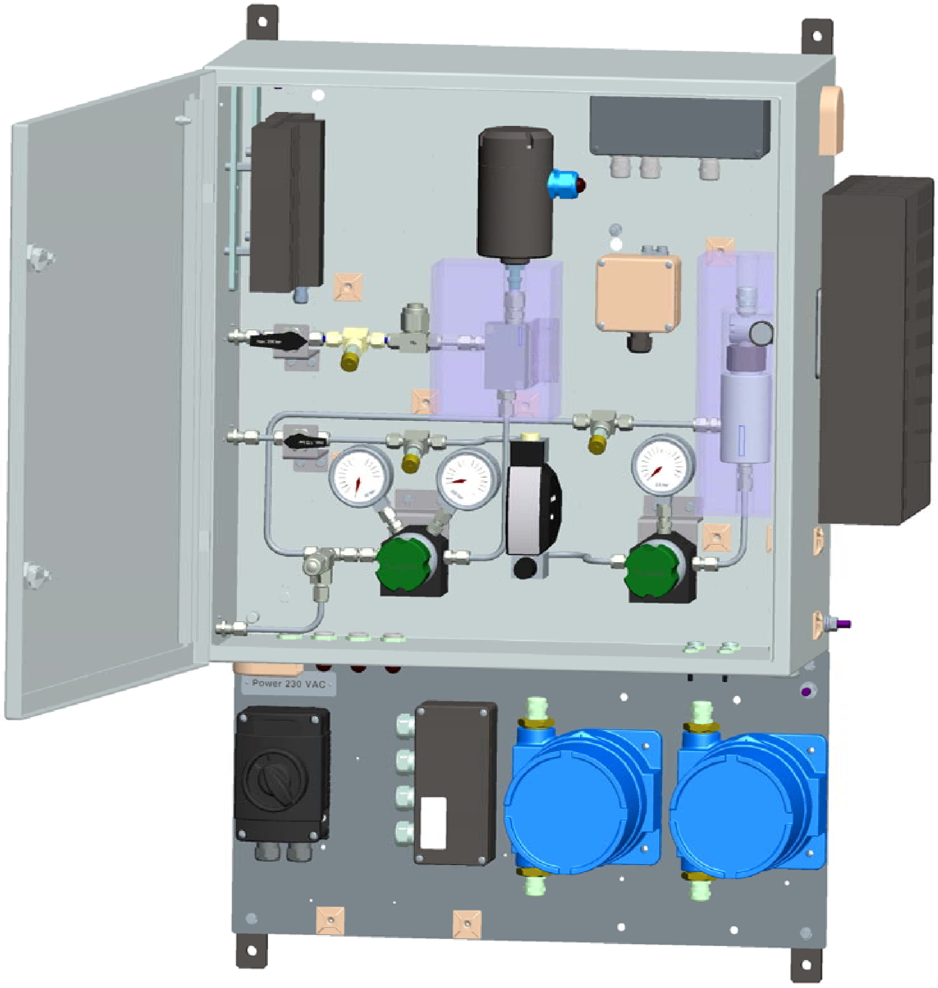
Product information

HYGROPHIL® HCDT

Measurement system for the detection of the hydrocarbon dewpoint and the water dewpoint in natural gas



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1 Introduction

The water dewpoint is generally defined as the temperature at which water vapour begins to condense. This phenomenon can be observed on every foggy morning. The air temperature decreasing down to the dewpoint temperature, water starts to condense and gathers in small drops. Something similar happens to eyeglasses steaming up on a humid day. The cold glass cools the air temperature down below the dewpoint temperature, water condenses on the cold side of the glass.

Compared to the hydrocarbon dewpoint, the water dewpoint can be determined quite easily because it is only a single component system.

The hydrocarbon dewpoint (**HCDT = H**ydro **C**arbon **D**ewpoint **T**emperature) behaves similarly to the water dewpoint, with the difference that this is a multi-component system. Natural gas consists of a multitude of lightweight, gaseous hydrocarbons and some heavy (longer-chained) hydrocarbons.
The composition of the gas and consequently also its quality heavily depends on the respective gas production area. First of all, the longer-chained heavy hydrocarbons condense and, in doing so, define the hydrocarbon dewpoint (HCDT) of the gas.

Why is it so important to measure the water and hydrocarbon dewpoint in natural gas?

As for the moisture (water dewpoint) in natural gas, the reason for this measurement is evident: Water vapour does not burn. Water vapour reduces the heating value and consequently impairs the quality of the gas. Far more important, however, are the reasons concerning the safety of the plant. Firstly, too much moisture in natural gas causes corrosion within the pipeline, which inevitably results in leakages.
Secondly, water may condense at cold places within the pipeline and, during the winter months, freeze to ice. This results in pipe blockages, cracking and leakages or even more severe damages of the equipment as well as safety risks.

Similar to the water dewpoint, the hydrocarbon dewpoint is primarily a measurement category for the quality of natural gas. The HCDT-value is depending on the amount of the higher hydrocarbons of the gas composition. Like water, hydrocarbons can condense in high-pressure lines at low temperatures and can cause plant damages and safety risks that have already been mentioned.
As hydrocarbons condense at significantly higher temperatures (cf. Fig. 1), however, it is especially important to monitor the HCDT value.

The combination of a high moisture content in high-pressured pipes with hydrocarbons can cause hydrate formation.
This natural gas hydrate (“burning ice“) is extremely bothersome in pipeline networks as it blocks the valves and the complete pipeline and causes pressure drops and a reduction of the flowrate.

To protect the equipment and to guarantee the failure-free operation of natural gas plants and pipeline networks, it is extremely important for natural gas companies to carry out exact, long-time stable and reproducible measurements of the water dewpoint and the hydrocarbon dewpoint.

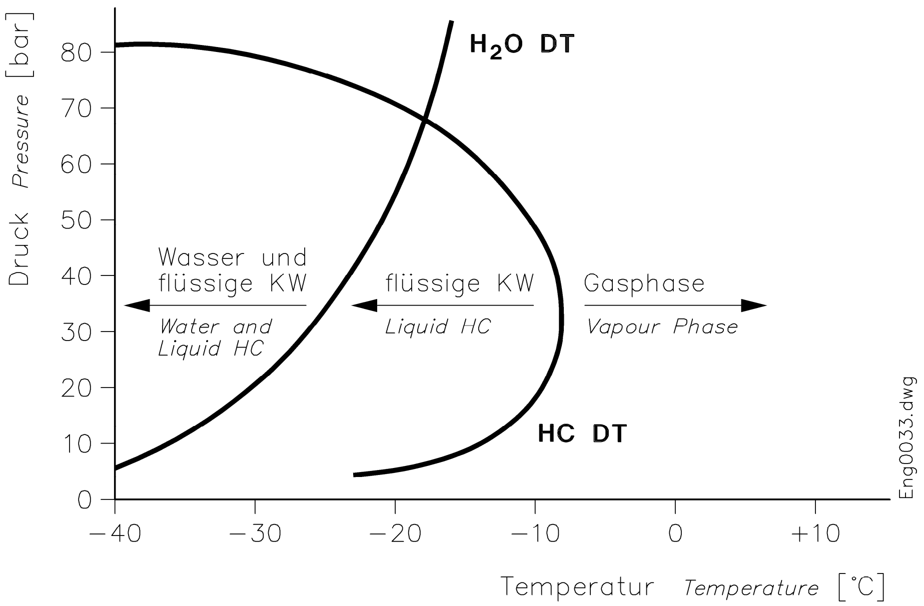
One of the conventional standard methods used so far is the time-consuming measurement by means of gravimetric procedures in accordance with BS EN ISO 6570 “Determination of the potential content of condensable hydrocarbons”. From the quantity of condensate measured at constant pressure and at different measurement temperatures, the hydrocarbon dewpoint can be determined. On the other hand, the hydrocarbon dewpoint can also be calculated by means of a gas-chromatographic analysis of the exact gas composition in combination with intricate mathematical interrelations.

2 Physical principle

For the determination of the hydrocarbon dewpoint temperature, the HYGROPHIL® HCDT made by BARTEC BENKE applies the fundamental and approved standard method of the chilled mirror principle. This principle, which was discovered by Regnault in the 19th century, is based on the cooling of a mirror surface which is flowed by gas. When the dewpoint temperature has been reached, condensate is deposited on the mirror surface.

Fig. 1 roughly illustrates the interrelationship between water dewpoint and hydrocarbon dewpoint

Fig. 1

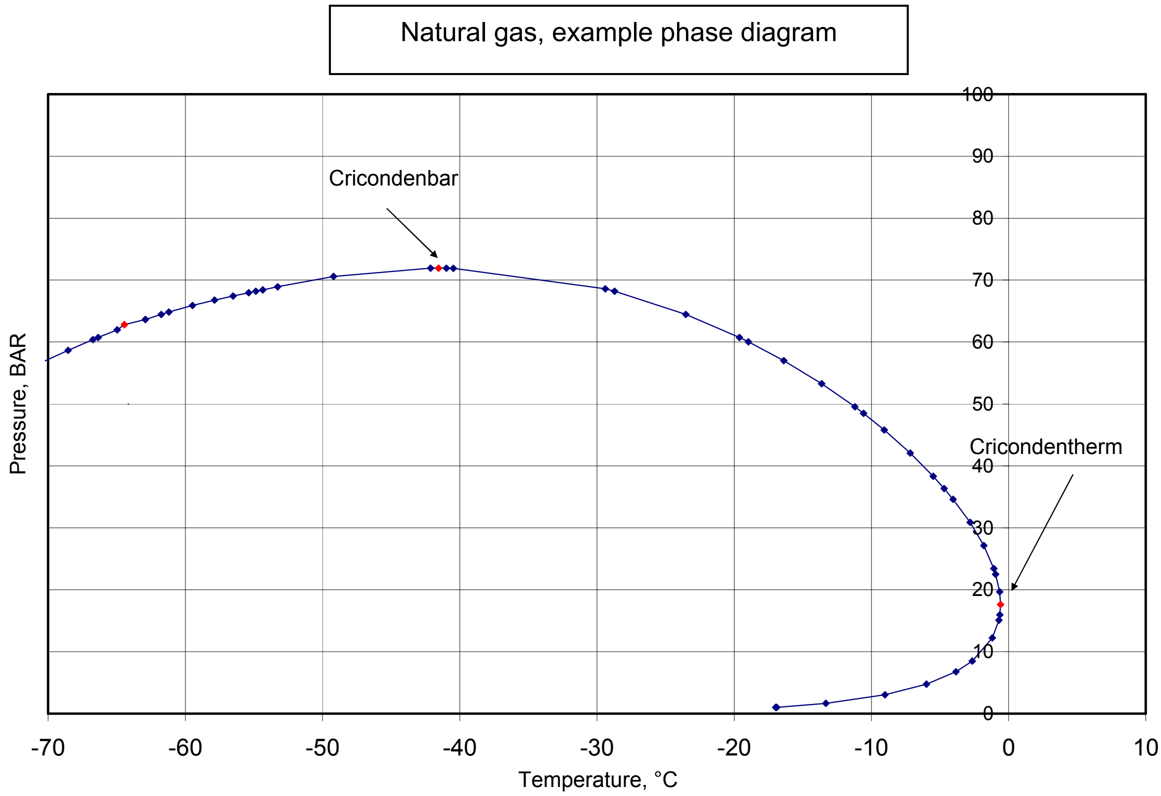


As can be seen in Fig. 1, in most of the cases the higher hydrocarbons condense before the water.
The phase diagram (HCDT curve in Fig. 1) can be calculated from the composition of the natural gas. Fig. 2 shows an exemplary phase diagram. The condensation curve represented there contains two extremums: the cricondentherm point and the cricondenbar point.

The cricondentherm point (“critical condensation temperature“) is the maximum temperature at which 2 phases (liquid phase, gas phase) can occur. In other words, at this specific temperature the condensation of the hydrocarbons starts, which corresponds to the hydrocarbon dewpoint.

The HCDT sensor 1510-11 measures the hydrocarbon dewpoint exactly at this point, whereas the moisture (water dewpoint) is measured under pipeline pressure and by means of the well-proven and long-time stable fiber-optical measurement principle of the L166x sensor.
To create these different measurement conditions, the gas will be prepared in a sample conditioning system.

Fig. 2

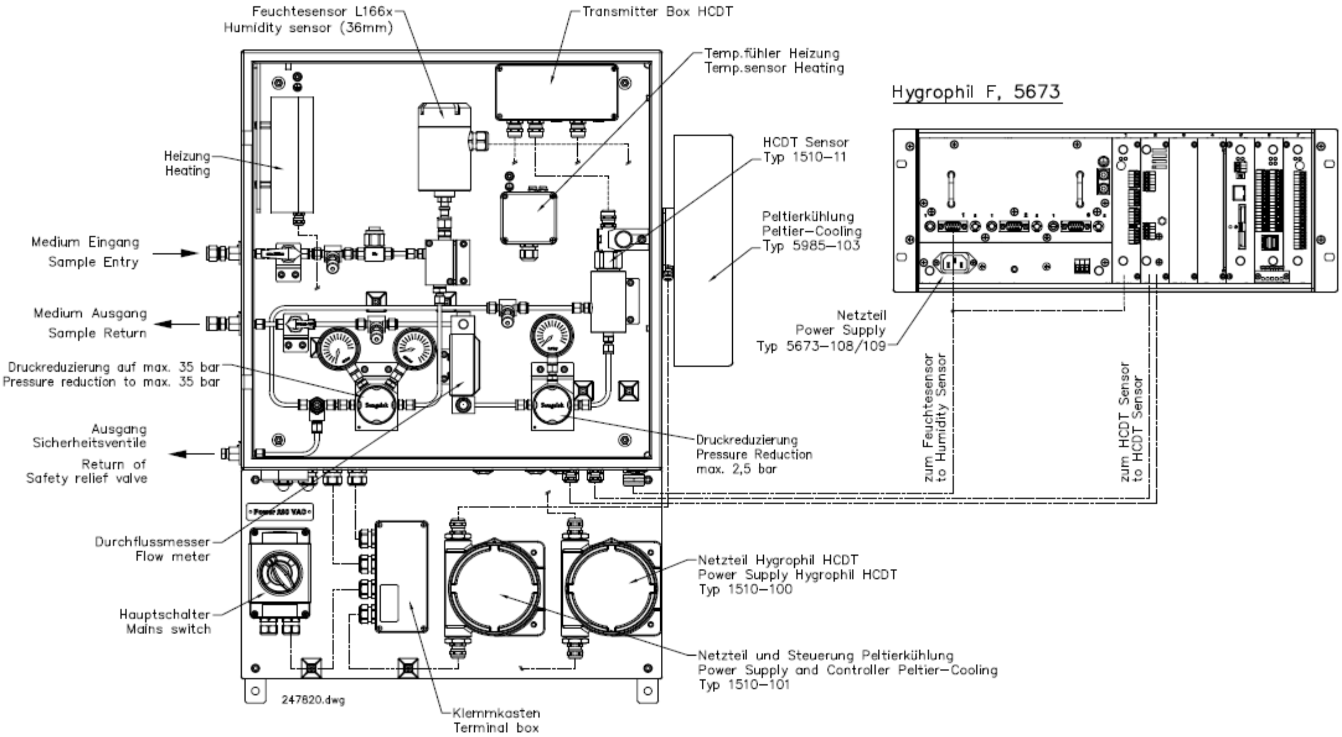

Natural gas, example phase diagram
Cricondenbar
Cricondentherm
Pressure, BAR
Temperature, °C
100
90
80
70
60
50
40
30
20
10
0
-70
-60
-50
-40
-30
-20
-10
0
10

3 Design of the measurement system HYGROPHIL© HCDT

The complete measurement sytem (cf. Fig. 3) consists of the following components:

- HCDT sample system 5985-7x
- HCDT sensor 1510-11 incl. transmitter
- Moisture sensor L166x
- HYGROPHIL® F 5673 display unit

Fig. 3

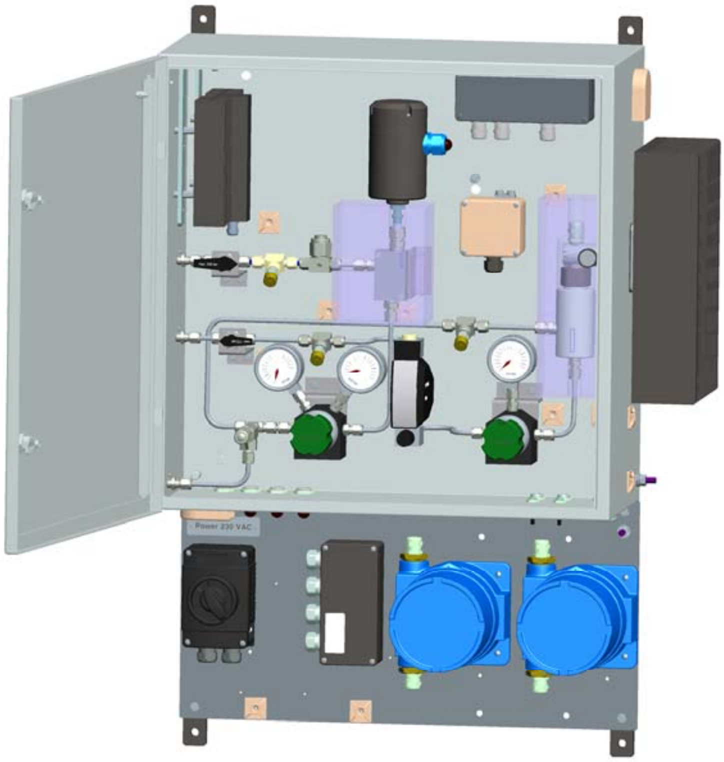


HCDT sample system 5985-xx

Via a heated pipe the sample system is connected to the pipeline (process). In the sample system, the natural gas is conditioned, i.e. pressures are reduced, the flowrate is regulated, and temperatures are controlled. The system includes the moisture sensor L166x for the measurement of the water dewpoint under line pressure, and the HCDT sensor 1510-11 for the measurement of the hydrocarbon dewpoint at the cricondentherm point.
The system is approved for ATEX and CSA.

Fig. 4 shows the HCDT sample system *(distance to analyzer > 20 m)*

Fig. 4



HYGROPHIL® F 5673

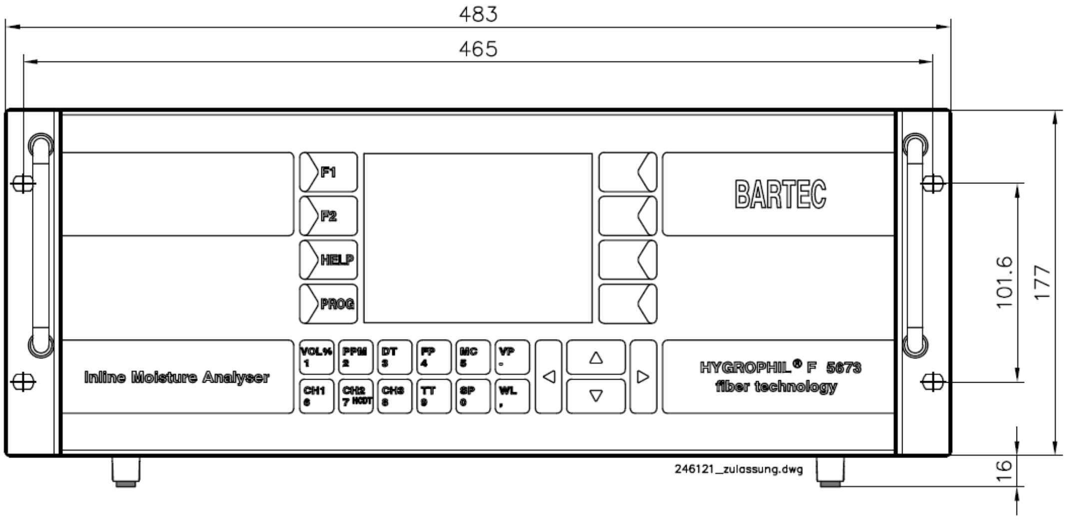
In the last 10 years, the measurement system HYGROPHIL® F 5673 with its fiber-optical sensor L166x has established itself very successfully in the field of ”moisture measurement in natural gas“.

The sensor regulation (HCDT-sensor 1510-11) is performed by the analyzer HYGROPHIL® F 5673.

The analyzer evaluates the sensor data, represents the data graphically and stores all available data in an integrated data logger. For the data transfer to superordinate conduct systems, not only analog outputs but Modbus, Profibus and USB are available.

Fig. 5 shows the display unit HYGROPHIL® F 5673

Fig. 5 Dimensions in mm



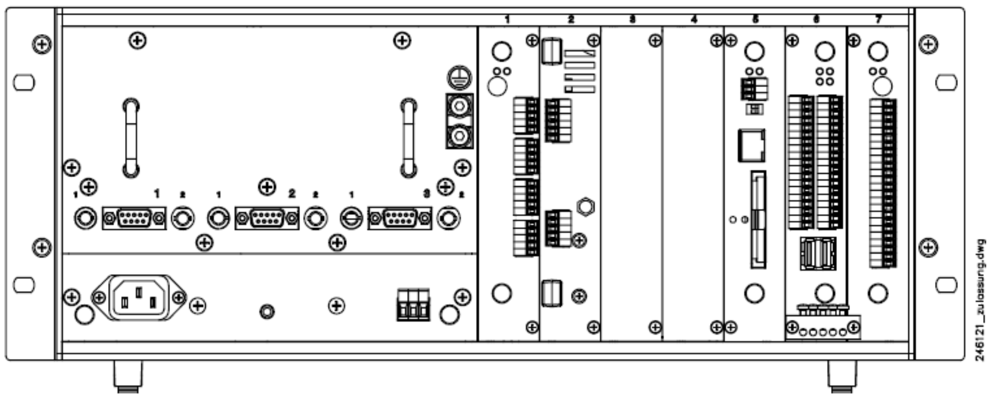
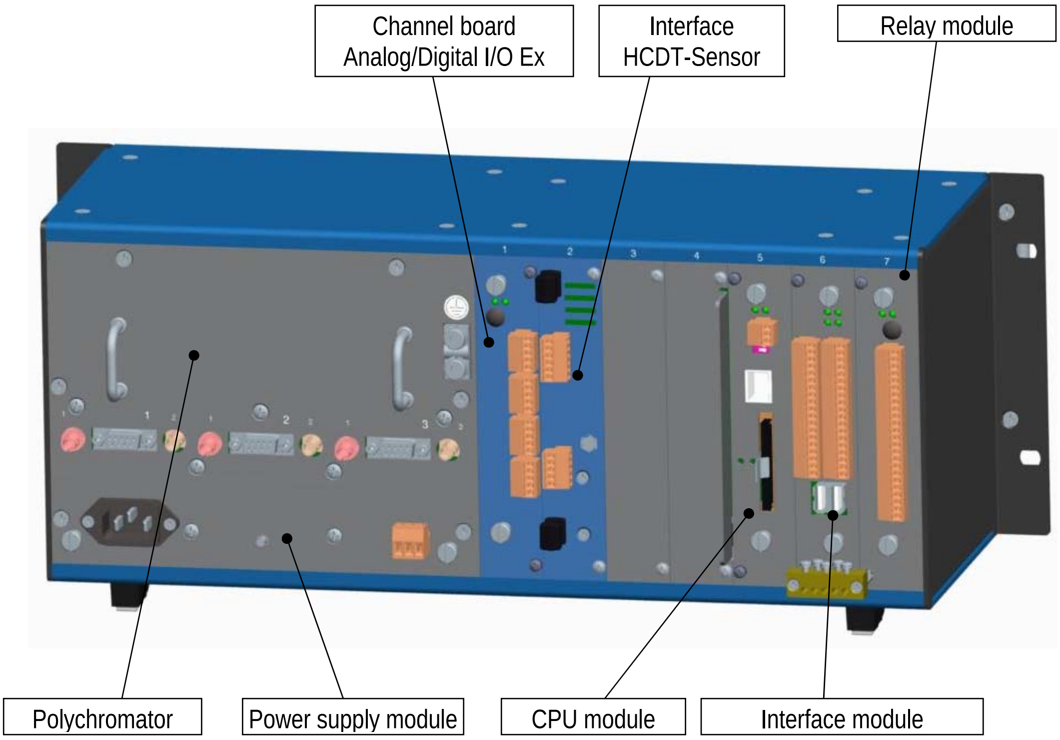
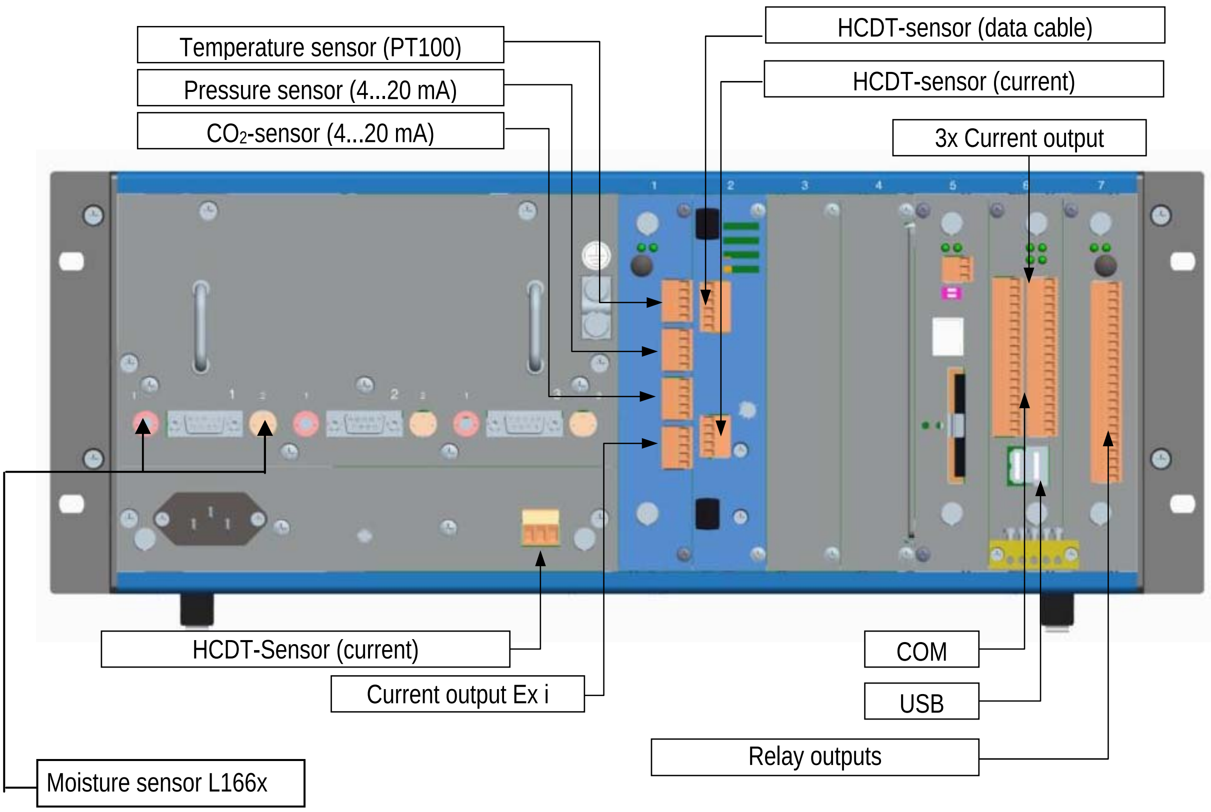


Fig 6 Overview of interfaces





4 Sensors

Measurement of the water dewpoint

The measurement of the water vapour dewpoint is carried out via Hygrophil® F and the sensor type L166x.
The moisture sensor type L166x consists of a robust multilayer of optically high-refractive and low-refractive layers connected to 2 fiber-optical cables. By means of a special thermal coating technique, pores with the diameter of a water molecule (approx. 0.3 nm) are generated on the layer. Due to the equilibrium relative humidity, water is deposited in the layer. Due to the different refraction indexes (air: 1.00 / water: 1.33), this results in a wavelength shift in the layer system in proportion to the moisture prevailing in the medium. This shift (i.e. no intensity! ->path-neutral) is registered by the display unit and assigned to a dewpoint.

L166x measures in a way that is both temperature-compensated (integrated Pt100) as well as pressure-compensated.

Hygrophil© F 5673 works in conjunction with a combination sensor which determines the moisture content in the medium in a fiber-optical way and the temperature in the medium via a Pt100.

Not only the highly robust design of the sensor but also the measurement principle itself offers a number of decisive advantages. Some of the advantages of this patent-protected measurement principle are:

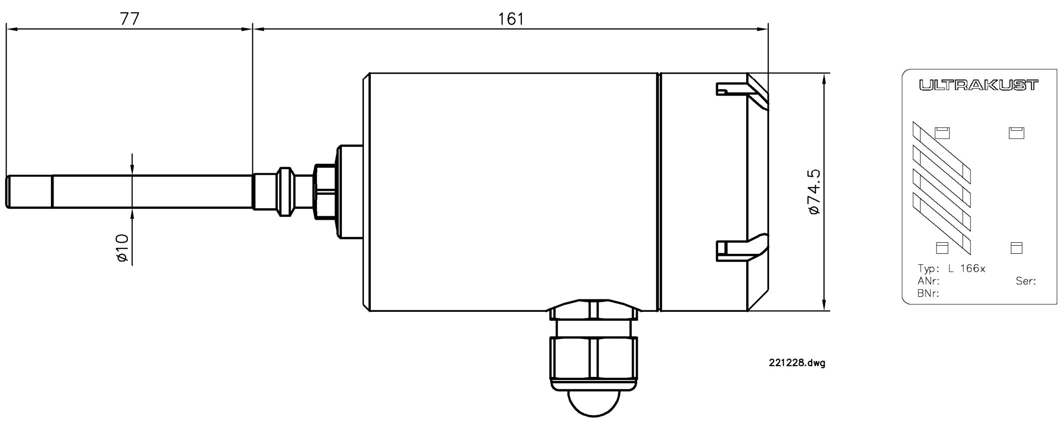
- High measurement safety including precision, reproducibility and low hysteresis
- Long-term stability of the sensor
- Measurement on high-pressure side is possible (pressure dewpoint!)
- Application in explosion-hazardous areas (zone 0 and higher)
- Easy installation and retrofitting (Swagelok, Parker, …)
- Low-maintenance

L166x has been developed specifically for the natural gas industry and is meanwhile used for the measurement of trace moisture in various gases and liquids. Due to the high-quality materials that are used, the sensor is extremely robust and resistant to almost all medium.

For more detailed information, see product information „HYGROPHIL® F 5673“

Fig. 7 shows moisture sensor L166x, dimensions in mm

Fig. 7



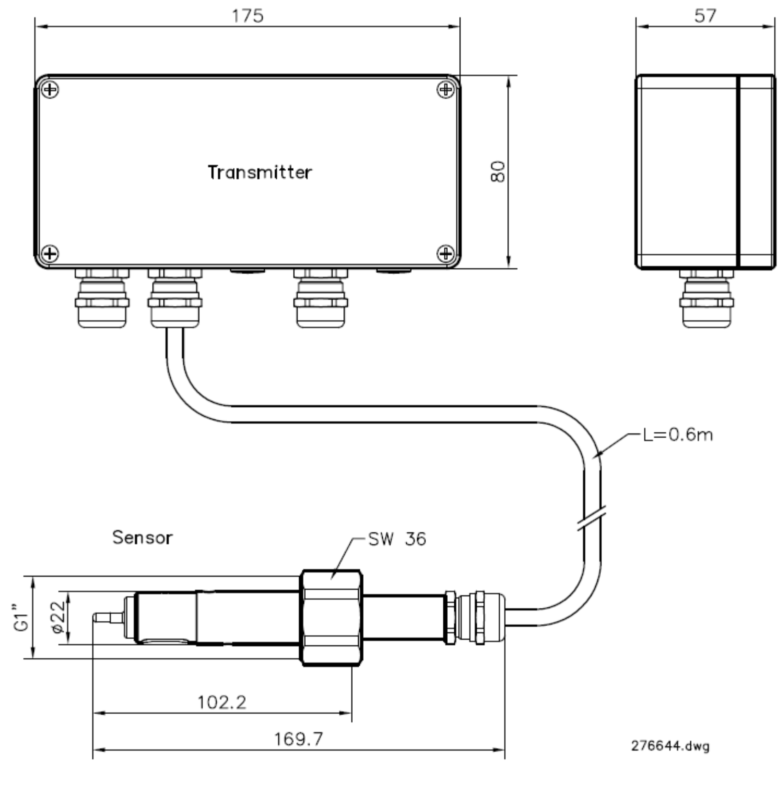
Measurement of the hydrocarbon dewpoint

For the measurement of the hydrocarbon dewpoint, the optical dewpoint sensor 1510-11 is integrated into the sample system after the pressure reduction (5…35 bar rel) (p corresponding to the cricondentherm pressure).

Fig. 8 shows the sensor tip of the HCDT sensor 1510-11, Fig. 8 shows the layout with the transmitter

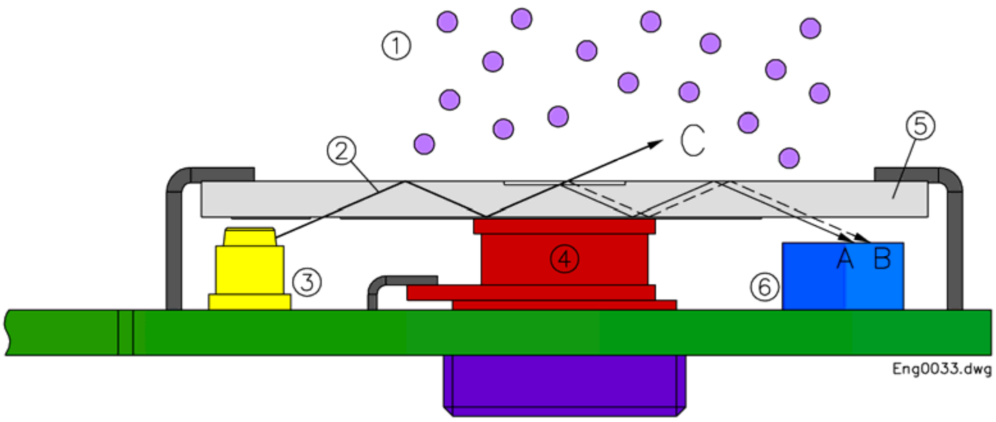
Bild 8

Fig. 9 Dimensions in mm



The HCDT sensor works according to the novel and patented method of internal total reflexion. Fig. 10 illustrates this measurement principle in detail.

Fig. 10



①	**Gas**	④	**Peltier element**
②	**Light beam**	⑤	**Glass substrate**
③	**LED**	⑥	**Photo diode**

The innovation consists essentially in the fact that the light signal is not conducted through the gas stream like in conventional chilled mirrors. The beam transmitted by LED is not sent to the mirror surface from above but fed into the mirror surface from below. By means of a screen, the light beam is coupled into the sensor glass under a certain angle and is totally reflected within the glass. A small area of the glass has been optically treated in such a way that the light is coupled out there as long as no condensation takes place.

By means of a Peltier element, the glass panel is cooled down until the condensation point is reached and the first longer-chained hydrocarbons deposit on surface. At the boundary area between condensation film and gas, the light that has originally been coupled out is coupled back into the glass and is conducted to the photodetector.
The temperature at this location is measured by means of a PT1000 sensor which is evaporated onto the sensor glass and frames the area decisive for the measurement.

Light beam A shows an undisturbed internal total reflection. Light beam B shows the development in the case of a a reflection at the boundary layer condensate - gas. Light beam C shows the development in the case of a coupling-out caused by a lack of condensate.

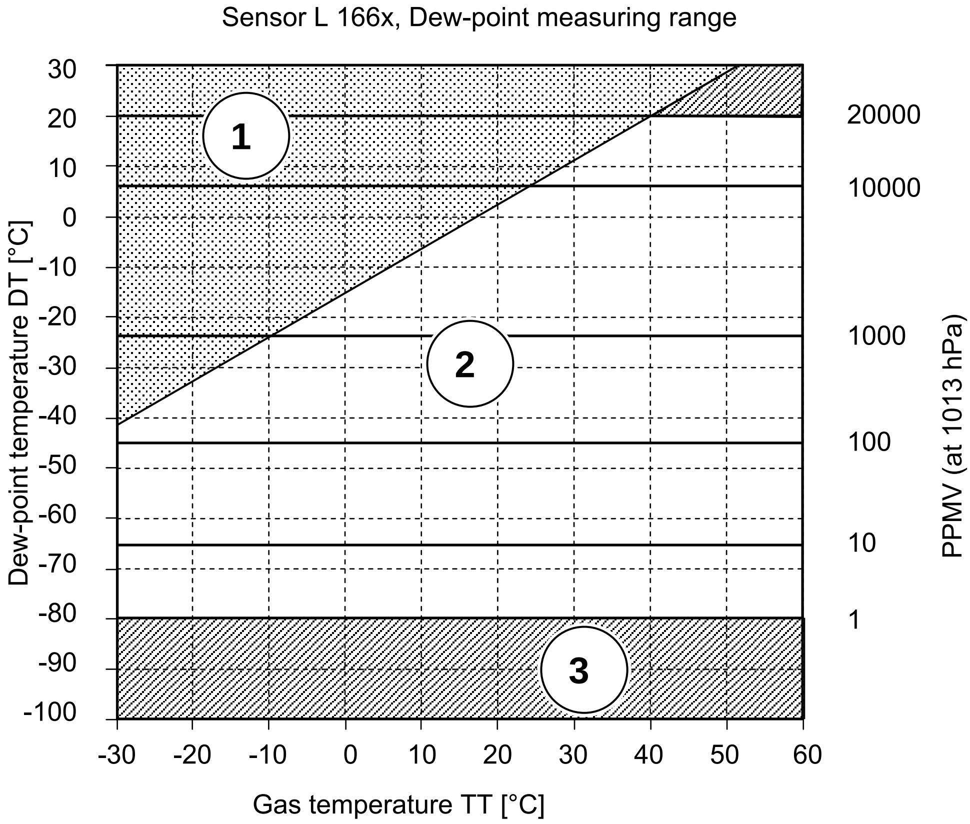
The advantage of the BARTEC BENKE design over conventional technology consists in the fact that particles carried along in the gas have no influence on the measurement. In addition, the size of the chilled mirror has been drastically reduced. This compact structural shape makes sure that heating and cooling processes can be carried out very quickly.
The chilled mirror technology is the most approved and most precise method to determine gas moisture. So far, it has mostly been applied for calibration and research purposes.

A measurement value drift can be excluded as, on the one hand, platinum temperature sensors are considered to be drift-free and, on the other hand, no movable and/or changing sensor components have been used. Therefore no cyclical recalibration of the sensor is required.

5 Measurement ranges

Measurement range of moisture sensor L166x

Fig. 11



① Out of calibrated range ② Calibratable range ③ Function range extrapolated

The sensor L 166x has a calibrated measurement range of -80 ° C ... +20 ° C DT in the pressure range up to 100 bar (200 bar per test certificate). The sensor measures with an accuracy of ± 1 K.

Application- and measurement range of HCDT sensor 1510-11

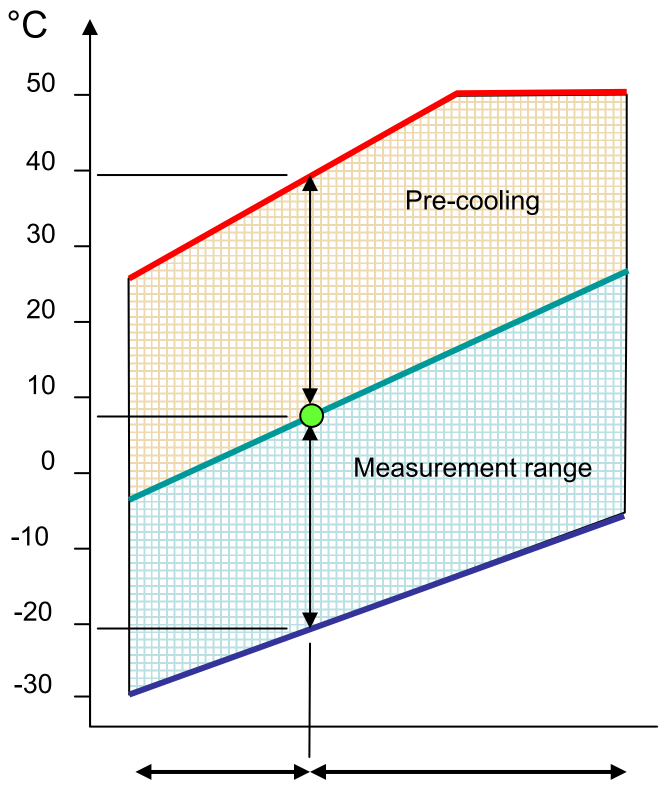
By means of the integrated Peltier cooling and depending on the density (pressure) of the gas, a cooling up to 35 K compared to the temperature of the sensor shaft can be reached. The pre-cooling unit expands the cooling range up to 60 K.

Fig. 12 shows the application- measurement range of the sensor. Via the default setting of pre-cooling the desired dew point measurement range is selectable, depending on the ambient temperature

.

Fig. 12

Application- measurement range



By default setting pre-selected sensor shaft temperature determines the dewpoint measurement range

Temperature sensor shaft — default setting

Lowest detectable hydrocarbon dew point

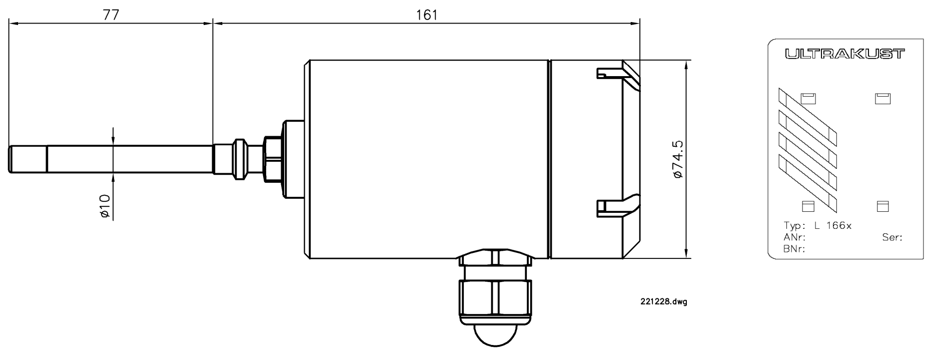
Maximum ambient temperature

6 Technical data

Technical data of Hygrophil F, type 5673-xx, display unit			
Device-specific data			
Display range (no measurement range)	**Measurand**	**Start of range**	**End of range**
	Vol %	0 %	100 %
	PPMV	1 ppm	25000 ppm
	VP	0 mbar	250 mbar
	MC	0 mg/m³	30000 mg/m³
	DT/FP / HCDT	-100 °C / -30°C	+100 °C / +30°C
	SP	0 bar	250 bar
	TT	-50 °C	+100 °C
Display	Graphic display 320 x 240 dots		
Keyboard	Touchscreen with red background illumination		
Electrical data			
Auxiliary energy	DC 10 - 36 V max. 60 W (Si 6.3 A T) AC 100 - 240 V max. 110 VA (Si 3.15 A MT)		
Auxiliary variables	Temperature (TT) at the measurement spot is measured by means of a Pt 100 sensor integrated in the humidity probe or entered manually as a constant factor. Pressure (SP) is measured via a 4 - 20-mA signal from an external pressure transmitter or entered manually as a constant factor. CO_2 content (0 - 100 %) is entered via a 4 - 20mA signal or entered manually as a constant factor.		
Measurement rate	Max. 3 measurements / minute DT / 6 measurements / hour at 5 °C HCDT (first measuring value after 30 min)		
Inputs	Light conductor connection for optical humidity probe 9-pole D-SUB plug for characteristic curve of sensor Clamp connection for Pt100 measurement from L166x Clamp connection for signal from a pressure transmitter, 4 - 20 mA (active or passive) Clamp connection for signal 4 - 20 mA (CO2 content) Clamp connections for HDCT-sensor All inputs Ex ia, galvanically separated		
Analog outputs	Clamp connection 0/4 - 20 mA, Ex ia, galvanically separated Source and sink, intrinsically save Resolution 0.0003 mA Burden < 500 Ω, Precision 0.03 mA Temperature drift < 0,001 mA/°C		
3 analog outputs interface board COM	Clamp connection 0/4 - 20 mA, galvanically separated Source; Resolution 0.0003 mA Burden < 800 Ω, Precision ± 0.15 % (0.03 mA) Temperature drift < 0.001 mA/°C		
Control outputs	8 relay changeover contact, 30 V/1 A Connection via plug-in terminals 2 switching outputs "Limit" and "Error"		
Interfaces	Ethernet, RS 232, RS 485 Modbus, Profibus, USB		
Ambient conditions			
Operating temperature	0 … +50 °C		
Storage temperature	-20 … +60 °C		
Climatic class	IWI in accordance with DIN 40040		
Approvals	ATEX, CSA, CRN, GOST		
Mechanical data			
Weight	approx. 8,5 kg		
Dimensions	W x H x D 483 x 192 x 212		
Casing	Suitable for 19" installation and as desktop device		

Technical data of moisture measurement probe, type L166x	
Device-specific data	
Integrated Pt100	DIN IEC 751, 4 conductor Class A
Calibrated range	-80 °C … +20 °C DT
Precision DT	+/- 1 K
Ambient conditions	
Operating temperature	-30 … +60 °C
Storage temperature	-30 … +60 °C
Maximal admissible working pressure	100 bar, 200 bar with test certificate
Protection type	IP 65 (when built-in)
Approvals	ATEX, CSA, CRN, GOST
Mechanical data	
Material	Shaft: 1.4571 Sensor head: POM

Dimensions of moisture sensor L166x (Dimensions in mm)



Technical data of HCDT sensor	
Measurement range	
Application range of HCDT	-30 … +30°C
Calibrated range (standard)	-20 … +5°C
Maximal cooling compared to pre-cooling	bis 35 K
Precision of HCDT	± 1 K
Ambient conditions	
Pressure range of probe	max. 40 bar
Mechanical data	
Material of casing (transmitter box)	Aluminium, coated
Material of probe shaft	Copper, nickel-plated 10µ
Protection type of casing	IP 65
Approvals	ATEX, CSA

Dimensions of HCDT sensor 1510-11 (Dimensions in mm)