

Fig. 28. . . . Piping for Single-Stage System with Low-Pressure Receiver and Liquid Ammonia Circulation

any accumulated liquid. The amount of pipe inside the shell should be kept to a minimum so as not to superheat more than 5 F deg the gas (without liquid) entering the compressor. The flow of high-pressure hot gas through the internal pipe should be such that the gas will not condense while flowing through it.

Pressurized Return Systems

Another method of transferring liquid from the suction trap to the high side is to have the main suction trap drain into an auxiliary suction trap located below it. When the auxiliary suction trap is nearly filled with ammonia liquid it is valved off. High-pressure gas is then directed into the auxiliary trap to increase the pressure sufficiently so that it can be returned either by gravity or by a low-head ammonia pump to the high-pressure receiver.

LIQUID AMMONIA RECIRCULATION SYSTEMS

In a liquid ammonia recirculating system, a pump is used to circulate the ammonia from a low-pressure receiver to the evaporators. The low-pressure receiver is a shell for storage of refrigerant at low pressure and used to supply evaporators with refrigerant, either by gravity or by a low head pump. It also takes the suction from the evaporators and separates the gas from the liquid. The amount of liquid fed into the evaporator is usually several times the amount that is actually evaporated in the evaporator and, therefore, there is always liquid present in the suction return to the low-pressure receiver. Frequently three times the amount that is evaporated is circulated through the evaporator.

In general, the sizing of the liquid ammonia pump is based on the gallons of ammonia required to be circulated versus a head differential between suction and discharge of approximately 20 psi. This is satisfactory for most single-story installations. If there is a static lift on the pump discharge, the differential would have to be increased accordingly.

The sizing of the low-pressure receiver is based on the cross-sectional area required to obtain liquid and gas separation and also on the volume between the normal liquid level and the alarm liquid level in the low-pressure receiver. This volume should be sufficient to contain the maximum fluctuation in liquid due to the various load conditions.

The liquid at the discharge of the pump is in the subcooled region. A total pressure drop of approximately 5 psi in the piping can be tolerated. The remaining pressure is expended through the control valve, coil, and suction return line. It is important that the pressure drop and heat pickup in the liquid supply line be low enough to prevent any flashing in the liquid supply line.

A relief valve is required from the liquid main back to the low-pressure receiver, so that when the liquid line solenoid

valves at the various evaporators are closed, either for defrosting or for temperature control reasons, the excess liquid can be relieved back to the low-pressure receiver. This pump relief valve is generally set at about 40 psi differential.

The suction header between the evaporators and the low-pressure receiver should be pitched $\frac{1}{8}$ in. per ft, if possible, in order to keep the excess liquid flowing back to the low-pressure receiver. It is important to design the header so that traps are avoided.

Liquid Recirculation in Single-Stage System

The piping of a typical single-stage system with a low-pressure receiver and liquid ammonia recirculating type feed is shown on Fig. 28. Some of the details shown in previous figures are omitted, but references are made to them in following text.

Liquid Recirculation and Evaporator Piping

The typical piping of an evaporator designed for liquid ammonia recirculation and equipped with hot gas defrosting is shown in Fig. 29. Liquid is normally fed through the liquid line into the vertical header and is distributed to the various coils through orifices in the header. Suction is taken from the suction header through a strainer and an automatic flow stop valve. This valve is wide open when the room thermostat is calling for cooling and regulates the back pressure at 80 psig during the defrost cycle.

When the unit is on the defrost cycle, the liquid line solenoid valve is closed and the hot gas solenoid valve is open. The hot gas flows through a coil located underneath the pan of the unit to keep the condensate from refreezing on the pan. It is then taken through a check valve into the liquid header and is distributed to the various coils where defrosting takes place. The condensed liquid is maintained at a temperature above 32 F and its pressure is relieved back to the low-pressure receiver and from there to the compressors.

COMPOUND COMPRESSION SYSTEMS

Compound compression systems compress the gas from the evaporator to the condenser in several stages. They usually are used to produce temperatures of -15 F and below, where this cannot be economically accomplished with single-stage compression.

The limit of single-stage compression systems is generally between 5 and 10 psig suction pressure. Two-stage systems are used down to about -65 F evaporator temperatures. Below this temperature three-stage systems become practical.

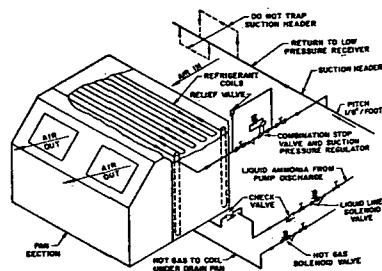
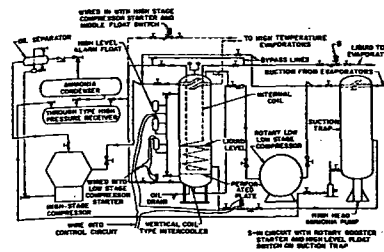


Fig. 29. . . . Piping for Evaporator with Liquid Ammonia Recirculation and Hot Gas Defrost



1. For suction trap and high head pump details see Fig. 25.
2. For rotary booster compressor cooling details see Fig. 10.
3. For high-stage compressor cooling see Fig. 7, 8 or 9.
4. For condenser-receiver details see Fig. 11.

Fig. 30. . . . Arrangement for Compound System with Vertical Type Intercooler and Suction Trap

In the area where either a single- or two-stage compression system can be used, it will usually be found that the two-stage system operates with less power requirements and, therefore, less operating cost but at increased first cost of equipment.

When the design compression ratio is approximately 9 to 1, the following items are of importance:

1. The discharge temperature on the high-stage compressor becomes high enough so that carbonization of the oil can result.
2. The volumetric efficiency on the high-stage compressor becomes low, resulting in higher compressor displacement per ton.
3. The refrigerating effect for each pound of ammonia circulated through the evaporator is at a comparatively low value.

Items 1, 2 and 3 can be circumvented by use of a two-stage system, with each compressor operating at a low compression ratio; having some means for cooling the discharge gas from the low-stage compressor and subcooling the liquid from the temperature corresponding to high-stage discharge pressure down to a temperature corresponding nearly to intermediate pressure.

The two-stage system consists of one or more compressors operating at the low suction pressure and discharging at an intermediate pressure and also with one or more compressors operating at the intermediate suction pressure and discharging to the condenser.

Gas and Liquid Intercoolers

The prime reason for using an intercooler in a compound system is to cool the discharge gas between stages to prevent overheating the higher-stage compressor. This is accomplished by bubbling the discharge gas from the low-stage compressor through a bath of liquid refrigerant at intermediate pressure and corresponding temperature. There is no heat rejected from the system in the intercooler. The heat removed from the discharge gas is absorbed by the evaporation of a portion of the liquid in the bath and is eventually passed through the high-stage compressor to the condenser.

For plant operating cost economy, the liquid for the evaporators on the low-stage compressor is subcooled after leaving the condenser so that the refrigerating effect per pound of ammonia is increased. This lowers the low-stage compressor displacement per ton and also reduces its operating brake horsepower.

Two types of intercoolers will be illustrated for compound

compression systems. In Fig. 30, a vertical coil type intercooler is shown. A liquid level is maintained in the intercooler by a float which controls the solenoid valve which feeds liquid into the shell side of the intercooler. Gas from the first-stage compressor enters the lower head of the intercooler, is distributed by a perforated plate, and is cooled to the saturation temperature corresponding to intermediate pressure.

High-pressure liquid from the receiver flows through a coil immersed in the lower part of the intercooler where it is subcooled to a temperature approaching that temperature corresponding to intermediate temperature before it flows to the evaporator. This liquid is kept at a high pressure which reduces the required size of the liquid control valve at the evaporators.

A horizontal flash type intercooler is illustrated in Fig. 31. A float switch maintains a level in the intercooler by controlling the flow of ammonia liquid from the high-pressure receiver and injecting it into the intercooler where it flashes to the intermediate pressure. After the intercooler has sufficient liquid in it, the excess will flow over a weir and be fed into the low-pressure receiver where the level is maintained by another float switch. Discharge gas from the low-stage compressor is piped to an internal slotted pipe in the intercooler through which it is distributed up through the liquid and is cooled to the saturation temperature corresponding to intermediate pressure.

Two-Stage System Piping

Fig. 30 illustrates a two-stage compound compression system utilizing a vertical coil type intercooler with a vertical suction trap in the suction line from the evaporators to intercept any liquid present.

A rotary low-stage compressor takes a suction from the vertical suction trap and discharges into the vertical coil type intercooler. A valved bypass line is provided around the rotary compressor and intercooler so that the plant suction pressure can be lowered with the high-stage compressor prior to starting the low stage so as not to overload the motor on the low-stage compressor. A check valve is provided in the discharge line of the rotary compressor to minimize the back flow of gas from the intercooler to the compressor and into the suction trap and evaporators upon a shut down due to a power failure or for any other reason. Likewise, a check valve is used from the gas space at the top of the intercooler to the top of the discharge line from the rotary compressor to keep the intermediate pressure in the intercooler from backing liquid up the discharge line and through the check valve and into the compressor.

Suction gas from high-temperature evaporators can be taken into the intercooler where any liquid present can be separated before going to the high-stage compressor.

An equalizer header is provided on the intercooler for mounting of float switches. The lowest float switch maintains the normal liquid level in the intercooler by controlling the flow of high-pressure liquid from the receiver to the intercooler.

If the intercooler should receive excess liquid from the high temperature evaporators, the liquid level will rise to the setting of the middle float switch. This switch opens a solenoid valve in a drain line from the intercooler at intermediate pressure to the suction trap where it can be pumped to the high-pressure receiver.

The highest float switch is for an alarm and sometimes for stopping the compression system in cases of excess liquid.

The high-stage compressor takes its suction from the top of the intercooler and discharges its gas into the condenser.