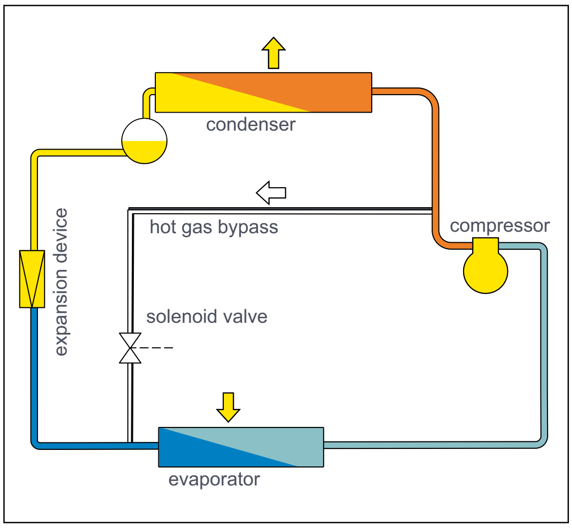
PRODUCT BULLETIN

Hot Gas Defrost with Secop Compressors

Hot gas defrost is used in various kinds of cooling cabinets (e.g. commercial freezers, ice cube makers, etc.) to remove ice from evaporator surfaces.



Cooling Cycle Design

A bypass tube is added to the standard cooling circuit between the compressor discharge tube and condenser inlet. This bypass creates a shortcut from the compressor to evaporator inlet and can be switched open or closed, in most cases by controlling a solenoid-valve.

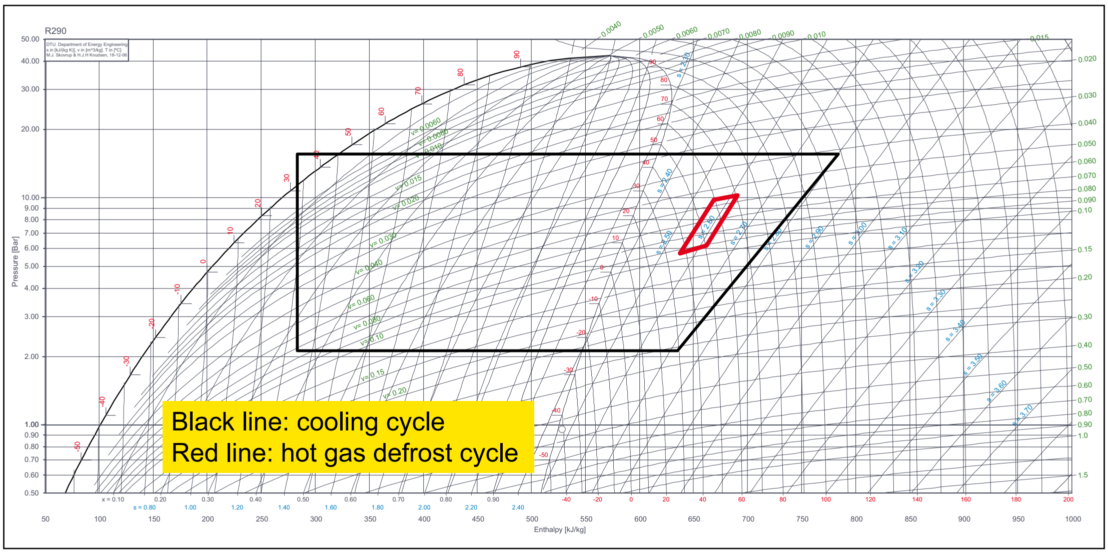
Function – Gas Flow

Hot gas bypass is inactive (solenoid valve is closed): The cooling system operates similar to a system without hot gas bypass. The tubing design (length, diameter, position of solenoid valve) may slightly influence refrigerant demand and dynamic behavior.

Hot gas bypass is active (solenoid valve is open): After switching the solenoid valve open (when the compressor is running), most of the discharge gas (high pressure, high temperature) leaving the compressor will take the "low restriction path" in the bypass tube. Without having a check valve near the condenser inlet, refrigerant from the condenser will also start evaporating (due to pressure equalization to evaporator), cooling down, and flowing through the bypass line into the evaporator. Due to equalization of pressure differences (condenser/evaporator) and forced mass flow of the compressor, hot refrigerant gas will be pushed into the evaporator inlet. Cold gas and liquid refrigerant will then be pushed out of the evaporator into the suction line and finally into the compressor.

The compressor runs similar to the usual state: intake → compression of gas → discharge.

Since the pressure difference is low after the solenoid valve is opened, the gas temperature after compressing is comparably low. This nearly cold gas is heated up by the hot components of the compressor (compressor cools down) and will finally continue to circulate: compressor → bypass → evaporator → compressor, until the solenoid valve is closed again.



Function – Defrosting

The hot gas from condenser and from compressor that enters the evaporator will transfer heat which warms up and finally melts ice on the evaporator surface.

The amount of heat which can be used for melting ice on the evaporator surface is limited. In fact, heat from the compressor (temperature × mass × specific heat capacity) and heat from the refrigerant inside the condenser can be transferred into the evaporator for defrosting.

Once the temperature of compressor and temperature of condenser are stabilized (with solenoid valve open), only very little heat will be generated by the compressor. If defrosting after temperature stabilization is not completed, the use of external heaters should be considered to avoid very long hot-gas-operation times.

Hot Gas Defrost – Special Demands for the Compressor

Running hot gas defrost in a cooling system creates a special overload situation for the compressor. Increased robustness and a special design of some components are needed for a compressor which can also operate in hot gas defrost.
Special demands are given for: bearings, valves, suction muffler.

Compressor Design for Hot Gas Defrost – Bearings

When the bypass valve is open, fast flowing gas enters the evaporator and mixes with the liquid (and also gas) refrigerant which is already inside the evaporator. In case no effective liquid/gas separator is installed between evaporator inlet and compressor, gas and liquid refrigerant will be pushed/sucked into the compressor. Some of the liquid refrigerant will evaporate due to the high temperature inside the compressor, but some other liquid refrigerant will mix with the compressor oil.
In order to lubricate the bearings inside the compressor (crankshaft, connecting rod, piston), oil from the bottom of the compressor is pumped into the bearings. During hot gas defrosting, when liquid refrigerant flows back into the compressor, a mixture of oil and refrigerant will be pumped up to lubricate the bearings. When this mixture enters the bearing gap, it will be heated up by friction and hot bearing surfaces. This rise in temperature will cause the liquid refrigerant to evaporate (even in high pressure ambient). Since it is now gas instead of liquid, the refrigerant needs much more volume and pushes some oil out of the bearing gap to be able to also "escape".
Special demand for compressors with hot gas defrost capability is to have a very robust slide bearing setup (large surface area, high viscosity oil, high oil quantity) which operates without wear even when the oil is mixed with liquid refrigerant.

Compressor Design for Hot Gas Defrost – Valves

When the hot gas bypass is active (the solenoid valve is open) the discharge pressure is quite low (creates no problem for the compressor) and suction pressure is very high. Suction pressure in this phase is still lower than during a pull down, so every compressor should be able to handle this situation. However, the total time operating at very high suction pressures is much higher for "hot gas defrost compressors" than for others. As a result, the valve system design must simply be more robust (e.g. higher valve stiffness) to be reliable for the entire lifetime.
In case small droplets of liquid refrigerant manage to enter the compression volume (between piston, cylinder and valve plate) hopefully all of the liquid will evaporate when it comes into contact with the hot surrounding surfaces. This event will create extremely high pressure (only for a single stroke) inside the cylinder and create high strain for the compressor mechanics. Bending the valves is no problem (due to the opening height limiter) but impact speed/forces between valve and limiter or valve and valve plate must be kept inside the design limits even for these random pressure peaks.

Compressor Design for Hot Gas Defrost – Suction Muffler

Compressing a small amount of liquid (can be refrigerant or oil) will lead to valve damage (often a permanent small deformation initially and finally breaking of the valve due to lowered fatigue limit) or direct fracture of connecting rod or crankshaft with higher amount of liquid.
To avoid this "liquid hammer", the suction path of the compressor must be able to separate gas and liquid. "Old fashioned" compressors have been designed in a way, which very effectively and safely separates gas and liquid (suction gas connector on the compressor shell and suction gas inlet to the pump unit are far away from each other). Unfortunately, this design offers a low rate of energy efficiency since the suction gas is heated up significantly. High efficiency compressors with ability to defrost hot gas use large volume suction mufflers and feature a special design for gas/liquid separation. Comparing old versus energy efficient design clearly shows that the old design is capable of tolerating a higher liquid intake. Energy efficient compressor and hot gas defrost is possible but the cabinet may need to be adapted.

Cabinet / Cooling System Design for Hot Gas Defrost

Without any doubt, the compressor has to be designed in a special way to be able to withstand hot gas defrost operation with the needed reliability but features of the cabinet also contribute on a significant level. Refrigerant charge, evaporator design, length of suction tube, gas/liquid separator, flow restriction in hot gas bypass, control algorithms (compressor, solenoid valve) and compressor: all these components must be in "harmony" to run hot gas defrost without damaging the compressor.

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