The Refrigeration Cycle

The Mechanics of a Basic Cooling System:

In order to accomplish the basic requirements necessary to maintain comfort conditions within a structure, the mechanical refrigerant system must be designed to carefully control pressures within the system that will assure that the air conditioner accomplishes its purpose.

The basic components to operate an air-cooled air conditioning system are the compressor, condenser, expansion device, and the evaporator. The function of these basic components are explained in the following paragraphs.

The Compressor

The function of the compressor is to maintain a pressure differential between its inlet (suction) and its outlet (discharge) that will cause the refrigerant within the refrigerant circuit to flow in sufficient quantities to meet the cooling requirements of the system.

A compressor circulating Refrigerant 22 must be capable of circulating about 180 pounds of refrigerant per hour for each 12,000 BTUH cooling capacity of the evaporator. The compressor motor input energy required for each 12,000 BTUH capacity is about 1.75 horsepower.

For example, a 36,000 BTUH air conditioner circulates about 540 pounds of refrigerant per hour and requires about 5.25 horsepower. This represents a large amount of heat that must be dissipated by the motor. In most compressors used in air conditioning equipment today, the motor is installed in the same housing with the compressor so that refrigerant circulating in the system must pass over the motor. The great volume of refrigerant vapor passing over the small motor dissipates motor heat rapidly resulting in very small motors with high horsepower ratings.

In fact, a 5.25 horsepower compressor motor cooled by refrigerant may be no larger than a .5 horsepower motor designed to operate in a free air location.

When the compressor motor is located in the same housing with the compressor and sealed into the refrigerant circuit such that circulating refrigerant passes over the motor for the purpose of cooling the motor, it is called a **hermetic motor-compressor**.

Heat dissipated into the refrigerant by the compressor must be rejected by the condenser.

Most hermetic compressors are equipped with a thermal overload protector buried in the motor winding. The protector senses current to the motor and the temperature of the motor winding. Any combination of motor current and winding temperature that could cause damage to the motor will automatically disconnect the electrical circuit to the motor.

This type motor protection system serves to interrupt power to the compressor if enough refrigerant is lost from the system that insufficient flow would cause the motor to overheat.

Refrigerant compressors are designed to pump refrigerant vapor only. If a saturated vapor or liquid is permitted to enter the compressor, it can result in dilution of the oil and damage to compressor bearings and valves.

The damage or resultant failure of the compressor depends upon the amount of liquid permitted to enter the compressor.

The Condenser

The function of the condenser is to change the high pressure, high temperature vapor discharged from the compressor to a high pressure liquid. Refrigerant vapor leaving the compressor contains the total heat removed by the evaporator, heat dissipated by the compressor motor, heat of friction generated by bearings and heat caused by molecular friction of the refrigerant itself.

Vapor entering the condenser is at high pressure and highly superheated. Since the air across the

condenser is much cooler than the vapor inside the condenser tubing, heat is transferred from the refrigerant to the condenser where it is dissipated or rejected into air surrounding the condenser. The refrigerant condenses to a liquid and is sub-cooled by the condenser.
Liquid refrigerant leaving the condenser is normally sub-cooled by 10 to 20 degrees F.
Proper operation of the condenser requires that it furnish a continuous supply of sub-cooled liquid to the expansion device.
Any dirt or foreign material that clogs the condenser or low air volume across the condenser could result in a saturated vapor instead of a sub-cooled liquid entering the expansion device. If this condition occurs, it is referred to as "gassing the expansion device", and will result in improper operation of the air conditioning system and may cause the evaporator to freeze ice on its surface.

Expansion Devices
Capillary tubes, expansion valves or calibrated metering orifices are often referred to as flow controls, metering controls or expansion controls.
Actually, the expansion device, regardless of its construction, introduces a calibrated friction loss that controls the evaporator inlet pressure.
The purpose of the expansion device is to maintain an evaporator pressure that will result in a saturated vapor temperature in the evaporator below entering air temperature so that heat can be transferred from the air to the refrigerant.
In air conditioning applications, it is desirable to control the evaporating or boiling temperature of the refrigerant at least 20 degrees F below the temperature of the air entering the evaporator surface temperature above 32 degrees F to prevent ice from forming on the evaporator surface.
Expansion devices are carefully selected for the specific system for which they were designed.
Any deviation from original capillary tube length and internal bore or deviation from tonnage rating of an expansion valve or deviation of a different size short orifice will result in improper system operation.

The Evaporator
The purpose of the evaporator is to transfer heat from air entering the evaporator to the refrigerant in the evaporator.
For maximum heat transfer it is necessary to maintain a constant refrigerant temperature throughout the evaporator. This can only be accomplished if the evaporator tubing is supplied with a saturated vapor that will evaporate at a constant temperature throughout the evaporator.
An evaporator that is filled with a saturated vapor is said to be "fully refrigerated". In other words, the entire evaporator has some liquid content in the saturated vapor that will evaporate at a constant temperature.
If the supply of refrigerant in the evaporator is evaporated before reaching the evaporator outlet, the vapor in the remainder of the evaporator will be superheat by the air across the evaporator and effective heat transfer for the superheated portion of the evaporator will be lost. (A slight amount of superheated refrigerant leaving the evaporator is desirable). This condition is referred to as a "starved evaporator" or not fully refrigerated."
If more saturated vapor is supplied to the evaporator than can be evaporated by the heat contained in the evaporator airstream, some of the saturated vapor will leave the evaporator and continue down the suction line to the compressor. When the refrigerant leaving the evaporator contains some liquid, the condition is referred to as "evaporator flooding" or "flooding the compressor." This is an undesirable condition since liquid entering the compressor can be detrimental to compressor reliability. Some flooding is normal at certain conditions when capillary tubes or short orifices are used.
Any reduction of heat load on the evaporator will cause flooding with a capillary tube or metering

orifice flow control. Evaporator unloading can be caused by dirty air filters, closing of air registers, failure of the evaporator motor or fan belt, or icing of the evaporator coil.

Some refrigerant systems utilize a suction accumulator located between the evaporator outlet and the compressor inlet to prevent liquid from entering the compressor when the evaporator is not fully loaded.
