ings. They are available for the smaller sizes of single-phase and polyphase motors up to approximately 7½ hp. Hermetically-sealed thermal protectors are used for protection of hermetic compressor motors of the same sizes for mounting inside the hermetic shell.

For complete discussion of motor protection, refer to the section Motor Control at the beginning of this chapter.

Present-day electrical equipment is highly reliable, when control and protection devices are kept clean and dry. Silver contacts are universally used and may become blackened, but the tarnish does not normally interfere with the current-carrying capacity. The rough surface resulting from arcing is not harmful. In controllers, contacts should be replaced only when worn out.

Thermal and magnetic relays can be checked for tripping by increasing the current through the heater or magnetic coil by a resistor connected across the motor terminals. When the current is increased to approximately twice the normal rating, the relay should trip in a few minutes.

For starting relays refer to sections Domestic Refrigeration and Room Air Conditioners.

SMALL COMMERCIAL REFRIGERATION

Practically all motors used in small refrigeration applications are below 5 hp. Compressor motors are usually hermetically sealed. Motor control for self-contained as well as remote condensing units depends upon type and size of the installation.

Motors

Single-phase motors are most common. Capacitor-start induction-run motors are used up to ½ hp because of starting torque requirements. Capacitor-start capacitor-run motors are used for larger sizes up to 6 hp, because they provide high starting torque as well as full load efficiency and power factor. Performance data are given in Table 4.

Shaded-pole and split-phase motors are used for air moving devices, with split-phase motors used in the higher horsepower range.

Motor Control

Automatic temperature or pressure control equipment, designed for the special requirements of commercial refrigeration, is almost universally used. Automatic controllers for motors up to 2 hp are similar to those used for room air conditioners. For larger motors and for most remotely mounted condensing units, magnetic contactors similar to those used on central air conditioners are employed.

Motor Protection

Protection equipment for small single-phase motors is the same as that used in domestic refrigeration and for room air conditioners. Either thermal protectors of the open type, located on the shell of the hermetically-sealed compressor, or sealed protectors, installed inside the hermetic unit are used. When used, overload relays are part of the magnetic controller and are usually manual reset. Overload relays for hermetically-sealed motors should be *quick-trip* units.

Because of their hermetic design, compressor motors need not be serviced. Fan motors are accessible and should be occasionally serviced in accordance with manufacturer's instructions.

LARGE COMMERCIAL REFRIGERATION

Compressors above 5 hp can be driven by electric motors, internal combustion engines and steam turbines. This chapter deals with motor-drive only.

Motors

Most compressor motors used in large commercial refrigeration installations are alternating 3-phase current or direct-current motors. Performance curves are given in Table 5.

When single-phase current is available, split-phase or capacitor-start induction-run motors are used for air moving equipment. When single-phase current is not available, 3-phase motors are used.

Motor Control and Protection

Motor control equipment used in large commercial refrigeration installations is essentially the same as that used for central air conditioners.

Motor bearings must be serviced in accordance with the manufacturer's recommendations. Motor enclosures should be cleaned occasionally to provide adequate ventilation. On direct-current motors, brushes and commutator must be regularly checked for good electrical contact.

CHAPTER 58

PIPE, TUBE, AND FITTINGS

Pipe Materials, Types of Pipe, Commercial Pipe Dimensions, Threading Practice, Pipe Fittings, Flange Facings and Gaskets, Valves, Welding, Expansion and Flexibility, Hangers and Supports, Application

IMPORTANT considerations in the selection and installation of pipe and fittings for heating, ventilating, and air conditioning are dealt with in this chapter.

PIPE MATERIALS

Use of corrosion-resistant materials for pipe, including special alloy steels, copper, and red brass, has increased considerably during the past few years. The following brief discussion indicates the variety of pipe materials and the types of pipe available.

Wrought-Steel Pipe. Because of its lower cost, the great bulk of wrought pipe used for heating and ventilating work at the present time is of wrought steel. The material used for steel pipe is a mild steel made by the acid-bessemer, the open-hearth, or the electric-furnace process. Ordinary wrought-steel pipe is made either by shaping sheets of metal into cylindrical form and welding the edges together, or by forming or drawing from a solid billet. The former is known as *welded pipe*, the latter as *seamless pipe*.

Many types of welded pipe are available, although the smaller sizes most frequently used in heating and ventilating work are made by the lap-weld, resistance-weld, or butt-weld process. While the lap-weld and resistance-weld processes produce a better weld than the butt type, lap-weld and resistance-weld pipe are seldom manufactured in nominal pipe sizes less than 2 in. Seamless pipe can be obtained in the small sizes at a somewhat higher cost, and is listed as pressure tubing below 2 in.

Seamless steel pipe is frequently used for high-pressure work or where pipe is desired for close coiling, cold bending, or other severe forming operations. Its advantages are its greater strength which permits use of a thinner wall and, in the small sizes, its freedom from the occasional tendency of welded pipe to split at the weld when bent.

Wrought-Iron Pipe. Wrought-iron pipe may be identified by the spiral line marked into each length, either knurled into the metal or painted on it in red or other bright color. Otherwise, there is little difference in the appearance of wrought-iron and steel pipe, although microscopic examination of polished and etched specimens will readily disclose different grain structures.

Cast-Ferrous Pipe. There are now available several types of cast-ferrous metal pipe made of a good grade of cast-iron with or without additions of nickel, chromium, or other alloy. This pipe is available in sizes from 1¼ in. to 6 in., and in standard lengths of 5 or 6 ft, with external and internal diameters closely approximating those of extra strong *wrought pipe*. Cast-ferrous pipe may be obtained coupled, beveled for welding, or with ends plain or grooved for the several types of couplings. It is easily cut and threaded as well as welded. The fact that it is readily welded enables the manufacturers to supply the pipe in any lengths practicable for handling.

Alloy Metal Pipe. Both iron and steel pipe are available in the alloy class. In the case of iron pipe, when copper and molybdenum are added, the material is known as *alloy wrought-iron* pipe.

By common custom, steel is considered to be an alloy when the maximum range of alloying elements exceed certain limits, such as 1.65 percent manganese, 0.60 silicon, or 0.60 copper. Also, a steel is an alloy if any of the following elements are specified in minimal quantities or within limits: Al, B, Cr (up to 3.99), Co, Cb, Mo, Ni, Ti, W, V, Zr, or any other element added to obtain a certain alloying effect. Small quantities of certain elements are present in alloy steels, are considered as incidental, and may be present up to the following maximum amounts: copper—0.35 percent, nickel—0.25 percent, chromium—0.20 percent, and molybdenum—0.06 percent.

Commercially, steel is considered stainless when chromium exceeds 3.99 percent, regardless of the inclusion of other alloying elements. With *tubing*, an alloy becomes stainless when it contains a minimum of 10.5 percent chromium.

The alloy and stainless steels are used for high temperature piping and for highly corrosive fluids and gases.

Copper Pipe and Fittings. Owing to inherent resistance to corrosion, copper and red brass pipe have always been used in heating, ventilating, refrigeration, and water supply installations, but the cost of standard dimensions for threaded connections has been high. The introduction of fittings which

The general responsibility for this chapter is assigned to TC 10.5, Refrigerant Piping.