



Manual

Moisture Sensor PCE-MWM 2xx



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1 Introduction

This manual as well as the technical description is both intended to introduce the user to the operating principle, installation and calibration of the moisture sensor. The manufacturer reserves the right to change the design and circuitry of the moisture sensor.

2 Safety notes

Please read this manual carefully and completely before you attempt to use the device for the first time. The device may only be used by qualified personnel and repaired by PCE Instruments personnel. Damages or injuries caused by non-observance of this manual are not covered by warranty.

- Only use the moisture sensor PCE-MWM 200 Series when the 24 V power supply is grounded
- Do not use the moisture sensor if the electronic unit cover has been removed
- Only open the cover of the electronic unit after the power supply was disconnected
- Do not open the sensor case
- All types of maintenance, repair and installation including disconnection, swapping wires as well as dismantling, should only be done when the device is disconnected from the power supply
- Do not operate the moisture sensor if the cables, plugs or the power supply are damaged
- Operation of the sensor system is only permitted in the approved temperature range
- Technical changes of the device are prohibited
- The sensor system should only be cleaned with a damp cloth and only ph-neutral cleaners may be used

This manual is published by PCE Instruments without any guarantee.

We explicitly refer to our general warranty terms which can be found in our general terms of business.

Please contact PCE instruments if you have any questions.

3 Scope of delivery

- 1 x PCE-MWM 2xx sensor
- 2 x 5 m cables
- 1 x CD (PC software, manual)
- 1 x RS-485 / USB converter

4 Specifications

	PCE-MWM 240-A/ 240-B/240-C	PCE-MWM 220	PCE-MWM 210
Sensor			
Measuring range	0 ... 100 %		
Absolute error of moisture measurement	see Table 1		
Measuring temperature range	+5 ... +80 °C / 40 ... 176 °F		
Temperature range of electronics	-20 ... +145 °C / -4 ... 293 °F		
Measuring interval	1 second		
Dimensions	Refer to technical drawings in respective chapters of this manual below		Length x Ø: 103 x 108 mm
Weight	Ca. 10 kg / 22 lbs		
Protection class	IP67, GOST 14254-96		
Cable length	1.5 ... 4 m / 5 ... 13 ft options		
Electronic unit			
Dimensions (L x W x H)	255 x 170 x 60 mm / 10 x 6.7 x 2.4 inches		
Weight	2 kg / 4.41 lbs		
Protection class	IP54, GOST 14254-96		
Operating temperature	+5 ... +60 °C / 40 ... 140 °F		
Output interface	Serial interface: RS-485 MODBUS RTU Current loop: 4 ... 20 mA		
Power supply	Nominal voltage: 24 V Permissible voltage: 18 ... 36 V		
Current draw	Max. 200 mA		
Max. length of cable <i>RS-485 to external control device (controller / computer)</i>	1000 m / 3280 ft		
Max. length of cable <i>4 ... 20 mA analog signal from electronic unit to external display</i>	100 m / 328 ft		
Inline measurement (PCE-MWM 220 only)			
Nominal size of pipe		DN50, DN80, DN125	
Max. overpressure		10 MPa	

PCE-MWM 240-A/240-B/240-C		PCE-MWM 220		PCE-MWM 210	
Moisture [%]	Min. error (absolute) [%]	Moisture [%]	Min. error (absolute) [%]	Moisture [%]	Min. error (absolute) [%]
0 ... 6	0.3	0 ... 0,3	0.03	Up to 10	0.5
6 ... 8	0.4	0,3 ... 3	0.1	10 ... 20	1
8 ... 10	0.5	3 ... 7	0.2	20 ... 50	2.5
10 ... 20	1	7 ... 10	0.3	50 ... 100	5
20 ... 50	2.5	10 ... 20	0.5		
50 ... 100	5	20 ... 40	1		
		40 ... 100	2.5		

Table 1: Minimal error of moisture measurement (absolute)

5 Mechanical installation

Note: After the mechanical installation, the sensors must be initialized. For this initial calibration (see 7.4) the measuring volume of the sensor needs to be empty.

Additionally a device or an opening to extract samples from needs to be in close vicinity to the installation position in order to calibrate the sensor (see 7.5).

5.1 Evaluation unit

The moisture sensors of the PCE-MWM 2xx series differ in the different versions of the sensor unit in order to be used in different applications. The sensor unit is connected to the evaluation unit, which contains the electronics for the control of the sensor and further signal processing. The housing of the evaluation units for the various sensors of the PCE-MWM 2xx series is identical and can be fixed with the help of 2 Bohrloch holes in the below drawing. They can be drilled out without damaging the water tightness of the housing.

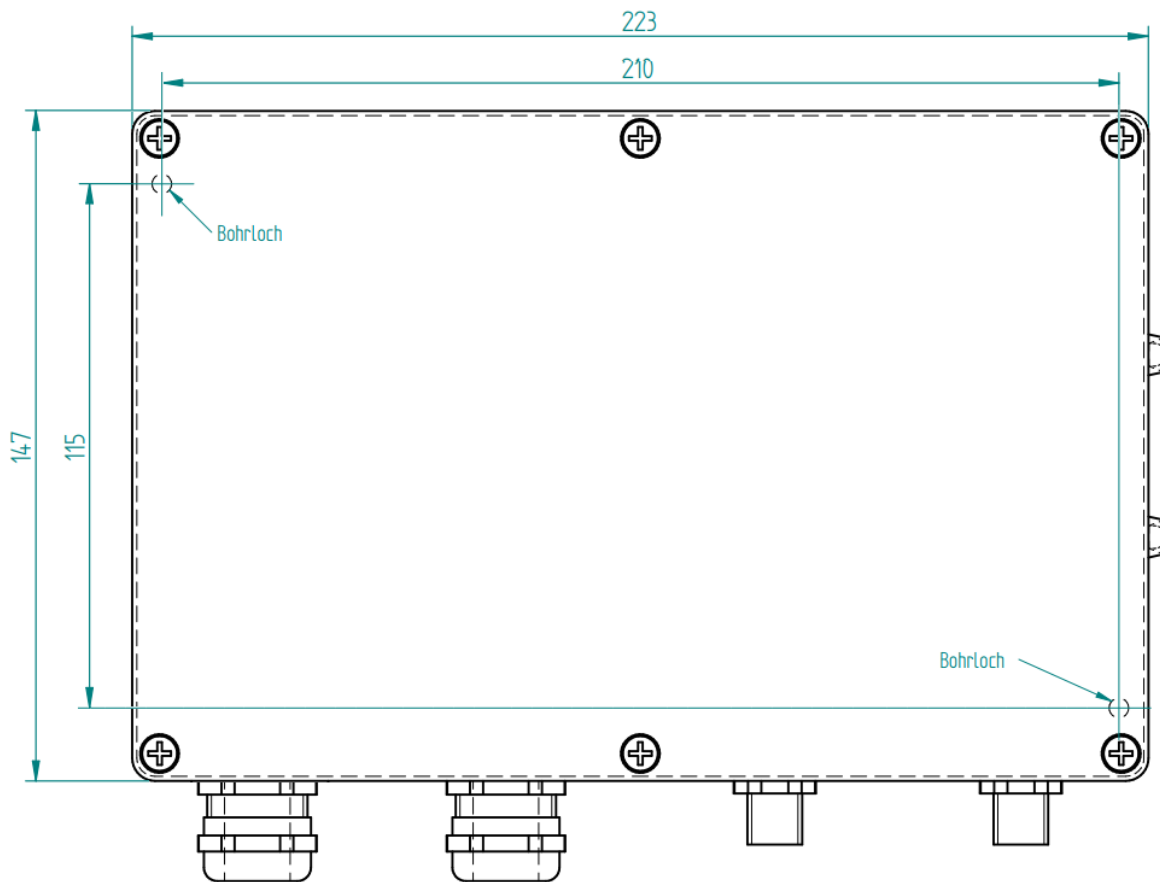


Fig. 1 Dimension of the evaluation unit

5.2 PCE-MWM 210

The sensor assembly is manufactured from galvanized steel and consists of two rings which are used to install the sensor to the container/mixer. The first ring is a welding flange which needs to be welded to the surface of the container/mixer. The second ring is used to clamp, mount and align the sensor unit inside the opening of the container/mixer wall.

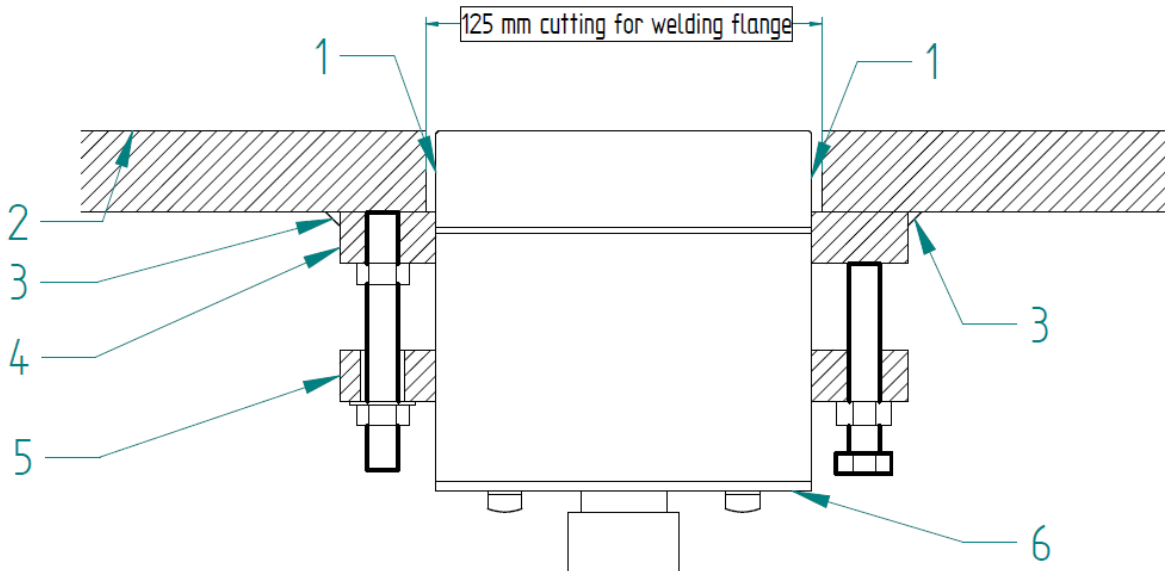


Fig. 2 Installation of PCE-MWM 210

- 1) Gap between sensor and wall of container/mixer which needs to be filled with an adequate sealant
- 2) Wall of container/mixer
- 3) Weld connecting the welding flange with the wall of the container/mixer
- 4) Welding flange (galvanized steel)
- 5) Clamping ring (galvanized steel)
- 6) Sensor unit

5.2.1 Flange

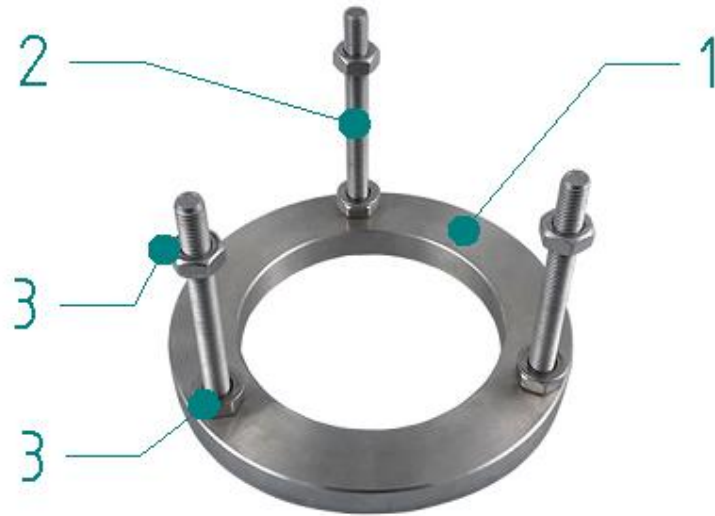


Fig. 3 Welding flange



Fig. 4 Clamping ring

- 1) Welding flange
- 2) Threaded bolt
- 3) Securing nut
- 4) Clamping ring
- 5) Clamping screws
- 6) Adjusting screws
- 7) Sensor
- 8) Through-bore

5.2.2 Installation

- 1) In order to install the sensor a hole with a diameter of 125 mm or 4.92 inches needs to be cut out of the wall of the container/mixer. Afterwards the welding flange (1) is welded centrally over the 125 mm hole. The welding flange is manufactured from galvanized steel. While cutting and welding, the sensor (7) must not be installed.
- 2) Screw three threaded bolts (2) into welding flange (1) and fix them with three securing nuts (3).
- 3) Fasten clamping ring (4) on the sensor (7) by using two clamping screws (5).
- 4) Position the assembly consisting of sensor and clamping ring on the welding flange by pushing the threaded bolts through the through-bores (8).
- 5) Align the sensor by using the adjusting screws (6). The surface of the sensor must be in line with the inner wall of the container/mixer.
- 6) Secure the assembly by screwing three securing nuts (3) on the threaded bolts.
- 7) After tightening all screws and nuts, check the alignment of the sensor on the inside of the wall of the container/mixer again. In any case the sensor must not protrude inside of the container/mixer. Otherwise the sensor may be damaged by mixing blades during the mixing process!

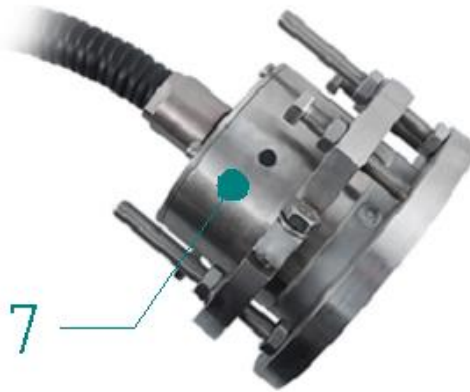


Fig. 5 Sensor fixed in ring-assembly



Fig. 6 Ring-assembly

5.2.3 Sensor Coverage

A sufficient material coverage is required to receive an accurate measurement of the material moisture. The measuring volume of the sensor is approximately $\text{Ø}108 \text{ mm} \times 100 \text{ mm}$ or $4.25'' \times 3.94''$. A sufficient material coverage should always be ensured even in case of minimal material level or flow inside the container or on a conveyor belt. Apart from sufficient material coverage it is also important to avoid metallic components within the measuring field of the sensor. The minimum distance to metallic components to the side is 50 mm or $2''$. All of the above factors have to be taken into account when choosing the installation position of the sensor.

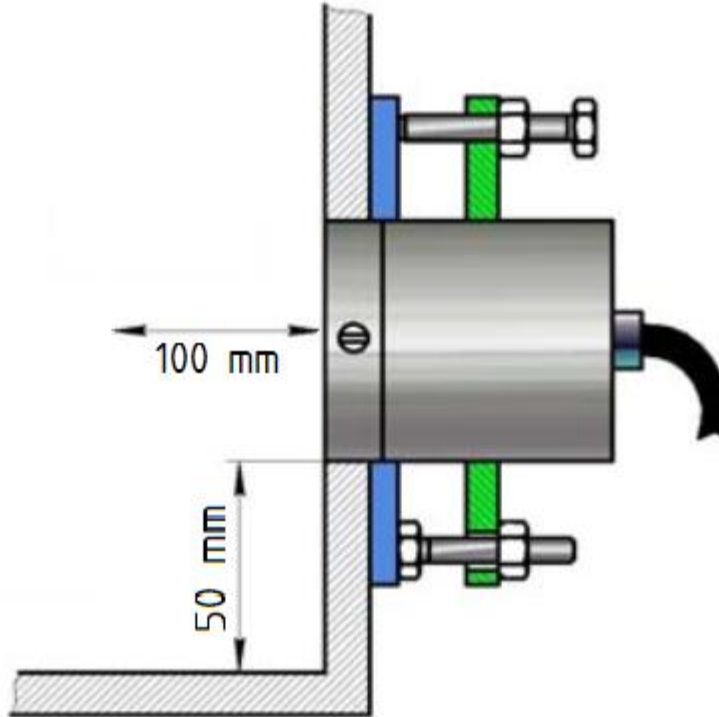


Fig. 7 Distance of PCE-MWM 210 to metallic components

5.3 PCE-MWM 220 (HC)

The PCE-MWM 220 sensor is installed in a pipe with the help of two welding flanges. There is also another variant with the designation PCE-MWM 220 HC which is used to measure materials with high electrical conductivity.

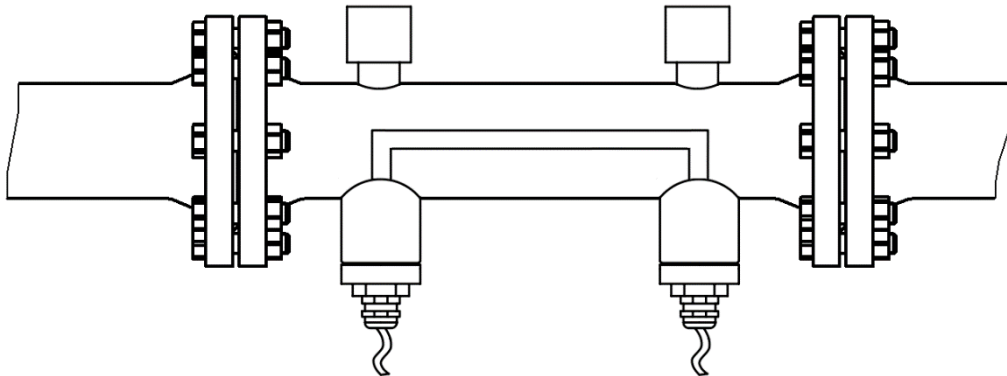


Fig. 8 Installation position of PCE-MWM 220

5.3.1 Dimensions of mounting flanges

Example DN 80:

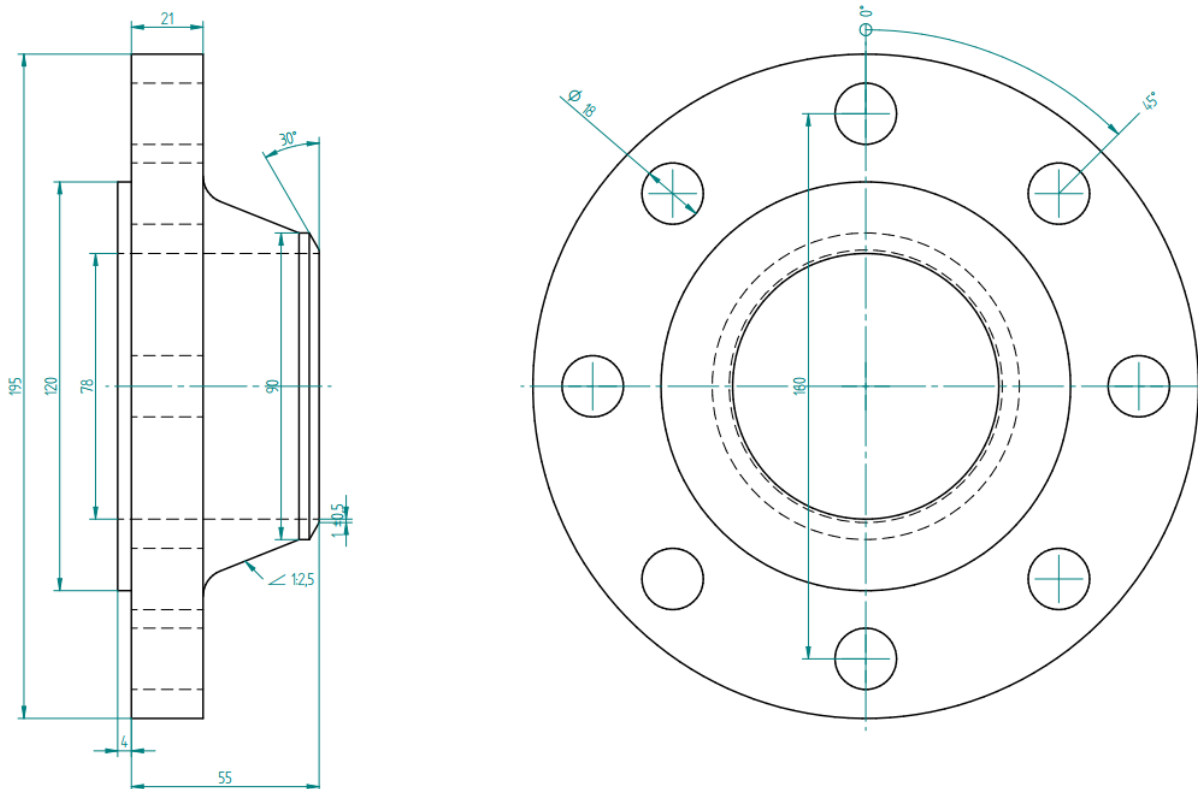


Fig. 9 Dimension of spring flange

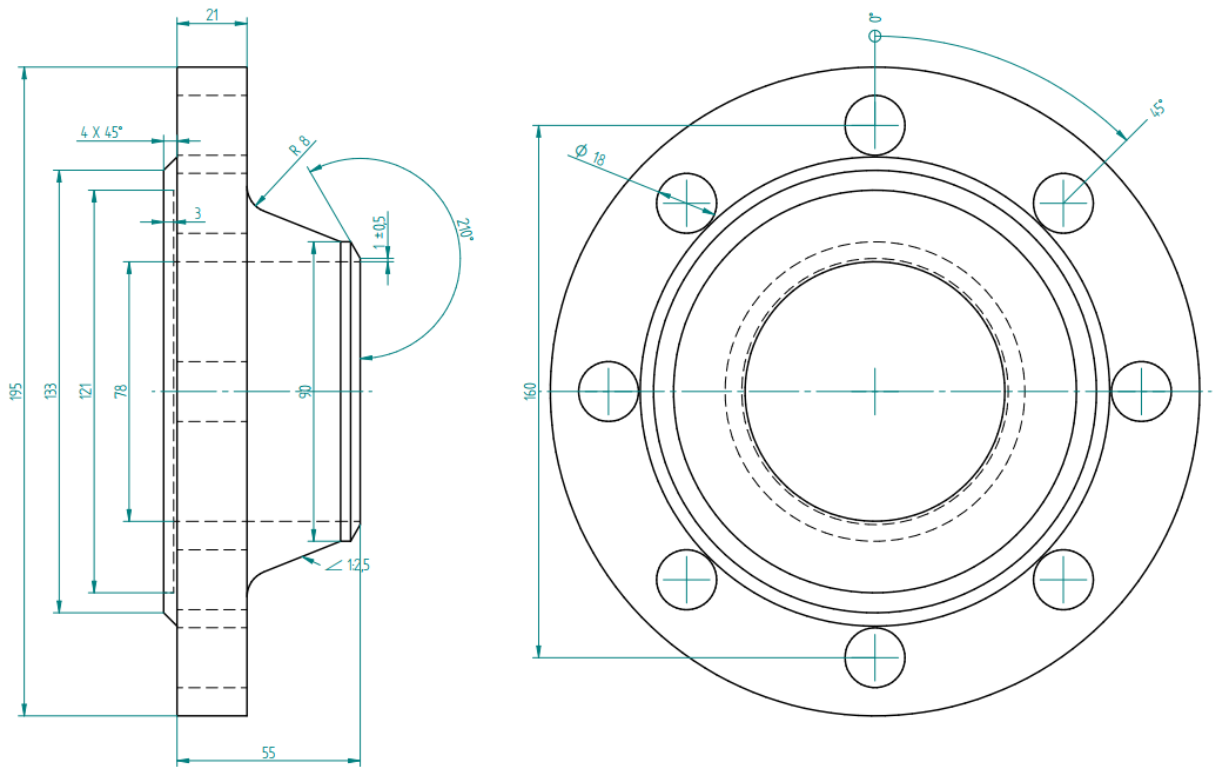


Fig. 10 Dimension of groove flange

5.3.2 Dimensions of sensor PCE-MWM 220

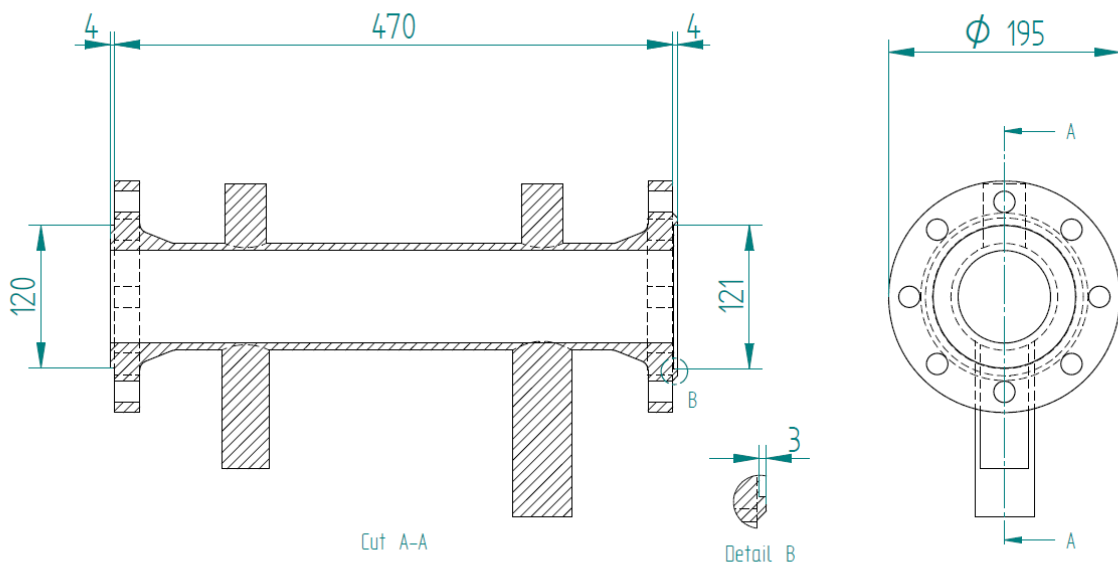


Fig. 11 Dimension of sensor PCE-MWM 220

5.3.3 Dimensions of sensor PCE-MWM 220 HC

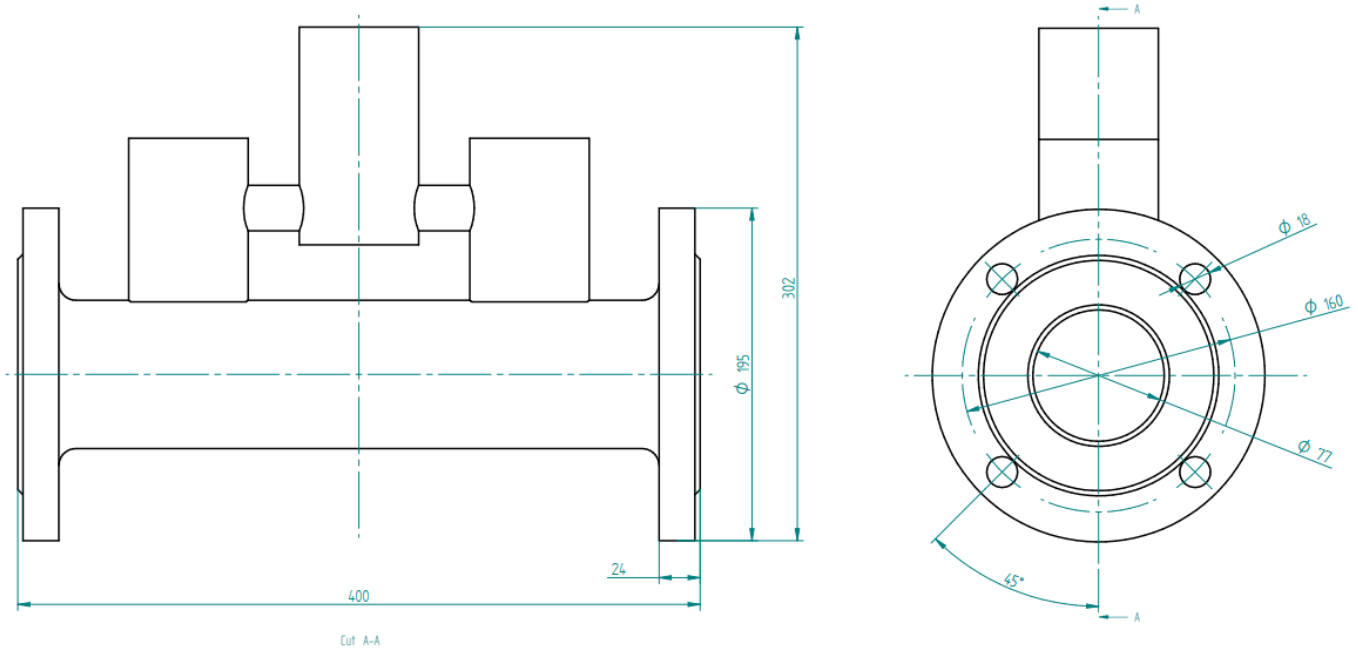


Fig. 12 Dimensions of sensor PCE-MWM 220 HC

5.4 PCE-MWM 240-A

There are several possibilities of installing the PCE-MWM 240-A moisture sensor to a container. The sensor can be connected to the container wall with welds or screws. The following figures show installation examples since several different installation setups are possible depending on container dimensions and geometry. The following examples display a vertical orientation of the sensor. Depending on the application, it is also possible to choose a horizontal orientation as well as any other angle.

5.4.1 Dimensions of the sensor PCE-MWM 240-A

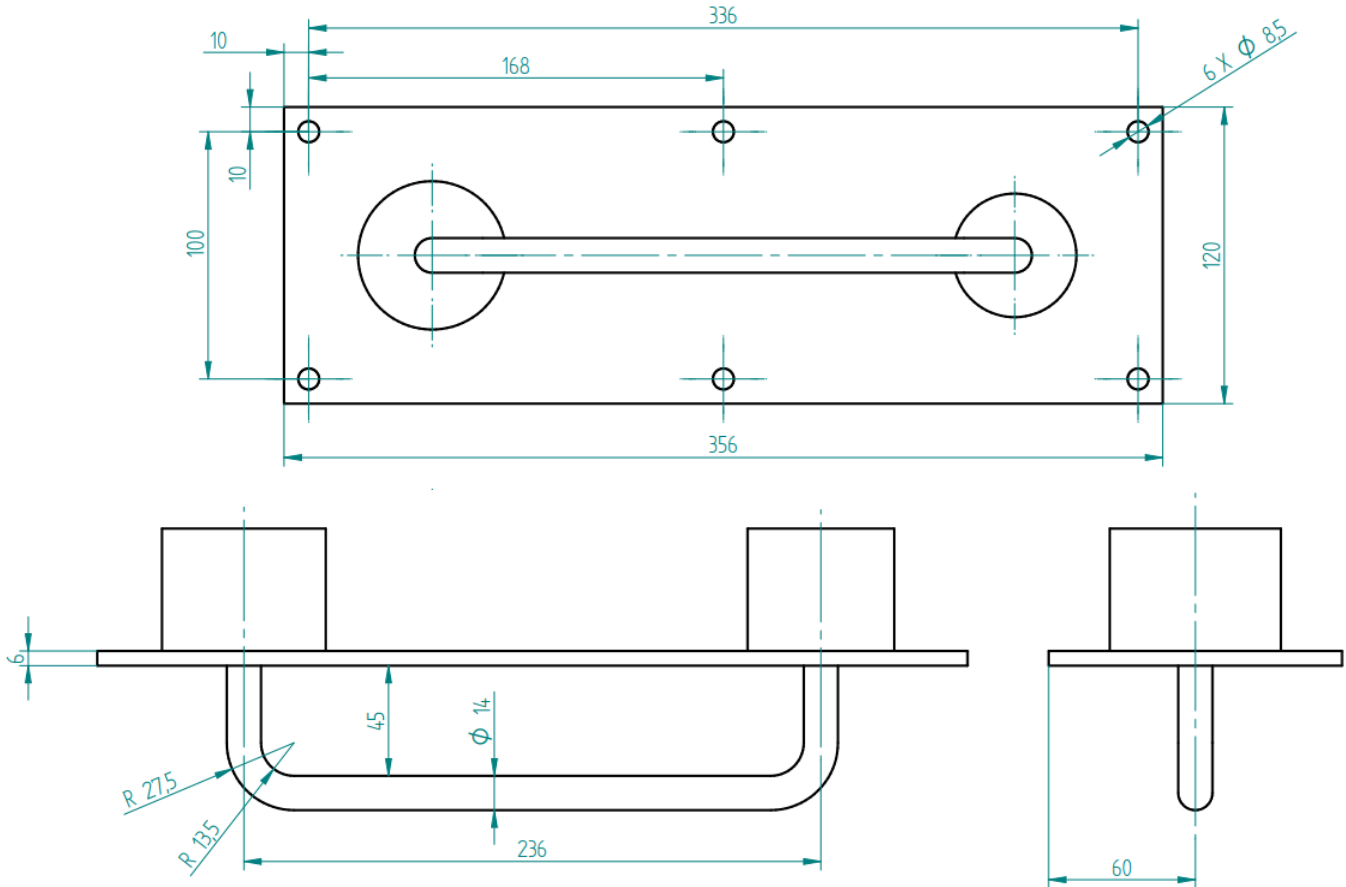


Fig. 13 Dimensions PCE-MWM 240-A

5.4.2 Installation with welds

In order to install the base plate of the sensor, a rectangular cut-out with dimensions of at least 315 x 80 mm or 12.4" x 3.15" needs to be cut out from the container. On curved surfaces the cut-out dimensions deviate and need to be calculated individually depending on the container.

The cutting edges should be smoothed to prevent material adhering to the inside after installation of the sensor and to prevent injuries caused by sharp edges.

Note: Please pay attention to the safety instructions regarding the use of the appropriate cutting tools. Only persons with appropriate training may carry out the task.

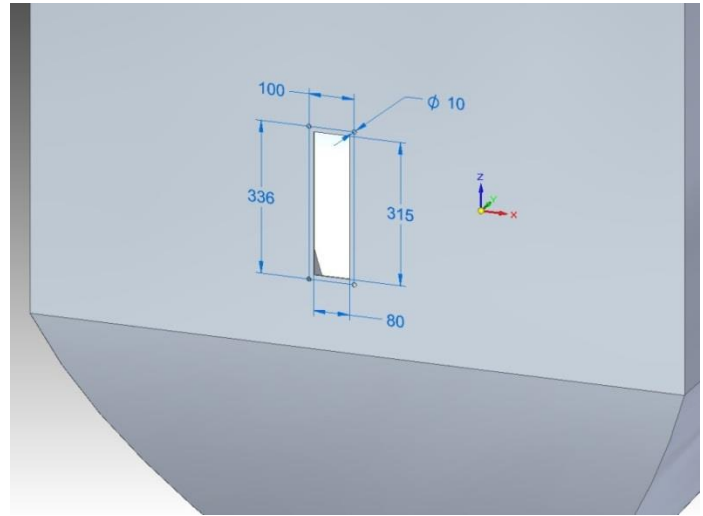


Fig. 14 Dimensions of the rectangular cut-out

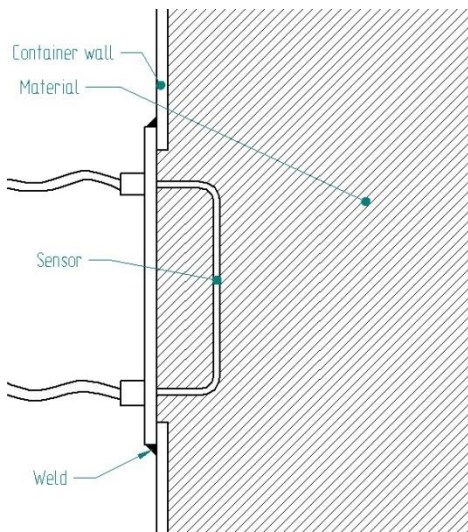


Fig. 15 Installation with welds

After the sensor is positioned in the rectangular cut-out, the base plate can be welded from the outside to the container wall.

Warning: It is prohibited to weld the base plate to the container wall while the electronic unit is connected to the power supply.

Note: Please pay attention to the safety instructions regarding the use of the appropriate welding tools. Only persons with appropriate training may carry out the task.

5.4.3 Installation with screws

In order to install the base plate of the sensor, a rectangular cut-out with dimensions of at least 315 x 80 mm or 12.4" x 3.15" needs to be cut from the container. Furthermore, four holes for the screws have to be drilled through the container wall with distances of 336 / 100 mm between them. On curved surfaces, the cut-out dimensions deviate and need to be calculated individually depending on the container.

The cutting edges should be smoothed to prevent material adhering to the inside after installation of the sensor and to prevent injuries caused by sharp edges.

Note: Please pay attention to the safety instructions regarding the use of the appropriate cutting tools. Only persons with appropriate training may carry out the task.

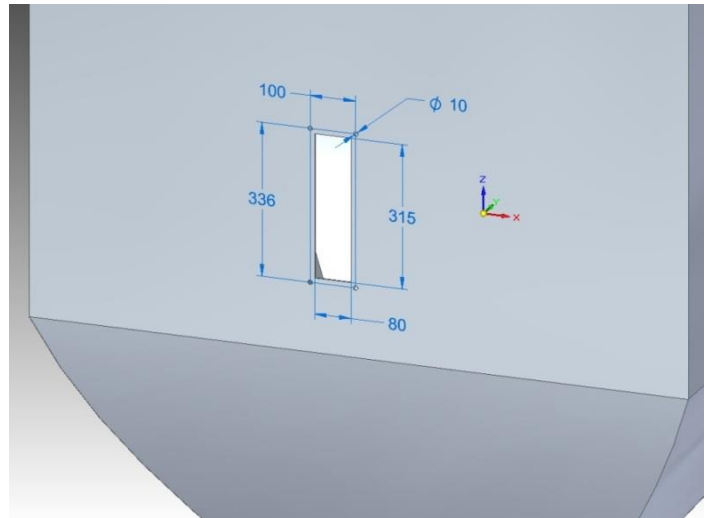


Fig. 16 Dimensions of the rectangular cut-out

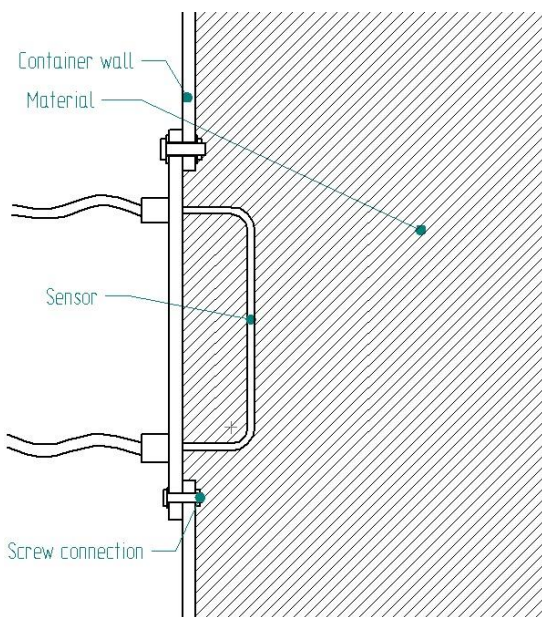


Fig. 17 Installation with screws

After the sensor is positioned in the rectangular cut-out, the base plate can be screwed from the outside to the container wall.

Warning: It is prohibited to screw the sensor to the container wall while the electronic unit is connected to the power supply.

Depending on the surface and geometry of the container wall it is possible that the connection exhibits gaps. In that case especially fine-grained materials can trickle through the small gaps between the base plate of the sensor and the container wall. An adequate sealant should be used to close these gaps.

5.4.4 Installation with flange

- 1) Rectangular cut-out in container wall with dimensions of at least 360 x 125 mm or 14.2" x 4.92". Smooth the edges of the cut-out.
- 2) Align flange with dimensions as shown in Fig. 19 over the cut-out and weld it to the container wall from the outside.
- 3) Screw the sensor with the base plate from the inside of the container to the flange.

The dimensions of the flange are an example and exact dimensions may change depending on the container. Different dimensions or shape of the flange does not affect the measuring accuracy of the sensor.

Note: Please pay attention to the safety instructions regarding the use of the appropriate tools. Only persons with appropriate training may carry out the task.

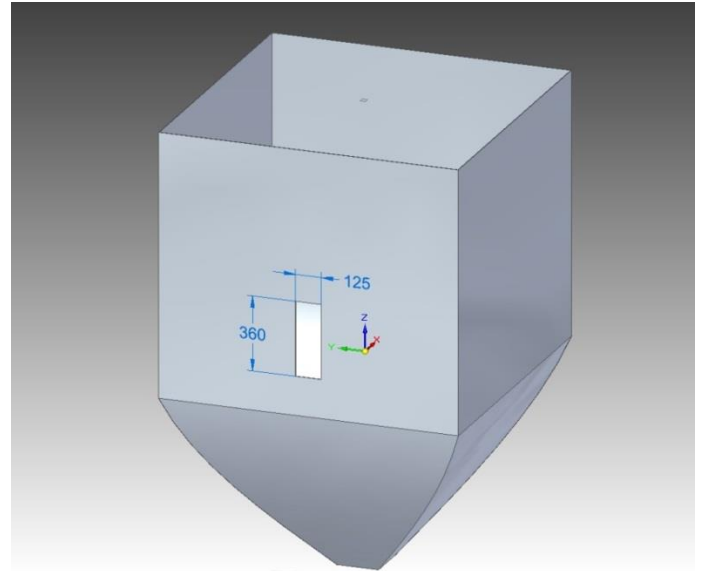


Fig. 18 Dimensions of the rectangular cut-out

Installation with a flange offers two advantages:

- 1) For maintenance purposes it is easier to remove the sensor since it is held with screws and is not welded to the container wall.
- 2) The base plate of the sensor can be mounted on the same level as the inside of the container wall. This can help to reduce material adhesion at the cutting edges and to improve material flow inside the container.

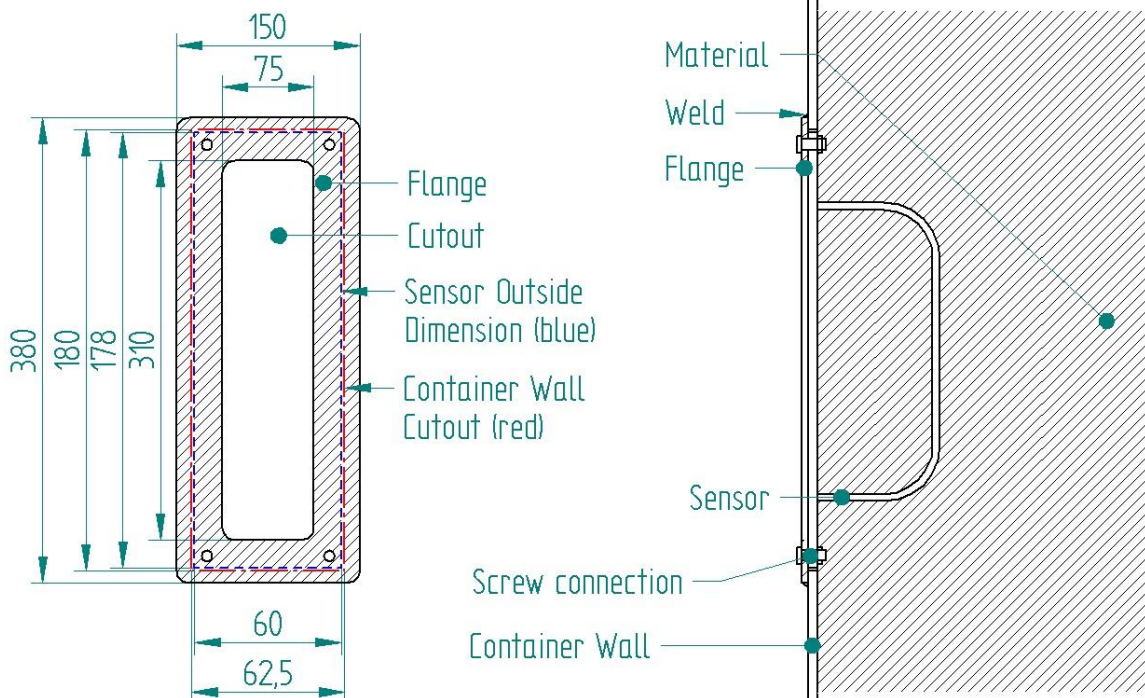
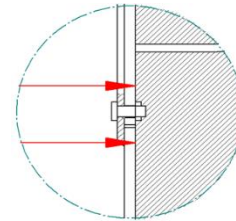


Fig. 19 Dimensions of the flange for installation of the moisture sensor PCE-MWM 240-A

5.4.5 Installation on curved surfaces

On curved surfaces the rectangular cut-out in the container wall needs to be individually adjusted to the curvature. Considering the size of the base plate of 356 x 120 mm a possible way is to adjust the cut-out in such a way so that one side is shorter and one side longer than the according length of the base plate. In this case one edge of the base plate would "fall" into the container while the other edge would rest on the cutting edges of the container wall. It is also possible to individually adjust the geometry of the flange to a container in order to install the sensor.

Gaps between the container wall and the sensor / flange should be sealed with a suitable sealant.

Fig. 20 shows the top view of an installation example.

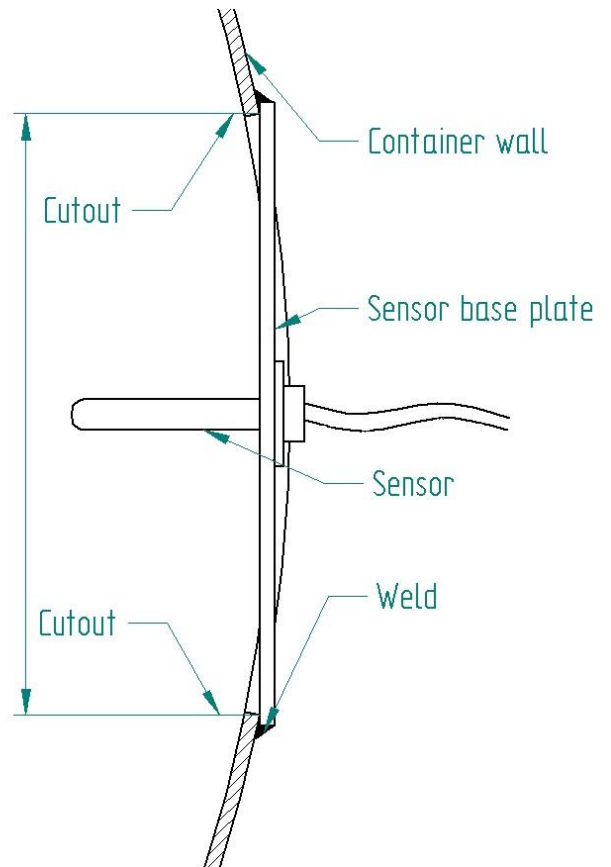


Fig. 20 Installation on a curved surface

5.4.6 Sensor coverage

A sufficient material coverage is required to receive an accurate measurement of the material moisture. The measuring volume of the sensor is approximately 360 x 130 x 100 mm or 14.17" x 5.12" x 3.94". A sufficient material coverage should always be ensured even in case of minimal material level or flow inside the container or on a conveyor belt. Apart from sufficient material coverage it is also important to avoid metallic components within the measuring field of the sensor. All of the above factors have to be taken into account when choosing the installation position of the sensor.

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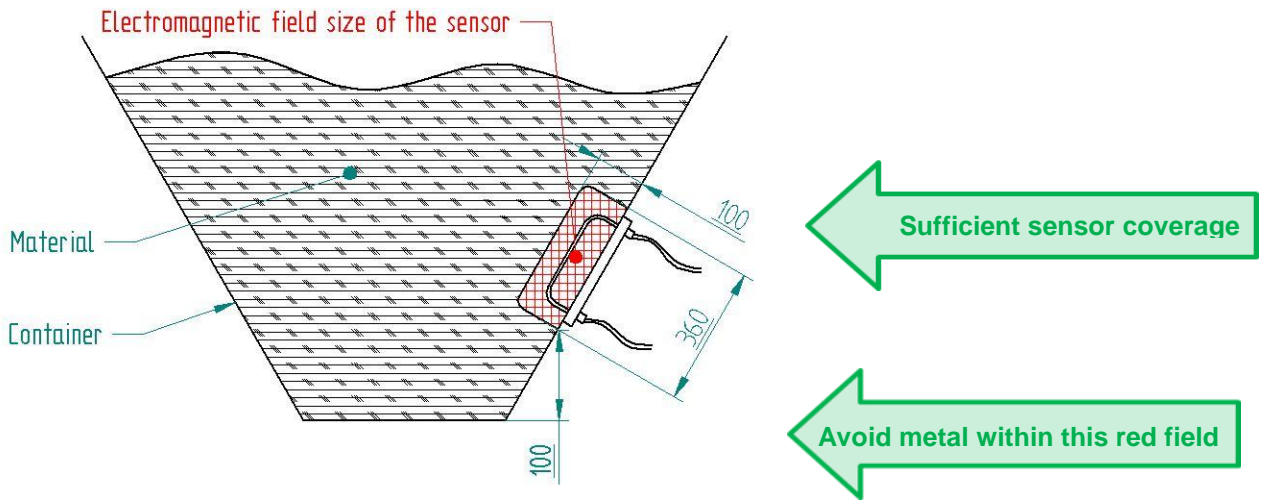


Fig. 21 Sufficient material coverage of the moisture sensor PCE-MWM 240-A

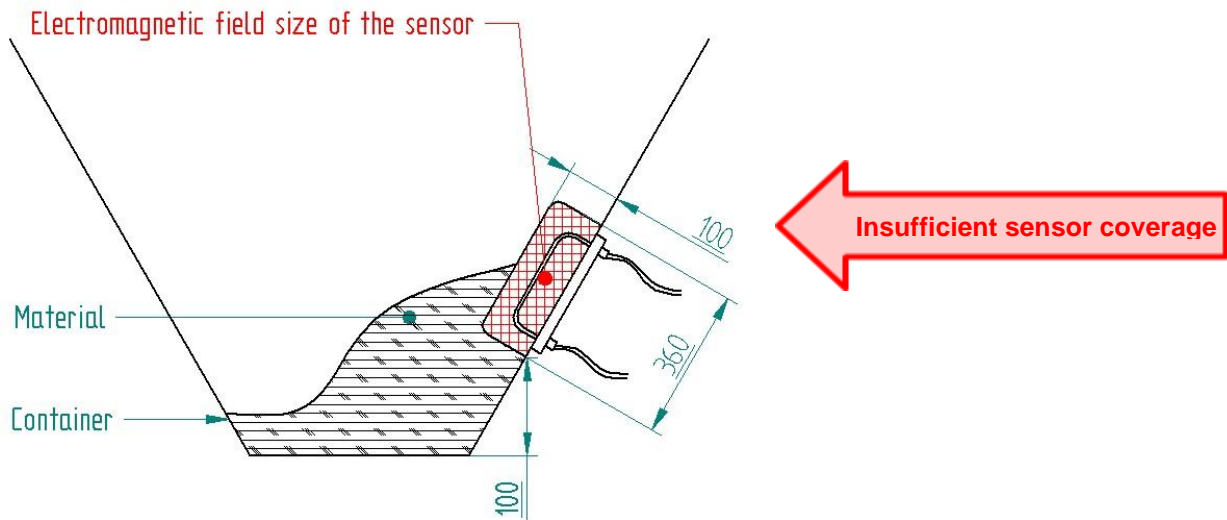


Fig. 22 Insufficient material coverage of the moisture sensor PCE-MWM 240-A

5.5 PCE-MWM 240-A-2

The PCE-MWM 240-A-2 is similar to the PCE-MWM 240-A and the difference consists of a double antenna that protrudes from the sensor base plate. In comparison to the PCE-MWM 240-A this feature enhances the noise immunity and reduces the influence of objects near the measurement field of the sensor.

5.5.1 Dimensions of the sensor PCE-MWM 240-A-2

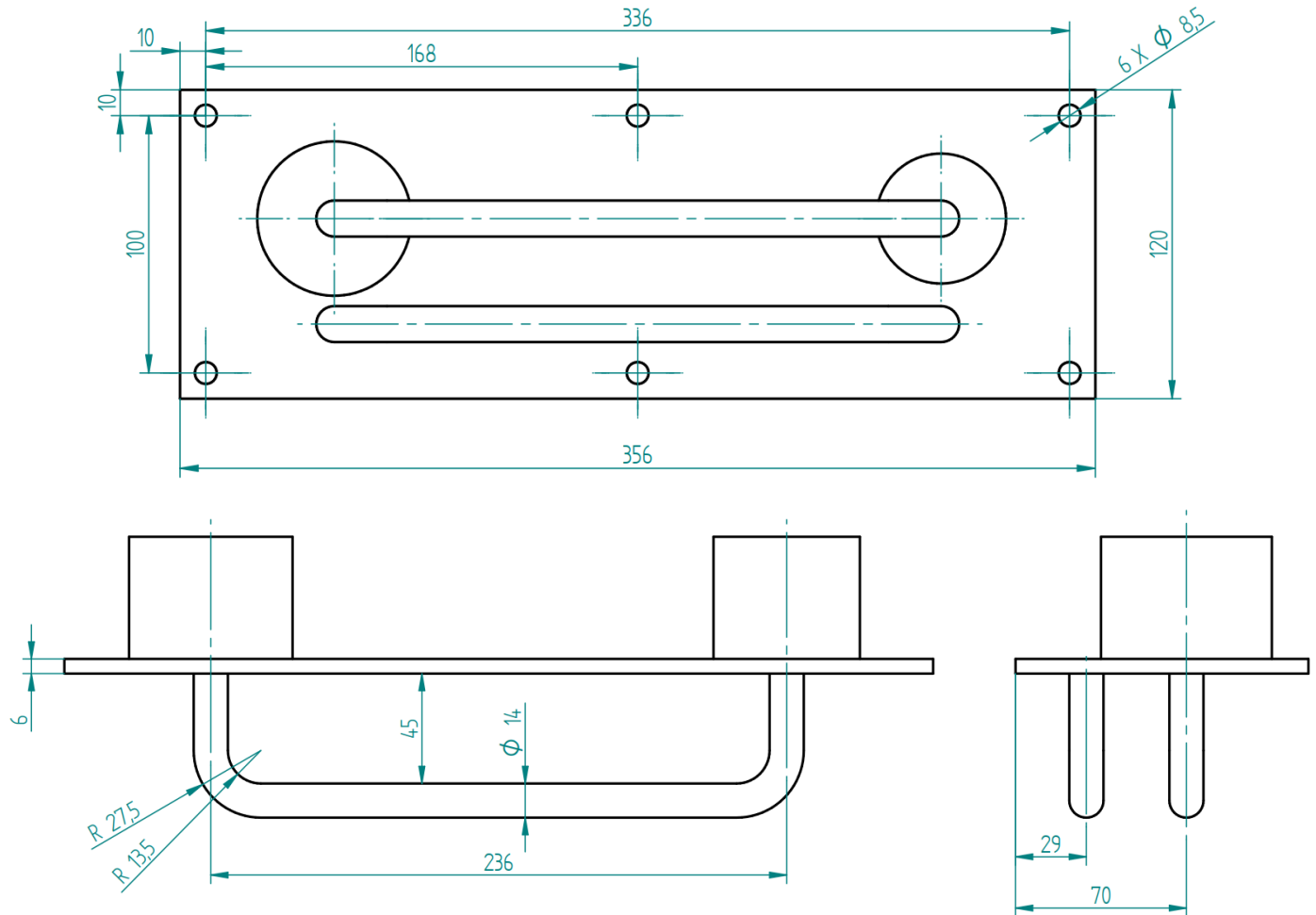


Fig. 23 Dimensions PCE-MWM 240-A-2

5.5.2 Installation and sensor coverage

Due to the similar dimensions, the same considerations of the PCE-MWM 240-A regarding installation and sensor coverage apply to the PCE-MWM 240-A-2 as well. Please refer to chapter 5.4 for the installation.

5.6 PCE-MWM 240-B

Two welding flanges are used to install the sensor at the measuring location. The length of the sensor rod can vary between 200 and 1500 mm or 7.9” to 59” and needs to be specified when ordering the sensor. The sensor must be disassembled previous to installation. In order to dismantle the sensor assembly sleeve 3, sleeve 4, welding flange 1 and welding flange 2 must be released and removed from the sensor rod. Sleeve 1 and sleeve 2 can remain on the rod.

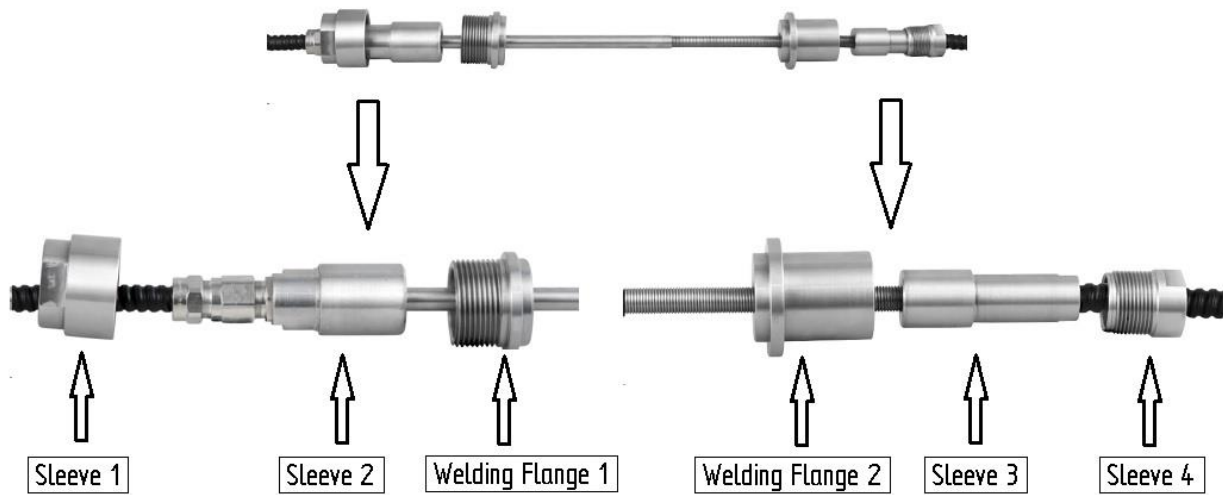


Fig. 24 Components of the moisture sensor PCE-MWM 240-B

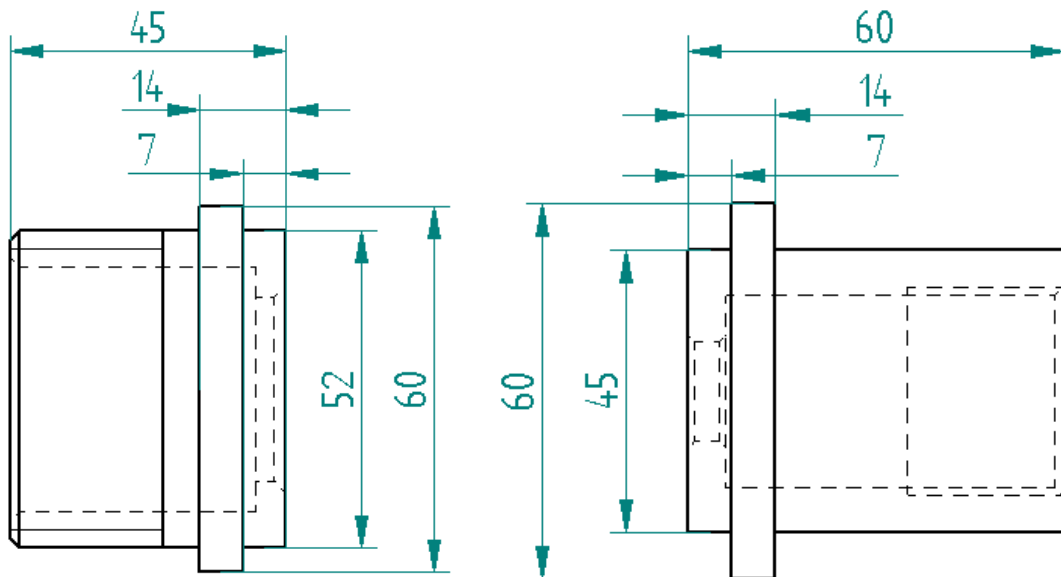


Fig. 25 Dimensions of the welding flanges

5.6.1 Installation

Fig. 25 shows the exact dimensions of the welding flanges. Accordingly, the round cut-out for welding flange 1 must be smaller than 60 mm but not smaller than 52 mm. The round cut-out for welding flange 2 must be smaller than 60 mm but not smaller than 45 mm.

Warning: It is not permitted to weld the flanges to the pipe or container while the flanges are connected to the sensor rod or sleeves. It is also not permitted to install the sensor while the electronic unit is connected to the power supply. The pipe or container needs to be empty during cutting and welding.

Note: Please pay attention to the safety instructions regarding the use of the appropriate cutting / welding tools. Only persons with appropriate training may carry out the task.

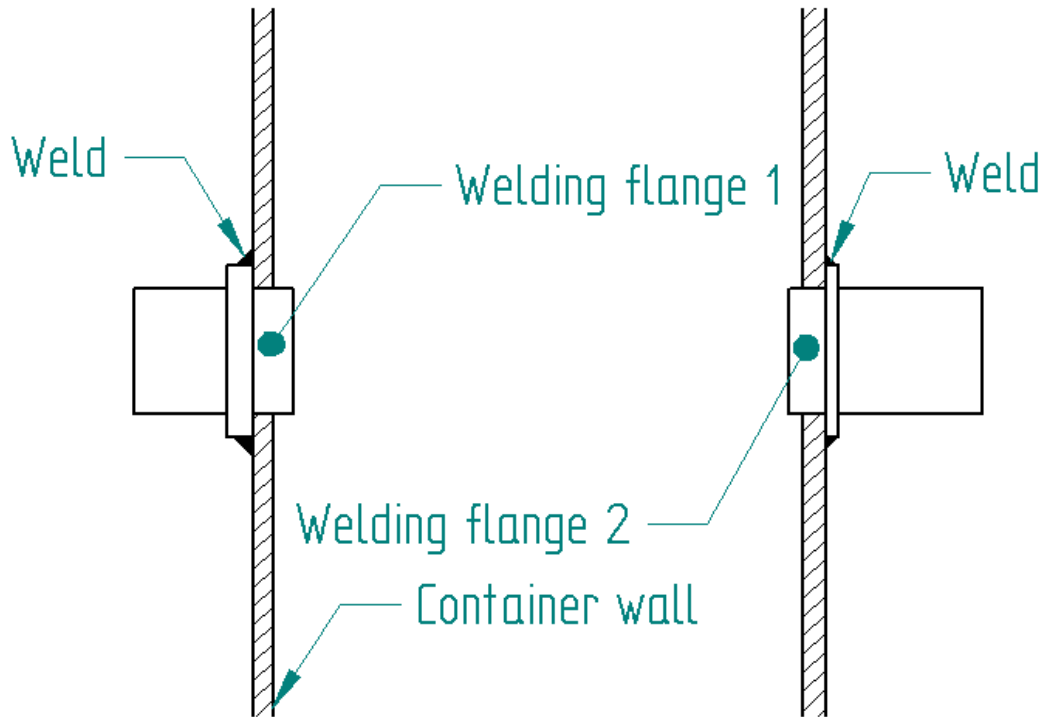


Fig. 26 Installation of the moisture sensor PCE-MWM 240-B

- 1) After welding the flanges to the pipe/container the sensor can be installed. The sensor rod is inserted from the left through welding flange 1 and welding flange 2 until sleeve 2 reaches the end position inside welding flange 1.
- 2) Sleeve 3 is screwed to the end position inside welding flange 2.
- 3) The already detached cable which contains the temperature sensor needs to be inserted into the sensor rod and secured with a temperature-resistant adhesive.
- 4) Sleeve 1 and sleeve 4 are screwed on the sensor assembly.
- 5) Gaps between the container wall and the welding flanges should be sealed with a suitable sealant.

5.6.2 Sensor coverage

A sufficient material coverage is required to receive an accurate measurement of the material moisture. Sufficient material coverage should always be ensured even in case of minimal material level or flow inside the container or on a conveyor belt. Apart from sufficient material coverage it is also important to avoid metallic components within the measuring field of the sensor. All of the above factors have to be taken into account when the installation position of the sensor is chosen.

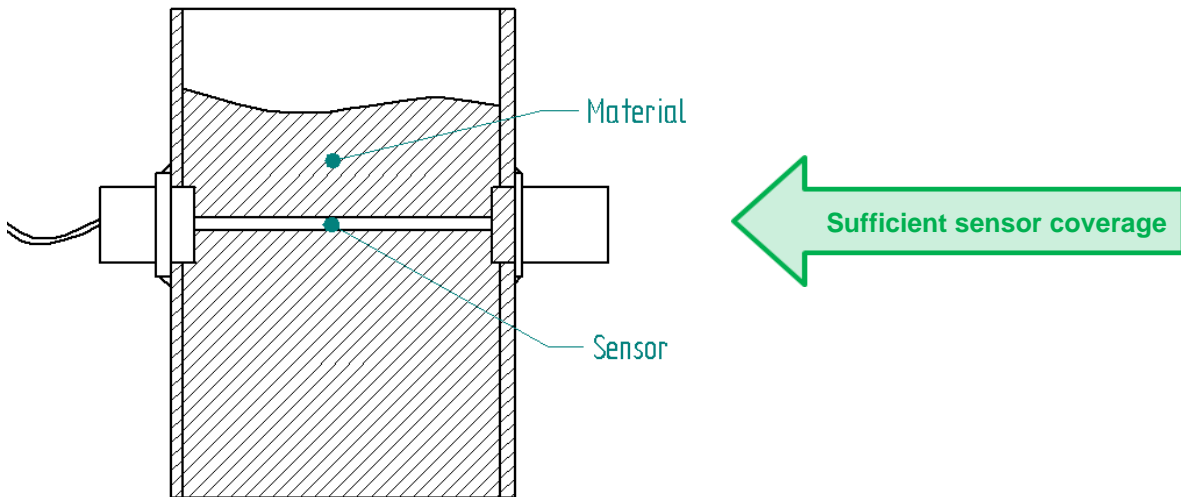


Fig. 27 Sufficient material coverage of the moisture sensor PCE-MWM 240-B

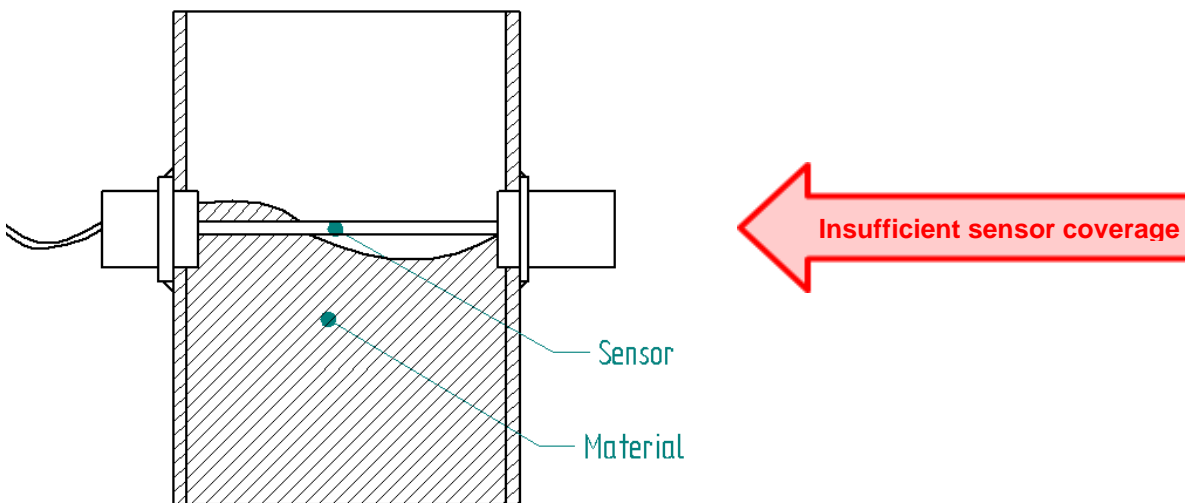


Fig. 28 Insufficient material coverage of the moisture sensor PCE-MWM 240-B

5.7 PCE-MWM 240-C

The PCE-MWM 240-C is similar to the PCE-MWM 240-A with slightly different dimensions. The main difference in comparison to the PCE-MWM 240-A consists of different measurement electronics and evaluation method to determine the moisture value. This enables the PCE-MWM 240-C to measure materials with high electrical conductivity.

5.7.1 Dimensions of the sensor PCE-MWM 240-C

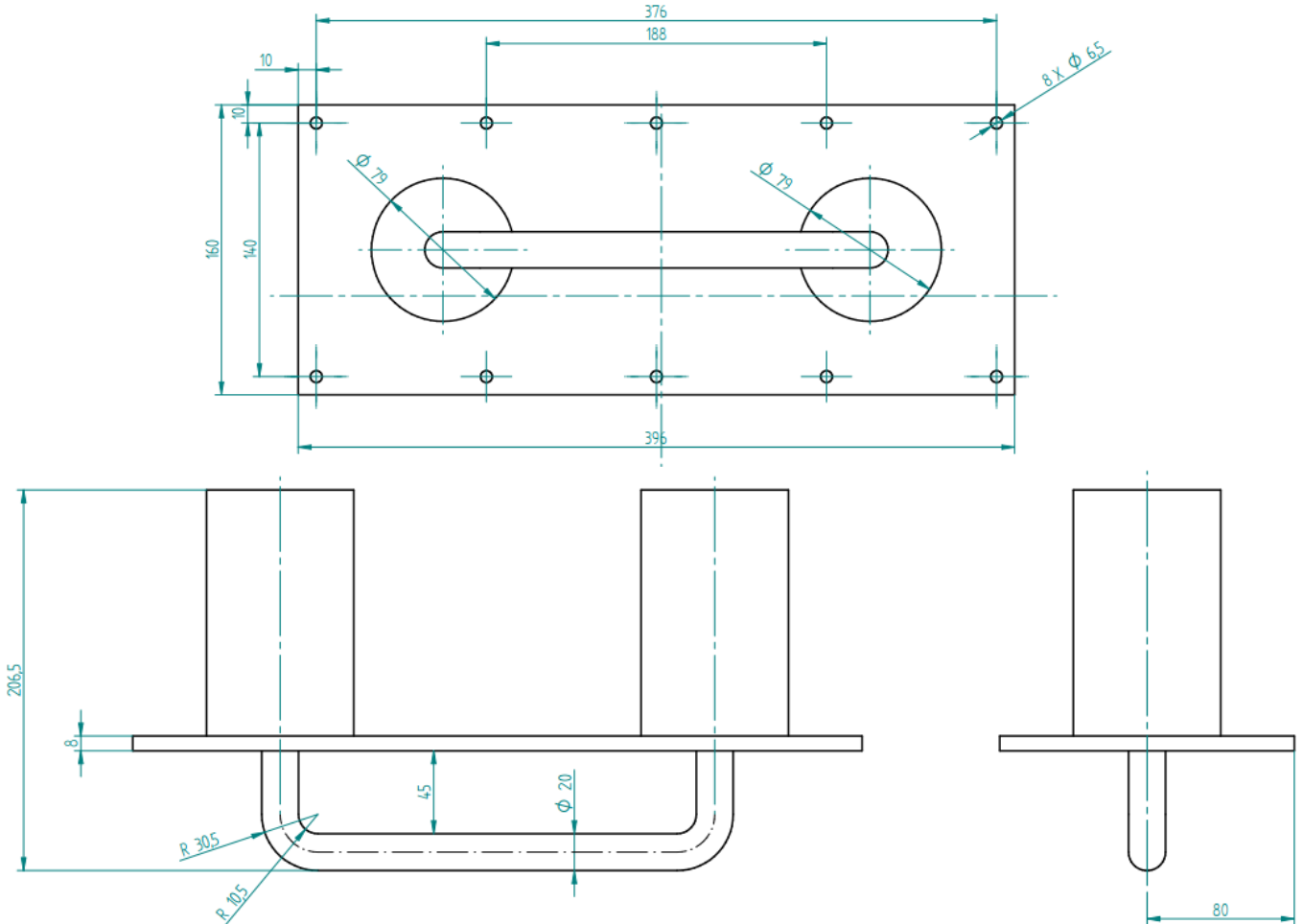


Fig. 29 Dimensions PCE-MWM 240-C

5.7.2 Installation and sensor coverage

Due to the similar dimensions, the same considerations of the PCE-MWM 240-A regarding installation and sensor coverage apply to the PCE-MWM 240-C as well. Please refer to chapter 5.4 for the installation.

6 Electrical installation

Always use shielded cables to connect the electronic unit of the moisture sensors to external devices, displays and the power supply.

6.1 Cabling

PCE Instruments recommends a sensor / actuator cable type M12 (e.g. Lapp Group).

6.1.1 General properties

Coding	A
Protection	IP65 / IP67 / IP68
Insulation resistance	$\geq 100 \text{ M}\Omega$
Volume resistance	$\leq 5 \text{ m}\Omega$
Overvoltage category	II

6.1.2 Power supply

The connector for the power supply needs to be a sensor / actuator cable, 4-pos., PUR black, straight socket M12 on free conductor end (e.g.: Lapp Group art. no. 22260322).

6.1.2.1 Technical data

Number of contacts	4
Core identification code	brown (1), white (2), blue (3), black (4)
Core insulation, material	PP
Outer sheath	PUR
Outer diameter, cable	4.1 mm
Conductor, cross-sectional area	0.34 mm ²
Ambient temperature, fixed installation	-40 °C ... +80 °C
Ambient temperature, flexing	-25 °C ... +80 °C
Minimum bending radius, fixed installation	5 x cable diameter
Minimum bending radius, flexing	10 x cable diameter
Nominal voltage	$\leq 300 \text{ V}$
Rated current	4 A
Test voltage	$\geq 3000 \text{ V}$
Standard / approvals	IEC 61076-2-101, E249137

6.1.2.2 Technical drawings

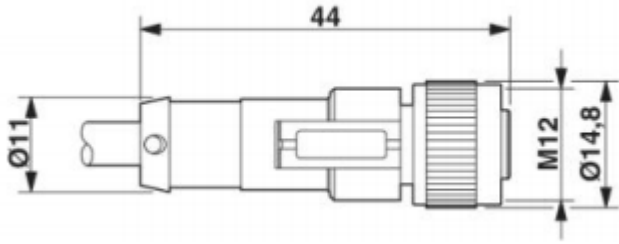


Fig. 30 M12 connector

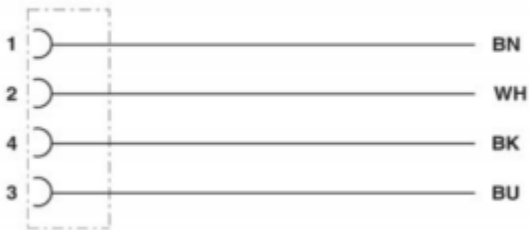


Fig. 31 Wiring diagram

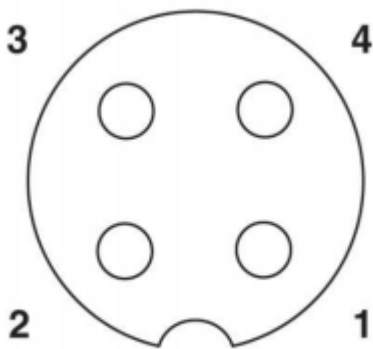


Fig. 32 Pin assignment



Fig. 33 Core identification code

| brown (1), white (2), blue (3), black (4)

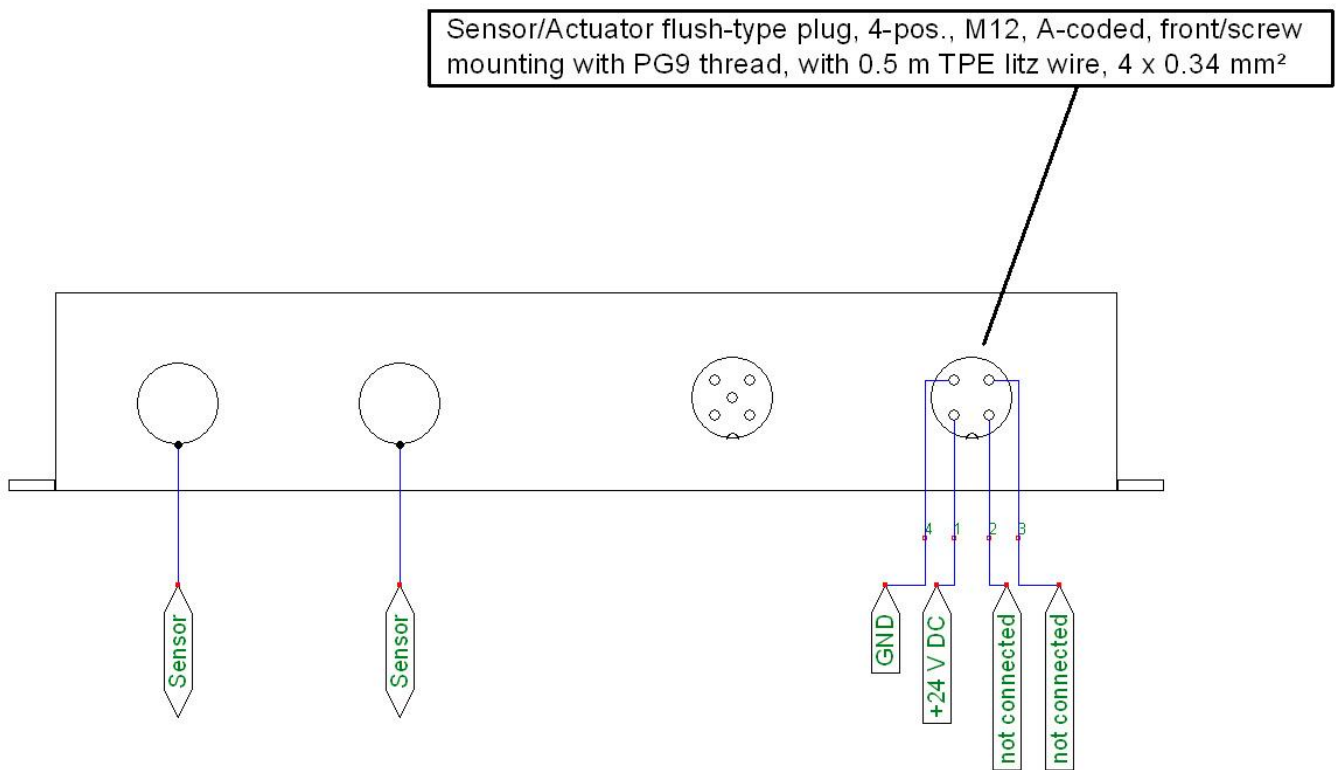


Fig. 34 Pin assignment for power supply

6.1.3 Communication

The connector for the communication interface needs to be a sensor / actuator cable, 5-pos., PUR black, straight socket M12 on free conductor end (e.g.: Lapp Group art. no. 22260404).

6.1.3.1 Technical data

Number of contacts	5
Core identification code	brown (1), white (2), blue (3), black (4), green-yellow (5)
Core insulation, material	PP
Outer sheath	PUR
Outer diameter, cable	4.5 mm
Conductor, cross-sectional area	0.34 mm ²
Ambient temperature, fixed installation	-40 °C ... +80 °C
Ambient temperature, flexing	-25 °C ... +80 °C
Minimum bending radius, fixed installation	5 x cable diameter
Minimum bending radius, flexing	10 x cable diameter
Nominal voltage	≤ 300 V
Rated current	4 A
Test voltage	≥ 3000 V
Standard/ approvals	IEC 61076-2-101, E249137

6.1.3.2 Technical drawings

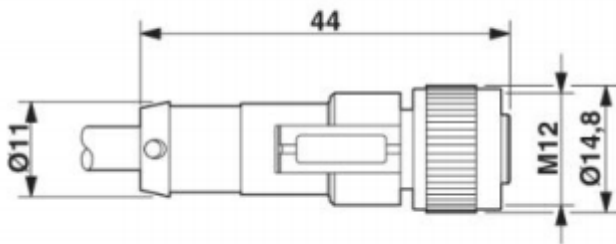


Fig. 35 M12 connector



Fig. 36 Wiring diagram

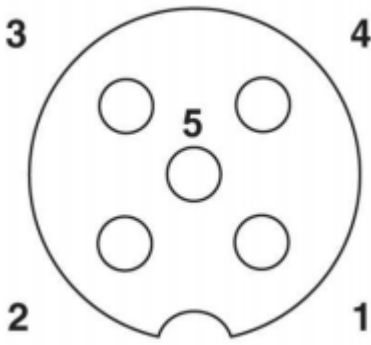


Fig. 37 Pin assignment



Fig. 38 Core identification code

brown (1), white (2), blue (3), black (4), green-yellow (5)

Sensor/Actuator flush-type plug, 5-pos., M12, A-coded, front/screw mounting with PG9 thread, with 0.5 m TPE litz wire, 5 x 0.34 mm²

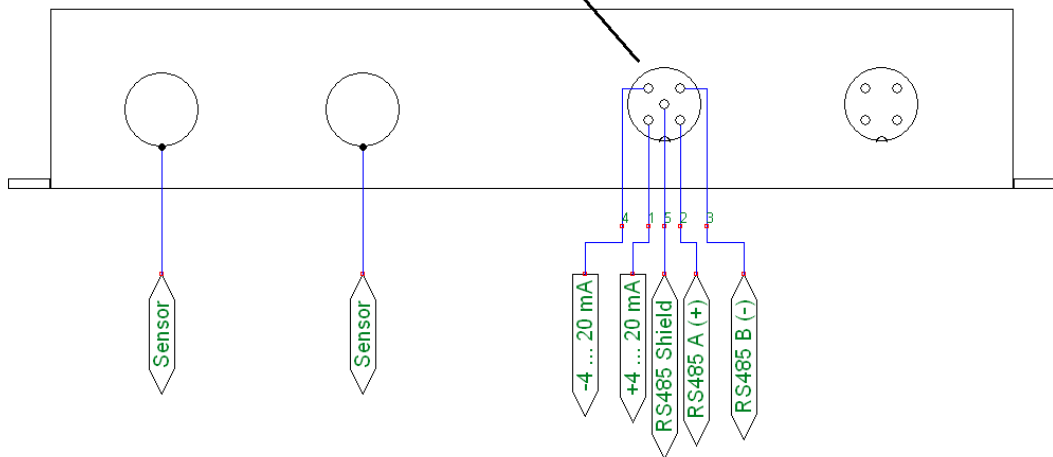


Fig. 39 Pin assignment for signal output

6.2 Analog output

The moisture measurement of the moisture sensors PCE-MWM 2xx can be forwarded with a 4 ... 20 mA current loop to external devices like e.g. PLC or display. The default scaling of the analog output is as followed:

- 4 mA → 0 % Moisture content
- 20 mA → 100 % Moisture content

This scaling can be adjusted with the program PCE-MWM Manager depending on the application.

6.2.1 Connection

- +4 ... 20 mA → Left sensor / actuator plug pos. 1 (brown)
- -4 ... 20 mA → Left sensor / actuator plug pos. 4 (black)

Sensor/Actuator flush-type plug, 5-pos., M12, A-coded, front/screw mounting with PG9 thread, with 0.5 m TPE litz wire, 5 x 0.34 mm²

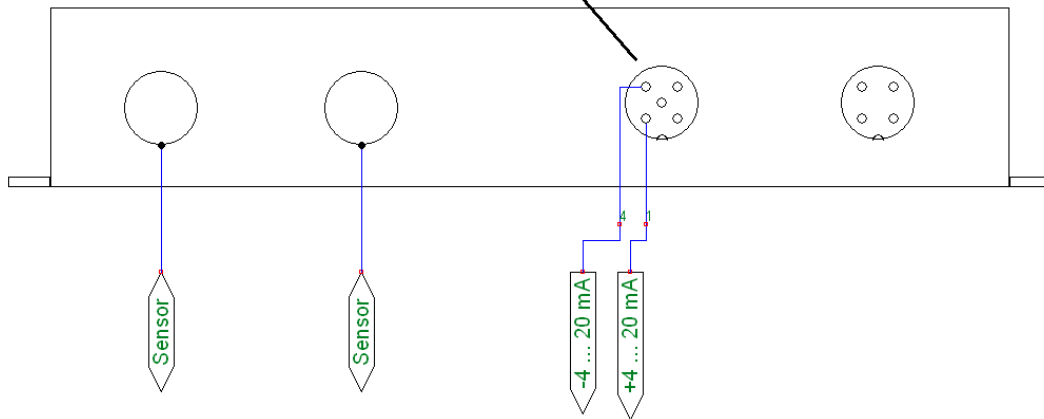


Fig. 40 Pin assignment for analog output

6.3 RS-485 interface

Another way to communicate with the moisture sensors PCE-MWM 2xx is the serial port RS-485. This port provides the Modbus RTU protocol. There are several registers which can be read in order to receive data regarding moisture content and temperature among other parameters.

6.3.1 Connection

- Modbus RTU A(+) → Left sensor / actuator plug pos. 2 (white)
- Modbus RTU B(-) → Left sensor / actuator plug pos. 3 (blue)
- RS-485 shield → Left sensor / actuator plug pos. 5 (green-yellow)

Sensor/Actuator flush-type plug, 5-pos., M12, A-coded, front/screw mounting with PG9 thread, with 0.5 m TPE litz wire, 5 x 0.34 mm²

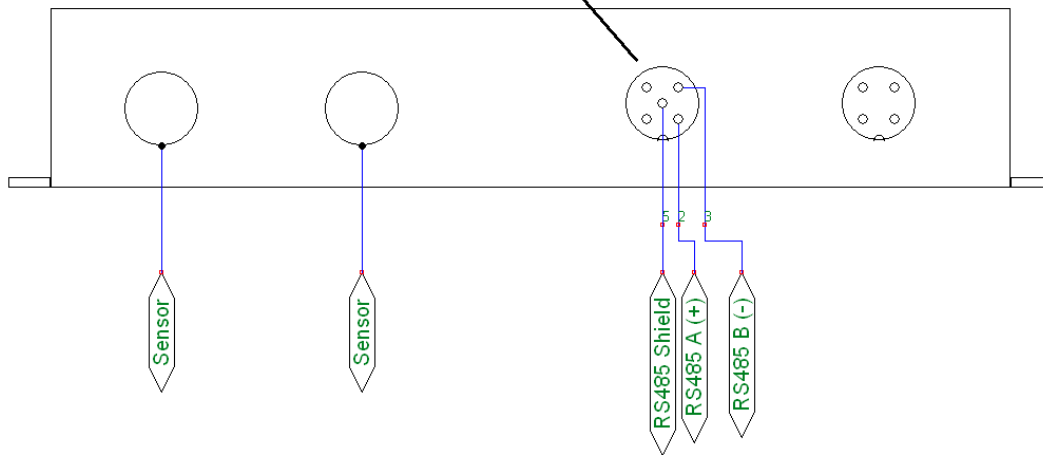


Fig. 41 Pin assignment for serial port RS-485

6.3.2 Protocol

- Reading of the registers is carried out with the command 03 (03h), recording - command 16 (10h)
- A command for testing echo returns is supported 08 (08h).
- Simultaneous recording (writing) or reading of not more than 48 registers is allowed for one query.

Supported Baud rates	300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 38400, 56000, 57600, 115200
Parity	None
Number of stop bits	2
Register types	16 bit unsigned integer

6.3.2.1 Write protection

Before attempting to write registers the write protection needs to be disabled by writing the number 4988 (137Ch) into the register 0020 (0014h). Additionally some registers are read-only and will not accept write commands. When attempting to write into read-only registers or when the write protection was not disabled, the moisture meter does not reply.

6.3.2.2 Default settings of the electronic unit

Baud rate	19200
Parity	None
Stop bits	2
Address	127

6.3.2.3 Description of registers

Register address (DEC)	Register address (HEX)	Description	R/W
0000	0000	Measured moisture in hundredths of a percent	R
0001	0001	Temperature in Kelvin	R
0002	0002	Error code. (If 0, there are no errors)	R
0020	0014	Code of write protection	R/W
0163	00A3	Total number of calibration tables	R
0164	00A4	The number of the current calibration table (starting with 1)	R/W

7 PCE-MWM Manager

7.1 Introduction

The measuring principle of the PCE-MWM 2xx moisture sensors utilizes the dielectric properties of material to determine their moisture. These dielectric properties change with moisture content which allows the sensor to measure the moisture. Different materials exhibit varying changes of their dielectric properties when the material moisture increases or decreases. Consequently a specific calibration is only valid for a single material and different materials need to be calibrated separately.

The program PCE-MWM Manager is used to create a calibration. It displays the dimensionless sensor data in a chart. The sensor data correlates with the moisture of the tested material (see Fig. 42) which shows the moisture content against the sensor data. Accordingly the calibration curves differ for various materials meaning the identical sensor value equals different moisture content depending on the material. The objective of the calibration is to create these characteristic curves for each material.

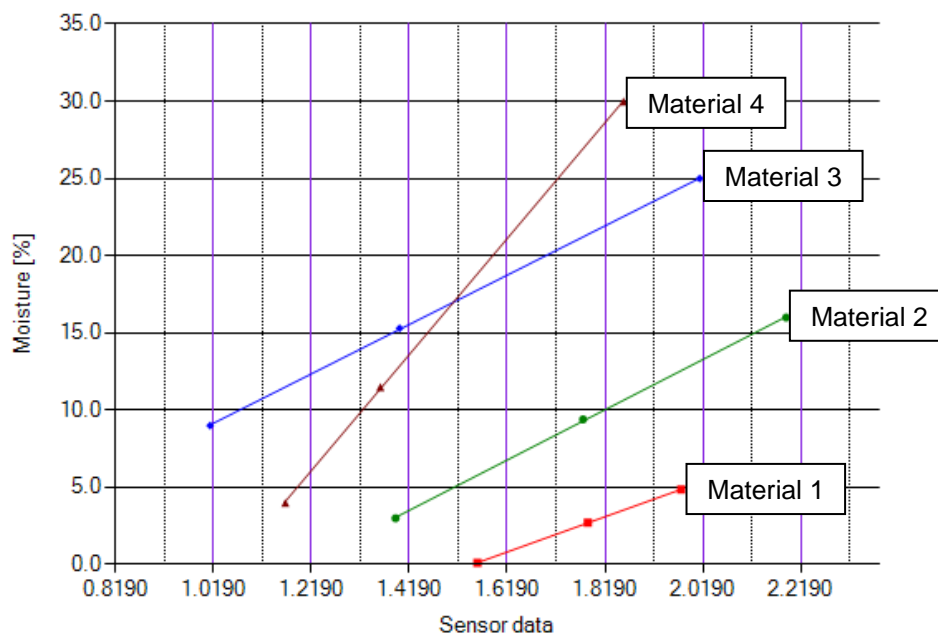


Fig. 42 Calibration curves for different material

7.2 Overview PCE-MWM Manager

The program PCE-MWM Manager is used to connect the electronic unit to a PC in order to change the settings and to create a material-specific calibration.

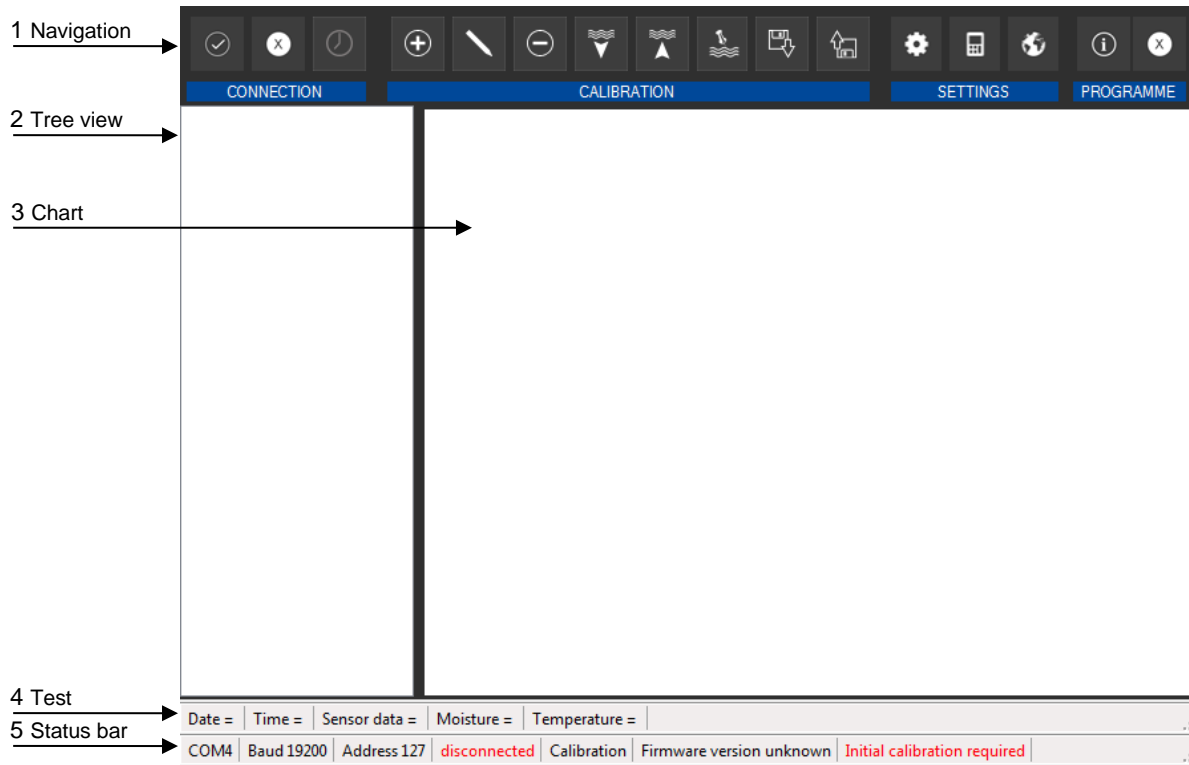


Fig. 43 PCE-MWM Manager main window

Description:

- 1) Navigation: Main navigation for connection, calibration and settings
- 2) Tree view: Display and selection of created calibrations
- 3) Chart: Display of measuring points and calibration curve of selected calibration
- 4) Test: Display of measurements when using the function *Test*
- 5) Status bar: General information and current parameters

7.3 Connection electronic unit

After attaching the electronic unit to a PC using an RS-485 converter, a connection can be established with PCE-MWM Manager. An RS-485/USB converter is included in the shipment but other RS-485/USB converter can also be used. When using the included converter it should be ensured that the RS-485 function of the converter (see Fig. 44) was automatically activated:

- 1) Open device manager
- 2) Extend *Ports (Com & LPT)*
- 3) Right-click on RS-485 converter
- 4) Select tab *Port Settings*
- 5) Check if checkbox *RS-485* is ticked and accept with *OK*

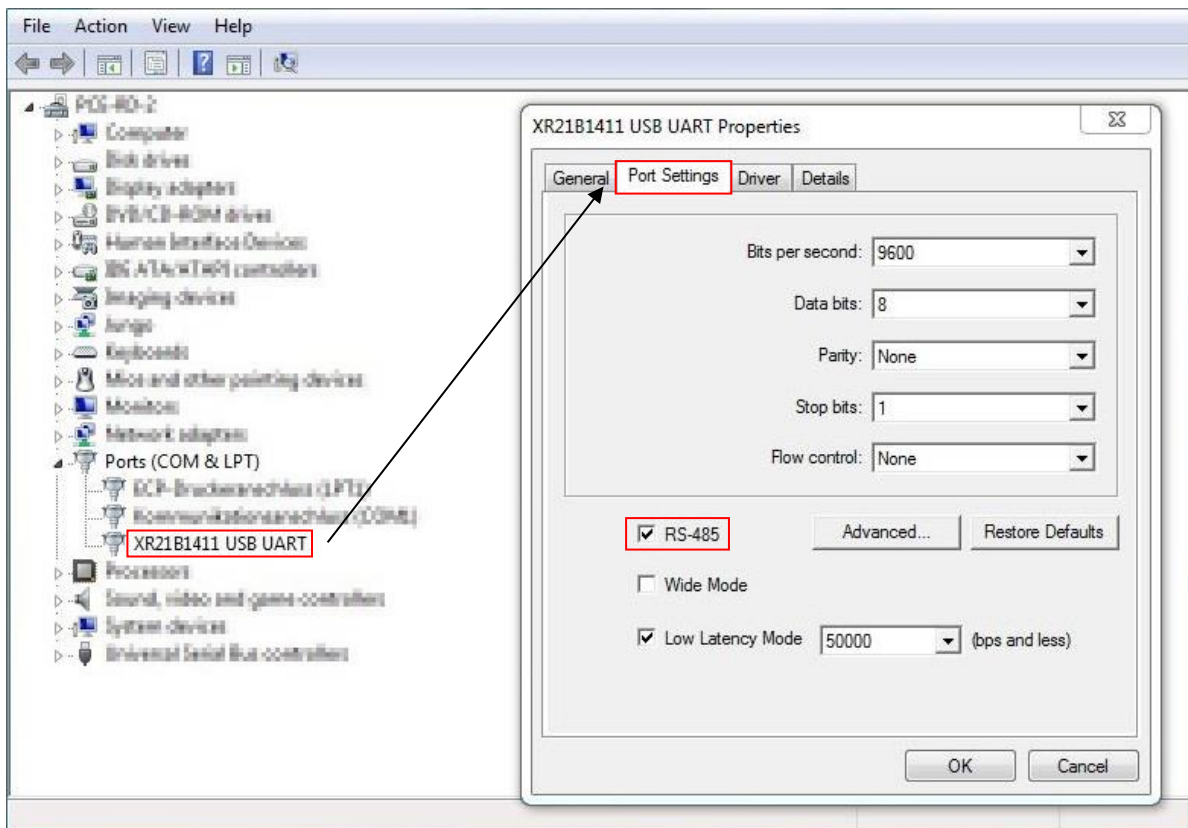





Fig. 44 Configuring RS-485 converter

After making sure that the RS-485 function of the converter is activated, a connection to the electronic unit can be established:

- 1) Open settings with the button  of the main navigation bar
- 2) Select correct COM-Port in the menu (see Fig. 45)
- 3) Select default parameters of the electronic unit: Baud rate 19200, address 127
- 4) Apply settings with 
- 5) Establish connection with the button  in the main navigation bar over the label *Connection*

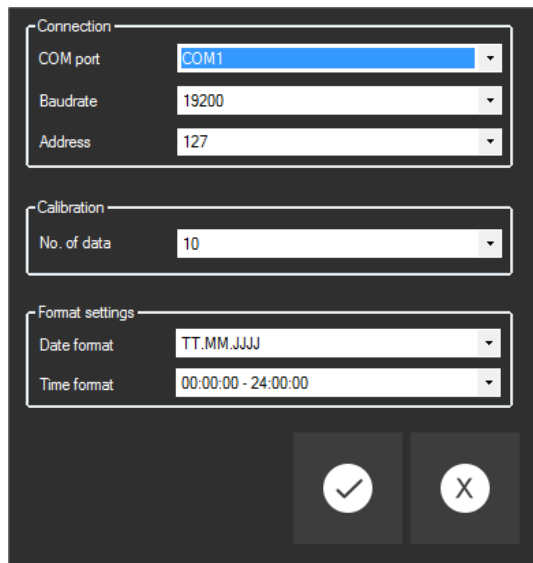


Fig. 45 Settings

A successful connection is indicated in the bottom status bar with the message *connected* (see Fig. 46).

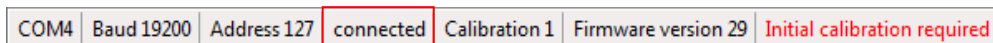


Fig. 46 Successful connection

After successfully connecting to the electronic unit, the initial calibration must be performed. The initial calibration needs to be carried out only once after the mechanical installation. The material calibration can be started after finishing the initial calibration. If the sensor is pre-calibrated then material calibration is not necessary and moisture measurement can begin immediately.

7.4 Initial calibration

Before the material calibration or moisture measurement in case of a pre-calibrated sensor can begin, an initial calibration must be performed. For this reason the buttons for the calibration are not active when starting PCE-MWM Manager for the first time and a corresponding message is displayed in the status bar (see Fig. 47).

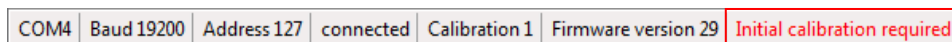




Fig. 47 Message about missing initial calibration

Warning: The measuring volume of the sensor must be empty while carrying out the initial calibration.

After making sure that the measuring volume of the sensor is empty, the initial calibration can be started:

- 1) Establish connection to the electronic unit (see 7.3).
- 2) Open menu *Configuration electronic unit* (see Fig. 48) with the button  of the main navigation bar
- 3) Start initial calibration with the button 

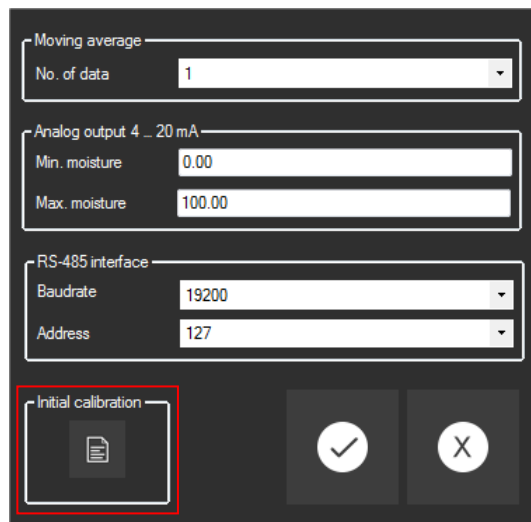


Fig. 48 Configuration electronic unit

Starting the initial calibration displays the following dialog box (see Fig. 49):

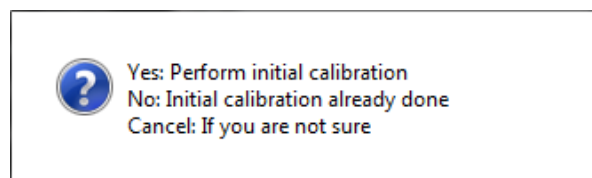


Fig. 49 Dialog for initial calibration

In case the initial calibration has not been carried out after mechanical installation the dialog must be confirmed with **Yes** which immediately performs the initial calibration. After successfully finishing the initial calibration, the message *Initial calibration OK* is displayed in the status bar (see Fig. 50) and material calibration can be started.

Note: The initial calibration must be carried out only a single time after mechanical installation and is used as a reference for subsequent material calibration. It is not required to repeat this procedure when calibrating the sensor to a new material.

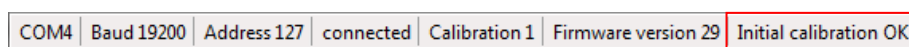


Fig. 50 Initial calibration successful

Performing the initial calibration creates a local entry on the PC which was used to carry out the initial calibration. If PCE-MWM Manager is started on another PC to create or resume a calibration, the status bar will indicate that an initial calibration is required. This is caused by the missing entry on the new PC and the buttons for the calibration are not active.

In this case the dialog for the initial calibration needs to be started and subsequently *No* must be selected. This correctly skips the initial calibration and creates a local entry on the PC regarding the already carried out initial calibration which activates the buttons for the calibration.

Note: If the sensor is moved to another position, a new initial calibration is required at the new position.

7.5 Calibration

After finishing the initial calibration, the buttons for the calibration are active. Generated or imported calibrations are displayed in the tree view (see Fig. 51) on the left side of the main window.

- Create new calibration
- Edit calibration
- Delete calibration

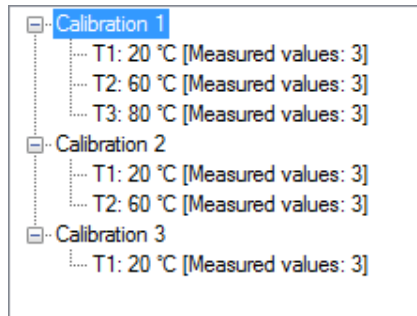


Fig. 51 Tree view of calibrations

The tree view shows the names of the calibrations and corresponding tables for different temperatures. Calibrations can be created, edited and deleted with the respective buttons of the main navigation.

7.5.1 Create new calibration

The button in the main navigation bar creates a new calibration. A name for the calibration needs to be entered in the new window (see Fig. 52) and up to 4 calibration tables can be added. Each calibration table is used to calibrate the sensor to a single material at a specific temperature.

- New calibration table
- Edit calibration table
- Delete calibration table

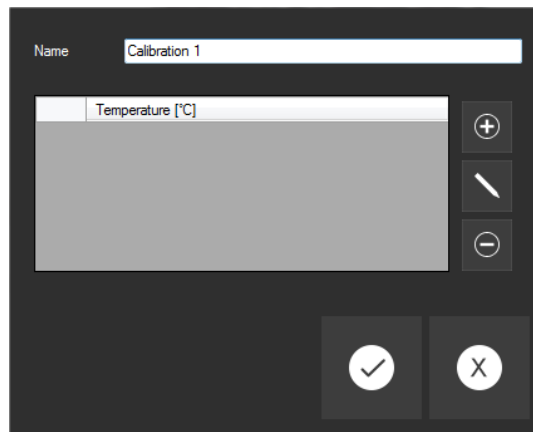



Fig. 52 Window for new calibration

Since the dielectric properties of a material change to a varying degree with the temperature, a calibration is usually only valid for a certain temperature range. If the material temperature varies greatly at the measuring position, it is possible to use multiple calibration tables to compensate the calibration for changes in material temperature. In case the material temperature does not change significantly, a single calibration table is sufficient and the remaining 3 tables can be left empty. A combination of 2, 3 or 4 calibration tables are also possible.

7.5.2 Calibration table

The button  in the window for a new calibration opens a new calibration table (see Fig. 53) which is used to calibrate a material at a specific temperature.

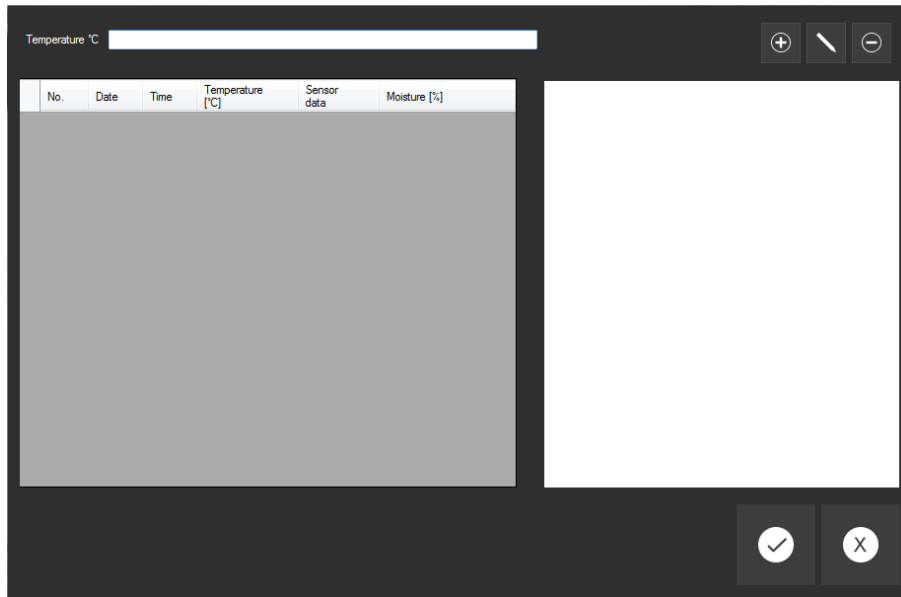






Fig. 53 Calibration table

-  Record sensor data
-  Enter moisture of material
-  Delete sensor data

After ensuring a sufficient coverage of the sensor with material, the current sensor data can be recorded with the button  which adds a new entry in the table (see Fig. 55). At the same time the integrated temperature sensor measures the material temperature which is added in the input box at the top of the window.

Depending on the material a calibration table is usually only valid for a certain temperature range. For this reason it is important to only add measuring data to the table which does not differ greatly in temperature.

Note: The following warning is displayed (see Fig. 54) if the temperature of newly recorded data exceeds the temperature which is shown in the box at the top of the window. This may lead to reduced accuracy when operating the sensor with this calibration. In any case the calibration can still be continued.

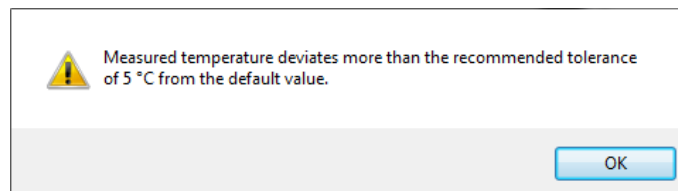


Fig. 54 Warning if measured temperature of recorded date exceeds threshold

The displayed sensor data is created by averaging multiple individual measurements of the sensor. By default 10 individual measurements are averaged and the amount can be changed in the settings if necessary (see 7.11).

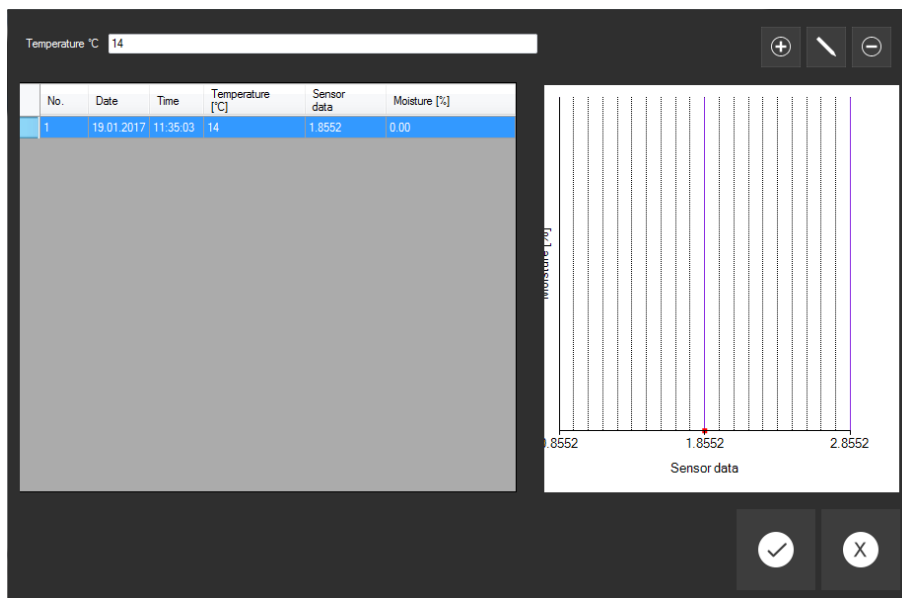


Fig. 55 Calibration table with first entry

The recorded sensor data is displayed in the table and the corresponding material moisture needs to be assigned. In order to assign the moisture a sample of the material needs to be gathered. The sample should be extracted as soon as possible after recording the sensor data and should be collected as close as possible from the installation position of the sensor. This procedure requires careful handling since it directly affects the quality of the calibration (see 8.1).

After the moisture content of the sample has been determined (see 8.2), it can be matched to the recorded data. Assigning the moisture can be accomplished with the button  or a double click on the entry in the table (see Fig. 56).

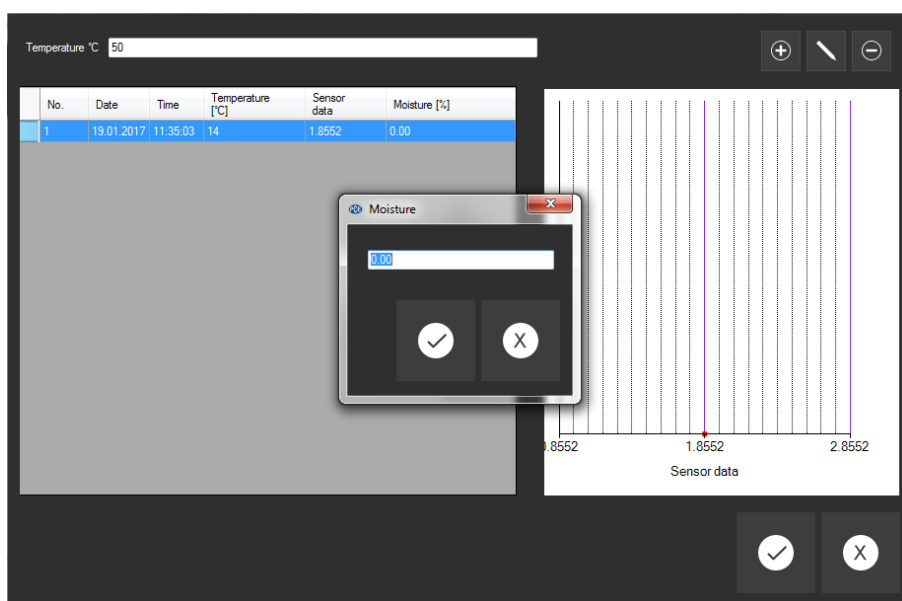


Fig. 56 Assign moisture to sensor data

This procedure needs to be repeated several times to generate enough data for the calibration (see Fig. 57). It is also possible to record multiple sensor measurements in one session and extract their respective samples for the purpose of analyzing multiple samples in parallel. Afterwards the moisture contents can be assigned to the respective sensor data. In that case correct labeling is required in order to ensure correct assignment of the moisture to the sensor data.

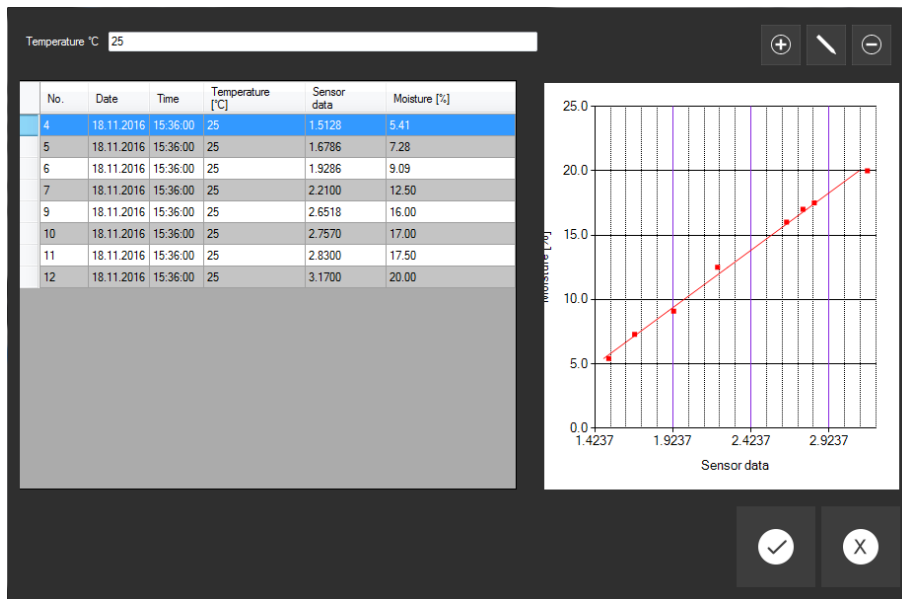


Fig. 57 Calibration table with multiple measurements

At minimum 3 measurements have to be completed in order to transfer the calibration to the electronic unit. Ideally multiple complete measurements cover the expected range of the material moisture.

A low amount of measurements, which barely differ in material moisture, could lead to high extrapolated errors when the current material moisture greatly differs from the measurements which were used to generate the calibration. Depending on the situation it may not be possible to complete enough measurements covering the whole expected range of material moisture in a short amount of time. In this case it is recommended to begin a calibration and add more measurements over a longer period for higher accuracy and validation.

7.5.3 Evaluate calibration

The completed measurements are displayed in a diagram in the right half of the window for the calibration table. A best-fit line is also displayed after at least 3 moisture contents were assigned to the respective sensor data. Since most materials exhibit a linear dependence between sensor data and moisture content, the best-fit line equals the calibration.

The best-fit line is used by the electronic unit to determine the moisture content which is sent to the output interface. Since the best-fit line represents a linear interpolation, small deviations between measurement data and best-fit line result in a calibration with high accuracy. This is illustrated with the following 3 examples:

Fig. 58 shows a calibration with high accuracy. In this case the measurement data coincide with the best-fit line in a nearly ideal way which results in little errors. Furthermore the measurement data sufficiently covers the expected range of material moisture.

When creating a new calibration high errors may occur if only a few measurements are recorded. This is further compounded if the material moisture is expected to vary a high amount but only a small range was covered with recorded data. Adding more measurement data to the calibration can help reduce this error.

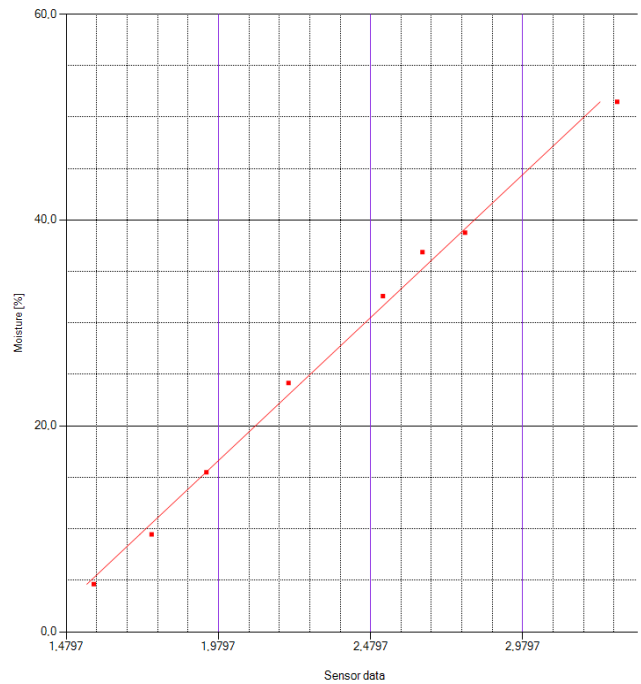


Fig. 58 Calibration with high accuracy

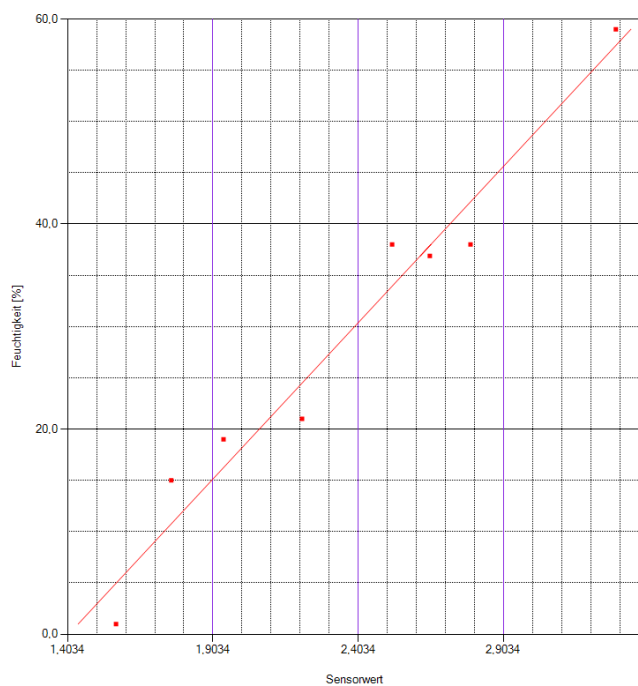


Fig. 59 shows a calibration with reduced accuracy. In general a linear dependence between sensor data and moisture can still be identified like in the previous example.

In comparison to Fig. 58 higher deviations exist between the measurement data and the best-fit line. This would result in errors of several percent of absolute moisture measurement when using this calibration to determine the moisture content with the sensor.

In this case outliers should be reviewed with regard to correct acquisition of sensor data or respective moisture content.

Depending on the desired accuracy the expected errors of this calibration can be acceptable and the calibration can still be expanded with more measurement data at any time.

Fig. 59 Calibration with reduced accuracy

Fig. 60 shows a flawed calibration. The measurement data does not exhibit a linear dependence between sensor data and moisture content. The data also spreads heavily around the best-fit line which means that this calibration is not suited to determine the moisture content.

In this case the installation position of the sensor needs to be reviewed in terms of sufficient material coverage at all times. Incorrect extraction or handling of the gathered samples could also lead to these errors. It should also be checked if the moisture contents of the extracted samples were assigned to the correct sensor data in the calibration table.

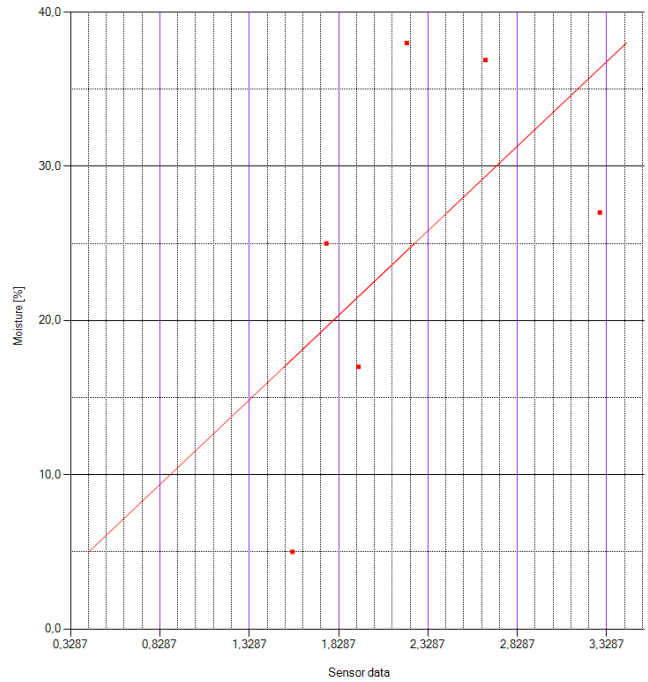


Fig. 60 Flawed calibration

7.5.4 Finish calibration

After recording at least 3 sensor data and subsequent assignment of corresponding moisture content, the calibration can be finalized by applying the entries with the button in order to access the buttons of the main navigation. The created calibrations need to be transferred to the electronic unit which calculates the moisture content from the sensor data and generates the signal for the serial interface and analog output.

7.6 Transfer calibration to / from electronic unit

Up to 20 calibrations can be saved on the electronic unit. This storage is independent of the calibrations in the program PCE-MWM Manager which means that the calibrations have to be transferred with these dedicated functions.

- Transfer calibration to electronic unit

This function transfers a calibration from PCE-MWM Manager to the electronic unit.

Add slot for calibration

Delete all calibrations

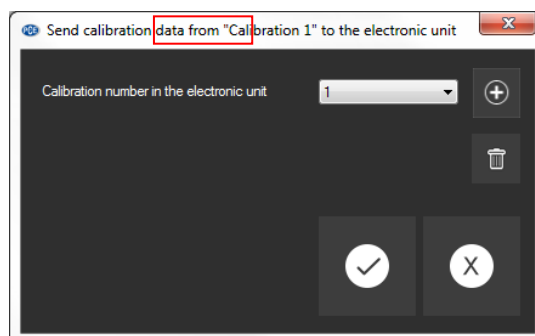







Fig. 61 Transfer calibration to electronic unit

At first a calibration needs to be selected in the tree view of PCE-MWM Manager. After starting the transfer with the button  the selected calibration is displayed in the title of the window (see Fig. 61) and an internal slot in the electronic unit needs to be selected. Upon confirmation with the button  the calibration will be transferred to the electronic unit.

Up to 20 calibrations can be saved and the current amount of slots can be increased with the button . It is also possible to overwrite an already existing calibration in a slot with a new calibration.

Warning: It is not possible to delete a single calibration. The button  deletes every calibration at the same time!

When transferring the calibration only the best-fit line is transferred and the measured data to create the best-fit line are not stored in the electronic unit. For the purpose of resuming and adding to a calibration it needs to be saved in a .csv-file (see 7.7).

- Transfer calibration from electronic unit 

This function is used to transfer a calibration from the electronic unit to the program PCE-MWM Manager. This function is used for diagnostics and backup and is not suitable to resume a calibration since only the best-fit line is stored in the electronic unit.

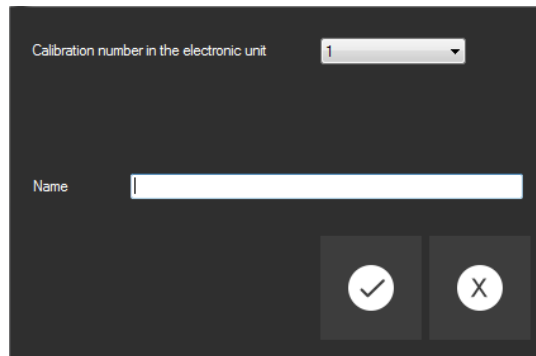




Fig. 62 Transfer best-fit line from electronic unit

The button  starts the dialog for transferring a calibration from the electronic unit. After selecting the internal slot, entering a name and confirming with the button , the calibration is loaded into the program PCE-MWM Manager (see Fig. 63). As mentioned above only the best-fit line is transferred which always includes 15 measured values.

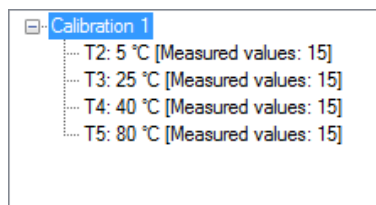





Fig. 63 Imported best-fit line from electronic unit displayed in the tree view

Furthermore the calibration always includes 4 calibration tables when transferred from the electronic unit. If the originally transferred calibration only included 1 calibration table, the remaining 3 tables are a copy of the first table. The equivalent is also true when the originally transferred calibration included 2 or 3 calibration tables, which means that the remaining calibration tables are a copy of the first table.

7.7 Export / import calibration in .csv-file

The calibration can be suspended at any time and resumed at a later time. For this purpose a calibration needs to be selected in the tree view which can then be exported  and imported  using a .csv-file. PCE-MWM Manager does not automatically save changes to calibrations and a note is displayed when trying to close the program and unsaved calibrations are detected.

7.8 Select calibration in electronic unit

The calibration is used to calculate the moisture content from the sensor data. Up to 20 calibrations can be saved in the electronic unit, but only one calibration can be active at any time. Since calibrations are only valid for a specific material this function is required to switch between calibrations, which are stored in the electronic unit, when the measured material changes. The calibration can be switched with the button  of the main navigation and after confirming the dialog the currently active calibration number is displayed in the status bar (see Fig. 64). It is also possible to change the calibration with the corresponding register if the electronic unit is integrated into an already existing RS-485 network.

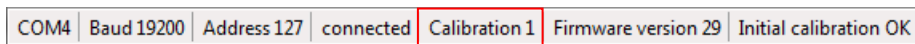


Fig. 64 Currently selected calibration in the electronic unit

7.9 Establish / close connection

After changing the connection settings (see 7.3), a connection can be directly established or closed with these buttons of the main navigation bar.

7.10 Test

This button activates the test function in the bottom bar (see Fig. 65). This display is refreshed every 2 seconds and shows the current sensor data, calculated moisture content and temperature. The moisture content is calculated with the currently selected calibration in the electronic unit (see 7.8).

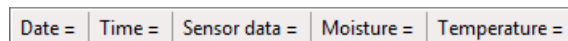


Fig. 65 Status bar for *Test*

7.11 Settings

The settings menu of the program PCE-MWM Manger (see Fig. 45) can be opened with the main navigation bar.

- Connection

In order to establish a connection to the electronic unit, the parameters COM-port, baud rate and address need to be adjusted (see 7.3). The parameters can be changed with these settings. The default parameters are: Baud rate 19200, address 127.


- Calibration

This setting changes how many individual measurements are averaged in order to generate an entry for the sensor data in the calibration table (see 7.5.2).

- Date format

The format of date and time can be changed with this setting.

7.12 Configuration electronic unit

After successfully establishing a connection between the electronic unit and a PC, the menu *Configuration electronic unit* can be opened with the main navigation bar (see Fig. 48). The settings in this menu are directly stored in the electronic unit after applying changes with the button .

- Moving average

This setting is used to adjust a moving average of the measure moisture content for the serial interface or analog output. By default this setting is set to 1 which means that every second the currently measure moisture content is forwarded to the output interface. This setting can be set from 1 ... 127 and the moving average is calculated accordingly. Depending on the application this option can help smooth the output signal.

- Analog output

The moisture measurement of the moisture sensors PCE-MWM 2xx can be forwarded with a 4 ... 20 mA signal to external devices like e.g. PLC or display. By default 4 mA and 20 mA equal 0% and 100% moisture content respectively. This scaling can be changed with these parameters.

- RS-485 interface

In order to integrate the electronic unit into an already existing RS-485 network, the baud rate or address of the electronic unit may need to be changed. This can be achieved by changing the settings in the *RS-485 interface* box which immediately changes the parameters of the electronic unit upon confirmation.

- Initial calibration

After the mechanical installation of the sensor, an initial calibration (see 7.4) must be carried out. The initial calibration can be started with this button.

7.13 Language

The language of the program PCE-MWM Manager can be changed with this menu. The currently supported languages include English and German.

8 Appendix

8.1 Notes for gathering and handling of samples

The following notes should be considered in order to create a calibration with high accuracy:

- The sample should be extracted immediately after recording sensor data
- The sample should be extracted as close as possible from the installation position of the sensor in order to receive a representative result
- An airtight container must be used to collect and store the sample
- The collected sample should not be exposed to heat or direct sunlight before determining the moisture content

8.2 Determining moisture content of samples

The calibration of a material requires assignment of the actual moisture to the corresponding sensor data. For most materials the Loss on Drying (LOD) method is sufficient to provide the actual moisture of a sample. With this method a sample is dried in an oven and the difference of start and end weight enables the calculation of the water content. This process can be performed manually with a drying oven or in an automated way with moisture analyzers.

8.2.1 Drying oven

Required equipment:

- Drying oven
- Oven-safe containers
- Scale (Example: [PCE-BSH 10000](#))

Before the sample is placed in the container, the container must be weighed. Then the sample can be placed in the oven-safe container. Depending on the accuracy of the scale, the weight of the sample must be above a certain threshold. Otherwise a too small sample would lead to inaccurate values when calculating the moisture content. Afterwards the container can be placed in the oven to dry the sample. The sample needs to be dried while being weighed periodically until the weight does not decrease anymore which means that all the water has evaporated. The water content W_{wet} of the sample can be calculated with the following formula:

$$W_{wet} [\%] = \frac{M_w - M_d}{M_w - M_c} * 100$$

with

$M_w = Mass_{wet} = Total\ mass\ of\ the\ sample\ before\ drying$

$M_d = Mass_{dry} = Total\ mass\ of\ the\ sample\ after\ drying$

$M_c = Mass_{container} = Mass\ of\ the\ oven - safe\ container$

The above formula calculates the moisture content of a sample against the mass before drying, i.e. wet sample. Some industries define the moisture content against the dry mass which can be calculated with the following formula:

$$W_{dry} [\%] = \frac{M_w - M_d}{M_d - M_c} * 100$$

A collected sample should be divided into several smaller samples which are then analyzed to determine their moisture content. Afterwards the average of the individual samples should be assigned to the respective sensor data in the calibration table.

The overall drying time mostly depends on the material, drying temperature and sample weight. Industry standards should be checked to set the correct drying temperature since an unsuitable drying temperature could lead to wrong results. This is caused by the evaporation of other volatile components when the drying temperature is set too high. Also the sample should not be too small since a bigger sample leads to more accurate results depending on the scale.

Example:

Total mass of collected sample: 10 kg

Sample M_w [g]	Container M_c [g]	Dried sample M_d [g]	Moisture content W_w [%] (wet)	Moisture content W_d [%] (dry)
2000	500	1700	20.00	25.00
2000	500	1705	19.67	24.48
2000	500	1695	20.33	25.52
Average:			20.00	25.00

If the moisture contents of the individual samples deviate by several percent, an inhomogeneous moisture distribution could be the cause. Another issue could be the extraction and storage of the samples or an insufficiently small sample. This may lead to reduced accuracy of the calibration.

8.2.2 Moisture analyzer

Moisture analyzers (Example: [PCE-MA Series](#)) determine the moisture in an automated manner. A sample is dried with integrated halogen lamps and automatically weighed before and after drying in order to calculate the moisture content. In comparison to the drying oven, moisture analyzers process a smaller sample. This is compensated by a precise scale which enables an accurate result. Another advantage is the much shorter drying time because of the smaller sample mass. For this reason the moisture content of a sample can be determined in an efficient way and with substantially less effort compared to the manual method described in the chapter before.

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