

be restricted. Improper selection of motors with regard to temperature ratings may result in high motor operating temperatures and accompanying reduction in motor life.

In general, the electrical insulation is the portion of the motor most susceptible to injury from high operating temperatures. Of the several types of insulation which are available, the most common type, specified as Class A by the *National Electrical Manufacturers Association*, consists of cotton, felt, paper or similar organic materials, and permits a 55 C rise in temperature over a 40 C ambient temperature for totally enclosed motors. Class B insulation consists of mica, asbestos, fiber glass, or similar inorganic materials, and permits a 75 C rise in temperature over the 40 C ambient for totally enclosed motors. Other types of insulation, such as silicone resin, are available and permit much higher operating temperatures.

The mechanical construction of the different types of motor enclosures, and the rise in temperature with Class A insulation for each type, are enumerated in the glossary at the end of this chapter. Since the difference between the hottest spot and the maximum observable temperature, as measured by a thermometer, is greater for an open machine than for an enclosed machine, the permissible temperature rise is 50 C for an open motor.

FUNCTIONS OF CONTROL EQUIPMENT FOR MOTORS

In general, control equipment for all types of motors should provide (1) means of disconnecting the motor from the power supply, (2) means for starting the motor, (3) overload protection for the motor, (4) protection against low voltage, and (5) means for varying the motor speed.

Full voltage starting for motors is preferable because of its lower first cost and simplicity of control. Except for d-c machines, most motors are mechanically and electrically designed for full voltage starting. The starting inrush current, however, is limited in many cases by regulations of power companies because of the voltage fluctuations which may be caused by heavy current surges. It is therefore often necessary to reduce the starting current below that obtained by across-the-line starting. The power supplier should be consulted to determine the allowable inrush current for any given location.

The choice between full voltage and reduced voltage starting is governed almost entirely by inrush current limitations. The starting torque of all motors varies with the starting current, and it is therefore necessary to insure that the motor is supplied with sufficient current to develop enough torque to accelerate the load.

In present practice overload protection of motors is obtained by use of thermal overload inverse time limit type protection. The usual setting of such protection devices is not to exceed 125 percent of rated full load current for open 40 C rise motors, and not to exceed 115 percent of rated full load current for all other motors, the element tripping after a definite interval of time. The *National Electrical Code* requires the addition of fuses or circuit breakers to protect the overload elements from severe short circuit currents.

Two types of protection are available against low voltage at the motor terminals. One type, called low voltage release, permits the motor line contactor to drop out on low voltage and to close again when the voltage returns to normal, thereby restarting the motor when the abnormal condition is ended. The second type, called low voltage protection, causes the motor line contactor to drop out on low voltage, but prevents restarting

when the voltage returns to normal except by the action of an operator. This latter type of protection is desirable where it is necessary for the operator to make initial starting adjustments on the machine.

Manual control for an alternating or a direct current motor is usually located near the motor. When so located an operator must be present to start and stop or change the speed of the motor by operating the control mechanism. Manual control is sometimes employed only as a device to give overload protection, and another device is employed to start and stop the motor. Manual control is used particularly on small motors which operate unit heaters, small blowers, and room coolers in an air conditioning system. In other cases manual control in the form of drums, when used with multi-speed motors, is used only as a speed setting device, while the starting and stopping functions operate automatically through thermostats and pressure switches.

Because of the increasing complexity of air conditioning systems, the equipment is operated preferably by automatic control, and less dependence is placed on manual operation and regulation.

Automatic control of motor starters may be accomplished by the use of remote push button stations, by a thermostat, float switch, pressure regulator, or other similar pilot devices. An added advantage of automatic control is that the main wiring for the starter may be installed near the motor, while the starter may be operated by a remote control device.

GLOSSARY

General Definitions

NEMA is the abbreviation for the *National Electrical Manufacturers Association*.
AEIC is the abbreviation for the *Association of Edison Illuminating Companies*.
EI is the abbreviation for the *Edison Electric Institute*.

Speed Regulation (d-c motors) is the change in speed between no-load and full-load, expressed in percent of full-load speed; for example, a motor having a no-load speed of 1200 rpm and a full-load speed of 1140 rpm would have a speed regulation of 5.26 percent.

Slip (a-c induction motors) is the difference between the motor speed and synchronous speed expressed in percent of synchronous speed, e.g., a 1200 rpm motor operating at 1140 rpm would have a slip of 5 percent.

Torque is an expression of the turning effort developed by the motor at the shaft, and is usually expressed in ounce-feet for fractional horsepower motors, and in pound-feet for motors of larger ratings.

Primary is the term usually applied to the high voltage or line side of a transformer or motor. In the case of the wound rotor motor the primary is the stator winding.

Secondary is the term usually applied to the low voltage or load side of a transformer or motor. In the case of the wound rotor motor the secondary is the rotor winding.

NEMA Classification of Motor Enclosures

Open motors (40 C rise, rated load, 50 C rise, service factor load) are self-ventilated machines having no restriction to ventilation other than that necessitated by mechanical construction.

Protected motors (50 C rise) have all ventilating openings in the frame protected by perforated covers.

Semi-Protected motors (50 C rise) have the ventilating openings in the top half of the frame only protected by perforated covers.

Drip Proof motors (50 C rise) are so constructed that drops of liquid or solid particles falling on the machine at any angle not greater than 15 deg from the vertical, cannot enter the machine either directly or by striking and running along a horizontal or inclined surface.

Splash Proof motors (50 C rise) are so constructed that drops of liquid or solid particles falling on the machine or coming toward it in a straight line at any angle