

Informative Application Guidelines, with respect to *Motors & Drives* to keep you better INFORMED.

APPLICATION GUIDELINE #04

(Common Causes of Motor Failure)

.....Brought to you by your Motor & Drive Specialists

How Do Motors Fail?

Bearings.....60-70%	Insulation.....30-40%
<ul style="list-style-type: none"> ➡ • Over/Under Lubrication ➡ • Misalignment/Belt Tension • Contaminants/Compatibility • Vibration • Thrust ➡ • High Ambient • Bearing Currents • Fatigue....L10 	<ul style="list-style-type: none"> ➡ • Overload ➡ • Excessive Number of Starts ➡ • Contaminants/Ventilation Failure ➡ • Thermal Aging • Voltage spikes from VFD's ➡ • System Disturbances ➡ • Excessive Load Inertia ➡ • Insufficient Torque ➡ • Locked Rotor ➡ • Single Phasing ➡ • High Ambient • Vibration

The proper application and selection of low voltage motors can be a demanding task. A good starting point, would be to consider why motors fail to begin with. The above table was created to try to sort through the reasons why motors fail, and to list them in the order in which they would most likely occur. If you were to talk to your local rewind shop, you would most likely find that they also would experience something if not identical, very similar to the above. Upcoming 'Application Guidelines', will investigate some of the causes mentioned above.

It has been observed that bearings fail more often than insulation systems, and the **number one cause of bearing failure** is due to, over/under lubrication. Improper lubrication, causes a heat buildup in the bearing cavity, the added heat causes the grease to break down prematurely, eventually resulting in failure. Ultimately, many of the bearing failures are a result of the bearing exceeding it's temperature limits in one form or another (see arrows).

When evaluating motor bearing systems, some important considerations should be made to the following.

- 1) **Temperature rise of bearings:** Temperature is the root cause of many of the failures listed above, a larger thermal margin in the bearing design is very good. For every 15°C cooler, you double bearing life.
- 2) **Grease nipples and grease relief valves:** To allow greasing and prevent over greasing.
- 3) **Sealed bearings or open style:** Sealed bearings don't require as frequent a greasing interval, and are commonly used on smaller frames which are often in hard to reach places. As frames get larger a transition to open style is important to allow for reduced temperature rises, which extends grease life and greasing intervals.
- 4) **Clearance rating of bearing:** C3 'loose' fitting bearings allow for thermal growth.

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- 5) **Shaft seals:** To protect against contaminants, a v-ring seal (forsheda seal) is better than a flat seal. Inpro seals provide IP55 protection and provides industry leading bearing protection.
- 6) **Bearing sizes on D.E. and O.D.E:** Larger bearings don't run as hot, can handle larger radial loads, have longer L10 lives to extend the affects of fatigue, and aren't as sensitive to small misalignments. 300 series bearings are wider and have much larger outside diameters.
- 7) **Inner bearing caps:** Caps can prevent failed bearings from causing damage to stator & rotor.
- 8) **Drain & breather plugs:** Allows water to escape but prevents water from entering.
- 9) **Grease type:** Premium grade polyurea based greases, extend grease life, have wider operating temperature ranges, contain rust and oxidation inhibitors, run quieter, and have high operating speed capability.

The **number one cause of an insulation failure** is due to, overload conditions, not just from a lack of proper protection but also because of abuse. Furthermore, as is the case in bearing failures, many of the insulation failures are a result of the insulation exceeding it's temperature limits in one form or another (see arrows), indicating that a *motor design with a large thermal margin is very valuable*. Thermal Margin is the difference between actual design temperature rise of the motor at 1.0SF load, and the rated maximum allowable temperature (in most cases, that would be 155°C, the limit for a CLASS F rated insulation system). Temperature rise will be discussed in detail in one of the upcoming guidelines. Insulation failures listed that are affected by temperature in one way or another include: *Overload, Excessive Number of Starts, Contaminants/Ventilation Failure, Thermal Aging, System Disturbances, Excessive Load Inertia, Insufficient Torque, Locked Rotor, Single Phasing, and High Ambient.*

When evaluating motor insulation systems, some important considerations should be made to the following.

- 1) **Temperature rise:** The cooler the motor operates, the longer the expected life of the motor will be. For every 10°C cooler, you double insulation life.
- 2) **Torque:** The more torque a motor has, the faster the acceleration time resulting in less heating of the motor. $t_{\text{accel}} = [\text{wk}2 \times \text{Speed Change}] / [308 \times \text{Avg Accelerating Torque}]$.
- 3) **Class of insulation:** Most motors sold meet class F insulation ratings, however a motor using class H materials in its construction will have a longer thermal life.
- 4) **Solid bracing of end turns / cuffed slot liners / # of dip & bakes / Proper Phase Separation:** *Heat shrink lacing* material helps ensure solid bracing of end turns. Lack of proper support of the insulation system can cause vibrations between turns, phases and ground at startup and when exposed to PWM waveforms. The more dip and bakes the more secure and solid the insulation system becomes. Proper phase paper placement is very important to ensure complete separation of phases minimizing opportunities for failures.
- 5) **Length of stator and rotor cores (Overall weight of the motor might be a good indication of core length in a properly designed motor):** Long cores not only indicate a motor with good efficiencies and torque capability, but also give the motor mass to absorb heat.
- 6) **Slot fill:** A tight slot fill, ensures maximum copper volume for reducing resistance losses in the stator, but also allows for proper heat conduction to the motor frame, and prevents potentially damaging vibrations between turns and ground.
- 7) **Efficiency design features:** Tooth density, thickness of laminations, size of end rings, width of the air gap, size of fan are all factors which can increase and/or decrease efficiency. More efficient motors run cooler. A well designed motor is one with very high efficiencies, very high torques and has a very large thermal margin (ie/ runs cool).
- 8) **Inverter duty wire:** Dielectric strength of insulation system rated to handle voltage spikes as per Nema MG1, Part 31, $V_{\text{peak}} = 3.11 \times V_{\text{RMS}}$, with a $\geq 0.1 \mu\text{s}$ rise time.

Reliability in motion