# Industrial Oil Moisture Sensor

## for moisture measurement in technical oils

KOBOLD

## AFO

Modbus

- Highly accurate moisture measurement in oils

- 2 x configurable analogue outputs, Modbus RTU (RS485)

- $p_{max}$: 300 bar

- $t_{max}$: +125 °C

**A2**

## Description

The AFO humidity and temperature transmitter is a reliable measuring device that can be used in various applications.

It is a microprocessor-controlled device that enables moisture measurement in the form of water activity or relative humidity. This is particularly useful in areas such as the lubrication of circulation systems or in oil transformers.

The analog interfaces with two current outputs can be freely configured, while a digital output (RS 485) is also available.

In addition, the AFO enables precise temperature measurement and is designed as an easy-to-install online probe.

The AFO is used to measure the moisture content in oil using water activity ($a_w$) and relative humidity (%rh). Using internal calculations on specific oil parameters, the AFO can also measure oil moisture in ppm (supported as standard for mineral transformer oil).

The water activity is measured on a scale from 0 to $1 a_w$, where $0 a_w$ stands for completely water-free oil and $1 a_w$ indicates that the oil is completely saturated with water. The relative humidity indicates the water content on a scale from 0 to 100 %rH, where 0 %rH stands for completely water-free oil and 100 %rH indicates that the oil is completely saturated with water.

If the water activity exceeds $0.9 a_w$ or the relative saturation exceeds 90 % rH, there is a risk of segregation in the system, especially at falling temperatures.

The water activity and relative humidity serve as critical parameters to indicate risks of free water in the system, especially when they reach values of $>0.9 a_w$ / >90 %rH.

The key advantages of this measuring system are that water activity and relative saturation are independent of oil ageing and immune to additives.

The AFO transmitter enables continuous online measurements and can also be calibrated with salt solutions without the need for reference oils.

### Programming by software

With the Service Software incl. USB / Modbus adapter settings like Modbus settings can be changed, analog output can be rescaled, and measured values can be assigned to adapt these oil specific parameters for different oil types.

### Special advantages of the AFO oil sensor:

- Fast response time
- Measured variables: Water activity ($a_w$), temperature (t) and water content in PPM (x) (for transformer oils)
- Two freely configurable analog outputs as well as Modbus-RTU (RS 485) interface available

## Technical Details

### Measured Values

#### Water activity

| | |
|---|---|
| Measuring range: | $0 \dots 1 a_w$ |
| Accuracy (including non-linearity, hysteresis and repeatability): | |
| | $0 \dots 0,9 a_w$: $\pm 0,02 a_w$ at +23 °C |
| | $0,9 \dots 1,0 a_w$: $\pm 0,03 a_w$ at +23 °C |
| Response Time in Oil Flow: | < 1 min (dry-wet) |

#### Temperature

| | |
|---|---|
| Accuracy: | $\pm 0,3$ °C |

| | |
|---|---|
| **Oil Moisture** | Moisture calculation in ppm for Transformer Oil |

### Ambient conditions

| | |
|---|---|
| EMV: | acc. to DIN EN 61326-1 |
| Oil temperature: | $-20 \dots +125$ °C |
| Ambient temperature: | $-20 \dots +70$ °C |
| Storage temperature: | $-40 \dots +80$ °C |
| Flow dependence: | continuous flow recommended |
| Pressure rating: | up to 300 bar |

### Inputs and Outputs

| | |
|---|---|
| Digital output: | RS-485, Modbus RTU protocol |
| Analogue current output: | 2 x 4 $\dots$ 20 mA, 3-wire (galvanically not isolated) |

### General Data

| | |
|---|---|
| Electrical connection: | M12, 8-pin, A-coding |
| Process connection: | G ½ ISO or ½" NPT |
| Material | |
| | Housing: zinc die casting |
| | Thread: st. st. 1.4404 |
| | Perforated cap: st. st. 1.4301 |
| Weight: | approx. 190 g |
| Supply voltage range: | $10 \dots 36$ V$_{DC}$ |
| Protection: | IP 66 |
| Load for Analogue output: | < 500 Ohm |
| Calibration certificate: | Yes |

## Spare parts and Accessories

### Electrical Connection

Plug Connector:    M12 cable box (female straight) with terminals, 8-pins gold-plated contacts, IP 67, PA housing / male insert, ring nut zinc die casting, nickel-plated; Order code: ZUB-KAB-12D800

## Applications

These applications illustrate how oil moisture meters contribute to optimizing machinery performance and preventing premature wear across diverse industries.

- Mechanical Engineering and Manufacturing: Monitoring hydraulic systems, transmissions, and machinery.
- Energy Sector: Testing transformer oils for secure insulation performance.
- Automotive Industry: Monitoring transmissions and hydraulic systems in vehicles.
- Aviation Industry: Ensuring oil quality in aircraft engines.
- Shipping: Ensuring reliability of ship engines and hydraulic systems.
- Paper and Printing Industry: Ensuring oil quality in printing machines and lubrication systems.
- Chemical Industry: Monitoring hydraulic systems and pumps.
- Food Processing: Ensuring cleanliness and contamination-free oil in conveyors and machines.
- Mining Industry: Monitoring lubrication performance in dusty environments.
- Construction Industry: Ensuring efficient operation of construction machinery and hydraulic systems.
- Metal Processing: Extending the lifespan of equipment in rolling mills.
- Pharmaceutical Industry: Using oils in the correct purity classes.
- Wind Energy: Monitoring gearboxes in wind turbines for efficient energy generation.
- Water Treatment: Ensuring the reliability of pumps and motors.
- Textile Industry: Minimizing friction and wear in spinning machines.
- Chemical Production: Optimizing lubrication in mixers and stirrers.
- Automation Technology: Ensuring smooth operation of industrial robots and automation systems.
- Plastic Processing: Improving material quality in extruders and injection molding machines.
- Petrochemical Industry: Monitoring the conditioning of lubricating oils in refineries.
- Medical Technology: Ensuring lubricants meet the requirements of precision instruments and medical devices.

## Why is oil moisture measurement necessary?

The presence of water in oil can cause significant damage to machinery and components. Even with a water content only slightly above the oil saturation limit, the lifespan of components can be significantly reduced. Therefore, it is crucial to maintain the water content below the oil saturation limit.

Air humidity in the environment can absorb water, which is then dissolved in the oil until the oil saturation limit is reached. As long as this limit is not reached, the oil remains clear. With changes in operating temperature and reaching the saturation limit, this mixture can either lead to an emulsion (for example, when the oil's water separation capability is poor) or to free water (for example, when the oil's water separation capability is good). If the mixture forms an emulsion, the oil becomes cloudy. If the water is released, a two-phase oil-water mixture is present.

The oil saturation limit depends on various factors, including the operating temperature. Some oils can absorb more water than others. However, the water separation capability of oils decreases during operation, leading to the formation of water-oil emulsions. The oil circulation system should be designed to separate water as efficiently as possible.

### Recommendation:

Installation in a constantly flushed measuring point for best results

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No responsibility taken for errors; subject to change without prior notice.

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3

## Order Details AFO (Example: **AFO-F R15 M WA TC T 0**)

| Model | Process connection | Output signal transmitter | Output 1 (4 ... 20 mA) [1] | Output 2 (4 ... 20 mA) [1] | Oil type | Option |
|---|---|---|---|---|---|---|
| AFO-F | **R15** = G½ male<br>**N15** = ½" NPT male | **M** = 2 x 4 ... 20 mA, 3-wire; RS485 Modbus RTU | **WA** = Water activity $a_w$ [ ]<br>**WC** [2] = Water content x [ppm]<br>**TC** = Temperature [°C]<br>**TF** = Temperature [°F] | **WA** = Water activity $a_w$ [ ]<br>**WC** [2] = Water content x [ppm]<br>**TC** = Temperature [°C]<br>**TF** = Temperature [°F] | **T** = Transformer oil<br>**9** [3] = Customer specific oil | **0** = w/o<br>**Y** = Special (specified in plain text) |

[1] Scale to be specified in plain text
[2] Configuration only for transformer oil
[3] For PPM calculation in customer specific oil, we need respective saturation curve, which may be determined in a suitable lab using Karl Fischer Titration.

## Order Details Service Software incl. PC connection

| Order code | Description | Image |
|---|---|---|
| **AFO-Soft** | Configuration software AFO incl. interface cable to PC (USB) and power supply - for configuration / parametrisation of AFO | |

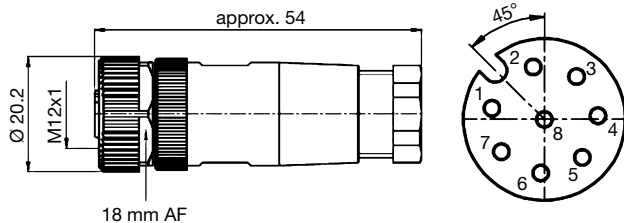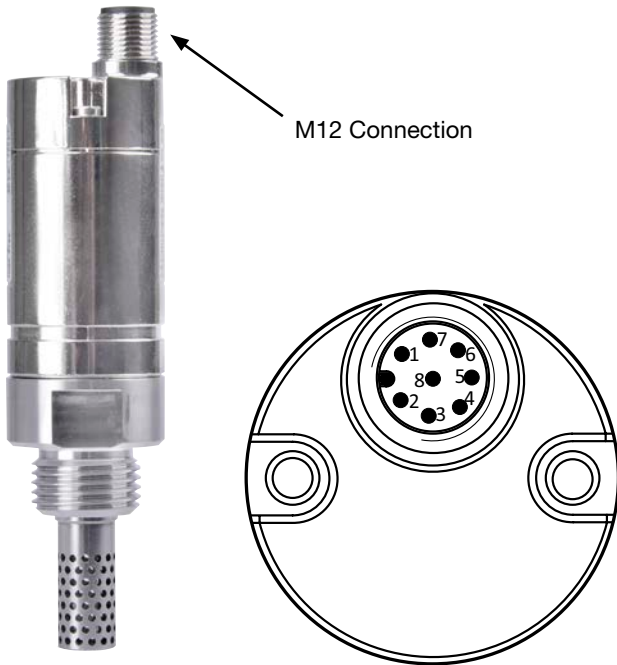## Accessories

**Order code:** ZUB-KAB-12D800
Plug connector: M12 cable box (female straight) with terminals, 8-pins
gold-plated contacts, IP 67,
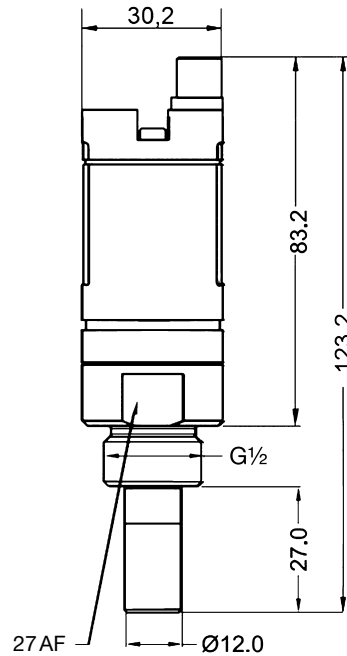PA housing / male insert,
ring nut zinc die casting, nickel-plated

## Dimensions [mm]

approx. 54
Ø 20.2
M12x1
18 mm AF
45°

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## Dimensions / Electrical Connection

M12 Connection

**Dimensions [mm]**

30,2

83.2

123,2

G½

27.0

27 AF

Ø12.0

| | Pin 1 | Pin 2 | Pin 3 | Pin 4 | Pin 5 | Pin 6 | Pin 7 | Pin 8 |
|---|---|---|---|---|---|---|---|---|
| | NC | RS485 (B) | RS485 (A) | +I output | +I output | -VB | NC | +VB |

| +VB | Positive supply voltage 24 $V_{DC}$ (10...30 $V_{DC}$) smoothed |
|---|---|
| RS485 (A) | Modbus A (+) |
| -VB | Negative supply voltage |
| RS 485 (B) | Modbus B (-) |
| +I | Positive 4...20 mA Signal ** |
| NC | not connected |

** Measuring value assignment for 4...20 mA signal selectable

## M12 Connector

### Connection diagram

8 — +VB
4 —
5 — 4..20mA
6 — 4..20mA — -VB

3 — RS 485 A
2 — RS 485 B
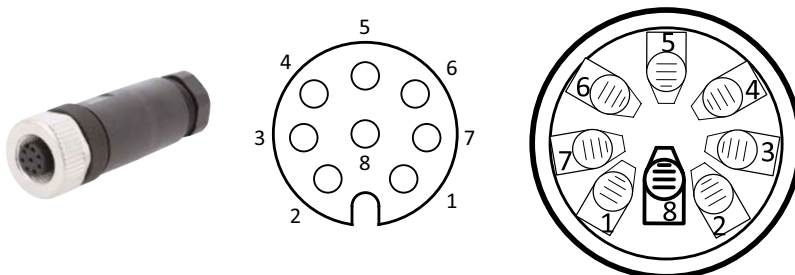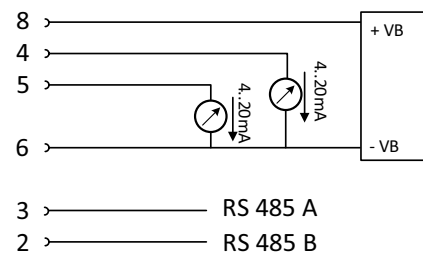
**Note:** The sensor must be connected in strainless state only.

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