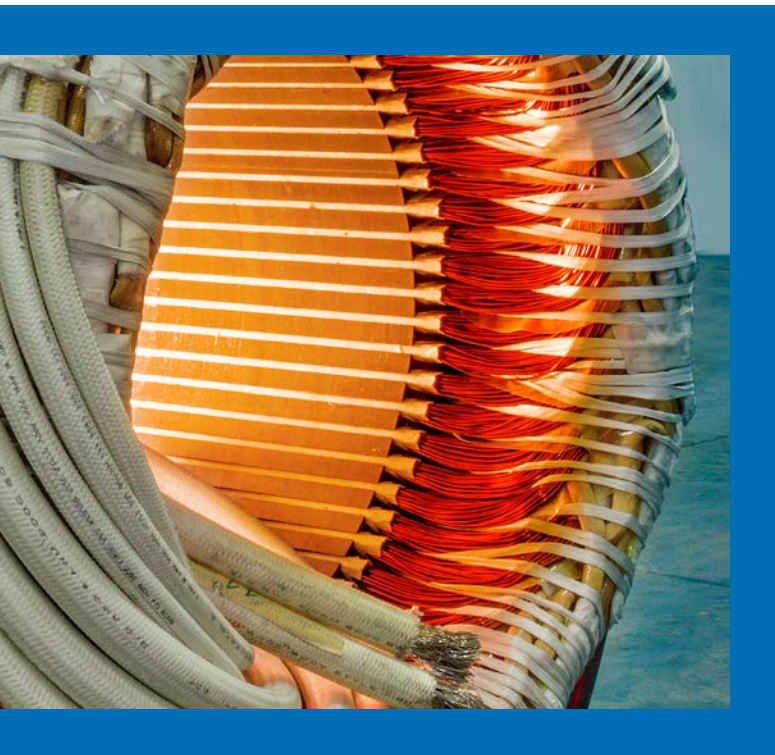


## MOTORS & DRIVES

# Temperature Rise

### TEMPERATURE KILLS MOTORS!

Ideally, a motor should have a relatively high insulation temperature rating and a relatively low operating temperature for both the insulation system and bearing system. This provides for thermal margins in the event of motor overload, severe starting duty, safety margin for adjustable speed drive applications, and for many other reasons. (A well-accepted rule of thumb is that for every 10°C that the motor temperature exceeds its rated insulation temperature, the insulation life is reduced by half, and likewise for every 10°C cooler, the insulation life is doubled).



### TODAY'S "HOT" AC MOTORS

During the reign of the Class A insulated found in U-frame motors, it was common practice to determine whether a motor was running efficiently by simply placing your hand on it. If the motor was too hot to the touch, it was overheating. With the advent of T-frame motors and the high temperature insulation that made them possible, this old rule of thumb is no longer valid. Surface (skin) temperatures usually run 20° to 30°C lower than the temperature at the windings. Subtracting 30°C from a Class F insulated motor whose total allowable running temperature is 155°C results in a skin temperature of 125°C (257°F); therefore if your T-frame motor is too hot to the touch, it does not necessarily mean that it is operating improperly. Today's motors are designed to run hotter than our human hands can tolerate.

NEMA specifies letter designations for motor insulation temperature ratings. These insulation temperature ratings are denoted as Class: A = 105°C, B = 130°C, F = 155°C, and H = 180°C. Furthermore, NEMA specifies allowable temperature rises for motors at full loads (and at service factors, if applicable). These allowable temperature rises are based upon a reference ambient temperature of 40°C, and are determined by the "resistance method", in which the resistance of the windings is measured with a bridge after the motor has achieved thermal equilibrium under full load. The resistance of the winding is a function of temperature of the winding. NEMA allowable temperature rises (at full-load) for a 1.0 S.F. motor are A = 60°C, B = 80°C, F = 105°C, and H = 125°C. NEMA allowable temperature rises (at service factor) for a 1.15 S.F. motor are A = 70°C, B = 90°C, and F = 115°C.

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Adding the NEMA allowable temperature rise of 105°C (for a Class F insulated, 1.0 S.F. motor), to the reference ambient temperature of 40°C results in a total operating temperature for the motor of (105+40) = 145°C. The 10°C temperature differential between the Class F insulation maximum temperature rating (155°C) and the allowable maximum temperature (145°C) provides an allowance for the “hotspot” temperature of the interior of the winding, which is difficult to measure directly. The overall winding resistance is the sum of the resistance of the cooler end turns, and the warmer (hot spot) windings embedded in the stator slots.

Although NEMA does not specify temperature rises by letter designation, it has become common practice in the industry to refer to the allowable temperature rise for a given insulation class as a temperature rise letter classification. For example, an 80°C rise is often referred to as a Class B temperature rise, since 80°C is the maximum allowable temperature rise (by resistance) for a 1.0 S.F. motor insulated with Class B insulation based on a 40°C ambient. Thus, a motor with Class F insulation and an 80°C rise is commonly referred to as an F/B motor.

Many improvements have been made in motor insulation systems in the past couple of decades, such that a Class F (or better) insulation system is common for motor winding insulation. With conservative motor design, a Class B temperature rise is quite achievable. For a 1.15 S.F. motor wound with Class F insulation, a Class B temperature rise at full load translates to a thermal margin of 155-(40+90) = 25°C. This means insulation life will be approximately five to six times that which would be expected with a motor operating at its rated insulation temperature (i.e. for every 10°C lower temperature, the insulation life is doubled).

**INSULATION LIFE – THERMAL DETERIORATION**

Above a certain threshold temperature, the insulation ages at an ever-increasing rate, which approximately doubles for every 10°C increase in temperature. By definition, Class F insulation will lose half its mechanical strength after being subjected to 20,000 hours at its rated temperature. This does not mean that the insulation will fail at this point; it just means that it is substantially weakened. For example:

- 20,000 hours (2.5 years) at 155°C
- 10,000 hours (1.25 years) at 165°C, or likewise, 40,000 hours (5 years) at 145°C
- 5,000 hours (<1 year) at 175°C, or likewise, 80,000 hours (10 years) at 135°C

Obviously, motors do not run continuously at one temperature since loads and ambient temperatures vary. Once thermal deterioration has occurred, it is non-reversible. Reducing the temperature can, however, stop further deterioration.

NEMA MOTOR INSULATION TEMPERATURE RATINGS		TEMPERATURE RISES			
		1.0 SF MOTORS			
Class	Temperature	Ambient	Hotspots	Rise @ 1.0	Rise @ 1.15
A	105°C	+40°C	+5°C	60°C	70°C
B	130°C	+40°C	+10°C	80°C	90°C
F	155°C	+40°C	+10°C	105°C	115°C
H	180°C	+40°C	+15°C	125°C	Not Defind



## TIPS TO MONITOR TEMPERATURE RISE

1. If RTDs are fitted in a motor, the temperature should be trended. If the temperature goes up, this is a clear indication that the ambient has increased, the load has increased, or it is time to clean the motor. A simple way to implement a trigger to perform cleaning is to monitor the temperature of a motor shortly after installation when it is running at its peak-operating load, ideally during the hottest ambient condition.

**(Note – if the ambient temperature is not at its highest level when initially monitoring the RTD reading, increase the alarm point by the amount of expected ambient increase).**

Set the alarm point of the RTD monitor 5° to 100°C hotter than the maximum expected operating temperature. If the RTD alarms in the future, either the load has changed or it is time to schedule cleaning of the motor.

2. There is a 10°C difference between temperature measurements by Resistance versus by Embedded Detectors (resistance elements, or thermocouples).

**For example, a Class F temperature rise of 105°C by Resistance is 115°C by Embedded Detector.**

