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.

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 1m3 of a mixture of air and water-vapour. Depending on the pressure and temperature, 1m3 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

3.3.2.1 Analog 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

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]: $VP = RH/100 \cdot SVP(TT)$

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	Max. temp.	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 ZA-9060VKC (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 can connected to the intelligent extension cable from revision R2E4.

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	97 080	0	0	0	0
0	32 650	0	0	0,01	0,02
25	10 000	0	0,01	0,03	0,06
50	3 603	0,01	0,02	0,09	0,18
70	1 752	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).

3.3.2.2 Digital capacitive humidity / temperature sensor

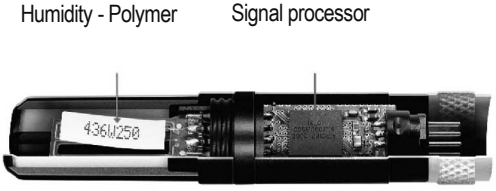
Measuring principle

The analog signals from a capacitive polymer humidity sensor and a temperature sensor are processed by a directly coupled chip offering a wide variety of functions. The integrated functions include (depending on variant) analog / digital conversion, a microcontroller for linearization, temperature compensation, and calculation functions (dew point), plus a digital serial interface as output.
Each sensor is calibrated to a highly precise reference (e.g. a dew point mirror hygrometer). The measured value deviations thus determined are stored on the sensor chip and used as adjustment values.

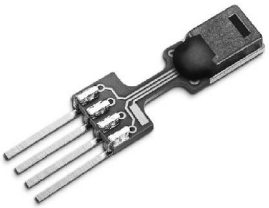
Advantages

All key sensor characteristics, settings, and adjustment data are stored on the chip in the sensor or sensor element and signal transmission is digital; this brings substantial advantages for practical operation.

- It excludes all risk of error involved in digital-to-analog conversion in the sensor and analog-to-digital conversion in the measuring instrument (as is the case with analog output signals).
- High level of reproducibility for measured results
- High long-term stability
- Quick and easy interchangeability without any need for readjustment and without incurring any loss of accuracy in the measuring chain
- Factory / DKD calibration of each sensor element or sensor retaining full accuracy, irrespective of connecting cable and ALMEMO® measuring instrument



Precision humidity / temperature sensor
FHAD 36 RS



Sensor element
FHAD460

Choosing a humidity / temperature sensor

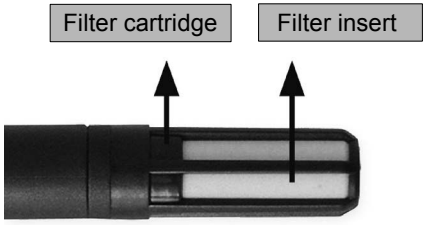
	FHAD 46x	FHAD 36 RSx
General description	Humidity / temperature sensor	Precision humidity / temperature sensor with wide operating temperature range
Possible uses	General climate measurements Heating, ventilation, air-conditioning, food storage, health sector (blood donor services, hospitals), climate control in warehouses, building services automation, paper, textiles, and pharmaceuticals industries	General climate measurements Heating, ventilation, air-conditioning, food storage, health sector (blood donor services, hospitals), climate control in warehouses, building services automation, paper, textiles, and pharmaceuticals industries
Operative range humidity	5 to 98% RH	0 to 100% RH
Operative range -temperature at sensor	Without sensor cover -20 to +80 °C With sensor cover -20 to +60 °C	-50 to +100 °C
Operative range - temperature of electronics	-20 to +80 °C	In the sensor connector -40 to +100 °C
Operative range - temperature at ALMEMO® sensor coupling	-	-40 to +90 °C

	FHAD 36 RICx	FHAD 36 RHKx
General description	Industrial humidity / temperature sensor	Hand-held high-temperature sensor
Possible uses	Process measurement in industry and research Fixed assembly	Test measurements in air ducts, dryers, climate chambers, and ovens
Operative range humidity	0 to 100% RH	0 to 100% RH
Operative range -temperature at sensor	-100 to +200 °C	Sensor length 250 mm maximum +150 °C Sensor length 400 mm maximum +200 °C
Operative range - temperature of electronics	In the sensor connector -40 to +100 °C	In handle -40 to +85 °C
Operative range - temperature at ALMEMO® sensor coupling	-40 to +90 °C	-40 to +90 °C

Choosing a filter (sensor protection)
for FHAD 46x
To provide extra protection the sensor element can be incorporated in a slotted sensor cover without any additional filter. (See Fig. for other variants, see AL-MEMO®-D measuring module for humidity / temperature FHAD 46)
for FHAD 36 RSx

To provide extra protection for the humidity polymer and the temperature sensor a filter cap can be fitted; this unit comprises a screw-fit filter cartridge made from polycarbonate and a set of interchangeable filter inserts of various specification. (See Table 1, Filter inserts, types and properties).

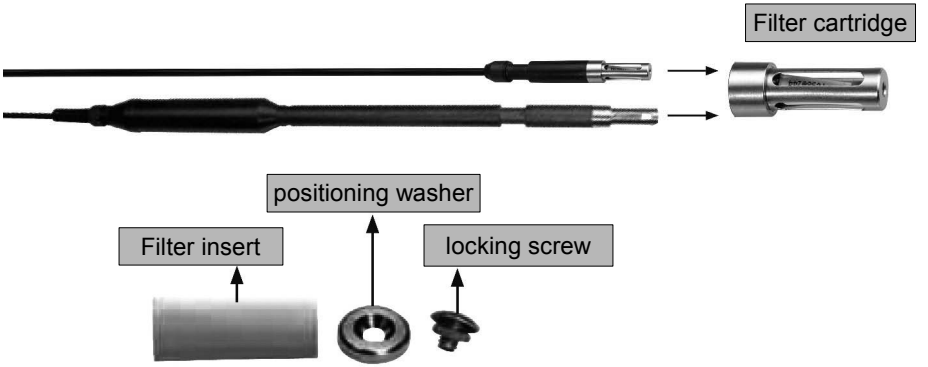
Filter cap	Order no.
Polycarbonate filter cartridge with a filter insert made from polyethylene	ZB9636PE
Polycarbonate filter cartridge with a filter insert made from stainless-steel wire fabric	ZB9636WM
Polycarbonate filter cartridge with a filter insert made from PTFE	ZB9636TF



Humidity / temperature sensors type FHAD36RS are supplied as standard with a filter cap comprising a polycarbonate filter cartridge with a filter insert made from polyethylene.

for FHAD 36 RICx, FHAD 36 RHKx
To provide extra protection for the humidity polymer and the temperature sensor a filter can be fitted; this comprises a screw-fit filter cartridge with a slotted case made from nickel-plated brass and a set of interchangeable filter inserts of various specification. (See Table 1, Filter inserts, types and properties). The filter insert is pushed over the filter cartridge, fixed in position with a washer, and secured by means of a locking screw.

Filter insert	Order no.
Filter insert made from stainless-steel wire fabric	ZB9636M15
Filter insert made from stainless-steel sinter	ZB9636S15
Filter insert made from PTFE	ZB9636T15



Humidity / temperature sensors types FHAD36RICx and FHAD36RHKx are supplied as standard with a filter cartridge and a filter insert made from stainless-steel wire fabric. For special applications an additional filter insert can be ordered. (Standard delivery : filter insert, positioning washer, locking screw)

Filter inserts, types and properties

Material	Max. temper-ature	Advisory notes on use
Polyethylene	100 °C (212 °F)	Recommended filter material for all uses below 100 °C Good response and good protection against fine particulates No absorption or storage of moisture
PTFE	200 °C (392 °F)	Good protection against fine particulates and salt (maritime environ-ment) Relatively slow response
Stainless-steel wire mesh DIN 1.4401 (V4A)	200 °C (392 °F)	Quickest response time Not recommended for environments that are bioactive or contaminated with fine particulates (risk of congestion)
Stainless-steel sinter filter DIN 1.4401 (V4A)	200 °C (392 °F)	Good response at low humidity values Not to be used for high humidity values Best protection against abrasive particles

* Abrasive wear and tear, removal of surface material by grinding media

Routine servicing - cleaning, replacing the dust filter

The filter should be checked from time to time - depending on measuring conditions. Any corroded, discolored, or clogged filter must be replaced.

1 In the case of sensors with an interchangeable filter insert (FHAD 36 RICx, FHAD 36 RHKx) only the insert itself needs to be replaced; (the metal cartridge is left in place on the sensor).

2 In the case of sensors with a plastic slotted case (FHAD 46x, FHAD 36 Rsx) and a built-in filter element the following steps must be taken :

- Unscrew the filter from the sensor and pull it out straight in line with the sensor, taking care not to catch on the humidity and temperature sensor.
- Before screwing on a new dust filter ensure that both sensor elements are correctly aligned with the sensor. The wires connecting the sensor elements with the sensor are very thin and may easily get bent. If necessary correct the alignment by tapping the sensor element very carefully into the correct position using a soft object (e.g. a plastic stick). Do not use any sharp or pointed instrument, e.g. tweezers, forceps, or pliers; you risk accidentally damaging the sensor element. Do not pull too hard on the sensor element.

Humidity / temperature sensor FHAD 46x
with ALMEMO® D measuring module

Connection to ALMEMO® devices is via a connecting cable incorporating a digital ALMEMO® D measuring module in the connector.
Four climate variables can be displayed in individual measuring channels :

- ***temperature, relative humidity, dew point,***
  + 1 function channel for mixture ratio or enthalpy

A variant of the ALMEMO® plug is available incorporating not only the ALMEMO® D measuring module but also a barometric pressure sensor.
(Technical data as for FDAD12SA) (Option OAD946AP)
This displays the following variables :

- ***temperature, relative humidity, dew point, barometric pressure***

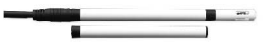
Extension cables up to 100 meters in length and various connection possibilities are available; these ensure optimal adaptation to the measuring task on hand. (See Manual, Section XREF and Catalog 2011/2012 page XREF).
Shorter extension requirements can be implemented using passive extension cables up to 4 meters in length (ZA 9060 VK1/2/4).

The total length of all passive extension cables connected to an ALMEMO® measuring instrument must not exceed four meters. If the total length exceeds this, the device's internal data bus may, depending on environmental conditions, be severely affected by interference.

Via USB data cable with power supply (ZA1919DKUV) the ALMEMO® D measuring module can be operated directly on a PC.
The sensor element can be connected to the ALMEMO® D connecting cable by simply plugging in.
In this way inexpensive replacement elements can be interchanged quickly and easily on site by virtually anyone without any need for readjustment and without incurring any loss of accuracy.

For certain applications (e.g. construction physics) sensor connections must be sheathed with silicone in a shrink-fit sleeve to protect them against damp (option W). However, the sensor element will then no longer be pluggable / unpluggable.

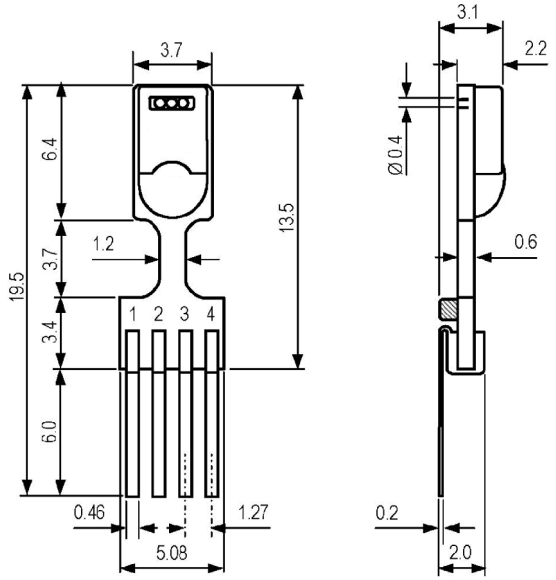
Operation in sleep mode is only possible with devices incorporating the sleep delay function. (only ALMEMO® 2590-2/3S/4S, 2690-8, 2890-9, 5690, 8590-9, 8690-9A, update may be necessary)

Variant / design	Description	Order no.
 Uncovered sensor element Most compact design Short response time	ALMEMO® D measuring module for humidity / temperature, with digital sensor element, unprotected, pluggable including ALMEMO® D connecting cable Length = 2 meters Length = 5 meters Length = 10 meters	 **FHAD460** **FHAD460L05** **FHAD460L10**
	Replacement sensor element for FHAD460, digital, adjusted	**FH0D460**
	Option W : Sensor connections protected against damp, no longer pluggable Width approx. 8 mm	 **OAD9460W**
 Sensor element incorporated in slotted sensor cover compact design Short response time	ALMEMO® D measuring module for humidity / temperature, with digital sensor element, in slotted sensor cover, pluggable including ALMEMO® D connecting cable Length = 2 meters Length = 5 meters Length = 10 meters	 **FHAD462** **FHAD462L05** **FHAD462L05**
	Replacement sensor element for FHAD462, digital, in slotted sensor cover, adjusted Sensor cover diameter 8 mm Length 36 mm Plug diameter approx. 9 mm	 **FH0D462**
	ALMEMO® D cable stub Length including sensor cover = approx. 80 mm	**FHAD462L00**
	Extension tube, diameter 8 mm Length 97 mm pluggable, for FHAD462	**ZB0D462VR**
Atmospheric pressure sensor integrated in the ALMEMO® plug	Measuring range 700 to 1100 mbar Technical data as for FDAD12SA	**OAD946AP**

Technical data

Operative range	
FHAD 460	-20 to +80 °C / 5 to 98 % RH
FHAD 462	-20 to +60 °C / 5 to 98 % RH
Humidity measuring circuit	
Measuring range	0 to 100 % RH
Sensor	CMOSens® technology
Measuring duration / output period	approx. 3 seconds
Accuracy	± 1.8% RH in the range 20 to 80 % RH at nominal temperature
Hysteresis	±1% RH
Nominal temperature	25 °C ±2 K
Sensor operating pressure	Atmospheric pressure
Response time T_{63}	typical 10 seconds at 25 °C and 1 m/s
Temperature measuring circuit	
Sensor	CMOSens® technology
Measuring duration / output period	approx. 3 seconds
Accuracy	±0.3 K at 25 °C, ±1 K (±1.2 K) in range -20 to +60 °C (up to +80 °C)
Reproducibility	±0.1 K
Response time T_{63}	typical 10 seconds
Cable	PVC, with ALMEMO® D plug (for available lengths see variants)

Sensor element, dimensions



Variants Standard humidity / temperature sensor FHAD 36 RSx, FHAD 36 RICx, FHAD 36 RHKx with ALMEMO® D measuring module

These capacitive humidity / temperature sensors with integrated signal processor meet the highest specifications and accuracy requirements in humidity measurement.

Connection to ALMEMO® devices is via a connecting cable incorporating a digital ALMEMO® D measuring module in the connector.

Four climate variables can be displayed in individual measuring channels :

- ***temperature, relative humidity, dew point,***
  + 1 function channel for mixture ratio or enthalpy

A variant of the ALMEMO® plug is available incorporating not only the ALMEMO® D measuring module but also a barometric pressure sensor. (Technical data as for FDAD12SA) (Option OAD936RAP)

This displays the following variables :

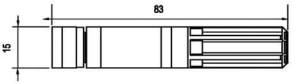
- ***temperature, relative humidity, dew point, barometric pressure***

Extension cables up to 100 meters in length and various connection possibilities are available; these ensure optimal adaptation to the measuring task on hand. (See Manual, Section XREF and Catalog 2011/2012 page XREF).

Operation in sleep mode is only possible with devices incorporating the sleep delay function. (only ALMEMO® 2590-2/3S/4S, 2690-8, 2890-9, 5690, 8590-9, 8690-9A, update may be necessary)

1. FHAD 36 RSx

connecting cable
with digital ALMEMO® D measuring module
in the connector



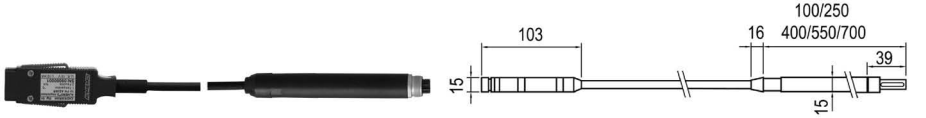
Standard
humidity / temperature
sensor

Variant / design	Description	Order no.
	SStandard humidity / temperature sensor with plug connector including filter cap with polycarbonate filter cartridge and filter insert made from polyethylene including connecting cable with ALMEMO® D plug Connecting cable, length = 2 meters Connecting cable, length = 5 meters	 FHAD36RS FHAD36RSL05
	Additional filters see “Choosing a filter (sensor protection)”	

Technical data FHAD 36 RSx

Operative range	-50 to +100 °C
Sensor housing, material	Polycarbonate
Response time T63	<15 seconds at typical 1 m/s
Accessories	Brackets for wall mounting see Catalog 2011/12, page 09.05 Order no. ZB9600W

2. FHAD 36 RICx



connecting cable with digital ALMEMO® D measuring module in the connector	High-temperature sensor cable with plug connector	Industrial humidity / temperature sensor

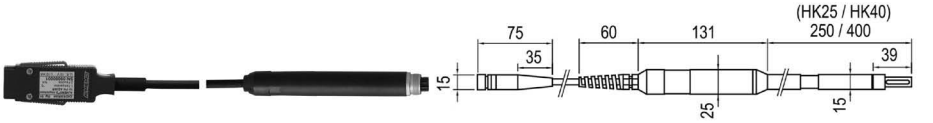
Variant / design	Description	Order no.
	IIndustrial humidity / temperature sensor with filter cartridge High-temperature sensor cable with plug connector including filter insert made from stainless-steel wire fabric including connecting cable with ALMEMO® D plug Sensor cable, length = 2 meters Connecting cable, length = 2 meters Sensor cable, length = 5 meters Connecting cable, length = 2 meters Sensor cable, length = 2 meters Connecting cable, length = 5 meters Sensor cable, length = 5 meters Connecting cable, length = 5 meters	 **FHAD36RIC102** **FHAD36RIC105** **FHAD36RIC102L05** **FHAD36RIC105L05**
	Additional filter inserts see “Choosing a filter (sensor protection)”	

Technical data FHAD 36 RICx

Operative range	-100 to +200 °C
Sensor length	100 mm Other lengths 250/400/550/700 mm are available on request.
Sensor housing, material	PPS (polyphenylene sulfide)
Filter cartridge	Brass, nickel-plated
Filter insert	Stainless-steel wire fabric
Response time T_{63}	<10 seconds at typical 1 m/s, without filter

Accessories	
	Assembly screw fittings for 15 mm sensor Brass, nickel-plated, Thread M20x1.5 Viton® seal, up to 200 °C Order no. ZB9636KV
	Mounting flange, Steel, nickel-plated, Diameter 80 mm Order no. ZB9636F

3. FHAD 36 RHKx



connecting cable with digital ALMEMO® D measuring module in the connector	sensor cable with plug connector	Hand-held humidity / temperature sensor

Variant / design	Description	Order no.
	Hand-held high-temperature sensor with filter cartridge 2-meter sensor cable with plug connector Operative range up to +150 °C Sensor length = 250 mm Operative range up to +200 °C Sensor length = 400 mm including filter insert made from stainless-steel wire fabric including connecting cable with ALMEMO® D plug Connecting cable, length = 0.3 meters	FHAD36RHK25 FHAD36RHK40
	Additional filter inserts see “Choosing a filter (sensor protection)”	

Technical data FHAD 36 RHKx

Operative range	-100 to +150/200 °C see variants
Sensor length	250 mm or 400 mm
Operative range of the electronics in the grip	-40 to +85 °C
Sensor housing, material	Shaft, PPS (polyphenylene sulfide) Grip,, POM (polyoxymethylene)
Filter cartridge	Brass, nickel-plated
Filter insert	Stainless-steel wire fabric
Response time T_{63}	<10 seconds at typical 1 m/s, without filter

Technical data common to all these devices
FHAD 36 RSx, FHAD 36 RICx, FHAD 36 RHKx

Operative range	(depending on sensor type) see "Choosing a humidity / temperature sensor"
Humidity measuring circuit	
Sensor	Capacitive
Measuring range	0 to 100 % RH
Adjusted	at 23 °C and 10%, 35%, 80% RH
Accuracy at +23 °C	±1.3 % RH
Reproducibility	0.5 % RH
Long-term stability	<1% RH per year
Temperature measuring circuit	
Sensor	Pt100, 1/3 class B
Measuring range	-100 to +200 °C
Accuracy at +23 °C	±0.2 K
Reproducibility	0.05 °C
Long-term stability	<0,1 °C per year
Operative range of the electronics	In the sensor connector -40 to +100 °C in the grip (of hand-held sensors) -40 to +85 °C
Sensor power supply	via the ALMEMO® device, approx. 12 mA
Sensor connection	on the sensor / sensor cable Plug connection Material : Anticorodal aluminum, anodized, IP65
ALMEMO® connecting cable	Sensor coupling with cable, Length 2 or 5 meters or for hand-held sensors 0.3 meters Material : TPU (thermoplastic polyurethane) -40 to +90 °C fitted with ALMEMO® D plug
Option OAD936RAP	Atmospheric pressure sensor integrated in the ALMEMO® plug Measuring range : 700 to 1100 mbar Technical data as for FDAD12SA see page 11.12

Calibrating and checking

Both the humidity / temperature sensor and the associated electronics are very stable; after initial adjustment at the factory they require no further calibration. However, to ensure maximum accuracy a sensor's calibration should be checked every 6 to 12 months.

And a sensor used in applications that expose it to contaminants may have to be checked more frequently.

If the sensor starts producing measured values that are not plausible it should be checked at the factory.

Since all adjustment and sensor data are saved in the sensor itself, factory / DKD calibration can be performed - irrespective of connecting cable or ALMEMO® measuring instrument - without adversely affecting the accuracy of the whole measuring chain.

For all variants (FHAD46x, FHAD36RSx, FHAD36RICx, and FHAD36RHKx) standard delivery includes a manufacturer's test certificate.

Guidelines for achieving the best measuring results using a sensor installed in a fixed position

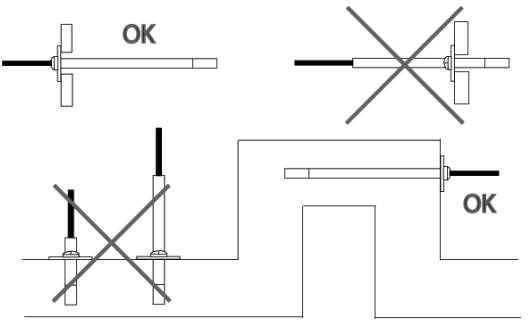
Install the sensor in a location where the humidity, temperature, and atmospheric pressure conditions are representative for the environment to be measured. The following should be avoided :

- Sensor too near to a heating element, a cooling coil, a cold or warm wall, or direct exposure to the sun's irradiation, etc.
- Sensor too near to a vapor injector, a humidifier, or direct exposure to rainfall or other precipitation, etc.
- Instable pressure conditions caused by strong atmospheric turbulence

If the sensor is to be mounted on a wall this should not be in a location directly above any element in the device that generates heat, e.g. measuring converter or Ethernet adapter (sources of ascending warm air).

If possible the location should ensure that the sensor is exposed to a reliable movement of air. An air velocity of at least 1 m/s will facilitate and accelerate the sensor's adaptation to changes in temperature.

If the sensor is to be fitted through a wall it should protrude as far as possible into the environment to be measured.



- The sensor should be arranged so as to prevent condensation forming and collecting near the sensor's connecting wires. The sensor should be installed with the sensor tip pointing downwards. If this is not possible, it should be installed at least in a horizontal position.
- Using a sensor fixture (comprising a flange with a cone fitting) may facilitate installation through a wall (depending on the sensor model).
- It may be easier to perform routine servicing work if a maintenance aperture next to the sensor is prepared in advance. In this way a reference sensor (for calibration) can be inserted quickly and easily for the duration of routine servicing. This aperture should be the same size as used to install the sensor. A fixture can then also be fitted for the reference sensor.

Guidelines for achieving the best measuring results using a hand-held sensor

The most frequent source of error when measuring relative humidity is a temperature difference between the sensor and the environment to be measured. At 50 percent relative humidity a temperature difference of just 1 °C will usually lead to an error of around 3% in the RH reading.

When using a humidity sensor with a hand-held measuring instrument it is advisable, experience suggests, to keep an eye on the display to check for temperature stability. When moving a sensor from one area to another it must be allowed sufficient time to adapt to the new environment to be measured. In extreme cases, if the sensor is colder than its immediate environment, condensation may form on its surface.

So long as one observes the sensor's permissible humidity and temperature ranges, condensation will not affect its calibration status. However, the sensor will not produce valid measured values again until it is completely dry.

Still air, it should be remembered, is an excellent insulating medium. When the air is not moving surprisingly large differences in temperature and humidity may occur even over small distances. Forced ventilation of the sensor will therefore generally ensure quicker and more accurate measuring operations.

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:

Partial vapour pressure [mbar]: (see 3.3.1)

$VP = SVP(HT) - C \cdot SP \cdot (TT-HT)$

$C = 0.00066 \cdot (1+0.00115 \cdot HT)$

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.

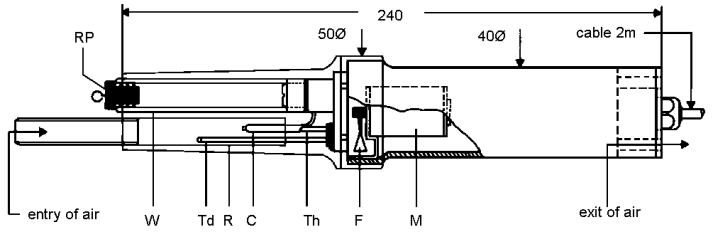
Atmospheric Pressure Compensation
On calculating the partial vapour pressure and the mixture ratio the current **atmospheric pressure** SP is depending on the sea level, which heavily influences the result of the measurement. For a compensation, the current atmospheric pressure can be entered and even 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
F = Fan blade
Td = Dry temperature sensor
Th = Humid temperature sensor
C = Cotton wick
S = Radiation protector
W = Water tank
RP = Rubber Plug with pin

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:

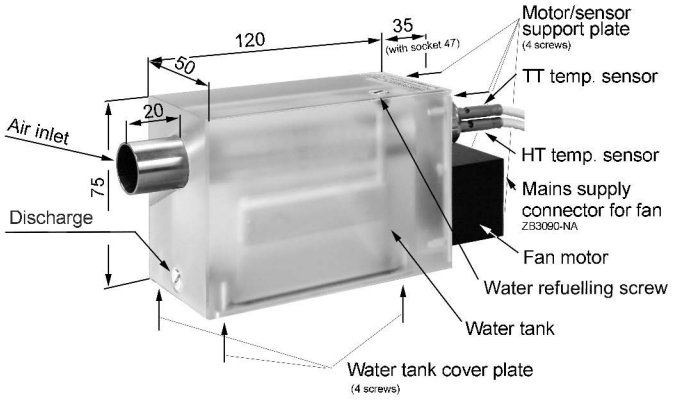
A psychrometer with Pt100 sensors for humid and dry temperature can be connected to any ALMEMO® measuring instrument that has at least 2 input sockets. For this purpose, all psychrometer measuring ranges for the determination of humidity data are supported. The two Pt100 sensors must be arranged in series 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: 1. Kanal	P204	TT	dry temperature in °C *)
	2. Kanal	P rH	RH	rel.humidity in %H
	bis	P dT	DT	dew point temperature in °C
	4. Kanal	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 DCthrough 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	

3.3.4 Sensors for measuring moisture in materials

Basic principles of measuring the moisture in materials

The amount of moisture in a substance plays an important part both in the processing of wood, paper, and building materials and in the assessment of soil quality.

Moisture content can be determined using a wide variety of measuring procedures. The most important of these are as follows :

Direct measuring procedures	Indirect measuring procedures
Gravimetric method (Darr method) Calcium carbide method (analytic) Karl Fischer titration method	• Microwave method • Infrared reflection / absorption method • Atmospheric humidity equilibrium method • TDR method (time-domain reflectometry) • Moisture tension meter (moisture in the soil, capillarity) • Capacitive methods • Conductance methods

Capacitive and conductance methods are particularly suitable for high-speed comparative measurements. Differences in moisture content can be measured in a non-destructive way; problem areas can be detected quickly and easily. However, the measured values may be affected by various factors. Results may be influenced in particular by fluctuating material densities, different constituent substances, and fluctuations in saline concentration and in the thicknesses of the various layers. Normally therefore measured values obtained using these methods should not be interpreted as absolute (unless it is always the same material that is used and a reference measurement is performed for calibration purposes).

Moisture content in materials can be represented in terms of various characteristic values.

– **Moisture content**

is the ratio mass of water contained in the substance to mass of the substance completely dry.

Formula $$u_m = \frac{m_w}{m_{tr}} = \frac{(m - m_{tr})}{(m - m_w)}$$

– **Moisture percentage**

is the ratio mass of water contained in the substance to total mass of the undried substance.

Formula $$\psi_m = \frac{m_w}{m} = \frac{(m - m_{tr})}{(m_w + m_{tr})}$$

– Moisture content by volume
is the ratio volume of water contained in the substance to volume of the substance completely dry.

Formula $$u_v = \frac{V_w}{V_{tr}} = \frac{m_w}{V_{tr}} = u_m * \rho_{tr}$$

– Moisture percentage by volume
is the ratio volume of water contained in the substance to total volume of the undried substance.

Formula $$\psi_V = \frac{V_w}{V} = \frac{m_w}{V} = \psi * \rho$$

- Dry mass percentage
is the ratio dry mass to total mass.

Formula $$T = \frac{m_{tr}}{(m_{tr} + m_w)} = 1 - u_m$$

m_w = *Mass of the water content*
m_{tr} = *Mass of the substance completely dry (i.e. free from water)*
m = *Total mass of the undried sample (i.e. of damp material)*
V_w = *Volume of water content*
V_{tr} = *Volume of the substance completely dry (i.e. free from water)*
V = *Total volume of the undried sample*
ρ = *Density of the sample*
ρ_{tr} = *Density of the sample completely dry*

Standardization
For absolutely accurate results other methods must be used, namely the drying chamber or the Darr method. With these methods a sample of the material is weighed and then dried in the drying chamber until weight change ceases altogether. The moisture content can now be obtained by simply calculating the weight difference.
However, different calculation methods must be used, depending on the type of material.

Wood (DIN 52183)	u = 100% * (NG - TG) / TG
Mineral building materials (DIN EN ISO 12570)	u = 100% * (NG - TG) / TG
Paper and cardboard (DIN EN 20287)	u = 100% * (NG - TG) / NG
Leather (DIN 53304)	u = 100% * (NG - TG) / NG

NG = Moist weight; TG = Dry weight

Calculating moisture content in building materials by mass

$$u_m \text{ in } \% = \frac{(m_f - m_{tr})}{m_{tr}} * 100 \qquad u_m \text{ in } \% = \frac{f_v}{\rho} * 1000$$

um = Moisture content of material by mass in [%]
uv = Moisture content of material by volume in [%]
mf = Mass of the undried materials in [kg]
mtr = Mass of the dried materials in [kg]
ρ = Bulk density of the material in [kg/m³]

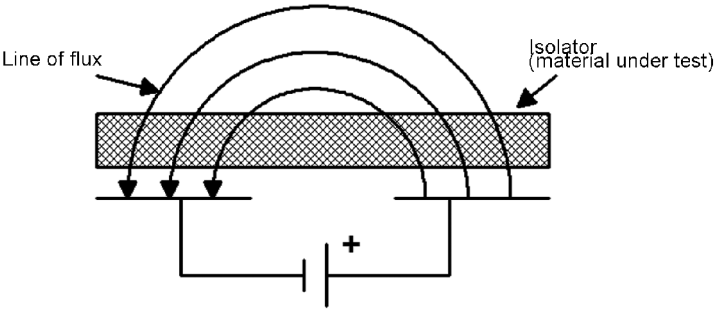
Bulk density (ρ) refers to the ratio - mass of a substance to its volume including its own or cell pores. Bulk density is one of the important values when it comes to assessing the solidity, thermal conductivity, and permeability etc. of building materials.

3.3.4.1 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

Bei jeder Materialart gibt es eine Reihe von Materialgruppen, die durch einen spezifischen Offset gekennzeichnet sind. Dieser Offset muss im Messgerät als BASISWERT entsprechend der folgenden Tabellen eingegeben werden:

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

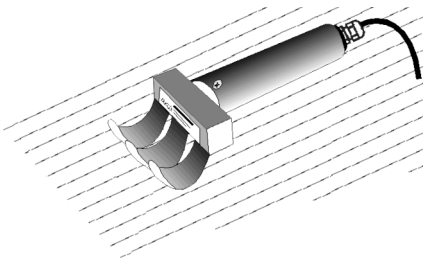
As the environmental conditions have a strong influence on the capacitive measurement of the moisture in materials, the zero point should be

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).



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the plastic handle at the rear end (to avoid any influences the hand should not be near to the probehead 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

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

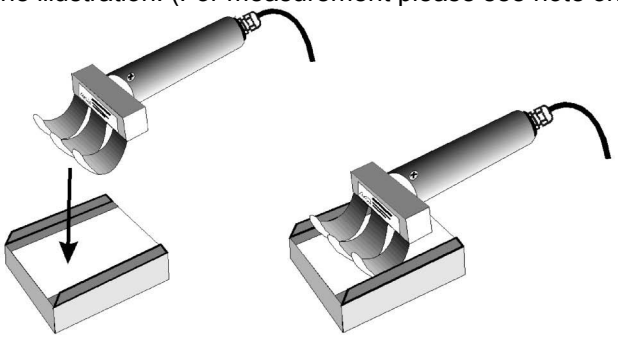
These consist of a plastic material that provides dielectric characteristics that remain stable at temperatures from 0°C to +30°C for many years.

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.

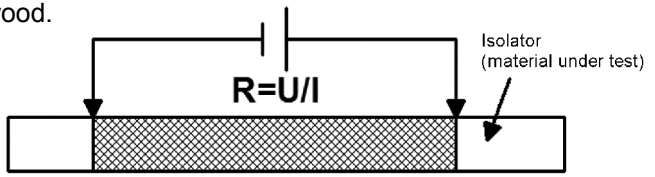
Technical Data

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 Æ, 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

3.3.4.2 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. 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).
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.

PTFE-insulated measuring tips help avoid measuring errors in the event of surface moisture. ZB9636MFST, 1 piece (2 pieces are needed per probe.)

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 1GW 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.

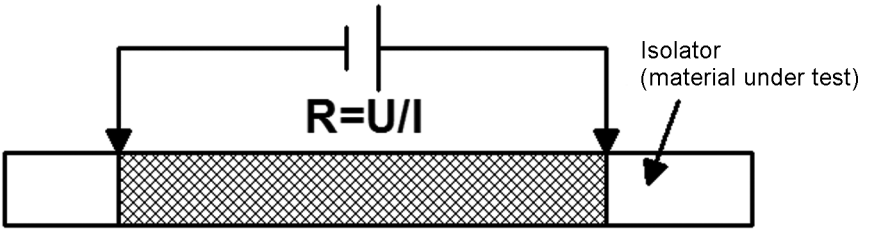
Technical Data

Measuring method:	conductivity principle
Measuring range:	7 to 30 % wood moisture
Housing:	plastic handle 40mm Æ, 130mm long
Measuring tips:	stainless steel, non-isolated, 3 mm Æ, 50 mm long
Weight:	260 g
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

3.3.4.3 Wood moisture probe for long-term measuring

Measuring principle

The ALMEMO® wood moisture probe employs the conductivity principle. Electrical resistance through a substance varies according to the amount of moisture it contains; this can thus be used to measure moisture content. Electrical resistance through the wood can be measured via the stainless-steel hanger bolts (included



in standard delivery) which are screwed into it.
From this value the microprocessor, incorporated in the electronics housing, calculates the wood's moisture content as a percentage of total weight.

ALMEMO® wood moisture probe FHA 636 MF 10

The sensor electronics activates the measuring current on a time basis (intermittent operation); this prevents salinization or dehydration of the material.
No later than 10 seconds after the supply voltage is switched on the measured value is output correctly for the first time; it is then continuously updated for the duration of the next 2 minutes. The last measured value then remains unchanged - until after a further pause (approx. 120 minutes with the measuring current switched off) a new measuring operation is performed and the new measured value is output.
Power is supplied via the connected ALMEMO® data logger.

Positioning and use

The sensor is designed for long-term monitoring of moisture in wood in the wooden parts of buildings (e.g. roof structures with laminated beams); it can be connected to any ALMEMO® data logger.
The 2 stainless-steel M4 hanger bolts are screwed into the wood at right angles to the grain at intervals of 2.5 cm.

Operation with the device in SLEEP mode is not possible.

Technical data

Measuring method	Conductivity principle
Measuring range	5 to 50 % moisture (approx. 100 GΩ to 10 kΩ)
Housing	Metal housing, 65 x 60 x 35 mm (LxWxH) with cable bushings
Measuring cable	permanently fitted 2 sensor wires PTFE-insulated Length = 0.1 m (= maximum possible length) with cable lugs in circular form Diameter 4 mm
Measuring tips	2 stainless-steel M4 hanger bolts Total length = 60 mm including 4 stainless-steel nuts 2 stainless-steel locking washers
Spacing	2.5 cm at right angles to the grain
Operative range	0 to +60 °C
Storage temperature	-20 to +80 °C
Signal output	0.2 V means 5 %, 2.0 V means 50 % wood moisture
Power supply	via ALMEMO® plug
Connecting cable	PVC Length = 5 meters, with ALMEMO® plug

3.3.4.4 Sensor for measuring moisture in materials for determining the water content in wood chips, wood pellets, and sawdust

General

There are several procedures for measuring the moisture in materials or the water content in granulates more or less exactly, e.g. the hygroscopic method, the distillation method, or the Karl Fischer titration method.

Basic principles of moisture in wood and its water content

Another very accurate procedure for measuring these values is the Darr method.

Firstly a wood sample is taken and weighed. This sample is then dried at a temperature of 103 ±2 °C, ideally in a ventilated oven, until its weight remains constant. The loss in weight caused by the drying process indicates the quantity of water that was originally contained in the wood sample. In practice the most suitable methods for measuring wood moisture are the electrical ones employing either the ohmic resistance or the dielectric properties of the material, e.g. water (ε_r = 80) and wood (ε_r = 1 to 7). The bulk density of the wood to be measured must also be considered because both the grain between the electrodes and the depth of penetration of the electrodes may influence the measured results in both these types of procedure .

Definition - wood moisture

$$\%u \text{ in } \% = \frac{\text{m (Mass of water in the wood)}}{\text{m (Dry mass of wood)}} * 100$$

If wood is freshly felled or wet the wood moisture may be over 100 percent. (see example 2).

Example 1
Our sample of wood has a mass ("weight") of 100 grams;
from this 40 grams of water is obtained. Our wood sample then weighs only 60 grams.
This gives us a ratio of 40 grams of extracted water to 60 grams of dried wood.

$$\%u \text{ in } \% = \frac{\text{m (Mass of water in the wood)}}{\text{m (Dry mass of wood)}} * 100 = \frac{40}{60} * 100 = 66{,}67$$

This wood according to the formula has a moisture content of 66,67 %

Example 2
Our sample of wood has a mass ("weight") of 100 grams;
from this 60 grams of water is obtained. Our wood sample then weighs only 40 grams.
This gives us a ratio of 60 grams of extracted water to 40 grams of dried wood.

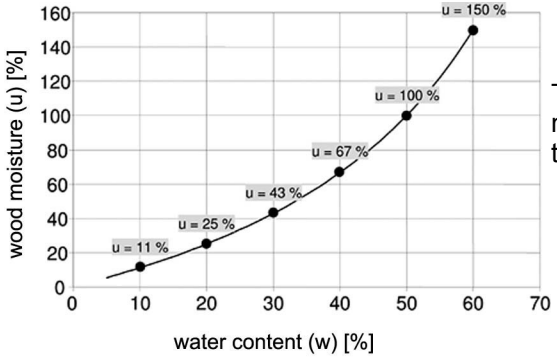
$$\%u \text{ in } \% = \frac{\text{m (Mass of water in the wood)}}{\text{m (Dry mass of wood)}} * 100 = \frac{60}{40} * 100 = 150$$

This wood according to the formula has a moisture content of 150 %.

Definition - water content

$$\%w \text{ in } \% = \frac{\text{m (Mass of water in the wood)}}{\text{m (Total mass of moist wood)}} * 100$$

The percent water content can - unlike the percent wood moisture - must always be a value < 100 %.



The graphic illustrates the connection between wood moisture (u) and water content (w).

Wood moisture and water content have different meanings

Wood moisture and water content should not be equated or even compared; one must first be converted before comparison with the other. While wood moisture is based on the Darr weight (completely dried wood), water content is based on the ratio of water percentage to wet weight of the wood (total mass of damp wood). The following tables show easy conversion formulae for calculating water content from wood moisture - and vice versa.

conversion formula

Water content ***w*** [%] from Wood moisture ***u*** [%]	Wood moisture ***u*** [%] from Water content ***w*** [%]
$w = \frac{u}{100 + u} * 100$	$u = \frac{w}{100 - w} * 100$

conversion table

w	5	10	15	20	25	30	35	40	45	50	55	60	**%**
u	5	11	18	25	33	43	54	67	82	100	122	150	**%**

Standardization

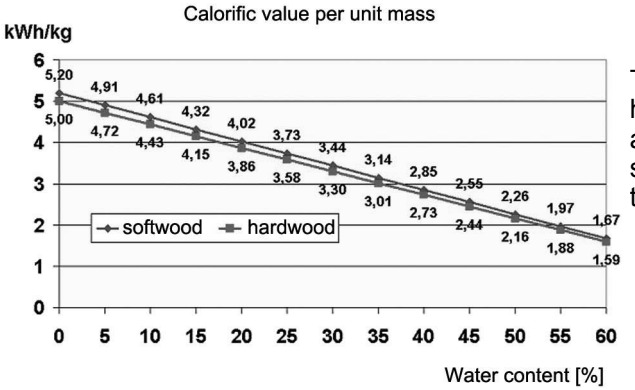
The Darr method is the only one that is standardized (DIN 52 183) and is thus also suitable as calibration for the other methods.

The properties and quality requirements for wood chips and pellets are described, for example, in Austria by ÖNORM M 7132 to 7137, in Germany by DIN plus.

A draft version of the European standard, EN 15210, Edition 2009, “Solid biofuels. Determination of mechanical durability of pellets and briquettes” (Part 1 - pellets, Part 2 - briquettes) defines procedures for measuring the mechanical solidity and durability of solid biofuels.
An EU standard, valid With effect from 2010, provides a uniform ruling for pellet qualities. The EU standard “EN 14961-2 Pellets" will supersede German DIN standards, Austrian Ö-Norm standards, and other individual rulings on the various pellet markets across Europe.

Net calorific value

The net calorific value of wood is the heating value of the dry mass it contains - less the energy needed to vaporize its water content. This gives 0.63 kilowatt-hours per kilogram of water.



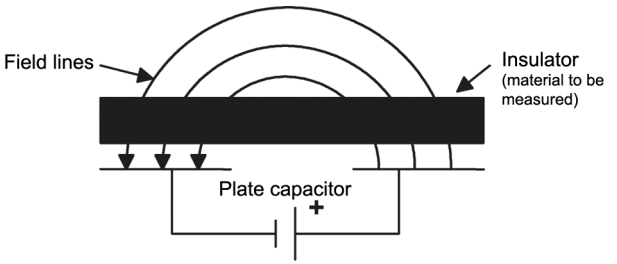
This graphic shows how the amount of usable energy tends to sink as the water content increases.

Physical units of energy (net calorific value)

1 MJ/kg = 1000 kJ/kg; 1 MJ = 0.27778 kWh or 1 kWh = 3.6 MJ

Measuring principle

The sensor operates on the principle of an open plate capacitor. The capacity of the capacitor depends on the dielectric constants of the substance between the plates. Water has a very high dielectric constant (εr = 80) compared with e.g. air (εr = 1). The water content of a moist material can be measured by determining that material’s dielectric constants.



ALMEMO® sensor for measuring moisture in materials FH A696-GF1

The electrode of this device touches the material to be measured so that a high-frequency electrical field can pass through the material. A microprocessor receives the measuring signals and - from the measured value and with reference to the material curve set - will then determine the average percentage water content.
The following material base curve is saved in the ALMEMO® plug :

	Base value (BA)	Factor (FA)
Wood chips	-27,3	0,1833
Wood pellets	-11	0,0905

Uses
This sensor can be used to determine - in a matter of seconds - the moisture content in wood chips, wood pellets, and sawdust, in grain and cereals, and other granulated materials.

Care must be taken to ensure that the sensor's measuring radius / depth of penetration remain at approx. 10 cm. The bulk material to be measured should be properly compacted (by (shaking).
For reproducible results the sensor should be inserted to the same depth.

Safety instructions

- Please observe the operating instructions.
- The device must be used exclusively for its proper and intended purpose.
- Contact of the device with any parts carrying voltage / current must be avoided.
- The device must be protected against wet and damp.
- The device must be protected against impact and jolting.
- The device must be protected against sources of heat.
- The device must be protected against any foreign bodies likely to enter through openings in the housing.
- Routine servicing and repair work must be performed by qualified and expert specialists only.
- The device must be protected against electrostatic discharge.

Any damage resulting from failure to heed the operating instructions and these safety notes in particular will lead to loss of warranty and such claims may be refused.

Checking

In the following circumstances it makes good sense to check the probe :

- in the event of mechanical damage
- after use in extreme conditions (e.g. high temperatures)
- if the probe produces measured results that are not plausible

ALMEMO® sensor for measuring moisture in materials, adjustment FH A696-GF1

For the purpose of checking the sensor adjustment test block ZB 9696 PE22 is available.

Technical data

Probe / Order no.	FH A696-GF1	
Measuring principle	Capacitive	
Measuring range	0 to 99.9 % water content as a weight percentage H_2O	
Resolution	0,1%	
Measuring radius / penetration depth	approx. 10 cm around the sensor	
Signal output	ALMEMO® (voltage)	
Weight	300 g	
Dimensions	Sensor head diameter = 22 mm, length = 200 mm Rounded tip	Screw-on extension diameter = 18 mm, length = 300 mm

		End piece, plastic diameter = 22 mm, length = 30 mm
Temperature range of material Operating temperature range Storage temperature range	+5 to +40 °C +5 to +40 °C -20 to +70 °C	
Cable connection	Built-in plug on sensor head	
Cable(s)	PVC Length = 2 meters with ALMEMO® plug The cable is led through the extension tubes and end piece.	
Power supply	5 V from ALMEMO® measuring instrument	
Current consumption	approx. 5 mA	

Determining characteristics for special customer-specific materials
As a special service Ahlborn offers to program characteristics on a highly customized basis for a wide variety of granulates, e.g. various cereal types or plastics. Order no. OA 9696 GFK

1. All we need is a sample of approx. 10 liters of your granulate (e.g. wood, cereal, plastic). This sample should be sealed in an air-tight package, e.g. shrink-wrapped in plastic film.
2. We use various dried samples to determine the characteristics of your particular material.
3. We then program these characteristics in the ALMEMO® plug for the moisture content probe.

If the material cannot absorb water (not hygroscopic), it will not be possible to measure its moisture content. In this case the processing fee we charge will be reduced.

3.3.5 Moisture tension meter for moisture in the soil

3.3.5.1 Basic principles involved in measuring moisture tension

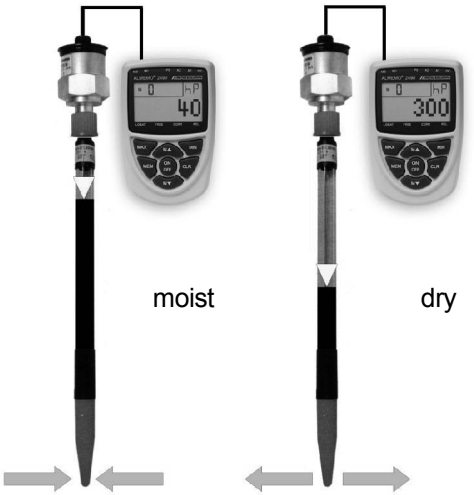
Moisture tension is the direct measurable variable indicating the availability of water in the soil for plants; it is the sum of all the moisture retaining forces in the soil - except osmotic potential, differential pressure potential, and gravitation potential.

3.3.5.2 Physical units for measuring moisture tension

Moisture tension is used to designate negative pressure in a substance; it is measured in the following units : 1 mbar = 1 hPa = 1 cm water column
The negative pressure thus measured is used to assess the moisture content in the soil / substrate; it is a transferable variable for such content expressed as a positive number.

3.3.5.3 Measuring principle

Moisture tension is measured using a moisture tension meter.
The moisture tension meter is hermetically sealed except for a semi-permeable ceramic membrane (sintered Al2O3) through which it sucks in water; it does so according to the moisture tension prevailing in the soil which depends on the soil's saturation level and the ground water table. The negative pressure resulting in the moisture tension meter tube is - ignoring the afore-mentioned potentials and minus the moisture tension meter's own vertical length - equal to the moisture tension value in the soil. This value can be displayed by means of a manometer or be acquired for further electronic processing by means of a pressure sensor.



Low negative pressure
The soil returns moisture to the moisture tension meter

High negative pressure The soil sucks moisture out of the moisture tension meter

Typical moisture tension values in pot substrates in hPa

30-40	very moist
50-120	moist
150-200	fairly dried out
>200	dry

Typical moisture tension values in the field (average soil type)

<50	saturated
100-150	Wet - moist
>200	drying out
200-500	Irrigation

3.3.5.4 Advantages and disadvantages of moisture tension measurement

Advantages	Disadvantages
The measured value obtained indicates the ground water directly available for plants on site.	Measuring operations must be performed at various points.
The measured value obtained does not depend directly on the prevailing soil conditions; (e.g. it is possible to measure the moisture in coarse and very loose substrate).	Measuring operations required all year round can only be performed at frost-proof depths or by using additional substances such as polyethylene glycols (PEG).
The measured value obtained is unaffected by the salt content in the soil or plant substrate (e.g. as caused by fertilizers).	The measured value obtained does not indicate moisture content in terms of volume-percent; (this must be determined specially for each type of soil).

Special features of moisture tension measurement

A rise in ambient temperature has the effect of temporarily reducing the moisture tension in the moisture tension meter tube; this is balanced out more or less quickly depending on the porosity of the moisture tension meter cell. The greater the air volume currently contained in the moisture tension meter tube, so the more pronounced the influence of temperature fluctuation becomes. To obtain more exact measured values the moisture tension meter should be deaerated as early as possible (see instructions for use) and as far as possible not exposed to direct sunlight.

When performing measuring operations with a long moisture tension meter calculations must offset the additional pressure generated by the vertical water column of the moisture tension meter tube. The value of interest is that obtained at the ceramic cell; the water column in cm must be deducted therefore from the displayed value. Correction is based on the following formula:

moisture tension at ceramic cell = measured value in hPa minus height of water column in cm .

Example for a moisture tension meter with water column of 20 cm

Displayed measured value in hPa	150 hPa
minus water column in cm	20 hPa (20 cm water column)
Actual measured value	130 hPa

3.3.5.5 Uses

For the purposes of investigating the soil's physical properties a number of moisture tension meters, inserted to various depths, can be used to continuously measure the soil's available water resources. In agriculture and market-gardening moisture tension meters are used for the purposes of automating irrigation systems. This helps in optimizing the supply of water to plants and in ensuring that water and nutrients are not flushed away into the underlying strata.

3.3.5.6 Moisture tension meter - explanation of terms

A moisture tension meter comprises a lower section with the probe and an upper section containing the electronics (pressure sensor, pressure switch, etc.).
In the following table "insert tension meter" refers to the moisture tension meter tube with the ceramic cell and "surface tension meter" refers to the ceramic base that comes into contact with the substrate.

Choosing a moisture tension meter - lower section

Design	Type	Application
Insert	L2 (ZB9602TML2)	Plants in open fields and substrate media
	LV (ZB9602TMLV)	Plants with flat roots in beds Plants in large containers → Low insertion depth and relatively dry setting
	LKV2 (ZB9602TMK2)	Plants in pots → Relatively dry setting, up to 200 hPa
Surface	FO (ZB9602TMFO)	Thin substrate layers Loose or granulated substrates (Seramis) → Inserted approx. 3 to 6 cm in the substrate On substrate surfaces On agricultural fleece, irrigation fleece → For moisture tension >300 hPa only short-term use
	FV (ZB9602TMFV)	General-purpose measuring operations on moist surfaces → Improved strength and resistance to breakage - thanks to heat-shrink film

3.3.5.7 ALMEMO® sensor - moisture in the soil - upper section

The moisture tension meter electronics section FDA602TM1 comprises a pressure sensor with measuring range 0 to 1000 hPa moisture tension and corresponding signal output 0 to 10 volts / linear. It can be screwed onto the various insert tension meters / surface tension meters (see Section 6.1).
It is connected to the measuring instrument via a 7- meter ALMEMO® connecting cable (included in delivery).
Via the ALMEMO® connector with voltage divider 100:1 (ZA9602FS/H) the sensor can be operated in conjunction with any ALMEMO® device that has measuring range "Diff-Millivolt 2 DC (± 260 mV)"; (see device instructions).
The parameters for scaling and units are stored in the ALMEMO® connector; the measured value is displayed directly as moisture tension hPa.
The moisture tension meter electronics and ALMEMO®- connecting cable are also separately available as spare parts; (see technical data).
With ALMEMO® relay trigger adapter (ZA8006RTA3/4, ES5690RTA5) or output modules (ZA1000EGK/EAK or ZA1000 GK) with relay adapter (ZB2280RA) the ALMEMO® system can also be used for the purposes of irrigation control.

3.3.5.8 Handling

Preparations

1 day watering

The dry ceramic cell must first be watered for one day. To ensure that air can escape from all pores the water should first be drawn in for a few hours from one side only, thus ensuring that the tube is filled before the whole ceramic cell is then immersed (overnight). Trapped air may have substantial adverse effects on the moisture tension meter's performance.

Filling

Fill to the brim with clean water

The moisture tension meter tube must be filled to the brim. Clean mains water - not too hard - is suitable (without any fertilizer additives) . Distilled water is not strictly necessary, although this does help prevent unwanted deposits and the early development of algae. In oxygen-rich water, as negative pressure increases, initially numerous air bubbles may form; this does not mean a leak; and it can be prevented by using pre-boiled water.

Closing and opening

Do not screw the cap on too tightly !
Important note ! Avoid hitting the top of any plastic threads;
(the sealing surface may easily be damaged by impact and then cause a leak)!

Do not screw the sensor cap on too tightly ! Screwing on too tightly may damage the seals. As soon as you feel the first slight resistance make only another 1/4 turn !
To open unscrew the caps and push these up; then lift the seal at the side and pull off. Before closing again the sealing surface, the O ring, and the top of the threaded muff must always be cleaned!

Insertion, general information

To ensure that moisture is released by the ceramic cell quickly and easily contact with the soil or substrate must be sound and firm. A residual amount of moisture must be kept in reserve; otherwise, if the soil or substrate is completely dry, the moisture tension meter will start functioning very sluggishly - or not at all.

Plants grown in pots and substrate layers:

TThe ceramic cone must be completely covered by substrate

With loose substrate the insert tension meter can be inserted directly without pre-drilling a hole, especially types with the short ceramic cone. The substrate can be slightly compacted round the moisture tension meter in order to hold it

firmly in position. Once in place the moisture tension meter tube should not be moved about; this helps prevent air pockets forming around the ceramic cone. When using a long ceramic cone (type L or LV) it is advisable to pre-drill a thin hole; this prevents the cone being subjected to unnecessary lateral pressure and helps avoid the risk of breakage.
The insertion depth depends on the desired measuring depth. It must be inserted at least deeply enough to completely cover the ceramic cone.

Plants grown in soil

Insert as deeply as possible

To insert a relatively long moisture tension meter with a long ceramic cone it is usually advisable to pre-drill a hole e.g. with a soil sampling drill, diameter 25 mm. If the substrate is sufficiently soft, the ceramic cone can be pushed down the last few centimeters (exerting vertical pressure only, otherwise risk of breakage); if this is not possible, it must be watered in, taking care not to ?*? flood the top of the hole.
The insertion depth depends on the desired measuring depth and possibly also on the root zone. The moisture tension meter should protrude only far enough above the ground so that the water column can be checked. If the moisture tension meter tube protrudes too far above the ground the effects of temperature fluctuation will be further aggravated (e.g. measuring errors, higher water consumption).

Deaerating

The moisture tension meter must be deaerated at regular intervals.

A moisture tension meter in the present design uses up a certain amount of water; this is because moisture tension is generated by moisture being released and then sucked back again with a small loss; as the volume of air in the tube increases, so water consumption increases too . And as the quantity of air increases, so the more sluggishly the moisture tension meter reacts. Moisture tension meters should therefore be checked at regular intervals and also occasionally deaerated - even though a meter's sluggish reactions rarely have any serious adverse effects on the irrigation system. The recommendation for a long insert tension meter used for soil measurement is that it should be refilled as soon as it reaches an air column of approx. 10 cm (deaerating and filling, see Section 8.2). Rapid loss of water (after just 1 or 2 days) and a simultaneous drop in moisture tension indicate a leak. In this event first check the screw fittings and the threaded muff for dirt or damage; this is before suspecting the ceramic cell or a joint; (if necessary send the tension meter to us). Insert tension meter KV 2 (for pot plants) During the vegetation period a moisture tension meter of this type, thanks to its short design, rarely needs to be deaerated and refilled - providing it is being used in the normal moisture range

(up to approx. 120 hPa). The water level and the air volume balance one another out.

Checks

Moisture tension meters must be checked at regular intervals.

The recommended regular checking procedure is to withdraw the tension meter by carefully twisting and then tipping to the side. You can see, in the inspection window directly under the cap, whether there is still any water. When it comes to re-inserting the moisture tension meter either a new position can be chosen or the same insertion hole can be used again; in this case the hole must be filled with loose substrate so that the tension meter cell can be fixed in position with the same firm contact with the substrate.

Routine servicing and maintenance

Accumulations of dirt or algae on the tension meter tube are best removed by mechanical cleaning with a pipe-brush (maximum diameter 20 mm). Particularly stubborn deposits can also be removed using a 1-percent solution of citric acid. The ceramic surface can be cleaned and reconditioned using the finest sanding paper available (320 grain) - but only when completely dry.

Important note !

The ceramic surface must not - under any circumstances - come into contact with any greasy or oily substances or inks or dyes that might penetrate into its pores!

While not in use for long periods moisture tension meters can be stored either completely dry or for fairly prolonged periods with the ceramic cell in distilled water. The distilled water helps to regenerate the permeability of he pores. That permeability of the ceramic cell has been seen occasionally to deteriorate - especially as a result of contact with intensive fertilization.

A tension meter can also be left in the ground over winter but the screw-fit cap should be opened to let any residual water seep through.

3.3.5.9 Technical data

Technical data - moisture tension meter electronics

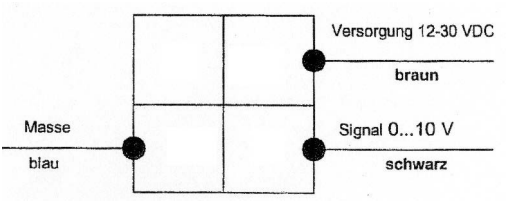
Type	FD9602TM1 (Electronics, replacement)	FDA9602TM1
Measuring range	0 to 1000 hPa	
Output signal	0 to 10 V / linear	
Supply voltage	12 to 30 VDC	12 VDC via ALMEMO® device
Operating conditions :		
Positioning	Preferably vertical	
Temperature range	-20 to +80 °C	
Protection class	IP65	
Connecting cable	ZA 9602AKTM1 (Connecting cable, replacement, 7 meters, with ALMEMO® connector)	7 meters, with ALMEMO® connector

Important note !
The afore-mentioned protection class applies only if used in conjunction with a standard integrated plug unit (i.e. cable with molded plug) or with your own plug - provided this has been fitted by specialist personnel. The sensor must not be immersed.

Pin assignment

Cable connection to sensor plug

The cable shielding (bare) should be connected to mass and grounded



Technical data - insert tension meter

Type	ZB9602TML2	ZB9602TMLV	ZB9602TMKV2
Measuring range	0 to 900 hPa		
Ceramic cell	Tapered cone Diameter = 18 mm Length = 85 mm	Tapered cone Diameter = 18 mm Length = 70 mm	Tapered cone Diameter = 18 mm Length = 45 mm
Overall length	350 mm	220 mm	145 mm
Insertion depth	approx. 250 mm	approx. 80 to 160 mm	approx. 50 to 120 mm

Technical data - surface tension meter

Type	ZB9602TMFO	ZB9602TMFV
Measuring range	0 to 900 hPa	
Ceramic base	Diameter = 70 mm	Diameter = 70 mm
Overall height	65 mm	65 mm
Positioning depth	approx. 30 to 60 mm	

Other lengths and variants are available by request

Labeling

The label on a moisture tension meter includes the following :
Unique test number “T .....”
Maximum suction force of tension meter cell (700 / 800 / 900 hPa)
Return suction factor - measure of tension meter reaction (0,1 / 0,2 / 0,3 minutes).

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.

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

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 Ø, 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 (Condensate Controlled Capacitance), 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

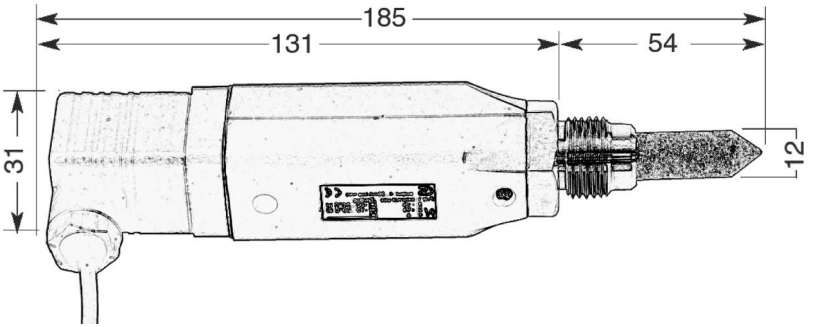
3.3.7.3 Dew Point Transmitter FHA646DTC1

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

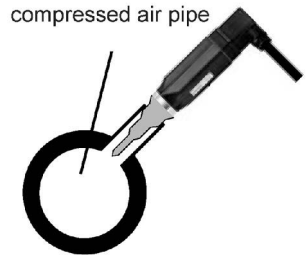
- Especially suitable for dew-point measurement with high level precision and long-term stability
- Digital transfer of measured values to the ALMEMO® display section (avoids risk of inaccuracy on the connecting lines or in the display section itself)
- High-level accuracy sustained down to -80 °C
-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

Dimensions (in mm)

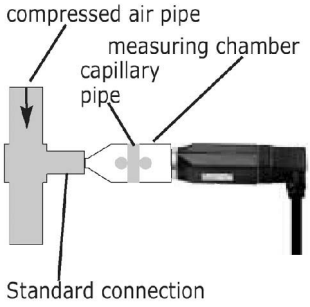


Installation

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.



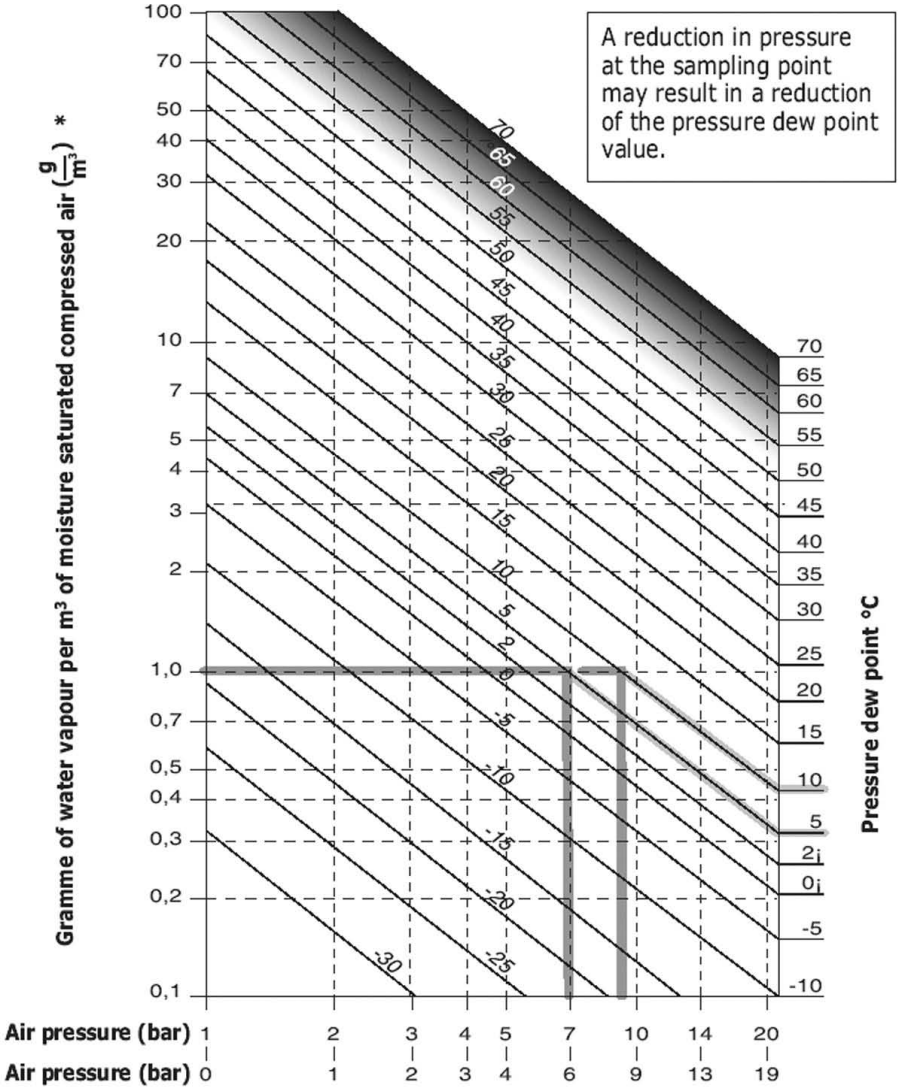
Indirectly in the compressed air system
Screw in probe with the G ½ " thread in the measuring chamber. Connect measuring chamber with the compressed air pipe using a ball valve and possibly a diffusion-tight connection pipe (max. 5m). In the case of compressed air containing oil and dirt particles, a 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 PTFE 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/m^3, 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 Power consumption	via ALMEMO® connector 5 mA
Output available on request	ALMEMO® digital 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 Protection system	 polycarbonate IP65

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