VAPOR QUALITY CONTROL

REDUCTION OF ENERGY CONSUMPTION USING VAPOR QUALITY CONTROL

VAPOR QUALITY • OVERFEED AND DX SYSTEMS

HB Products

With the increasing energy price, it has become more important than ever to reduce electrical energy consumption. Most refrigeration systems can be optimized and become more energy efficient. Especially systems operating in part load and systems with a pumped refrigerant with circulation ratios above 1:2 can expect large savings.

Vapor Quality Control

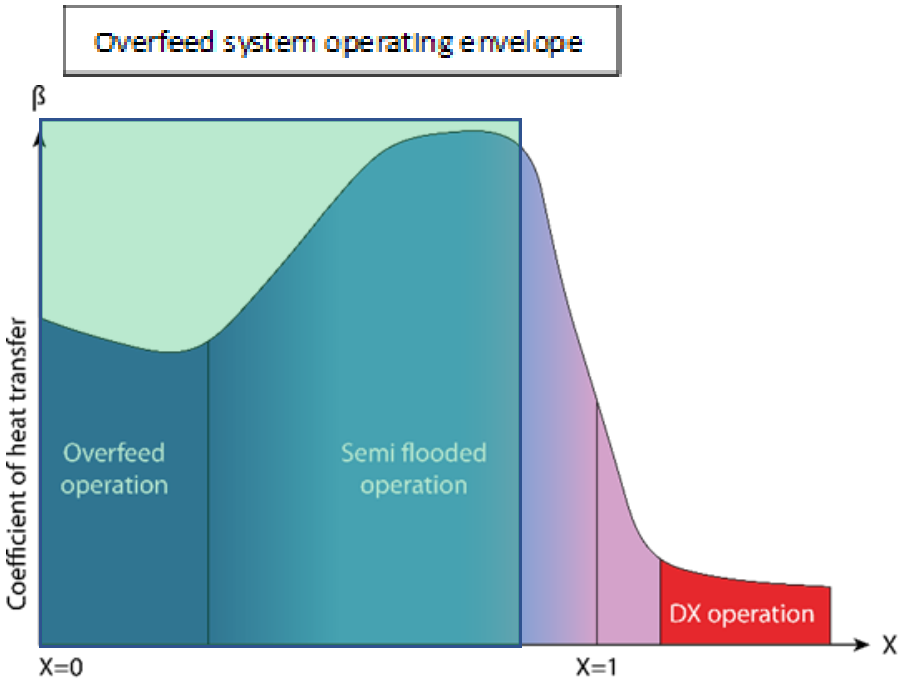
The Vapor Quality Sensor can measure the liquid content in the gas-liquid mix coming out of the evaporator. The output can be used for controlling the liquid refrigerant feed into the evaporator and optimizing the evaporator operation.

The sensor must be installed immediately after the evaporator to provide optimal feedback for the controller. Installation after a riser does not work properly, in part-load operation, because liquid tends to collect in the riser.
The sensor can be used both for pump circulated systems and DX systems. For both system types, the capacity can be increased and the power consumption can be reduced.

Pump circulated systems and other overfeed systems

To improve the energy efficiency of an overfeed system the circulation ratio must be as low as possible while maintaining a good liquid distribution in the evaporator. The low circulation ratio secures the refrigerant is boiling which leads to maximum heat transfer and efficiency. The optimal heat transfer is obtained when the gas content is high, and boiling is intensive.

When the load moves into part load the circulation ratio is typically increased if the pump capacity is maintained. This leads to more liquid in the evaporator and less boiling. The result is reduced cooling capacity and an increased pressure loss in the system. The consequence of the increased pressure loss is increased energy consumption. The solution to the problem is to control the circulation based on the Vapor Quality of the evaporator output and maintain the optimal circulation rate.



This can be done by frequency control of the pumps or by using liquid valves depending on the system design.

Another issue that increases the energy consumption and reduces capacity is risers filled with liquid during part load. If the riser pipes are too wide the gas velocity is not sufficient to transport the liquid upwards and the pipe gets filled with liquid. The solution is to measure the vapor quality at the evaporator and control the liquid feed so the riser is able to carry the surplus liquid back to the separator.

Low Charge DX systems

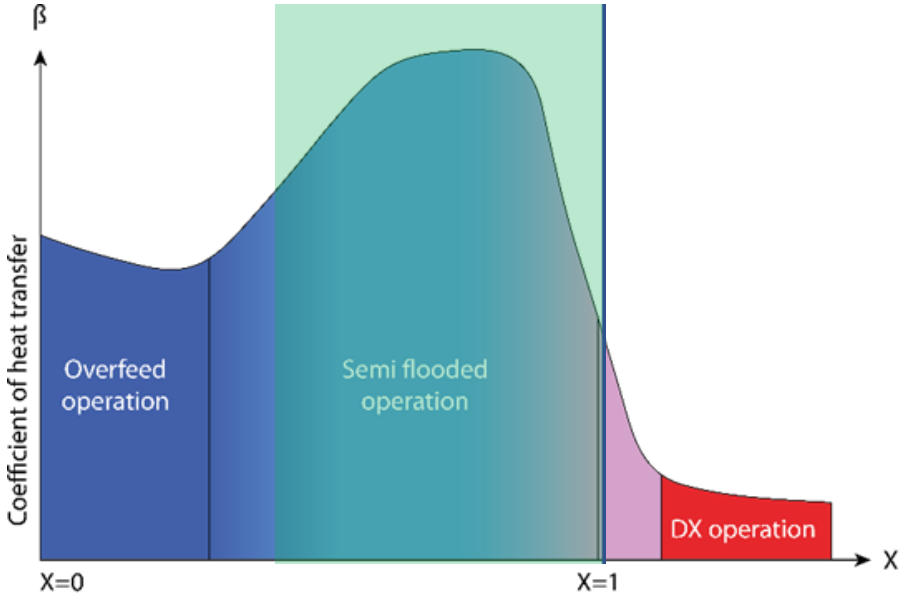
With direct expansion, it is possible to both reduce the refrigerant charge and reduce energy consumption. To reduce energy consumption it is important to use Vapor Quality control and avoid superheating.

The largest benefit is achieved when the system operates in part load. The saving is achieved by a lower pressure loss and less superheat of the gas. For every degree superheat the power consumption is increased by 3%.

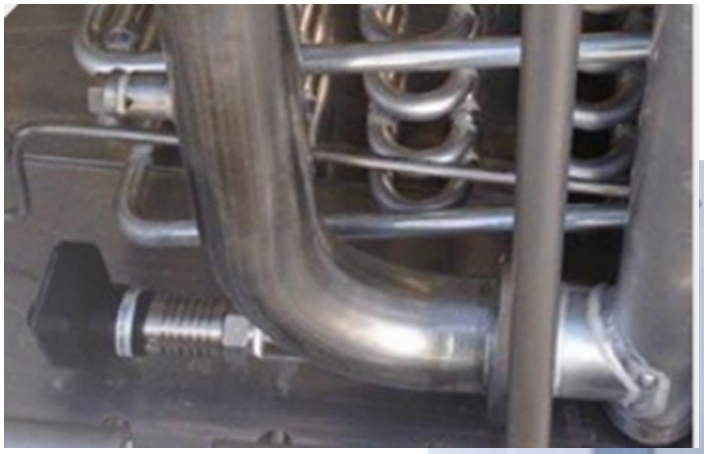
When designing the system, it is important to choose an evaporator designed for direct expansion. That means the evaporator must have a liquid distributor with a small pressure loss and it should be possible to install a Vapor Quality sensor close to the outlet. One manufacturer of evaporators already sells evaporators with a direct connector to a Vapor Quality sensor.

When operating with ammonia it is also crucial to use evaporators with an inner tube surface optimized for high heat transfer.

DX system operating envelope



The potential energy savings depends on how well the system is designed and how much part load operation is done, but typical numbers are from 20 to 50% savings. There are several examples of 80 % energy saving when replacing large old pumped systems using synthetic refrigerants with DX ammonia systems with a very small charge.



Liquid distributor for DX Ammonia systems ⟶

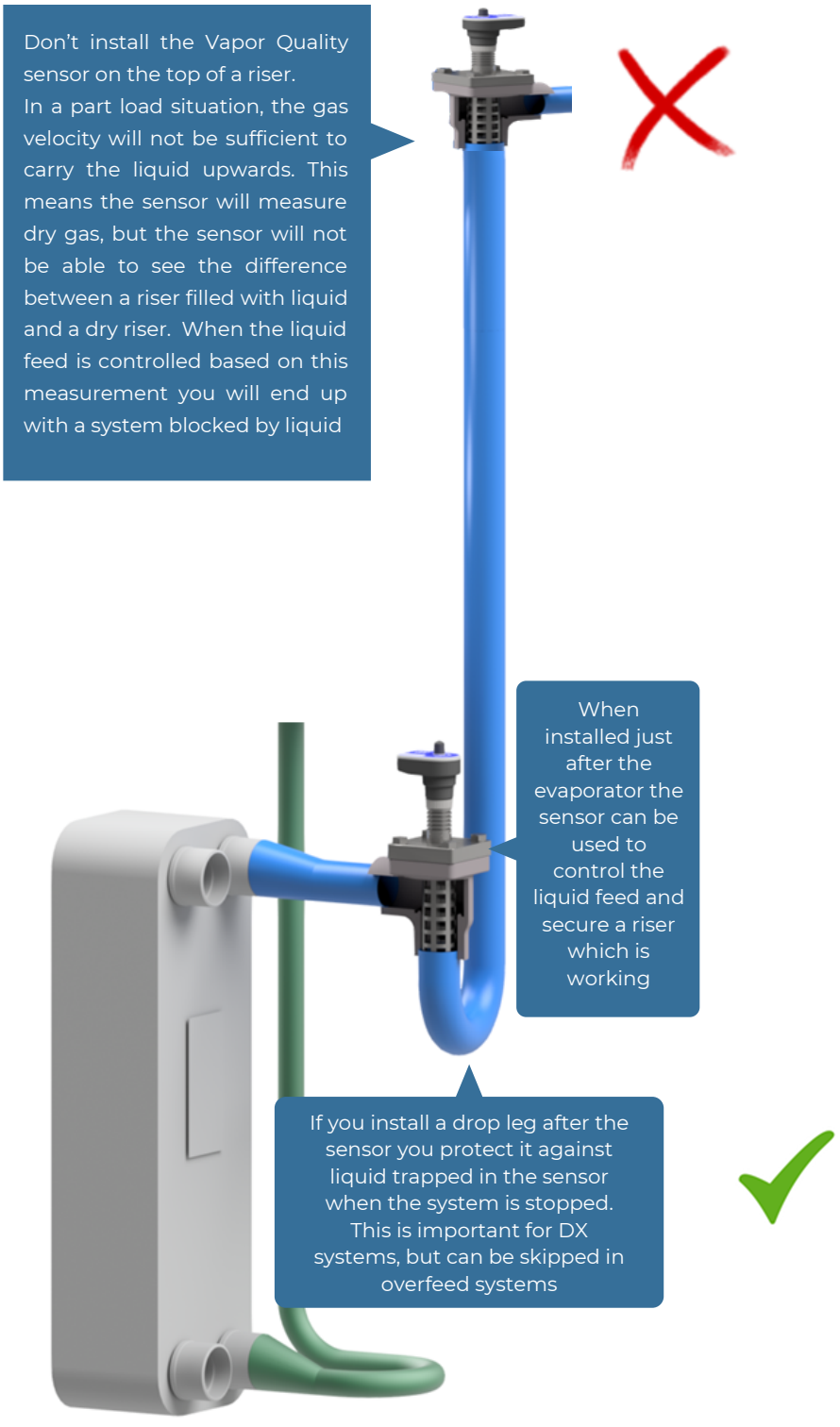
⟵ Vapor Quality sensor installed just before the riser on a DX evaporator

Where to install the Vapor Quality Sensor?

The Vapor Quality sensor detects the liquid content in the output from an evaporator. This output is used for controlling the liquid feed and securing a constant dryness. The sensor is used both in overfeed systems and in DX systems

- just with different targets for the liquid content.
The Vapor Quality sensor can have different shapes, but for all, it is important to install it as close to the evaporator as possible to get the best feedback for the control system.

Typically, the sensor must be installed in the cold room to be as close to the evaporator as possible. In addition to the energy saving, the capacity will normally increase because the evaporator will no longer be filled with liquid, and the heat transfer will increase significantly.



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