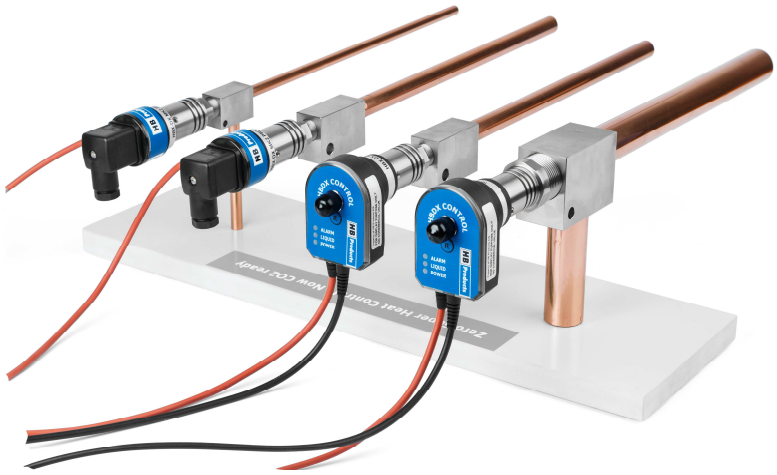
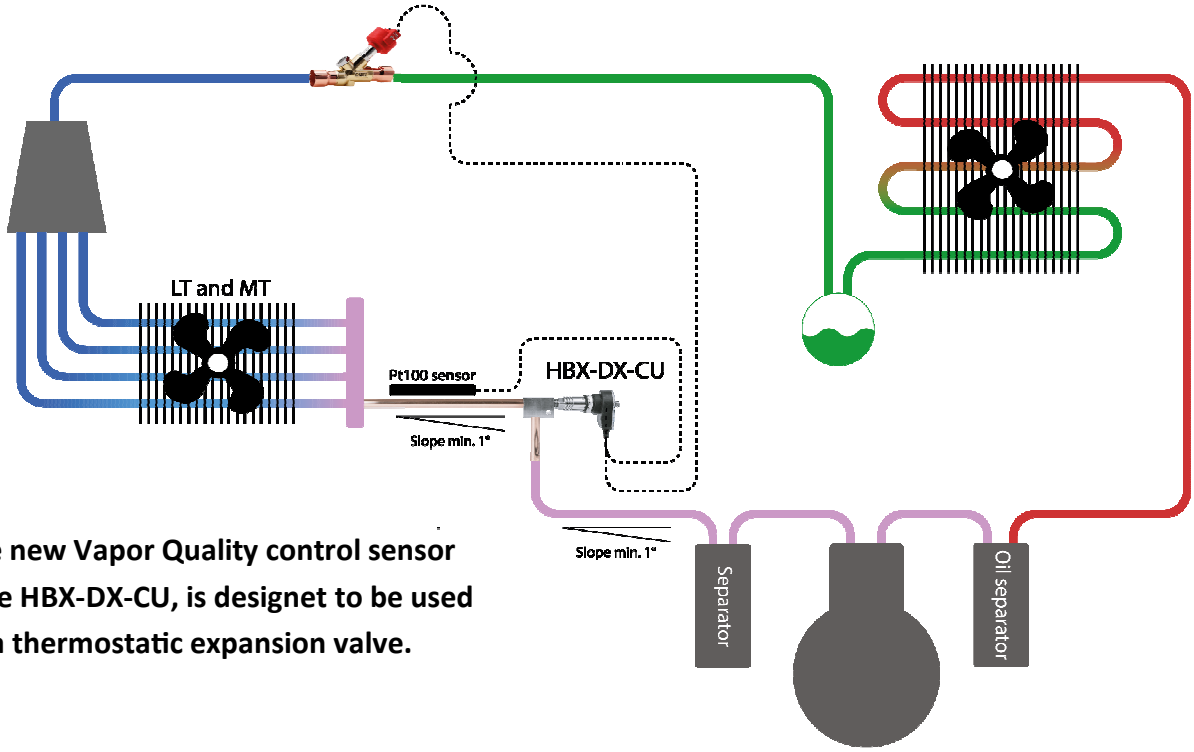
Zero Superheat Control Guide HBX-DX-CU

New Sensor Technologies Control phase of Refrigerant

Optimizing all types of Refrigeration Systems

Works with CO_2, Propane and HFC/HFO refrigerant





The new Vapor Quality control sensor type HBX-DX-CU, is designet to be used as a thermostatic expansion valve.

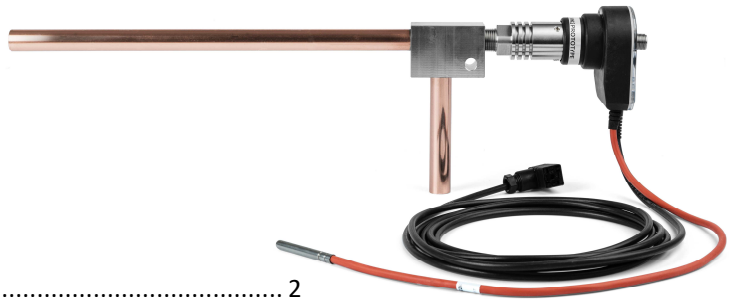
Low GWP Technologies

Patent No.:
US 9,587,866 B2
EU P18502PCDK
PA 2018 70481

HB Products WE INCREASE UPTIME, SAFETY AND EFFICIENCY

HBX-DX-CU sensor guide

FLOW DIRECTION →



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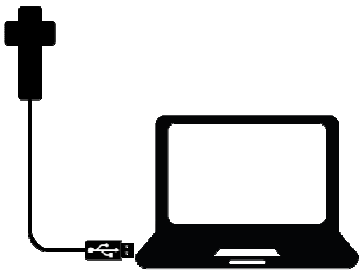


1. Download and install the HB-Tool software on the computer: https://www.hbproducts.dk/en/software1/hb-tool.html
2. Connect the HB USB/M12 cable to a PC USB port.

Note:

By connecting the HB sensor to the USB HB-Tool it will automatically read the sensor type and show the corresponding software version.

Introduction:

HBX-DX Vapor Quality Sensor/Control is a new sensor solution for optimizing Evaporator Control to Zero Superheat. The ”X”-sensor measures the phase of refrigerant and Vapor Quality as degree of dryness. The electronical part is fully separated from the sensor´s mechanical part and can be replaced without interference with the pressure side. The sensor is installed in the outlet of the evaporator, as part of the suction line. The soldering connections, fittings and pipes are all made of high pressure copper type K65 in CU-version and in stainless steel for SS-version. Setting for commonly used refrigerant types, CO2, Hydrocarbons, HFO’s and HFC’s is possible.

Measuring range: DX ”X” 0.85 to 1.0.

The HBX-DX-CU sensor is available in several versions, with and without cable for direct connection to an expansion valve. Type of expansion valve: stepper motor, PWM pulse modulating AKVA/AKV valves and modulating 4-20mA controlled expansion valve.

Safety Instructions

CAUTION! Read this setup guide before installing and using the HBX-DX Sensor.
Installation of HBX-DX must be carried out by a trained professional with in-depth knowledge of both refrigeration and electronics. Improper installation and use of the HBX-DX Sensor may result in damage to material and/or people. The installation and use of the HBX-DX Sensor must be done according to local regulation.

Altering type-approved equipment voids the type approval. The product's input and output, as well as its accessories, may only be connected as described in this guide. HB Products assumes no liability for damages resulting from failing to follow the instructions in this setup guide.

	CAUTION! This symbol refers to a possible limitation of functionality or risk in usage. NOTE! Contains important additional information about the product and provides further advice.

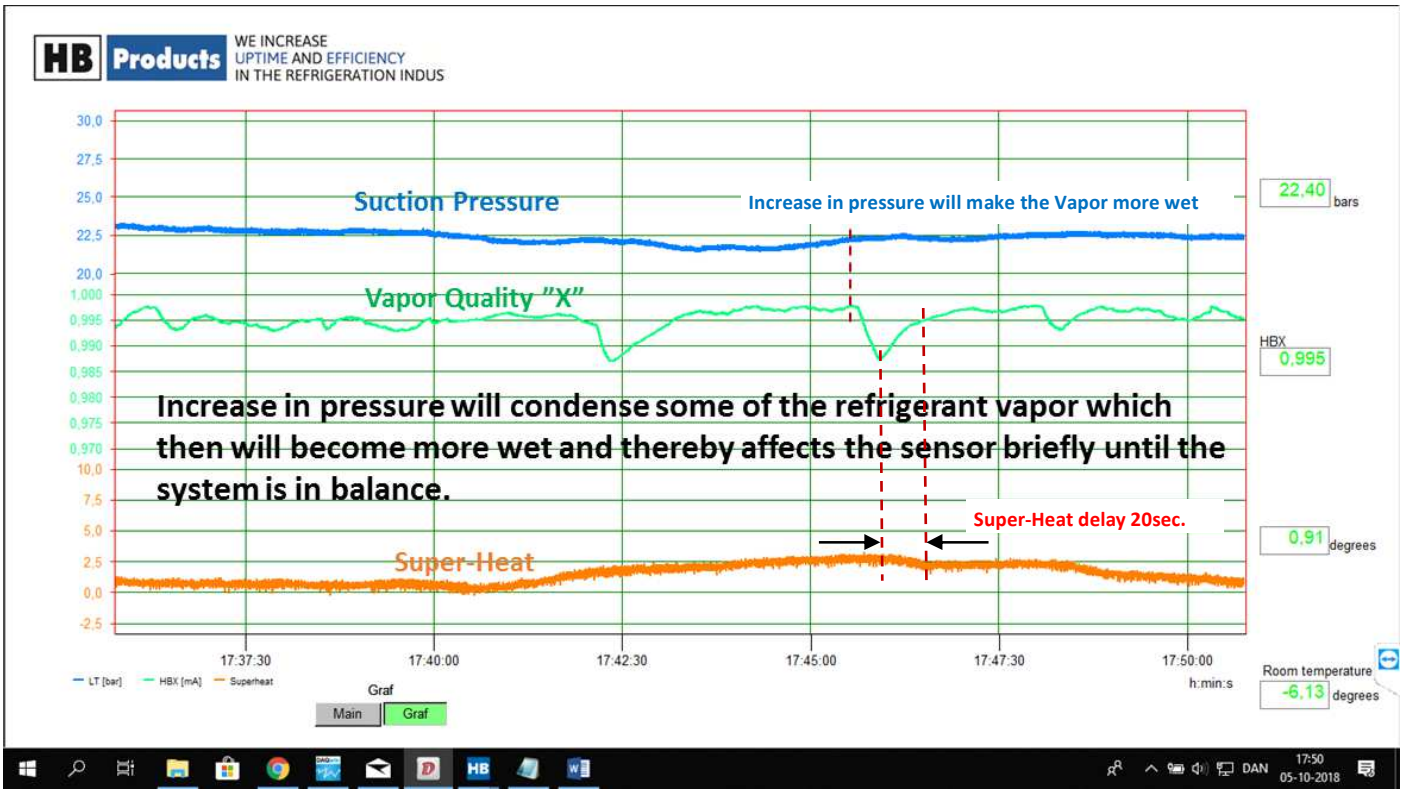
Intended use. The purpose of the HBX-DX sensor is refrigerant measurement and control.
If the HBX is to be used in a different way, prior, written consent must be obtained from HB Products.

Repair: Any repair must be carried out by a trained professional.

Disposal instructions: The HBX-DX is designed for long life operation. If or when it becomes necessary to dispose of the sensor it must be done according to local regulation.

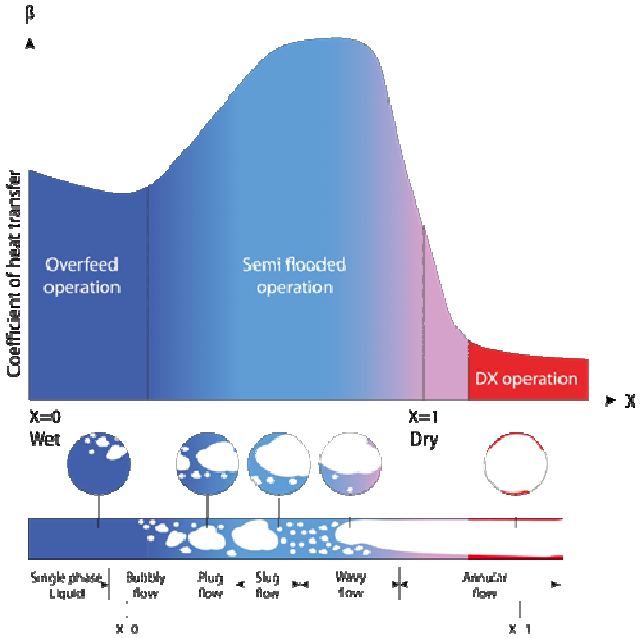
CAUTION! Factory settings do not guarantee safe operation since the configuration parameters depend on the system design

The graph shows a test where the evaporator control is Controlled according to the dryness of the vapor.



Fact:
In the case of small pressure changes (blue), it´s seen on the graph of the dryness(green) that change in the suction pressure immediately affects the degree of dryness, whereby it is possible to regulate the evaporator more precisely to the limit where the vapors become wet(minimum Super-Heat(orange)).

To avoid unintended pressure variation is important that capacity regulation is stepless by using frequency converter where the control is performed with a soft gradient ramp.



The major benefit of semi flooded operation is the improvement of the heat transfer coefficient .

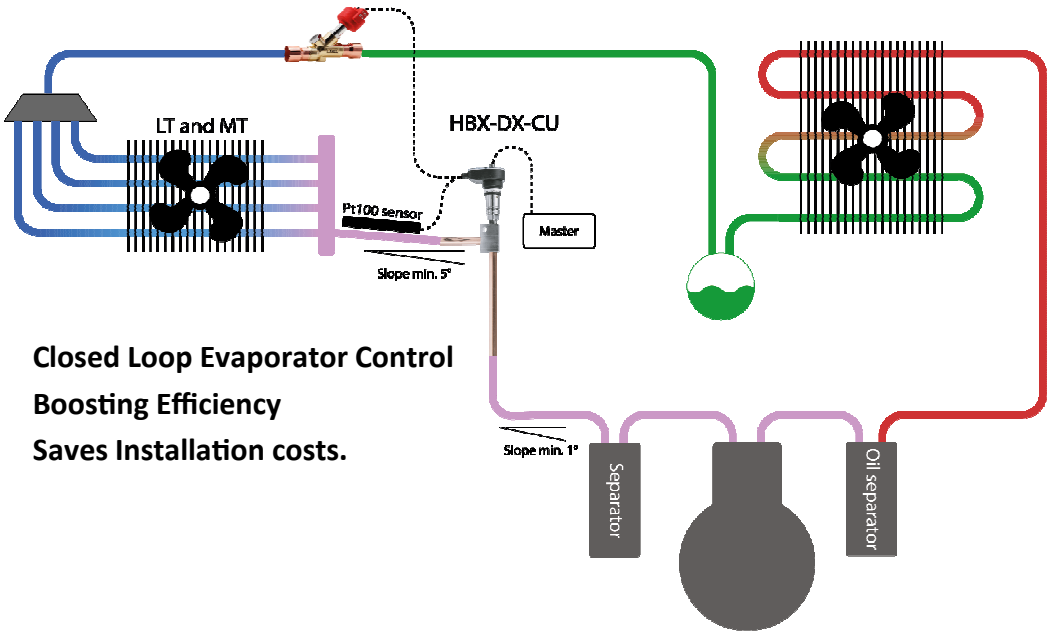
Dry expansion systems, here a part of the heat exchanger area is used to secure dry vapor, further tube length/area is add to obtain Super-heating of the vapor, in this area the heat transfer is very low.

Thermodynamic Effects:

- Semi Flooded evaporator operation ensures optimum heat transfer at all loads
- Increased evaporation pressure/ temperature
- Lower discharge temperature
- Optimal performance in all climates
- Compressor protection

Semi flooded operation ensure a much more balanced system with minimal variation of pressure and very little superheat from 0,5 to 1,0K. Semi flooded operation ensures maximum efficiency as 98% of the evaporator surface is wet. A controlled wet surface ensures optimum thermodynamic operation with higher heat transfer.

Installing the HBX-DX Sensor



Closed Loop Evaporator Control
Boosting Efficiency
Saves Installation costs.

NOTE: Slope the piping to ensure the liquid can flow freely. This reduces the risk of submerging (drowning) the sensor in oil or condensed liquid.

Flow pattern in two-phase flow varies depending on the evaporator load, type of refrigerant, tube diameter, Vapor Quality, mass flux and flow orientation.

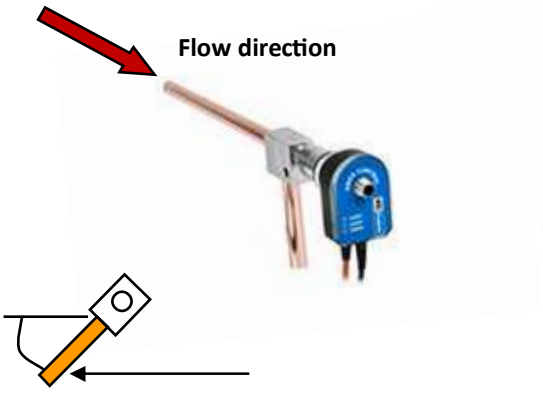
All refrigerant types will usually have a stratified two phase flow pattern in horizontal pipes and in rising pipes annular flow, in part load operation is it often slug or plug flow.

The sensitivity of the sensor depends on several parameters. Most important is that the sensor is installed in a position where it can catch the liquid-droplets at any two-phase flow regime and Vapor/gas velocity. Especially at DX regulation we recommend that the HBX-DX sensor is installed in countercurrent flow direction, with gas velocity range from 5 to 30m/s.

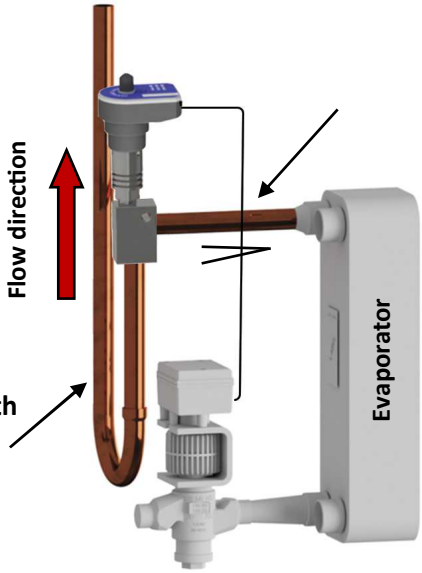
Inline type, we recommend that the sensor is installed in horizontal pipes, alternative downwards. (Sensor in the same size as the suction line).

Counter Flow direction is recommended for DX evaporator Control

Compressor Protection sensors can be installed in any directions, with optimum location in accordance to the liquid and Vapor/flow direction.



Angle minimum 30˚downwards

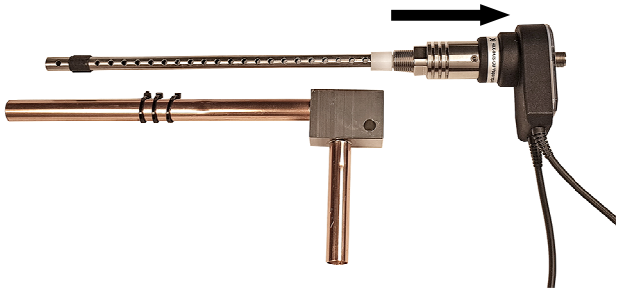


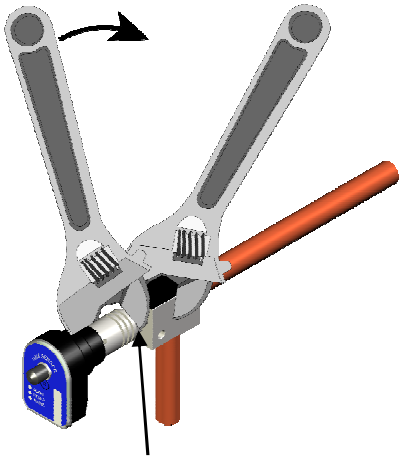
Pipe should be designed with a P-trap/drop-leg to avoid liquid accumulation around the sensor .

Installing the HBX-DX Sensor, *continued*

The sensor is installed in the outlet of the evaporator, as part of the suction line as shown on page 14.
Soldering connection, fittings and pipes are made of stainless steel or high pressure copper type K65.
The sensor part itself must be removed by unscrewing it from the steel block/base part before soldering.

Unsrcew sensor part before soldering.
Use two wrenches as shown below.

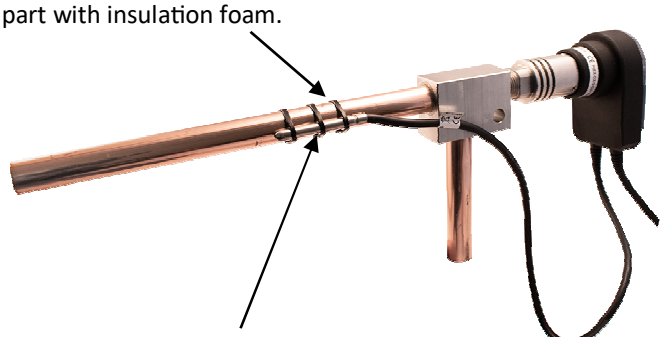




Use two wrenches when installing the HBX-DX-CU Sensor. One to fasten the sensor and one on to stabilize the steel block to avoid stress to the solderings.

Use thread sealant.
We recommend using liquid theread sealant.

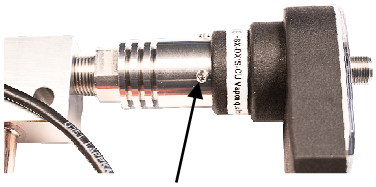
Insulate the entire mecanical sensor part with insulation foam.



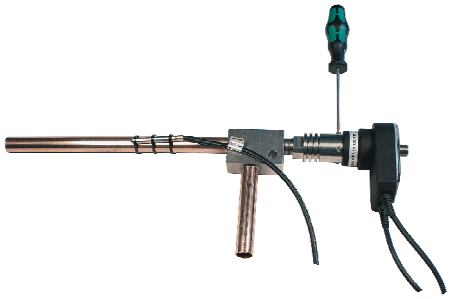
The Temperature compensation sensor should be mounted in position 3 or 9 o'clock with strips as shown.

The build in temperature compensation, automatically compensate the value of the /zero/dry vapor calibration.

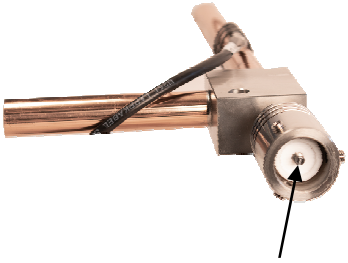
Electronic part is fully separated from the mecanical sensor part and can be replaced without interference with the pressure side.



Unscrew the 3 unbraco screws



End view
Without electronic

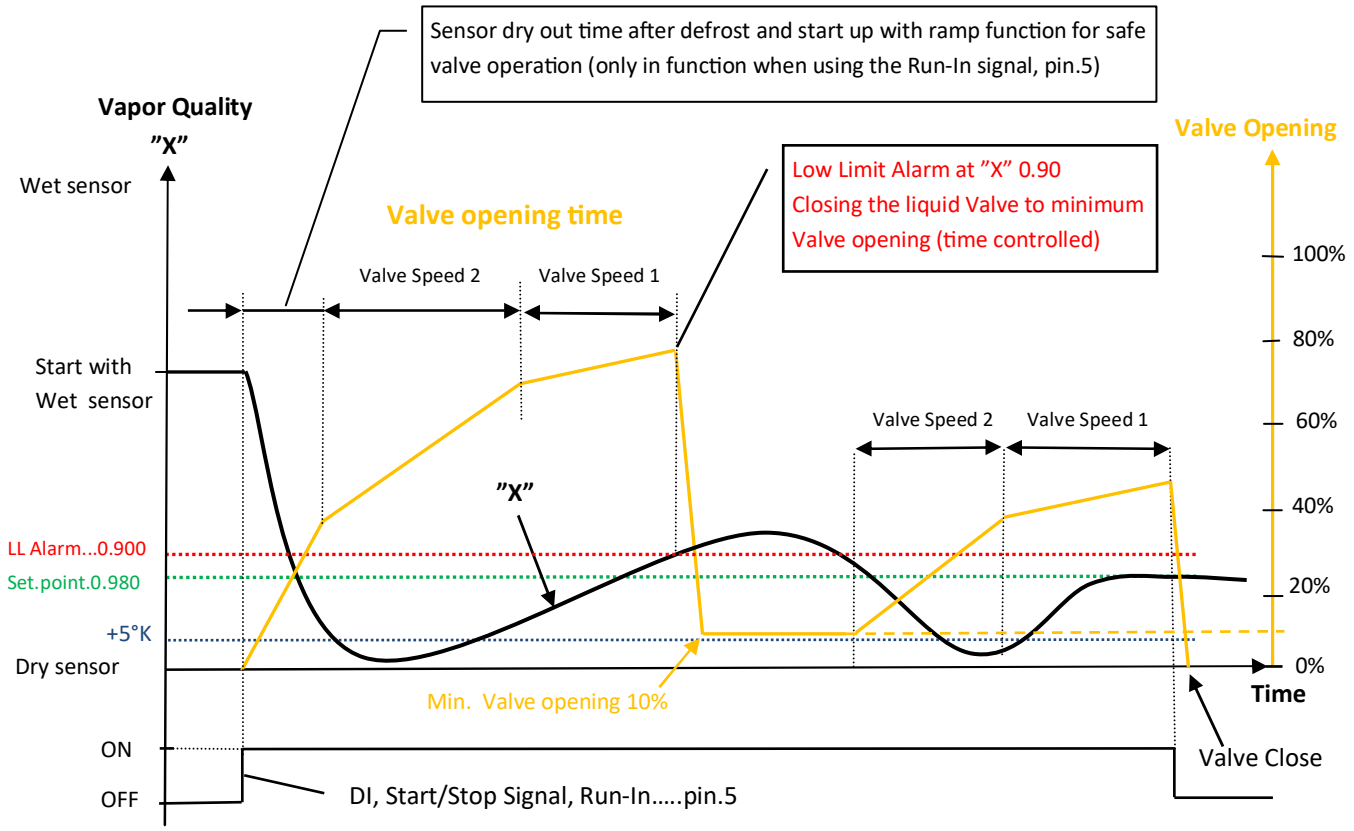


Threaded contact to the electronic sensor head

Remove temperature sensor from the strips.

Unscrew the electronic part from the mecanical sensor.
(8-10 turns counter clockwise, take care Be careful with the integrated cables for temperature and expansion valve)

Advanced Closed loop evaporator control



The sensor has built-in advanced control where it is possible to control all types of evaporators, expansion valve open and close times can be varied fro 0.1 to 10% / sec., Start-up with ramp function and sensor drying ensure secure startup, low limit safety alarm closing the liquid valve to minimum opening.

External start and stop function from a master control system is required when the sensor is used for control.

NOTE:

During start up or after defrost there are liquid droplets on the sensor part from condensated vapor. These droplets will affect the sensor and give a high mA output. Alarm could also be activated if the alarm delay is too short. This phenomenon should be managed during start up. We recommend drying out the sensor during start up by opening the liquid valve for 15 to 30 seconds and adding refrigerant to the evaporator. This will ensure that the vaporized gas will dry the sensor before starting to control from dry sensor (zero signal 4mA +0.5).

Increase of pressure will also condense some of the refrigerant vapor which then will become wetter and thereby affecting the sensor briefly until the system is in balance.

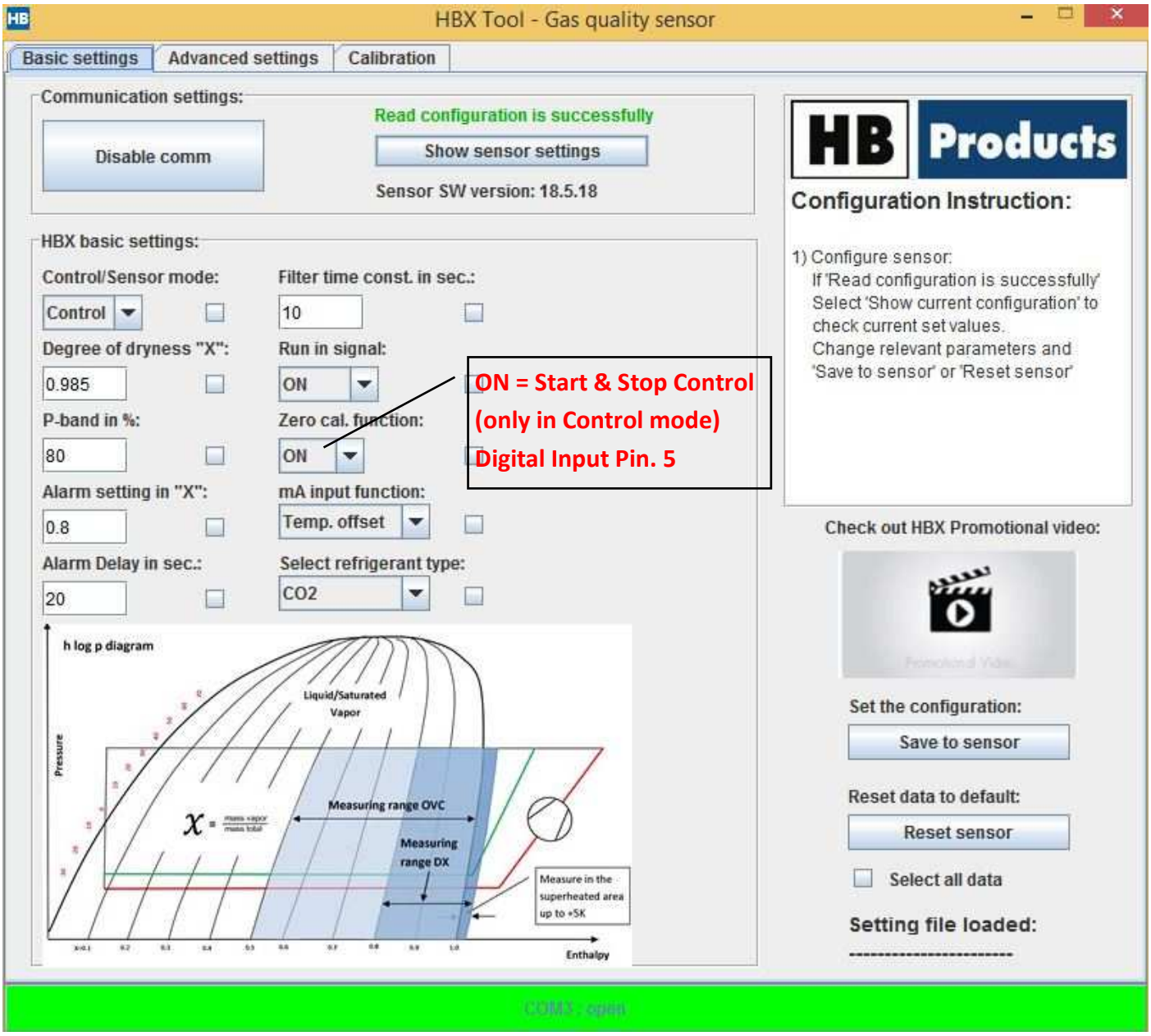
The minimum opening of the expansion valve ensures that there is always a small load of the evaporator. The opening must be limited to ensure that all refrigerant is evaporated with fans/ventilators running at minimum speed and with maximum ice build-up on the evaporator surface.

We recomend use of a HBDF defrost on demand sensor to control the defrost cycle.

Test showed that the sensor can be mounted in all directions, only requirement is that the outlet should be angled so that the oil is drained during operation and standstill.

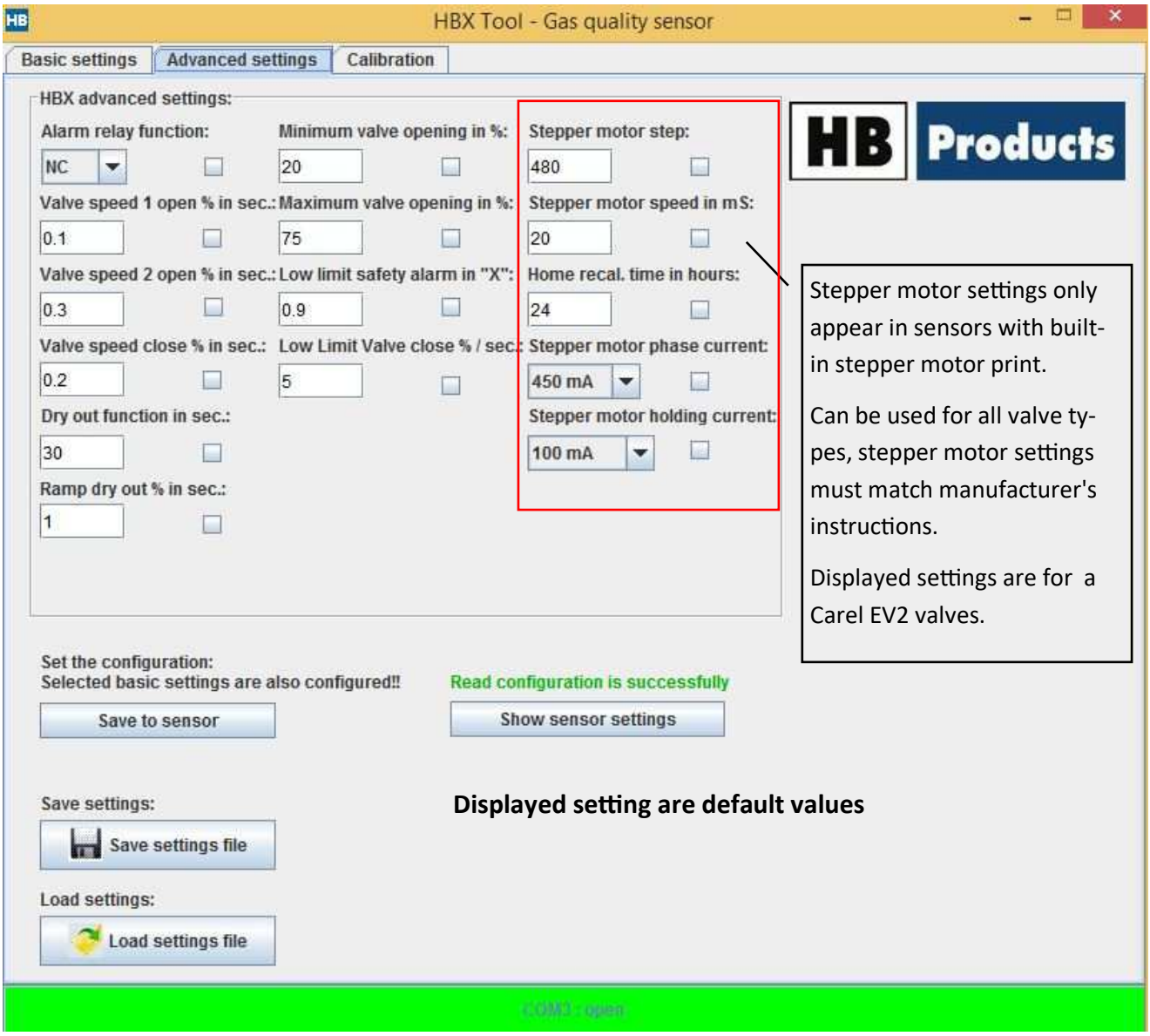
At low loads it may be necessary to force high loads for a period to ensure proper oil return.

During startup, the time based dry-out function will ensure that accumulated refrigerant and oil will be drained.

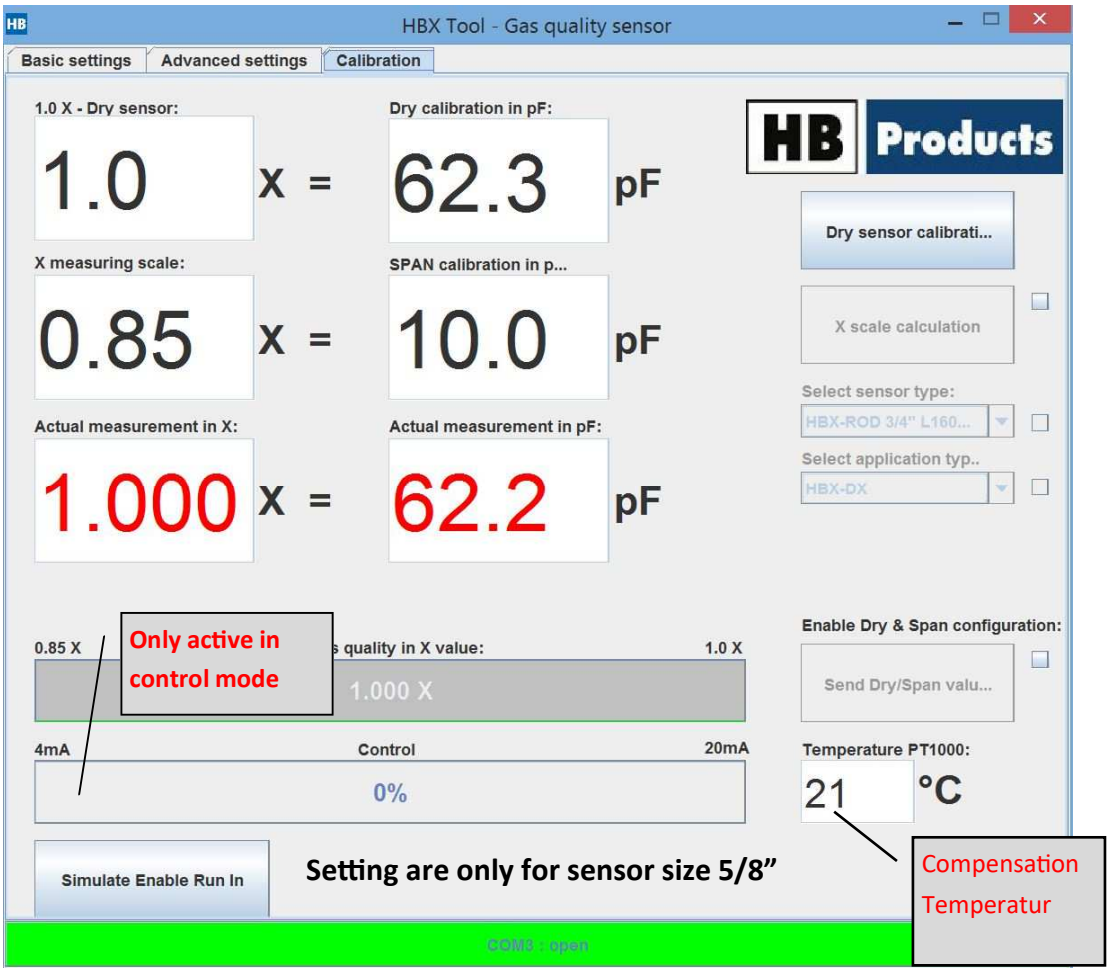


Displayed setting are default values, when used for Control.

1. Choose sensor mode: sensor or control mode (Control mode is used for direct valve operation)
2. The value shown is typical for DX operation
3. Set alarm switch point, ”X” value, default is 0.8 (DX operation)
4. Set alarm delay in seconds, default is 10 sec.
5. Set filter time. Range is from 1 to 120 sec. Default setting is 10 sec.
6. Run in signal (digital input pin.5) is used as external start and stop signal when set to ”ON”
7. Zero cal. function: Choose ”ON” if you want to use the push botton ”R” for zero calibration
8. After change settings push the button ”Save to sensor” (the message ”OK” on the screen indicates that the settings are saved)
9. Check all settings by pushing the button ”Show sensor settings”
10. Go to next page: Advanced settings



1. Alarm output, NO or NC, default is normally closed ”NC” (Fail safe function)
2. Valve speed 1 opening time in sec. , Default is 0.1sec.
3. Valve speed 2 opening time in sec. , Default is 0.3sec. (fast opening during start-up)
4. Valve speed closing time in sec., default is 0.2sec.
5. Dry out time function in sec., (opening the expansion valve to dry-out the sensor)
6. Ramp dry-out %, degree of valve opening in % per second (safe function to minimize hydraulic shock)
7. Minimum valve opening in % (ensures against stops due to low suction pressure)
8. Maximum valve opening in % (ensures against to much liquid supply if the Kv value of the valve is too large)
9. Low limit safety alarm in ”X” value, default value is 0.9 (Close the expansion valve to minimum opening)
10. Low limit valve close time in sec., default value is 5% per second (fast closing when the sensor getting wet)
11. After Change settings push the button ”Save to sensor” (a message ”OK” on the screen indicate that the settings is 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 a existing txt file (copy data to a new sensor)
15. Go to next page, Calibration



1. **Left window shows sensor scaling in “X” value, right shows dry and span calibration values in pF.**
2. **Windows Below is actual measuring capacitance in pF typed in red color.**
3. **Green Bar graph indicates actual vapor/gas quality in “X” value, 0.85 = 20mA(wet) and 1.0 = 4mA(dry).**
4. **Gray Bar graph indicates control output in percentage, 0 to 100% (only active in control mode)**
5. **Dry sensor calibration button are used for zero calibration with dry vapor/gas.**
6. **Calculated pF values can be overwritten by enableing/cross Enable Dry & Span configuration beside the Send Dry/span valu... Button (used to overwrite the calculated span value).**

Sensitivity of the sensor is dependent on the SPAN settings, lower SPAN value will increase the output signal.

The sensitivity of the sensor depends on several parameters, most important are correct mounting position that securing optimal vapor/gas velocity, especially at DX regulation we recommend that the HBX-rod style sensor is mounted in countercurrent flow direction, with vapor/gas velocity range from 5 to 40m/s.

Span settings: (values are approximate values dependent on experience from field testing)

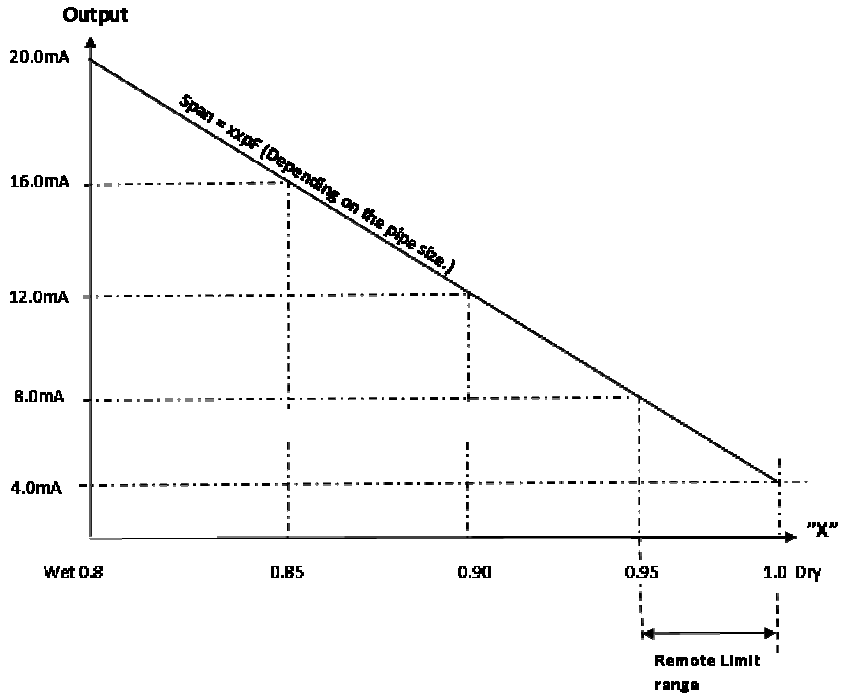
⇒ **10pF, measuring range “X” 0.850 to 1.0**

Example: if the superheat is too low with a set point "X" 0.980, then attempt gradually to change the Span value to desired superheat is achieved, increase by 0.005 to 0.985 will effect the Super-heat by + 0.5 to 1.0K.
Less Span value will increase superheat, field testing have proved that 1K superheat +/-1 are obtainable.

Last page shows graphical view of the relationship between "X" and span settings in pF.

For highest accuracy zero Calibration must be done during start up with pressurized dry Vapor/gas in the sensor section.

Graphical scaling of the 4-20mA remote signal related to "X" value. (Option on mk2 & mk3 version)



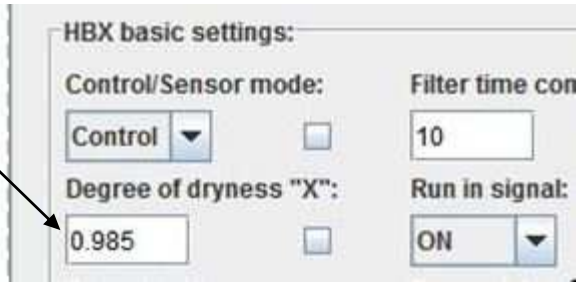
Remote control is used when there is a need to change the desired set-point during operation.
During part load, it may be advantageous to reduce the refrigerant charge in order to get the system in better balance with higher energy efficiency and safe operation.**Note:**

The remote signal is limited to avoid malfunction and fluid overflow (to wet vapor/gas), the signal is limited to 12mA corresponding to a dryness "X" 0.950.
Normal set value is between 0.980 to 0.995 (superheat signal will be in the range +0.5 to 1.5K)

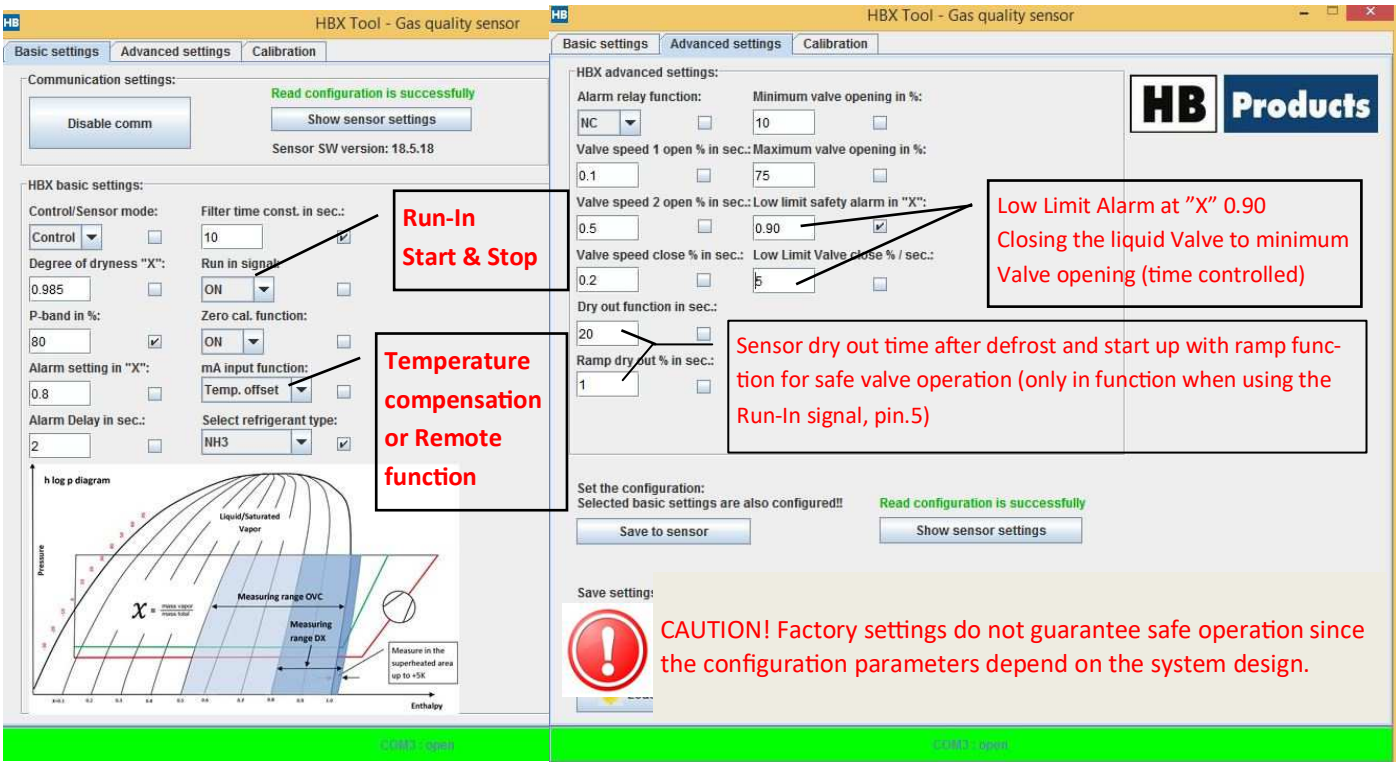
"X" Sensor	1.00	0.99	0.98	0.97	0.96	0.95
mA value	4.00	4.80	5.60	6.40	7.20	8.00

The table shows the correlation between the mA remote signal and the degree of dryness in "X" value.

Note: When the remote signal is below 4.0mA, then the controller uses selected setting in he HB-TOOL.



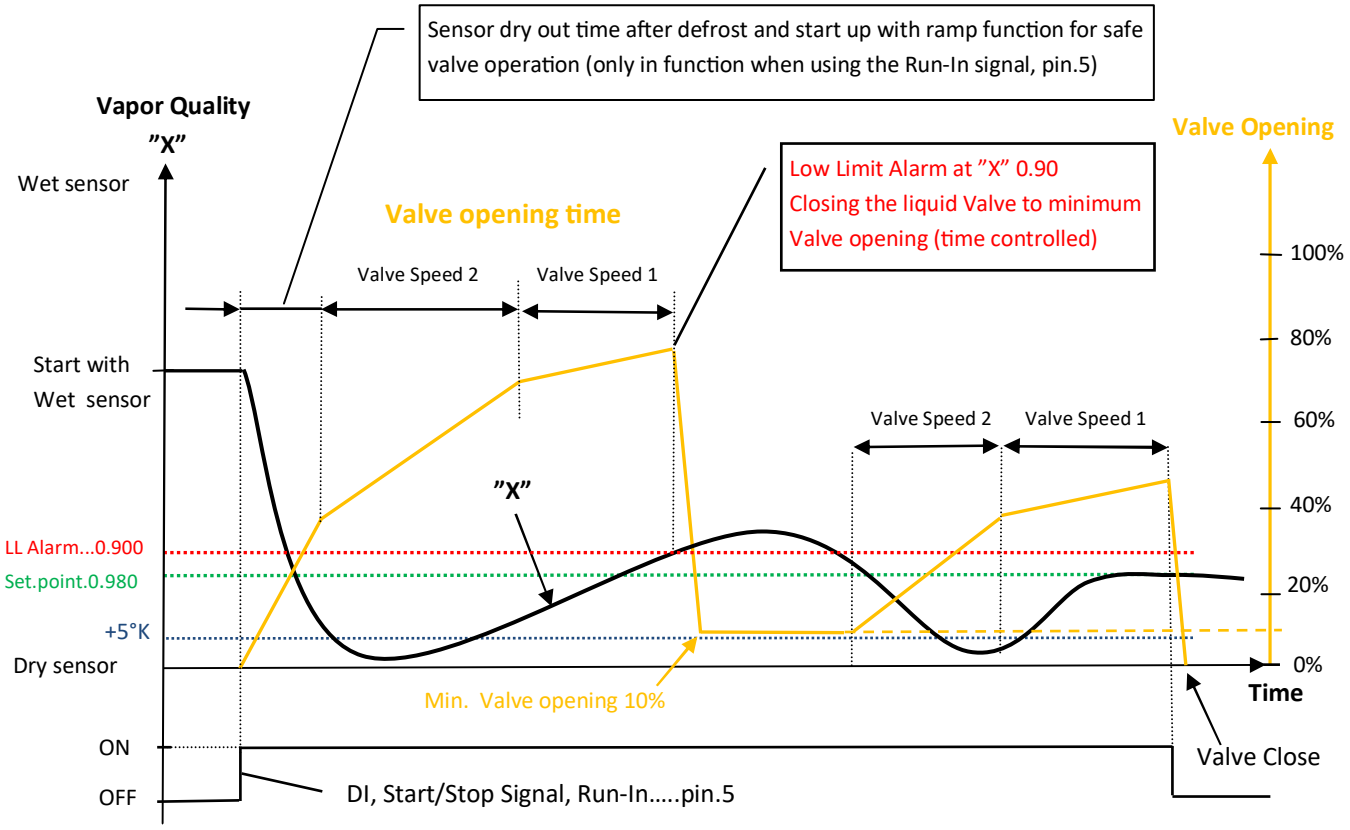
CAUTION! Factory settings do not guarantee safe operation since the configuration parameters depend on the system design and Control



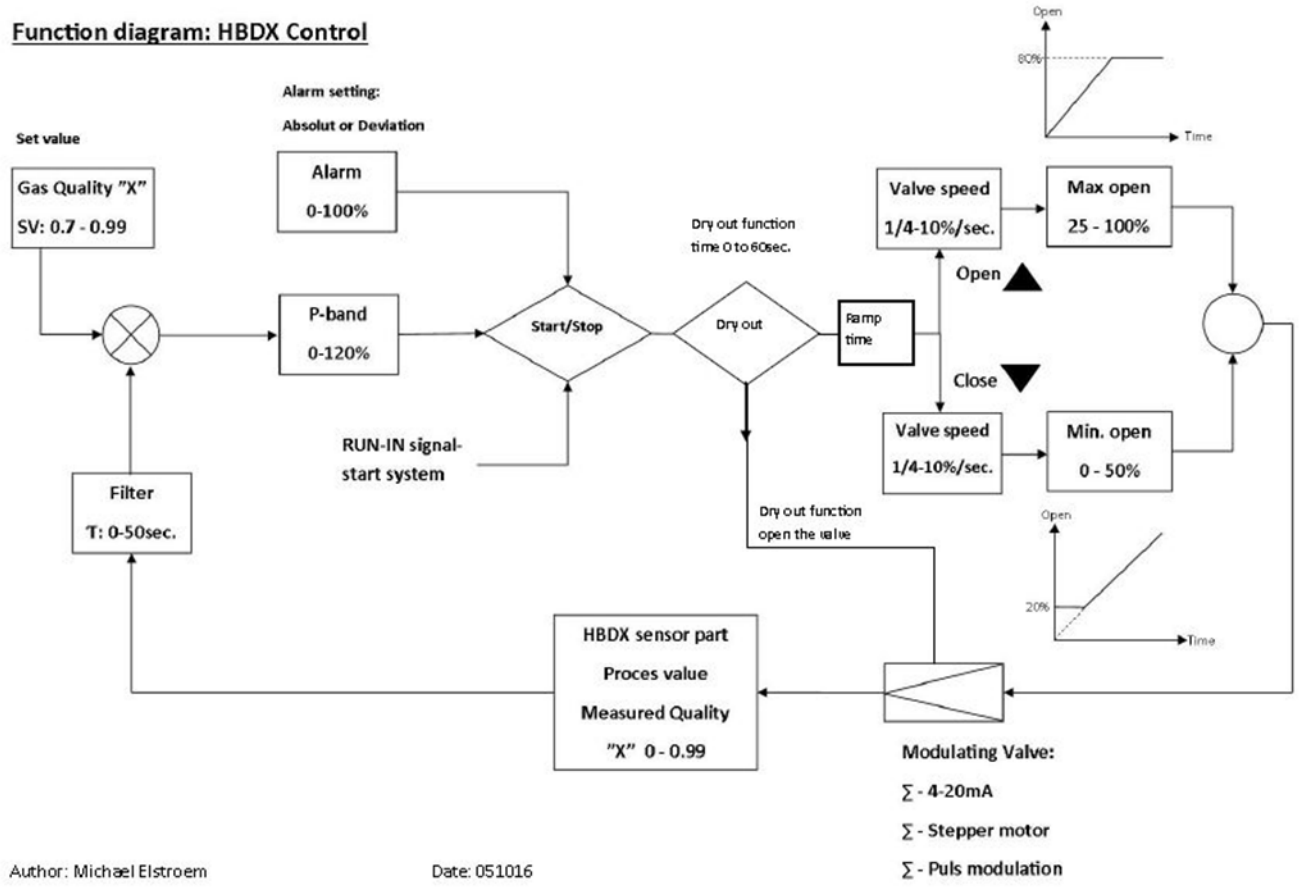
The values shown above are typical for DX operation, **we recommend using temperature compensation especially on CO_2 systems where high pressure variations occur during startup.**

Advanced PI controller with variable valve opening and closing times, Low Limit Safety Alarm closes valve to minimum opening degree, valve open speed 2 only works when sensor signal is completely dry, valve open speed 1 is active when sensor sensor is in optimum control area (safe window from "X" 1.0 to 0.9)

Showing control pattern with Sensor dry out time during start up and after defrost, dry out time is adjustable with ramp function for safe opening of the liquid valve. (control of the valve opening time)



HBX Sensors with integrated Control function



- In Control mode, you can optimize all required control parameters as shown in the diagram. It is especially important to start and stop the control function with the digital input on pin.5 (Run-In signal) to close the expansion valve at stop and defrost.
- Use Run-IN signal for Start/Stop Control (Shut-off) and defrost.
- Sensor dry out time and ramp startup are only active when using the Run-In signal.
- **Sensor dry out time after defrost and start up with ramp function for safe valve operation (only enabled with Run-In function set to ON).**
- Low limit safety Alarm Closing the liquid Valve to minimum valve opening, with ramp closing time function.

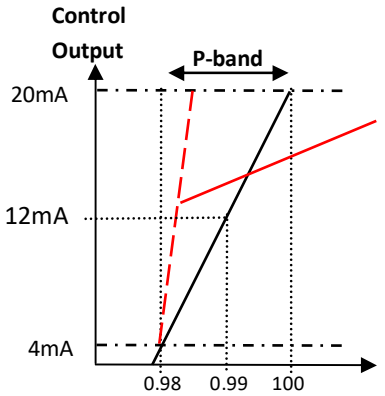
Controlling the evaporator capacity:

The expansion valve opens as a function of a deviation from the desired set-value, the opening degree depends on the amplification (P-band) and opening / closing times for the expansion valve.

Eksample, Set-value "X" on 0.980, P-band on 50%

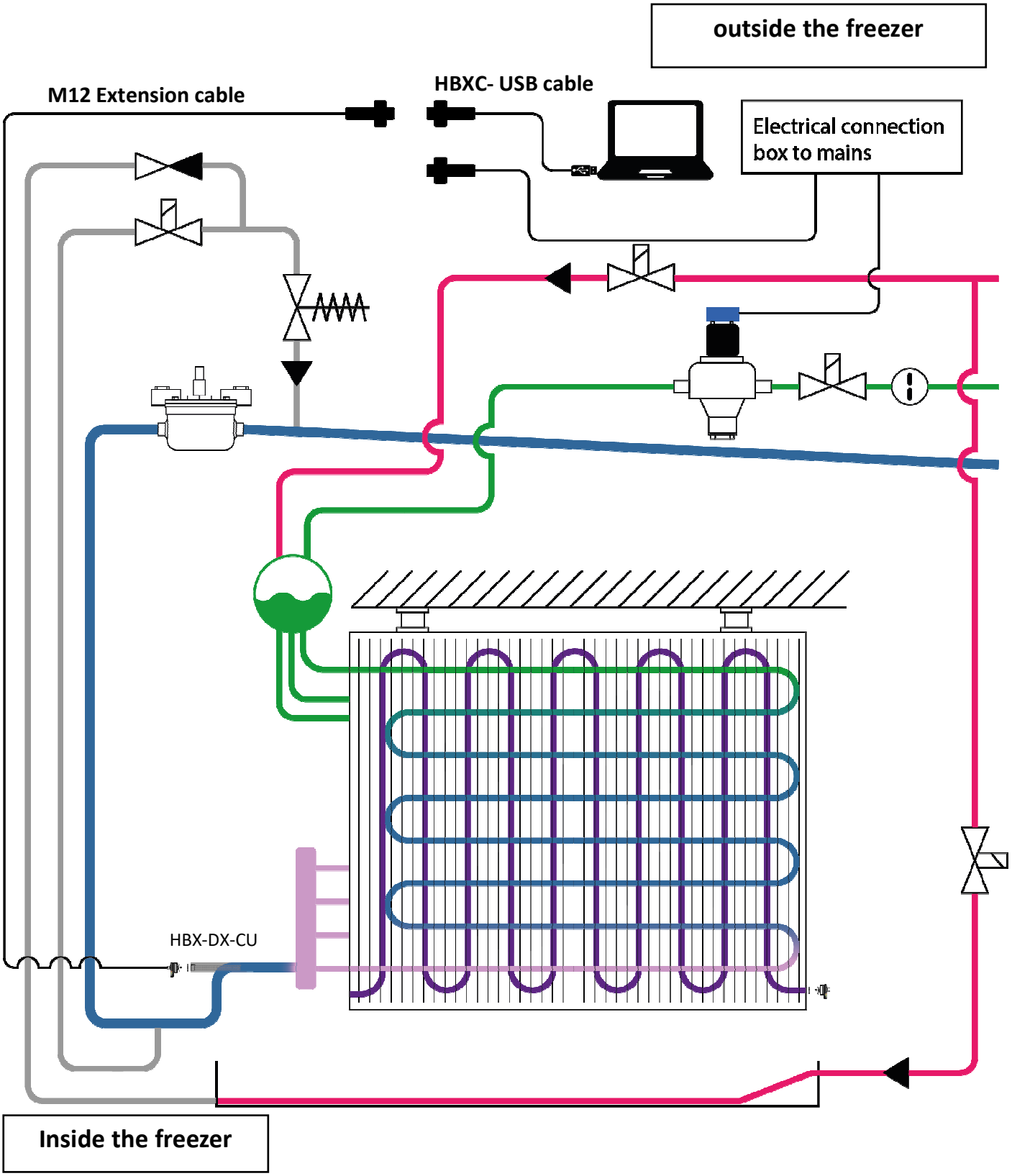
Output at "X" 0.990 $\frac{1 - 0.990}{(1-0.98) \times 50)/100} = x\ 100 = 50\%$

"X" value — P-band in %



With to small P-band it will act more or les as ON / OFF control where the control valve hunting.

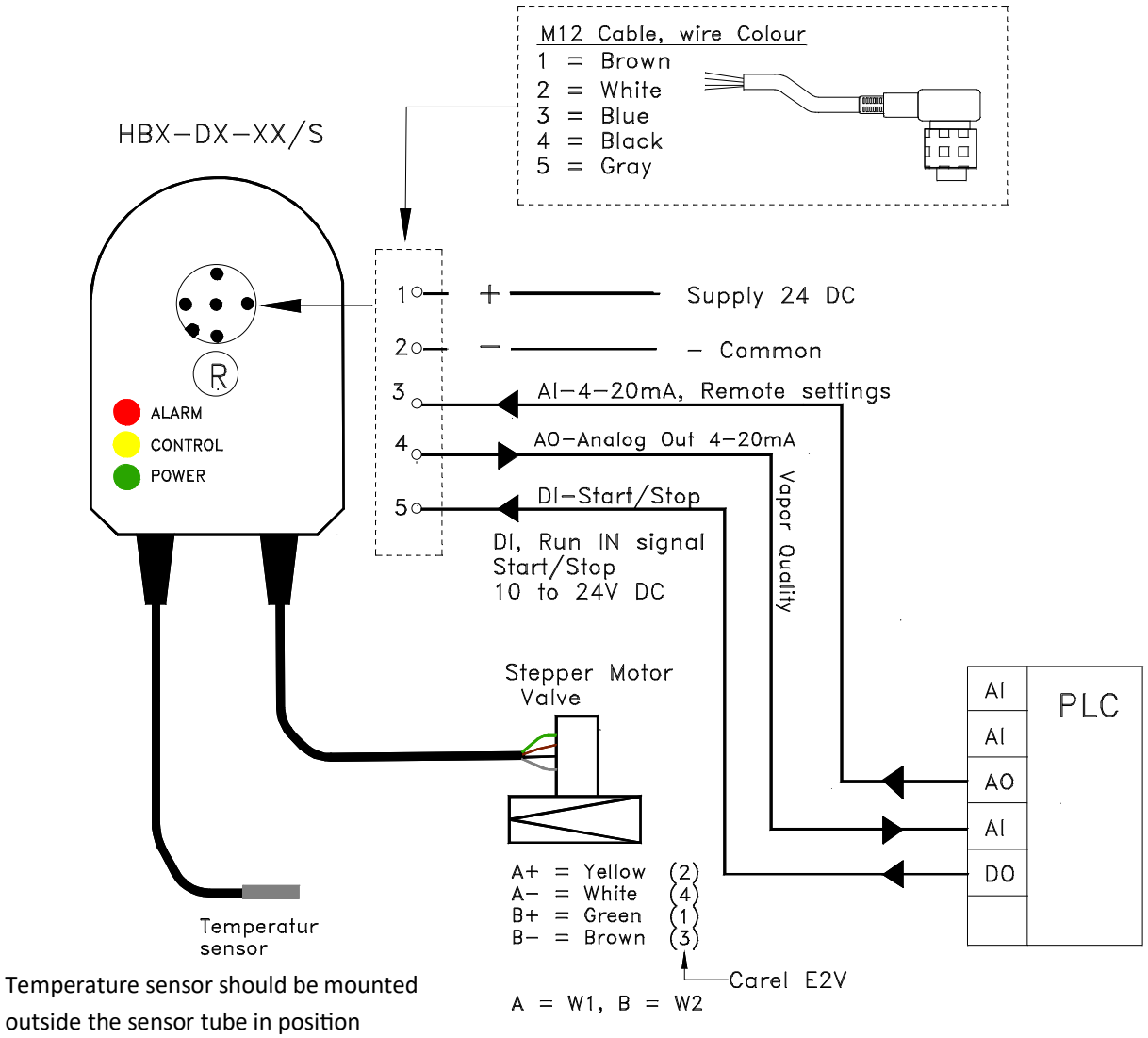
Example of an installation where you can perform setup and settings outside the freezer.



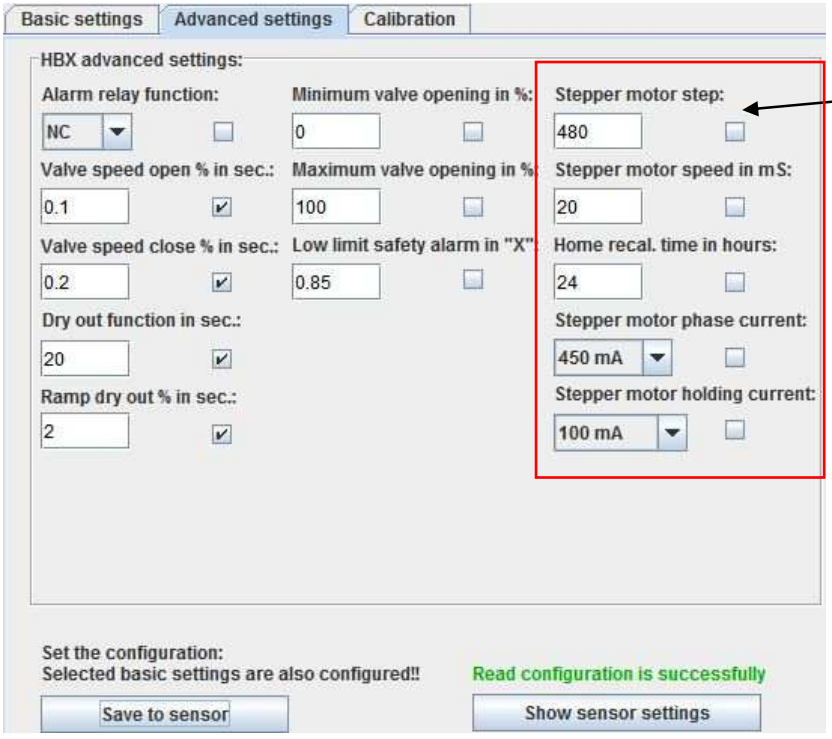
Order code HBX Cable:
HBXC-USB, (PC communication cable)
5meter = HBXC-M12/5 extension
10meter = HBXC-M12/10 extension

Note:
5 meter M12 sensor cable is supplied standard with the HBX sensor.

Connection diagram for HBX/S (stepper motor) with pressure/temp. compensation.



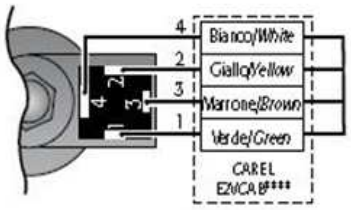
Temperature sensor should be mounted outside the sensor tube in position 3 or 9 o'clock

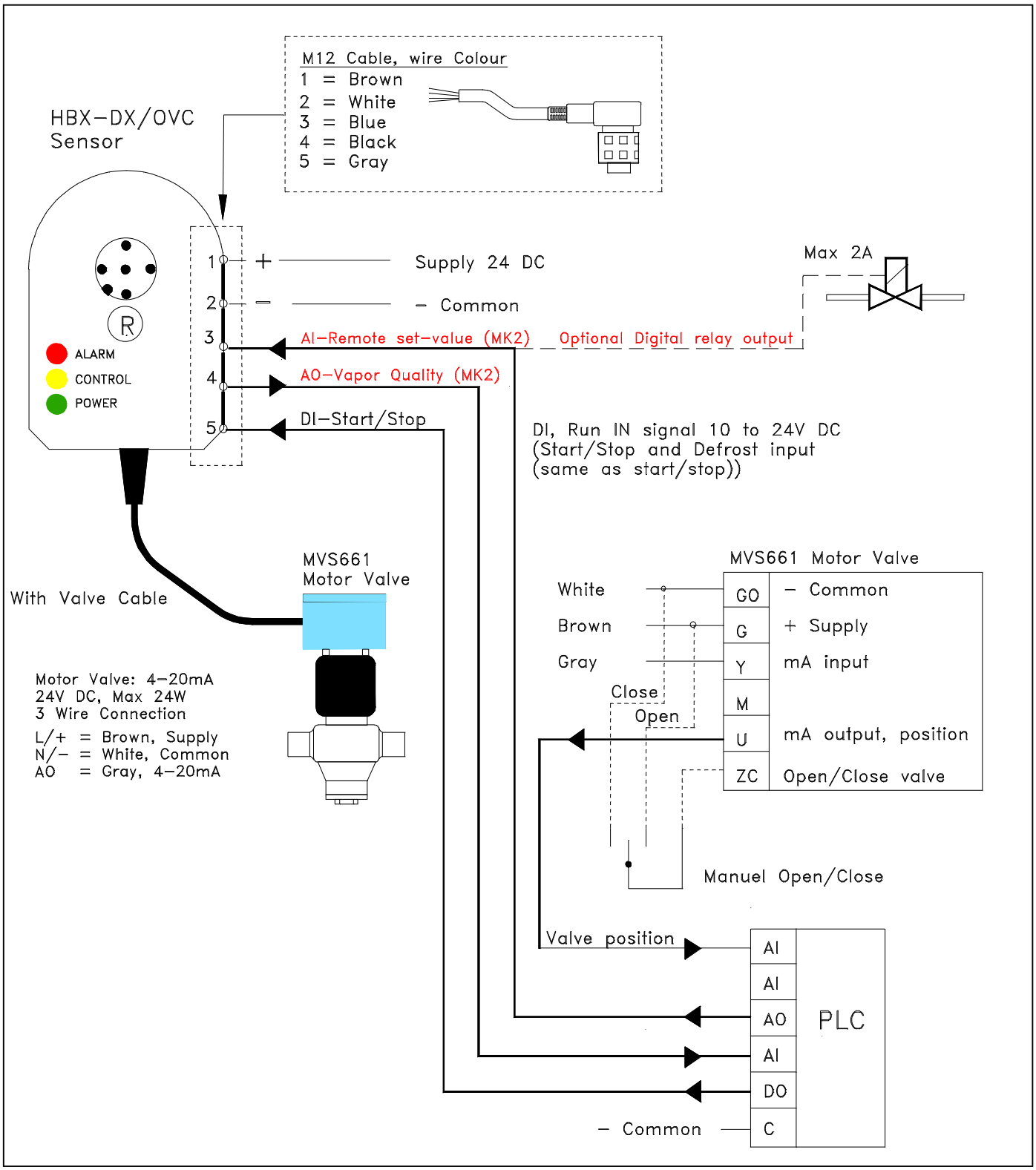


Advanced settings:

Stepper motor settings should be set according to the type of valve.

Carel E2V





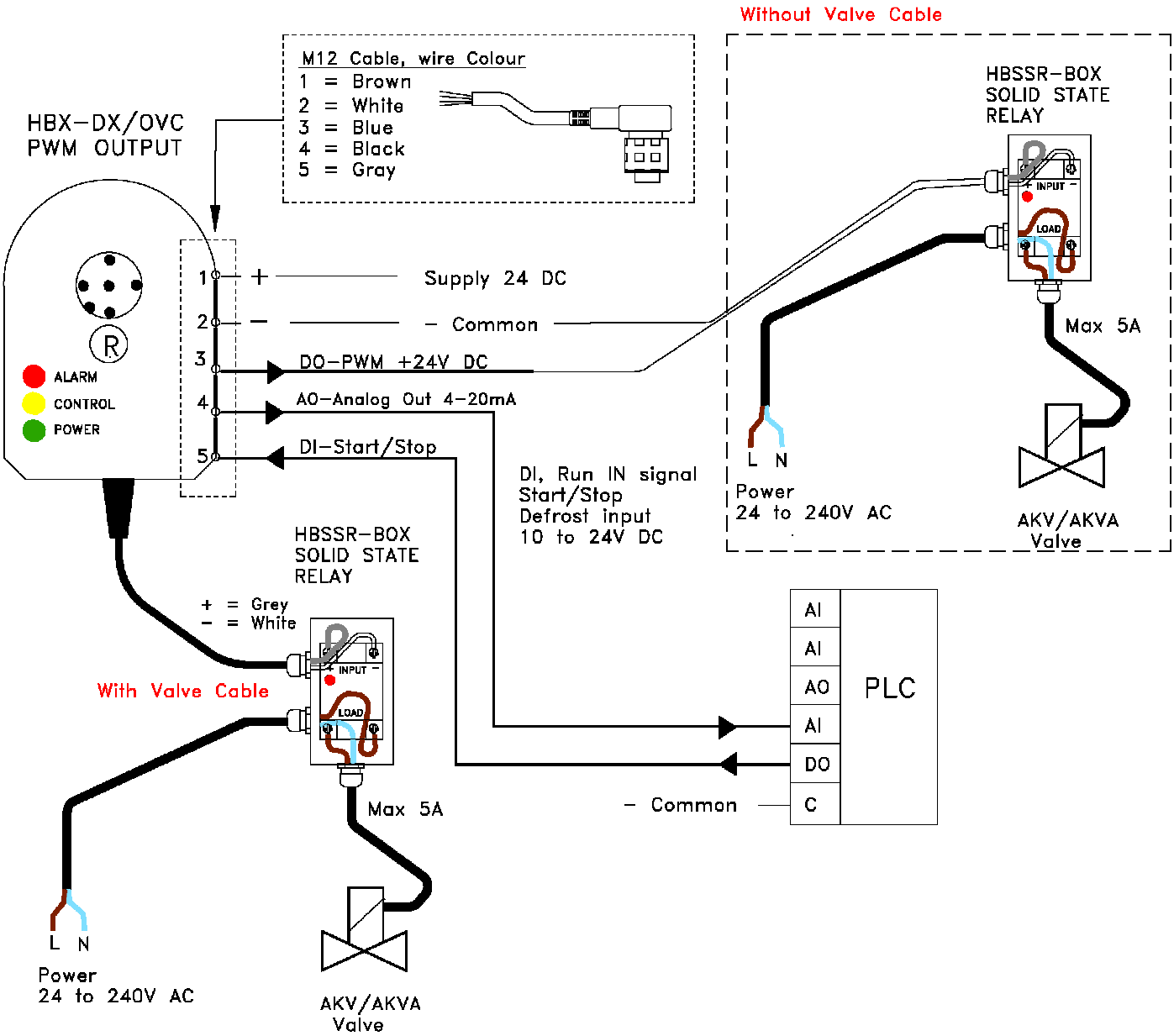
New HBX-DX & HBX-OVC mk2 sensors

New opportunities when used as controller:

- Addinational analog output showing Vapor Quality, 4-20mA (sensor pin. 4).
- Change set-value by remote setting, 4-20mA (sensor pin. 3).
- Sensor output 3 can be changed to a digital relay output opening and closing a solenoid valve (used to control the draining of condensate during defrost or closing a liquid solenoid valve).
- 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)

HBX-DX PWM + HBPWM-BOX, here the control output is performed as pulse modulation 0 to 6second duty cycle, where you can control a solinoid expansion valve directly without the need for an external controller.

⇒ **Work with Danfoss AKV/AKVA and Hansen PXV/PXVW pulse modulating liquid refrigerant expansion valves, Coils 24 to 240V AC .**



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).

The HBSSR-BOX is included.

Sensor settings

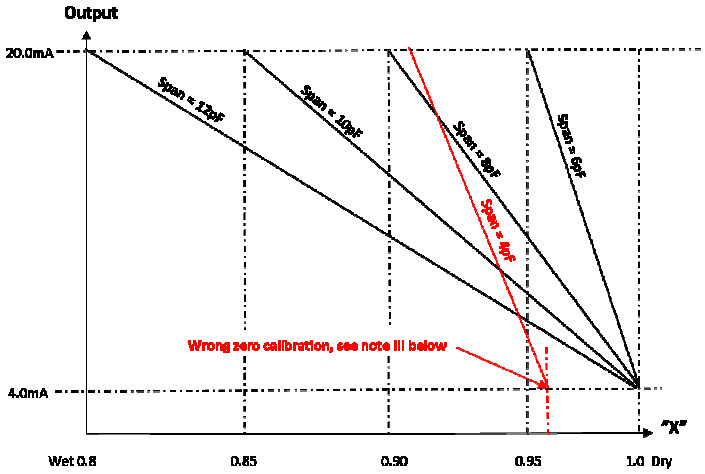
The build in temperature compensation, automatically compensate the value of the dry calibration (zero start point) making the readings more precise regardless of temperature and operating situation, it enables improved control during startup and not least it`s possible to deliver the system as Plug & Play, ready to run.

Temperature ˚C.	Sensor size 1/2”	5/8”	3/4”	7/8”	11/8”
-33	Zero: 3,2pF	60,6pF	62,4pF	76,3pF	92,3pF
+18	Zero: 57,6pF	63,5pF	65,1pF	80,9pF	99,5pF
+35	Zero: 57,5pF	65,3pF	65,3pF	81,8pF	100,9pF

Table showing CO_2 refrigerant and temperature change in pF (zero value/dry Vapor)

Sensor size	1/2”	5/8”	3/4”	7/8”	11/8”
Span	10,0pF	12,0pF	14,0pF	16,0pF	20,0pF

Table showing recommended span settings, only for CO_2 refrigerant in pF.



CAUTION! Factory settings do not guarantee safe operation since the configuration parameters depend on the system design and Control

Graphical view of the relationship between "X" and span settings in pF for HBX-DX-CU-5/8”, CO_2 sensor.

Span settings: (values are approximate values dependent on experience from laboratory and field testing)

⇒ 6pF, very sensitive, should only be used for compressor protection (very sensitive)

⇒ 8pF, measuring range “X” 0.900 to 1.0 +5°K…….0.9 = 20mA…….1.0 +5°K = 4mA (sensitive)

⇒ 10pF, measuring range “X” 0.850 to 1.0 +5°K (Recommended setting for normal operation)

Note:

A. If zero calibration is carried out with degree of a wet sensor it would result in a sensor offset where the sensor not measure from completely dry, Hereby there will be a risk of to wet vapor/gas and thus increased risk of liquid overflow/flood back.

B. If a control system does not modulate correctly, this will typically be either an not correctly calculated expansion/ liquid valve (Kvs value) or the sensor system is too sensitive or wrong calibrated.

X. By selecting a to small measuring range there is a risk that the system will be to sensitive and reacts to excessive on small changes of liquid content (wet vapor) in the gas, then the control system not modulate appropriately and act more or les as ON / OFF control where the control valve fluctuate (hunting).

Δ. At low loads it may be necessary to force high loads for a period to ensure proper oil return.

E. During startup, the time based dry-out function will ensure that accumulated refrigerant and oil will be drained.

Φ.