The Mining & Minerals Monthly

Application Guidelines to Keep You Better Informed

SERVICE FACTOR

MOTORS RUNNING INTO SERVICE FACTOR (SF)

All NEMA frame low voltage motors are typically designed with a 1.15 Service Factor (SF). It is common on some higher horsepower, or application-specific motors to be 1.0 SF based on special design, enclosure size etc. There are two aspects to SF:

The first is ***motor temperature***. Temperature rise is described thoroughly in last month's issue. The relationship between motor heating and current is a square function, and motor current draw is generally proportional to load. Heating is a function of *current*^{2} *x resistance x time*. This is usually referred to as *current*^{2} *x time*, or I^2t. At SF loading, if current is 1.15 x rated, the heating effect will be 1.152 = 1.32 x normal. This roughly means that if the temperature rise at full load is 80°C ('B' rise) the temperature rise at 1.15 SF loading will be in the order of (1.15)2 x 80°C = 105.8°C ('F' rise). This is why most manufacturers design a motor to have a B rise or less at full load for a 1.15 SF motor.

[ASIDE: This clearly shows how a motor designed with a 'B' rise @ 1.15 SF, which is 90°C, is better than a motor with a 'B' rise @ 1.0 SF, because this motor with a 'B' rise @ 1.0 SF, loaded to 1.15 SF will have a temperature rise of 105.8°C.]

In general, Toshiba motors use an insulation system that is Class F (155°C) rated and has B rise or less @ 1.0 SF (80°C), and in the case of the EQP Global® series, all motors 445T frame and smaller have a B rise or less @ 1.15 SF. This means that the insulation will be well below design temperature of the insulation system even when operated at continuous overload up to 115% of nameplate. The smaller the motor frame, the larger the thermal margin, and the greater the overload a motor can

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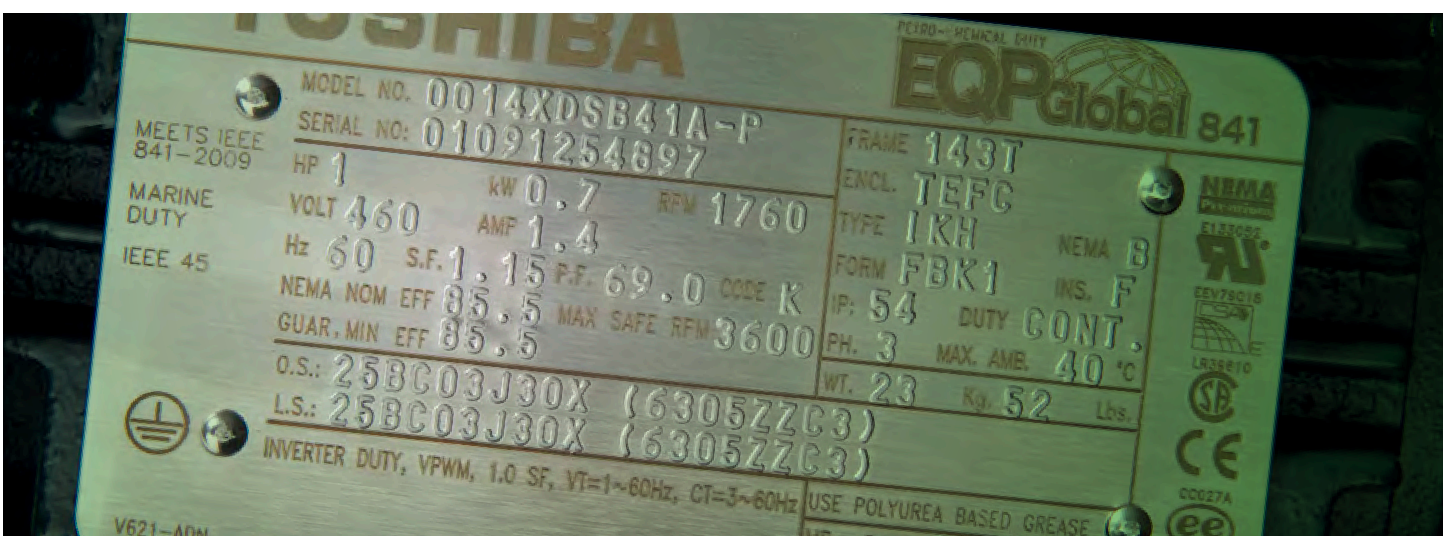

handle. This is why you'll often see motor manufacturers advertise as a 1.25 SF rating on the smaller frames. Furthermore, in the case of TEAO (Totally Enclosed Air Over) motors used in ventilation fans for the mining industry, the increased air flow from being mounted in the center of the fan (3000 ft./min.) often allows for 1.35 SF as standard.

The second issue is ***mechanical capability.*** Bearings are an important part of the mechanical capability and life of a motor. For every 15°C hotter that a bearing runs, the grease life is cut in half. Open-style bearings run cooler than sealed or even shielded bearings. When a motor is run into its SF, it runs hotter and consequently, so does the bearings. As a result, grease life, or re-greasing intervals, is reduced.

Shaft strength is another consideration when designing a motor with a SF capability. A 1.15 SF motor has a strong enough shaft to handle the additional continuous shaft load. Although this is not usually an issue with smaller HP motors, it becomes a real consideration on larger machines. Just because a motor is specified with a B rise at full load doesn't necessarily mean that it is suitable to be rated as a 1.15 SF motor.

The preceding issues are concerned with sinusoidal operation. When an ASD is utilized, the motor sees additional heating over and above the I^2t heating effect. This is due to the harmonic content of the drive's output waveform. This additional heating can range from 5% extra heating for a good quality PWM drive with an adequately high carrier frequency to up to 30% additional heating for a square wave variable voltage inverter (VVI) drive. When using an ASD on a 1.15 SF motor, as a rule of thumb, you should now treat your motor as being a 1.0 SF motor, as a result of the heating from the ASD.

A 1.15 SF motor installed "across the line" can be operated at 1.15 SF. However, you will theoretically get a varying insulation life depending on the operational temperature of a motor on a specific application. For a fixed set of conditions on an application, the motor manufacturer with the largest thermal margin (difference between actual design temperature rise v. insulation class) will give you a longer insulation life span overall.

Having said the above, even though a 1.15 SF motor can be operated at 1.15 SF, when sizing motors for a new installation, Service Factor should be considered as a ***Safety Factor***, allowing some thermal margin for the following reasons:

- Voltage Unbalances
- Error in the Distribution Transformer Tap Connection
- Unstable Utility Voltage Supply
- Poor Power Supply Connections
- Open Delta Transformer Systems
- Improper Functioning Capacitor Banks
- Unbalanced Power Supply
- Increased Overload Requirements
- Additional Ambient Temperature
- Higher Altitude Installation
- Longer Motor Life
- Longer Grease Life
- Brown-outs

Furthermore, a motor's optimum efficiency and power factor is at approximately 75 to 100% load, which changes to less favorable values as you move further away from this load range.

INSULATION CLASSIFICATION WINDING RISE °C

Insulation Class	1.0 SF	1.15 SF	Total
B	80	90	130
F	105	115	155
H	125	—	180

NEXT MONTH'S ISSUE: REPETITIVE STARTS