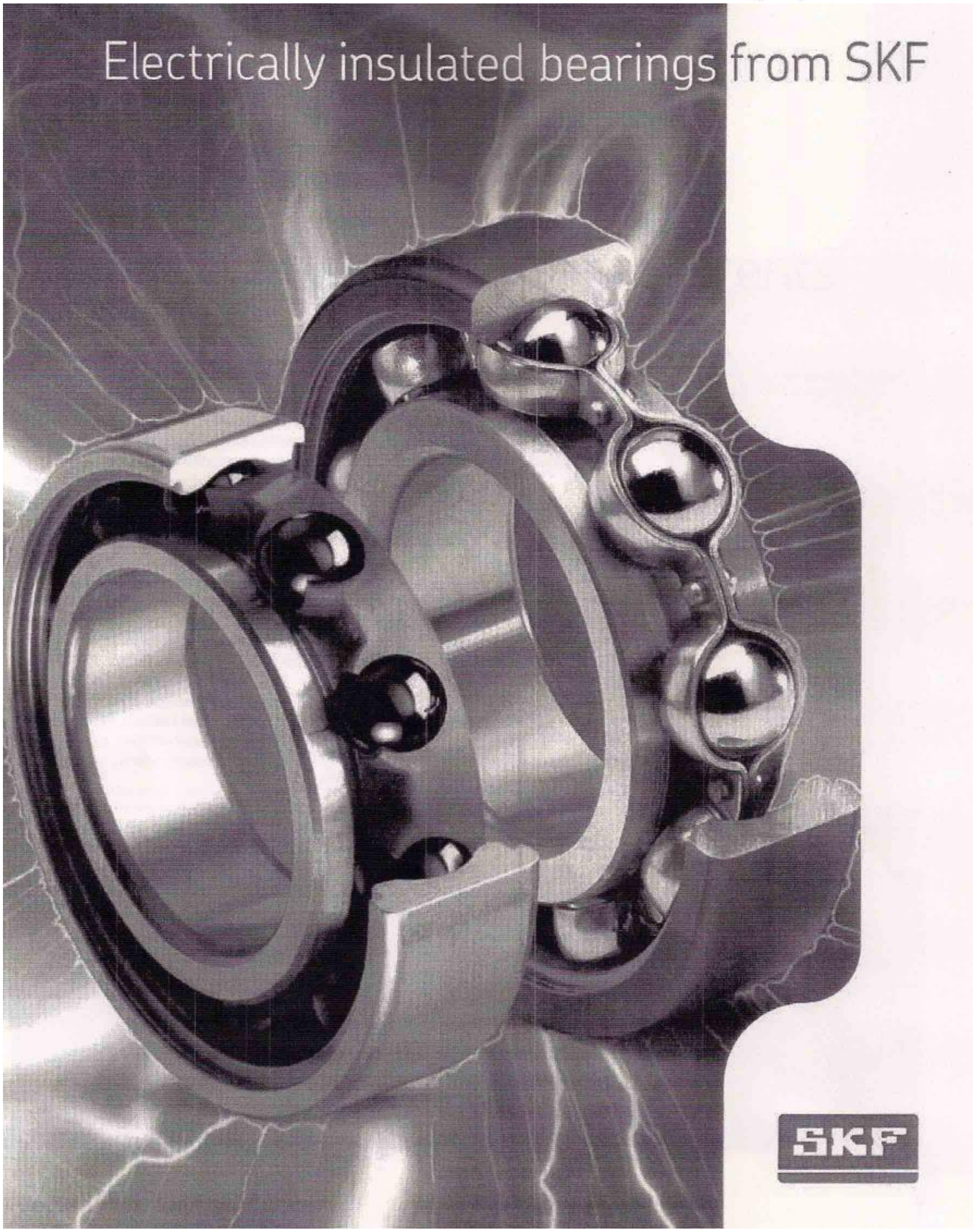
Phone: 604 - 619 - 9381 (24/7)



THE PHOTOS ATTACHED ARE AN ACTUAL APPLICATION EXAMPLE OF INSULATING A MOTOR BEARING.

THE INSULATED BEARING AND SHAFT JOURNAL IS ON THE OPPOSITE DRIVE END OF THE MOTOR. NOTE - ON THE SAME MOTOR A GROUNDING SEAL (Inpro-Seal MGS - Photo) WAS ALSO SPECIFIED ON THE DRIVE END.

REFERENCE - Frequently asked questions & answers: www.usmotors.com/default_service.htm


Electrically insulated bearings from SKF
SKF

Virtually eliminate the damaging effects of stray electric currents

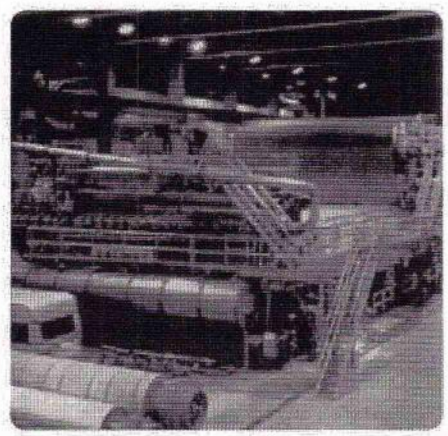
The problem of stray electric current bearing damage

When a stray current in an electric motor uses a bearing as its path to ground, bearing damage can occur. The most common causes of stray electric currents are: asymmetry in the motor's magnetic circuit, unshielded power cables, and fast switching pulse width modulated (PWM) frequency converters used in modern variable frequency drives (VFDs). The increasing popularity of VFDs is directly linked to the increase in electric current related bearing damage.

When an electric current passes through the bearing it can cause micro-cratering in the raceways of inner and outer rings and on the rolling element surfaces (→ **fig. 1**). The heat, which is generated by the discharges, causes local melting that creates small craters and changes in the structure of the metal. As a result of this initial damage, a "washboard pattern" may be found on the raceways and rolling elements (for roller bearings) (→ **fig. 2**). This secondary damage is wear caused by the dynamic effect of the rolling elements when they roll over the smaller craters. Current discharges also cause the lubricant in the bearing to change its composition, degrade rapidly and fail prematurely (→ **fig. 3**).

Once bearing damage from electric erosion has begun, increased noise levels, reduced effectiveness of the lubricant, increased heat and finally excessive vibration, all contribute to drastically decrease bearing service life.

Stray electric currents can occur almost anywhere from windmills to papermills



SKF

A cost-effective solution

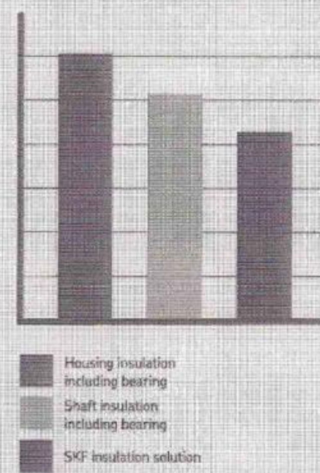
To overcome this problem, SKF has developed two electrically insulating rolling bearing solutions: SKF® hybrid bearings and INSOCOAT® bearings. The solution one chooses depends on the severity and cause of the stray electric current and size of the bearing. In either case, SKF hybrid bearings and INSOCOAT bearings provide a number of benefits

- two functions in one solution:
  - a bearing function
  - electrical insulation
- virtually eliminates premature bearing failures caused by stray electric currents
- increases machine uptime
- reduces maintenance costs
- provides an economical solution when compared with other insulation solutions
- global availability.

Recommended range

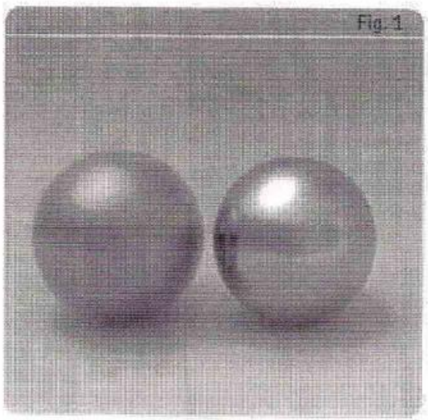
SKF has defined a recommended range of INSOCOAT and hybrid bearings specifically for electric motors and generators. This range enables fast and secure delivery around the globe.

Total cost of SKF insulated bearing solution relative to other insulation approaches



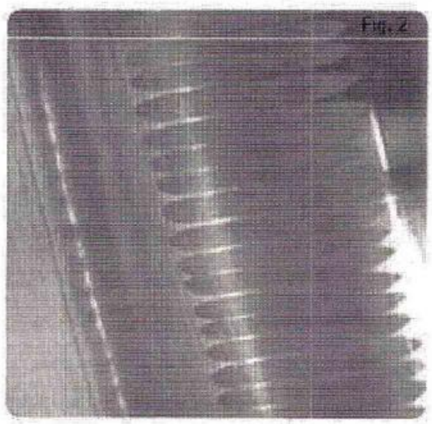
Micro-cratering
Micro-cratering is the result of electric current passage in bearings. The damaged surface appears dull and is characterized by small craters of a few microns in diameter.

Fig. 1



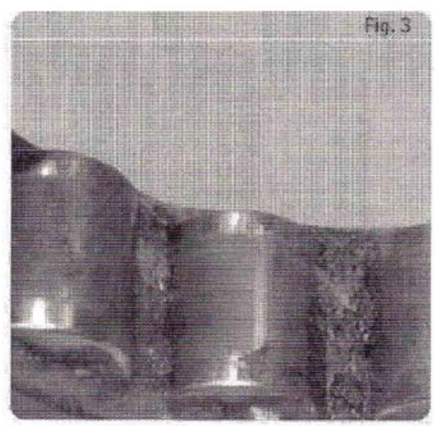
Fluting or washboard pattern
A pattern of lines (fluting) across the raceways can be a sign that current has passed through the bearing. Fluting is not primary damage resulting from stray electric currents but is secondary damage that becomes visible over time.

Fig. 2



Grease-blackening
Electric discharges cause the base oil in the lubricant to burn and harden to create a poor lubrication condition.

Fig. 3

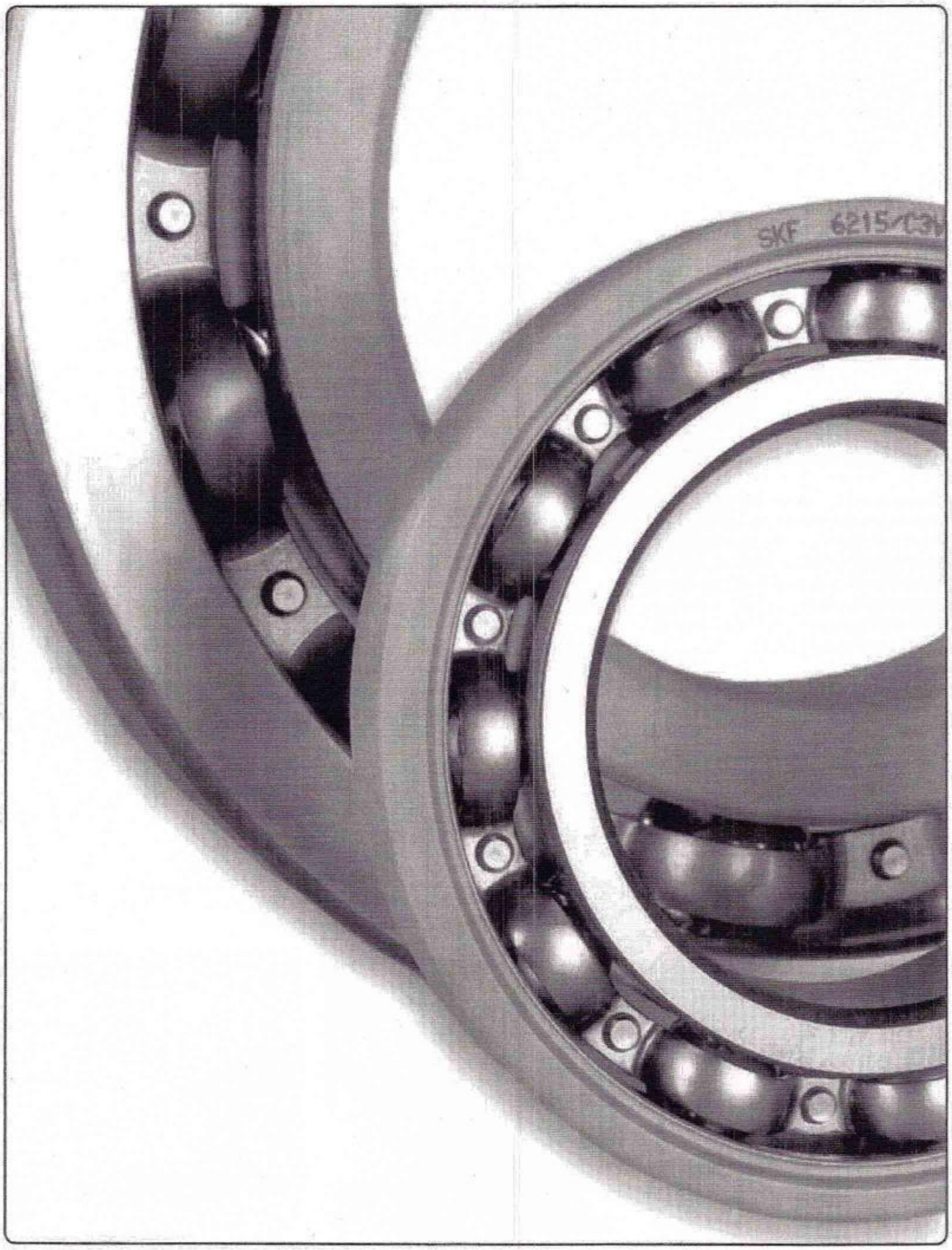


SKF

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)



SKF

INSOCOAT

An INSOCOAT bearing is a very economical solution when compared with other insulation methods that protect a bearing against electric current passage. By integrating the electrical insulation function into the bearing, SKF has been able to increase reliability and machine uptime by virtually eliminating the damaging effects of stray electric currents.

INSOCOAT bearing designs

The standard range of INSOCOAT bearings in the most frequently used sizes and variants are available from stock as

- single row deep groove ball bearings
- single row cylindrical roller bearings.

The performance data as well as the dimensional and running accuracy of INSOCOAT bearings are identical to standard non-insulated bearings.

INSOCOAT bearings with coated outer ring

Bearings with an electrically insulating coating on the external surfaces of the outer ring are the most common INSOCOAT bearings. They are identified by the suffix VL0241.

Outer ring coated INSOCOAT bearings are recommended for medium size motors, that use 6215, 6313 size bearings and larger. For applications where smaller bearings are used, SKF recommends hybrid deep groove ball bearings.

INSOCOAT bearings with coated inner ring

Bearings with an electrically insulating coating on the external surfaces of the inner ring provide enhanced protection against electric current damage. The enhanced protection results from the increased impedance due to the smaller coated surface area. Bearings with a coated inner ring are identified by the suffix VL2071 and are recommended for larger size motors (typically from bearing sizes 6226, 6324 sizes and larger), or other applications where the bearings risk being subjected to high shaft voltages.

Technical features and benefits

- The coating is applied using a plasma-spray technique. Sophisticated pre- and post- application processes yield an outstanding coating quality.
- INSOCOAT bearings are treated with a unique sealant to guard against humidity and water from penetrating the coating and reducing its effectiveness.
- Due to the quality of the application and finishing processes, INSOCOAT bearings provide reliable and consistent insulation, that is virtually insensitive to heat, moisture and chemicals.
- SKF can supply values for relevant electric parameters for the bearings (capacitance, impedance) to optimize the insulating solution for any application.
- INSOCOAT bearings are environmentally friendly.
- INSOCOAT bearings with an outer ring coating are suitable for all types of housings. No additional mounting precautions are necessary.

SKF

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

Dimensions

The boundary dimensions of INSOCOAT deep groove ball bearings and cylindrical roller bearings are in accordance with ISO 15:1998.

Tolerances and fits

INSOCOAT bearings are produced to Normal tolerances. Some deep groove ball bearings are also available with higher accuracy to tolerance class P5.

The aluminium-oxide layer applied either to the external outer ring surfaces or the external inner ring surfaces does not influence running accuracy.

INSOCOAT bearings can be mounted with the same fit as a standard bearing in an electric motor or generator, without risk of damaging the coating. Fits up to and including p6 for inner ring coated variants and P6 for outer ring coated variants can be applied.

Internal clearance

Standard INSOCOAT deep groove ball bearings and cylindrical roller bearings are manufactured with the radial internal clearance to the class shown in the bearing designation. Before ordering, check the availability of bearings with clearances other than standard.

Cages

Depending on the bearing type and size, INSOCOAT bearings are equipped with one of the following cages

- a riveted cage of pressed steel, no designation suffix, or
- a two-piece machined brass cage, rolling element centred, designation suffix M.

Electrical properties

INSOCOAT bearings provide effective protection against AC and DC currents. The specifications for different variants are:

VL0241 Electrical resistance: min. 50 MΩ, breakdown voltage: max. operating voltage 1 000 V DC.

VL0246 Electrical resistance: > 150 MΩ, breakdown voltage: max. operating voltage 3 000 V DC.

VL2071 Electrical resistance: min. 50 MΩ, breakdown voltage: max. operating voltage 1 000 V DC.

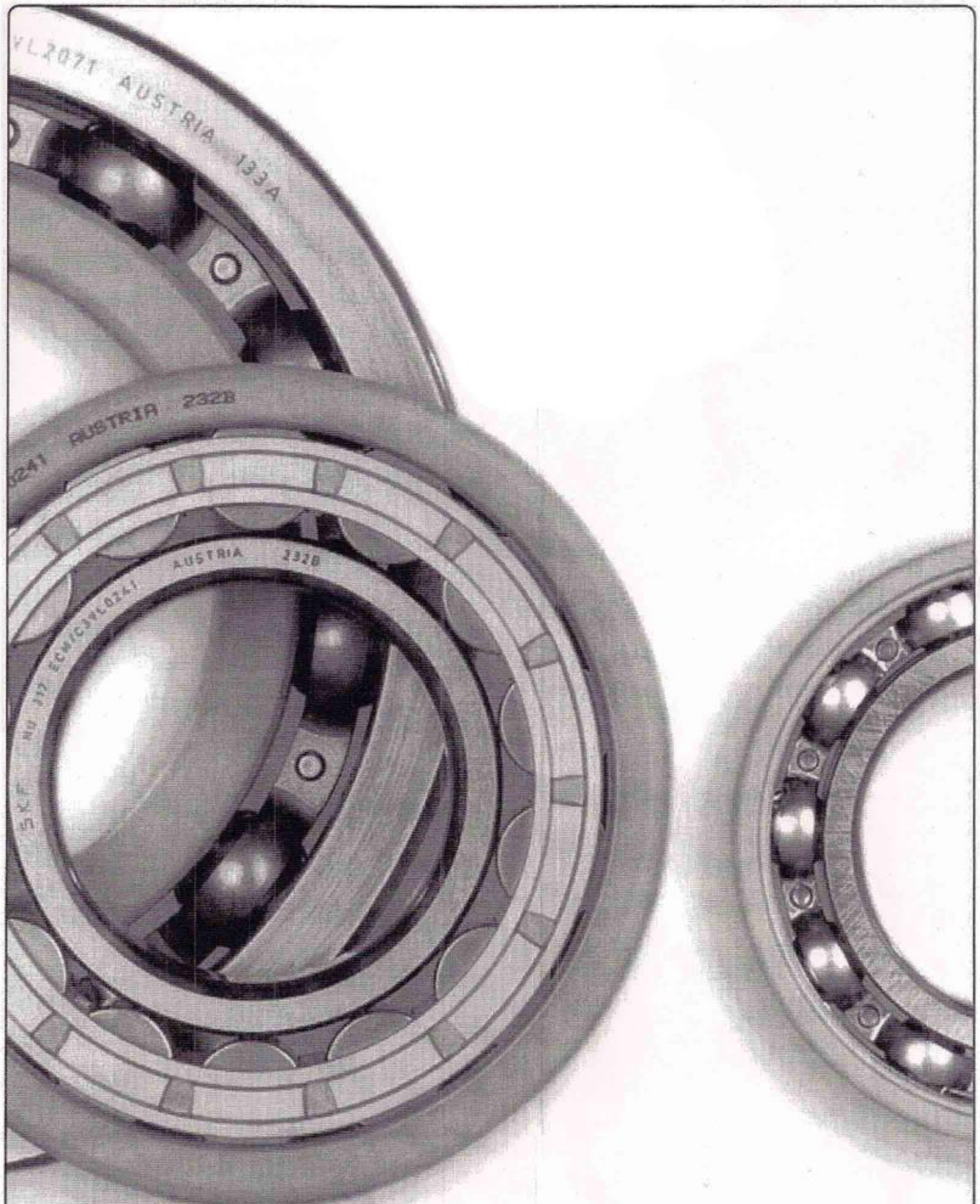
VL2074 Electrical resistance: > 150 MΩ, breakdown voltage: max. operating voltage 2 000 V DC.

Design of associated components

To maximize the effects of the insulating properties of INSOCOAT bearings, SKF recommends the following:

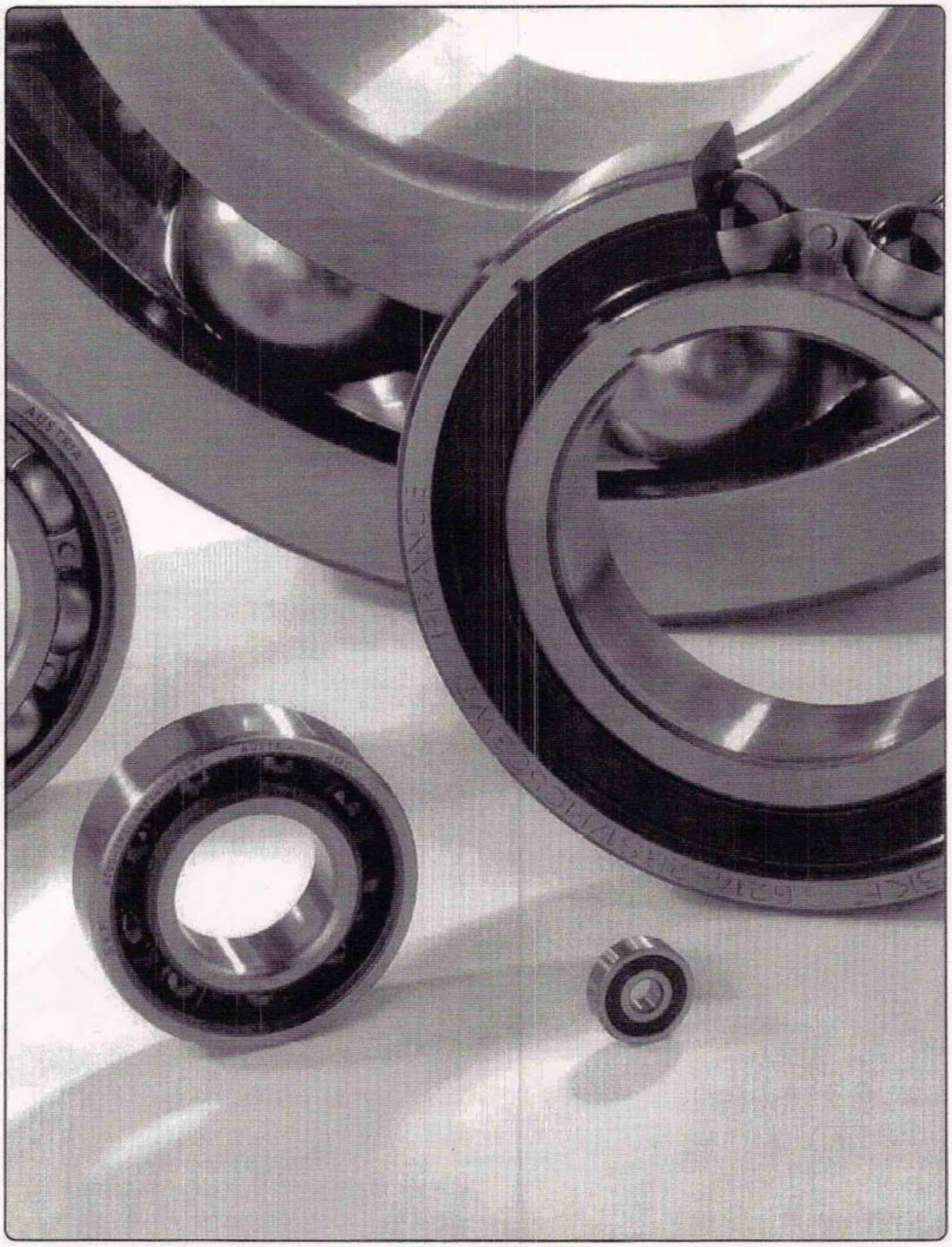
- For bearings with a coated outer ring designation suffix VL0241, the housing shoulder or spacer sleeve should not have a diameter smaller than the abutment dimension D_a min listed in the assortment tables. For VL0246 abutment dimensions, contact SKF.
- For bearings with a coated inner ring designation suffix VL2071, the shaft shoulder or spacer sleeve should not have a diameter larger than the abutment dimension d_a max listed in the assortment tables. For VL2074 abutment dimensions, contact SKF.

SKF



The coating can be applied to either the outer or inner ring to provide protection against electric current damage in bearings. Designation suffix VL0241 or VL2071 respectively.

SKF



SKF

Hybrid bearings – more than an insulator

Hybrid bearings have rings made of bearing steel and rolling elements made of bearing grade silicon nitride (Si_3N_4). Because silicon nitride is such an excellent insulator, hybrid bearings can be used effectively to insulate the housing from the shaft in both AC and DC motors, as well as in generators.

In addition to being an excellent insulator, hybrid bearings have higher speed capabilities and will provide longer bearing service life under the same operating conditions than a similarly sized all-steel bearing.

Features and benefits

Lower density

The density of a bearing grade silicon nitride rolling element is 60 % lower than a similarly sized rolling element made from bearing steel. Less weight means lower inertia – and that translates into superior behaviour during rapid starts and stops as well as higher speeds.

Lower friction

The lower density of a silicon nitride rolling element combined with its low coefficient of friction, significantly reduces bearing temperatures at high speeds. Cooler running increases the service life of both the bearing and the lubricant.

High hardness and high modulus of elasticity

The high degree of hardness of a silicon nitride rolling element means high wear-resistance, increased bearing stiffness and longer bearing service life in contaminated environments.

Low coefficient of thermal expansion

A silicon nitride rolling element has a lower coefficient of thermal expansion than a similarly sized rolling element made from bearing steel. This means less sensitivity to temperature gradients at high temperatures for better, more accurate preload control.

Runs faster, lasts longer

Combine the lower density of silicon nitride with its lower coefficient of friction, high hardness and the fact that silicon nitride will not smear the raceways under poor lubrication conditions, and the result is a bearing that will run faster and longer even under the most difficult operating conditions.

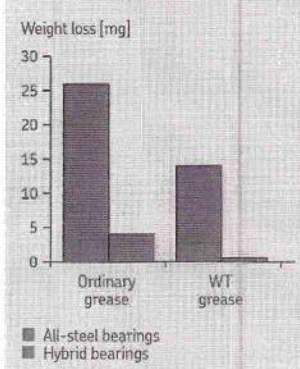
Resists false brinelling

If a stationary bearing is subjected to vibrations there is a risk that "false brinelling" will occur. False brinelling is the formation of small indentations in the raceways that will eventually lead to spalling and premature bearing failure. In cases where steel balls were replaced by ceramic balls the bearings were found to be much less susceptible to false brinelling.

Hybrid bearings supplied with SKF wide temperature grease (WT) were found to sustain less false brinelling damage than bearings containing other types of greases (→ **diagram 1**).

Diagram 1

"False brinelling" at 25 Hz



SKF

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

Cages

Depending on their size, standard SKF hybrid deep groove ball bearings are fitted with

- an injection moulded snap-type cage of glass fibre reinforced polyamide 6,6 or
- a riveted pressed steel cage.

Hybrid bearings with a polyamide 6,6 cage can be operated at temperatures up to +120 °C (+250 °F).

Polyetheretherketone (PEEK)

The use of glass fibre reinforced PEEK cages is becoming more common for applications where there are high speeds or high temperatures. PEEK provides a superior combination of strength and flexibility and does not show signs of ageing due to high temperatures or oil additives. The maximum temperature for high-speed use is limited to +150 °C (+300 °F) as this is the softening temperature of the polymer. For additional information about PEEK cages, contact the SKF application engineering service.

Seals

The SKF standard range of hybrid bearings for electric motors consists primarily of single row deep groove ball bearings. Sealed and greased-for-life SKF hybrid deep groove ball bearings are protected on both sides by

- a low-friction RSL seal, fitted to bearings with an outside diameter ≤ 52 mm, designation suffix 2RSL
- a low-friction RZ seal, fitted to bearings with an outside diameter > 52 mm, designation suffix 2RZ
- an RS1 contact seal, fitted to bearings with an outside diameter ≥ 90 mm, designation suffix 2RS1.

All seals are made of acrylonitrile-butadiene rubber (NBR) with sheet steel reinforcement. The permissible operating temperature range for these seals is –40 to +100 °C (–40 to +210 °F) and up to +120 °C (+250 °F) for brief periods. For operating temperatures up to +180 °C (+355 °F), seals made from fluoro rubber are available. For additional information about these seals, contact the SKF application engineering service.

Lubrication

The standard sealed hybrid bearing is filled with a premium quality synthetic ester oil based grease, containing a polyurea thickener (designation suffix WT). This grease, which has an operating temperature range from about +70 to +120 °C (+160 to +250 °F), has excellent lubrication properties and provides extremely long service life.

Hybrid bearings perform extremely well under vibrating or oscillating conditions. It is therefore not usually necessary to use special greases for these conditions.

Comparison of the material properties of bearing steel and bearing grade silicon nitride

Material properties	Bearing steel	Bearing grade silicon nitride
Mechanical properties		
Density (g/cm^3)	7,9	3,2
Hardness, HV 10 (kg/mm^2)	700	1 600
Modulus of elasticity (GPa)	210	310
Thermal expansion (10^{-6}/K)	12	3
Electrical properties (at 1 MHz)		
Electrical resistivity (Ωm)	$0,4 \times 10^{-6}$ (conductor)	10^{12} (insulator)
Dielectric strength (kV/mm)	–	15
Relative dielectric constant	–	8

SKF

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

Grease life in hybrid bearings

Tests have shown that when used with sealed hybrid bearings, the wide temperature grease (WT) from SKF has a very long service life even at high speeds and high temperatures. One example (→ **diagram 2**) shows where the life of WT grease in hybrid bearings was four times longer than in all-steel bearings. The shaft diameter was 20 mm, the speed 20 000 r/min and the operating temperature +120 °C (+250 °F).

Most SKF hybrid deep groove ball bearings are sealed and greased-for-life.

SKF recommends relubrication of open bearings with SKF grease LGHP 2. In general, the relubrication interval is 3 to 5 times longer than for an all-steel bearing.

For very high-speed applications at temperatures below +70 °C (+160 °F) the use of either SKF grease LGLC 2 or SKF grease LGLT 2 is recommended.

The recommended bearing operating temperature range for maximum grease life is +70 to +120 °C (+160 to +250 °F).

Equivalent bearing loads

The equivalent dynamic and static bearing loads of hybrid deep groove ball bearings are calculated using the equations for all-steel deep groove ball bearings.

Typical hybrid bearing designations suffixes

The designation suffixes used to identify certain features of SKF hybrid deep groove ball bearings are explained in the following.

- **C3** Radial internal clearance greater than Normal
- **HC5** Rolling elements of silicon nitride
- **TNH** Injection moulded snap-type cage of polyetheretherketone (PEEK)
- **TN9** Injection moulded snap-type cage of glass fibre reinforced polyamide 6,6
- **WT** Grease with a polyurea thickener of consistency 2–3 to the NLGI Scale for a temperature range –40 to +160 °C (–40 to +320 °F) (normal filling grade)
- **2RS1** Sheet steel reinforced contact seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing
- **2RSH2** Sheet steel reinforced contact seal of fluoro rubber (FKM) on both sides of the bearing
- **2RSL** Sheet steel reinforced low-friction seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing
- **2RZ** Sheet steel reinforced low-friction seal of acrylonitrile-butadiene rubber (NBR) on both sides of the bearing

Dimensions, tolerances, internal clearance

Standard SKF hybrid deep groove ball bearings are manufactured as standard with

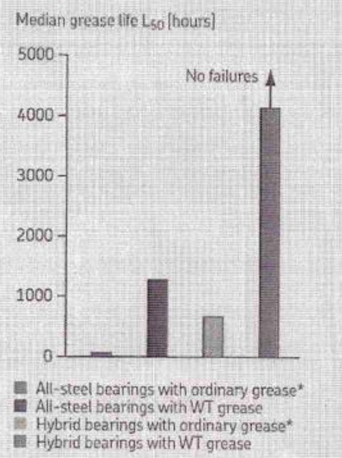
- boundary dimensions to ISO 15:1998
- Normal tolerances to ISO 492:2002
- C3 radial internal clearance to ISO 5753:1991.

Recommendations for installation

Hybrid bearings should be handled and mounted in the same manner as conventional all-steel bearings. Always use the right tools and correct methods for mounting and dismounting.

Diagram 2

Long grease life with WT grease in hybrid bearings



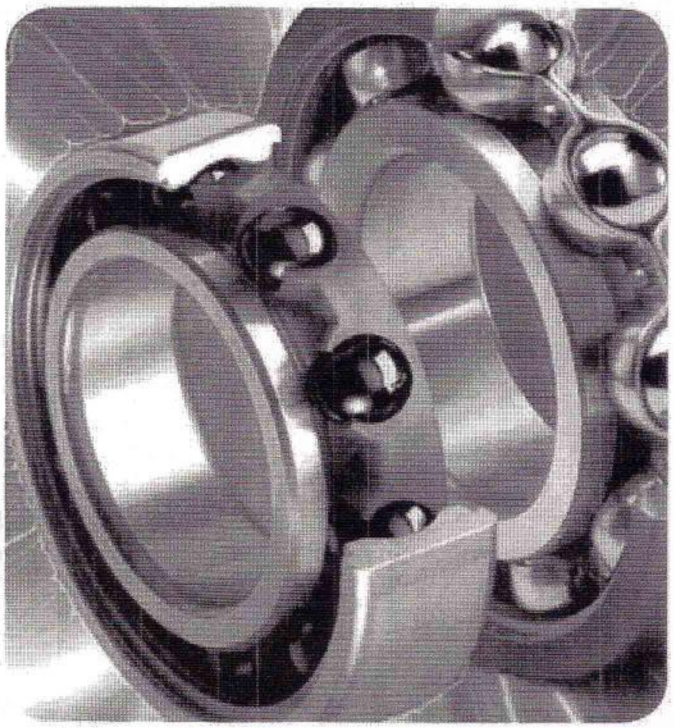
* At +120 °C (max temperature for ordinary grease)

Grease alternatives offering long service life in hybrid bearings

SKF grease	Temperature range*
WT	–40 to +160 °C –40 to +320 °F
LGHP 2	–40 to +150 °C –40 to +300 °F

* For additional information about safe operating temperatures, refer to the chapter "Lubrication" in the SKF General Catalogue

SKF



Publication **6160 EN** · May 2006

This publication supersedes publications 5128 E and 5225 E.

Printed in Sweden on environmentally friendly paper.

SKF

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

SKF TKED 1

Instructions for use

EC Declaration of conformity

We, SKF Maintenance Products, Kelvinbaan 16,
3439 MT Nieuwegein, declare that the

SKF TKED 1

is designed and manufactured in accordance with European Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States related to electromagnetic compatibility and repealing Directive 89/336/EEC and conforms with:

EN 61326 - 1:2006
EN 61000 - 6-3:2007
EN 61000 - 4-2
EN 61000 - 4-3*
EN 61000 - 4-8

*with the exception of the electromagnetic field immunity in the frequency range of 80 MHz to 300 MHz at 2.5 V/m, where the instrument is sensitive to the electromagnetic field.

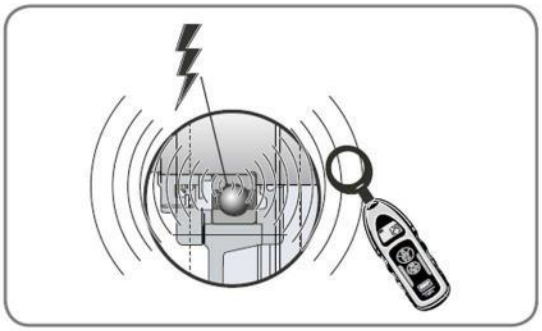
The Netherlands, 06 October 2008

CE

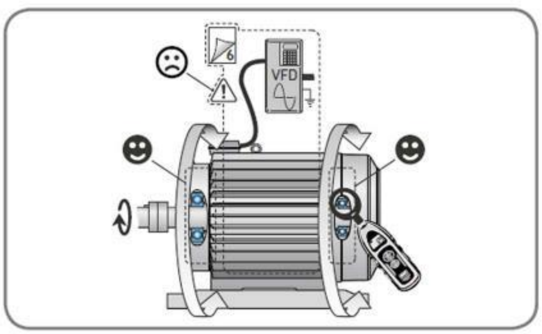
Sébastien David
Manager Product Development and Quality

Instructions for use

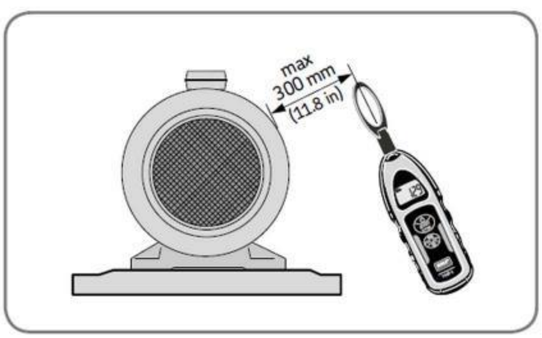
1. TKED 1 detects electrical discharge within the frequency range of 50 MHz to 200 MHz:



2. Use the TKED 1 as close as possible to the bearing location to perform a detection. Avoid the vicinity of the cables and the Variable Frequency Drive (VFD) controller, which could induce some disturbances:

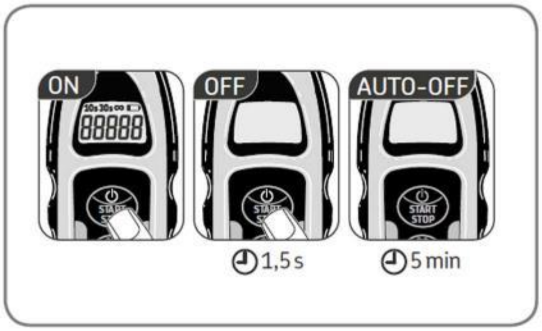


3. The maximum measuring distance is 300 millimetres (11.8 inches):

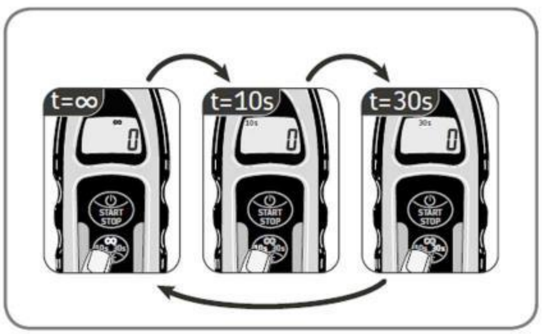


720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

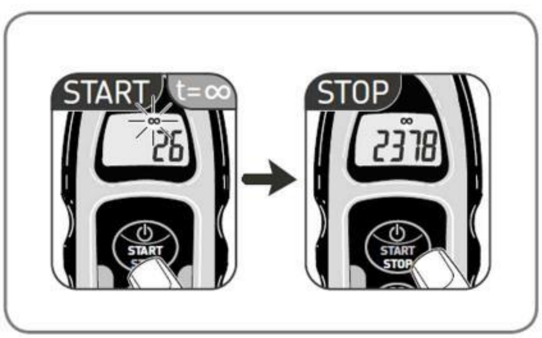
4. Press on/off button to switch the unit on.
   Press on/off button during 1.5 seconds to switch the unit off.
   The unit switches automatically off after 5 minutes if no buttons are pressed:



5. Press the sampling time mode to toggle between the default measuring time (infinite, 10 or 30 seconds):

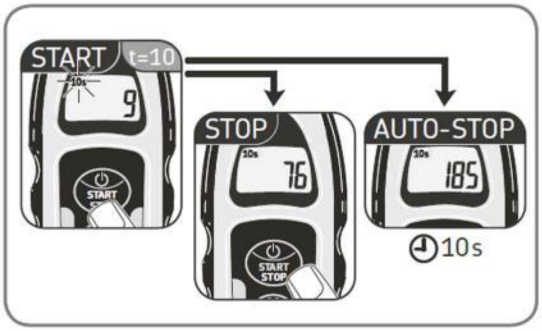


6. If the measuring time selected is infinite: press the start/stop button once to begin the measurement, and press the start/stop button once again to stop the measurement:

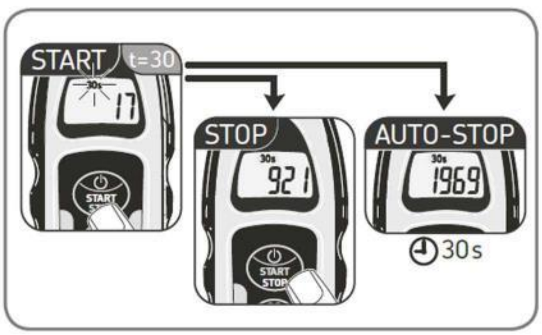


720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

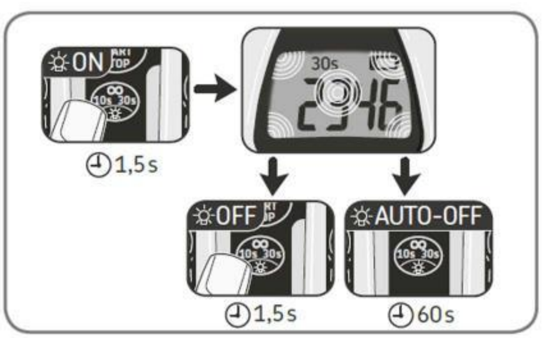
7. If the sampling time selected is 10 seconds: press the start/stop button once to begin the measurement. The measurement will stop after 10 seconds, or if the start/stop button is pressed again:



8. If the sampling time selected is 30 seconds: press the start/stop button once to begin the measurement. The measurement will stop after 30 seconds, or if the start/ stop button is pressed again:

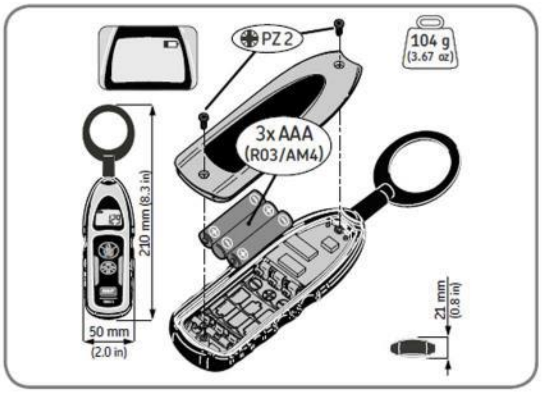


9. To enable/disable the backlit, press the key displaying the light symbol during 1.5 seconds. The backlit will stop automatically after 60 seconds.

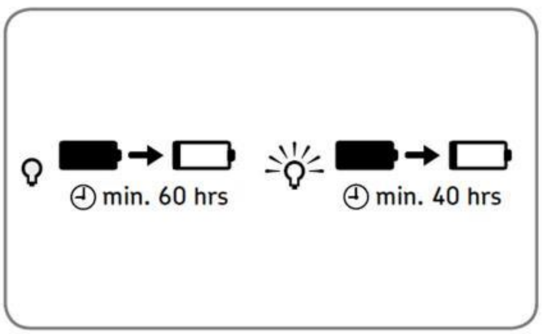


720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

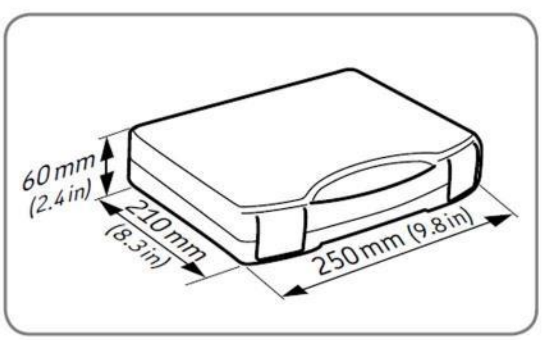
10. When the low battery symbol is displayed on the screen, replace the batteries (3 x Alkaline AAA). To access the battery compartment, use a PZ2 screwdriver.



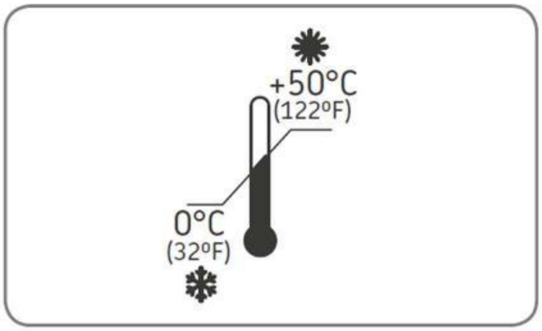
11. Battery life time is
   - 60 hours without the backlit on
   - 40 hours with the backlit on:



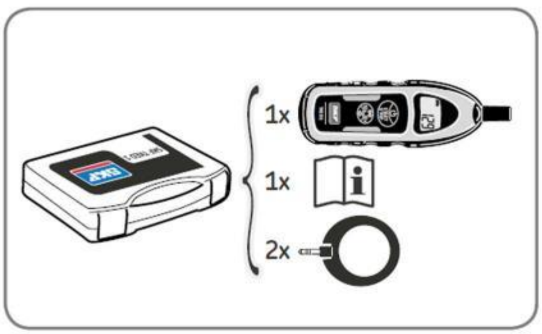
12. Case dimensions:



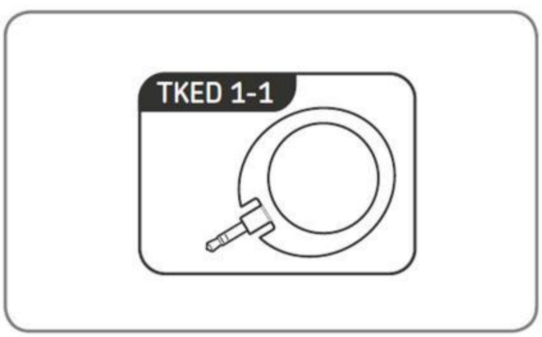
13. Storage and service temperature:



14. Content of the kit:
    - one TKED 1 display unit
    - one instruction MP5355
    - two identical antenna's



15. Spare part designation:



VIBES Corp®
Est. 1967
SERIOUS SERVICE®
Professional Machinery Health Care
(Fan Doctor®)
Vibration Industrial Balancing & Equipment Services, Corporation
720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

MaPro TechNote

TechNote nr. 009
Date: 2011-06-27

Product group	: Instruments
Product	: SKF Electrical Discharge Detector Pen (EDD Pen) TKED 1
Category	: Background knowledge and application
Author	: Sylvain Humbert / Julien Meunier
Subject	: **SKF Electrical Discharge Detector Pen TKED 1 in 19 questions**

The TKED 1 is a unique instrument and as a consequence has lead to many questions being asked about this instrument. This TechNote seeks to answer the nineteen most common questions,

1. **What is electrical erosion in a bearing?**
   Electrical erosion (shaft currents, stray currents) is internal bearing damage due to induced currents in the motors under normal running conditions.

2. **What does the EDD Pen detect?**
   The EDD Pen detects electrical discharges (or pulses) in bearings of electrical motors on a chosen time base. The more pulses counted, the higher the risk of electrical erosion and lubricant degradation occurrence.

3. **What does the number displayed after checking mean?**
   The number displayed is the number of discharges detected and counted by the EDD Pen in a given time frame.
   The EDD Pen counts the occurrence of electrical discharges in the selected time frame. For example: if the 10s time base is selected, and at the end of the detection time, we have "233", then we know that the motor is experiencing electrical discharges in the bearings (because it's not "0"). Furthermore we detected 233 electrical discharges in 10 seconds.

   The TKED 1 must then be used as a trending instrumentation. The user can create their own database.

   In a population of similar motors under similar loads, it is assumed that the number displayed would not differ greatly. If a motor shows a reading significantly different then it is more likely to suffer from electrical erosion than the other bearings.

   Examples:
   If you measure 25 motors using the EDD Pen and motors #1 to #24 show a reading between 1100 and 2400 but motor #25 shows a reading of 10000, then this means that motor #25 is more likely to suffer the effects of electrical discharge currents. In this case the bearing of motor #25 should be checked at the first opportunity.

   Looking at one motor in isolation, a significant increase in electrical discharge over time would suggest a higher risk of electrical erosion.
   However comparative measurement at a given time between similar machines would better identify a machine more likely to suffer the effects of electrical erosion.

4. **What justifies the choice of 10s, 30s or indefinite?**
   The choice of the time base detection is just for the comfort of the user: depending on the number of motors to check and the importance of the motor in the application. For example: in a park of 100 motors, a 10s checking of every bearing will help identifying the faulty ones quickly. Conversely, one single motor in critical application will need more time and investigation on its bearings, and then the indefinite time period can be selected in order to screen the bearings.
   Beware: there is no difference regarding the detection principles between these 3 time bases.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5
www.vibescorp.ca email: info@vibescorp.ca
Phone: 604 - 619 - 9381 (24/7)

5. **What is the maximum distance to the motor when using the EDD Pen?**
   In general, depending on motor type and duty *30 cm (12 in)* is the maximum distance away from the motor to obtain a representative reading.

6. **How do I get meaningful measurements with the EDD Pen?**
   Like all condition monitoring equipment used for predictive maintenance, the EDD Pen should be used in a consistent way. Before every measurement, make sure that the EDD Pen is at *the same distance and direction* from the bearing, and check that you measure using the *same time base*.

   Like all condition monitoring measurements of electric motors, you can only compare when the running conditions are similar. To get the best results, use the EDD Pen to compare your motor in the *same running conditions* over time. This means that it is not wise to compare results if your motor is running at different speeds or loads.

   You should also not compare an inspection of your motor that has just started and is cold with one that has been running some time and has reached its operating temperature. To compare inspections of your motors running under different conditions will add little value to your predictive maintenance program and will cause confusion when interpreting the results.

7. **What are the principles behind the TKED 1?**
   The EDD Pen is detecting every significant modification of the local surrounding magnetic field (we talk about "*near-field H-field*" detection) in a given frequency (50Mhz to 200Mhz: VHF). Every time an electrical discharge takes place in a bearing (between the inner or outer ring and the rolling element), the local magnetic field surrounding the bearing at that moment is disturbed and acts like a pulse. The electrical discharge last only for a few nano-seconds, but thanks to the EDD Pen, we can detect its effect in the magnetic field changes induced. The EDD Pen detects those pulses.

8. **Is there any other way to detect electrical erosion in bearings?**
   Yes there are two other ways:
   One is dismounting the bearing and analyzing it (very often because it has failed)
   The other way is to use an oscilloscope to detect electrical discharges, which requires wiring and sensors and a good knowledge on electrical analysis issues.
   Neither is as easy or as cost-effective as the EDD Pen.

9. **Who can use the EDD Pen?**
   Everybody! Any person within a facility can learn within a few minutes how to use this easy-to-use instrument.

10. **Can we always expect to detect some discharges on an electric motor?**
    No, fortunately, a large majority of motors are not suffering from electrical erosion; therefore, they don't face any electrical discharges inside their bearings.
    In those cases, the EDD Pen will display only "0", which is a good news for the concerned machine. However, remember that potentially all motors can suffer from electrical erosion.

11. **Can I use the EDD Pen for all electric motors?**
    The EDD Pen is especially suitable for use on motors driven by a *Variable Speed Drives* (also known as frequency drives or inverters) that have a potential risk of suffering electrical erosion of bearings. It should be mentioned that not all motors driven by a VFD suffer from electrical erosion, although the potential risk is always present.

    Also the EDD Pen can be used for some older electrical motors using DOL (Direct On Line) that can potentially suffer from electrical erosion due to low frequency circulating currents.

12. **Is it possible to detect electrical discharges on DOL (direct on line) motors?**
    Yes, rarely, even without a variable frequency drive, some AC motors can suffer from electrical erosion because of their rotor asymmetry and rotor eccentricity creating some low frequency circulating currents. This is actually not very common due to the good manufacturing and good quality motors nowadays.

720 - 999 W. Broadway, Vancouver, BC V5Z 1K5

www.vibescorp.ca email: info@vibescorp.ca

Phone: 604 - 619 - 9381 (24/7)

13. **Can I use the EDD Pen to check DC motors or Generators?**
The EDD Pen will detect any electrical discharge occurring in bearings, whether it's on an AC motor, DC motor or generator, however, on the market today, AC motors are the most commonly used. On a DC motor, the NDE (non drive end) bearing is difficult to check because of the proximity of the collector and the electrical discharges between the brushes and the collector laminations. On a generator, large machines can also suffer from electrical erosion.

14. **Can we detect exactly the same phenomenon with vibration analysis before the bearing is fluted**
No, vibration analysis can help only on an advanced stage of the damages. When the first signs of electrical erosion occur, only micro-cratering due to the electrical discharges take place, that's why the EDD Pen can help identifying a faulty motor at an early stage.

15. **Can we determine the criticity of the electrical discharges based on the number displayed on the EDD Pen?**

Not exactly, the EDD Pen is a quick diagnosis tool that helps identifying faulty installations (AC motors and drives, DC motors, generators...) suffering from electrical erosion. It gives the user the information whether we have or not some electrical discharges taking place in the bearings. The numbers displayed, if different from "0" or thousands in a short time (see IFU's warning) will help us prioritize the need of action in a park of motors, or to gain experience for every application for the future maintenance.
The criticality of the electrical discharges is shown in the number of electrical discharges and in their intensity, so on top on their occurrence, because we talk about near-field H-field detection, only the distance to the bearing will give us a comparative idea on the intensity of the electrical discharges: the further we stand from the bearing with the EDD Pen, the fewer electrical discharges are detected, and these are the major ones.

16. **What parameters influence the presence of electrical discharges?**
There are many parameters that influence the presence of this phenomenon, that's why it's today impossible to link it to the service life of the bearings: load on the bearing, axial or radial, lubricant temperature, lubricant type, operating conditions, speed, cables used, grounding used, switching frequency, etc...

17. **Is there any guideline on the best way to inspect an electric motor with the EDD Pen?**
Yes there is, and for that, a good knowledge of the machine observed is necessary: the area where the most likely electrical discharges will appear if existing will be in the area where the bearing is loaded, so, it is advised to set the EDD Pen as close as possible to this area. Remember, it's near-field H-field detection, so the closer we are from the source, the better we can detect the discharges. However, the user must remain in a safe zone from the rotating machinery.
Second, inspections should be performed once the full machine has achieved its running in period, because the lubricant is then in its operational conditions, and so is the bearing.
Third, inspections should be performed when the motor is in its normal operating conditions (not at start up, not just after re-greasing or maintenance, at normal load, normal speed...). In case of comparative checking when actions couldn't be taken after first diagnosis, it's recommended to do the measures in the same operating conditions with the EDD Pen at exactly same distance, position and orientation.

18. **I see that with an oscilloscope, there are many different peaks of electrical discharges occurring in the bearing, a lot of small peaks, meaning low intensity discharges and a few major peaks, meaning high intensity discharges. Does the EDD Pen detect them all?**
No, the EDD Pen alone detects major electrical discharges which can significantly damage the bearing and lubricant. (remote vs contact)

19. **What do SKF recommends when in presence of a faulty installation?**
SKF recommends to take corrective actions in case of electrical discharges detected in a bearing, by many means, typically: checking grounding, connections, and if this doesn't give any result, it is recommended to use insulated bearings (INSOCOAT) or Hybrid bearings to either insulate the bearings or offer an easier path than the bearings for the current to discharge to the earth.