

bellows measuring suction pressure. This valve is supplied with oil pressure from the compressor oil pump and has an oil outlet connection to each cylinder unloader. This valve supplies oil pressure to, or releases it from, the cylinder unloaders progressively as the suction pressure increases or decreases. The suction pressure bellows is opposed by a spring which has an external manual adjustment for selection of the desired operating range. The other side of the bellows may be open to atmosphere so that the suction pressure is controlled with reference to atmospheric pressure, or it may be sealed and provided with an air connection which permits variation of the operating range as a function of air pressure from a pneumatic controller. For example, if the spring is so adjusted that the basic operating range is 35 to 40 psi suction pressure when the pressure from the pneumatic controller is zero, it will be increased to 45 to 50 psi when the control pressure is 10 psi. Thus these self-contained cylinder unloaders not only can control the suction pressure within a fixed range, but this range can be moved up or down automatically to meet the varying demands on the system. Pneumatic controllers used for this purpose often are supplied with air pressure up to 25 psi to permit a wide range of suction pressure variation. Most of these self-contained cylinder unloaders also can be arranged for mechanically varying the suction pressure by means of an electric motor operator acting against the manual adjustment spring to permit the use of proportional electric or electronic controls.

3. **Speed Control.** Multi-speed motors are sometimes used, actuated by a multi-stage thermostat or a proportional thermostat and a program or step controller.

Safety Control are provided on reciprocating compressors to stop the motor whenever certain conditions are outside of safe limits. These conditions include:

1. **Low Suction Pressure.** This is a pressure controller responsive to the suction pressure. It stops the compressor when the suction pressure drops below a safe limit. It is sometimes also used as a capacity control, as described in preceding section, paragraph numbered 1, when it is desired to start and stop the compressor in accordance with the load demand as determined by changes in suction pressure. When other means are provided for starting and stopping the compressor in accordance with load, the low pressure control functions solely as a safety device.

2. **High Head Pressure.** This is a pressure controller responsive to the high side pressure. It stops the compressor when the high-side pressure exceeds a safe limit. This is strictly a safety device and frequently is of the manual reset type so that the compressor cannot again start until the reset button is manually operated. In many cases the high and low pressure switches are combined into a single unit.

3. **Low Oil Pressure.** This is a pressure controller which stops the compressor in the event of low oil pressure. It also is frequently of the manual reset type.

4. **Low Line Voltage.** This is a low-voltage cutoff which stops the compressor when the line voltage drops below a minimum value.

5. **High Motor Current.** This may be built into the motor or into the motor starter. It stops the motor in the event excessive current persists for more than the brief interval required in starting.

6. **High Pressure Relief.** This is a device for preventing damage if excessive head pressures are encountered, and provides protection from damage beyond that provided by the high-pressure cut-out. It may be a relief plug which blows out in the event of excessive pressure. This has the disadvantage of losing the entire refrigerant charge. A relief valve, which functions like a pop-safety valve, is preferred since it wastes only enough refrigerant to relieve the danger.

7. **Low Water Temperature.** If the compressor is used for chilling water, a low-limit thermostat usually is installed in the chiller to stop the compressor in the event a freezing temperature is approached. This is in addition to a controlling thermostat which also may respond to water temperature.

Centrifugal Compressors

Centrifugal compressors are used with very low pressure refrigerants; sometimes both evaporator and condenser work below atmospheric pressure. Trichlorotrifluoroethane ($C_2Cl_2F_2$) and monofluorotrichloromethane (CCl_3F) are the refrigerants commonly used in centrifugal machines.

Compression of the refrigerant is accomplished by means of centrifugal force; therefore, this type of compressor is inherently suitable for large

volumes of refrigerant at low pressure differentials. Two or more stages are usually required and high speeds are necessary to obtain good efficiency.

The evaporator is usually constructed as an integral part of the centrifugal type condensing unit, to chill water which is then circulated to the air conditioning system. This is done because it would not be economical to pipe these large volumes of refrigerant any distance.

Centrifugal compressors, like reciprocating compressors, can be divided into two general types, open and enclosed. In general, the open type compressor is geared to the driving mechanism, and operates at higher speed than the driving motor or turbine. A modern, completely enclosed, direct-driven centrifugal compressor is illustrated in Fig. 16.

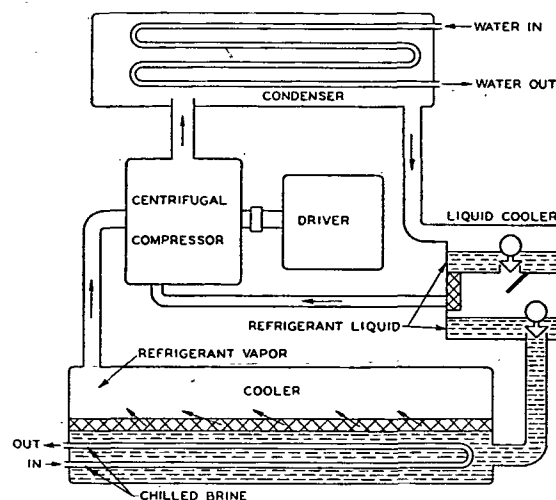


FIG. 16. ENCLOSED TYPE CENTRIFUGAL CONDENSING UNIT

Centrifugal refrigeration compressors are particularly well suited to direct steam turbine drive because of their high operating speed. Water cooling equipment of one design is operated between 3500 and 4000 rpm for units developing 1000 to 2000 tons capacity, and from 7000 to 8000 rpm for units developing 100 to 200 tons capacity. However, a great many applications, particularly in the smaller sizes, are electric motor-driven and equipped with standard gear-type speed increasers. Centrifugal systems are particularly well adapted to large capacities (up to 3000 tons) although it is also possible to secure units as low as 50 tons in rating. Because centrifugal units operate best with refrigerants possessing a high specific volume, and because of the simplification of lubrication difficulties, they are frequently used for extremely low temperature applications. They are adaptable to a wide range of temperatures from -130°F to 50°F . One important advantage is their flexibility under varying loads, since units may be designed to operate with reasonable efficiency at capacities as low as 20 percent of normal load.

Control of Centrifugal Compressors

Capacity Control usually is accomplished by a controller measuring the chilled water or evaporator pressure and either (1) varying the flow of