Vapor quality sensors

for

- ## Simple efficient DX systems

  With the Vapor Quality sensor you can eliminate superheat and control your expansion valve directly

- ## Overfeed systems

  Control your circulation rate and make your system more efficient at any load

- ## Ammonia carbamate detection

  Leak alarm for CO_2 into ammonia for cascade systems at an early stage before the system get damaged

- ## Compressor protection

  Detect liquid in the suction line and prevent liquid hammering

Functionalities

- Measures the content of liquid in a refrigerant gas
- Instant measurement
- No moving parts
- Suited for most common refrigerants and pipes dimensions from ½” to DN300

Benefits and opportunities

- Energy savings for DX systems—ensures semi-flooded operation and eliminates superheat
- Low charge—high efficiency DX plants are possible also for ammonia
- Optimized evaporation control for both DX and overfeed systems
- Direct control of electric expansion valve or liquid valve in overfeed systems—No PLC needed

What is a vapor quality sensor

A vapor quality sensor can measure the mix between gas and liquid in a refrigerant from 0% gas to 100 % gas, a measurement which no other sensor can provide. It consists of a tube, with simple metal inserts, where the mix of two phases pass through. The sensor measures the dielectric constant of the fluid, and as two different phases (liquid/gas) has different dielectric constant, the mix between the two, can be calculated. The output of the sensor is the "X" value which is the Volume % of liquid in the gas.

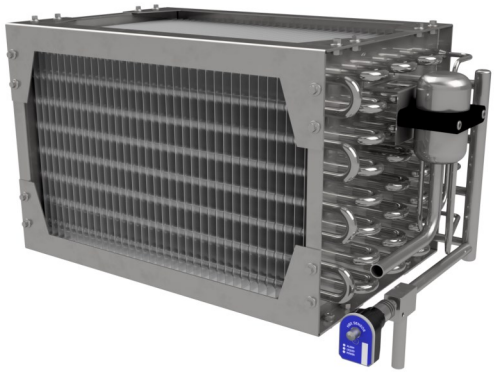
Benefits and opportunities when using a vapor quality sensor

The sensor provides an instant signal without delay which is ideal for controlling the evaporation process in a refrigeration plant. The conventional thermo valve reacts significantly slower and a significant superheating of the gas is needed.
The sensor has no moving mechanical parts and no service is needed. The mechanical part is made from stainless steel and there are a few plastic parts all approved for most common refrigerants including ammonia.
The vapor quality sensors are mounted in straight pipes or in an elbow normally used for strainers. This secures a precise positioning of the sensor element and repeatable results.

Vapor quality sensor in DX application

One of the large benefits by using the sensor is in DX systems, where it controls an electronic expansion valve directly. Superheat can be eliminated and evaporator capacity can be increased using semi-flooded operation. At the same time the installation cost is reduced as the PLC is not needed, and the cabling is simpler. With the right evaporator design the suction pressure can be significantly reduced and the COP is improved.

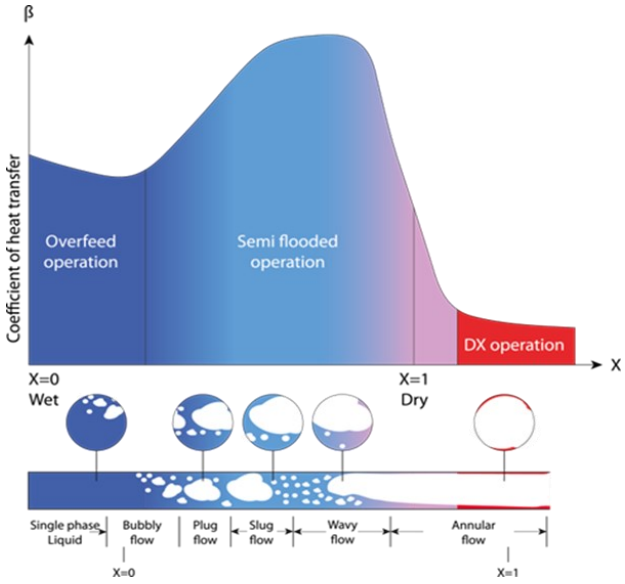
Simple DX evaporator with vapor quality sensor



Energy efficient systems are normally constructed as overfeed systems with circulated refrigerant which is the normal way to eliminate superheat —but with a vapor quality sensor you can get even better efficiency at a lower cost and with a significant lower refrigerant charge.

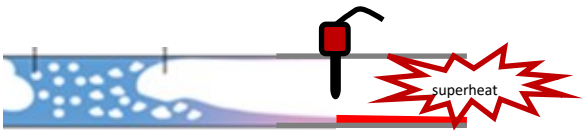
Optimizing the evaporator

The evaporator efficiency depends on the liquid content of the substance and the flow rate. The figure shows that the efficiency depending on the vapor quality from X=0 wet to X=1 dry gas The highest efficiency is achieved in the semi flooded operation area from a X value 0.5 to 0.9. In this area the substance is a mix between some liquid and a lot of gas.

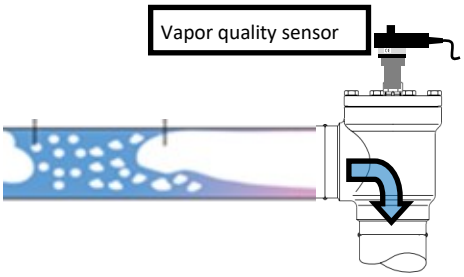


As soon as the gas becomes dry beyond 0.9 the efficiency drops dramatically and at the same time the gas is superheated.
In a conventionally DX (direct expansion) system the gas is heated up to 5-10 K superheat and that creates a loss in efficiency in the evaporator as 20-30 % of the area is used for superheating. At the same time superheating is a waste of energy and should be avoided.

Conventional temperature sensor/thermostatic valve



Vapor quality sensor



Optimize your overfeed system with a vapor quality sensor

By using the vapor quality sensor in the evaporator outlet and using it for controlling the refrigerant feed, it is possible to reduce the pressure drop. This makes the system significantly more energy efficient even during part load. Improved heat transfer in evaporators and plate heat exchangers increases the capacity and makes it possible to reduce the needed refrigerant charge. When using the outlet vapor quality for controlling the liquid feed it is possible to maintain a stable flow, even in risers, with a low pressure drop.

Thermosiphon system with both a vapor quality sensor in the evaporator outlet and a level sensor in the vessel

Simple installation

The vapor quality sensors can control a valve directly. Both for DX systems and in overfeed systems the valves can be controlled directly without a PLC. Cabling can be more simple and much shorter. This means the total installation cost and complexity can be reduced.

Mechanical and electrical element

The complete sensor consists of two elements which are joined with a simple threated union. The mechanical part is installed in the pressurized system. The mechanical part of the angle sensors can be split into a housing, which is welded or brazed into the pipework and the sensing element. The sensing element is mounted in the pressurized system and can not be dismantled when the system is under pressure.

The electrical element is outside the pressurised system and can always be removed and replaced.

Special applications

Compressor protection

The vapor quality sensor can also be used for compressor protection when mounted in the compressor suction line. Here it detects liquid like in a DX application and can prevent liquid hammering.

Leak detection of ammonia carbamate and vapor quality at the same time

The sensor can be used for detecting CO2 leaking into an ammonia cascade system creating ammonia carbamate. The sensor can actually also be used as a vapor quality sensor because it is only the alarm function which is used when detecting ammonia carbamate.

The sensor

The sensor consists of metal parts ,which are placed in a pipe with the gas/liquid stream and a electronic unit. The metal parts together with the pipe represent two surfaces in a capacitor and the gas/liquid stream the isolator. The gas/liquid stream has dielectrical property which is measured by the electronic element and the mix between liquid and gas can be calculated. One of the settings in the sensor is the type of liquid and these data are used in the calculation.
The output from the sensor is the X value for a PLC which can be used to control a refrigeration system The sensor can also provide direct control of either an expansion valve for a DX system or a liquid valve in an overfeed system.

Vapor quality products

The sensors are currently developed for most common refrigerants, as a straight pipe version and two elbow versions. Basically they have the same functionality but with a different design to match different system designs. All sensors have to be mounted so it is draining refrigerant and no refrigerant is trapped when the system is stopped.

In-line sensor

The straight version called in-line is available from 1” to 2” and the sensor accepts flow **in both directions**. The sensor can be mounted both horizontal and vertical position and is made only in stainless steel. The sensor can be buttwelded (TIG) into the system.

Angle rod sensor

The angle rod sensor is made in stainless steel from 3/8” to 7/8” and the sensor accepts flow **in both directions.** The outer pipe has a larger diameter than the system pipe diameter to make room for the sensor element and avoid pressure drop. To make the sensor fit to the pipework in the system pipe reductions are part of the delivery and these will be different depending of the refrigerant. The sensor can be brazed or buttwelded into the system.

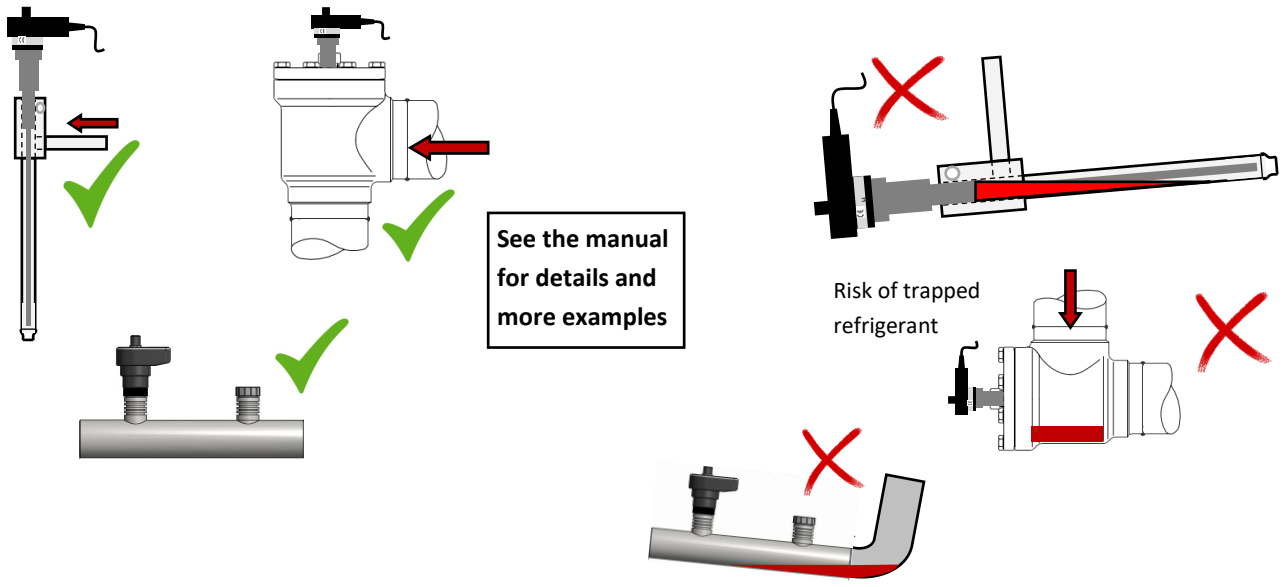
Angle strainer sensor

The largest versions are build into strainer houses made from carbon steel available from DN20 to DN300 or in stainless steel from DN20 to DN65. The strainer houses does not include a strainer, but it can be mounted in some of the versions; please contact HBproducts if this is needed.
The flow direction is limited to **one direction** and it has to be mounted with the lid and electronic part upwards to secure refrigerant drainage, when the system is stopped. .

The angle strainer houses from DN40 and sizes below have an additional pipe welded on to create sufficient room for the sensor element

How to install the sensor

The sensor is mounted in the suction line just after the evaporator, where it can measure the X value. It is important to mount the sensor in a pipe which is dry when the system is stopped and place the sensor so no refrigerant or oil can be trapped in parts of the sensor. The manual shows in detail how to install and connect the sensor.



How can the sensor be used

Four major applications

1. **As vapor quality sensor with 4-20 mA output**
2. **As controller of a valve and as option deliver vapor quality input for a PLC**
3. **As an alarm for leakage in a CO2/NH3 cascade system (ammonia carbamate) and as vapor quality sensor**
4. **As compressor protection to avoid liquid hammering—All sensors can be used for this application**

The sensor version is straight forward and exists in a standard and a special ATEX version for hazardous areas.
The versions able to control a valve comes in different versions with different functionalities mainly due to limitations in the electronic unit. Here is a list of the functionalities:

Temperature sensor is mounted to compensate for changing dielectrical constant of the refrigerant in relation to temperature. For instance after a longer stop the temperature has risen and the measurement is less accurate especially for CO2

Control of **stepper motor** requires different output than control of a **motor valve** or a **modulating valve**. The unit got to have the suitable control capability.

Remote setting makes it possible to operate with a different set point depending on the system load and is used for sensors controlling a valve and at the same time has connection to a PLC

Alarm for X is a functionality used when a PLC is connected and you like an alarm when there is liquid in the suction line.
Leak detection of ammonia carbamate in CO_2/NH_3 cascade systems is using the alarm function and will only work when the sensor has an alarm output.

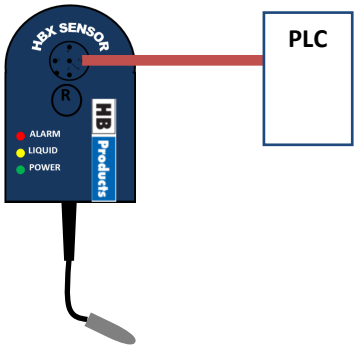
Five different control/sensor versions

Five different versions exist due to the way the electronic unit is configured and which additions are made to the unit. The different versions have different functionalities which can be seen in the tables. All four can be connected to a PLC but the last three can control a valve without a PLC connection. All five can be used for compressor protection.

This version is connected to a PLC and has no control cable. The typical purpose is providing input to a controller and is typically used in larger plants controlled by a PLC.

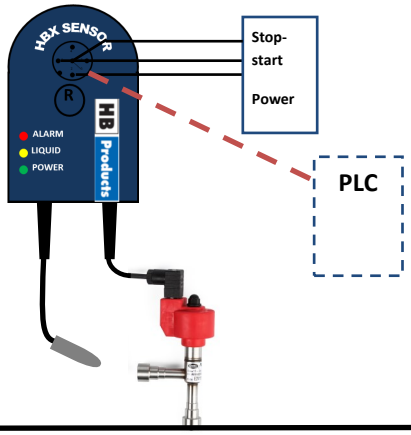
Suited for ammonia carbamate leak and compressor protection

Sensor version	
+	Temperature sensor
-	Control stepper motor
-	Control PWM/Mod Valve
-	Remote setting
+	Alarm for "X" & Leak detection



This version can both be connected to a PLC and provide input to an expansion valve or a liquid valve in a flooded system. Only a fixed set-point for the vapor quality is possible

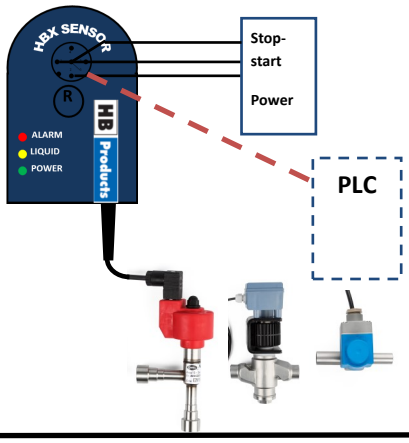
Standard version	
+	Temperature sensor
+	Control stepper motor
-	Control PWM/Mod Valve
-	Remote setting
+	Alarm for "X" & Leak detection



Stepper motor, motor and modulating valve together with remote setting of the "X" set point is available at the same time.

The sensor has no temperature sensor and is only suitable for NH3 and only for refrigeration

NH3 Control version	
-	Temperature sensor
+	Control stepper motor
+	Control PWM/Mod Valve
+	Remote setting
-	Alarm for "X" & Leak detection

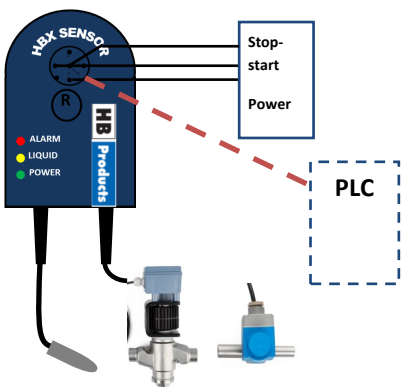


This version can both control a motor valve and a modulating valve, but not a stepper motor valve. At the same time it has remote setting of the "X" set point

Temperature sensor is available as an option

The alarm function is not available

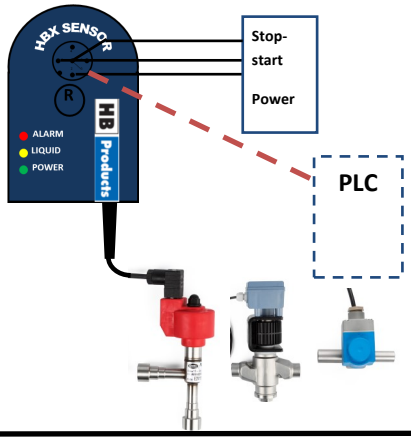
PWM/Motor valve and remote version	
+	Temperature sensor (option)
-	Control stepper motor
+	Control PWM/Mod Valve
+	Remote setting
-	Alarm for "X" & Leak detection



Stepper motor, motor and modulating valve together with alarm for ammonia carbamate is available at the same time.

The sensor has no temperature sensor and is only suitable for NH3 and only for refrigeration

NH3 Control & leak version	
-	Temperature sensor
+	Control stepper motor
+	Control PWM/Mod Valve
-	Remote setting
+	Alarm for "X" & Leak detection



Product range

The vapor quality products are still being improved and developed. The web page reflects the current product range in details.

In-line sensor

DN25—1"
DN40—1½"
DN50—2"

Angle rod sensor

3/8"
½"
5/8"
7/8" not for HFC/HFO

Angle strainer sensors

Stainless version

DN20—3/4"
DN25—1"
DN32—1¼"
DN40—1½"
DN50—2"
DN65—2½"

Steel version

DN20—3/4"
DN25—1"
DN32—1¼"
DN40—1½"
DN50—2"
DN65—2½"
DN80—3"
DN100—4"
DN125—5"
DN150—6"
DN200—8"
DN250—10"
DN300—12"

DX system with vapor quality control of a motor valve