



Avoiding Motor Shaft
Voltage & Bearing
Current Damage

Avoiding Motor Shaft Voltage & Bearing Current Damage

The use of variable frequency drives (VFDs) has grown significantly over the last decade, and rightly so — their operating cost is low, they notably enhance motor performance, and can lead to significant energy savings for your motor system.

Unfortunately, while VFDs prevent multiple motor problems, they can also bring in a new one: motor bearing damage. VFDs create common mode current buildup that travels from the VFD to the motor along the cable. This common mode current induced in the cable can cause serious damage to both the motor bearings and the motor itself, ultimately leading to motor failure.

Generally speaking, motor bearings are designed to function 100,000 hours of operation. That's over 11 years of continual daily usage. Despite this expectation, electric motors equipped with VFDs can experience bearing failure in a month or less. With the growth in VFD usage, bearing failure now accounts for roughly 50% of all reported motor failures.

Motor Bearings are Designed to Function for

100,000
Hours of Operation

To prevent this reoccurring issue, Renown Electric examined the underlying causes of motor bearing damage and found a solution which is simple to install or retrofit into existing applications.

Let's first take a look at how VFDs cause motor bearing damage with high-frequency currents.

What is High Frequency Current?

Motor Failures Cost an Average of

\$10,000

in Production Downtime

Unplanned production downtime from bearing failure is costly. Not including part and repair costs, motor failures in smaller systems cost an average of \$10,000 in production downtime — in systems with larger electric motors (300 HP or larger), production downtime costs approach and can even surpass \$100,000.

These bearing-related motor failures do not simply happen — they are allowed to develop, slowly, over time. The longer the issue is allowed to progress

unmitigated, more damage will occur in your motor. To keep motors operating perfectly and avoid costs, it is important to understand the cause — VFDs and the high frequency current they induce.

VFDs improve motor efficiency by controlling both speed and torque. They do so by running digital signals from a micro-processor based controller through a switch, generally an insulated-gate bipolar transistor, which converts it to an electrical signal usable by the motor. A byproduct of this conversion is electrical noise, a significant spike in voltage.

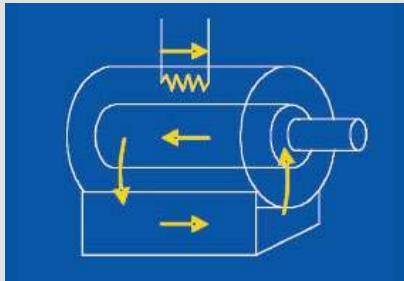


These high frequency voltage spikes accumulate in the cable similar to charging a capacitor, and in the motor itself. Once the charge is high enough it looks for the fastest path to ground. The quickest route to ground in an electric motor is through the motor bearings, a phenomenon known as bearing current.

The discharge caused by these high frequency bearing currents is similar to EDM (Electro-static Discharge Machining) and will cause fluting, scoring, cracks, and fractures. This damage leads to bearing failure and, ultimately, motor failure.

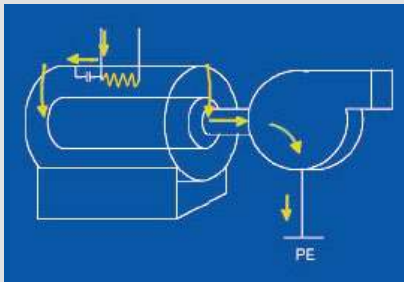
Current Types

VFDs can cause three different types of current, all of which are harmful to motor shafts, motor bearings, or even complete motors.



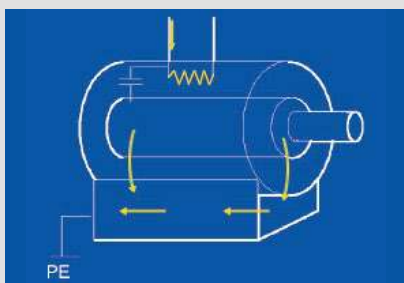
LOW FREQUENCY CIRCULATING CURRENTS

Low frequency circulating currents are a form of common mode current. Induced via the air gap between stator and rotor circuits, this transient voltage travels circuitously through the motor frame and motor bearings. When high enough, circulation currents can break down bearing lubrication and cause discharge currents.



HIGH FREQUENCY SHAFT GROUNDING CURRENTS

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CAPACITIVE DISCHARGE CURRENTS

When the air gap capacity functions as a common mode voltage divider, the voltage couples between the motor shaft and motor frame. The created air gap capacity discharges through the motor bearings to ground.

Identifying Bearing Damage Symptoms

An electric motor experiencing bearing current displays a range of symptoms. The most obvious symptom is audible noise emanating from the motor bearing — it is also one of the last symptoms to present itself, usually indicative of advanced bearing failure.

Though they require production shutdowns — in fact, these are often not performed until after motor failure — there are a number of bearing current symptoms on both bearing races and balls/rollers that can be visually identified and used to diagnose bearing current and shaft current.



Lubricant can be dark, or even black, in color when it picks up microscopic particles of metal dislodged from the balls or races by electrical currents. Burnt lubricant (black) in a motor bearing is often caused by bearing currents that essentially create an electrical storm in a bearing

and cause the carbon in the lubricant to drop out causing the black appearance. Thin or otherwise degraded lubricant, as well as reduced amounts of lubricant, are indicative of bearing current.

Fluting, or a picket fence-like pattern, is an indication as well — caused by the flow of electrical current, fluting is a series of lines situated perpendicularly across the bearing races. Both balls and bearings can also take on either a frosted appearance or an abnormally “smoky,” or dull, appearance — this is caused by microscopic pitting of the metal by electrical current.

Solutions

As with any potential problem in any field, preventative maintenance should be performed in order to minimize or eliminate bearing currents. Preventative maintenance tests include:

- **Vibration Analysis** — When fluting is present in a bearing, a vibration spectrum analysis will display as a series of hill-like peaks in vibration. Spike energy analysis, a function of certain vibration analyzers, can detect acceleration — often a sign of impending bearing failure. This is one of the most common modern methods used to avoid mechanical failure while prolonging the lifespan of monitored equipment.
- **Shock pulse monitoring and bearing temperature readings** can also be valuable in determining if bearing currents are present in an electrical motor. If the presence of bearing currents is confirmed, shaft grounding brushes and shaft grounding rings, which help to direct some of the current away from motor bearings, can be installed in the system. Brushes and rings, however, require a great deal of maintenance.

FLUTING

FROSTING

DARKEN FINISH

PITTING

DULL FINISH

PICKET FENCE

The problem with all of these methods is that they are preventative only in that they allow you to prevent bearing current damage from worsening — none of them will stop bearing current generation or eliminate bearing currents from your system entirely.

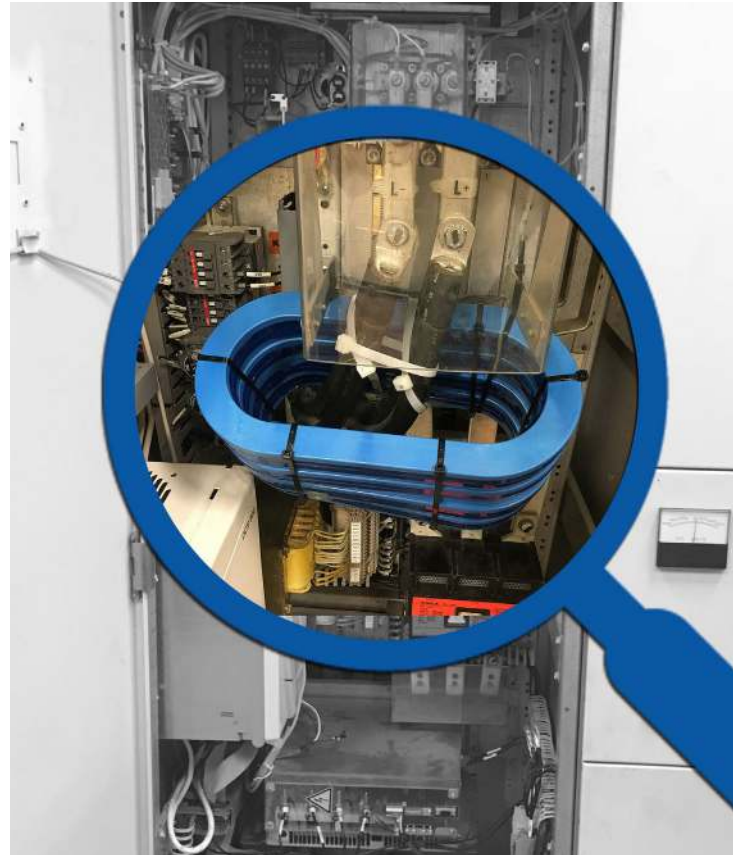
The only true way to prevent bearing currents and the damage they cause is to interrupt or block the current path with the use of common mode chokes. Common mode chokes, sometimes referred to as inductive absorbers, are designed specifically to block, or choke, particular current frequencies. When installed correctly between a VFD and the motor that it controls, common mode chokes reduce peak common mode current and the frequency of discharges, the current that becomes shaft current and bearing current in a motor, to lower levels that will not damage motor bearings.

Testing Common Mode Choke Performance: Case Studies

Renown Electric recently tested the efficacy of common mode chokes in reducing common mode current in two different scenarios, a DC electric motor and an AC electric motor.

Using an oscilloscope and a Rogowski coil, a type of toroidal coil used to measure current, we tested the two different systems before and after installing CoolBLUE inductive absorbers, an industry leading common mode choke. The results showed that the CoolBLUE inductive absorbers reduced common mode current by an average of 65%, bringing levels well within safe operating parameters for the motors.

To learn more about CoolBLUE inductive absorbers and how they can reduce or eliminate bearing and motor failure in your electric motor-run systems, visit our [CoolBLUE product page](#) or [contact](#) Renown Electric today.



Learn more about
CoolBLUE
Inductive Absorbers



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