TECHNI/TIPS

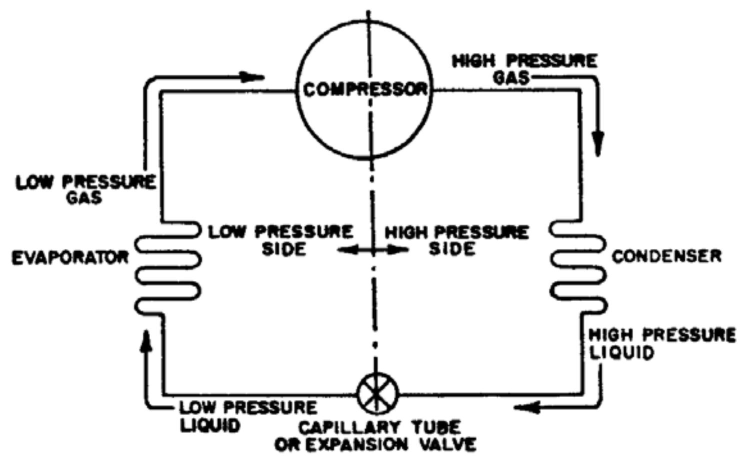
A Publication of the Lubrication Engineers Technical Department

LEADERS IN LUBRICANTS NUMBER 48

REFRIGERATION SYSTEMS

Cold is a relative term which specifically refers to a reduced temperature condition within a confined space. A mechanical refrigeration system produces this condition by piping a volatile liquid through to be cooled, extracting heat and then releasing the heat in another part of the system.

The compression refrigeration system is widely used in both domestic and industrial applications. The basic parts of this sys-tem include a compressor, condenser, expansion valve, evaporator and the interconnecting piping. A simplified diagram is shown at right:



COMPRESSION REFRIGERATION CYCLE

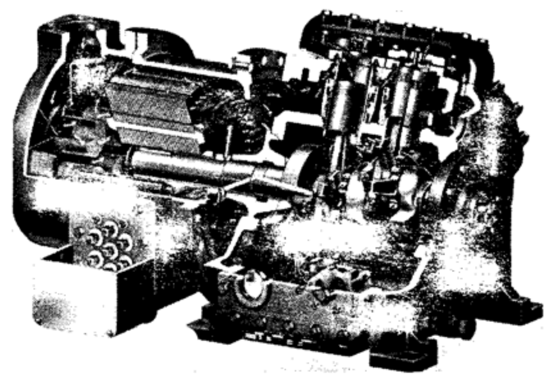
The compressor compresses the low pressure refrigerant gas to a high pressure gas, at the same time raising its temperature. The hot high pressure gas then passes through the condenser which is water or air cooled. This removes the latent heat of vaporization from the refrigerant and turns it into a liquid under high pressure which enters a capillary tube or expansion valve, which reduces the pressure on the liquid. The boiling point of the liquid refrigerant decreases as the pressure decreases, but in order to boil and become a gas, the refrigerant must absorb heat. Therefore, as the low pres-sure liquid passes through the evaporation or cooling unit, it picks up heat from the surrounding area, becomes a gas again and enters the compressor where the cycle is repeated.

COMPRESSORS

The heart of the compression refrigeration system is the compressor. Reciprocating, rotary, centrifugal and screw type compressors are used. The purpose is to convert incoming low pressure refrigerant gas to a high pressure gas. With regard to lubrication, we are only concerned with the open type compressors which are driven by a separately mounted motor or engine.

Lubrication is the most important part of the refrigeration system. The primary functions of the lubricant are to minimize friction and wear and to seal the gas pressure between the high and low pressure sides. Selection of the proper lubricant depends on the requirements of the compressor, the temperature range and the type of refrigerant.

Reciprocating compressors are somewhat similar to gasoline engines. When the piston moves down, a partial vacuum is produced and gas is drawn into the cylinder. On the upward stroke, the gas is compressed, forced through the exhaust valves and into the system. Compression and oil scraper rings are used on the pistons in large compressors to provide the necessary seal. In smaller compressors, a very close fit between the piston and cylinder, and the lubricating oil film are adequate for this purpose. Construction design and material se-lection details vary with different manufacturers. Small compressors may be lubricated with splash systems, while larger compressors have positive displacement oil pumps driven directly from the crankshaft as in an auto-mobile or truck engine.



Courtesy of Worthington Air Conditioning Company
Sectional view of hermetic 8 cylinder reciprocating compressor.

In rotary compressors, compression is produced by circular or rotary motion rather than the reciprocating piston motion. There are two basic types, the stationary vane with a rolling piston type or the sliding vane type. The rolling piston type uses a roller on a shaft having an eccentric. As the shaft rotates in the chamber, the eccentric on the shaft is in constant contact with the outer wall of the chamber. One or more spring loaded vanes are located in the periphery of the chamber. The gas is compressed and discharged as the eccentric completes a revolution in the chamber.

In the sliding vane compressor, eccentricity is provided by locating the shaft off center with respect to the cylinder. The rotor (which contains one or more vanes) and the shaft are a single piece. Low pressure gas trapped between the blades is compressed as the shaft rotates and is then discharged.

Centrifugal compressors are very similar to centrifugal pumps. A rapidly rotating impeller rotates low pressure gas and discharges it outwardly by centrifugal force, thereby increasing the pressure. Higher discharge pressures are obtained by passing the gas through additional impellers or stages. The centrifugal compressor is a constant pressure machine capable of handling large volumes of refrigerant at high, even pressures. With no rubbing parts, such as piston rings and cylinder walls, wear is less of a problem. Since the motion is purely rotational, the absence of vibration in this type compressor is an advantage. The centrifugal compressor is particularly well suited to heavy duty, continuous and large horsepower operations.

The screw compressor consists essentially of two mating, helically grooved rotors - a male with lobes and female with gullies in a stationary housing equipped with inlet and outlet ports.

A normal design would be a four-lobe male rotor, usually the driver, rotating at 3,600 rpm combined with a six-gully female rotating at 2,400 rpm.

Courtesy of Dunham—Bush, Inc.
Male and female rotors for screw type compressor.

One of the factors which differentiates refrigeration systems from other types of compressors is the solubility characteristics of the oil and refrigerant. The degree of solubility depends upon the temperature, pressure and type of refrigerant. These conditions vary from one refrigeration system to another. Any refrigerant absorbed in the oil will lower the viscosity of the lubricant. Where refrigerants with high miscibility characteristics are used, then a heavier viscosity oil is usually specified.

Lubrication requirements in refrigeration applications differ appreciably from those in other types of equipment. Although the lubricant is only required in the compressor, it circulates throughout the entire system with the refrigerant. The lubricant has to be suitable for high temperatures as well as low pressures and low temperatures. The lubricant should also have a low pour point and be properly inhibited for resistance to oxidation and deposits in the system.

Viscosity is another important factor in refrigeration systems. The correct viscosity grade for use in a refrigeration compressor is very important. Anticipated dilution effects must be considered by the manufacturer when selecting the preferred viscosity grade. Moisture and air contamination of the refrigerant and/or refrigeration oil can result in degradation of the refrigerant. This in turn leads to sludging of the refrigeration oil. This situation is especially important in systems using refrigerant R-11. Oils should be stored so that "breathing" of opened containers is minimized.

One of the major causes of compressor failure is from liquid refrigerant in excessive quantities in the compressor crankcase. Since improper control of the liquid refrigerant can sometimes cause a loss of lubricant in the compressor, most such compressor failures have been classified as lubrication failures. Most people fail to realize that the problem actually originates with the refrigerant.

A well designed, efficient compressor for refrigeration is primarily a vapor pump designed to handle a reasonable quantity of liquid refrigerant and the oil. When excessive amounts of liquid refrigerant and oil circulate in the system, it becomes an operating problem.

The potential hazard increases with the size of the refrigerant charge, and problems can usually be traced to one or more of the following:

Excessive refrigerant charge
Incorrect capillary tubes
Refrigerant migration
Incorrect selection or adjustment of expansion valves
Frosted evaporator
Dirty or plugged evaporation filters
Failure of evaporator fan or fan motor.

Liquid refrigerant problems can take several different forms, each having its own distinct characteristics:

(1) Refrigerant migration - A term used to describe the accumulation of liquid refrigerant in the compressor crankcase. If excessive liquid refrigerant has migrated to the compressor crankcase, severe liquid slugging may occur at start-up. Compressor damage such as broken valves, damaged pistons, bearing washout (refrigerant washing oil from the bearings) can occur.

(2) Liquid refrigerant flooding - If the expansion valve malfunctions or the evaporator fan fails or the air filter clogs, liquid refrigerant may flood through the evaporator and return through the suction line to the compressor as liquid rather than vapor.

During the running cycle this can cause excessive wear in the moving parts because of dilution of the oil or loss of oil pressure from the crankcase. During the off cycle, after running in this condition, migration of refrigerant to the crankcase can occur rapidly.

(3) Tripping of the oil pressure safety control - One of the common field complaints is that the oil pressure safety trips after a defrosting period on a low temperature unit. The design of many units allows refrigerant to condense in the evaporator and the suction line during the defrost period, and on start-up this refrigerant floods back to the compressor crankcase, causing a loss of oil pressure and trips the oil pressure safety control.

Recommended corrective action:

(1) Minimize the refrigerant charge - The best means of properly controlling liquid refrigerant, particularly if the charge is large, is by means of a pump down cycle. By closing a liquid solenoid valve, the refrigerant can be pumped into the condenser and the receiver. The refrigerant can be isolated during periods when the compressor is not in operation, and the migration to the compressor crankcase is prevented. A recycling pump down control is recommended to protect against leakage. With a single pump down, sufficient leakage may occur during long off periods to endanger the compressor.

(2) On some systems, operating requirements, costs or customer preference may make the use of a pump down cycle undesirable. Crankcase heaters are frequently used to retard migration and to hold the oil in the compressor at a certain temperature, so that refrigerant entering the crankcase will then be vaporized and driven back into the suction line.

(3) On systems where liquid flooding is a apt to occur, a suction accumulator should be installed in the suction line. The accumulator serves as a temporary storage container for liquid refrigerant which is flooded through the system. A provision for metered return of the liquid to the compressor can be controlled.

(4) Oil separators cannot cure oil return problems or remedy liquid refrigerant control problems. How-ever, oil separators may be helpful in reducing the amount of the oil circulating through the system, making possible safe operation through critical periods until the system can be returned to a normal condition.

LUBRICANTS - Lubrication Engineers, Inc. has designed the very finest lubricant called 6723 MONOLEC® Refrigeration Oil. It contains LE's exclusive wear-reducing additive MONOLEC®. It also protects against rust and corrosion, as well as copper plating on steel, since much of the tubing and piping in refrigeration systems is made from copper which plates out on the steel parts, and ultimately corrosion and pinholes will result.

LE's MONOLEC® Refrigeration Oil is designed to give the very best oxidation protection, which means it will control sludge and varnish formation, providing longer system and oil life. This will insure the very lowest wear and longest life for the compressor.

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