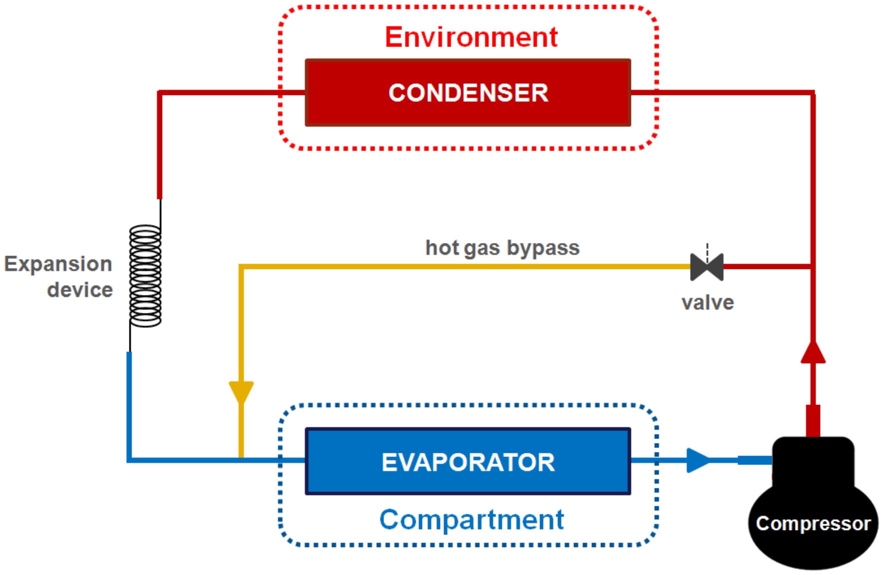
HOT GAS DEFROST AT COOLING CIRCUIT

In conventional refrigeration appliances, the evaporator is responsible for cooling the air in the refrigerated compartment. During this process, air humidity is condensed on the evaporator surface and eventually freezes. This reduces the efficiency of the evaporator to exchange heat. In other appliances, such as ice machines, the evaporator is in direct contact with water to produce ice cubes during the cooling period. In both cases the ice must be removed from the evaporator surface, either to improve its efficiency or to enable the ice cube harvest.

The Hot Gas Defrost method is commonly used in commercial appliances, e.g. ice machines, commercial freezers, sealed units, and some medical applications. This method uses the compressor’s discharge gas energy, which is at a high temperature and pressure, to melt the ice. The advantage of Hot Gas Defrost is the melting occurs from the evaporator surface and works its way outwards resulting in a quicker defrosts and less heat being deposited in the refrigerated space (radiated heat).

To enable this method a bypass tube (hot gas bypass or hot gas line) is added to the compressor discharge line to create a shortcut between compressor discharge and evaporator inlet.



During the cooling period, the hot gas bypass is denergized (valve normally closed) and the system operation is similar to a standard cooling circuit. To perform defrost, the bypass is energized and the valve opens, commonly by means of a solenoid valve. This valve operation can occur with the compressor running or off depending on appliance configuration. After switching the valve to open state, most of the compressor discharge gas, which is at a high temperature and pressure, will flow through the hot gas bypass due to lower restriction compared to the condenser and expansion device (capillary tube or expansion valve). From the hot gas line, it flows into the evaporator where it condenses and rejects heat into the evaporator, melting the ice, and performing the defrost. During almost all of the hot gas defrost period, the evaporator outlet condition will be a mixture of liquid and vapor refrigerant. Finally, the gas-liquid refrigerant mixture is pushed from the evaporator to the compressor and heated by its components. During the cycle, the refrigerant continues to circulate in the following sequence: compressor, hot gas bypass, evaporator and compressor. At a given time the hot gas defrost is terminated, by a temperature sensor or other means, and the solenoid valve is closed. Before the cooling cycle is started again, a defrost water dripping time may be applied.

COMPRESSOR OPERATION DURING HOT GAS DEFROST

At the beginning of the hot gas defrost process, the solenoid valve is opened and a high refrigerant mass flow rate pushes the liquid refrigerant from the evaporator to the compressor. The amount of liquid that reaches the compressor suction tube depends on the characteristics of the appliance. When the liquid refrigerant reaches the compressor it may (i) evaporate when entering in contact with hot elements, (ii) enter the suction muffler or (iii) accumulate at compressor shell. Each of these “liquid paths” may happen in parallel and affect the compressor components in different ways, leading to special design requirements.

If liquid enters the suction muffler and reaches the compression chamber, load will increase significantly for the compressor motor. In addition to the liquid return, the higher evaporation pressures during hot gas defrost will also increase the load on other components. Due to the aforementioned loads, increased robustness is required for compressors which may be applied in systems with hot gas defrost. Special designs need to be utilized for the bearings, valves, manifold, and suction muffler.

Suction Muffler

The liquid entering the compressor must go through the suction muffler if it is to reach the compression chamber. When some amount of liquid (oil or refrigerant) is compressed, load peaks known as “liquid hammer” may happen. To reduce the probability of this “liquid hammer”, the suction path of the compressor can be designed in such a way that it provides effective and safe vapor and liquid separation. This is done, for example, when the suction tube connector on the compressor shell and the suction gas inlet to the muffler and pump unit are located on opposite sides of the shell (indirect suction). However, this concept reduces the compressor efficiency since the suction gas is superheated significantly in the compressor shell. In the high-efficiency compressors, the suction muffler is designed to reduce the refrigerant superheating, which requires a more direct path for the refrigerant to reach the compression chamber (semi-direct and direct suction). For the direct suction muffler, where the refrigerant path is “bounded” with a connector, the likelihood of “liquid hammer” increases. In this case, it is suggested to apply an adequate gas/liquid separator after the evaporator outlet to avoid liquid reaching the compressor suction tube.

Valves

Even during hot gas defrost, if the design of the suction line and the muffler considers this condition, only a fraction of the liquid should be able to reach the compression chamber. However, when this liquid is compressed, it leads to extreme pressure peaks inside the cylinder chamber and imposes additional load at valves and mechanical kit. Compressing a given amount of liquid (refrigerant or oil) may lead to valve damage, such as a permanent deformation, which can result in valve failure once the fatigue limit is reached. Another possibility is a direct fracture of other mechanical components with higher amounts of liquid. In addition to the return of liquid, the hot gas defrost conditions usually imply that the compressor will operate outside of the approved operating envelope, with higher evaporating and lower condensing temperatures than those that characterize the compressor envelope. This may cause a more stressful condition for the valve system (mainly for LBP models). For the reasons stated above, in compressors that are approved for hot gas defrost conditions, the valve system must be robust enough to withstand the operation outside of the envelope as well the additional loads imposed by eventual compression of liquid droplets.

Bearings

The liquid refrigerant, which is returned to the compressor, will be mixed with compressor oil and reduce the oils lubricating properties. While pumped through the bearings, the oil pressure is reduced and the mixture is heated by hot surfaces and friction, which promote liquid refrigerant evaporation, resulting in a two-phase flow that may lead to cavitation in the bearings. Cavitation will reduce the bearing load capacity, which can lead to wear. Therefore, compressors approved for hot gas defrost have special requirements for bearing design. The oil quantity, viscosity and bearing load capacity are some design variables to result in robust hot gas defrost operation.

Refrigeration System Design

In addition to the compressor design itself, the cabinet design can also contribute to the compressor reliability during hot gas operation. This can be done through an appliance design that minimizes liquid return to the compressor. Components that most influence are: liquid-vapor separator, refrigerant charge, accumulator, suction tube length and orientation, evaporator design, hot-gas bypass flow restriction and control algorithm for solenoid valve switch and compressor. For more details refer to the Embraco Installation Manual available online (sections Hot gas Defrost 11.6.6 and Max Refrigerant Charge 10.6.1.5).

REMARKS SUMMARY

As explained in this informative, Embraco compressors, which is a brand in the Nidec Global Applicance portfolio, when approved to operate in systems that perform defrost using hot gas have special design features that provide robustness to withstand such condition. In this way, when selecting a compressor for appliances with hot gas defrost always check if the compressor model is designed considering such conditions. In case of doubts or additional questions contact your Nidec Global Appliance Technical Support.