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

# APPLICATION GUIDELINE #13

## (Motor Protection)

Brought to you by your Motor & Drive Specialists……

Motor protection relays protect a motor against damage from operation outside of its design values. Please note that many electronic overload relays will not properly protect against excessive number of starts. Repetitive start protection may require some additional circuitry to be added to a system, possibly as part of a PLC program, which locks out the motor starter until the appropriate rest time has occurred before allowing a start.

Adjustable Speed Drives come standard with built in motor protection. Toshiba offers Built in ground fault protection, and speed sensitive overload from 10% - 100% of the drive's rating, which provides motor protection even for constant torque applications at reduced speeds when the fan becomes less effective. The speed sensitive portion of the overload is selectable so can be disabled for motors, which have separately powered cooling fans. The 10-100% of drive rating range allows a larger drive to properly protect a much smaller motor, which can help minimize spare drive requirements. Additional motor protection is required if one ASD operates multiple motors, and if a by-pass scheme is provided. In each of these cases a motor thermal overload is required.

## *Types of Motor Protection*

### *Thermal Overload*

In its simplest, most economical form, a thermal overload heater provides motor protection. A thermal overload heater consists of a heater element which motor current directly flows through. On higher HP motors, a proportional amount of current flows from the secondary of a current transformer (CT) then through the heater. The heater is in close proximity to a bimetallic strip, which bends and causes a trip when the $I^2t$ value is exceeded. This type of heater comes in various classes, the most common of which is a class 20. The class number indicates the time in seconds that the relay will take to trip at 600% current. During a locked rotor condition, most motors draw 600 – 650% of full load current. Higher HP motors will often be damaged or start to be damaged well before 20 seconds of 600% current. <u>This means that a standard, class 20 thermal overload will not adequately protect a motor during a stalled or locked rotor condition.</u>

### *Electronic Overload*

There are many varieties of Electronic overloads ranging from relatively simple and economical to very complex and expensive. The degree of protection afforded, typically increases with cost. Motor protection is much like buying insurance. The more critical the application and expensive the motor, the better the protection should be. In all cases, an evaluation should be done to determine the appropriate protection for the specific motor / application. For example, if a motor is subject to stalling, such as a chipper head on a canter line, it is important to make sure that the motor protection relay provides adequate stall protection. This will probably require some form of electronic relay. If the motor is a low voltage motor on a fan and is not likely to ever stall, or to see excessive repetitive starts, steady state overload protection is all that is probably required which can be handled quite adequately with a standard thermal overload relay. If a large refiner motor is being protected, it makes sense to provide the best relay available plus the addition of specialty protection, such as the addition of a differential relay and auxiliary synchronous motor protection relay(s).

## *Short Circuit Protection*

Overload Relays protect a motor against overload situations, however they are much too slow to afford proper circuit protection in the event of a motor fault, including a short circuit. To complete the motor circuit protection, either a fuse or a magnetic only or motor circuit protector (MCP) is used to disconnect the motor circuit very quickly in the event of a line to line or line to ground fault.

### *Motor Circuit Protectors*

MCP's are essentially circuit breakers without the overload element installed. Their job is to trip if the value of current exceeds the locked rotor value of the motor. There is one slight problem however, which is that the instantaneous current that the motor draws for the first few cycles is significantly higher than the nominal 6 times full load current value expected for starting. During the first cycle, depending on the position of the value of the voltage at the instant of closing, the current can peak at up to 2 times the nominal locked rotor current. The sinusoidal current being offset from the zero axis causes this. This means that it is possible for the peak current to be RMS locked rotor current x 2 x 1.414 . If the locked rotor current is 6 times full load current, the instantaneous current for the first cycle can be close to 17 times motor full load current. If the locked rotor current is 6.5 times full load current, this value can become over 18 times full load current. As time goes on, the current starts to become symmetrical with respect to the zero axis and usually within approximately 6 cycles, the current peaks fall to RMS inrush current x 1.414. Refer to fig.1 for a graphic illustration of the offset current. Without going into great detail, premium efficiency motors which have higher inductive reactance and lower internal resistance and therefore a higher X/R ratio exhibit a higher peak current than standard efficiency motors. Because of this phenomenon, users may experience nuisance MCP trips with premium efficiency motors that they did not experience with older standard efficiency motors. Some manufacturers' MCPs either ignore the first few cycles or are slow enough not to trip because of this very high peak current during the first few cycles. Some MCPs however, will trip. The only solutions are to replace the overly sensitive MCPs with a different manufacturer's unit or to increase the instantaneous trip level. Increasing the trip level, to a value, which will not cause nuisance trips, will often exceed the current code allowance. Apparently, the code covering this topic is being reviewed.

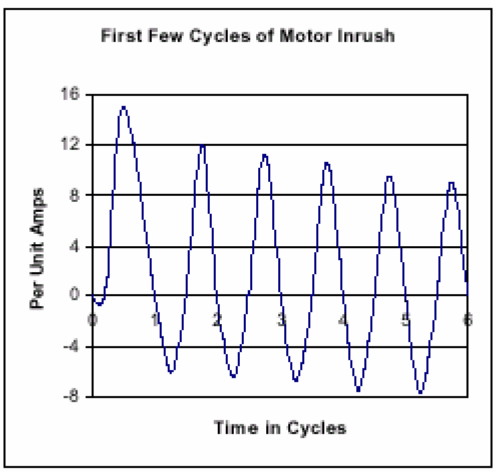


**Fig.1 Peak current values during initial stating of an induction motor**

### Fuses

Fuses used in combination with overload relays are designed to protect the motor circuit against abnormal faults such as short circuits. Fuses used with motor starters are different than standard fuses because, like MCPs they do not protect against overloads, only against short circuit conditions. Unlike MCPs, fuses are not adjustable and must be sized properly so as not to blow during the motor inrush.

## *Auxiliary Thermal Protection*

There are several devices to choose from which provide protection against winding over-temperature and act as backup protection to the overload relay plus, provide the opportunity to monitor bearing temperature.

**Klixons** are the simplest thermal protection device. A Klixon essentially is a temperature sensitive switch. When a certain temperature is reached, a contact inside the Klixon opens. This is tied into the motor starter's control circuit and shuts the motor down. Klixons are widely used in explosion proof motors to meet CSA requirements.

**Thermocouples** are devices that are not in common use, but are mentioned because they are still used on occasion. Essentially, a thermocouple consists of two different metals that are welded together. Because of a phenomenon known as the Seebeck effect, the junction produces a small voltage that's related to temperature. Different combinations of metals identified by letters such as J, K or T create different thermocouple types.

**Thermistors** are devices which dramatically change resistance value when they reach a certain temperature. Thermistors, when connected to a Thermistor relay provide motor over-temperature protection. The Thermistor relay (available as Solid State or transformer/rectifier type) provide an open/close output to an external circuit, this in turn may operate an alarm, or shut the motor down. Thermistors are typically installed by connecting 3 of them in series. (Most Thermistor relays are designed to read the series temperature of 3 Thermistors.)

**RTD's** (Resistive Temperature Devices) change resistance value in relation to temperature. Because of their predictable resistance versus temperature characteristic, they, when connected to an RTD relay or electronic relay with RTD capability, provide an actual temperature readout of the motor windings. Because of the actual temperature reading, RTD's can be used to monitor motor condition, alarm at selected temperatures and trip at selected temperatures. RTD's are typically installed in the motor winding slot in multiples of 3 (1 per phase or 2 per phase). The most common RTD types are 100 Ω platinum, 100Ω nickel, 120 Ω nickel and 10 Ω copper.

## *Vibration Protection*

Vibration protection devices range from relatively inexpensive devices which mount on the bearing bracket and directly sense vibration, to devices such as those made by Bentley Nevada which measure the dynamic distance between the shaft and the specially mounted sensor. These optical devices require special modification to the motor at time of manufacture plus special machining and polishing of the shaft where the sensor is mounted. Much like motor protection relays, the more expensive the device, the more accurate the detection. Vibration monitors are typically only installed on critical applications and on high HP motors. Examples are large refiner motors and large high-speed (3600RPM) motors.