

# APPLICATION GUIDELINE #6

## (Service Factor)

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### MOTORS RUNNING INTO SERVICE FACTOR

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 1.0SF based on special design, enclosure size etc. There are two aspects to Service Factor.

- 1) The first is motor temperature. Temperature rise is described thoroughly in 'Application Guideline #5'. 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  $\text{current}^2 \times \text{resistance} \times \text{time}$ . This is usually referred to as  $\text{Current}^2 \times \text{time}$  or  $I^2t$ . At service factor loading, if current is 1.15 x rated, the heating effect will be  $1.15^2 = 1.32$  x normal. This roughly means that if the temperature rise at full load is 80°C ('B' rise) the temperature rise at 1.15SF loading will be in the order of  $(1.15)^2 \times 80\text{C} = 105.8\text{C}$  ('F' rise). This is why most manufacturers' design a motor to have a B rise or less at full load for a 1.15SF motor.

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

All Toshiba motors use an insulation system which is advertised as **Class F** (155°C) rated. Although, many components of the insulation are **class H** (180°C) materials or higher. Toshiba designs motors for a **B rise or less@1.0SF** (80°C), and in the case of the EQPIII series, all motors 445T frame and smaller have a **B rise or less@1.15SF** loading. 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 handle. This is why you'll often see motor manufacturers advertise a 1.25SF 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 (3000ft/min), often allows for 1.35SF as standard.

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

Shaft strength is another consideration when designing a motor with a service factor capability. A 1.15 service factor 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 1.15SF motor.

The preceding issues are concerned with sinusoidal (non variable frequency drive (VFD)) operation. When a VFD 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 a VFD on a 1.15SF motor, as a rule of thumb, you should now treat your motor as being a 1.0SF motor, as a result of the heating from the VFD.

A 1.15SF motor installed 'Across the Line', can be operated at 1.15SF. 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 a application, the motor manufacturer with the largest 'thermal margin' (difference between actual design temperature rise VS. class of insulation), will give you a longer insulation life span overall.

Having said the above, even though a 1.15SF motor can be operated at 1.15SF, 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**
- Etc.....**

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

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