Electric Motors Operating on Line Voltage

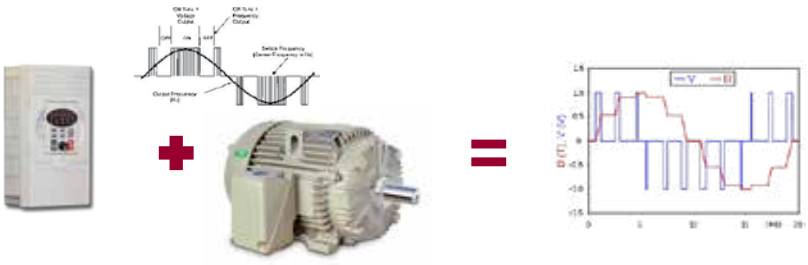
Balanced voltage condition

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

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

Electric Motors Operated by Variable Frequency Drives (VFD)

Unbalanced voltage condition



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

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

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

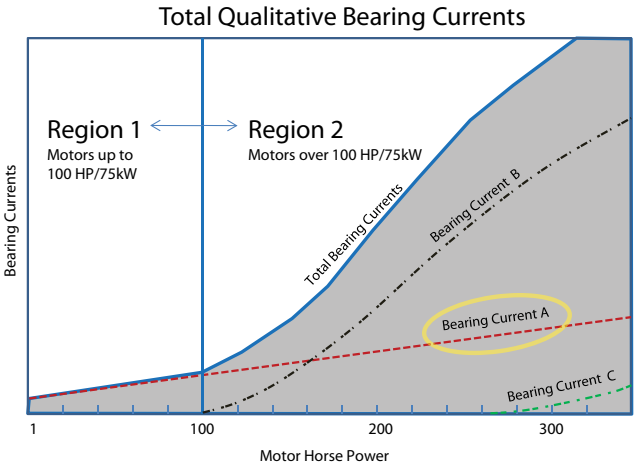
Bearing Current A: is a capacitive induced shaft voltage that discharges in the motor bearings. The VFD induced shaft voltages are capacitively coupled from stator to rotor through parasitic capacitance and create the possibility of bearing currents.

a. Virtually any motor from fractional HP to large motors may have bearing currents from this source.

a. Voltages can discharge through the motor bearings resulting in EDM pitting and fluting failure.

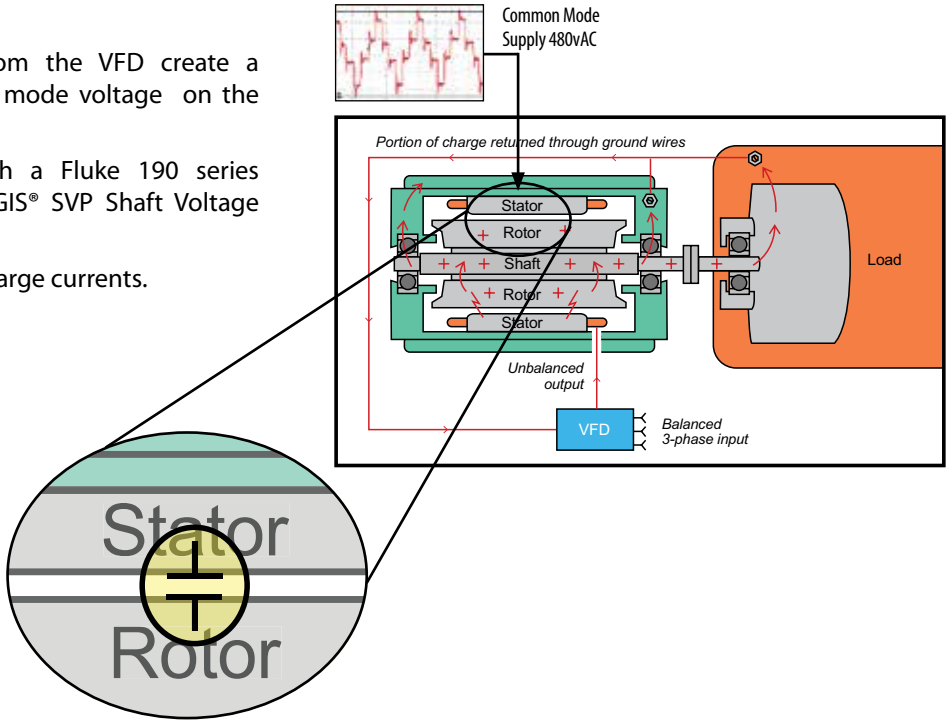
Best Practice: Ground the motor shaft with the AEGIS® Shaft Grounding Ring to provide a path of least resistance to ground and divert current away from the motor's bearings.

Ref: NEMA MG1 Part 31.4.4.3



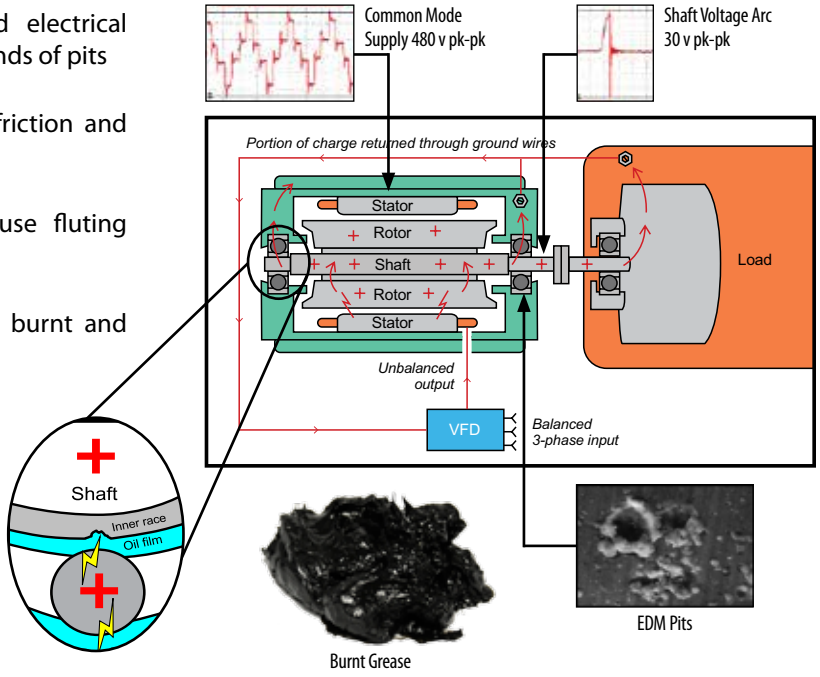
An Electric Motor behaves like a Capacitor *(Bearing Current A)*

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



Voltage arcs through the bearing

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



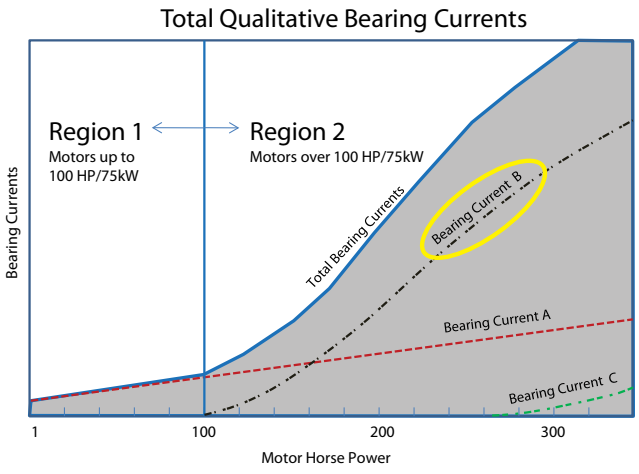
High Frequency Circulating Currents

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

a. May be present in motors above 100 HP.

a. Circulate through the motor bearings, shaft to frame.

Best Practice: Interrupting the high frequency circulating current in the bearing is the best approach to mitigating potential bearing damage. Also, motors subject to Current B (high frequency circulating currents) will also be subject to Current A (capacitively induced shaft voltage) and therefore need an AEGIS® Shaft Grounding Ring.



A third source of bearing currents are circulating currents from 60Hz/50Hz Line Voltage (motors over 500 Frame):

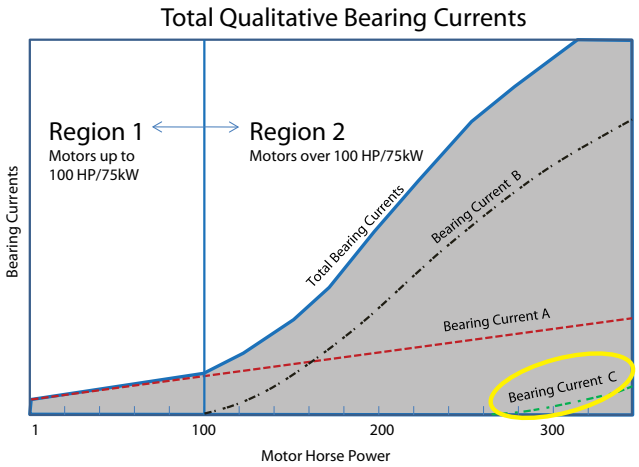
Bearing Current C: Sinusoidal voltage sources can cause circulating currents in large machines due to the motor's asymmetrical design. 50/60Hz operation can result in circulating currents due to motor magnetic asymmetries.

a. Usually present in very large machines only.

a. Circulate through the motor bearings, shaft to frame.

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

Ref: NEMA MG1 Part 31.4.4.3



AC Induction Motors

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