

the drive-motor. Long-coupled centrifugal pumps are mounted on a common base with their motor. They are assembled at the factory, and properly aligned. However, all base plates are flexible to some degree, and each pump, therefore, must be re-aligned after installation in accordance with the manufacturer's instructions. Alignment can be maintained only when the foundation has been correctly designed and the base plate has been properly bolted to it.

The foundation must always be sufficiently rigid for proper support of the base plate and should weigh from 1½ to 3 times the total pump weight for proper vibration control.

APPLICATIONS

Heating and cooling systems, or combinations of both, are usually closed systems, where the pump or pumps circulate either hot or chilled water. As long as these systems are closed and are adequately maintained, system corrosion is no problem. If the systems are chemically treated, high chemical concentrations and leak-preventative compounds will directly influence both seal and packing gland life. The higher the chemical concentration, the greater will be the reduction in gland or seal life expectancy. It has been the usual practice to place chemical feeders across the pump connecting it from suction to discharge. As systems of this type usually have bronze-fitted pumps, caustics should not be fed directly through the pump. Chemical feeders, when and if necessary in the system, are best installed downstream so as to feed chemicals into the discharge line rather than the suction line. This prevents collection of a high concentration of chemicals

in the pump during operation as well as during idle or shut-down periods. If pumps are to be subjected to high chemical concentrations, they should be selected accordingly.

Cooling-tower pumps also are almost always bronze-fitted centrifugal pumps. The comments in the foregoing paragraph apply, although tower systems are classified as open hydraulic systems. Erosion in the pumps will be excessive, if solids are permitted to concentrate in the system due to evaporation of water and collection of dust from the cooling air dust. This can be prevented by maintaining a continuous loss or blow-down from the system during pump operation. This keeps the accumulation of suspended solids to a minimum.

Condensate pumps handle condensed steam from condensers and other heat exchange equipment. Since the condensate is usually hot, a pump with the proper required NPSH characteristics must be selected. Packing glands or seals must usually be suitable for operation under vacuum conditions. Bronze-fitted pumps are ordinarily selected. Pumps handling condensate at high pressure and high temperatures require special materials as well as special seals or packing gland material. (See Chapter 8 of the 1964 Guide And Data-Book.)

Boiler-feed pumps usually take water from a deaerating heater or a feed-water heater and deliver it to the boiler. Here, too, care must be taken that the available NPSH at the pump exceeds the required NPSH. Materials used in the boiler feed-pumps must be suitable to withstand corrosive and erosive action of treated feed-water. The pump design will also follow the pattern for high-temperature pumps both as to materials and special cooling of glands and bearings.

MOTORS AND MOTOR PROTECTION

Electric Power Supply; Electric Motors: Types, Application; Motor Control; Codes and Standards; Domestic Refrigeration; Room Air Conditioners; Central Air Conditioners; Small Commercial Refrigeration; Large Commercial Refrigeration

CHAPTER 57

THE electric motor, available in many different types suitable for various services, is now the most widely used form of motive power. The equipment for starting, controlling, and protecting these motors varies with the type and with the functions it is desired to attain. Motors are divided into two general classifications, *alternating-current* or *direct-current*, depending on the power source to be used.

ELECTRIC POWER SUPPLY

The following characteristics of the power supply are important: (1) whether current is alternating or direct, (2) voltage, (3) the number of phases of alternating current, (4) alternating-current frequency, (5) voltage regulation, (6) continuity of power.

Alternating-current (a-c) is available throughout the U.S.A. Direct-current (d-c) is still used in some parts of the country. The various types of electrical power supply in the U.S.A. are shown in Table 1.

Alternating-current must be used in hermetically-sealed refrigeration compressors. Otherwise the electric arcing at the commutator of d-c motors would result in breakdown of the refrigerant into corrosive materials.

Motors are usually guaranteed to operate satisfactorily and to deliver their full horsepower at the rated frequency and a voltage 10 percent above or below rating; or at the rated voltage and plus or minus 5 percent frequency variation. Table 2 shows the effect of voltage and frequency variation on induction-motor characteristics.

ELECTRIC MOTORS

Types

The electrical industry classifies motors as fractional hp and integral hp. Fractional hp motors have ratings of less than 1 hp at 1700 to 1800 rpm, and are available in a wide variety of types and sizes depending upon the application. In refrigeration and air conditioning applications, mostly single-phase fractional hp motors are used. Integral hp motors are largely single-phase through 6 hp. Larger motors are polyphase or use direct-current.

Table 3 lists motors used for hermetic-compressor and fan-drive. All motors listed are suitable for either direct or belt drive, except shaded pole motors and permanent-split-capacitor motors which can be used for direct drive only.

Compressor motors are either complete induction motors or hermetic motors. A hermetic motor consists of a stator and rotor without shaft, end shields or bearings for installation in refrigeration condensing units of the hermetically sealed type (NEMA). With the motor and compressor sealed in a com-

mon chamber, the insulation of the unit must therefore withstand the action of the refrigerant and the lubricating oil.

Application

When applying an electric motor, the following characteristics are important: (1) mechanical arrangement including position of motor and shaft, portability desired, drive connection, and space limitations; (2) speed range desired; (3) horsepower requirement; (4) torque; (5) inertia; and (6) frequency of starting. Motor characteristics frequently used are generally presented in curve form (Fig. 1).

Torque. The torque required to operate the driven machine at every moment between initial breakaway and final shut-down is important in determining the type of motor.

The torque available at zero speed or standstill, the *starting torque*, depending upon the design of the motor, may be less than 100 percent, or as high as 300 percent of full-load

Table 1.... Types of Electrical Power Supply in the United States*

Supply to System	Kind of Motor	Commonly Available Voltage & Freq.†
2-wire, 1-phase, ungrounded or one conductor grounded A-C or D-C	1-phase A-C or D-C	115 and 230 volt 120 and 240 D-C
3-wire, 1-phase A-C or D-C grounded neutral	1-phase A-C or D-C	120/240 D-C 115/230 A-C
3-wire, 2-phase A-C ungrounded or one conductor grounded	2-phase A-C	220
4-wire, 2-phase A-C grounded or ungrounded	2-phase A-C	220
5-wire, 2-phase A-C grounded neutral or ungrounded	2-phase A-C	220
3-wire, 3-phase A-C ungrounded	3-phase A-C	220, 440, and 550
3-wire, 3-phase A-C one conductor grounded	1-phase A-C and 3-phase A-C	110 and 220 1-phase 220 3-phase
3-wire, 3-phase A-C grounded neutral	3-phase A-C	222, 440, 550
4-wire, 3-phase A-C grounded neutral or ungrounded	1-phase A-C and 3-phase A-C	120 1-phase 208 3-phase

* Types of power supply in cities throughout the world are listed in a publication, *Electric Current Abroad* (United States Department of Commerce).

† Commonly available power supply is 60 cycles.