

through the system before returning, at the risk of machine failure. Normally, however, the system should be designed, using pump down control or crankcase heaters, so that liquid absorption in the crankcase is kept to a minimum.

2. In systems using flooded evaporators, where refrigerant bleed-off is necessary for oil removal from the evaporator. Oil separators used on these systems remove a substantial portion of the oil in the hot gas discharge line, and this makes it possible to operate with much less bleed-off from the flooded cooler than would otherwise be necessary to keep the oil concentration down in the cooler. For widely varying loads, or low temperature applications, they appear to be useful. For steady loads at air conditioning level they are seldom used.

3. In direct expansion systems using coils or tube bundles that require bottom feed for good liquid distribution and where refrigerant slop-over is essential from the top of the evaporator for proper oil removal. In the same manner as in the preceding paragraph, the use of an oil separator here will substantially cut down on the amount of slop-over necessary from the evaporator in order to return oil.

4. In low temperature systems. It is advantageous to have as little oil as possible going through the low side, especially in Refrigerant 13 systems where the oil is not miscible with the refrigerant.

Potential problems. In applying oil separators in refrigeration systems there are certain potential hazards which must be fully recognized and properly dealt with.

1. The main hazard to guard against in the use of oil separators is their tendency to condense out liquid refrigerant during compressor off cycles and on compressor start-up. This is true if the condenser is in a warm location, such as an evaporative condenser and receiver on a roof.

During the off cycle, the oil separator cools down and acts as a condenser for liquid refrigerant that evaporates in warmer parts of the system. Thus, a cool oil separator will act as a liquid condenser during off cycles, and also upon compressor start-up until the separator has warmed up, and will automatically drain this condensed liquid into the compressor crankcase. On start-up, then, there is excessive boiling in the crankcase because of the presence of a large amount of liquid refrigerant. This will result in poor lubrication and wear on the compressor, and may even end up in completely cleaning the oil out of the crankcase as a result of this violent boiling action. Then, if not protected by an oil safety switch, compressor failure may result.

2. Oil separators are not 100 percent efficient and therefore, it is still necessary to design the complete system for oil return to the compressor.

3. The float valve is a mechanical device which may stick open or closed. If it sticks open, hot gas will be continuously bypassed to the compressor crankcase and this will cause the compressor to operate at an elevated temperature and will, of course, reduce capacity. If the valve sticks closed, then, of course, no oil is returned to the compressor.

Precautions. Where oil separators are used, it is recommended that precautions be taken to prevent draining condensed refrigerant into the crankcase. To minimize this possibility, the drain connection from the oil separator can be connected into the suction line entering the compressor. In this way, any liquid refrigerant returning from the separator would go into the suction manifold rather than directly into the crankcase. This drain line should be equipped with the following: shut-off, hand throttling, and solenoid valves, and sight glass. The throttling valve should be adjusted so that the flow through this line is very small, in fact only a little greater than would be normally expected for the return of oil through the suction line. The use of the sight glass will help in adjusting this flow. The solenoid valve should be wired so that it is open only when the compressor is running; closed when the compressor is off.

The above arrangement will prevent liquid draining down into the compressor during an off cycle. When the compressor starts up with liquid refrigerant in the oil separator, it will also prevent this liquid from dumping directly into the crank-

case. It will allow it to be bled slowly into the suction line where it can be taken care of in the normal manner, similar to oil returning from the system.

The hazard of draining condensed refrigerant into the crankcase can also be minimized by insulating the oil separator and installing it ahead of a hot gas loop to the floor so that there will be a trap between it and any evaporative condenser installed above. Insulating the oil separator keeps it warm for a longer period after shutdown of the compressor and cuts down on the amount of condensation in the shell during shutdown, unless it is for a prolonged period. One manufacturer returns oil from an oil separator through an oil reservoir which is heated, boiling off the refrigerant into the suction line.

Surge Drums or Accumulators

The above names are alternately used to describe the same piece of equipment.

A surge drum is required on the suction side of almost all flooded evaporators to prevent liquid slop-over to the compressor. The exceptions are shell-and-tube coolers and similar shell-type evaporators which provide ample surge space above the liquid level, or contain eliminators for the separation of gas and liquid. A horizontal surge drum is sometimes used where head room is limited.

Figs. 34 and 35 illustrate applications using a horizontal surge drum.

The drum may be designed with baffles or eliminators to separate liquid from the suction gas returning from the top of the shell to the compressor. More often there is simply allowed sufficient separation space above the liquid level for this purpose. Such a design is usually of the vertical type with a separation height above the liquid level of from 24 to 30 in. and with the shell diameter sized to keep the suction gas velocity at a value low enough to allow the liquid droplets to separate and not be entrained with the returning suction gas off the top of the shell.

Since these vessels are also oil traps it is necessary to provide oil bleed arrangements (Figs. 34 and 35), to keep a minimum oil concentration in the surge drum and flooded evaporator, and continuously return oil to the compressor.

Compressor Flood-Back Protection

In most air conditioning and refrigeration systems it is possible to control the refrigerant feed so that liquid refrigerant does not return to the compressor during operation.

Some systems, by reason of poor expansion valve operation, sudden changes in loading, etc., periodically return liquid refrigerant to the compressor, although not in sufficient quantities to do real damage.

There are certain systems, however, which by their very design will periodically flood the compressor with excessive amounts of liquid refrigerant. Principally, these are systems in which there is a periodic reversal of the refrigerant cycle to: (a) provide hot gas defrosting of an evaporator, (b) furnish heat for release purposes in ice-making apparatus, or (c) change from cooling to heating cycle, or vice versa, in heat pump systems.

These systems are almost identical in operation and effect on the compressor. Consider an air source heat pump for a typical analysis of what happens. The flood-back occurs when reversing the cycle, in either direction. During the cooling cycle the outdoor coils act as condensers and have warm liquid continually draining from them. Also the lines to which the thermal expansion valve bulbs are strapped are now hot

gas lines and are hot. When the cycle reverses to a heating one, the outdoor coils change from condensers to evaporators. The liquid that has been draining from them, during the condensing cycle, is now dumped into the suction line. Of even greater significance, the thermal expansion valves also open wide as the result of their bulbs being on warm lines (those lines were previously hot gas lines). These valves will therefore flood through until control is re-established at the bulbs. The total of these two effects constitutes a substantial liquid flood-back through the suction line.

When there is no way to control the hazard of periodic flood-back of substantial proportions through the suction line, it is necessary to take measures to protect the compressor against it. Otherwise compressor life will be materially shortened.

The most satisfactory method appears to be a trap arrangement that catches the liquid flood-back and may do one of the following: (1) meter it slowly into the suction line when it is cleaned up with a liquid-suction heat interchanger, (2) evaporate the liquid 100 percent in the trap itself and automatically return oil to the suction line; or (3) return it to the receiver or one of the evaporators. (The latter is used in ammonia systems only because of the no-oil-return feature.)

Fig. 39 illustrates an arrangement which will handle moderate liquid flood-backs, getting rid of the liquid by a combination of boiling off in the exchanger plus a limited bleed-off into the suction line. This device, however, would not have sufficient trapping volume for most heat pump jobs or hot gas defrost systems employing reversal of the refrigerant cycle.

For heavier periodic flood-backs a larger volume is required in the trap. The arrangement shown in Fig. 41 has been employed successfully in reverse cycle type heat pump jobs using Refrigerants 12 and 500. It consists of a suction line accumulator with sufficient volume to hold the maximum expected flood-back and of large enough diameter to effect liquid separation from the suction gas. The trapped liquid is slowly bled off through a controlled drain line into the suction line, where it is boiled off in a liquid-suction heat interchanger, between cycle reversals.

A proprietary device is available for preventing liquid slugs

from returning to the compressor. Liquid returning in the suction line is trapped out in the upper part of the shell, while the gas returns to the compressor through the outlet connection at the top. The liquid, together with any oil that is mixed with it, falls by gravity through the inner tube of the heat exchanger section below the separator plate. This inner tube is orificed and sized so the refrigerant passing through it will be 100 percent vaporized before returning to the suction line. The design also requires that the refrigerant gas velocity through this heat exchanger tube be sufficiently high to entrain oil and return it to the suction line. Warm liquid from the condenser is routed through the lower part of the shell to provide the source of heat for vaporizing any liquid in the heat exchanger tube.

Refrigerant Driers

The effect of moisture in refrigeration systems is discussed in Chapters 59 and 61 of the 1961 Guide And Data Book.

The use of a permanent refrigerant drier is recommended on most systems using Refrigerants 12, 22, and 500. It is a must on all low temperature systems, including those using Refrigerant 13.

The decision of whether or not to use a permanent drier on the higher temperature systems is one of judgment. In the case of package type air conditioners and water chillers it may not be necessary if proper dehydration techniques have been followed at the factory, no refrigerant connections are broken in the field, and any refrigerant added is at a sufficiently low moisture content. If there is any doubt that the system is initially free of moisture, or that the system can be maintained dry in operation, then a drier is indicated for protection of the compressor and to prevent freezing at the liquid feed device.

In the case of hermetic compressors there is an additional reason for keeping moisture out of the system. The motor windings are exposed to the refrigerant gas and excessive moisture can cause breakdown of the motor winding insulation possibly resulting both in burn-out of the motor and the distribution of the products of decomposition throughout the refrigeration system.

A full flow drier is usually recommended in hermetic compressor systems to keep the system dry and to prevent the products of decomposition from getting into the evaporator in the event of a motor burn-out.

Side outlet driers are preferred since the drying element can be replaced without breaking any refrigerant connections. The drier is usually located in the liquid line near the liquid receiver. It may be mounted horizontally or vertically with the flange at the bottom, but should never be mounted vertically with the flange on top since any loose material would then fall into the line when the drying element is removed.

A three-valve bypass is usually used as shown in Fig. 42 to provide a means for isolating the drier for servicing and to allow only partial refrigerant flow through the drier, in many cases using open type compressors, to reduce pressure drop and allow smaller drier selection in those cases. In systems using hermetic compressors, it is preferable to have all refrigerant going through the drier at all times for the reasons given previously.

The refrigerant charging connection should be located between the receiver outlet valve and the liquid line drier so that all refrigerant added to the system will pass through the drier.

Reliable moisture indicators are now on the market for installation in refrigerant liquid lines. These devices will in-

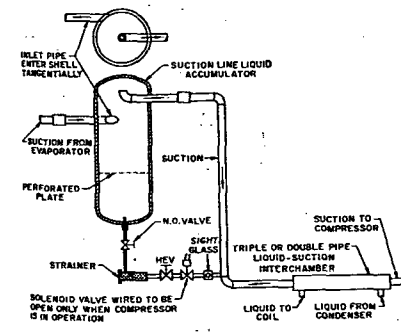


Fig. 41 . . . Compressor Flood-Back Protection Using Accumulator with Controlled Bleed²