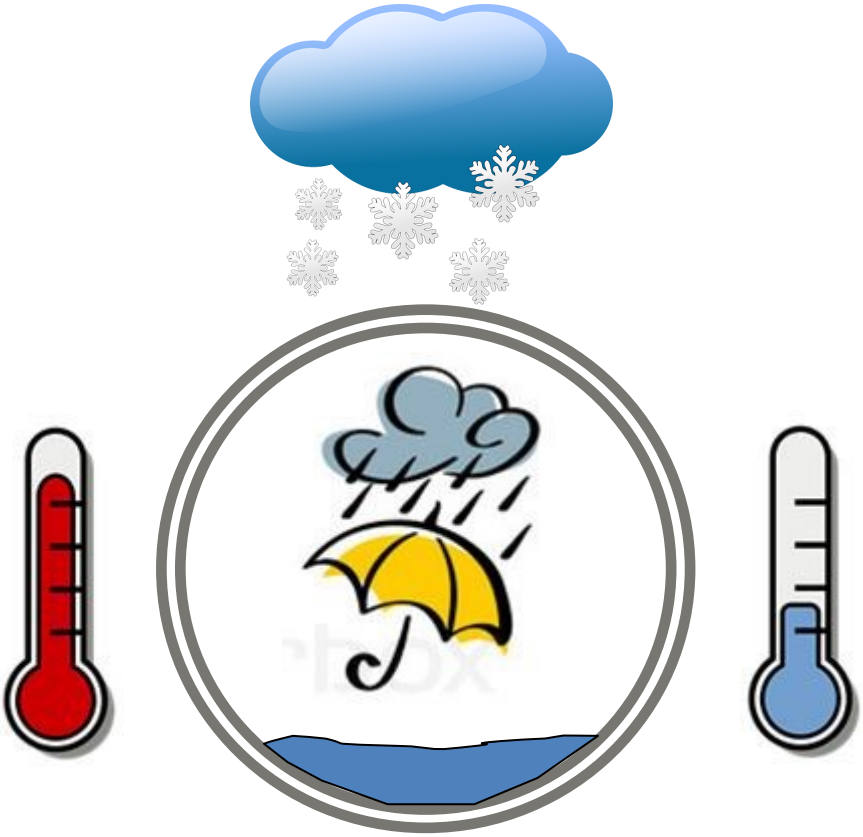
New Sensor Technologies Control phase of Refrigerant, made Ammonia more Safe and Optimizing all type of Refrigeration systems Will also work with HFC/HFO Refrigerant

Start-up guide HBX-DX

Include Electrical wiring diagram

measuring weather condition inside the pipe

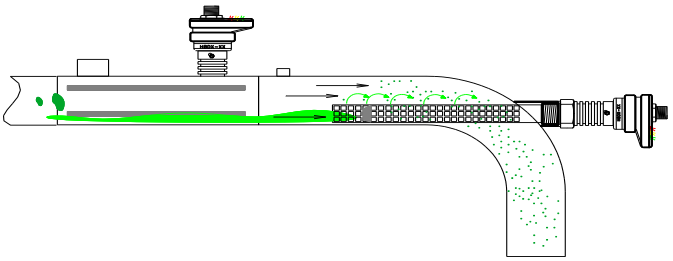


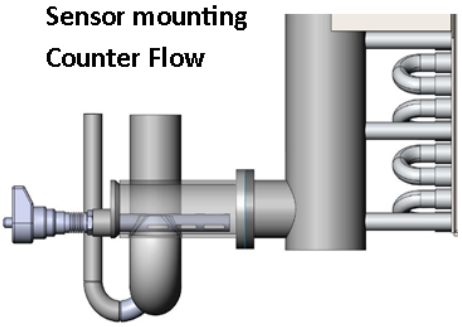
Low Carbon Technologies

Patent No.: US 9,587,866 B2

HB Products WE INCREASE UPTIME AND EFFICIENCY IN THE REFRIGERATION INDUSTRY

HBX-XXX sensor start-up guide





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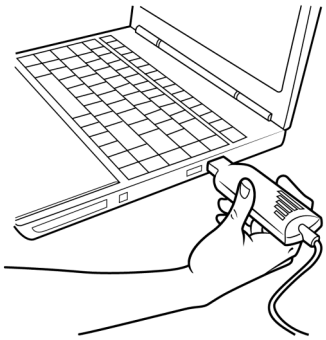


1. Download and install the HB-Tool software on the computer: http://www.hbproducts.dk/en/software/hb-tool
2. Connect the HB USB/M12 cable to a PC USB port.

Note:

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

Introduction:

The sensor directly measures the degree of dryness, due to the difference between the dielectric constant of gas and liquid in a two-phase vapor-liquid flow the measured capacitance between the electrodes is linked to the void fraction as explained on page 3. 0.5 is 50% wet, and 1.0 is completely dry. The measuring range can be changed according to the system in the "X" range from 0.5 to 1.0.

Safety Instructions

CAUTION! Always read the operational guidelines before commencing work! Heed all warnings to the letter! Installation of HBDX requires technical knowledge of both refrigeration and electronics. Only qualified personnel should work with the product. The technician must be aware of the consequences of an improperly installed sensor, and must be committed to adhering to the applicable local legislation.

If changes are made to type-approved equipment, this type approval becomes void. The product's input and output, as well as its accessories, may only be connected as shown in this guide. HB Products assumes no responsibility for damages resulting from not adhering to the above.

Explanation of the symbol for safety instructions. In this guide, the symbol below is used to point out important safety instructions for the user. It will always be found in places in the chapters where the information is relevant. The safety instructions and the warnings in particular, must always be read and adhered to.

	CAUTION! Refers to a possible limitation of functionality or risk in usage. NOTE! Contains important additional information about the product and provides further tips. The person responsible for operation must commit to adhering to all the legislative requirements, preventing accidents, and doing everything so as to avoid damage to people and materials.

Intended use, terms of use. The purpose of the HBDX sensor and regulator is refrigerant measurement and regulation. If the HBDX is to be used in a different way and if the operation of the product in this function is determined to be problematic, prior approval must be obtained from HB Products.

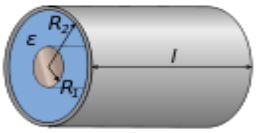
Preventing collateral damage: Make sure that qualified personnel assess any errors and take necessary precautions before attempting to make replacements or repairs so as to avoid collateral damage.

Disposal instructions: HBDX is constructed so that the modules can easily be removed and sorted for disposal.

HOW IT WORKS (principle of measurement)

The sensor is based on the capacitive measurement principle. Two or more measuring electrodes (conductors) measure the charges and change it into an electrical field/resistance depending on the difference in the dielectric properties of various media. Hereby the ratio between vapor and liquid amounts is measured instantaneously, i.e., without delay as a void fraction measurement.

Coaxial design



$$\frac{2\pi\varepsilon l}{\ln(R_2/R_1)}$$

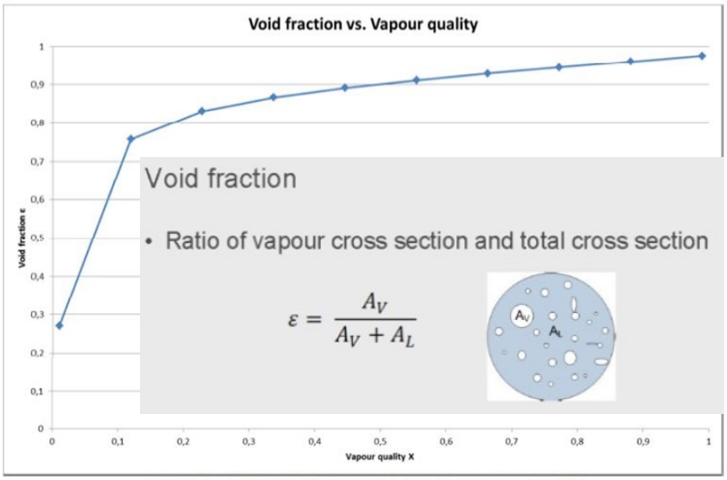
The measured value depends on the total sensing area and the internal distance between the conductors/electrodes. The ratio of the capacitance measured in pF depends on the material between the electrodes. Relative permittivity is the factor by which the electrical field/charges on the electrodes is changed and named as dielectric constant ε, refrigerants have ε > 1.

The capacitance relationship is illustrated with the following equation:
***C* = 0.225 *K* (*A/D*)**

C = Capacitance in Pico Farads "pF"
K = Dielectric constant of material ("ε" relative permittivity)
A = Area of the inner electrodes in square inches
D = Distance between the electrodes in inches

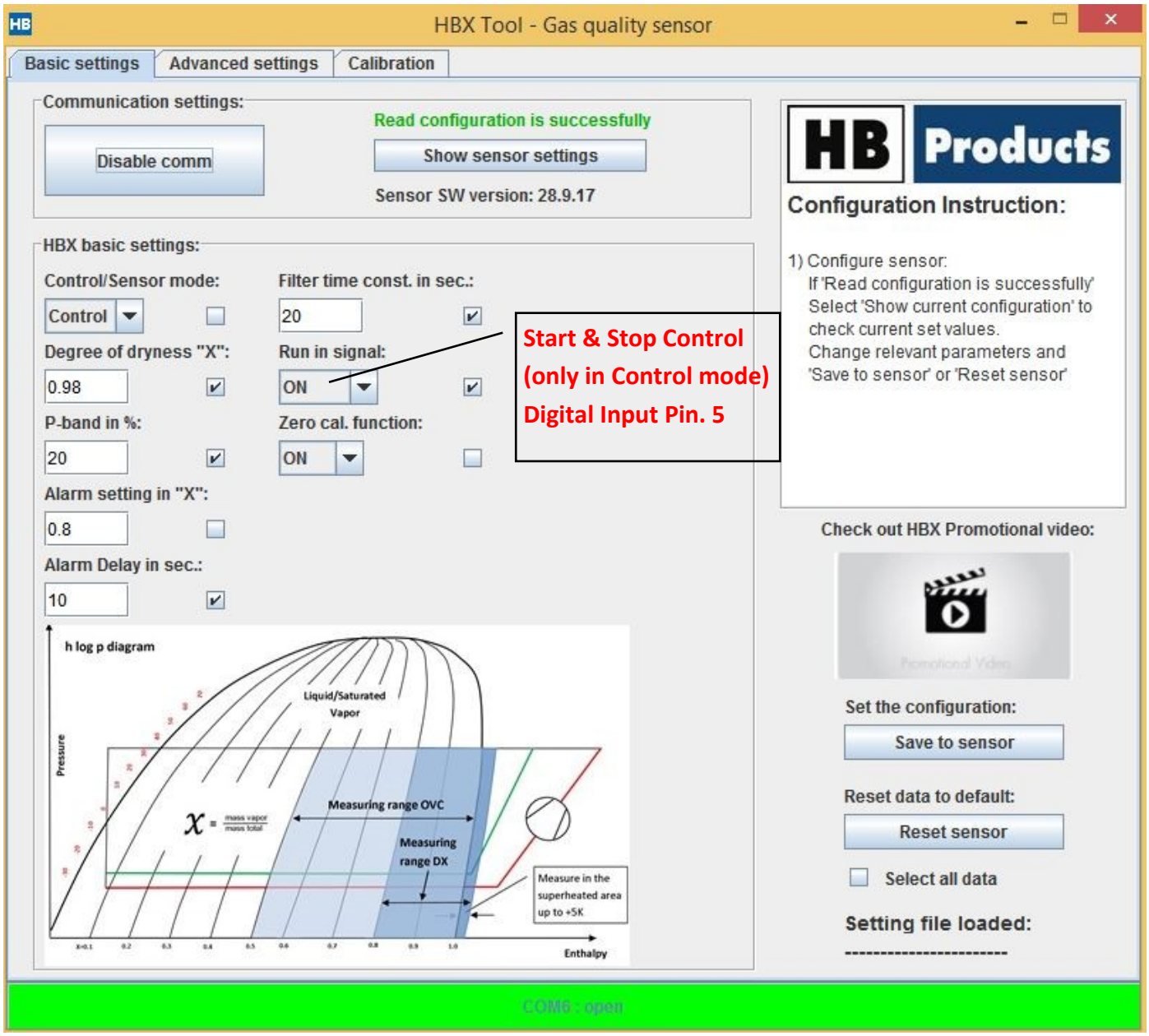
The dielectric constant (relative permittivity) is a numerical value on a scale of 1 to 100. This relates to the ability of the dielectric material to store an electrostatic charge. The dielectric constant of a material is determined in an test cell. Values for many materials are published on the internet.

Due to the difference between the dielectric constant of gas and liquid in a two-phase vapor-liquid flow, the measured capacitance between the electrodes depends on the **void fraction**.

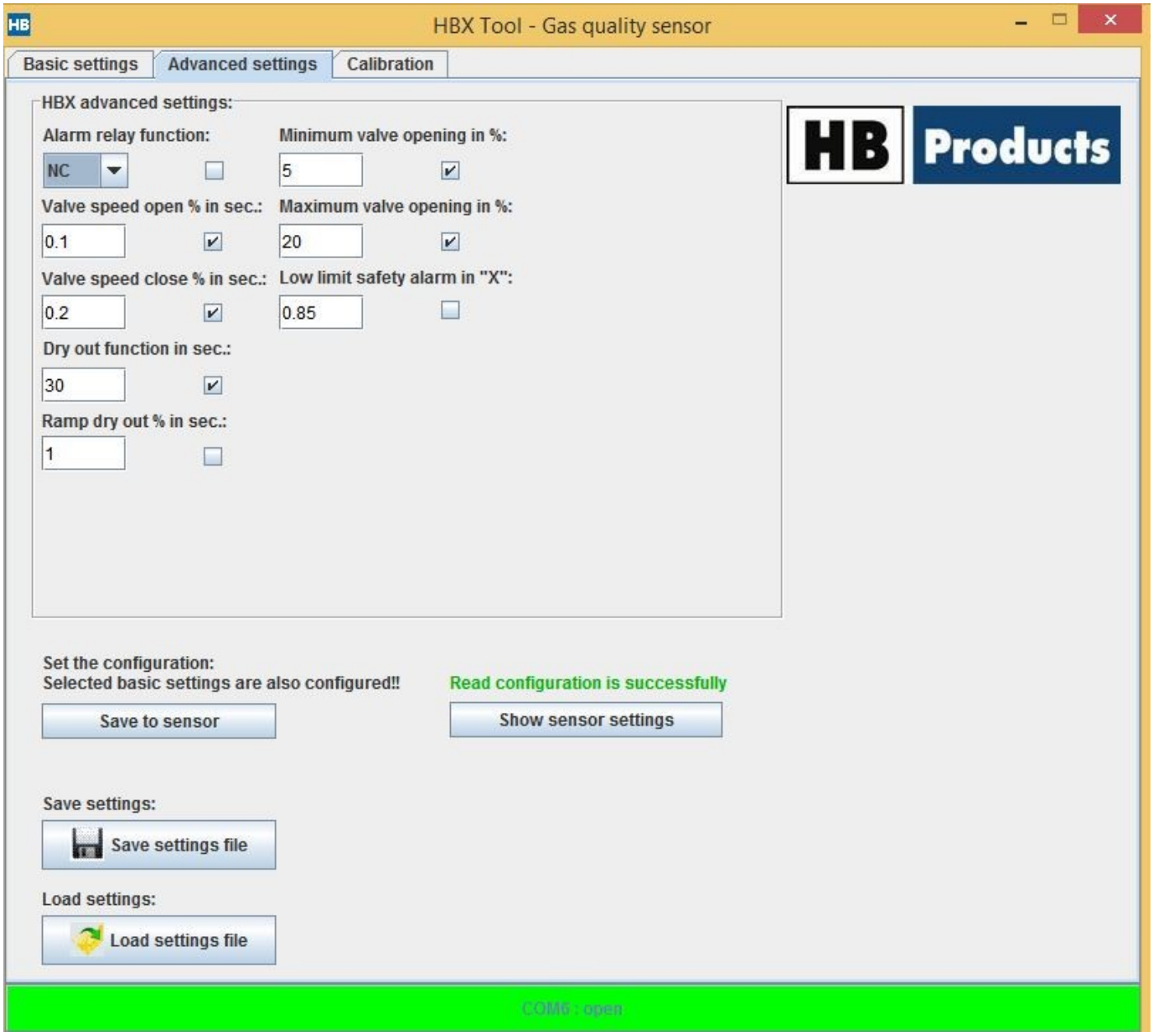


The volumetric void fraction is defined as the ratio of the volume occupied by the liquid (wet vapor) in the tube and the total volume of the tube. It can be seen as an average of the cross sectional void fraction over the tube.
For vapor qualities above 0.5, there is approximately a linear link to the void fraction.

HBX-OVC start-up guide: sensor mode



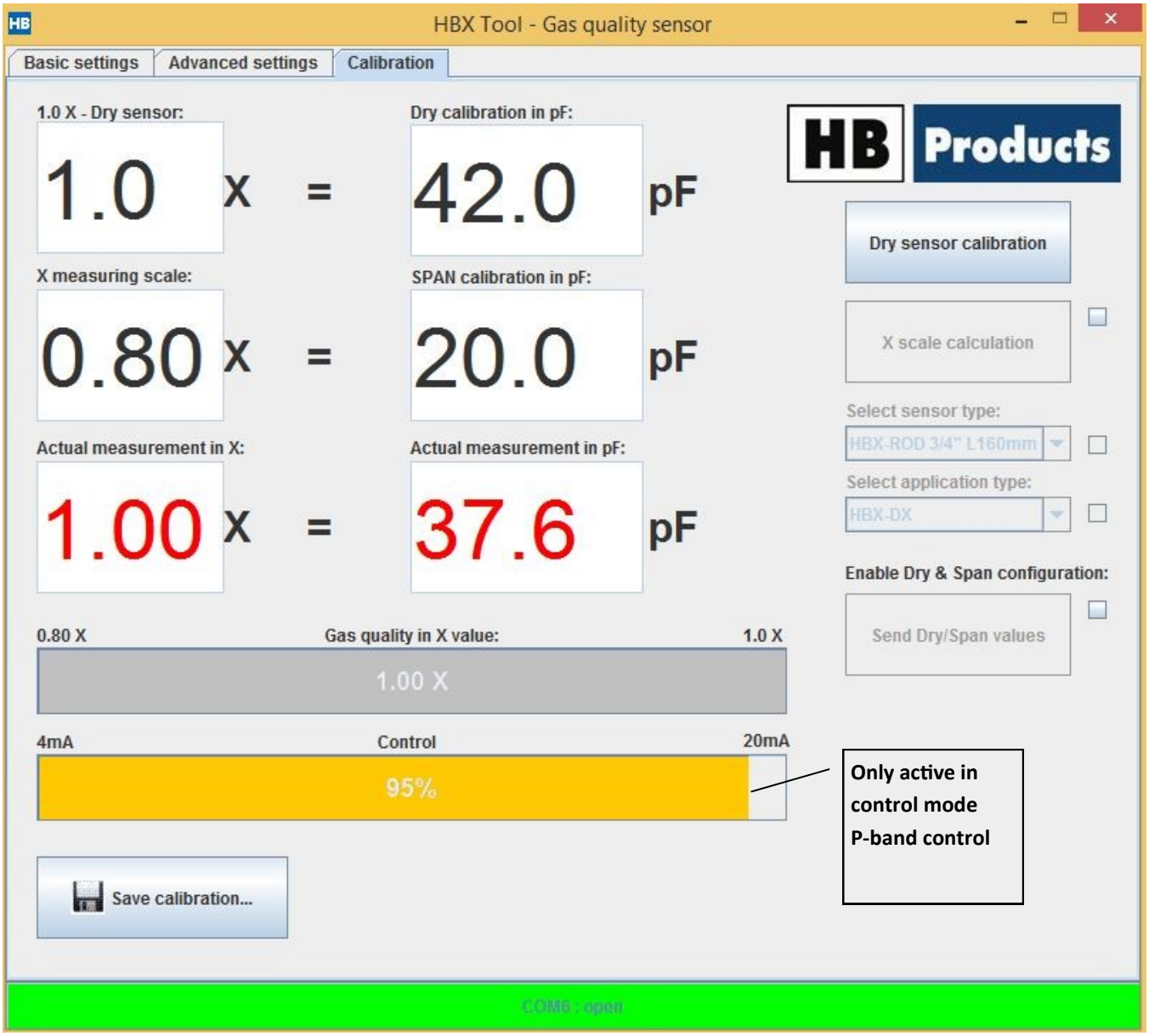
1. Choose sensor mode: sensor or control
2. Set alarm switch point, ”X” value, default is 0.5 (OVC operation)
3. Set alarm delay in seconds, default is 10 sec.
4. Set filter time, range is from 1 to 120 sec, default settings is 5 sec.
5. Run in signal (digital input pin.5) is used as external start and stop signal when set to ”ON”
6. Zero cal. function: Choose ”ON” if you want to use the push botton ”R” for zero calibration
7. After change settings push the button ”Save to sensor” (the message ”OK” on the screen indicates that the settings are saved)
8. Check all settings by pushing the button ”Show sensor settings”
9. Go to the next page: Advanced settings



1. Alarm output, NO or NC, default is normally closed ”NC” (Fail safe function)
2. After Change settings push the button ”Save to sensor” (a message ”OK” on the screen indicate that the settings is saved)
3. Check all settings by push the button ”Show sensor settings”
4. Save settings file is used to save the settings as a txt file on note pad
5. Load settings file is used to set up all parameters from a existing txt file
6. Go to next page, Calibration

Note:

If the sensor is set to sensor mode, then all control function is hidden.



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, 0.8 = 20mA(wet) and 1.0 = 4mA(dry).**
4. **Dry sensor calibration button are used for zero calibration with dry vapor/gas.**
5. **Calculated pF values can be overwritten by enableing/cross Send Dry/span values button.**

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 10 to 30m/s.

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

⇒ **10pF, measuring range "X" 0.90 to 1.05…….0.9 = 20mA…….1.05 = 4mA**

⇒ **15pF, measuring range "X" 0.85 to 1.05**

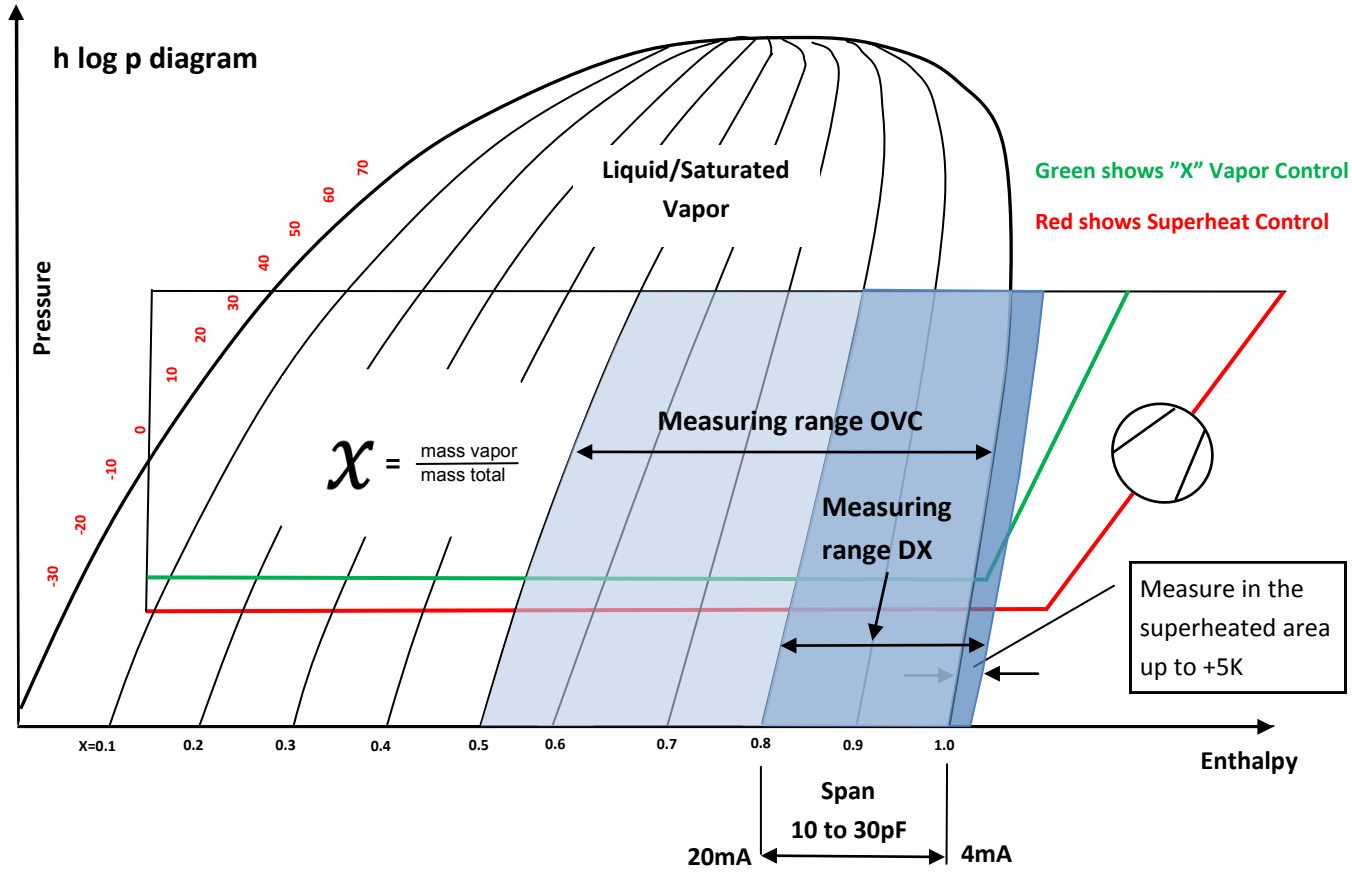
⇒ **20pF, measuring range "X" 0.80 to 1.05**

Example: if the superheat is too low with a set point "X" 0.98, then attempt gradually to change the Span value to desired superheat is achieved.

”X” Vapor Sensors for efficient Evaporator Control

Low Charge Operation DX Control

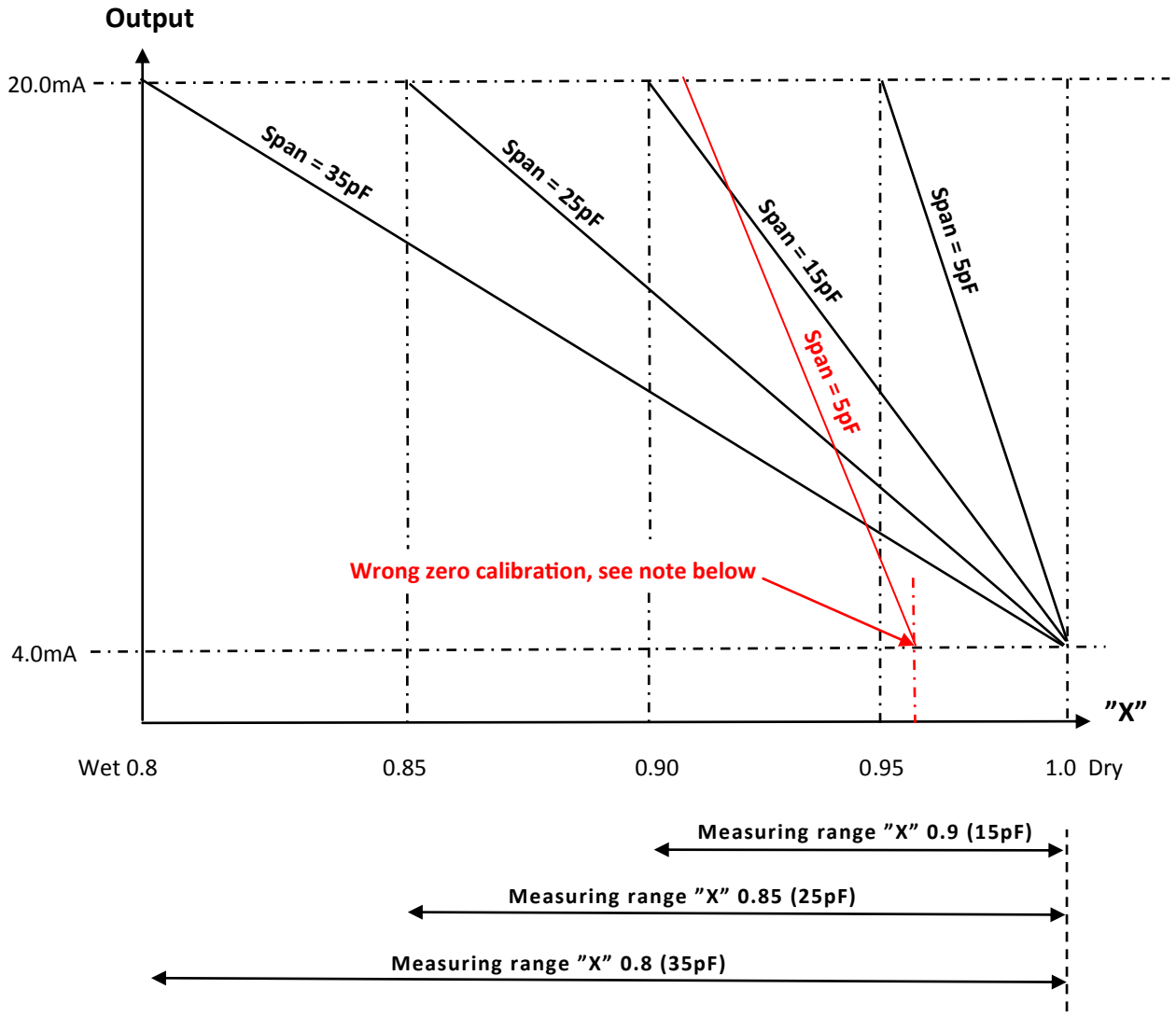
New energy efficient system for super heat control



Experience has proven that the sensor measures in the superheated range up to 5K.
The sensor is independent by the boiling point and measure directly degree of dryness ”X” as Void Fraction.

Note:
During start up or after defrost there are liquid droplets on the sensor part from condensated vapor. These droplets will effect 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 to dry out the sensor during start up by opening the liquid valve in xx sec. 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 more wet and thereby affects the sensor briefly until the system is in balance.

Graphical view of the relationship between "X" and span settings in pF for HBX-DX-ROD 3/4”



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

⇒ **5pF, very sensitive, should only be used for compressor protection**

⇒ **10pF, measuring range “X” 0.90 to 1.0 +5°K…….0.9 = 20mA…….1.0 +5°K = 4mA (sensitive)**

⇒ **15pF, measuring range “X” 0.85 to 1.0 +5°K**

⇒ **20pF, measuring range “X” 0.80 to 1.0 +5°K**

Note:

I. **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.**

II. **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 does not modulate and act more or les as ON / OFF control where the control valve fluctuate (hunting).**

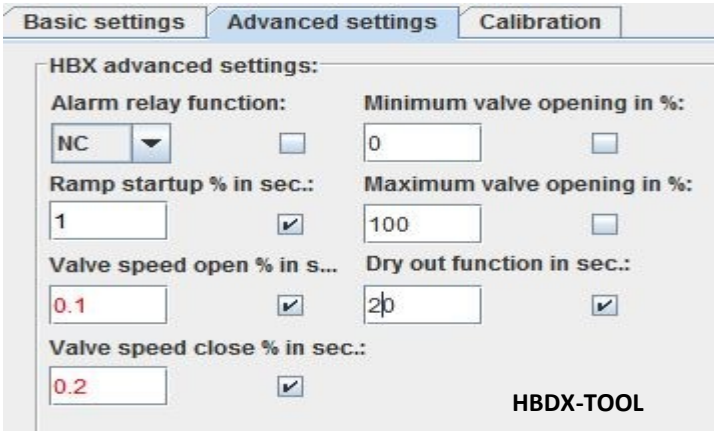
III. **If zero calibration is carried out with degree of a wet sensor it would result in a sensor offset where the sensor not measure from completely dry, Hereby there will be a risk of to wett vapor/gas and thus increased risk of liquid overflow/flood back.**

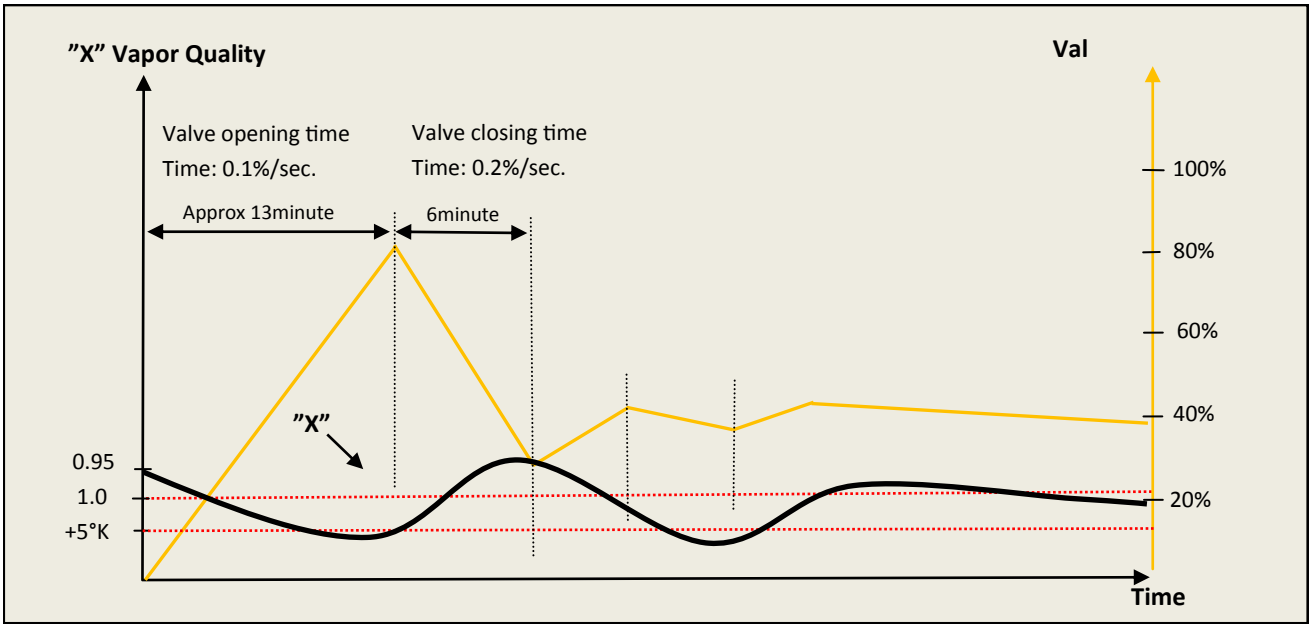
Graphics display of the Control pattern

P-band approx: 30%, +20/-10

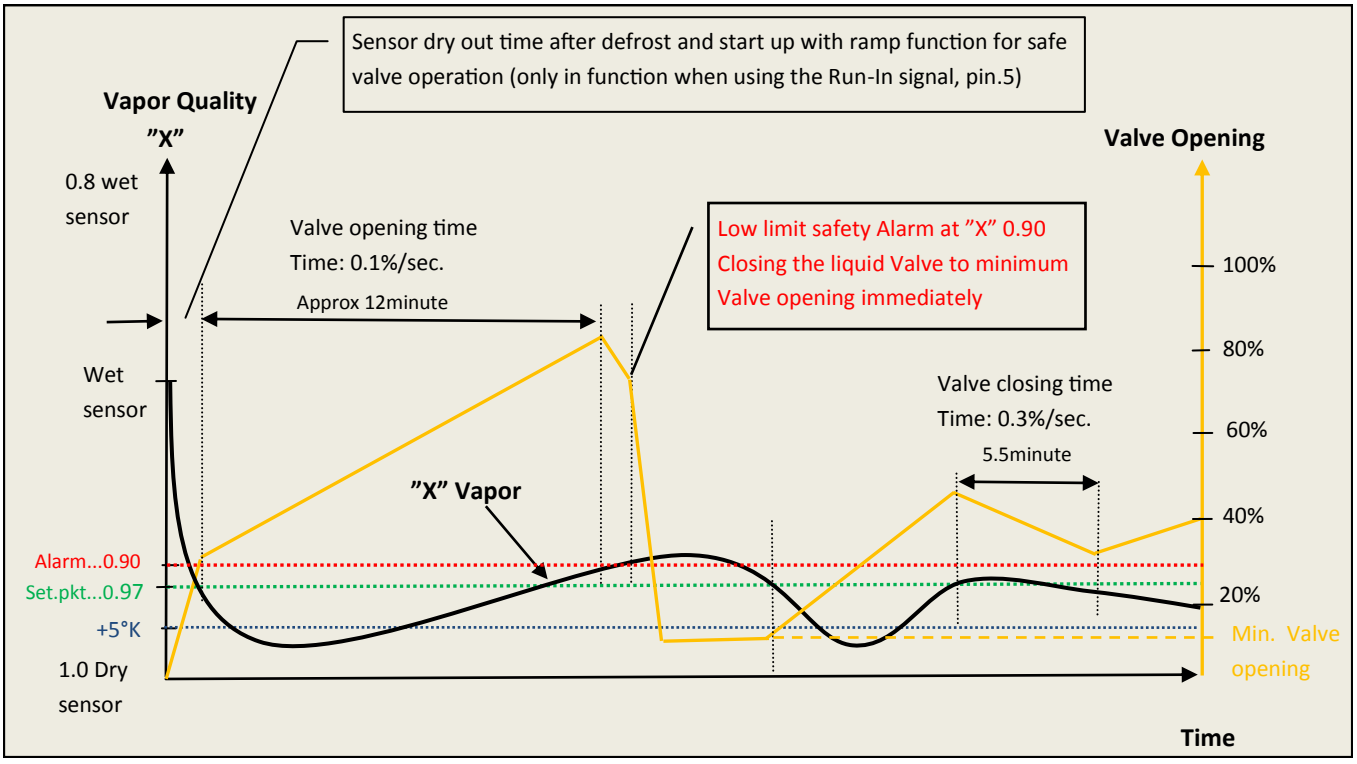
Set Value approx: 0.97 +/-0.02

Start and stop function, Run-In signal, pin 5 should be used during start/stop and defrost for closing the liquid valve.

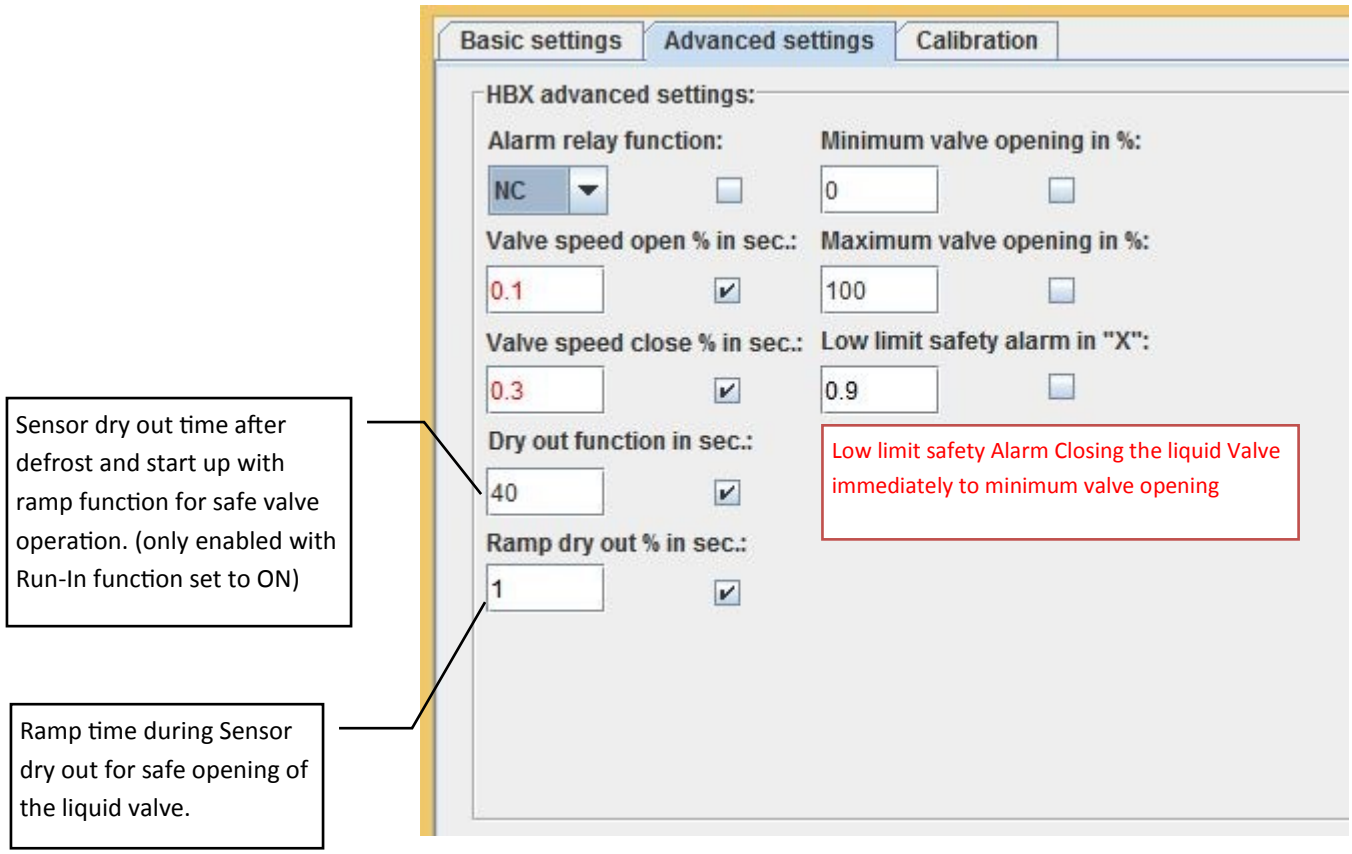




Typically control pattern for P-control with time-based valve-opening and closing-time



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)



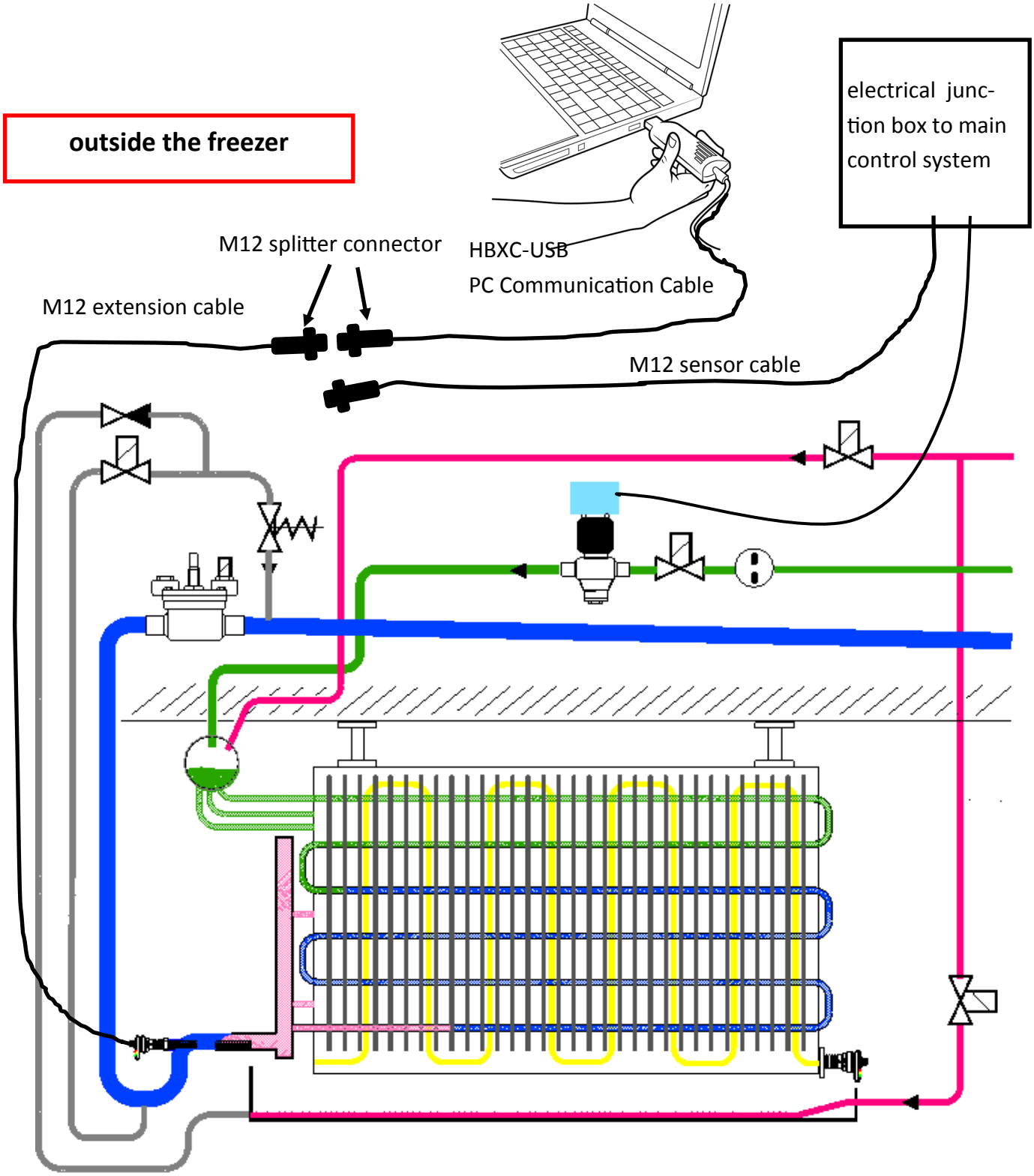
NOTE:

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

Higher operating pressures require a different adjustment of the zero value (dry vapor/gas) because of a higher relative density, for example will a change in pressure from 0.2bar to 5bar resulting in a changes from 42pF to 44pF (HBX-DX, Rod 160mm)

By performing the zero calibration at desired operating temperature / pressure, compensation will be done automatically and ensure highest measurement accuracy.

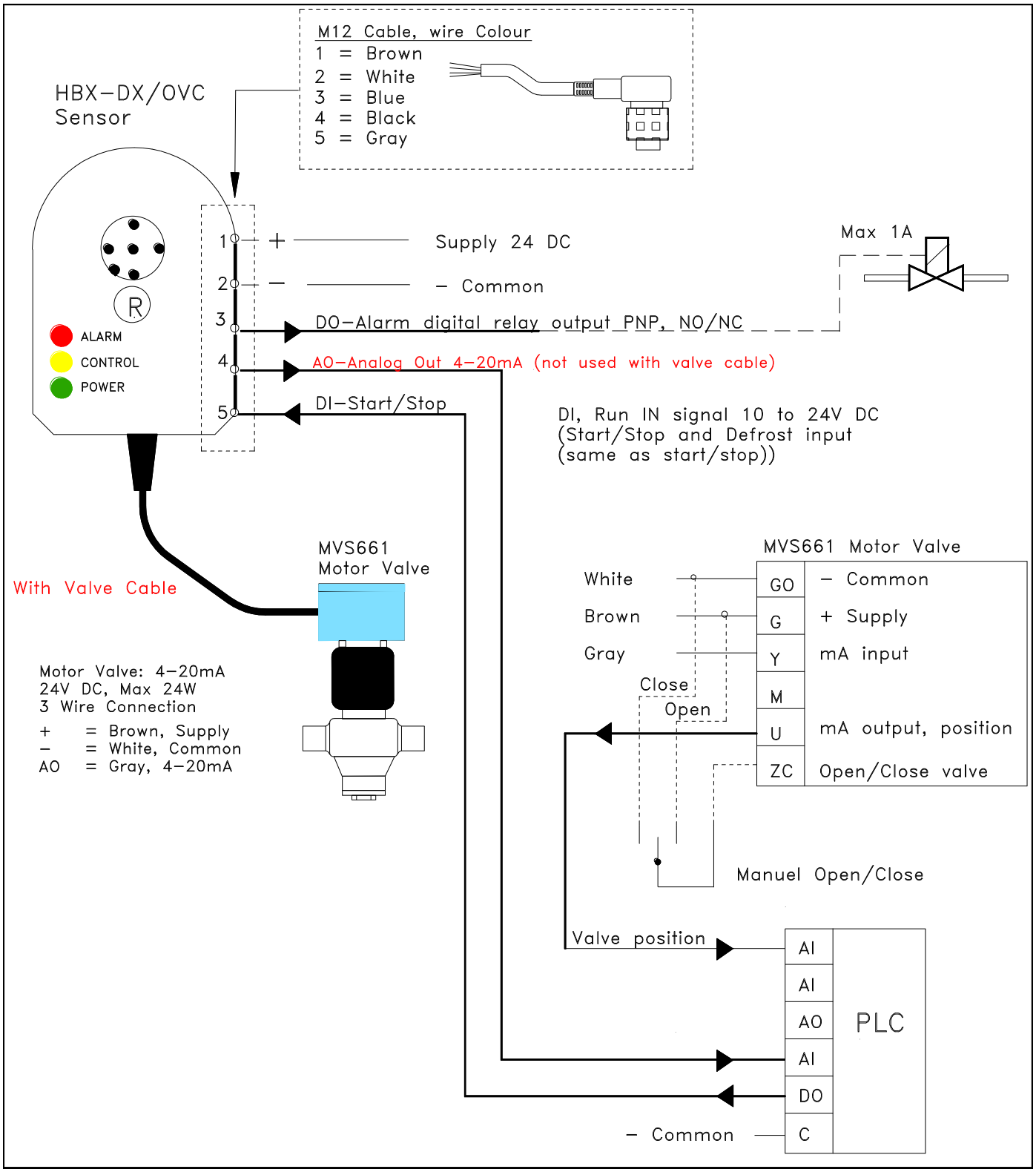
Example of an installation where you can perform setup and settings outside the freezer.



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

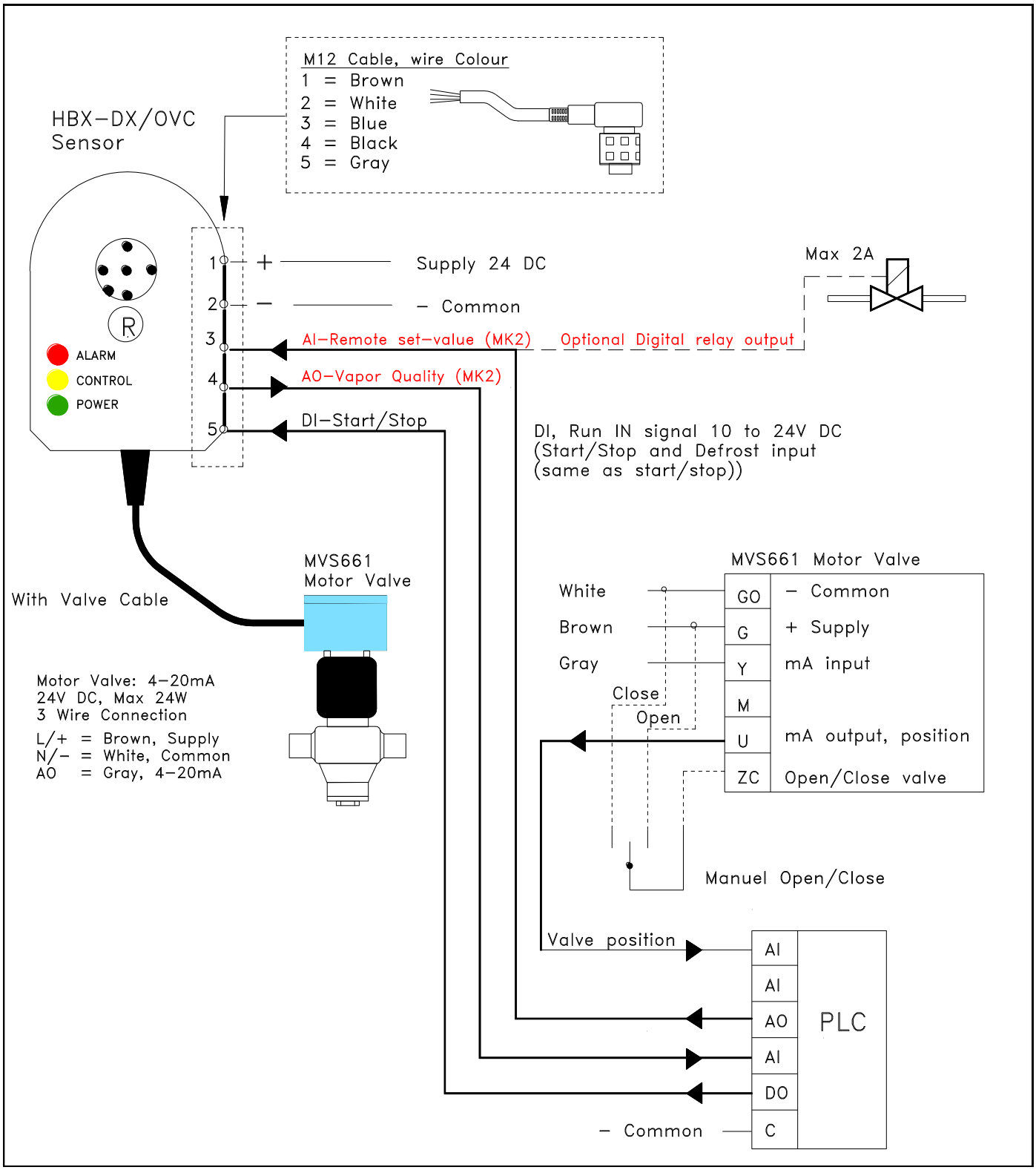
Inside the freezer

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



HBX-DX & HBX-OVC sensors used as control

- With valve cable is there no mA output on pin.4.
- Sensor output 3 is 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).
- Digital input pin.5 is used to start and stop control.
- 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)



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)

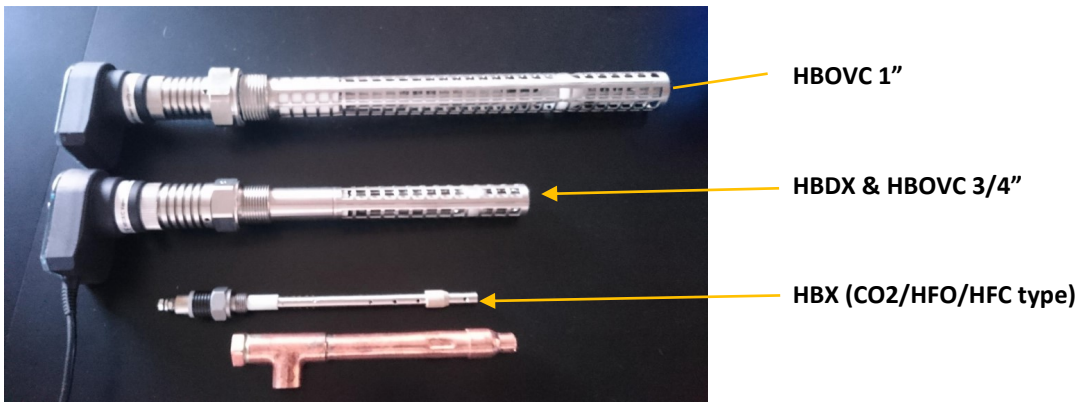
Setting : HBX-DX & HBX-OVC Rod style sensors

Application	3/4" Rod type, 160mm	1" Rod type, 300mm
Zero settings HBDX & HBOVC	**Zero: 42pF +/-1pF (W. Temp. –30C)**	**Zero: 46pF +/-1pF (W. Temp. –30C)**
Span settings **HBX-DX ("X"=0.8 to 1.05)**	**Span: 20pF +/-5pF**	
HBX-OVC ("X" = 0.5 to 1.0)	**Span: 50 to 400pF**	**Span: 50 to 200pF**
Basic settings HBX-DX	**Filter: 10sec. Run-In: ON** **Alarm: 0.8 Alarm delay: 10sec**	
Basic settings HBX-OVC	**Filter: 10sec. Run-In: OFF** **Alarm: 0.5 Alarm delay: 60sec**	**Filter: 10sec. Run-In: OFF** **Alarm: 0.5 Alarm delay: 60sec**

Note:

Higher operating pressures require a different adjustment of the zero value (dry vapor/gas) because of a higher relative density, for example will a change in pressure from 0.2bar to 5bar resulting in a changes from 42pF to 44pF (HBX-DX, Rod 160mm)

By performing the zero calibration at desired operating temperature / pressure, compensation will be done automatically and ensure highest measurement accuracy.



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