HB Products WE INCREASE UPTIME, SAFETY AND EFFICIENCY

Appendix HBX Vapor Quality sensor with Direct valve control

Strainer house versions

Rod style version

Angle rod version

In-line version

Direct valve control or valve control via a PLC

Level sensors and vapor quality sensors is normally used for controlling a liquid or expansions valve. These HB sensors can be supplied with direct valve control which makes cabling easier and makes it possible to make the control without a PLC or other controllers. This feature has both benefits and challenges, and the list below shows the most important ones.

Direct valve control

Pros

- Simple cabling
- No need for a PLC
- Reduced installation cost

Cons

- No feedback from valve
- No remote control - all must be done directly from the sensor only.
- Limited control features
- Only available from HB products
- Controller location can be difficult to access.

Valve control from PLC

Pros

- Standard PLC programming
- Remote access to valve control available
- Independent of transmitter type

Cons

- PLC and programming required.
- Cabling is more complicated.
- Cost of PLC or separate controller

Our recommendation

The direct valve control can be attractive for smaller systems where simplicity is valued high and where no PLC is installed. If the sensor is installed in a cold room or if you like to have remote access to the control system, it will typically be better to use a PLC or separate controller for the valve.

How to use the vapor quality sensor with direct valve control.

The sensor has a cable which is connected to the valve. The sensor also has a measurement output on pin4. These two outputs are different as the valve output is an opening or closing signal for the valve depending on the setpoint.

The built-in controller is a standard PI controller based on a fixed setpoint called “degree of dryness ”X” ” or a dynamic setpoint called remote set point.

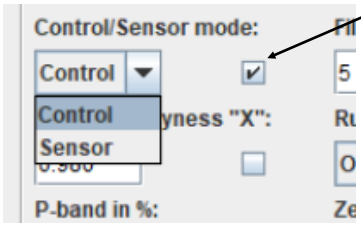
The controller can be turned on and off remotely by setting a run-in signal. You can also have the controller running continuously by setting the run-in signal to of in the parameter setting

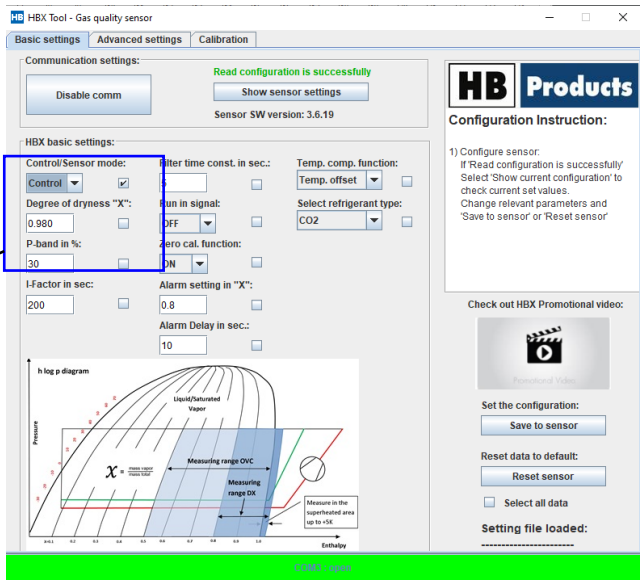
Setup — sensor or control

To get the sensor into control mode select control

- As sensor input to a PLC, computer or other device that uses the sensor signal
- A direct controller of an electrically controlled expansion or liquid valve version with a cable output that can be set up as a controller

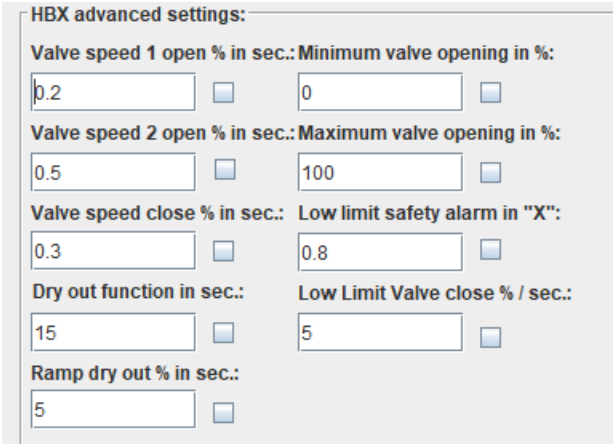
Select Control/Sensor to select the mode





Controller setup

The control is specified by the P and I parameters but also limited by maximum values shown below for the opening speed of the valve. This means that if you set the valve limitations too low the controller will not be able to provide the correct control.



How does the expansion valve control loop work for DX operation

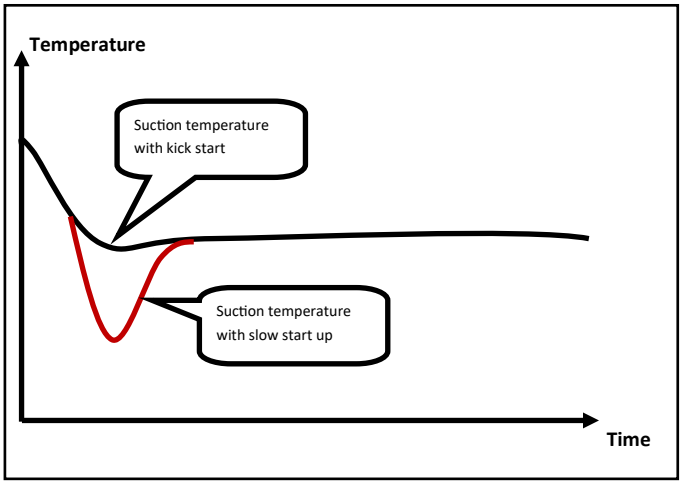
From stop to start

To start the process you need to activate the run in signal by applying 5-24 V on pin 5 when you remove the voltage the system will stop. If this signal is not set the automatic dry-out is not enabled. The run in signal should be applied when the compressor starts to benefit from the start up process with a dry out period.

Dry out period and kickstart period

The controller will open the expansion valve to dry out the sensor and start the process. This function is only active if the sensor basic setting "run in signal" is set to "ON" The idea behind the dry out and kickstart function is to ensure a rapid start up to avoid compressor cut out due to low pressure and avoid very low evaporator temperatures. The process can be started by a fast opening of the expansion valve to generate a high gas flow from the evaporator through the sensor and removing potential liquid refrigerant and oil. The opening of the expansion valve also prevents the system from shutting down due to low suction pressure.

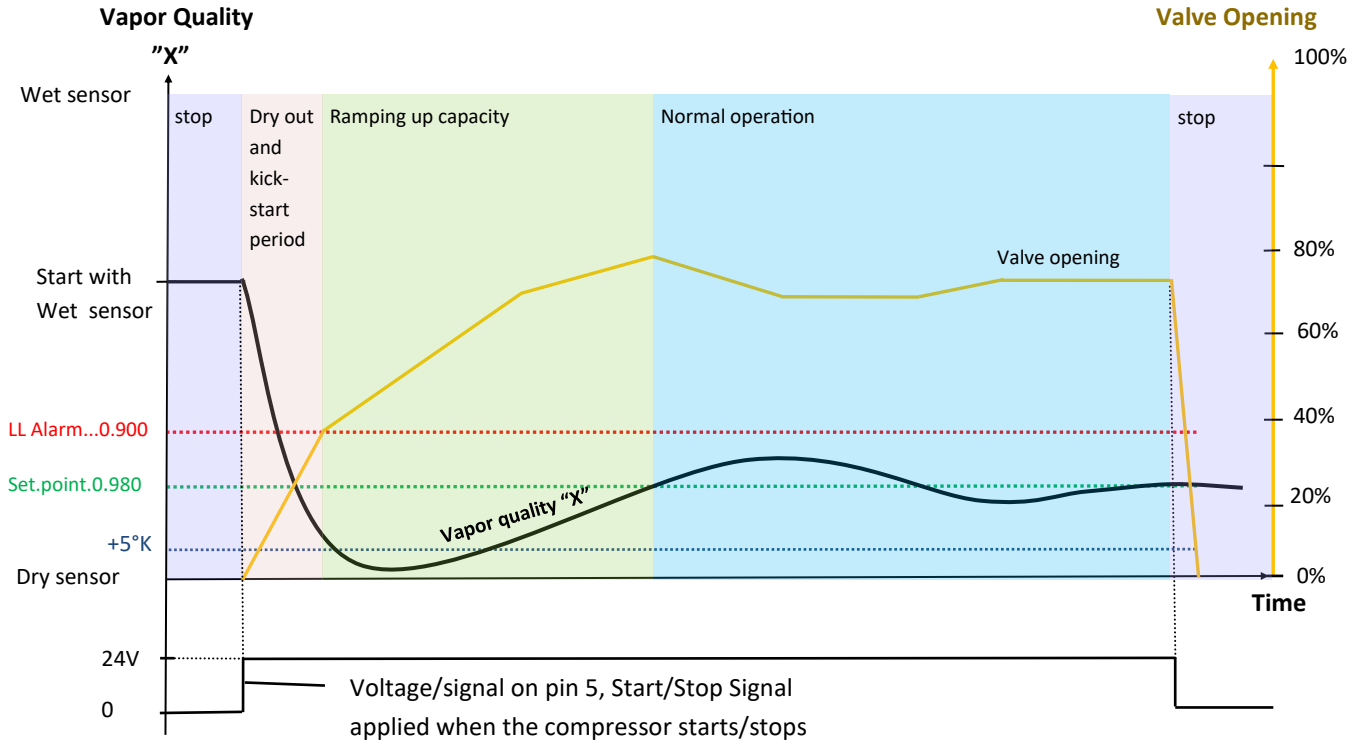
When a plate heat exchanger is used we recommend to kickstart process to avoid freezing. Without kickstarting the very low suction pressure might result in local freezing on the secondary side and damage the heat exchanger.



The dry out run for a period specified in the parameter: "Dry out function in sec" and is ramped up with the speed set in the parameter: "Ramp dry out % in sec". When the dry out is done, ramp up to normal operation will begin. If the system usually is dry after a stop or defrost, the period can also be used as a kickstart period. This is typically needed in small system and especially in heat pumps where the compressor has a tendency to drop out due to low suction pressure. Here you can try to increase the opening until it works. Note you might hit the low level alarm limit.

Ramping up capacity

The system will start slowly due to a PI controller which will ramp up the capacity depending on the settings. The "P-band in %" specify the target for the expansion valve opening and the "I-factor in sec" specify how long time it takes to reach the target.



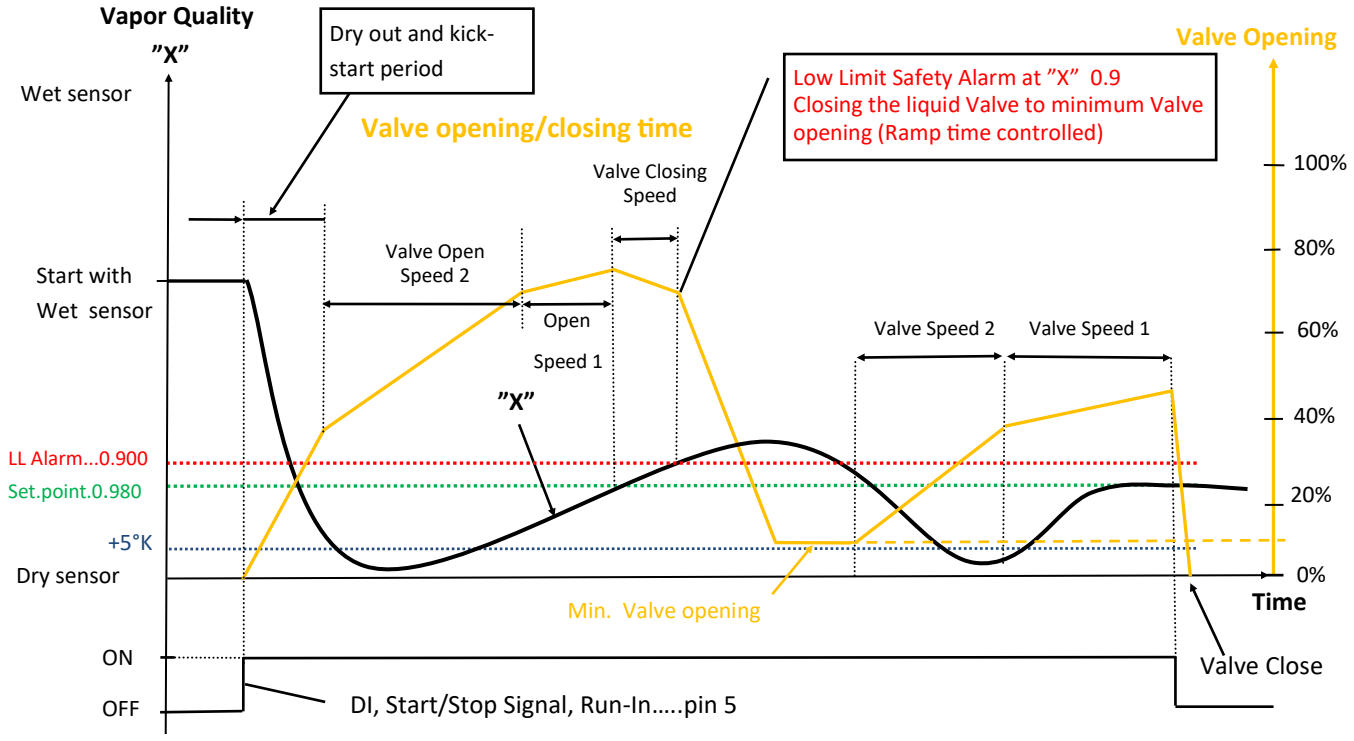
What then happens is that the controller starts opening the expansion valve at "valve speed 2 open % in sec" which means more and more liquid is sent to the evaporator. After a period the maximum capacity is reached and the HBX sensor begins to detect liquid and the opening of the expansion valve is reduced to "valve speed 1 open % in sec". At this point the X value passes 1, where X value is a measure for the vapor quality where X=0 is all liquid and X=1 is dry gas.
With the reduced valve opening speed the capacity will still increase until the setpoint "Degree of dryness "X" " is reached. After this point the controller will open and close the valve to maintain a stable "X "value.

Normal operation and stopping

The normal operation will continue until the system is stopped by removing the voltage on pin 5 for defrost or a regular stop. After stop, the process will restart with a new dry out period, which is important for a smooth operation.

What happens when the process is disturbed

If something happens with the complete system which results in liquid in the evaporator outlet there is a build in safety system that protects the compressor. If the sensor measures a "X" value lower than the "low limit safety alarm in "X"" the valve will be closed rapidly until setpoint "Degree of dryness "X" " is reached again. The speed can be adjusted in the parameter: "Low Limit Valve close %/sec" and is as default set very high for safety reasons—it might lead to unstable operation. If the system has an accumulator before the compressor the "Low Limit Valve close%/sec" can be set to a lower value e.g. 0.8 instead of the default 0.9 to avoid instability. The figure below shows what happens when the low limit safety alarm is hit.



To make sure the compressor is not shut down due to too low suction pressure there is a parameter: "Minimum valve opening in %" in the system. There is also a parameter: "Maximum valve opening in %" which is there to limit the liquid injection if the valve is too large.

How does the control loop work for flooded operation

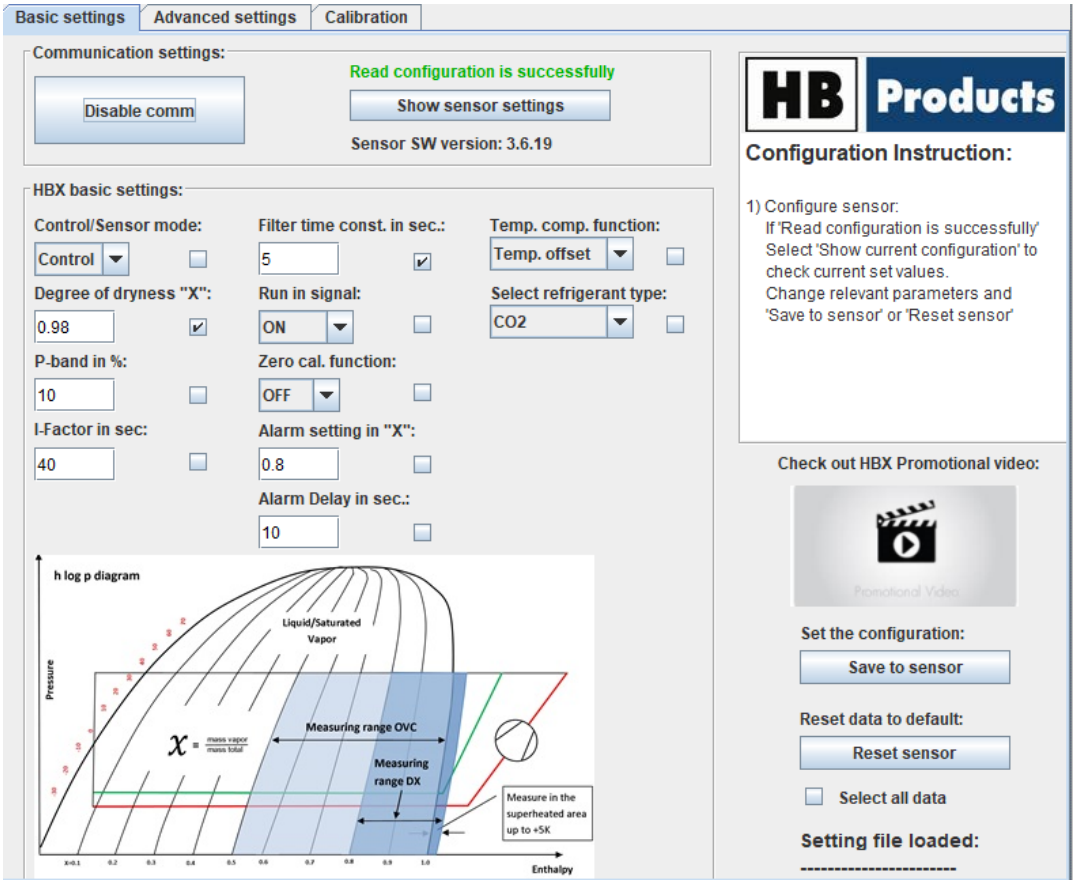
The sensor can control a liquid valve or a circulation pump directly in a similar matter as for an expansion valve in DX operation. The control loop can work with any vapor quality all the way to X=0 (all liquids) if needed.

HB-products support can help you with setting up the system.

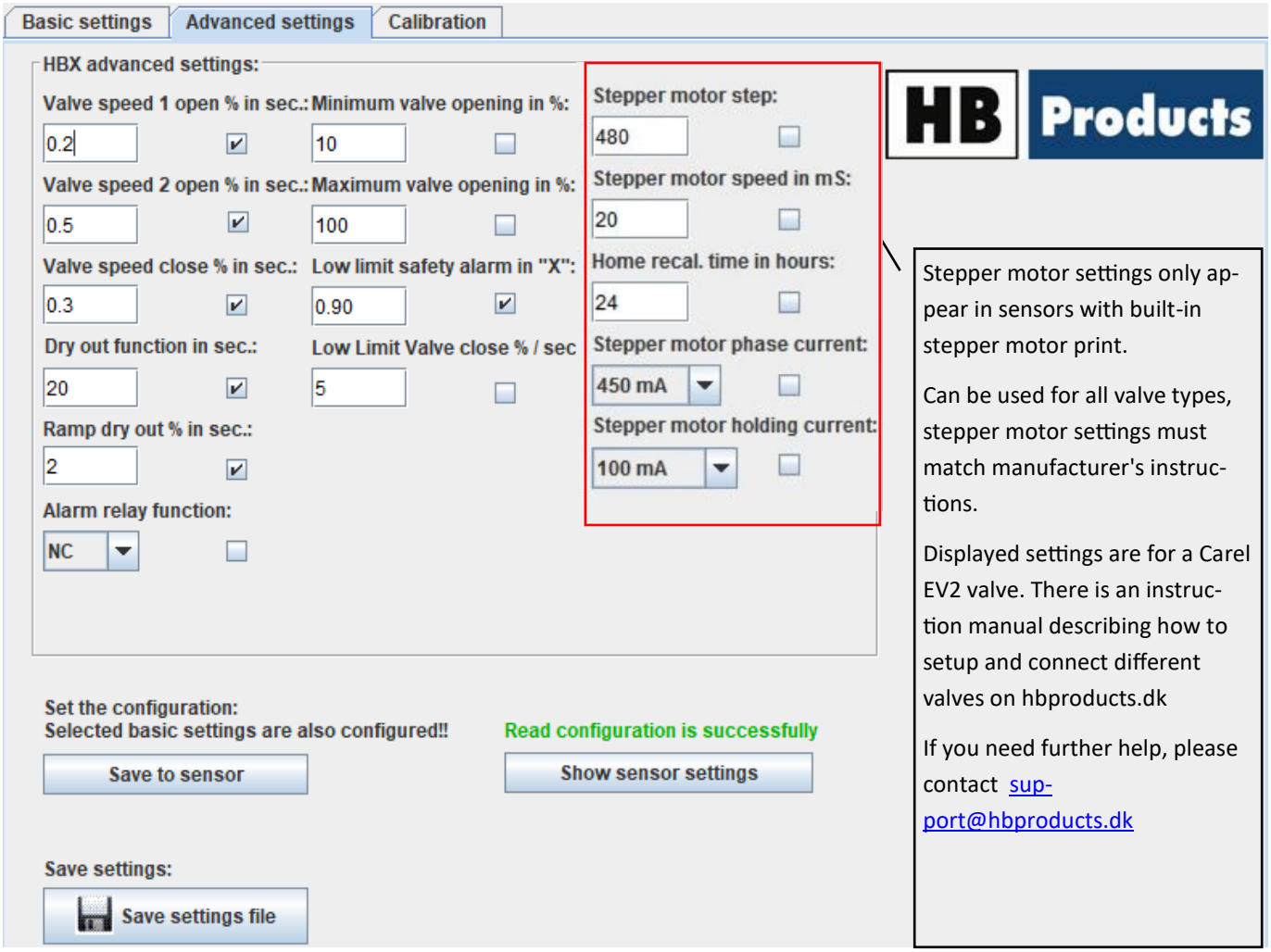
How to setup the sensor as direct controller of an expansion valve.

Typical values for **DX operation**

1. Set the desired degree of dryness, ”X” value. For DX operation a good starting point would be 0.98 the closer to 1 you go the dryer the gas will be. The X value is the Vol% of liquid
2. Set the P-band to 10% as a starting point. If the value is set higher the valve will react slower
3. Set the I-factor to 40 sec as a starting point. This means the system will ramp up over a period of 40 seconds. If the I value is set higher the system will be very slow
4. Set filter time to 5 seconds. The filter time is the period of time over which the X measurement is averaged over. Increased filter time smoothens the measurement, but the risk is that the system becomes too slow.
5. Run in signal (digital input pin 5) is used as external start and stop signal when set to ”ON”. This is important. If set to “OFF” the dry-out will not work and there is a risk that the control system will not really start up because the sensor is wet to begin with.
6. Zero cal. function: Choose ”ON” if you want to use the push button ”R” for zero calibration. Default is “OFF”
7. The “Alarm setting in “X” “ is 0.8 as default, and the “Alarm delay in seconds” is as default 10 sec. The alarm is normally only used when the sensor act as leakage control or as compressor protection—se special section
8. If the sensor has a temperature sensor it has to be mounted according to the installation guide and the “Temp. comp. function” should be set to “Temp. offset” This activates the temperature compensation and gets a more accurate “X” measurement
9. “Select refrigerant type” is for information only and should **not** be used for changing refrigerant as it does not change the important settings, and the sensor will not provide the correct measurements. If your refrigerant is not correct you need a complete settings file - please contact HB-products for this.
10. After changing settings push the button ”Save to sensor” (the message ”OK” on the screen indicates that the settings are saved)
11. Go to next page: Advanced settings



Advanced settings for sensor as direct controller of an expansion valve.



1. Valve speed 1 opening time in sec., Default is 0.2 sec. and a good starting point
2. Valve speed 2 opening time in sec. Used for fast opening during start-up , Default is 0.5sec.
3. Valve speed closing time in sec., default is 0.3 sec. and a good starting point
4. Dry out time function in sec., This function opens the expansion valve to dry-out the sensor after a stop or defrost, and is essential for a good starting process. Default is 20 sec. and a good starting point
5. Ramp dry-out %, degree of valve opening in % per second (safe function to minimize hydraulic shock) 2 % is a good starting point. The function can also be used a kickstart function if the compressor tends to stop due to low pressure. This function is typically needed for smaller heat pumps.
6. Alarm output, NO (normally open) or NC (normally closed) , default is "NC" (Fail safe function) This setting is linked to the alarm on the previous page and is normally only used when the sensor act as leakage control or as compressor protection—se special section
7. Minimum valve opening in % (ensures against stops due to low suction pressure) 10 % is a good starting point
8. Maximum valve opening in %, normally set to 100% but a lower number is used for oversized valves
9. Low limit safety alarm in "X" value, default value is 0.9 This is a safety function which closes the expansion valve rapidly to minimum opening in order to protect the compressor. 0.9 or 0.85 are a good starting points for DX. Choose 0.85 if you have a system with large capacity variations. For flooded operation the setpoint have to be 10% lower than the "degree of dryness, "X"
10. Low limit valve close time in sec., default value is 5% per second used for fast closing when the sensor getting wet, 5% is a good starting point
11. After Changing settings push the button "Save to sensor" (a message "OK" on the screen indicates that the settings are saved)
12. Check all settings by push the button "Show sensor settings"
13. Save settings file is used to save all the settings as a txt file
14. Load settings file is used to set up all parameters from an existing .hbp file (copy data to a new sensor)The content can be read in a text program like MS word+

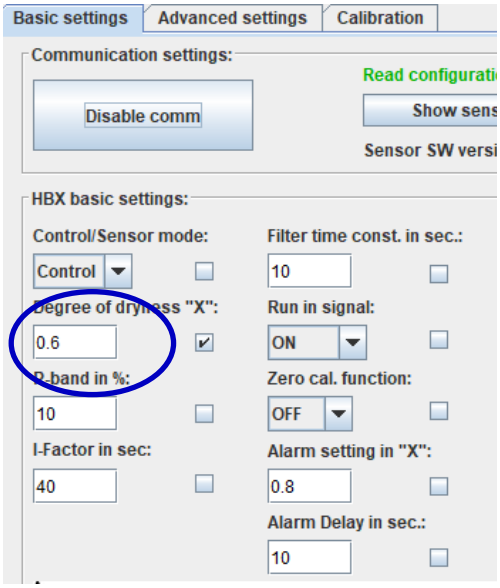
Controlling a flooded or semi flooded evaporator

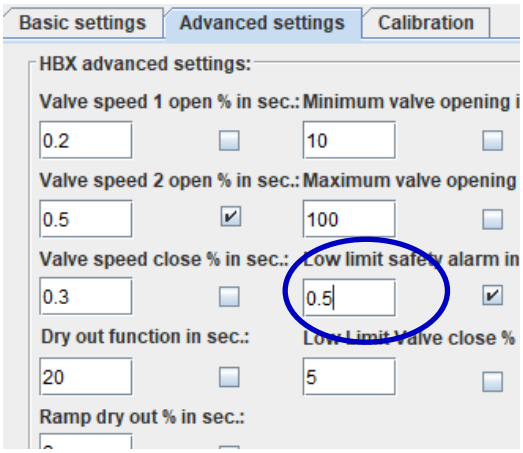
The sensor can be used direct control of a liquid valve in an overfeed system. The settings are similar to the DX system but a few settings have to be different .

The degree of dryness “X” have to be lower and the rule of thumb is that the CR (circulation ratio) is CR=1/”X” so if you aim for CR = 2 put in 1/2 = 0.5 as The degree of dryness “X”

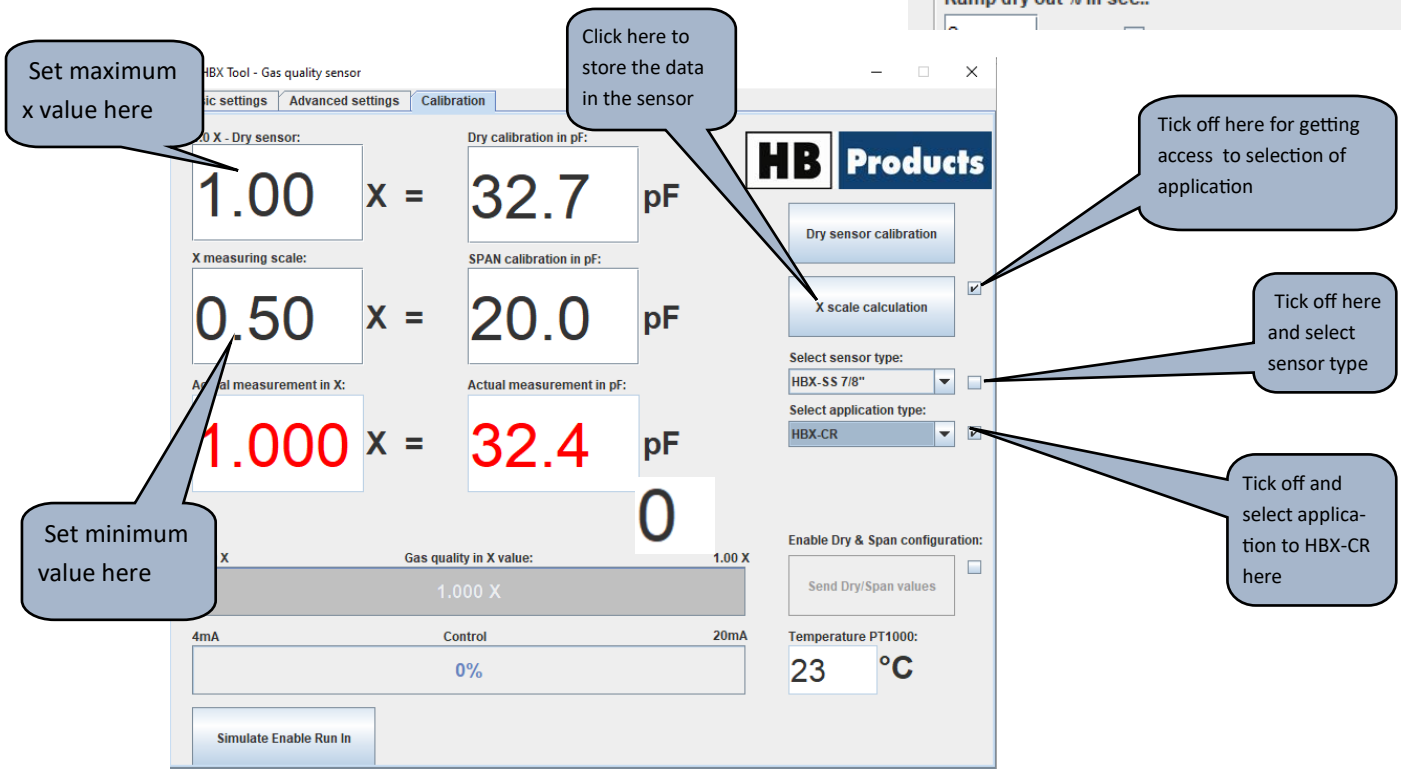
The remaining parameters in basic settings can be the same as for DX

For the advanced settings, the “Low limit safety alarm in “X” har to be set approx. 10 % lower than the “degree of dryness “X” . An example: for a value “degree of dryness “X” = 0.6 you choose around 0.54. If you have a system with large variations in load you need a large gap between the two values than if you have a very stabile system. If the “Low limit safety alarm in “X” is too close to the “degree of dryness “X” there is a risk that the system becomes unstable because you hit the limit and the liquid valve will close rapidly.



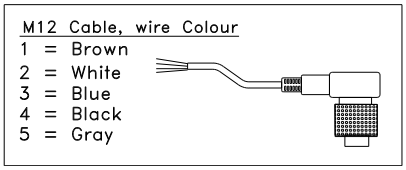


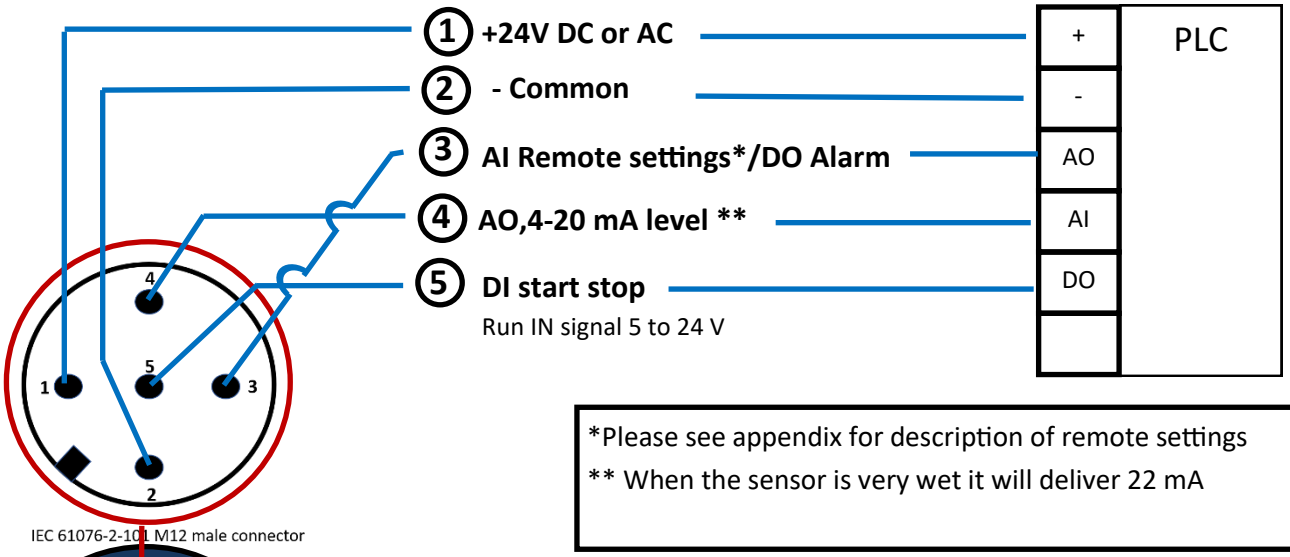
Under the calibration tab, the sensor has to be set to flooded operation called “HBX-CR” which is normally done at delivery. If this is not done or the sensor has to be used for another purpose it can be changed here. You start by ticking off the three small boxes to the right. Then the large input boxes come to live and you can change the application to “HBX-CR” for flooded operations and set the sensor type if wrong. At the same time you can change the operation range from minimum in the box called “X measuring scale” to maximum called “Dry sensor”. When you are done changing the parameters, you store them in the sensor by clicking on “X scale calculation”.



Connection diagram for HBX/S (stepper motor) with temperature compensation — here shown with Carel E2V

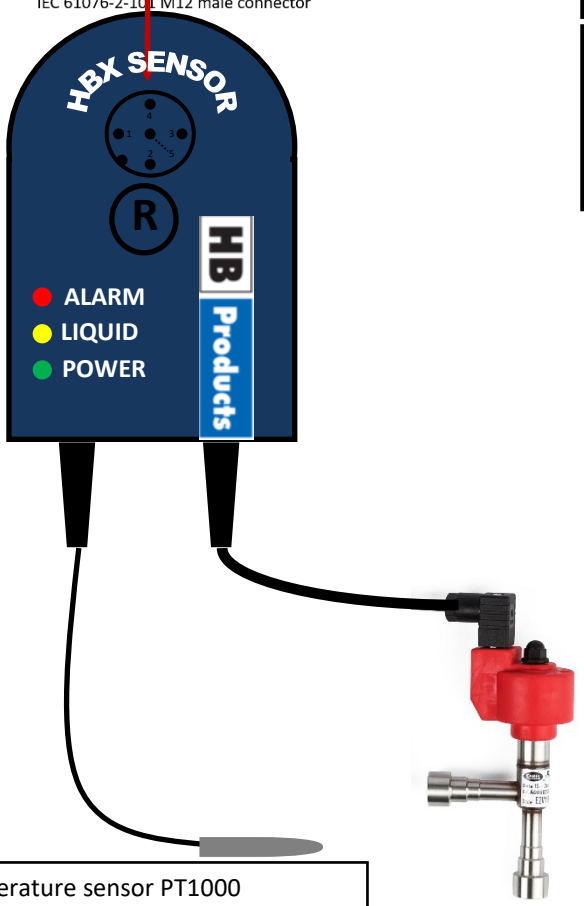
M12 Cable, wire Colour
1 = Brown
2 = White
3 = Blue
4 = Black
5 = Gray

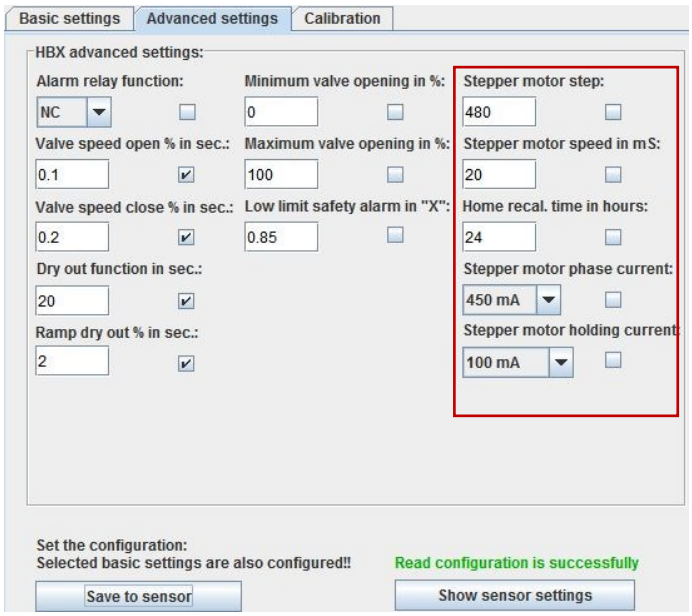




*Please see appendix for description of remote settings
** When the sensor is very wet it will deliver 22 mA

- Under ”advanced settings” the stepper motor settings for the valve should be specified
- Analog output see page 19

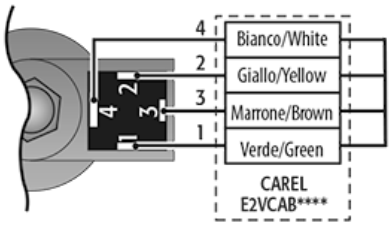




Temperature sensor PT1000

Should be mounted on the outside of the tube in position 3 or 9 o´clock with cable ties

Color coding
A+ = yellow(2)
A- = white (4)
B- = green (1)
B+= brown (3)



Connection diagram for HBX/C motor valve— here shown with Siemens MVS661

- = White common

+ = Brown Supply

AO = Gray , 4-20 mA

MVS661 motor valve

G0	-common
G	+ supply
Y	mA input
M	
U	mAoutput position
ZC	Open/Close valve

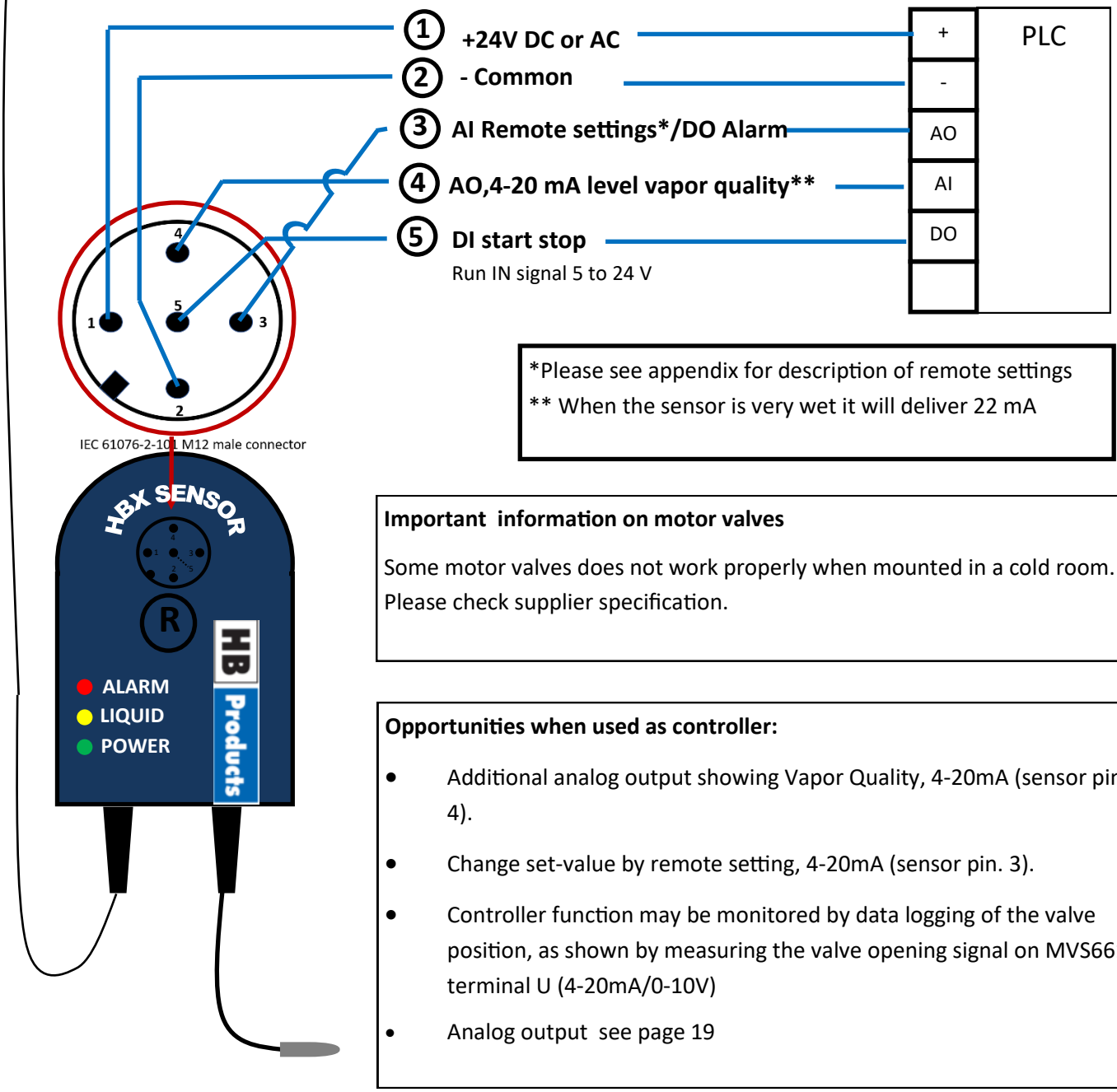
Close

Open

Manual open/close

Motor valve: 4-20 mA 24 V DC, max 24 W

3 wire connection



*Please see appendix for description of remote settings

** When the sensor is very wet it will deliver 22 mA

Important information on motor valves

Some motor valves does not work properly when mounted in a cold room. Please check supplier specification.

Opportunities when used as controller:

- Additional analog output showing Vapor Quality, 4-20mA (sensor pin. 4).
- Change set-value by remote setting, 4-20mA (sensor pin. 3).
- Controller function may be monitored by data logging of the valve position, as shown by measuring the valve opening signal on MVS661 terminal U (4-20mA/0-10V)
- Analog output see page 19

Connection diagram for HBX/PWM— pulse modulating expansion valves

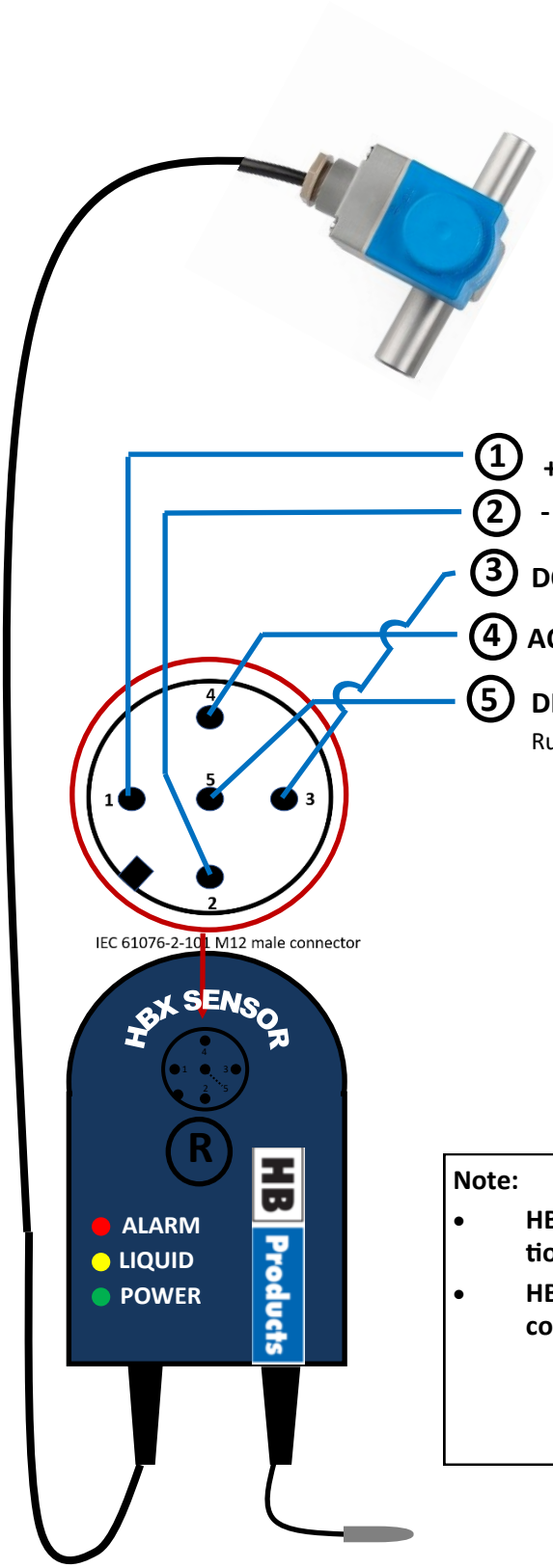
Danfoss AKV/AKVA and Hansen PXV/PXVW

Wiring using cable

Brown: + when using DC

White: - common when using DC

The cable can supply AC as well



1 **+24V DC or AC**

2 **- Common**

3 **DO—PWM +24V DC***

4 **AO, 4-20 mA level vapor quality****

5 **DI start stop**

Run IN signal 5 to 24 V

PLC
+
-
DI
AI
DO

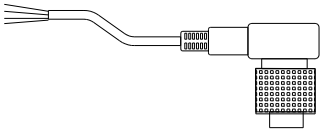
IEC 61076-2-101 M12 male connector

* Pin 3 can be used for DO alarm signal when cable is used

** When the sensor is very wet it will deliver 22 mA

M12 Cable, wire Colour

1 = Brown
2 = White
3 = Blue
4 = Black
5 = Gray



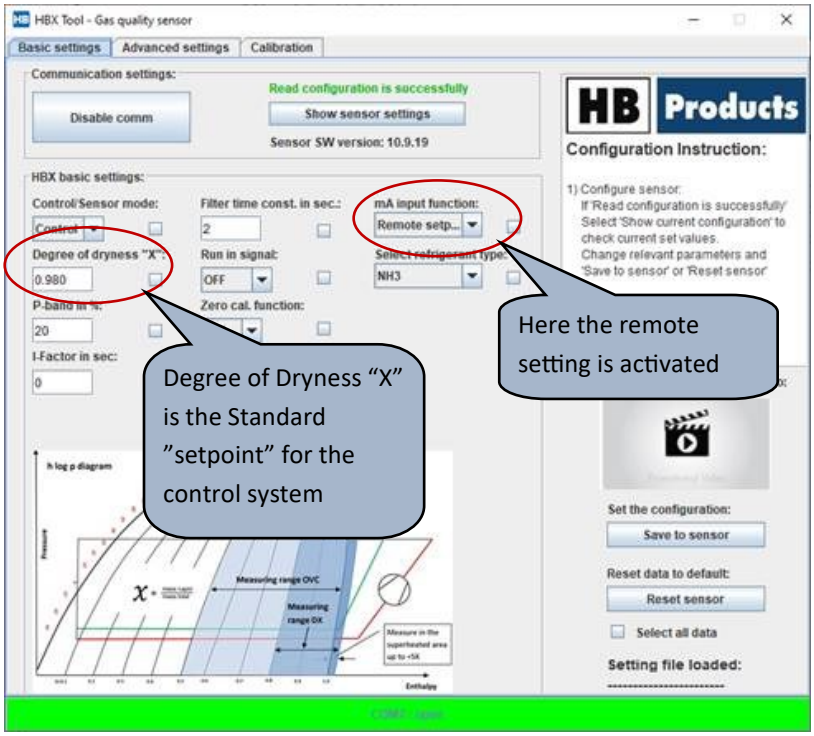
Note:

- **HBX-DX/C-R-3-X/PWM, with valve cable for easy electrical connection.**
- **HBX-DX-R-3-X/PWM, without valve cable, then the PWM output is connected to PIN3 (blue colour).**

Remote setting (Only special versions of the sensor)

For special versions of the sensor controlling an expansion valve or a liquid valve there is a possibility to change the "degree of dryness X" dynamically from a PLC. This is done by using a function called remote setting and it is activated by selecting "Remote setpoint" in the field called "mA input function" This field is only visible for sensors with this function.

The remote setting works with a signal 4 to 20 mA applied on pin 3 in the M12 connector. When less than 4 mA is applied the prespecified "degree of dryness "X" is used



Remote setting is used when there is a need to change the desired set-point during operation.

During part load, it may be advantageous to reduce the refrigerant charge in order to get the system in better balance with higher energy efficiency and safe operation.

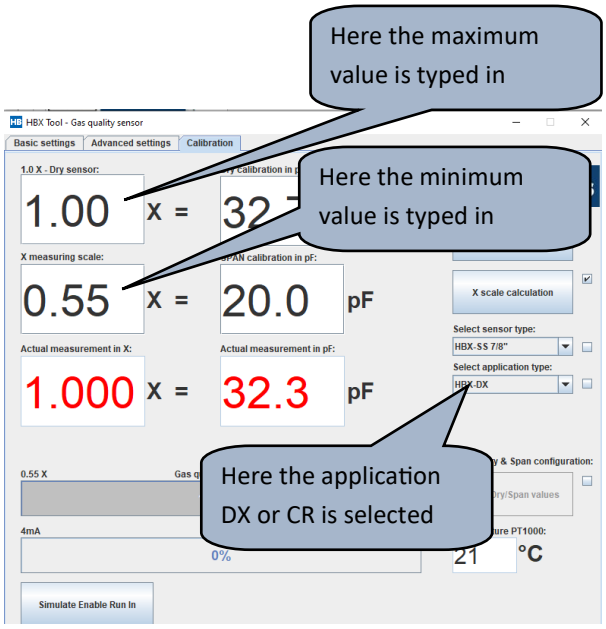
DX operation

In DX operation there is a fixed linear scaling between the current applied on pin 3 and "degree of dryness "X"" according to this table.

Degree of dryness "X"	1.00	0.99	0.98	0.97	0.96	0.95
mA value	4.00	7.20	10.40	13.60	16.80	20.00

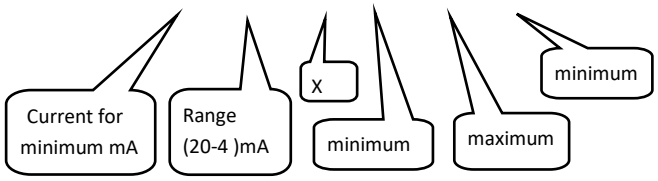
Flooded and CR operation

Here it is possible to move the setpoint "degree of dryness "X"" all the way down to 0 equal to liquid only.
Start by selecting application to CR.
You key in the minimum in the field called "X measuring scale" and the maximum in "Dry sensor". Minimum is equal to 20 mA and 4 mA is equal to maximum.



An Example:
If you set the minimum to 0.55 and like to reach a set point "degree of dryness "X"" of 0.8 you need to apply

Remote signal: 20 — 16* (0.8-0.55) / (1-0.55) =7,5 mA



The LED indications on sensor head

The electronic element has build in LED's red, yellow and green and they will light up depending of the conditions and can be used for diagnostics. The table shows the different indications:

LED light	Appearance	Functionality
Green	ON	The HBX sensor is on. It gives analog feedback to the PLC, but it is not controlling the expansions valve (the valve is turned off)
	Flashing	The sensor is on. It gives analog feedback to the PLC, and contros the expansion valve (The sensor receives a Run-in signal (Digital input))
	OFF	The sensor is not receiving power
Green and Red	Flashing Individually	There is no connection between mechanical- and electrical part
Yellow	Flashing	The flashing sequence indicates if the valve is opening or closing: Long time between flashes= The valve is barely open Short time between flashes = The valve is "much" open
Red	ON	The ammonia is too wet
	Flashing (one pr. sec)	The sensor detects a lot of liquid. The sensor will give 22-24mA
	Flashing (two pr. sec.)	The sensor is connected with USB-cable
Red and Yellow	Flashing at the same time (two pr. sec.)	The splitter box is connected
Red, yellow and green	Red Flashing (two pr. sec.) Yellow flashing (one pr. sec) Green constant on	The sensor is connected with USB-cable

Use of the sensor with other refrigerants

The sensor must be ordered for a specific refrigerant. It is possible to change the sensor to work with another refrigerant, but a full package of new settings have to be uploaded. HB products has the setting files for most refrigerants and you can get them on request. The refrigerant the sensor is specified for can be found under the basic settings tab. Please note that the list of refrigerants is not complete and the sensor might be specified for instance for CO2 and can be used for R290 as an example.

Contact HBproducts support if you need more information

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