Fact or Myth: Common Misconceptions About Motors

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An old saying claims: "If it's in black and white, it must be right." Seeing something in writing makes it more believable than the spoken word. However, that does not mean it is true. We should always look for substantiation to back up statements, whether written or verbal.

A more recent saying is: "If it's on the Internet, it must be true." Apply that same fact-check here. Look for substantiation before accepting information gleaned from the Internet.

Here is a random collection of some relatively common misconceptions about three-phase squirrel cage motor performance characteristics.

Soft-Starting Motors Reduce Utility Demand Charges.

Typically, soft starters ramp up the voltage applied to a motor over a few seconds at start-up, reducing winding heating and starting current. Thus, soft starters may extend motor winding life for motors that are frequently started.

However, demand charges from utilities are not affected because the electric meter averages the kW consumed over each 15- or 30-minute period. Since soft starters affect motor input power for just a few seconds, there is not enough time to measurably impact the time over which demand is measured.

Higher Current Means a Motor Is Less Efficient.

Input power is not a function of current alone. Other factors are voltage, power factor and efficiency. As an example, **Table 1** shows the key data for two 460-volt motors of the same 75 hp (55 kW) rating.

Note that although Motor B is rated over 3 amps greater than Motor A, both have the same full load efficiency. If you want to fact-check this, use the formula in **Figure 1**.

Table 1: Example of motor current versus efficiency.

Motor	Amps	Power factor	Efficiency
A	85.0	0.866	0.954
B	88.2	0.835	0.954

$$\frac{746 \times hp}{1.732 \times E \times I \times PF}$$

Figure 1: Formula for 3 phase motor efficiency. Note: hp = horsepower, E = voltage, I = current, and PF = power factor.

Power Factor Correction Capacitors Can Reduce the Energy Consumption of a Motor.

Applying power factor capacitors at the terminals of a motor increases the power factor on the cables supplying the motor. However, the power factor of the motor remains unchanged. Since increasing the power factor of the supply lines reduces current in them, there is a corresponding reduction in I^2R losses in the supply wiring. That energy reduction is typically not significant, and the primary reason for reducing supply circuit ampacity is to allow for additional electrical loads without rewiring a facility.

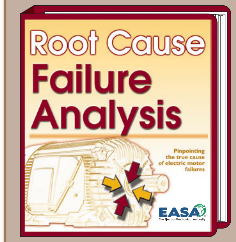
A Motor Can Be Loaded Up to Its Service Factor Current.

Such is the case of loading a 1.15 service factor motor up to its service factor current (typically ~1.15 x rated current). The NEMA MG 1-2016 (hereafter MG1) standard for motors and generators clause 14.37.1 states: "A motor operating continuously at any service factor greater than 1 will have a reduced life expectancy compared to operating at its rated nameplate horsepower. Insulation life and bearing life are reduced by the service factor load."

Further, the service factor only applies as described in MG 1 clause 14.2, Usual Service Conditions. This includes environmental conditions such as an ambient temperature range of 5°F to 104°F (-15°C to 40°C), altitude less than 3300 feet (1000 meters), installation on a rigid base and installation in areas or supplementary enclosures which do not seriously interfere with the ventilation of the machine.

A 230-Volt Motor Can Be Used on A 208-Volt Electrical System.

Per NEMA MG1 clause 12.45, motors can operate successfully at ±10 percent of their rated voltage. Since 10 percent below 230 volts is 207



volts, a 208-volt motor would appear to be acceptable. However, for a 208-volt power system, ANSI standard C84.1 permits the service entrance voltage to be as low as 191 volts. Since there will be additional voltage drop in the building wiring, the voltage supplied to the motor could be less than 191 volts, well below the 207-volt minimum required for the 230-volt motor.

If the motor is nameplate rated 208-230 volts, ask the manufacturer for a suitable voltage range. Said another way, ask if the manufacturer warranty will apply if used anywhere between 187 volts (208 volts minus 10 percent) and 253 volts (230 volts plus 10 percent).

Oversized Motors, Especially Motors Operating Below 60% of Rated Load, Are Not Efficient + Should Be Replaced with Appropriately Sized Premium Efficiency (IE3) Motors.

Matching motor horsepower (kW) rating to the load will usually mean a slightly lower efficiency at that load than using the next larger size motor. The reason is that motors tend to peak in efficiency between 75-80 percent load. Motors that drive supply or return air fans in heating, ventilation and air-conditioning (HVAC) systems generally operate at 70 to 75 percent of rated load, making them candidates for use with oversized motors. Further, even at 60 percent of rated load (which more than one industrial motor study found to be the average load level), the next higher power rating motor could be more efficient at that load than the appropriately sized power rating. Some high inertia loads require more HP/kW to start than is required to run the load. Reducing the HP/kW to match the running load could result in the motor being unable to start the load.

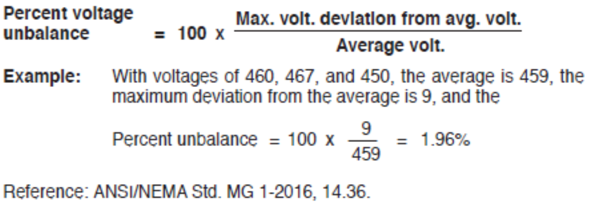
It Doesn't Matter Which of the Three Line-to-Line Voltages in a Three-Phase System You Measure to See If a Motor Is Supplied with the Proper Voltage.

It does matter. Three-phase motors are negatively affected by voltage unbalance, which is the extent to which the three line-to-line voltages vary from each other. Even a modest difference among the three voltage levels can result in a considerable increase in motor heating. Voltage unbalance is expressed as a percent and determined by the formula in **Figure 2**.

The percent additional temperature rise in a motor winding due to unbalanced supply voltages is given by the formula 2 x (% voltage unbalance)^2. For a voltage unbalance of only 3.5 percent, the additional temperature rise = 2 x 3.5^2 = 24.5%, a substantial amount.

Table 2: Summary of motor failure surveys for motors rated up to 4 kV. [RCFA ed.2, p.1-5]

Component	Survey 1	Survey 2	Survey 3	Survey 4
Stator	36.5%	24.8%	25.0%	15.8%
Rotor	9.5%	6.0%	6.0%	4.7%
Bearing	41.0%	51.6%	51.0%	51.1%
Other	13.0%	17.6%	18.0%	28.4%



Percent voltage unbalance $= 100 \times \frac{\text{Max. volt. deviation from avg. volt.}}{\text{Average volt.}}$

Example: With voltages of 460, 467, and 450, the average is 459, the maximum deviation from the average is 9, and the

$$\text{Percent unbalance} = 100 \times \frac{9}{459} = 1.96\%$$

Reference: ANSI/NEMA Std. MG 1-2016, 14.36.

Figure 2: Formula for voltage unbalance.

The additional ~25 percent temperature rise would be about 36°F (20°C) for many motors. A well-accepted guideline is that for each 18°F (10°C) increase in temperature, motor winding life is halved. Thus the 36°F (20°C) additional rise due to a 3.5 percent voltage unbalance can be expected to cut the motor's insulation life to about a quarter of what it should be.

Hand Contact on a Motor Surface Is A Reliable Way to Judge Operating Temperature.

One should never use their hand to check the motor surface temperature. Modern motors can have surface temperatures near or above the boiling point of water and not be overheated. Devices such as thermometers or pyrometers, thermocouples and thermal imagers are commonly used to measure surface temperatures. Also, the MG 1 standards set specific limits for internal winding temperatures but not for motor surfaces. Where MG 1 does address parts other than windings (e.g., in clause 12.43), it states that the temperature attained by such parts "shall not injure the insulation or the machine in any respect." So, unless the motor surface exceeds the winding temperature rating, or something on the surface is damaged or otherwise degraded, the temperature would not be deemed too hot.

Winding Burnout Is the Most Common Cause of Motor Failure.

Although a winding failure usually results in a more costly and longer downtime repair, bearing failures are the most common cause of motor failure. **Table 2** is adapted from the EASA *Root Cause Failure Analysis, 2nd Edition* seminar text. ■

Table 2 Survey References

1. P.F. Albrecht, J.C. Appiarius, and D.K. Sharma, "Assessment of reliability of motors in utility applications – Updated." IEEE Transactions on Energy Conversion, vol. EC-1, no. 1, pp. 39-46, March 1986.
2. O.V. Thorsen and M. Dalva, "Failure Identification and Analysis for High-Voltage Induction Motors in the Petrochemical Industry," IEEE Transactions on Industry Applications, vol. 35, no. 4, pp. 810-818, July/Aug. 1999.
3. Monitoring und Diagnose elektrischer Maschinen und Antriebe, Allianz Schadensstatistik an HS Motoren 1996-1999 in VDE Workshop, 2001.
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