3.3 Humidity Sensors

3.3.1 Selecting the Right Humidity Sensor

Different methods are usually used for measuring humidity variables:

Air Humidity:	**Advantages**	**Disadvantages**
Capacitive Sensor	The sensor can be used over long time periods, even at subzero temperatures without maintenance required. Independent from atmospheric pressure, also operational under pressure.	Sensitivity with respect to moisture condensation and certain aggressive media. Limited long-term stability.
Psychrometer	No aging of the sensor except the contamination of the wick. High accuracy and high-quality measurement. Can be used up to 100%r.H. in all media, without problems.	Long-term measurements are limited by water supply and maintenance of the wick. Use at subzero temperatures and low humidity levels is difficult. Depends on atmospheric pressure.
Hygrometer	Easy and less expensive measuring method. Also suitable for contaminated environment, easy to clean.	Limited accuracy. Limited measuring range. Slow-acting measurement.
Dew point mirror	High accuracy, reliability and reproducibility. Large meas. range. Independent from atmospheric pressure. Also for subzero temperatures.	Lavish measuring method, high power consumption and danger of contamination. Not useful for control measurements.
CCC* Dew point probe according to Heinze	High accuracy, reliabiity and reproducibility. Large measuring range.	Lavish measuring method. Not useful for quick control measurements. Not to be used at subzero temperatures.
Moisture:		
Moisture probe for materials dielectric	Simple and fast measuring technique, non-contact measurement. Long-term use is possible.	Limited accuracy.
Moisture probe for materials using the conductivity principle	Simple and fast measuring technique	Limited accuracy. Probe punctures, short-term control measurement only.

3

Basic Principles of Humidity Measurements

The atmospheric air always contains humidity in the form of water vapour. The contents of the water vapour can vary. The **saturation vapour pressure** is the maximum possible partial pressure of the water vapour that can be reached at a given air temperature above a level water surface. It is temperature depending and, therefore, there is a maximum content of water for each temperature, which can be contained in a given air quantity. The air humidity is specified either as **absolute humidity** or as **relative humidity:**

The **absolute humidity** is also called water vapour content. It indicates the weight of the water vapour contained in $1m^3$ of a mixture of air and water-vapour. Depending on the pressure and temperature, $1m^3$ can contain a varying air mass. Therefore, it is in many cases easier to relate the absolute humidity to 1kg of dry air. This variable is also called the mixture ratio (MH).

The **relative humidity** (RH) is the ratio of the water vapour partial pressure (VP) in a water vapour-air mixture to the saturation vapour pressure (SVP) at the air temperature (TT). The temperature of where the saturation occurs (VP=SVP, RH=100%) is also called the dew point temperature (DT). If the temperature falls below that specific temperature the water vapour will precipitate in a form of droplets. The enthalpy is the heat content of the water vapour-air mixture.

Saturation vapour pressure [mbar]:	SVP = C1 · EXP(C2 · TT/(C3+TT))
	C1=6.1078 mbar, C2=17.08085, C3=234.175 K
Relative humidity [%H]:	RH = 100 · VP/SVP(TT)
Mixture ratio [g/kg]:	MH = 622 · VP/(SP-VP)
Enthalpy [kJ/kg]	h = 1.006 · TT + 0.00186 · MH · TT + 2.5 · MH
Dew point temperature [°C]:	DT = C3 · LN(VP/C1)/(C2-LN(VP/C1))
	VP = Water vapour pressure [mbar]
	SP = Atmospheric pressure [mbar]

Humidity Measurement Using ALMEMO® Sensors:

When using ALMEMO® sensors, important functions for measured values are automatically activated in ALMEMO® devices when humidity measurements are performed. The most important humidity variables (temperature, rel. humidity, dew point, mixture ratio, partial vapour pressure or enthalpy) can be programmed on four channels with the corresponding sensors. For psychrometers the function atmospheric pressure compensation will be also activated.

3.3.2 Capacitive Humidity Sensors

Measuring Principle

Capacitive sensors contain a glass substrate with a humidity-sensitive polymer layer between two metal electrodes. By absorption of water, corresponding to the relative humidity, the dielectric constant and, as a result, the capacity of the thin-film capacitor are changing. The measuring signal is directly proportional to the relative humidity and is not depending on the atmospheric pressure.

Sensor

3

The variables humidity and temperature are directly measured with the capacitive humidity sensors FH A6x6. This allows to firstly calculate the partial vapour pressure and to determine the dew point and mixture ratio:

Partial vapour pressure [mbar]: VP = RH/100 · SVP(TT)
With standard sensors FHA646-x temperature compensation for humidity measurement takes place passively (range "°orH"). With ALMEMO humidity sensors FHA646-xC, an additional measuring range "HcrH" is available, within which the humidity is compensated actively over the whole operating temperature range (by means of the integrated NTC sensor); this is only available for certain types and versions of ALMEMO device (devices from 2003).

On ready-to-install sensors the measurable variables : air temperature (TT), relative humidity (RH), dew-point temperature (DT), and mixture ratio (MH) are already preprogrammed on four channels. Measurable variables TT and RH are assigned to channels 1 and 2; operands VP, DT, MH, and h can be assigned to channels 3 and 4. If an operand is selected, temperature and humidity are continuously measured in order to update the value displayed.

Measuring Variables	Des.	ALMEMO Meas. Ranges			Range	Dim
Air temperature:	TT	-50.00 ...	100.00	°C	Ntc	°C
Relative humidity:	RH	0.0 ...	100.0	%rH	°orH	%H
Rel. humidity FHA646-xC:	RH	0.0 ...	100.0	%rH	HcrH	%H
Rel. humidity FHA646-R:	RH	0.0 ...	100.0	%rH	H rH	%H
Dew point temperature:	DT	-25.0 ...	100.0	°C	F dt	°C
Mixture ratio:	MH	0.0 ...	500.0	g/kg	F AH	gk
Partial vapour pressure:	VP	0.0 ...	1050.0	mbar	H UP	mb
Enthalpy:	h	0.0 ...	400.0	kJ/kg	H En	kJ

As the maximum water vapour pressure (saturation vapour pressure) is depending on the temperature, the relative humidity is also, to a large extent, depending on the temperature. The relative humidity rises with falling temperatures and it drops with increasing temperatures.

☞ When measuring the relative humidity allow for the humidity sensor and the substance under test to reach the same temperature and a steady state. Temperature variations of only 1°C can invalidate the measuring result up to 6%.

Filter caps

Humidity sensors are protected by a protective cap against the risk of mechanical damage and against dirt / dust. There are, depending on application, various filter types available as options :

Model	Designation	Pore size	Maximum temperature	Typical application
ZB9600SK7	Metal-mesh filter in PC housing	100 µm	120°C	universal, for medium contamination, also high humidity
ZB9600SK6	PTFE sinter filter	50 µm	180°C	high chemical resistance
ZB9600SK8	stainless steel sinter filter	10 µm	180°C	for severe mechanical stress, heavy contamination, strong air flow

Maintenance and Calibration

The capacitive humidity sensors FH A6x6 are designed to operate reliably and efficiently with little maintenance efforts.
Please observe the following notes:

☞ The standard sensors are equipped with a dust filter. As a result of operation in dusty air the filter will become contaminated. Replace contaminated filters promptly as the response times will increase and measured values may be invalidated.

⚠ **CAUTION** when opening the protective cap!
The humidity sensor must never be touched! There is no warranty claim in case of a mechanical destruction of the humidity sensor.

Incorrect measuring data and exceeding of measuring ranges must be expected if the sensor is used at a high humidity level (>90%H) and if water is condensing for long periods.

☞ In such cases, allow the sensor to 'dry out' for several hours in an environment with the lowest possible humidity and a good air flow.

Check the test probes in regular intervals, e.g. yearly (depending on the application) and have them re-calibrated, if necessary.

Technical Data:

Humidity sensor:	capacitive thin-film sensor
Measuring range:	5 to 98 %rH
Operating temperature:	standard range -20 to +80 °C
	FH A646-xC: -20 to +80 °C
	FH A646-R: -30 to +100 °C
Nominal temperature:	25 °C ± 3K
Max. linearity deviation:	± 2 %rH (5...98%rH) by nominal temperature
Max. hysteresis:	1 %rH by nominal temperature
Operating pressure:	athm. pressure
	FH A646-7 up to 16 bar
Temperature sensor:	NTC type N (10kΩ at 25 °C)
Accuracy:	± 0.1 K (0...70°C)
Electronics:	
Storage requirements:	-20 to +85 °C, 0...90 %rH, non-condensing
Current consumption:	approx. 2 mA

Cable extension for capacitive humidity sensors

Capacitive humidity sensors are usually supplied with a sensor cable 1.5 meters long. However, depending on type, a longer sensor cable can be supplied (with FHA 646-Ex/ FHA 646-AG/ FHA 646-5x, up to 30 meters). Type FHA 646-R can only be supplied with a high-temperature cable 2 meters long. For all FHA 646 types, extensions of up to 4 meters can be implemented using passive extension cables ZA9060VK (see 3.10). Extensions of up to 100 meters can be implemented using intelligent ALMEMO extension cables ZA9060VKC (see 3.10). These cables are suitable for type FHA 646-ExC ("HcrH" range) and also for the type FHA 646-E1 ("°orH" range with multiplexer M4 C-B). Older FHA 646-x sensors with the "°orH" range can also be used if in the connector EEPROM the multiplexer is programmed to position M4 C-B (using AMR-Control software, “Program measuring points”, “Multiplexer”). With the intelligent ALMEMO extension cables the humidity correction values for the sensor connector are transmitted to the ALMEMO device automatically. This means that the sensor can be quickly and easily exchanged and calibrated (on site using a short cable)

Sensors with multi-point calibration on V6 devices cannot be connected to the intelligent extension cable.

When measuring humidity accuracy is not influenced by the manner of the extension. When measuring temperature (with the integrated NTC sensor) the extension does cause certain deviations depending on the temperature measured and on the cable length.:

NTC temperature sensor °C	NTC resistance sensor ohms	Error at 5 meters °C	Error at 10 meters °C	Error at 50 meters °C	Error at 100 meters °C
-20	97080	0	0	0	0
0	32650	0	0	0.01	0.02
25	10000	0	0.01	0.03	0.06
50	3603	0.01	0.2	0.09	0.18
70	1752	0.02	0.04	0.21	0.42
100	678.3	0.06	0.13	0.65	1.3

The values indicated are typical deviations for cables with a wire cross-section of 0.14 mm². This represents, at a cable length of 100 meters, a typical loop resistance of approx. 25 ohms (= 2 wires).

3.3.3 Psychrometer

Measuring Principle

A psychrometer is a precision instrument containing two accurate temperature sensors for determination of all humidity variables. One of the sensors is covered with a cotton stocking that is kept permanently wet by a water supply and kept cool by an air flow. If the integrated ventilator is operated after connection to the power supply, the moistened temperature sensor cools down by a defined amount, depending on the air temperature and humidity. From this psychrometric temperature difference, using the Sprung formula, the water vapour partial pressure and all other variables related to humidity can be calculated:

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Partial vapour pressure [mbar]: VP = SVP (HT) - C · SP · (TT-HT)
(see 3.3.1) C = 0.00066 · (1+0.00115 · HT)
SP = air pressure [mbar]

Measurement

The humidity variables can only be calculated correctly if both temperatures are continuously measured. This is automatically achieved with the Ntc psychrometer by alternatingly scanning both integrated Ntc sensors. With Pt100 sensors the acquisition of temperature data must be guaranteed by a manual, cyclic or continuous measuring point scan.

The appropriate use of the psychrometer is extremely important for obtaining reliable measuring results. Therefore, please follow these instructions:

1. After the fan has been started it takes approximately 20 to 30 seconds until the wet temperature sensor has cooled down. Only from that point in time reliable humidity data will be available.
2. Ensure that the humidity sensor is sufficiently moistened at all times (Section 4.1). If in doubt, visually check how moistened the cotton stocking or cotton wick is. Only use distilled water for moistening the wick, otherwise the wick could calcify.
3. Only for hand-held psychrometers:

   During measurement, if possible, hold the psychrometer so the water tank is located below the sensor and no additional water drops can form on the wick. Water drops on the dry temperature sensor or in the intake tube would invalidate the measuring result.
4. If the wick does not absorb any more water (contaminated or dried out) the cotton stocking should be replaced.
5. The **air velocity** at the intake tube must be 2m/s at minimum. Therefore, ensure that the air intake is not obstructed.

6. Only for hand-held psychrometers:
   If the BAT symbol is indicated on the display the supply voltage of the fan is no longer sufficient and the fan will not provide sufficient air velocity to the intake tube. Replace the battery.
7. Avoid **heating** of the measuring head by any external heat sources including body heat.

Atmospheric Pressure Compensation

On calculating the partial vapour pressure and the mixture ratio the current **atmospheric pressure** SP is depending on the sea level, which heavily influences the result of the measurement. For a compensation, the current atmospheric pressure can be entered and even measured (see 6.2.6). The input via keyboard is described in the operation manual of each device.

Three psychrometers are available in the ALMEMO® sensor range:

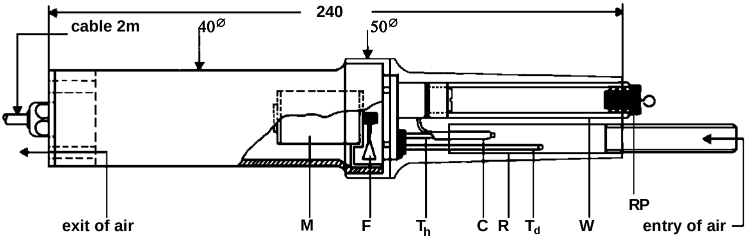
1. Hand-held psychrometer with 2 Ntc´s FN A846 (0...60°C), (water, no ice)
2. Stationary psychrometer with 2 Ntc´s FN A846-3 (0...90°C), (water, no ice)
3. Stationary psychrometer with 2 Pt100 FP A836-3 (0...90°C), (water, no ice)

3.3.3.1 Hand-held Psychrometer

Ntc Psychrometer FN A846:

The sensor for the dry temperature TT is allocated to the first measuring channel and the sensor for the humid temperature HT is allocated to the second measuring channel. The operands vapour pressure VP, rel. humidity RH, dew point temperature DT, mixture ratio MH and enthalpy h can be programmed to any channel of the measuring range, but the first two channels must be occupied (RH only is not possible!).

Measuring variables	**Des.**	**ALMEMO Meas. Ranges**		**Range**	**Dim**
Dry temperature:	TT	-30.00 ... 100.00	°C	Ntc	°C
Humid temperature:	HT	-30.00 ... 100.00	°C	P Ht	°C
Dew point temperature:	DT	-25.0 ... 100.0	°C	P dt	°C
Relative humidity:	RH	0.0 ... 100.0	% rH	P rH	%H
Mixture ratio:	MH	0.0 ... 500.0	g/kg	P AH	gk
Partial vapour pressure:	VP	0.0 ... 1050.0	mbar	P UP	mb
Enthalpy:	h	0.0 ... 400.0	kJ/kg	P En	kJ



Hand-held psychrometer FN A846

M=	Motor	C	= Cotton wick
F	= Fan blade	S	= Radiation protector
T_d	= Dry temperature sensor	W	= Water tank
T_h	= Humid temperature sensor	RP	= Rubber Plug with pin

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Filling the Water Tank:

A water tank is integrated in psychrometer sensors for moistening the humid temperature sensor. The filling can vary depending on the model.

1. Remove the rubber plug (RP) and pour in distilled water.
2. Close the water tank with the plug (wire removed).
3. Remove the plexiglass cover and position the psychrometer sensor so that the water tank is above the temperature sensors.
4. Turn the water tank counterclockwise (approx. 2-3mm) to initiate the water supply to the cotton stocking. When the cotton stocking looks darker and slightly shiny, turn the water tank 1-2mm clockwise to reduce the water supply.
5. Place the psychrometer in a vertical position and check whether a water drop forms. If so, wipe the water drop off. If another water drop forms afterwards, slightly turn the water tank once again clockwise.
6. Install plastic cover and perform the measurements.
7. After the measurements insert wire in the plug and rotate the water tank 1-2mm clockwise to reduce the water supply to the cotton stocking.

In certain circumstances a germination of the water in the tank can occur. Therefore, the water tank must be decontaminated approximately every 6 weeks. The tank should be emptied in case of longer shutdown periods or before transportation.

Replacing the Cotton Wick

A contaminated or crusted cotton wick is no longer adequately soaked, and this invalidates the measured value. Depending on the purity of the air and water it must, therefore, be replaced regularly.

1. Remove the cover (plexiglass) from the psychrometer sensor.
2. Unscrew the water tank.
3. Remove the cotton wick including the rubber and plastic disc from the bottom of the water tank.
4. Thread the open end of the new cotton wick through the holes of the rubber and plastic disc.
5. Guide the sensor tip of the short sensor through the hole, 3cm before the end, so that it rests securely at the served section. Place the cotton stocking together with the threaded discs on the bottom of the water tank.
6. Screw on the water tank.

3.3.3.2 Stationary Psychrometer FP A836-3; FN A846-3

Pt100-Psychrometer FP A836-3:

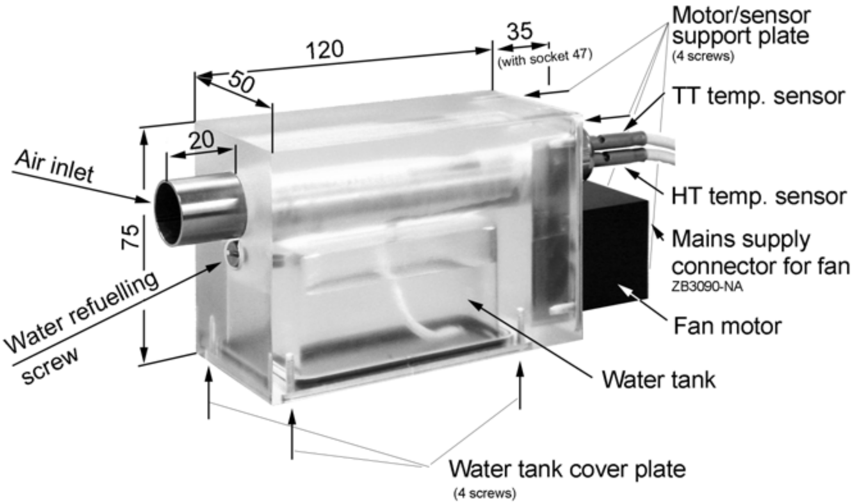
A psychrometer with Pt100 sensors for humid and dry temperature can be connected to any ALMEMO® measuring instrument that has at least 2 input sockets. For this purpose, all psychrometer measuring ranges for the determination of humidity data are supported. The two Pt100 sensors must be arranged in series and provide the P204 range, the humidity parameters must be programmed in the second sensor on the second to the fourth channel:

Sensor	Mst	Range	Dim	Description
Pt100	Mx:	P204	HT	humid temperature in °C *)
Pt100	Mx+1: chan. 1	P204	TT	dry temperature in °C *)
	chan. 2	P rH	RH	rel.humidity in %H
	to	P dT	DT	dew point temperature in °C
	chan. 4	P AH	MH	mixture ratio in g/kg
		P UP	VP	partial vapour pressure in mbar
		P En	h	enthalpy in kJ

*) Humid and dry temperature sensors must not be confused!

Programming of the Ntc Psychrometer FN A846-3:

The programming is the same as with the hand-held psychrometer, see section 3.3.3.1 Ntc Psychrometer FN A846 on page 3-3-6.



Fill water tank of stationary psychrometers:

1. Open the water refuelling screw.
2. Use the wash bottle supplied to fill distilled water into the water tank.
3. Re-screw the refuelling screw and perform the measurement.

Under certain conditions a germination of the water in the tank can occur. Therefore, the tank must be cleaned every 6 weeks (approx.). The tank should be emptied in case of longer intermissions or for transportation.

Replacing the wick of stationary psychrometers

A contaminated or crusted cotton wick is not adequately soaked and this will invalidate the measured value. Depending on the purity of the air and water it must, therefore, be replaced regularly.

1. Empty the water tank (see above).
2. Unscrew the cover plate of the water tank.
3. Unscrew the motor/sensor support plate and
   pull the old wick off the HT sensor.
4. Insert the new wick from the water tank side into the psychrometer tube and pull it over the HT sensor.
5. Re-screw the motor/sensor support plate.
6. Tighten the wick from the water tank side,
   re-screw the cover plate of the water tank and fill the water tank.

Technical Data

	FN A846	FN A846-3	FP A836-3
Humidity measuring range:	10 to 100% rH		
Accuracy at nominal conditions:	±1 %rH		
Temperature sensor:	2x NTC type N (10 k at 25°C)		2x Pt100
Accuracy:	0 to 70°C: ±0.1°C, 70 to 90°C: ±0.4°C		PT100 accord. to DIN/EC 751
Operat. temperature:	0 to +60°C	0 to +90°C	
Reproducibility:	< 1% rH		
Nominal conditions:	25°C ±3°C, 1013 mbar, 50% rH		
Air velocity:	approx. 2.5 m/s		
Operating voltage:	9 V DC through ALMEMO® device	12 V DC through external plug-in power supply ZB3090NA, (Option : extension cable for mains supply unit, 5 meters, ZB5090VK05)	
Current consumption:	approx. 10 mA	approx. 40 mA	
Dimensions, housing:	50 mm Ø, 245 mm long plastic	175 x 50 x 75 mm plastic (from 2003: polycarbonat)	
Weight:	approx. 300 g	approx. 890 g	

3.3.5 Moisture Sensors for Materials

Basic Principle of Moisture Measurement in Materials

The moisture in materials plays an important role in the processing of construction materials, wood and paper. It can be measured by a dry-out process in a heating cabinet, by measuring the balance humidity or, indirectly, by measuring the dielectric constant.

The latter two methods are especially suitable for quick comparison measurements. Differences in moisture can be measured in a non-destructive way and, as a result, problem areas can be easily identified. However, the measured values are depending on various factors. The measuring result is influenced by fluctuations in density, different ingredients, fluctuations in salt concentration and thickness of layer. For that reason, the measured values must not usually be interpreted as absolute values unless it is always the same material that is used and a reference measurement is performed for a calibration.

To obtain absolutely accurate measurement results the **drying chamber method** is indispensable. With this method, a sample of the material is taken and its weight measured. The sample is dried in the drying chamber until no change in weight can be measured anymore. From the weight difference the moisture content can then be accurately calculated.

Depending on the application two different calculation methods can be used:

Paper, construction materials:

$$\text{Moisture content of material} = \frac{\text{Wet Weight - Dry Weight}}{\text{Wet Weight}} \bullet 100\%$$

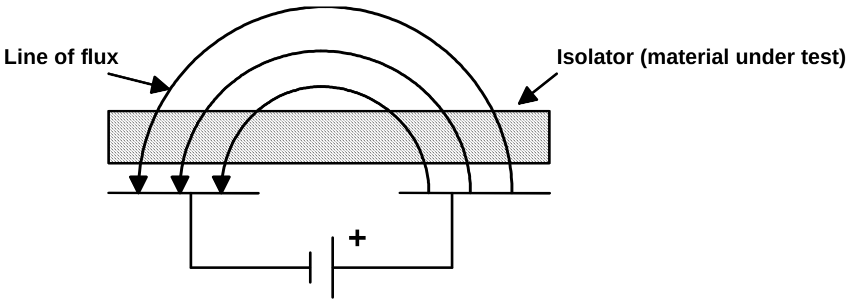
Wood:

$$\text{Moisture content of material} = \frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \bullet 100\%$$

3.3.5.1 Capacitive Moisture Probe for Mineral Construction Materials, Woods, Paper and Cardboard

Measuring Principle

The ALMEMO® moisture sensor FH A696-MF utilises the dielectric constant of water (Er=80) for measuring the moisture content in mineral construction materials, in wood, paper and cardboard, in a matter of seconds. A high frequency field penetrates the material under test and, by a capacity test (open capacitor), generates a voltage signal, which is proportional to the moisture content in the material.



The depth of the penetration into the material is approximately 25mm and this allows to measure the moisture content in deeper layers.

ALMEMO® Moisture Sensor

The measuring probe FH A696-MF can be easily connected to an ALMEMO® measuring instrument and can be used immediately. Time-consuming efforts to prepare the measurement are not required. The measuring probe is placed on the surface of the object under test and the moisture can be read immediately. To obtain maximum accuracy the material to be measured can be set at the ALMEMO® measuring instrument.

Choice of Materials

For the following types of material three measuring channels have been set up and individually aligned and have been provided with a characteristic dimension:

Measuring channel	Resol.	Dim	Range	Exp.	Base value
1. Min. construct. material	0.1 %	B%	d2600	3	cf. material
2. Wood types	0.1 %	H%	d2600	3	cf. material
3. Paper and cardboard	0.1 %	P%	d2600	3	cf. material

Each type of material covers a number of material groups that are characterised by a specific offset. This offset must be entered into the instrument as BASE VALUE according to the following tables:

Mineral construction materials:

Group	**Material**	**BASE**
B1	Ytong	0.0
B2	Clay brick, plaster, wall tiles	2.5
B3	Sand, cement, asbestos cement plaster boards, floor tiles, anhydrite floor	5.0
B4	Cement floor, concrete	6.0
B5	Marble	7.0

Wood types:

Group	**Material**	**BASE**
H1	Balsa	0.0
H2	Abachi, Samba	1.0
H3	Spruce, Gaboon, Ilomba, Lauan, Meranti light, Oregon, Poplar, Red-Pine, Fir	2.0
H4	Carolina Pine, Pine, Limba, Limewood, Horse-Chestnut, Silver Willow, Cedar	3.0
H5	Maple, Birch, Beech, Ash, Cherry, Nut, Pitch Pine, Red Oak, Ramin, Sipo, Teak, Elm	4.0
H6	Apple, Pear, Stalk and Grape Oak, Zebrano, Meranti dark, Merbau, Padouk, White Beech	5.0
H7	Hardboard, Jarrah, Keruing, Macore, Mahogany, Red Balau, Wenge	6.0
H8	Bongossi, Cocobolo, Ebony, Snakewood *With this group, not only the base value must be changed but also the slope must be changed to 0.9!*	7.0

Paper and cardboard:

Group	**Material**	**BASE**
P1	Filter paper, tissue paper	2.0
P2	Half stuff, crepe paper, Graupack, Testliner	2.5
P3	Packaging paper, cellular board	3.5
P4	Sulfate paper	4.5
P5	Offset paper	5.5

Programming the Base Value

The programming is performed as follows:

1. Using the measuring point selector key, choose one of the three channels for the corresponding type of material (e.g. channel 2 with H% for woods).
2. Select the function BASE.
3. Program the required base value. The input of a slope correction can be done similarly (e.g. 0.9 for group H8).

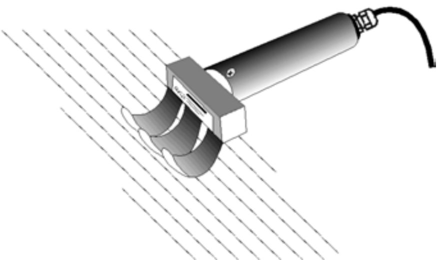
Zero Point Correction

As the environmental conditions have a strong influence on the capacitive measurement of the moisture in materials, the zero point should be checked and corrected, if necessary, before each measurement.

1. Hold probe in the open air.
   The instrument should indicate the set BASE VALUE as a negative measured value.
2. If this is not the case, press the keys ENTER and ± to correct the measured value.

Measuring Process

1. Switch the measuring instrument on.
2. Use the measuring point selector key and set the material type 'construction materials B%', 'wood H%' or 'paper P%'.
3. For changing the material group BASE VALUE enter the SLOPE CORRECTION accordingly.
4. Check the zero point and correct, if necessary.
5. Place the probe, with the sensors on the material, so that the measurement is taken at a right angle to the structure of the material (e.g. grain of the wood).



☞ For the measurement hold the plastic handle at the rear end (to avoid any influences the hand should not be near to the probe head or should not touch it, respectively).

6. Read the measured value. The function MAXVALUE of the measuring instrument can be used for keeping the maximum value.

Thin Materials

For materials that are thinner than 25mm (plywood, gypsum plasterboards, paper), the sensitivity of the probe will be too low (i.e. the measured value is too low). However, comparison measurements can be performed and materials that are too wet can be identified. To accurately measure the moisture in thin materials the measurement must be performed at a pile or reel. Metal plates should not be used as base support because the measured value would be invalidated by the depth effect.

☞ As material parameters such as layer thickness, material density or drying conditions are different for each individual application, it is usually not possible to exactly determine the true contents of moisture in a material over a large area. Due to varying and unknown local conditions, no liability claim can be derived in case of consequential damages.

Verification of the Probes

Two adjustment modules are available for verification of the probe alignment:

- ZB 9696-PE05 for the construction material channel
- ZB 9696-PE30 for the wood and paper channel

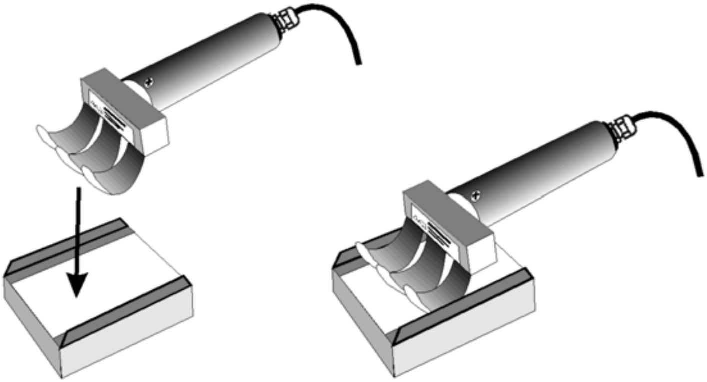
These consist of a plastic material that provides dielectric characteristics that remain stable at temperatures from 0°C to +30°C for many years.

Test Conditions

The verification of the probes, using the adjustment module, should be performed in an enclosed room at a room temperature between 15°C and 25°C. The measuring instrument, the connected probe and the adjustment module must be stored in that room for at least one hour before the verification can be performed. The probe must be clean and dry.

Adjustment Instruction

1. Clear the programmed base values.
2. Place the adjustment module with its aluminium side downwards on a table.
3. For measurement of the zero point, hold the probe in the open air.
   The corresponding output voltage is measured. If the measuring instrument indicates a value that is different from zero, subsequently press the keys ENTER and ± to correct the measured value.
4. Press the probe on the adjustment module (contact pressure 10N), as shown in the illustration. (For measurement please see note on p. 3-3-16)



5. The output voltage that is obtained, with the determined zero point value to be deducted, is a measure for the sensitivity of the probe.
6. When the base value is cleared, the following test values must be indicated when positioning the probe:

On the 1st ch. for mineral constr. material	on test block PE05:	9.0 B%
On the 2nd ch. for wood types	on test block PE30:	12.0 H%
On the 3rd ch. for paper and cardboard	on test block PE30:	8.5 P%

7. If the measured value largely deviates from the nominal value, either the slope correction (SK) function can be used to enter the correction factor, or a new calibration can be performed in the factory.

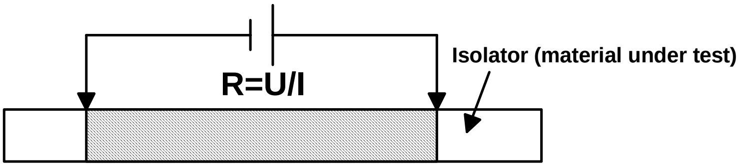
Technical Data

Measuring method:	capacitive (company: Doser)
Measuring range:	construction material 0 to 20 % moisture
	wood 0 bis 50 % moisture
	paper 0 bis 20 % moisture
Housing:	plastic handle 40mm ∅, 130mm long
Connection block:	aluminium/plastic 20 x 25 x 70mm
Measuring probe:	spring steel, stainless, 0.5mm, 70 x 35mm
Weight:	260 g
Nominal temperature:	15 to 25°C
Operating temperature:	0 to +60 °C
Storage temperature:	-20 to +80 °C
Signal output:	0 to 2V
Supply voltage:	+8 to +12V
Current consumption:	ca. 7mA

3.3.5.2 Conductivity Probe especially for Moisture in Wood

Measuring Principle

The ALMEMO® Wood Moisture Probe FH A636-MF operates according to the principle of conductivity. The dependence of the electrical resistance on the moisture is used for determining the moisture content in the material. The electrical resistance is measured by sharpened tips of the wire electrodes, which are pressed into the wood.



The microprocessor that is integrated into the probe handle calculates the moisture in the material as a percentage by weight.

ALMEMO® Sensor

In the measuring range from 7 to 30% the ALMEMO® Wood Moisture Probe FH A636-MF provides the measurement of the moisture contained in wood material in a matter of seconds. The probe consists of a round black plastic housing where 2 collets are attached. Time-consuming preparations for the measurement are not required. The measuring probe can be easily connected to an ALMEMO® measuring instrument and be used immediately.

Meas. Variable	Meas.Range	Resol.	Dim	Range	Exp.
Wood moisture	7.0 ... 30.0	0.1 %	%	d2600	3

Measuring Process

When measuring, it must be ensured that the electrodes are pressed into the substance under test during the measurement.

1. Press the probe electrodes into the material.
2. Switch the measuring instrument on.
3. Read the measured value. For keeping the maximum value, the function MAXVALUE of the measuring instrument can be used.

Replacing the Electrodes

When replacing the electrodes the collet chuck must be fixed using a fork wrench (span width 7mm). With a second fork wrench (span width 7mm) the tightening nut can be loosened. This helps to avoid a torsion of the collet chuck and damage to the probe handle. The electrode can then be replaced. When re-tightening the tightening nut it must, again, be ensured that the collet chuck does not move within the housing.

Calibration of the Probe

1. Hold the probe in the open air (no material contact at the electrodes) and determine the control value. The nominal value for measurements **in air** is **7.0%**.
2. For calibration connect calibration resistor with 1GΩ and determine the control value. The nominal value **with reference resistor** is **12.0%**
3. If the measured value largely deviates from the nominal value, either the SLOPE CORRECTION (SC) function can be used to enter the correction factor, or a new calibration can be performed in the factory.

Technical Data

Measuring method:	conductivity principle
Measuring range:	7 to 30 % wood moisture
Housing:	plastic handle 40mm ∅, 130mm long
Measuring tips:	stainless steel, non-isolated, 3 mm ∅, 50 mm long
Weight:	260 g
Accuracy:	± 2%
Reproducibility:	± 1%
Nominal temperature:	23°C ±2°C
Operat./storage temp.:	0 to +60 °C / -20 to +80 °C
Signal output:	0 to 2V
Supply voltage:	7.5 to +12V
Current consumption:	max. 10mA

3.3.6 Water Detector Probe

Measuring Principle

The ALMEMO® Water Detector Probe FH A936-WD operates according to the principle of conductivity. The change of the electric resistance is used for the detection of water. The electrical resistance is measured via the measuring electrodes.

ALMEMO® Sensor

The ALMEMO® Water Detector Probe FH A936-WD provides the detection of uncombined water, especially in construction applications, at locations that are difficult to check visually (at sealing joints, under cement floors etc.). Time-consuming preparations for the measurement are not required.

3

Measuring Range		Resol.	Dim	Range	Exp.
no water	<10%	0.1 %	%	d2600	3
water	>10%				

The probe consists of a round black plastic housing where 2 collets are attached. The measuring probe can be easily connected to an ALMEMO® measuring instrument and can be used immediately. The collets can accept different electrodes that are shaped depending on the application:

1. uninsulated, with rounded tip, 200mm long, 3mm diameter
2. uninsulated, with sharp tip, 50mm long, 3mm diameter
3. spring steel strap, 200mm long, 6mm wide

Verification of the Probes and Measuring Process

The probe should pass a functional check before it is used for a measurement. For this purpose the electrodes are inserted in a water bath. The measuring instrument should indicate the value 100%. If the control value largely deviates from the nominal value, the probe must be returned to the factory for recalibration of the sensor.
During the measurement it must be ensured that the electrodes, depending on the application, either rest tightly on the material to be measured or are punctured into the material:

1. Puncture the probe electrodes into the material.
2. Switch on the measuring instrument.
3. Read the measured value. For keeping the maximum value, the function MAXVALUE of the measuring instrument can be used.

If the probe is held into the open air, a negative value is indicated because the necessary correction values are stored in the connector.

Replacing the Electrodes

When replacing the electrodes the collet chuck must be fixed using a fork wrench (span width 7mm). With a second fork wrench (span width 7mm) the tightening nut can be loosened. This helps to avoid a torsion of the collet chuck and damage to the probe handle. When re-tightening the tightening nut it must, again, be ensured that the collet chuck does not move within the housing.
A new calibration is not required after replacing the electrodes.

Technical Data:

Measuring method:	detection of water
Measured values:	<10% no water is present >10% water is present
Housing:	plastic handle 40mm ∅, 130mm long
Electrodes:	stainless steel
Weight:	260 g
Nominal temperature:	23°C ±2°C
Operat./storage temperature:	0 to +60 °C / -20 to +80 °C
Signal output:	ALMEMO® (ca. 0 to 2V)
Supply voltage:	7.5 to 15V
Current consumption:	max. 10mA

3.3.7 Dew Point Sensors

3.3.7.1 Measuring Principles

For determining humidity variables by means of the dew point, a measuring element with Peltier elements is cooled until the measuring element becomes covered with moisture. The temperature reached is indicated as the measured value 'dew point temperature'. It is totally independent from ambient temperature and atmospheric pressure and is, therefore, a very accurate and reliable method for measuring humidity. Two methods can be used for a detection of the dew point:

Dew Point Mirror Method
A mirror that is optically monitored by a light sensor is used as a measuring element. The change in the reflection of light, which is caused by the dewing, indicates the dew point.

CCC Dew Point Principle according to Heinze
Instead of the cooled mirror the integrated sensor chip contains a cooled stray field capacitor with capacitive condensate detection (**C**ondensate **C**ontrolled **C**apacitance), which is mounted on a miniature cooling element. The active sensor surface, which is in contact with the substance to be measured, is a hygroscopically neutral, wear-resistant and chemical-resistant insulation layer, with the stray field capacitor being located under the layer. The capacitance shows a sudden increase as soon as water condensate is forming.
The sensor unit is also connected to a control circuit that regulates the operating current of the cooling element so that a defined condensate is forming. As a result, the dew point temperature (the actual measuring variable is the temperature of the sensor surface) can be measured by an integrated temperature sensor and provided in a format that can be further processed.

3.3.7.2 Dew Point Detector

Description and Application

The ALMEMO® Dew Point Detector FH A946-1 is for determination of dew conditions. It consists of an NTC type N (1st measuring channel) and a CCC dew point sensor (2nd measuring channel). The corresponding evaluation electronics is integrated in the ALMEMO® connector. The dew point detector does not provide a continuous measuring signal but a step function (0 >> 100%). This function corresponds to a scaled voltage from approximately 0 to 1V. An output function 'Alarm' has been programmed (see 6.10.4) so the sensor either provides the exact value "0%" when the sensor surface is dry ('no dew') or the value "100%" when the sensor surface is condensated ('bedewed'). Older ALMEMO® devices do not provide this 'Alarm' output function and, consequently, indicate values between 0 and 100, corresponding to partial dew conditions on the sensor surface.
The dew point detector should be installed at the coldest point of the unit under test.

Ensure a good heat contact (e.g. by using heat conducting paste/glue) between sensor back side and measuring point.

The current consumption is very low (approximately 3mA). Therefore, battery-operated instruments can be also used for longer recording periods. To save memory space the dew point detector can be used as on/off switch for automatic scanning, i.e. measured values will only be recorded in case of a dew condition. Furthermore, this allows to record more measuring variables such as temperature, humidity, time and date. The ALMEMO® Dew Point Detector FH A946-1 is, therefore, especially suitable for control measurements, e.g. in building physics.

Technical Data

Operating range:	0°C to +70°C (no ice formation, no salty atmosphere)
Settling time:	final value after 2 to 60 seconds
Temperature sensor:	NTC type N (10 k at 25°C), accuracy: ±0.1°C (within operating range)
Signal output:	scaled voltage, approx. 0 to 1 V
Heat flow plate:	aluminium, 40 x 40 mm
Storage temperature:	–10°C to +70°C

3.3.7.4 Dew Point Transmitter FHA646DTC1

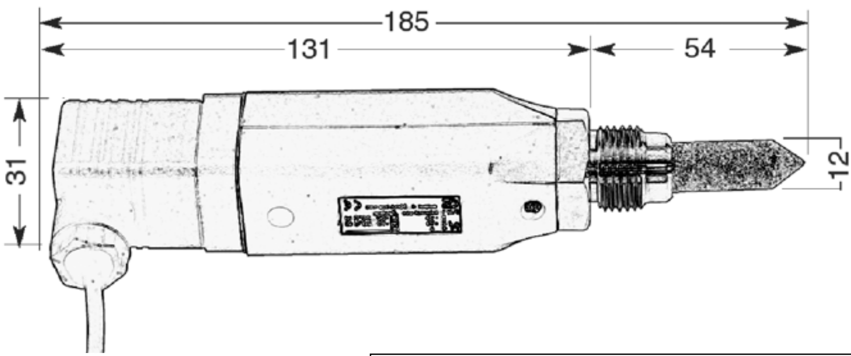
Notes on safety

Please read prior to operation !
Warning: Do not exceed pressure range of > 50 bar with standard versions.
With special versions up to 350 bar.
Observe measuring ranges of sensor!
The probes are damaged if overheated.
Observe max. storage and transport temperature as well as max. operating temperature. (e. g. protect measuring instrument from direct sunlight).
Warranty claims no longer apply if the instrument is opened, in the case of inexpert handling or use of force.
Adjustments or calibrations should be carried out by qualified measurement and control engineering staff only.
Important: Before installation shortly trail the compressed air in order to remove condensate and particles. Prevents soiling the sensor. Standing air leads to long measuring times.

Description

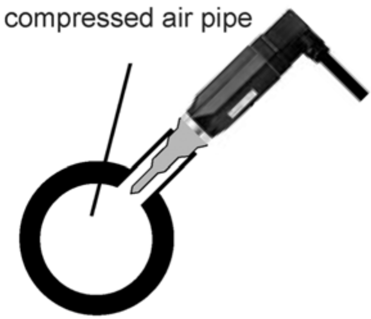
Especially suitable for dew-point measurement with high level precision and long-term stability
Automatic calibration
Digital transfer of measured values to the ALMEMO® display section (avoids risk of inaccuracy on the connecting lines or in the display section itself)
High-level accuracy sustained down to -80 °C
High-speed reaction time
Displayed variables : temperature, rel. humidity, dew-point
Process connection for high pressures (optionally up to 350 bar)

Dimensions (in mm)

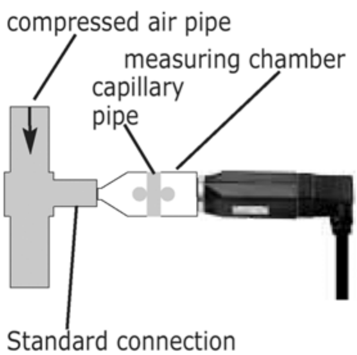


Installation

Please note: For safety we recommend the installation of a second measuring instrument with the option to monitor with a switch contact for especially critical and expensive productions.



Directly in the compressed air system
Screw in probe with G ½ " thread pressure-tight in the centre or in the compressed air pipe where the measurement is to take place.Ensure that the measurement is carried out close to the compressed air flow. U-bend pipes or non-flowing compressed air result in very slow reaction times for the moisture reading. Installation is recommended following drying of the compressed air and all bypass pipes or for critical compressed air users.



Indirectly in the compressed air system
Screw in probe with the G ½ " thread in the measuring chamber. Connect measuring chamber with the compressed air pipe using a ball valve and possibly a diffusion-tight connection pipe (max. 5m). In the case of compressed air containing oil and dirt particles, a 40µm pre-filter should be installed in front of the measuring chamber. Compressed air flows continuously (at 7 bar, approx. 1 l/min. expanded) in the capillary pipe of the measuring chamber. The reaction times for the humidity reading are shorter than when directly mounted.

Advantage: Easy mounting and dismounting of the probe,fast adaptation time.

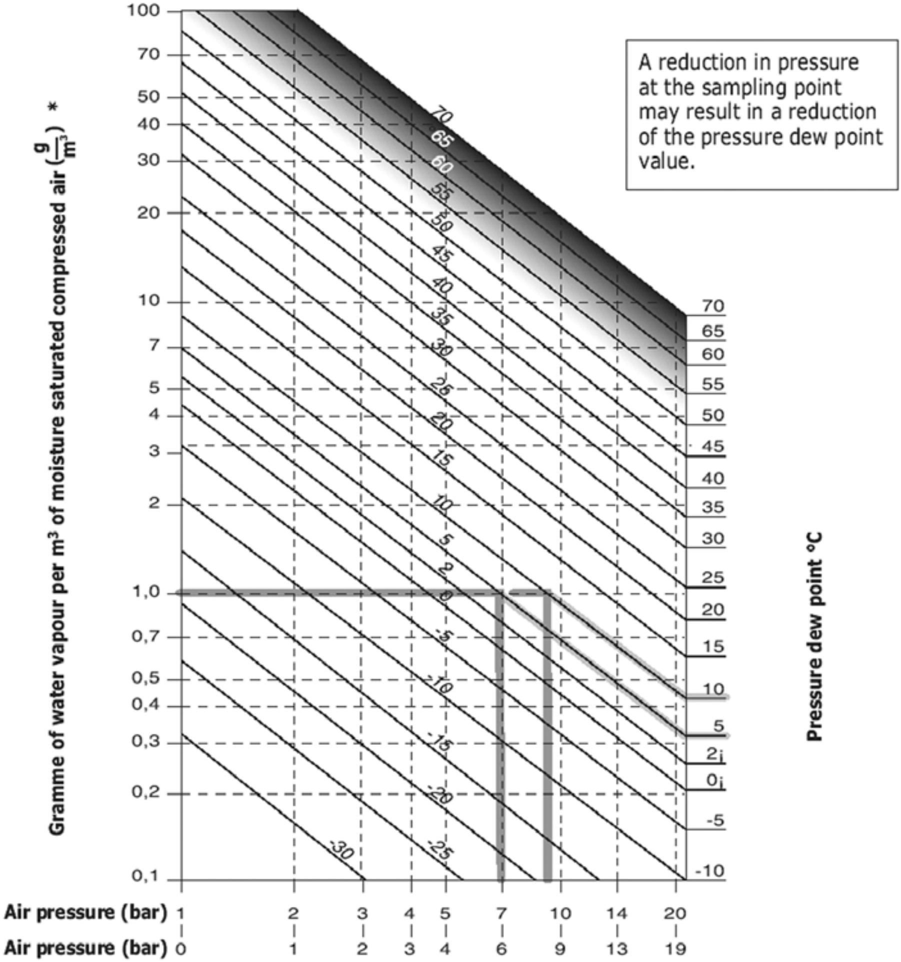
Measurable gases:
In general humidity can be measured in all non-corrosive active gases. For corrosive gases please query with Ahlborn Mess- und Regelungstechnik.

To enable accurate measurements in the low dew point range (–30 to –80 °Ctd), the measuring temperature of the gas should, if possible, be that of room temperature (20 to 35 °C). With resin driers, for example, or other applications, the temperature of the measuring gas is often higher, e.g. 80 to 120 °C. In this case we recommend installing a "cooling tunnel" of impermeable material in front of the screw-on measuring chamber. A Teflon pipe or a copper pipe would be ideally suitable for this purpose, as the hot gas is cooled to ambient temperature over the length of the pipe, approx. 2 to 5 m.
Please do not use ordinary plastic tubes!
The dew point temperature in °Ctd does not change when cooled as it is an absolute humidity value, which, like other measured variables e.g. g/m3, is independent of temperature.

Installation recommendation
It is possible to mount the pressure dewpoint meters directly in the airflow. We generally, however, recommend the use of a screw-on measuring chamber.

Dew point diagram for compressed air

The diagram provides information on the change in pressure dew point when there is a drop in pressure. Example: a drop in pressure from 8 bar to 6 bar working positive pressure is shown. In this case the pressure dew point drops from 10 °C to 5 °C.



* referred to 0 bar and 20 °C

Technical data

Measuring range	-80 to +20°C dew-point temperature (DT)
Measuring accuracy	± 0.5°C from -10 to +50 °C DT, typical ± 2°C at -40 °C DT
Operating temperature	-20 to +70 °C
Process connection	Screw thread G 1/2”, stainless steel
Pressure range	-1 to +50 bar standard
Storage temperature	+40 to +80 °C
Voltage supply	via ALMEMO® connector
Power consumption	5 mA
Output	ALMEMO® digital
available on request	4 to 20 mA in 2-wire technology Power consumption : 25 mA Load for analog output : < 500 W
Connection cable	1.5 meters with ALMEMO® connector
Housing	
Material	polycarbonate
Protection system	IP65

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Types

Dew-point transmitter with connecting cable,
1.5 meters long, and ALMEMO® connector Order no. : FHA646DTC1

Option:

Dew-point sensor for process pressure up to 350 bar
Order no. : OA9646DTCP

Accessories :

Screw-on measuring chamber for connecting a dew-point transmitter
to compressed air pipes via a ball valve Order no. : ZB9646DTCK
Advantage : high-speed measuring without waiting for installation