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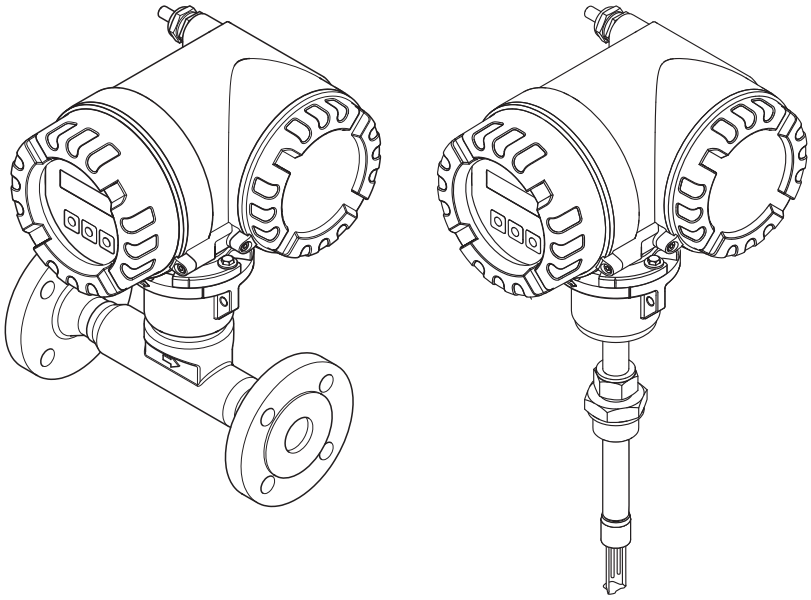
Valid as of version
V 3.06.XX (Device software)

Operating Instructions
Proline t-mass 65
Modbus RS485

Thermal Mass Flowmeter



Endress+Hauser
People for Process Automation

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1 Document information

1.1 Document conventions

1.1.1 Safety symbols

Symbol	Device particularities and document content
Caution!	“Caution” indicates an action or procedure which, if not performed correctly, can result in incorrect operation or destruction of the device. Comply strictly with the instructions.
Warning!	"Warning" indicates an action or procedure which, if not performed correctly, can result in injury or a safety hazard. Comply strictly with the instructions and proceed with care.
Note!	"Note" indicates an action or procedure which, if not performed correctly, can have an indirect effect on operation or trigger an unexpected response on the part of the device.

1.1.2 Electrical symbols

Symbol	Meaning
A0011197	Direct current A terminal at which DC voltage is present or through which direct current flows.
A0011198	Alternating current A terminal at which alternating voltage (sinusoidal) is present or through which alternating current flows.
A0011200	Ground connection A grounded terminal which, as far as the operator is concerned, is grounded via a grounding system.
A0011199	Protective ground connection A terminal which must be connected to ground prior to establishing any other connections.
A0011201	Equipotential connection A connection that must be connected to the plant grounding system: This may be a potential equalization line or a star grounding system depending on national or company codes of practice.

1.1.3 Symbols for types of information

Symbol	Meaning
 A0011182	Permitted Indicates procedures, processes or actions that are permitted.
 A0011183	Preferred Indicates procedures, processes or actions that are preferred.
 A0011200	Forbidden Indicates procedures, processes or actions that are forbidden.
 A0011193	Tip Indicates additional information.
 A0011194	Reference to documentation Refers to the corresponding device documentation.
 A0011195	Reference to page Refers to the corresponding page number.
1., 2., 3. etc.	Series of steps
✔	Result of a sequence of actions
 A0013562	Help in the event of a problem

1.1.4 Symbols for graphics

Symbol	Meaning
1, 2, 3 etc.	Item numbers
A, B, C etc.	Views
A-A, B-B, C-C etc.	Item numbers
 A0013441	Flow direction
 A0011187	Hazardous area Indicates the hazardous area.
 A0011187	Safe area (non-hazardous area) Indicates the non-hazardous area.

2 Safety instructions

2.1 Designated use

The measuring device described in these Operating Instructions is to be used only for measuring the mass flow rate of gases (e. g. kg, Nm^3 sft^3). At the same time, it also measures gas temperature. The measuring device can be configured to measure a standard range of pure gases or gas mixtures.

Examples:
- Air
- Oxygen
- Nitrogen
- Carbon Dioxide
- Argon, etc.

The use with corrosive, saturated or unclean gases should be treated with caution In such cases, please contact your Endress+Hauser sales center for clarification. The use with unstable gases or gases not deemed to be suitable by Endress+Hauser must be avoided. The measuring device is not designed to be used with liquids or fluids in the liquid phase.

Resulting from incorrect use or from use other than that designated, the operational safety of the measuring devices can be jeopardized. The manufacturer accepts no liability for damages being produced from this.

2.2 Installation, commissioning and operation

Note the following points:
- Installation, connection to the electricity supply, commissioning, operation and maintenance of the measuring device must be carried out by trained, qualified specialists authorized to perform such work by the facility's owner operator. The specialist must have read and understood these Operating Instructions and must follow the instructions they contain.
- Endress+Hauser is willing to assist in clarifying the chemical resistance properties of parts wetted by special fluids, including fluids used for cleaning. However small changes in temperature, concentration or the degree of contamination in the process can result in changes of the chemical resistance properties. Therefore, Endress+Hauser can not guarantee or accept liability for the chemical resistance properties of the fluid wetted materials in a specific application. The operator is responsible for the choice of fluid wetted materials in regards to their in-process resistance to corrosion.
- If carrying out welding work on the piping, the welding unit should not be grounded by means of the measuring device.
- The installer must ensure that the measuring device is correctly wired in accordance with the wiring diagrams. The transmitter must be grounded unless special protection measures have been taken e.g. galvanically isolated power supply SELV or PELV! (SELV = Safe Extra Low Voltage; PELV = Protective Extra Low Voltage)
- Invariably, local regulations governing the opening and repair of electrical devices apply.

2.3 Operational safety

Note the following points:

- Measuring devices for use in hazardous environments are accompanied by separate "Ex documentation", which is an integral part of these Operating Instructions. Strict compliance with the installation instructions and ratings as stated in this supplementary documentation is mandatory.
  The symbol on the front of this supplementary Ex documentation indicates the approval and the certification body (e.g. Ⓔx Europe, FM USA, CSA Canada).
- Burn hazard! When hot fluid passes through the measuring tube, the surface temperature of the housing increases. In the case of the sensor, in particular, users should expect temperatures that can be close to the fluid temperature. If the temperature of the fluid is high, implement sufficient measures to prevent burning or scalding.
- The measuring device complies with the general safety requirements in accordance with EN 61010-1, the EMC requirements of IEC/EN 61326, and NAMUR recommendation NE 21, NE 43 and NE 53.
- The separate document on the Pressure Equipment Directive must be observed for measuring devices used in Category II or III installations in accordance with the Pressure Equipment Directive.
- The manufacturer reserves the right to modify technical data without prior notice. Your Endress+Hauser sales center will supply you with current information and updates to these Operating Instructions.

2.4 Return

- Do not return a measuring device if it is not absolutely certain that it has been fully cleaned of all traces of hazardous substances, e.g. substances which have penetrated crevices or diffused through plastic.
- Costs incurred for waste disposal and injury (burns, etc.) due to inadequate cleaning of the measuring device will be charged to the owner-operator.
- Refer to the measures on → 91.

2.5 Product safety

This measuring device is designed in accordance with good engineering practice to meet state-of-the-art safety requirements, has been tested, and left the factory in a condition in which it is safe to operate. It complies with the applicable standards and regulations in accordance with EN 61010-1 "Safety requirements for electrical equipment for measurement, control and laboratory use". It can, however, be a source of danger if used incorrectly or for other than the designated use.

3 Identification

3.1 Device designation

The "t-mass 65" measuring device consists of the following components:
- t-mass 65 transmitter
- t-mass F, t-mass I sensors

Two versions are available:
- Compact version: transmitter and sensor form a single mechanical unit.
- Remote version: transmitter and sensor are installed separately.

3.1.1 Nameplate of the transmitter

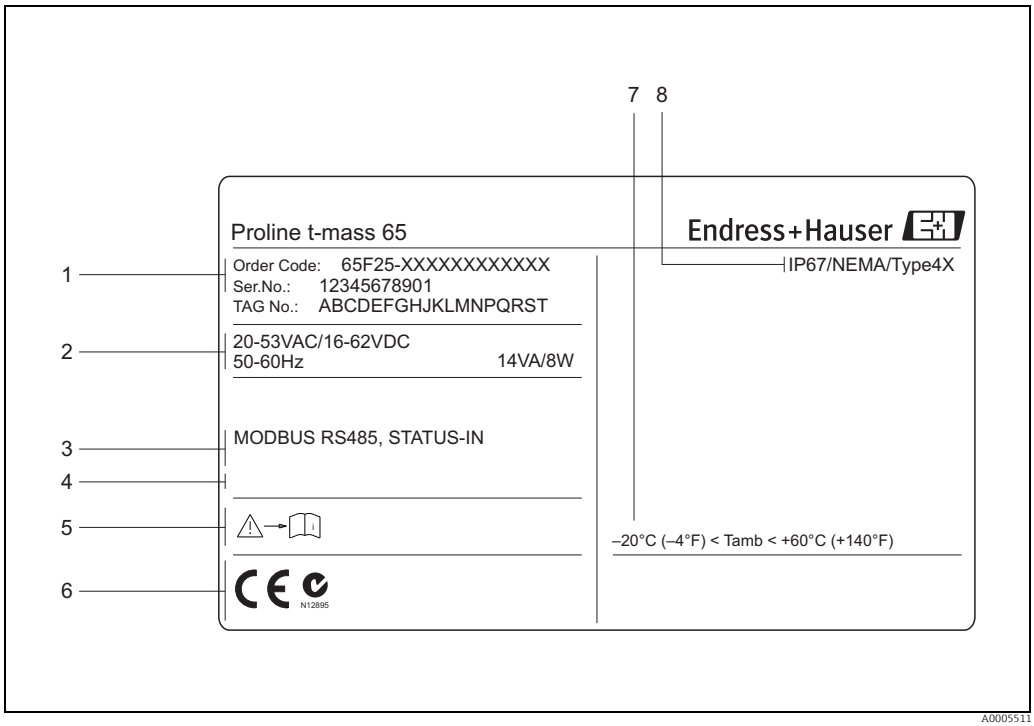


Fig. 1: Nameplate specifications for the "t-mass 65" transmitter (example)

1 Order code, serial number: See the specifications on the order confirmation for the meanings of the individual letters and digits.
2 Power supply, frequency, power consumption
3 Available inputs/outputs:
4 Reserved for information on special products
5 Please refer to measuring device documentation
6 Reserved for certificates, approvals and for additional information on device version
7 Ambient temperature range
8 Degree of protection

3.1.2 Nameplate of the sensor

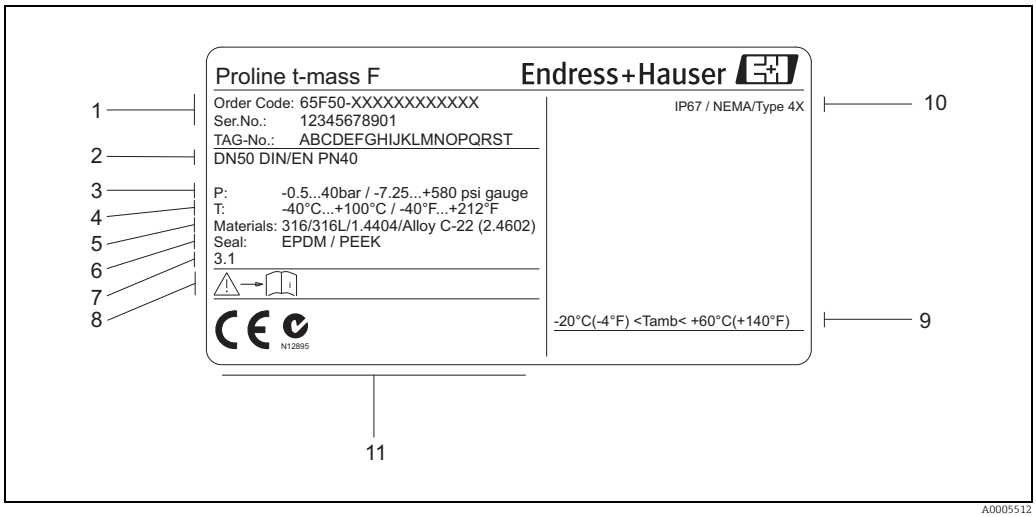


Fig. 2: Nameplate specifications for the "t-mass F" sensor (example)

1 *Order code, serial number: See the specifications on the order confirmation for the meanings of the individual letters and digits.*
2 *Nominal diameter device*
3 *Pressure range*
4 *Temperature range*
5 *Material of measuring tubes*
6 *Seal material*
7 *Reserved for information on special products*
8 *Please refer to measuring device documentation*
9 *Ambient temperature range*
10 *Degree of protection*
11 *Reserved for additional information on device version (approvals, certificates)*

3.1.3 Nameplate for connections

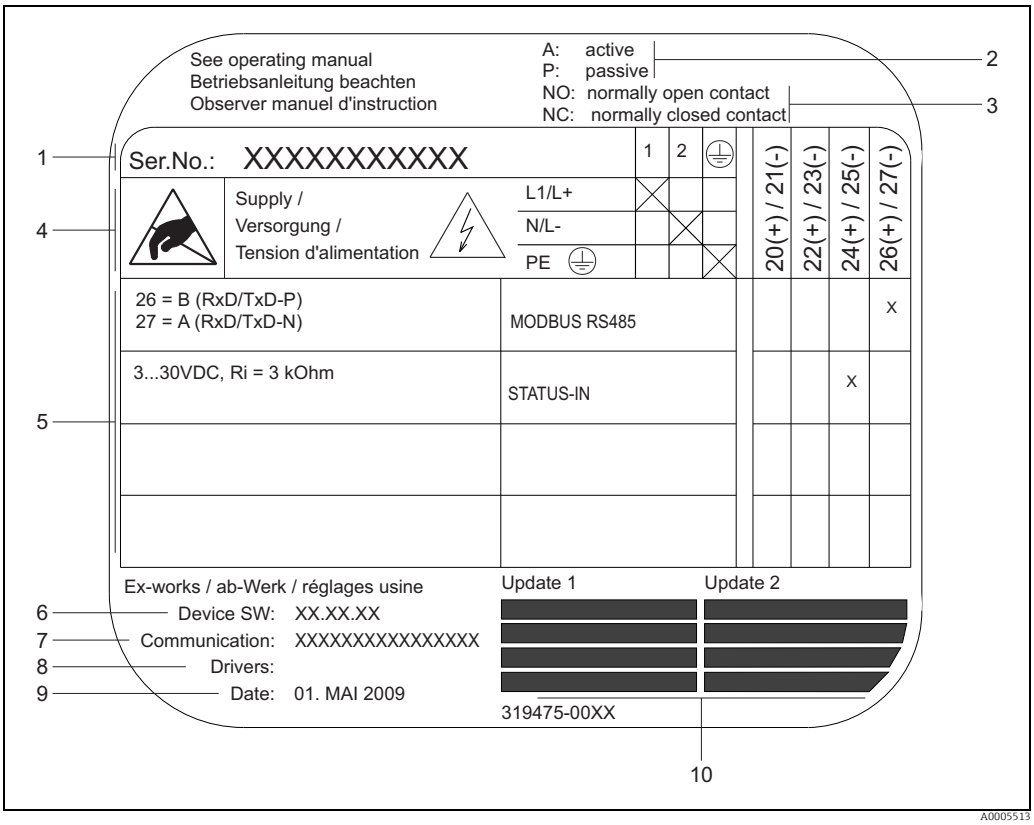


Fig. 3: Nameplate specifications for transmitter connections (example)

1 Serial number
2 Possible configuration of current output
3 Possible configuration of relay contacts
4 Terminal assignment, cable for power supply: 85 to 260 V AC, 20 to 55 V AC, 16 to 62 V DC
*Terminal **No. 1**: L1 for AC, L+ for DC*
*Terminal **No. 2**: N for AC, L– for DC*
5 Signals present at inputs and outputs, possible configuration and terminal assignment (20 to 27), see also "Electrical values of inputs/outputs", → 🖹 93
6 Version of measuring device software currently installed
7 Installed communication type
8 Information on current communication software
9 Date of manufacture
10 Current updates to data specified in points 6 to 9

3.2 Certificates and approvals

This measuring device is designed in accordance with good engineering practice to meet state-of-the-art safety requirements, has been tested, and left the factory in a condition in which it is safe to operate. The measuring device complies with the applicable standards and regulations in accordance with EN 61010-1 "Safety requirements for electrical equipment for measurement, control and laboratory use" and with the EMC requirements of IEC/EN 61326.
The measuring device described in these Operating Instructions thus complies with the statutory requirements of the EC Directives. Endress+Hauser confirms successful testing of the measuring device by affixing to it the CE mark.
The measuring device meets the EMC requirements of the Australian Communications and Media Authority (ACMA).

The measuring device meets all the requirements of the Modbus/TCP conformity test and holds the "Modbus/TCP Conformance Test Policy, Version 2.0". The measuring device has successfully passed all the test procedures carried out and is certified by the "Modbus/TCP Conformance Test Laboratory" of the University of Michigan.

3.3 Registered trademarks

KALREZ® and VITON®
Registered trademarks of DuPont Performance Elastomers L.L.C., Wilmington, USA

Modbus®

Registered trademark of SCHNEIDER AUTOMATION, INC.

HistoROM™, S-DAT®, T-DAT™, F-CHIP®, FieldCare®, Fieldcheck®, Applicator®, t-mass®
Registered or registration-pending trademarks of businesses in the Endress+Hauser Group

4 Installation

4.1 Incoming acceptance, transport and storage

4.1.1 Incoming acceptance

On receipt of the goods, check the following points:
- Is the packaging or content undamaged?
- Is the delivery complete and do the delivered goods match your order?

4.1.2 Transport

Observe the following instructions when unpacking and transporting the device to its final location:
- Transport the measuring device in the container in which it is delivered.
- The covers or caps fitted to the process connections prevent mechanical damage to the sealing surfaces and contamination in the measuring tube when the unit is being transported or in storage. Do not remove these covers or caps until immediately before installation.
- Do not lift measuring devices of nominal diameters > DN 40 (1½") by the transmitter housing or the connection housing in the case of the remote version → 4. For transportation purposes, use webbing slings slung round the two process connections. Do not use chains, as they could damage the housing.

Warning!
Risk of injury if the measuring device slips. The center of gravity of the assembled measuring device might be higher than the points around which the slings are slung.
When transporting, make sure that the measuring device does not unexpectedly turn around its axis or slip.

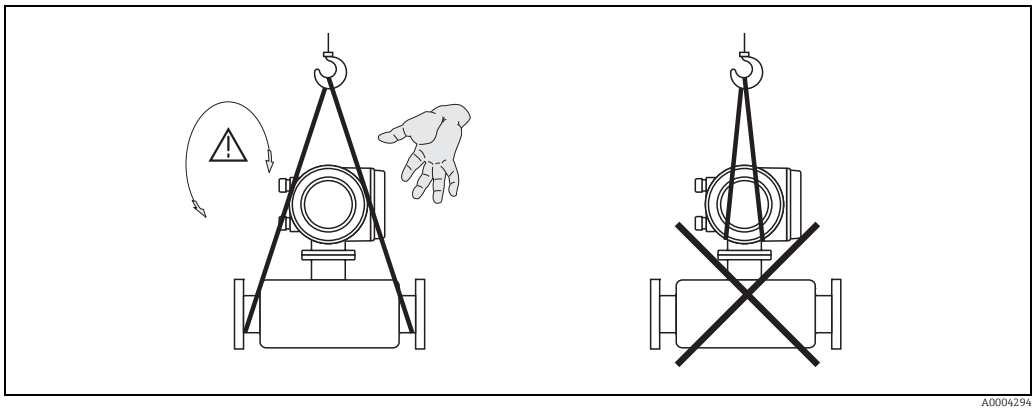


Fig. 4: Instructions for transporting sensors with > DN 40 (> 1½")

4.1.3 Storage

Note the following points:
- Pack the measuring device in such a way as to protect it reliably against impact for storage (and transportation). The original packaging provides optimum protection.
- The permissible storage temperature is: −40 to +80 °C (−40 to +176 °F), preferably +20 °C (+68 °F).
- Do not remove the protective covers or caps on the process connections until you are ready to install the device.
- The measuring device must be protected against direct sunlight during storage in order to avoid unacceptably high surface temperatures.
- Devices delivered with special sealing or bagging for oxygen service must remain sealed or bagged until ready for installation.

4.2 Installation conditions

Note the following points:
- The thermal dispersion principle is very sensitive to disturbed flow conditions.
- Observe the recommended inlet and outlet requirements.
- Good engineering practice is necessary for the associated pipe work and installation.
- Ensure correct alignment and orientation of the sensor.
- Take measures to reduce or avoid condensation (e.g. install a condensation trap, thermal insulation, etc.).
- The maximum permitted ambient temperatures → 97 and the medium temperature range → 97 must be observed.
- Install the transmitter in a shaded location or use a protective sun shield.
- For mechanical reasons, and in order to protect the pipe, it is advisable to support heavy sensors.

4.2.1 Dimensions

The dimensions and installation lengths of the sensor and transmitter can be found in the "Technical Information" for the device in question. This document can be downloaded as a PDF file from www.endress.com. A list of the "Technical Information" documents available can be found in the "Documentation" section on → 103.

4.2.2 System pressure and pulsating flow

Reciprocating pumps and some compressor systems can create strong changes in process pressure that can induce spurious internal flow patterns and therefore cause additional measurement error. These pressure pulses must be reduced by the appropriate measures:

- Use of expansion tanks
- Use of inlet expanders
- Relocate the flowmeter further downstream

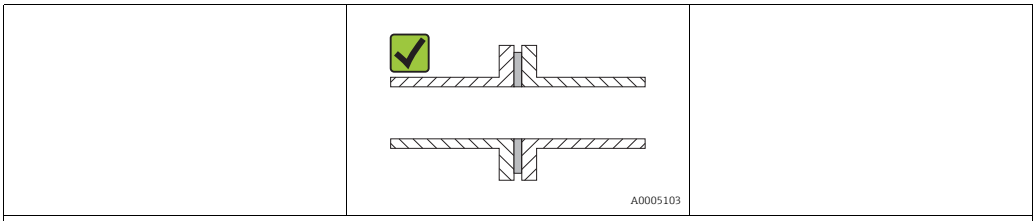
In compressed air systems, it is recommended to mount the flowmeter after the filter, dryer and buffer devices to avoid pulsations and oil/dirt contamination.
Do not mount the flowmeter directly after the compressor outlet.

4.2.3 Pipework requirements

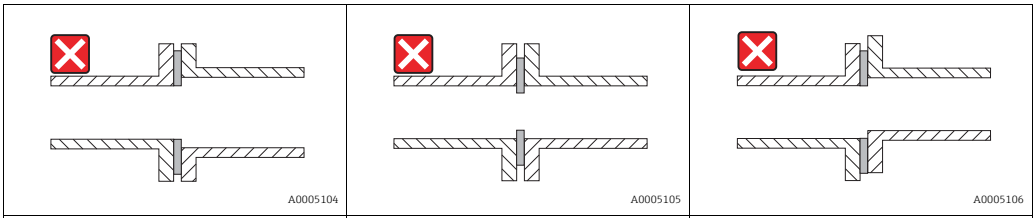
Good engineering practice should be followed at all times:

- Correct preparation, welding and finishing techniques
- Correctly sized gaskets
- Correctly aligned flanges and gaskets
- Connecting pipe work should match the internal diameter of the flowmeter. Maximum pipe diameter mismatch should not exceed:
  - 1 mm (0.04 in) for diameters < DN 200 (8")
  - 3 mm (0.12 in) for diameters ≥ DN 200 (8")

Further information is provided in ISO Standard 14511.



Correctly aligned flanges and gaskets

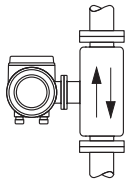
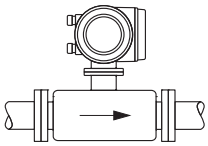
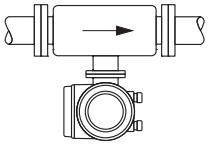
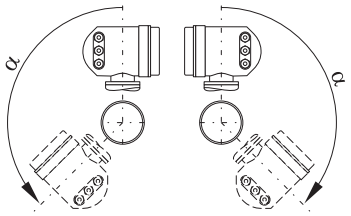


Pipe diameter one is not equal pipe diameter two	Incorrectly sized gaskets	Incorrectly aligned flanges and gaskets

Caution!
New installations should be free of metallic and abrasive particles to prevent damage to the sensing elements on start-up.

4.2.4 Orientation

Make sure that the direction arrow on the sensor matches the direction of flow through the pipe.

	Flanged sensor		Insertion sensor	
Vertical orientation				
 A0013785	compact ✔✔ ①	remote ✔✔ ①	compact ✔ ①, ②	remote ✔✔ ①
Horizontal orientation, transmitter head up				
 A0013786	compact/remote ✔✔ ②			
Horizontal orientation, transmitter head down				
 A0013787	compact/remote ✔ ③			
Inclined orientation, transmitter head down				
 A0009897	compact/remote ✔ ④			

✔✔ = Recommended orientation
✔ = Orientation recommended in certain situations

① In the case of saturated or unclean gases, upward flow in a vertical pipe section is preferred to minimize condensation/contamination.
② Not recommended if the vibrations are too high or if the installation is unstable.
③ Only suitable for clean/dry gases. Do not mount the sensor from the bottom, on horizontal pipes, if build-up or condensate are likely to be present. Mount the sensor in a position as indicated below
④ If the gas is very wet or saturated with water (e. g. biogas, undried compressed air), mount in inclined orientation (α = approx. 135° ±10°).

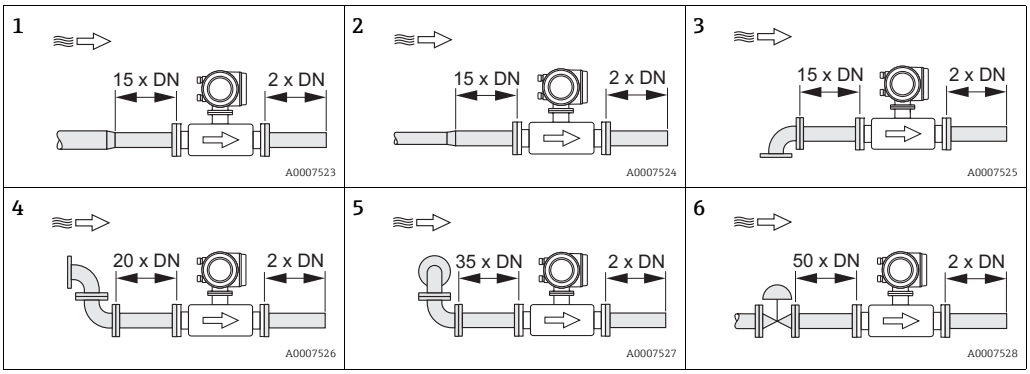
4.2.5 Inlet and outlet runs

The thermal dispersion principle is sensitive to disturbed flow conditions.
As a general rule, the thermal flowmeter should always be installed as far away as possible from any flow disturbances. For further information → ISO Standard 14511.

Note!
- Where two or more flow disturbances are located upstream of the meter, the longest indicated inlet length should prevail. For example if a control valve is additionally mounted upstream from the measuring device and an elbow on the inlet side, select the recommended inlet length for control valves: 50 × DN
- For very light gases such as Helium and Hydrogen all upstream distances should be doubled.

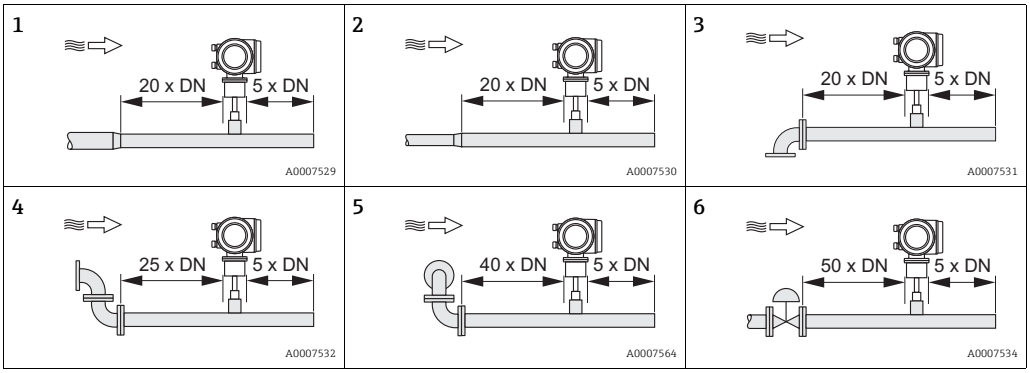
The minimum recommendations for inlet and outlet runs (without flow conditioner) are:

Flanged sensor



1 = Reduction, 2 = Expansion, 3 = 90° elbow or T-piece, 4 = 2 × 90° elbow,
5 = 2 × 90° elbow (3-dimensional), 6 = Control valve

Insertion sensor



1 = Reduction, 2 = Expansion, 3 = 90° elbow or T-piece, 4 = 2 × 90° elbow,
5 = 2 × 90° elbow (3-dimensional), 6 = Control valve or pressure regulator

Note!
A specially designed perforated plate flow conditioner can be installed if it is not possible to observe the inlet runs required (→ 16).

Outlet runs with pressure measuring points

The pressure measuring point should be installed downstream of the measuring device, so that there is no potential influence of the pressure transmitter process connection on the flow entering the measuring point.

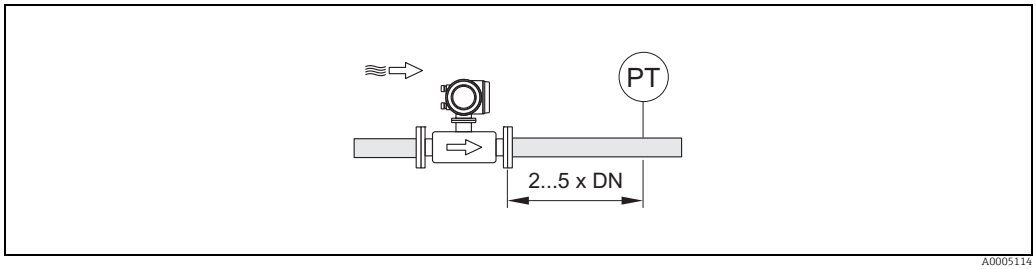


Fig. 5: Installing a pressure measuring point (PT = pressure transmitter)

Perforated plate flow conditioner

It is recommended to install a perforated plate flow conditioner if the recommended inlet runs are not available.

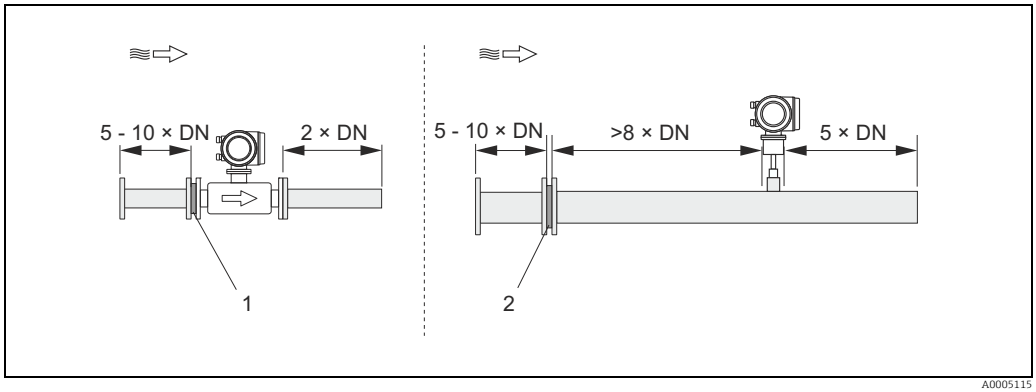


Fig. 6: The figure above illustrates the minimum recommended inlet and outlet runs expressed in multiples of the pipe diameter using a flow conditioner.

1 = Flow conditioner with the flanged sensor, 2 = Flow conditioner with the insertion sensor

Flow conditioner for use with insertion sensors 65I
→ 📄 *73*

The well known "Mitsubishi" design is recommended for this application DN 80 mm to DN 300 mm (3" to 12"). The flow conditioner must be installed at a distance of 8 × DN upstream of the sensor. A further 5 pipe diameters minimum inlet run is required upstream of the actual conditioner itself.
Measured errors can occur depending on disturbances in the inlet run. Therefore it is advisable to choose inlet runs that are as long as possible.

Note!
In the case of insertion devices, the inlet run selected downstream of the conditioner should be as long as possible.

Perforated plate flow conditioners (19 hole) for use with flanged sensor 65F → 73

This is a special Endress+Hauser version designed especially for use with the t-mass F sensor (sizes DN 25 to 100 / 1" to 4"). The mounting hole patterns and sizing are of a multi-variant design which means that one plate will fit different flange pressure classes e.g. Cl. 150 and Cl. 300.

The flow conditioner and gaskets are fitted between the pipe flange and the measuring device → 7. Use only standard bolts which match the flange bolt hole to guarantee that the flow conditioner is centered correctly.
The alignment notch must also be pointing in the same plane as the transmitter. Incorrect installation of the flow conditioner will have a small effect on the measurement accuracy.

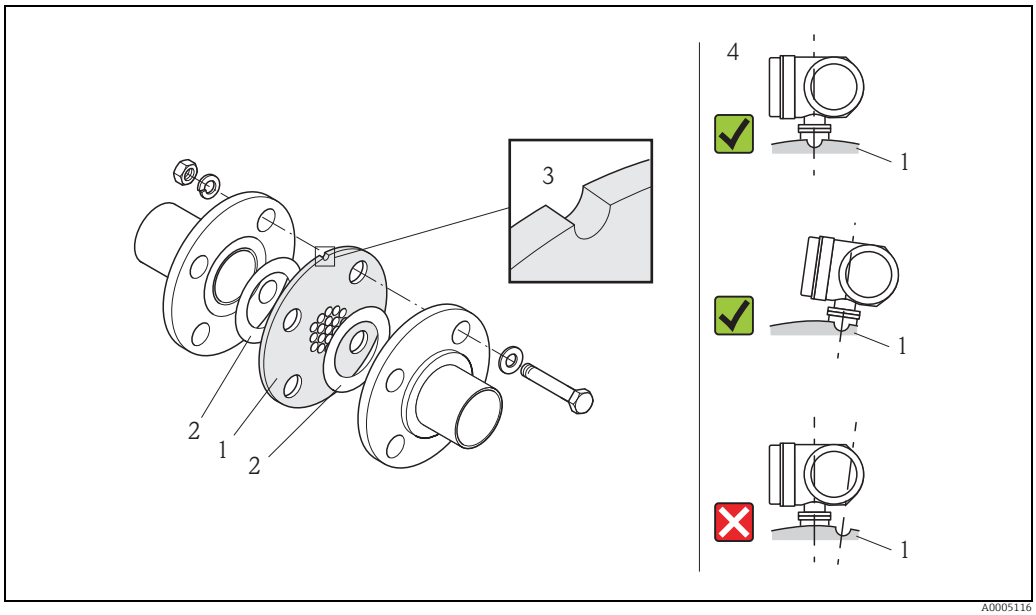


Fig. 7: Flow conditioner mounting arrangement (example)

1 = perforated plate flow conditioner, 2 = aeal/gasket, 3 = alignment notch, 4 = alignment in the same plane as the transmitter

Note

- Order the t-mass F sensor and the flow conditioner together to ensure that they are calibrated together. Joint calibration guarantees optimum performance. Ordering the flow conditioner separately and using it with the measuring device will further increase measurement uncertainty.
- The use of conditioners from other suppliers will affect the flow profile and pressure drop and will have an adverse effect on performance.
- Bolts, nuts, seals, etc. are not included in the scope of supply and must be supplied by the customer.

4.2.6 Heating

Some applications require suitable measures to avoid heat loss (condensation). Heating can be electric, e. g. with heated elements, or by means of hot water, steam pipes or insulation.

Caution!
Risk of electronics overheating! Consequently, make sure that the adapter between sensor and transmitter and the connection housing of the remote version always remain free of insulating material.

4.2.7 Thermal insulation

When the gas is very damp or saturated with water (e. g. bio gas), the piping and flowmeter body should be insulated to prevent water droplets condensing on the measuring sensor.

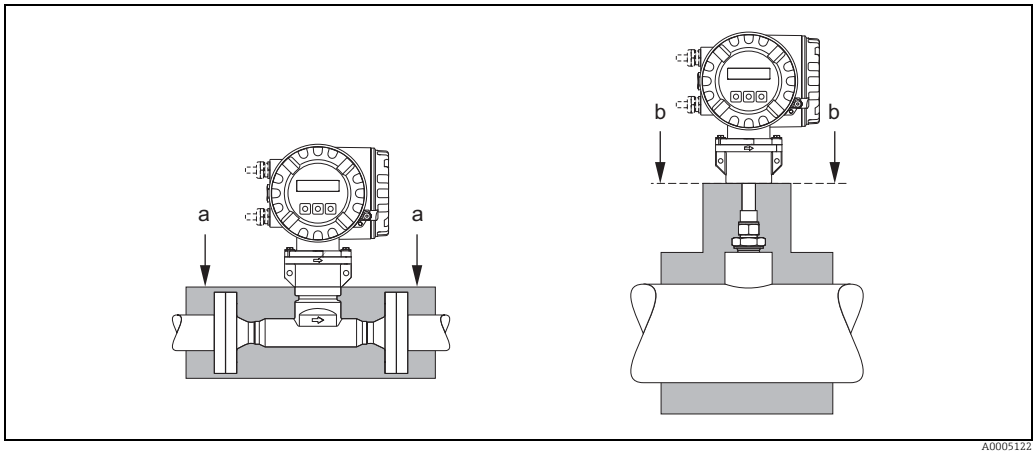


Fig. 8: Maximum thermal insulation for t-mass 65F and 65I

a Maximum insulation height for the flanged sensor
b Maximum insulation height for the insertion sensor

4.2.8 Vibrations

Caution!
Excessive vibration can result in mechanical damage to the measuring device and its mounting.
Observe the vibration spezification in the technical data section → 97

4.3 Installation

4.3.1 Mounting the insertion sensor

The sensor can be mounted into a welding socket or a retractable mounting set. If a retractable mounting set is being used, then refer to the supplementary documentation delivered with the mounting set.

Mounting the welding socket

This instruction describes mounting of the Endress+Hauser welding socket. If a welding boss is already available or a customer-specific one is being used, then go to the next section "Insertion depth calculation and adjustment."

Note!
- Take the orientation and inlet and outlet runs into account before mounting the welding socket→ 14 ff.
- The welding socket is made of stainless steel 1.4404 (316/316L). Use appropriate welding technique.

Caution!
- When mounting the fitting to a thin wall duct, use a suitable support bracket for the sensor and weld the welding socket to a base plate to spread the load. Otherwise, the mounting may be unstable and the duct wall can be damaged.

Warning!
- These instructions are only applicable to installation in an un-pressurized line, without gas present and at safe temperatures.

1. Drill or a cut hole of Ø 31.0 mm ± 0.5 mm (1.22 ± 0.019") in the pipe.
2. Deburr the hole.
3. Fit the edge of the welding socket into hole, align it vertically and weld it on → 9.

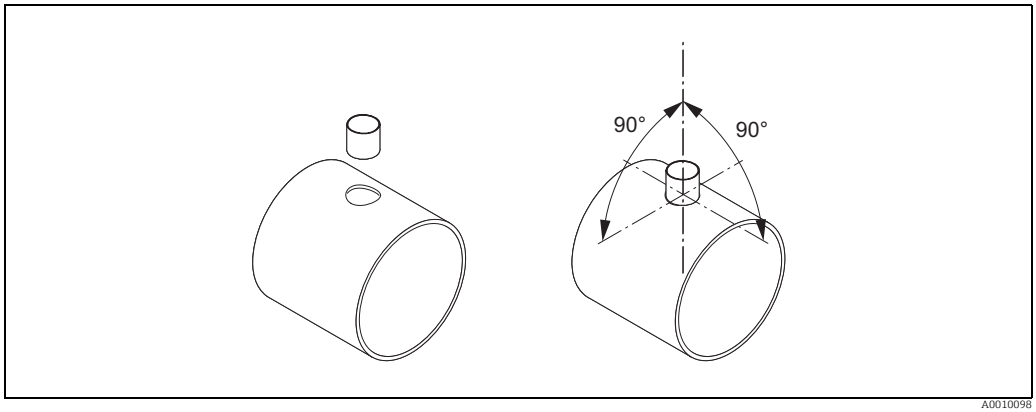


Fig. 9: Positioning the welding socket on the pipe (or duct)

Insertion depth calculation and adjustment

To ensure optimum measurement performance, the insertion sensor must be installed in the correct position in the pipe or duct (30% of the internal diameter).
A millimeter and inch scale is provided along the entire length of the sensor tube. This makes it possible to align the sensor at the right depth.

4. Calculate the insertion depth:
   – with the help of the Quick Setup "Sensor" → 58 or
   – using the following dimensions and formulae

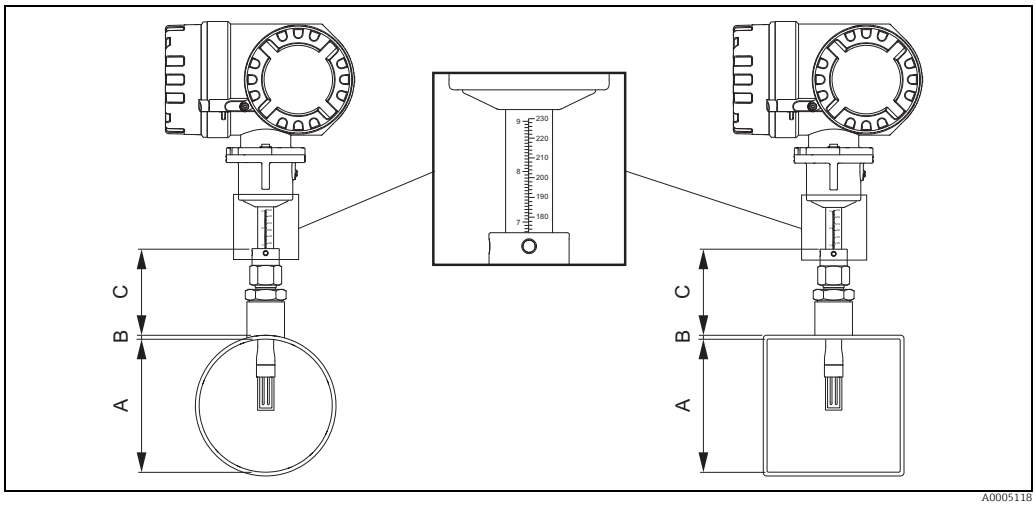


Fig. 10: Dimensions needed to calculate the insertion depth

A Pipes: internal diameter
Ducts: internal dimension
B Wall thickness
C Dimension from pipe/duct to the compression fitting

The following dimensions are required to calculate the insertion depth:

A	• For circular pipes: the internal diameter (DN) • For rectangular ducts: – The internal duct height if the sensor is installed vertically – The internal duct width if the sensor is installed horizontally Note! Minimum length of dimension A = 80 mm (3.15 in)
B	Pipe / duct wall thickness
C	Height of the welding nozzle at the pipe/duct including the sensor compression fitting or low pressure mounting set (if used).

Note!
For detailed remarks on calculation refer to Technical Information TI00069D.

- Calculated insertion depth = (0.3 × A) + B + C + 2 mm (0.08 in)

Note down the calculated value.

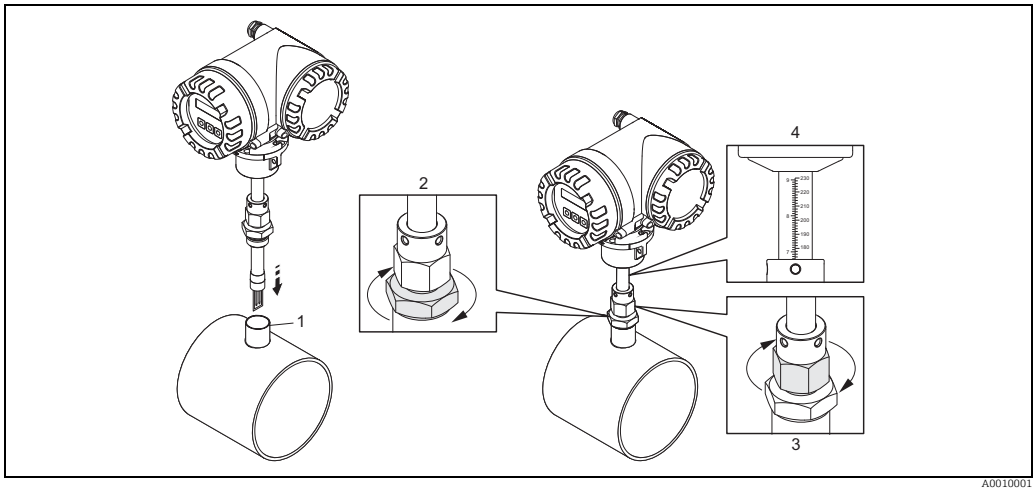


Fig. 11: Aligning the sensor to the calculated insertion depth

5. Insert the sensor in the nozzle (1) and tighten the lower nut of the compression fitting (2) finger-tight.

   Caution!
   – NPT thread: use a thread sealing tape or paste
   – G 1 A thread: the sealing ring supplied must be installed

6. Tighten the upper nut of compression fitting (3) such that the sensor can still be adjusted.
7. Read off the calculated insertion depth from the scale and adjust the sensor so that the value aligns with the upper end of the compression fitting (4).
8. Tighten the lower nut of the compression fitting 1¼ revolutions using a wrench (42 mm).

Aligning the sensor with the flow direction

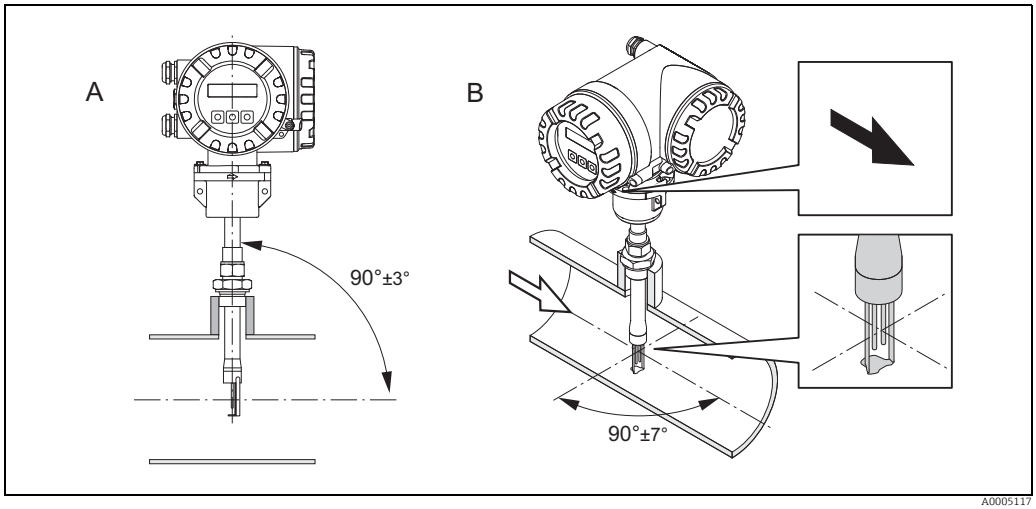


Fig. 12: Aligning the sensor with the flow direction

9. Check and ensure that the sensor is aligned vertically at a 90° angle on the pipe/duct. Turn the sensor so that the arrow marking matches the direction of flow.

Note!
To ensure optimum exposure of the measuring transducer to the flowing gas stream, the sensor must not be rotated more than 7° from this alignment.

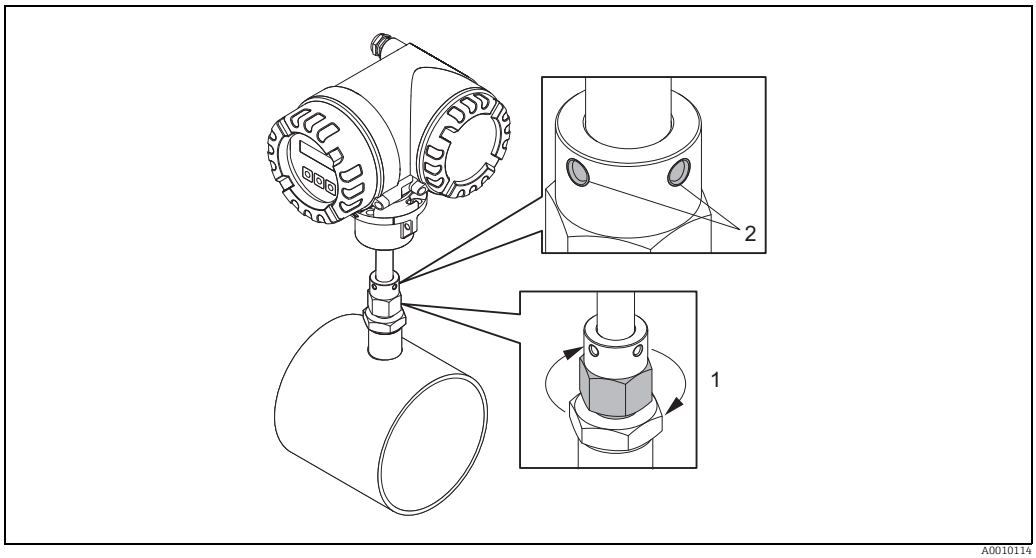


Fig. 13: Securing the position of the sensor

10. Tighten the compression fitting (1) by hand to secure the position of the sensor. Then, using an open-ended wrench, tighten another 1¼ revolutions in a clockwise direction.
11. Fix the two securing screws (2) (Allen key 3 mm; (1/8")).

    ⚠ Warning!
    Observe torque: 4 Nm (2.95 lbf ft)
12. Check that the sensor and transmitter do not turn.
13. Check the measuring point for leaks at the maximum operating pressure.

4.3.2 Removing the insertion sensor

Warning!
- Do not remove the measuring device when it is pressurized! Stop the gas flow and unpressurize the process pipe.
- In the case of toxic, explosive or flammable gases, the pipe in which the measuring device is installed must be purged with an inert gas to remove all traces of the gas used.
- Make sure that the process cannot be resumed while removal work is in progress.
- Allow the system and device to cool to a safe temperature (i.e. <50 °C, (<120 ° F)).

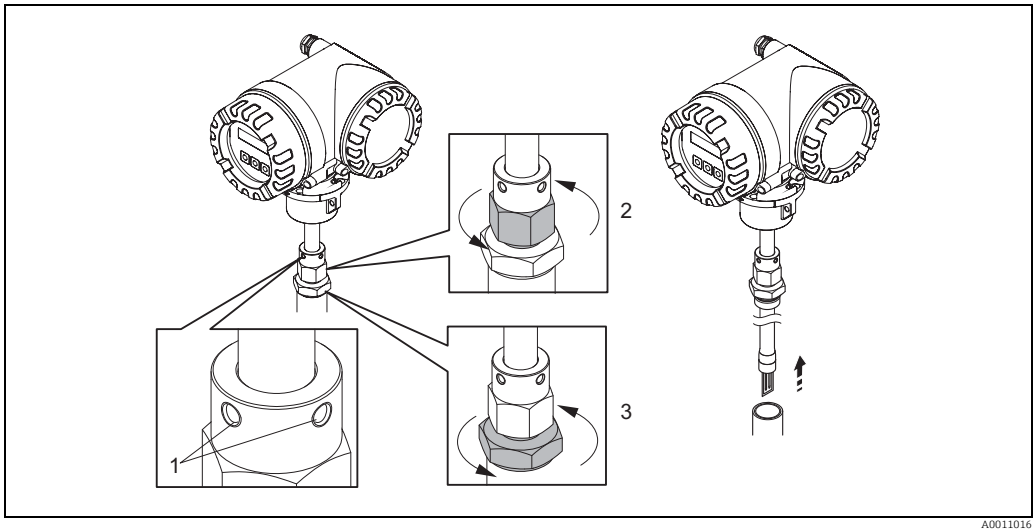


Fig. 14: Removing the insertion sensor

1. Release the securing screws (1).
2. Release the upper nut of compression fitting using a wrench, turning in a counterclockwise direction (2).

   Caution!
   In the case of vertical installation, do not drop the measuring device into the pipe.
3. Unscrew the lower nut of compression fitting (3) and remove the sensor.

4.3.3 Mounting the flanged sensor

The arrow on the sensor must match with the actual direction of flow through the pipe.

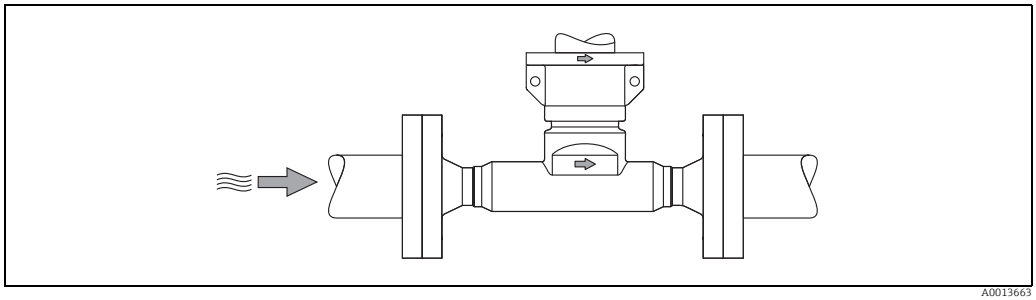


Fig. 15: Mounting in direction of flow

4.3.4 Turning the transmitter housing

Turning the aluminum field housing

Warning!
The rotating mechanism for measuring devices for hazardous areas Zone 1 (ATEX/IEC Ex) or Class I Div. 1 (FM/CSA) is different to that described here. The procedure for turning these housings is described in the Ex-specific documentation → 🖹 103.

1. Loosen the two securing screws.

Caution!
Special screw! Do not loosen screw completely or replace with another screw.
Use only original Endress+Hauser parts.

1. Turn the bayonet catch as far as it will go.
2. Carefully lift the transmitter housing as far as it will go.
3. Turn the transmitter housing to the desired position (max. 2 × 90° in either direction).
4. Lower the housing into position and re-engage the bayonet catch.
5. Retighten the two securing screws.

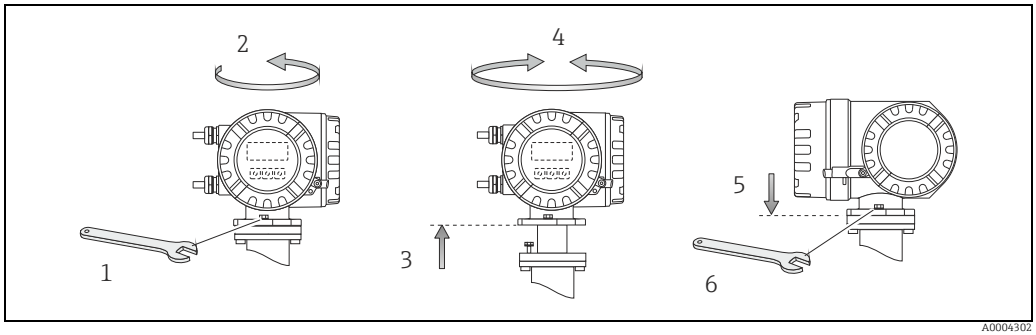


Fig. 16: Turning the transmitter housing (aluminum field housing)

4.3.5 Turning the local display

1. Unscrew cover of the electronics compartment from the transmitter housing.
2. Press the side latches on the display module and remove the module from the electronics compartment cover plate.
3. Rotate the display to the desired position (4 × 45 ° in both directions), and reset it onto the electronics compartment cover plate.
4. Screw the cover of the electronics compartment firmly back onto the transmitter housing.

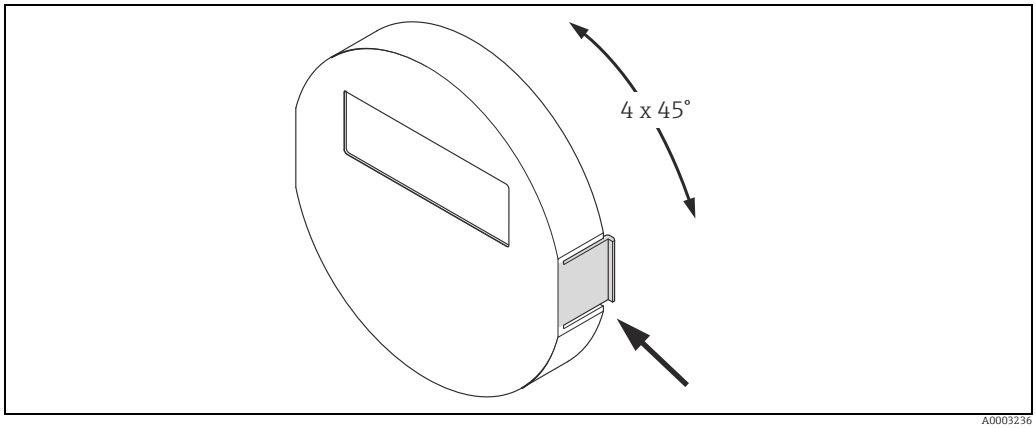


Fig. 17: Turning the local display (field housing)

4.3.6 Installing the wall-mount transmitter housing

There are various ways of installing the wall-mount transmitter housing:

- Mounted directly on the wall
- Installation in control panel → 📄 26 (separate mounting set, accessories) → 📄 73
- Pipe mounting → 📄 26 (separate mounting set, accessories → 📄 73)

Caution!

- The ambient temperature may not exceed the permissible range of −20 to +60 °C (−4 to +140 °F), optionally
  −40 to +60 °C (−40 to +140 °F), at the mounting location.
- Install the device in a shady location. Avoid direct sunlight on the display.
- Always install the wall-mount housing in such a way that the cable entries are pointing down.

Mounted directly on the wall

1. Drill the holes as illustrated in the diagram.
2. Remove the cover of the connection compartment (a).
3. Push the two securing screws (b) through the appropriate bores (c) in the housing.
   – Securing screws (M6): max. Ø 6.5 mm (0.26 inch)
   – Screw head: max. Ø 10.5 mm (0.4 inch)
4. Secure the transmitter housing to the wall as indicated.
5. Screw the cover of the connection compartment (a) firmly onto the housing.

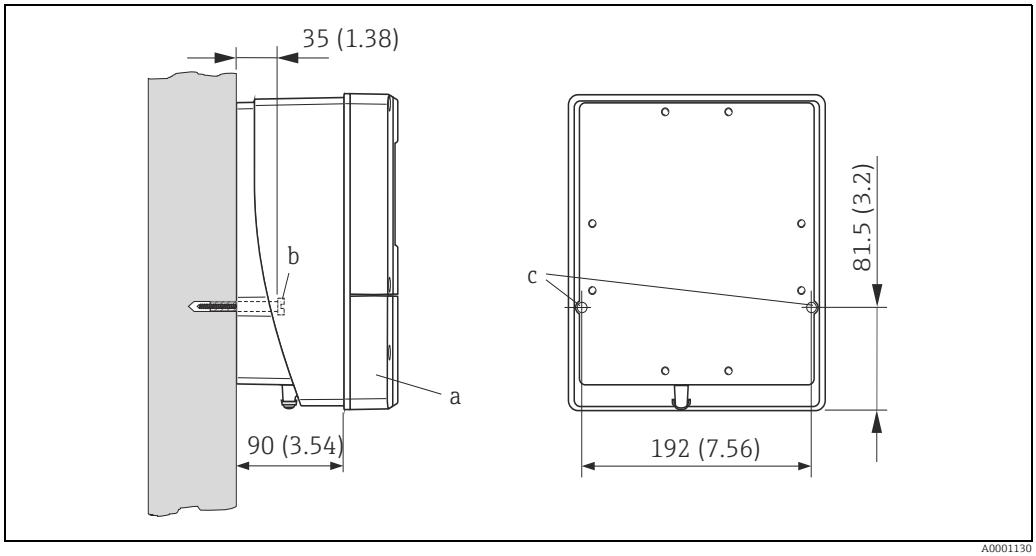


Fig. 18: Engineering unit mm (in)

Installation in control panel

1. Prepare the opening in the panel as illustrated in the diagram.
2. Slide the housing into the opening in the panel from the front.
3. Screw the fasteners onto the wall-mount housing.
4. Screw threaded rods into holders and tighten
   until the housing is solidly seated on the panel wall. Afterwards, tighten the locking nuts.
   Additional support is not necessary.

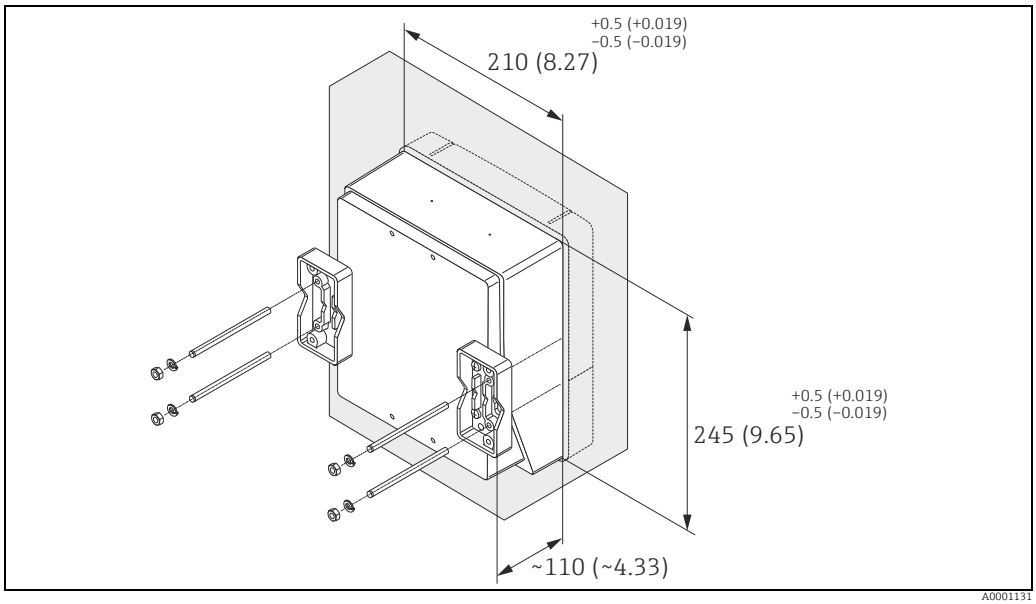


Fig. 19: Engineering unit mm (in)

Pipe mounting

The assembly should be performed by following the instructions in the diagram.

Caution!
If a warm pipe is used for installation, make sure
that the housing temperature does not exceed the max. permitted value of +60 °C (+140 °F).

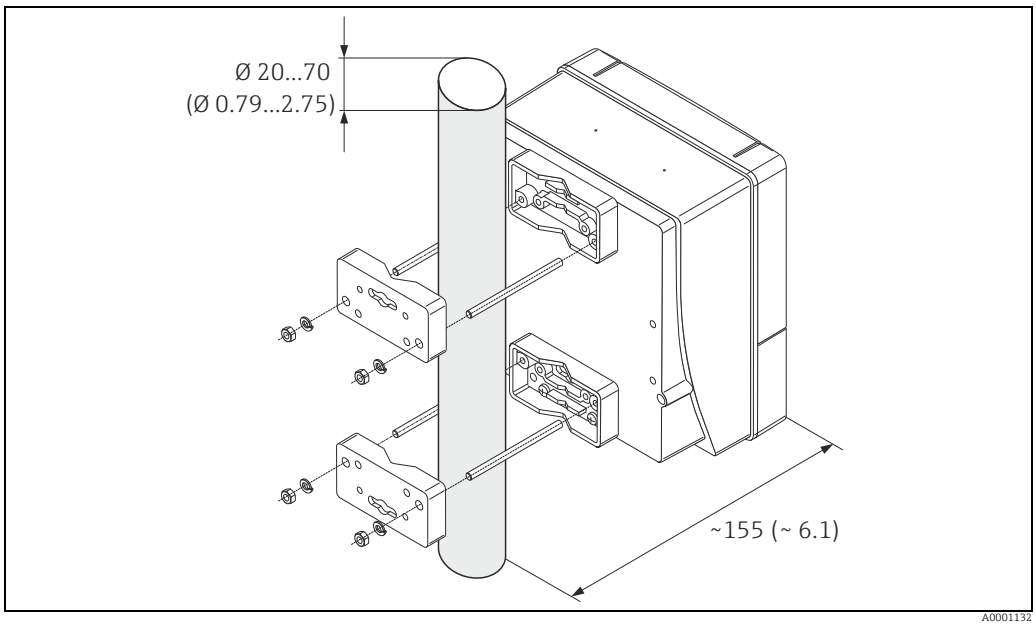


Fig. 20: Engineering unit mm (in)

4.4 Post-installation check

Perform the following checks after installing the measuring device in the pipe:

Measuring device condition and specifications	Notes
Is the measuring device undamaged (visual inspection)?	–
Does the device correspond to specifications at the measurement point, including process temperature and pressure, ambient temperature, measuring range, etc.? Check the name plate.	→ 🖹 7
Installation	**Notes**
Correct alignment of pipe/gasket/flowmeter body?	→ 🖹 13
Professional installation, e.g. correct pipe internal diameter, correctly sized gaskets?	→ 🖹 13
Is the position chosen for the sensor correct, in other words suitable for sensor type, fluid properties and fluid temperature?	→ 🖹 14
Is there sufficient upstream and downstream pipe sensor?	→ 🖹 15
Correct installation of flow conditioner (if fitted)?	→ 🖹 16
Does the arrow on the sensor match the direction of flow through the pipe?	→ 🖹 14
Correct sensor depth (insertion sensor only)?	→ 🖹 19
Process environment/process conditions	**Notes**
Is the measuring device protected against moisture and direct sunlight?	–
Is the measuring device protected against overheating?	→ 🖹 18
Is the measuring device protected against excessive vibration?	→ 🖹 18, → 🖹 97
Check gas conditions (e. g. purity, dryness, cleanliness)	Select suitable orientation → 🖹 14

5 Electrical connection

Warning!
When connecting Ex-certified measuring devices, see the notes and diagrams in the Ex-specific supplement to these Operating Instructions. Please do not hesitate to contact your Endress+Hauser sales center if you have any questions.

Note!
- The measuring device does not have an internal power isolation switch. Therefore provide an isolation switch or circuit breaker which can be used to disconnect the power supply to the measuring device.
- The electrical characteristic quantities are listed in the "Technical data" section.

5.1 Cable specification Modbus RS485

5.1.1 Cable type

In the EIA/TIA-485 standard, two versions (cable type A and B) are specified for the bus line and can be used for all transmission rates. However, we recommend you use cable type A. The cable specification for cable type A are provided in the following table:

Cable type A	
Characteristic impedance	135 to 165 Ω at a measuring frequency of 3 to 20 MHz
Cable capacitance	<30 pF/m
Core cross-section	>0.34 mm², corresponds to AWG 22
Cable type	Twisted pairs
Loop-resistance	≤110 Ω/km
Signal damping	Max. 9 dB over the entire length of the cable cross-section
Shielding	Copper braided shielding or braided shielding and foil shielding

Note the following points for the bus structure:
- All the measuring devices are connected in a bus structure (line).
- Using cable type A and with a transmission rate of 115200 Baud, the maximum line length (segment length) of the Modbus RS485 system is 1200 m. The total length of the spurs may not exceed a maximum of 6.6 m here.
- A maximum of 32 users are permitted per segment.
- Each segment is terminated at either end with a terminating resistor.
- The bus length or the number of users can be increased by introducing a repeater.

5.1.2 Shielding and grounding

When planning the shielding and grounding for a fieldbus system, there are three important points to consider:

- Electromagnetic compatibility (EMC)
- Explosion protection
- Safety of the personnel

To ensure the optimum electromagnetic compatibility of systems, it is important that the system components and above all the cables, which connect the components, are shielded and that no portion of the system is unshielded. Ideally, the cable shields are connected to the normally metal housings of the connected field devices. Since these are generally connected to the protective ground, the shield of the bus cable is grounded many times. Ensure that the stripped and twisted lengths of cable shield to the ground terminal are as short as possible. This approach, which provides the best electromagnetic compatibility and personnel safety, can be used without restriction in systems with good potential matching. In the case of systems without potential matching, a power supply frequency (50 Hz) equalizing

current can flow between two grounding points which, in unfavorable cases (e.g. when it exceeds the permissible shield current) may destroy the cable.
To suppress the low frequency equalizing currents, it is therefore recommended - in the case of systems without potential equalization - to connect the cable shield directly to the building ground (or protective ground) at one end only and to use capacitive coupling to connect all other grounding points.

Caution!
The legal EMC requirements are fulfilled **only** when the cable shield is grounded on both ends!

5.2 Connecting the remote version

Note!
A cable is not supplied for the remote version.

5.2.1 Connecting connecting cable for sensor/transmitter

Warning!
- After removing the electronics cover, there is a risk of electric shock as shock protection is removed! Switch off the measuring device before removing internal covers.
- Risk of electric shock. Connect the protective earth to the ground terminal on the housing before the power is supplied.

1. Remove the connection compartment cover by loosening the fixing screws on the transmitter and sensor housing.
2. Feed the connecting cable through the appropriate cable entry.
3. Establish the connections between sensor and transmitter in accordance with the wiring diagram (→ 21 or see wiring diagram in screw cap; wire cross-section: max. 2.5 mm² (14 AWG)).
4. Screw the connection compartment cover back onto the sensor and transmitter housing.

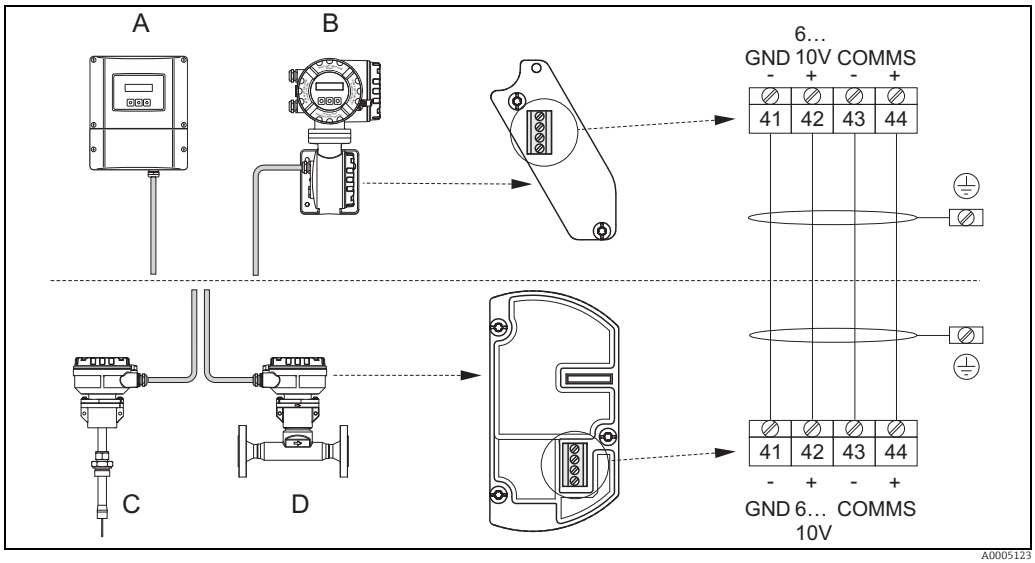


Fig. 21: Connecting the remote version

A Wallmount housing; Non-hazardous area and zone 2 (ATEX II3G, FM/CSA) → see separate "Ex documentation"
B Field housing; Zone 1 (ATEX II2GD, IECEx, FM/CSA) → see separate "Ex documentation"
C Remote sensor insertion
D Remote sensor flanged

Wire colors (when supplied by Endress+Hauser):
Terminal no. 41 = white; 42 = brown; 43 = green; 44 = yellow

5.2.2 Cable specification, connecting cable

A cable with the following specifications must be used for the remote version:

- 2 × 2 × 0.5 mm² (AWG 20) PVC cable with common shield (2 twisted pairs)
- Conductor resistance: ≤ 40 Ω /km (≤ 131.2 Ω /1000 ft)
- Operating voltage: ≥ 250 V
- Temperature range: −40 to +105 °C (−40 to +221 °F)
- Overall nominal diameter: 8.5 mm (0.335")
- Maximum cable length: 100 m (328 feet)

Note!
- The cable must be installed securely to prevent movement
- The cable should be of sufficient diameter to provide adequate sealing of the cable gland → 95.

5.3 Connecting the measuring unit

5.3.1 Terminal assignment

Order variant	Terminal No. (inputs/outputs)							
	20 (+)	21 (−)	22 (+)	23 (−)	24 (+)	25 (−)	26 (+)	27 (−)
65F**-**********Q 65I-**********Q	–		–		Status input		B Modbus RS485 A = RxD/TxD-N B = RxD/TxD-P	A

5.3.2 Transmitter connection

Warning!
- Risk of electric shock. Switch off the power supply before opening the measuring device. Never mount or wire the measuring device while it is connected to the power supply. Failure to comply with this precaution can result in irreparable damage to the electronics.
- Risk of electric shock. Connect the protective earth to the ground terminal on the housing before the power supply is applied unless special protection measures have been taken (e.g. galvanically isolated power supply SELV or PELV).
- Compare the specifications on the nameplate with the local supply voltage and frequency. The national regulations governing the installation of electrical equipment also apply.

1. Unscrew the connection compartment cover from the transmitter housing.
2. Feed the power supply cable, the fieldbus cable and the signal cable through the appropriate cable entries.
3. Perform wiring:
   - Wiring diagram → 31
   - Terminal assignment → see above

   Caution!
   - Risk of damage to the fieldbus cable!
     Observe the information about shielding and grounding the fieldbus cable .→ 28
   - We recommend that the fieldbus cable not be looped using conventional cable glands. If even just one measuring device is later replaced, the bus communication will have to be interrupted.
4. Screw the cover of the connection compartment back onto the transmitter housing.

5.3.3 Modbus RS485 connection diagram

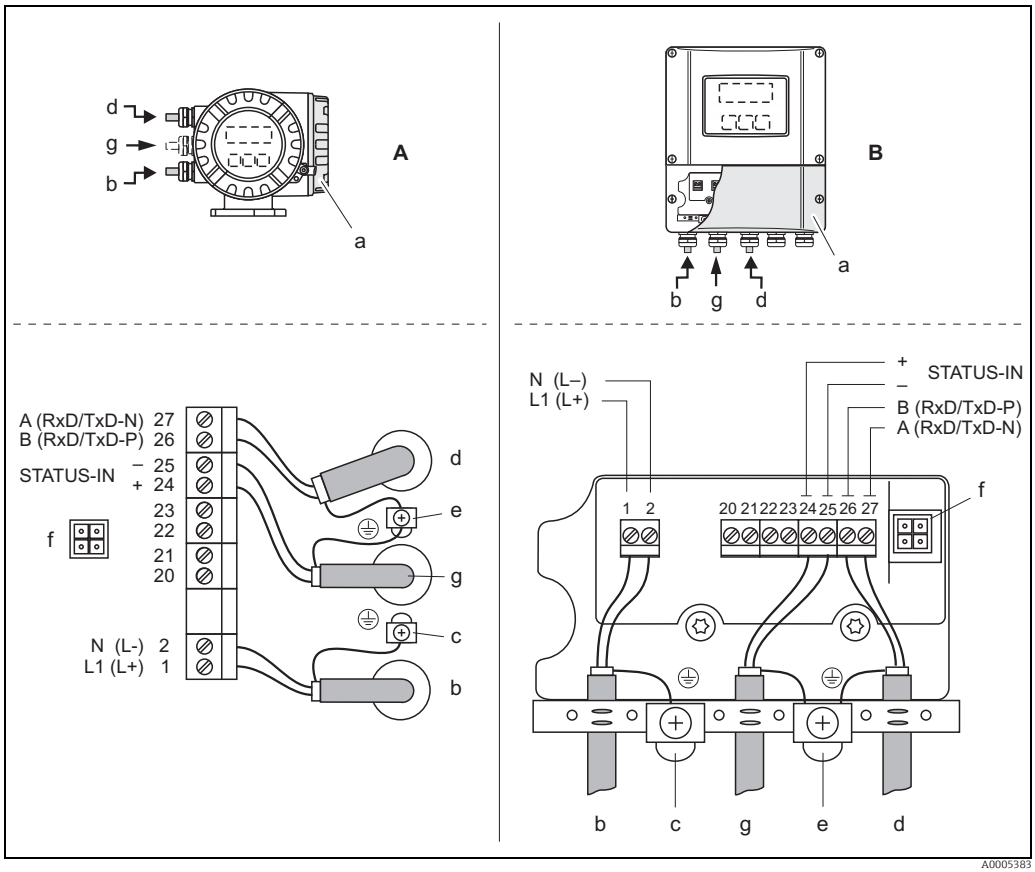


Fig. 22: Connecting the transmitter, cable cross-section max. 2.5 mm² (14 AWG)²

A Field housing
B Wall-mount housing

a Connection compartment cover
a bCable for power supply: 85 to 260 V AC, 20 to 55 V AC,16 to 62 V DC
Terminal No. 1: L1 for AC, L+ for DC
Terminal No. 2: N for AC, L– for DC
c Ground terminal for protective conductor
d Fieldbus cable
Terminal No. 26: B (RxD/TxD–P)
Terminal No. 27: A (RxD/TxD–N)
e Ground terminal, for RS485 line/signal cable shield
Observe the following:
– the shielding and grounding of the fieldbus cable → 🖹 28
– that the stripped and twisted lengths of cable shield to the ground terminal are as short as possible
f Service socket for connecting service interface FXA 193 (FieldCare or Fieldcheck)
g Signal cable: see Terminal assignment → 🖹 30

5.4 Degree of protection

The measuring devices fulfill all the requirements for IP 67 (NEMA 4X).

Compliance with the following points is mandatory following installation in the field or servicing, in order to ensure that IP 67 (NEMA 4X) protection is maintained:

- The housing seals must be clean and undamaged when inserted into their grooves. The seals must be dried, cleaned or replaced if necessary.
- All threaded fasteners and screw covers must be firmly tightened.
- The cables used for connection must be of the specified outside diameter (cable entry → 95)
- Firmly tighten the cable entries (a).
- The cables must loop down before they enter the cable entries ("water trap") (b). This arrangement prevents moisture penetrating the entry. Always install the measuring device in such a way that the cable entries do not point up.
- Remove all unused cable entries and insert blanking plugs instead.
- Do not remove the grommet from the cable entry.

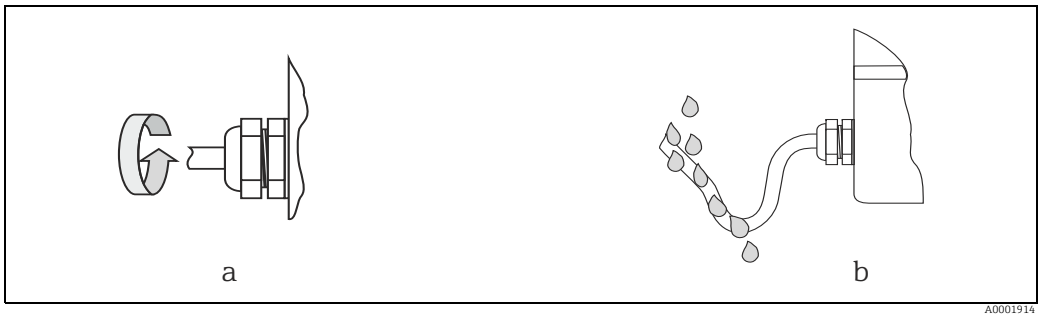


Fig. 23: Installation instructions, cable entries

5.5 Post-connection check

Perform the following checks after completing electrical installation of the measuring device:

Measuring device condition and specifications	Notes
Are cables or the measuring device undamaged (visual inspection)?	-
Electrical connection	**Notes**
Does the supply voltage match the specifications on the nameplate?	85 to 260 V AC (45 to 65 Hz) 20 to 55 V AC (45 to 65 Hz) 16 to 62 V DC
Do the cables comply with the specifications?	Modbus RS485 → 🖹 28 Connecting cable → 🖹 30
Do the cables have adequate strain relief?	-
Cables correctly segregated by type? Without loops and crossovers?	-
Are the power supply and signal cables correctly connected?	→ 🖹 31 or See the wiring diagram inside the cover of the terminal compartment
Only remote version: Is the flow sensor connected to the matching transmitter electronics?	Check serial number on nameplates of sensor and connected transmitter.
Only remote version: is the connecting cable between sensor and transmitter connected correctly?	→ 🖹 29
Are all screw terminals firmly tightened?	-
Are all cable entries installed, firmly tightened and correctly sealed? Cables looped as "water traps"?	→ 🖹 32
Are all housing covers installed and firmly tightened?	-
Electrical connection of Modbus RS485	**Notes**
Has each fieldbus segment been terminated at both ends with a bus terminator?	→ 🖹 54
Has the max. length of the fieldbus cable been observed in accordance with the Modbus RS485 specifications?	→ 🖹 28
Has the max. length of the spurs been observed in accordance with the Modbus RS485 specifications?	→ 🖹 28
Is the fieldbus cable fully shielded and correctly grounded?	→ 🖹 28

6 Operation

6.1 Quick operation guide

The user has a number of options for configuring and commissioning the device:

1. **Local display (option)** → 📄 35
   The local display makes it possible to read all important variables directly at the measuring point,
   configure bus-specific and device-specific parameters in the field and perform commissioning.
2. **Configuration programs** → 📄 51
   Operation via FieldCare
   The measuring devices are accessed via the service interface or via the service interface FXA193.
3. **Jumpers/miniature switches for hardware settings**→ 📄 52
   The following hardware settings can be made using a jumper or miniature switches on the I/O board:
   - Address mode configuration (select software or hardware addressing)
   - Device bus address configuration (for hardware addressing)
   - Hardware write protection enabling/disabling

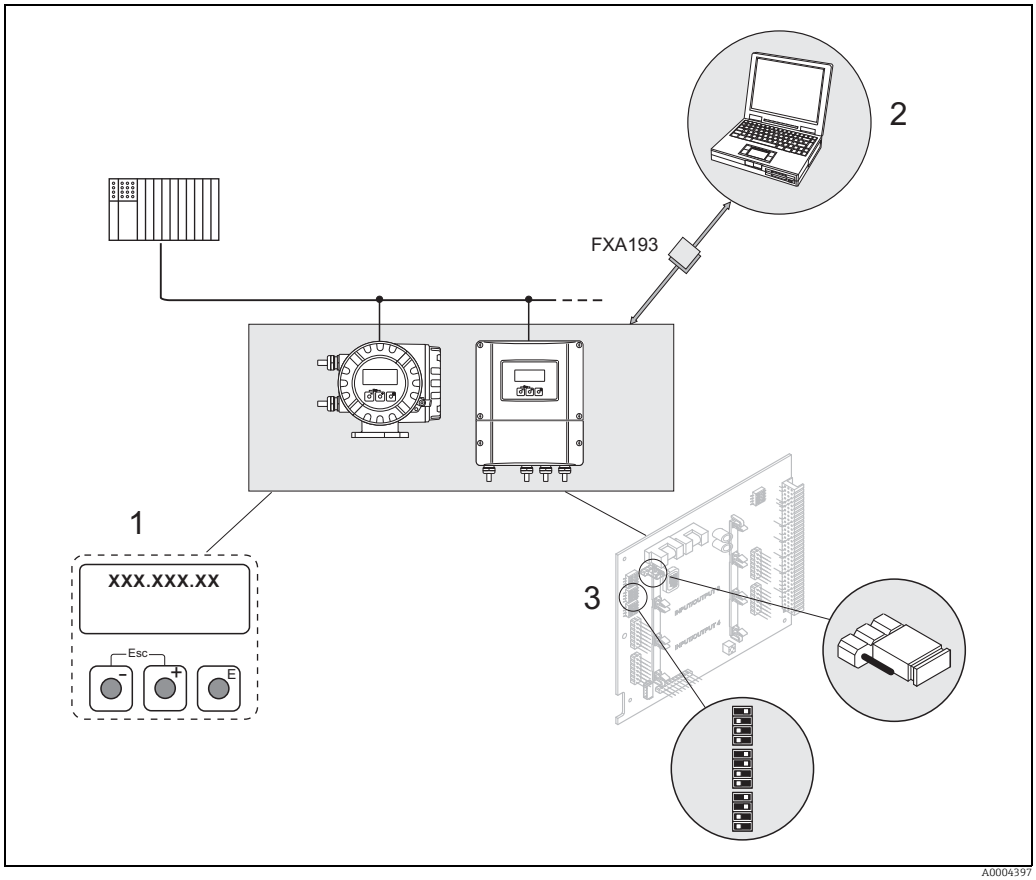


Fig. 24: Methods of operating Modbus RS485 measuring devices

1 Local display for measuring device operation in the field (option)
2 Configuration/operating program for operating via the service interface FXA 193 (e.g. FieldCare)
3 Jumper/miniature switches for hardware settings (write protection, measuring device address, address mode)

6.2 Display and operating elements

The local display makes it possible to read all important parameters directly at the measuring point or configure the measuring device via the "Quick Setup" or the function matrix.
The display consists of two lines; this is where measured values and/or status variables (process/system error messages, bar graph, etc.) are displayed. You can change the assignment of display lines to different variables to suit your needs and preferences (→ see the "Description of Device Functions" manual).

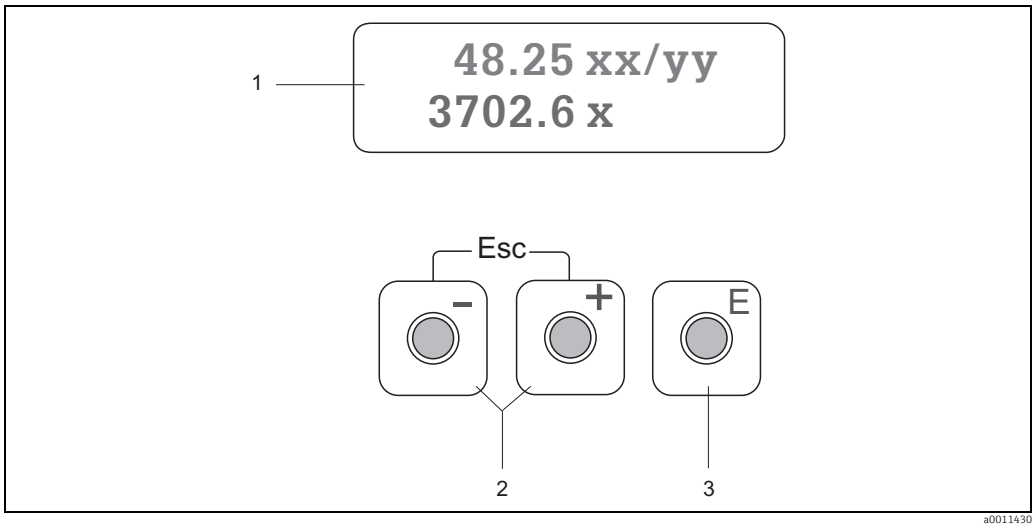


Fig. 25: Display and operating elements

1 Liquid crystal display
The backlit, two-line liquid crystal display shows measured values, dialog texts, fault messages and notice messages. The display as it appears when normal measuring is in progress is known as the HOME position (operating mode).
- *Upper display line: shows primary measured values, e.g. mass flow in [kg/h] or in [%].*
- *Lower display line: shows additional measured variables and status variables, e.g. totalizer reading in [kg], bar graph, measuring point designation.*

2 +/– keys
- *Enter numerical values, select parameters*
- *Select different function groups within the function matrix*

Press the +/– keys simultaneously to trigger the following functions:
- *Exit the function matrix step by step → HOME position*
- *Press and hold down +/– keys for longer than 3 seconds → Return directly to HOME position*
- *Cancel data entry*

3 E Enter key
- *HOME position → Entry into the function matrix*
- *Save the numerical values you input or settings you change*

Icons

The icons which appear in the field on the left make it easier to read and recognize measured variables, measuring device status, and error messages.

Icon	Meaning	Icon	Meaning
S	System error	P	Process error
↯	Fault message (with effect on outputs)	!	Notice message (without effect on outputs)
⇳	Low flow cut off or extended flow function is active		
	Modbus communication active		

6.3 Brief operating instructions for the function matrix

Note!
- See the general notes → 37
- Function descriptions → see the "Description of Device Functions" manual

1. HOME position → E → Entry into the function matrix
2. Select a function group (e.g. CURRENT OUTPUT 1)
3. Select a function (e.g. TIME CONSTANT)
   Change parameter / enter numerical values:
   +/− → Select or enter enable code, parameters, numerical values
   E → Save your entries
4. Exit the function matrix:
   – Press and hold down Esc key (Esc) for longer than 3 seconds → HOME position
   – Repeatedly press Esc key (Esc) → Return step by step to HOME position

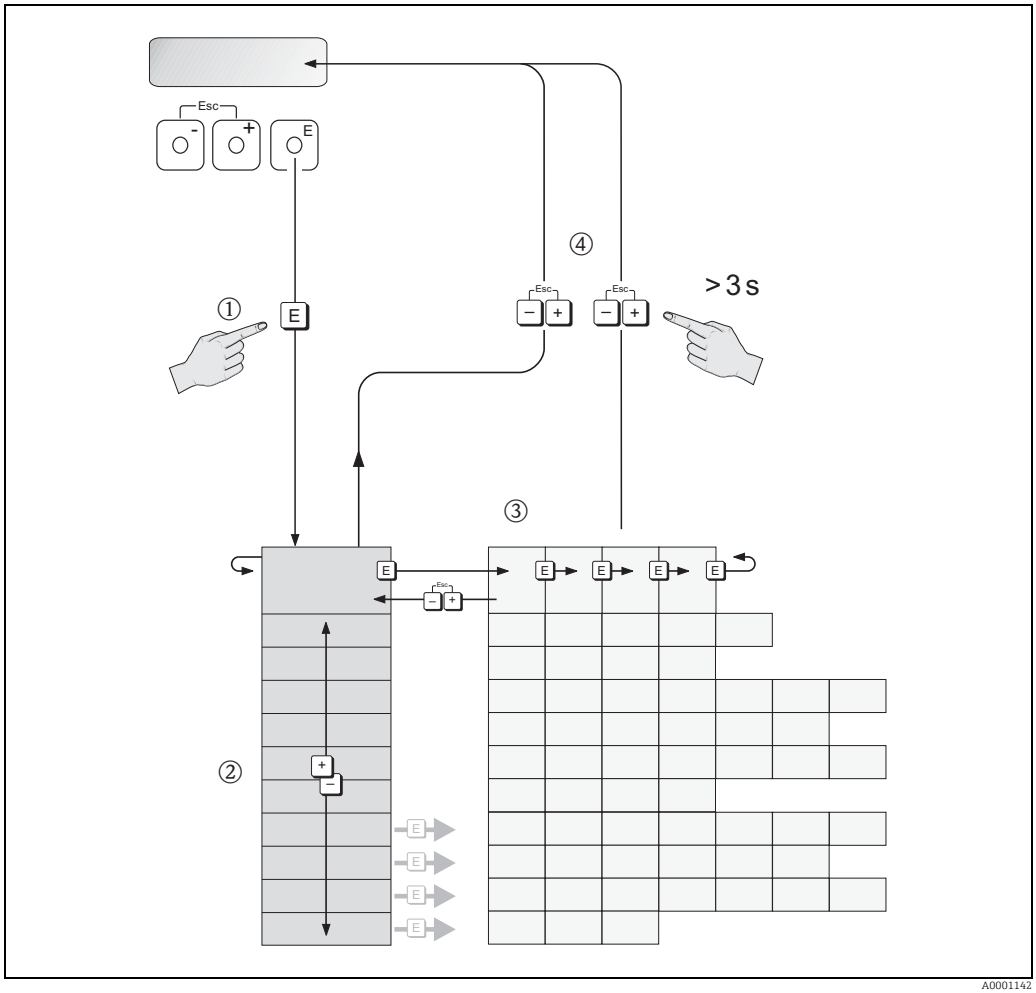


Fig. 26: Selecting functions and configuring parameters (function matrix)

6.3.1 General notes

The Quick Setup menu contains the default settings that are adequate for commissioning. Complex measuring operations on the other hand necessitate additional functions that you can configure as necessary and customize to suit your process parameters. The function matrix, therefore, comprises a multiplicity of additional functions which, for the sake of clarity, are arranged in a number of function groups.

Comply with the following instructions when configuring functions:
- You select functions as described already. → 📖 36
- You can switch off certain functions (OFF). If you do so, related functions in other function groups will no longer be displayed.
- Certain functions prompt you to confirm your data entries. Press P to select "SURE (YES)" and press E to confirm. This saves your setting or starts a function, as applicable.
- Return to the HOME position is automatic if no key is pressed for 5 minutes.
- Programming mode is disabled automatically if you do not press a key within 60 seconds following automatic return to the HOME position.

Caution!
All functions are described in detail, as is the function matrix itself, in the "Description of Device Functions" manual, which is a separate part of these Operating Instructions.

Note!
- The transmitter continues to measure while data entry is in progress, i.e. the current measured values are output via the signal outputs in the normal way.
- If the power supply fails, all preset and parameterized values remain safely stored in the EEPROM.

6.3.2 Enabling the programming mode

The function matrix can be disabled. Disabling the function matrix rules out the possibility of inadvertent changes to device functions, numerical values or factory settings. A numerical code (factory setting = 65) has to be entered before settings can be changed.
If you use a code number of your choice, you exclude the possibility of unauthorized persons accessing data (→ see the “Description of Device Functions” manual).

Comply with the following instructions when entering codes:
- If programming is disabled and the ± operating elements are pressed in any function, a prompt for the code automatically appears on the display.
- If “0” is specified as the customer's code, programming is always enabled.
- Your Endress+Hauser sales center can be of assistance if you mislay your private code.

Caution!
Changing certain parameters, such as all sensor characteristics, for example, influences numerous functions of the entire measuring system, particularly measuring accuracy. There is no need to change these parameters under normal circumstances and, consequently, they are protected by a special code known only to the Endress+Hauser sales center. Please contact Endress+Hauser first if you have any questions.

6.3.3 Disabling the programming mode

Programming mode is disabled if an operating element is not pressed within 60 seconds following automatic return to the HOME position.
Programming can also be disabled by entering any number in the "ACCESS CODE" function (other than the customer's code).

6.4 Error messages

6.4.1 Type of error

Errors that occur during commissioning or measuring are displayed immediately. If two or more system or process errors occur, the error with the highest priority is the one shown on the display.

The measuring device distinguishes between two types of error:
- *System error:* This group includes all measuring device errors, e.g. communication errors, hardware errors etc. → 77
- *Process error:* This group includes all application errors, e.g. flow limit etc. → 80

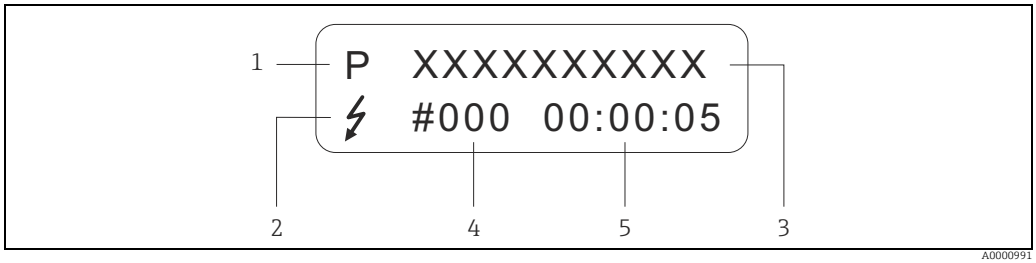


Fig. 27: Error messages on the display (example)

1 Error type: P = process error, S = system error
2 Error message type: ϟ = fault message, ! = notice message, definition
3 Error designation: e.g. FLOW LIMIT = maximum flow limit exceeded
4 Error number: e.g. #422
5 Duration of most recent error occurrence (in hours, minutes and seconds)

6.4.2 Error message type

Users have the option of weighting system and process errors differently, by defining them as **Fault messages** or **Notice messages.** This is specified via the function matrix (see the "Description of Device Functions" manual).
Serious system errors, e.g. module defects, are always identified and classified as "fault messages" by the measuring device.

Notice message (!)
- The error in question has no effect on the outputs of the measuring device.
- Displayed as → Exclamation mark (!), error designation (S: system error, P: process error).

Fault message ($)
- The error in question has a direct effect on the outputs. The response of the outputs (fail-safe mode) can be defined by means of functions in the function matrix.→ 75
- Displayed as → Lightening flash (ϟ), error type (S: system error, P: process error)

Note!
For safety reasons, error messages should be outputted via the status output.

6.5 Modbus RS485 communication

6.5.1 Modbus RS485 technology

The Modbus is an open, standardized fieldbus system which is deployed in the areas of manufacturing automation, process automation and building automation.

System architecture

The Modbus RS485 is used to specify the functional characteristics of a serial fieldbus system with which distributed, digital automation systems are networked together. The Modbus RS485 distinguishes between master and slave devices.

- **Master devices**
  Master devices determine the data traffic on the fieldbus system. They can send data without an external request.
- **Slave devices**
  Slave devices, like this measuring device, are peripheral devices. They do not have their own access rights to the data traffic of the fieldbus system and only send their data due to an external request from a master.

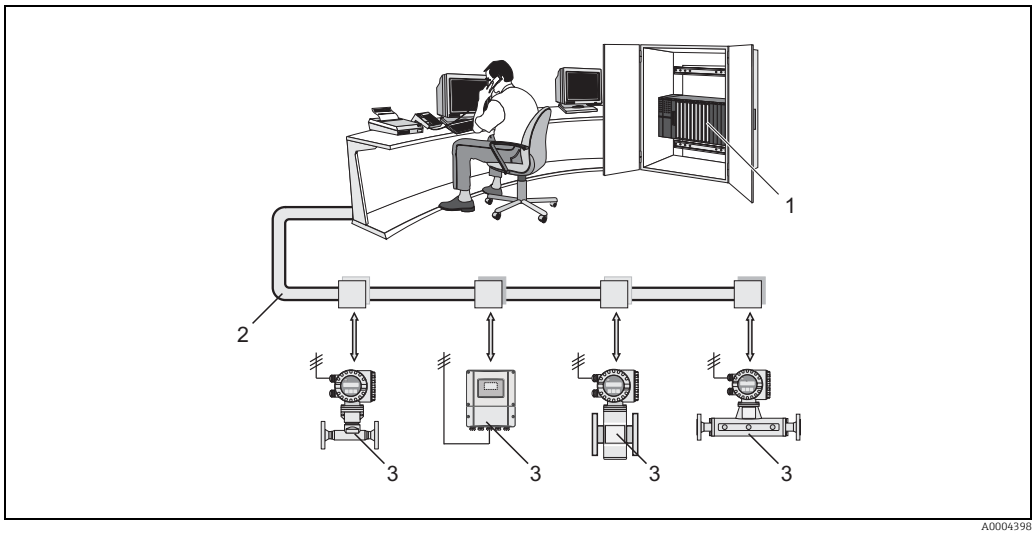


Fig. 28: Modbus RS485 system architecture

1 Modbus master (PLC etc.)
2 Modbus RS485
3 Modbus slave (measuring devices etc.)

Master/slave communication

A distinction is made between two methods of communication with regard to master/slave communication via Modbus RS485:

- **Polling (request-response-transaction)**
  The master sends a request telegram to **one** slave and waits for the slave's response telegram. Here, the slave is contacted directly due to its unique bus address (1 to 247).

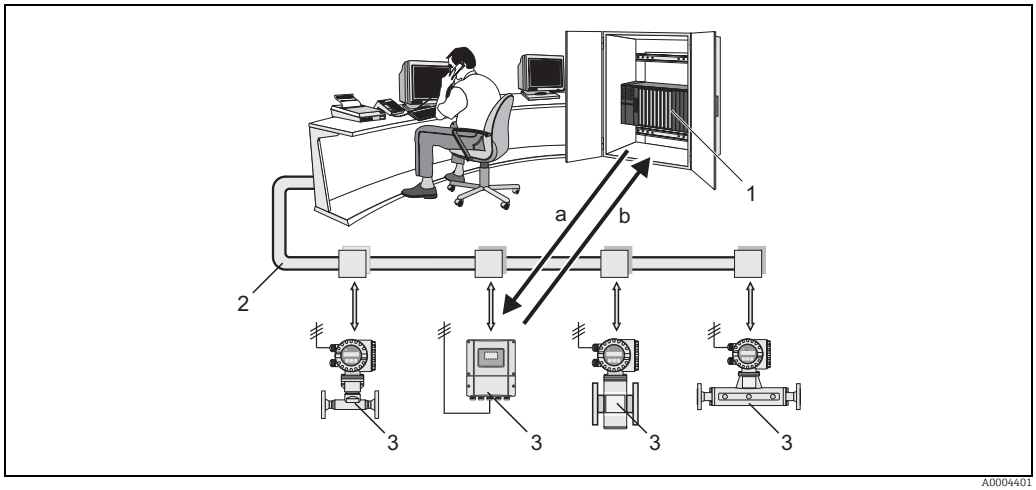


Fig. 29: Modbus RS485 polling data traffic

1 Modbus master (PLC etc.)
2 Modbus RS485
3 Modbus slave (measuring devices etc.)
a Request telegram to this one specific Modbus slave
b Response telegram to the Modbus master

- **Broadcast message**
  By means of the global address 0 (broadcast address), the master sends a command to all the slaves in the fieldbus system. The slaves execute the command without reporting back to the master. Broadcast messages are only permitted in conjunction with write function codes.

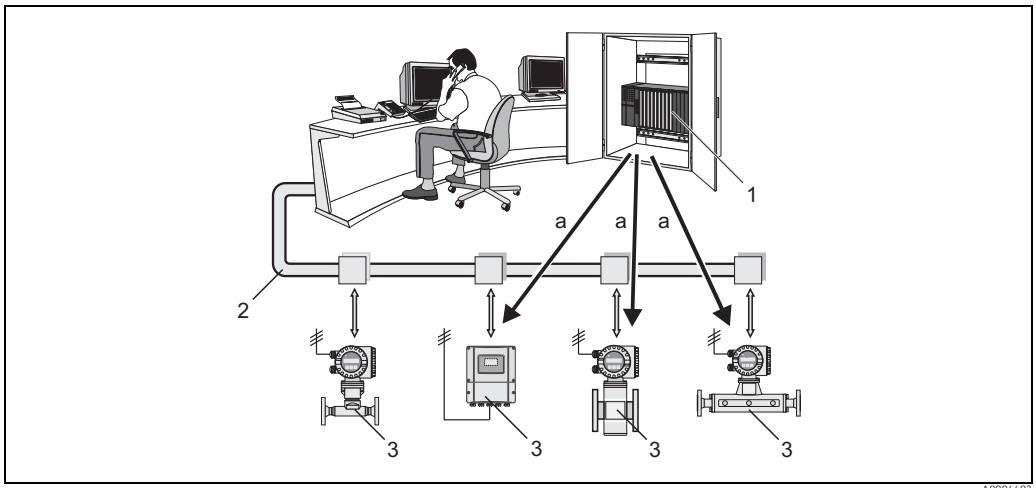


Fig. 30: Modbus RS485 broadcast message data traffic

1 Modbus master (PLC etc.)
2 Modbus RS485
3 Modbus slave (measuring devices etc.)
a Broadcast message command to all Modbus slaves (request is executed without a response telegram to the master)

6.5.2 Modbus telegram

General

The master-slave process is used for data exchange. Only the master can initiate data transmission. Following the prompt, the slave sends the master the necessary data as a response telegram or executes the command requested by the master.

Telegram structure

The data is transferred between the master and slave by means of a telegram.
A request telegram from the master contains the following telegram fields:

Telegram structure:

Slave address	Function code	Data	Check sum

- **Slave address**
  The slave address can be in an address range from 1 to 247.
  The master talks to all the slaves simultaneously by means of the slave address 0 (broadcast message).
- **Function code**
  The function code determines which read, write and test operations should be executed by means of the Modbus protocol.
  Function codes supported by the measuring device → 📄 42
- **Data**
  Depending on the function code, the following values are transmitted in this data field:
  – Register start address (from which the data is transmitted)
  – Number of registers
  – Write/read data
  – Data length
  – etc.
- **Check sum (CRC or LRC check)**
  The telegram check sum forms the end of the telegram.

The master can send another telegram to the slave as soon as it has received an answer to the previous telegram or once the time-out period set at the master has expired. This time-out period can be specified or modified by the operator and depends on the slave response time.

If an error occurs during data transfer or if the slave cannot execute the command from the master, the slave returns an error telegram (exception response) to the master.

The slave response telegram consists of telegram fields which contain the requested data or which confirm that the action requested by the master has been executed. It also contains a check sum.

6.5.3 Modbus function codes

The function code determines which read, write and test operations should be executed by means of the Modbus protocol. The measuring device supports the following function codes:

Function code	Name in accordance with Modbus specification	Description
03	READ HOLDING REGISTER	Reads one or more registers of the Modbus slave. 1 to a maximum of 125 consecutive registers (1 register = 2 byte) can be read with a telegram. **Application:** For reading measuring device parameters with read and write access, such as reading the flow damping.
04	READ INPUT REGISTER	Reads one or more registers of the Modbus slave. 1 to a maximum of 125 consecutive registers (1 register = 2 byte) can be read with a telegram. **Application:** For reading measuring device parameters with read access, such as reading the measured values (mass flow, totalizer value etc.).
06	WRITE SINGLE REGISTERS	Writes **a** slave register with a new value. **Application:** For writing just one measuring device parameter, such as resetting the totalizer. ✎ Note! Function code 16 is used for writing several registers by means of just one telegram.
08	DIAGNOSTICS	Checks the communication connection between the master and slave. The following "diagnostics codes" are supported: ▪ Sub-function 00 = Return query data (loopback test) ▪ Sub-function 02 = Return diagnostics register
16	WRITE MULTIPLE REGISTERS	Writes several slave registers with a new value. A maximum of 120 consecutive registers can be written with a telegram. **Application:** For writing several measuring device parameters, such as changing the totalizer mode and resetting the totalizer.
23	READ/WRITE MULTIPLE REGISTERS	Simultaneous reading and writing of 1 to max. 118 registers in a telegram. Write access is executed before read access. **Application:** For writing and reading several measuring device parameters, such as writing the low flow cut off value, starting the zero point adjustment and reading the totalizer value.

✎ Note!
- Broadcast messages are only permitted with function codes 06, 16 and 23.
- The measuring device does not differentiate between function codes 03 and 04. These codes have the same result.

6.5.4 Maximum number of writes

If a nonvolatile measuring device parameter is modified via the Modbus function codes 06, 16 or 23, this change is saved in the EEPROM of the measuring device.
The number of writes to the EEPROM is technically restricted to a maximum of 1 million. Attention must be paid to this limit since, if exceeded, it results in data loss and measuring device failure. For this reason, avoid constantly writing nonvolatile measuring device parameters via the Modbus!

6.5.5 Modbus register addresses

Each measuring device parameter has its own register address. The Modbus master uses this register address to talk to the individual measuring device parameters and access the measuring device data. The register addresses of the individual measuring device parameters can be found in the "Description of Device Functions" manual under the parameter description in question.

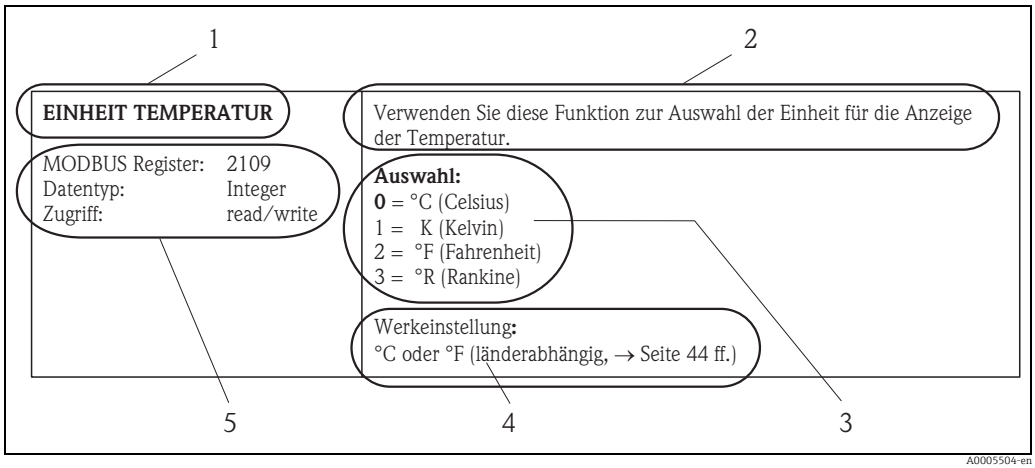


Fig. 31: Example of how a function description is illustrated in the "Description of Device Functions" manual

1 Name of the function
2 Description of the function
3 Selection or entry options or display
4 Factory setting (the measuring device is delivered with this setting/selected option)
5 Information on communication via Modbus RS485
– Modbus register (information in decimal numerical format)
– Data type: float (length = 4 bytes), integer (length = 2 bytes), string (length = depends on function)
– Possible ways of accessing the function:
read = read access via function code 03, 04 or 23
write = write access via 06, 16 or 23

Modbus register address model

The Modbus RS485 register addresses of the measuring device are implemented in accordance with "Modbus Applications Protocol Specification V1.1".

Note!
In addition to the specification mentioned above, systems are also deployed which work with a register address model in accordance with the "Modicon Modbus Protocol Reference Guide (PI–MBUS––300 Rev. J)". With this specification, the register address is extended, depending on the function code used. A "3" is put in front of the register address in the "read" access mode and a "4" in the "write" access mode.

Function code	Access type	Register in accordance with: "Modbus Applications Protocol Specification"		Register in accordance with: "Modicon Modbus Protocol Reference Guide"
03 04 23	Read	XXXX Example: mass flow = 2007	→	3XXXX Example: mass flow = 32007

Function code	Access type	Register in accordance with: "Modbus Applications Protocol Specification"		Register in accordance with: "Modicon Modbus Protocol Reference Guide"
06 16 23	Write	XXXX Example: reset totalizer 1 = 2608	→	4XXXX Example: reset totalizer 1 = 42608

Response times

The time it takes a measuring device to respond to a request telegram from the Modbus master is typically 25 to 50 ms. If faster response times are needed for time-critical applications, the "auto-scan buffer" is to be used.

Note!
It may take longer for a command to be executed in the measuring device. The data is not updated until the command has been executed. Write commands are especially affected by this!

Data types

The following data types are supported by the measuring device:

- **FLOAT** (floating-point numbers IEEE 754)
  Data length = 4 bytes (2 registers)

Byte 3	Byte 2	Byte 1	Byte 0
SEEEEEEE	EMMMMMMM	MMMMMMMM	MMMMMMMM

S = sign
E = exponent
M = mantissa

- **INTEGER**
  Data length = 2 bytes (1 register)

Byte 1	Byte 0
Most significant byte (MSB)	Least significant byte (LSB)

- **STRING**
  Data length = depends on measuring device parameter,
  e.g. illustration of a measuring device parameter with a data length = 18 bytes (9 registers):

Byte 17	Byte 16	...	Byte 1	Byte 0
Most significant byte (MSB)		...		Least significant byte (LSB)

Byte transmission sequence

Byte addressing, i.e. the transmission sequence of the bytes, is not specified in the Modbus specification. For this reason, it is important to coordinate the addressing method between the master and slave during commissioning. This can be configured in the measuring device by means of the "BYTE ORDER" parameter (see "Description of Device Functions" manual). Depending on the selection in the "BYTE ORDER" parameter, the bytes are transmitted as follows:

FLOAT

	Sequence			
Selection	**1st**	**2nd**	**3rd**	**4th**
1 - 0 - 3 - 2*	Byte 1 (MMMMMMMM)	Byte 0 (MMMMMMMM)	Byte 3 (SEEEEEEE)	Byte 2 (EMMMMMMM)
0 - 1 - 2 - 3	Byte 0 (MMMMMMMM)	Byte 1 (MMMMMMMM)	Byte 2 (EMMMMMMM)	Byte 3 (SEEEEEEE)
2 - 3 - 0 - 1	Byte 2 (EMMMMMMM)	Byte 3 (SEEEEEEE)	Byte 0 (MMMMMMM)	Byte 1 (MMMMMMM)
3 - 2 - 1 - 0	Byte 3 (SEEEEEEE)	Byte 2 (EMMMMMMM)	Byte 1 (MMMMMMMM)	Byte 0 (MMMMMMMM)

* = Factory setting
S = sign
E = exponent
M = mantissa

INTEGER

	Sequence	
Selection	**1st**	**2nd**
1 - 0 - 3 - 2 * 3 - 2 - **1 - 0**	Byte 1 (MSB)	Byte 0 (LSB)
0 - 1 - 2 - 3 2 - 3 - **0 - 1**	Byte 0 (LSB)	Byte 1 (MSB)

* = Factory setting
MSB = most significant byte
LSB = least significant byte

STRING

Illustration using the example of a measuring device parameter with a data length of 18 bytes.

	Sequence				
Selection	**1st**	**2nd**	**...**	**17th**	**18th**
1 - 0 - 3 - 2 * 3 - 2 - **1 - 0**	Byte 1	Byte 0 (LSB)	...	Byte 17 (MSB)	Byte 16
0 - 1 - 2 - 3 2 - 3 - **0 - 1**	Byte 0 (LSB)	Byte 1	...	Byte 16	Byte 17 (MSB)

* = Factory setting
MSB = most significant byte
LSB = least significant byte

6.5.6 Modbus error messages

If the Modbus slave detects an error in the request telegram from the master, it sends a reply to the master in the form of an error message consisting of the slave address, function code, exception code and check sum. To indicate that this is an error message, the lead bit of the returned function code is used. The reason for the error is transmitted to the master by means of the exception code.

The following exception codes are supported by the measuring device:

Exception codes	Description
01	ILLEGAL_FUNCTION The function code sent by the master is not supported by the measuring device (slave). ✎ Note! Description of the function codes supported by the measuring device → 🖹 42.
02	ILLEGAL_DATA_ADDRESS The register addressed by the master is not assigned (i.e. it does not exist) or the length of the requested data is too big.
03	ILLEGAL_DATA_VALUE ▪ The master is attempting to write to a register which only allows read access. ▪ The value that appears in the data field is not permitted, e.g. range limits exceeded or incorrect data format.
04	SLAVE DEVICE FAILURE The slave did not respond to the request telegram from the master or an error occurred when processing the request telegram.

6.5.7 Modbus auto-scan buffer

Function description

The Modbus master uses the request telegram to access the device parameters (data) of the measuring device. Depending on the function code, the master gains read or write access to a single device parameter or a group of consecutive device parameters. If the desired device parameters (registers) are not available as a group, the master has to send a request telegram to the slave for each parameter.
The measuring device has a special storage area, known as the auto-scan buffer, for grouping nonconsecutive device parameters. This can be used to flexibly group up to 16 device parameters (registers). The master can talk to this complete data block by means of just one request telegram.

Structure of the auto-scan buffer

The auto-scan buffer consists of two data records, the configuration area and the data area. In the configuration area, a list known as the scan list specifies which device parameters should be grouped. For this purpose, the corresponding register address, e.g. the register address 2007 for mass flow, is entered in the scan list. Up to 16 device parameters can be grouped.

The measuring device cyclically reads out the register addresses entered in the scan list and writes the associated device data to the data area (buffer). The request cycle runs automatically. The cycle starts again when the last entry in the scan list has been queried.
By means of Modbus, the grouped device parameters in the data area can be read or written by the master with just one request telegram (register address 5051 to 5081).

Configuration of the scan list

During configuration, the Modbus register addresses of the device parameters to be grouped must be entered in the scan list. The scan list can contain up to 16 entries. Float and Integer-type device parameters with read and write access are supported.

The scan list can be configured by means of:

1. The local display or a operating program (FieldCare).
   The scan list is configured here by means of the function matrix:
   COMMUNICATION → SCAN LIST REG. 1 to SCAN LIST REG. 16
2. The Modbus master.
   Here, the scan list is configured via the register addresses 5001 to 5016.

Scan list		
No.	**Modbus configuration register address (data type = Integer)**	**Configuration via local operation / operating program (COMMUNICATION →)**
1	5001	SCAN LIST REG. 1
2	5002	SCAN LIST REG. 2
3	5003	SCAN LIST REG. 3
4	5004	SCAN LIST REG. 4
5	5005	SCAN LIST REG. 5
6	5006	SCAN LIST REG. 6
7	5007	SCAN LIST REG. 7
8	5008	SCAN LIST REG. 8
9	5009	SCAN LIST REG. 9
10	5010	SCAN LIST REG. 10
11	5011	SCAN LIST REG. 11
12	5012	SCAN LIST REG. 12
13	5013	SCAN LIST REG. 13
14	5014	SCAN LIST REG. 14
15	5015	SCAN LIST REG. 15
16	5016	SCAN LIST REG. 16

Access to data via Modbus

The Modbus master uses the register addresses 5051 to 5081 to access the data area of the auto-scan buffer. This data area contains the values of the device parameters defined in the scan list. For example, if the register 2007 was entered for mass flow in the scan list by means of the SCAN LIST REG. 1 function, the master can read out the current measured value of the mass flow in register 5051.

Data area				
Parameter value/Measured values		**Access via Modbus register address**	**Data type ***	**Access****
Value of scan list entry No. 1	→	5051	Integer / Float	Read/write
Value of scan list entry No. 2	→	5053	Integer / Float	Read/write
Value of scan list entry No. 3	→	5055	Integer / Float	Read/write
Value of scan list entry No. 4	→	5057	Integer / Float	Read/write
Value of scan list entry No. 5	→	5059	Integer / Float	Read/write
Value of scan list entry No. 6	→	5061	Integer / Float	Read/write
Value of scan list entry No. 7	→	5063	Integer / Float	Read/write
Value of scan list entry No. 8	→	5065	Integer / Float	Read/write
Value of scan list entry No. 9	→	5067	Integer / Float	Read/write
Value of scan list entry No. 10	→	5069	Integer / Float	Read/write
Value of scan list entry No. 11	→	5071	Integer / Float	Read/write
Value of scan list entry No. 12	→	5073	Integer / Float	Read/write
Value of scan list entry No. 13	→	5075	Integer / Float	Read/write
Value of scan list entry No. 14	→	5077	Integer / Float	Read/write
Value of scan list entry No. 15	→	5079	Integer / Float	Read/write
Value of scan list entry No. 16	→	5081	Integer / Float	Read/write

* The data type depends on the device parameter entered in the scan list.

** The data access depends on the device parameter entered in the scan list. If the device parameter entered supports read and write access, the parameter can also be accessed by means of the data area.

Response time

The response time when accessing the data area (register addresses 5051 to 5081) is typically ?between 3 to 5 ms.

Note!
It may take longer for a command to be executed in the measuring device. The data is not updated until the command has been executed. Write commands are especially affected by this!

Example

The following device parameters should be grouped via the auto-scan buffer and read out by the master with just one request telegram:
- Mass flow → Register address 2007
- Totalizer 1 → Register address 2610
- Actual system condition → Register address 6859

1st Configuration of the scan list
- With the local operation or a operating program (via the function matrix):
  COMMUNICATION function group → SCAN LIST REG. function:
  → Entry of the address 2007 under SCAN LIST REG. 1
  → Entry of the address 2610 under SCAN LIST REG. 2
  → Entry of the address 6859 under SCAN LIST REG. 3
- Via the Modbus master (the register addresses of the device parameters are written to the registers 5001 to 5003 via Modbus):
  1. Write address 2007 (mass flow) to register 5001
  2. Write address 2610 (totalizer 1) to register 5002
  3. Write address 6859 (actual system condition) to register 5003

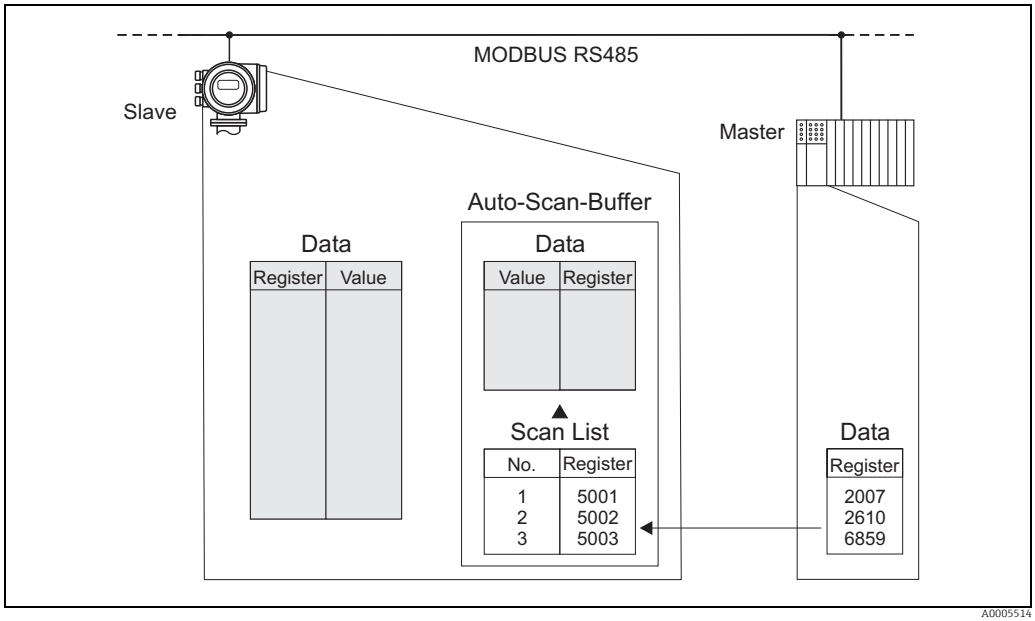


Fig. 32: Configuration of the scan list via the Modbus master

2nd Access to the data via Modbus

By specifying the register start address 5051 and the number of registers, the Modbus master can read out the measured values with just one request telegram.

Data area			
Access via Modbus register address	Measured values	Data type	Access
5051	Mass flow = 4567.67	Float	Read
5053	Totalizer 1 = 56345.6	Float	Read
5055	Actual system condition = 1 (system ok)	Integer	Read

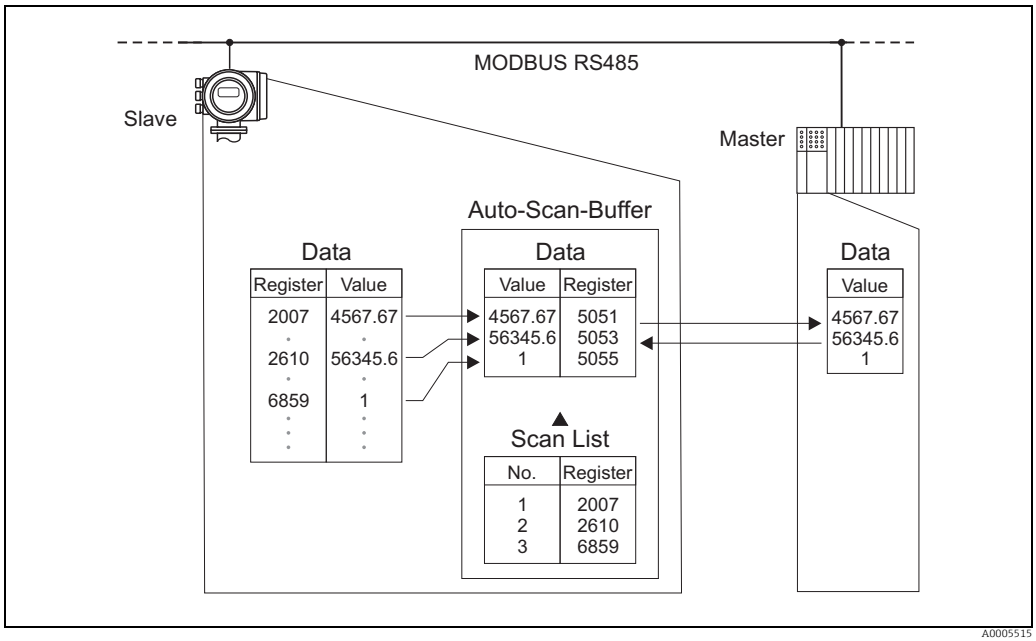


Fig. 33: With just one request telegram, the Modbus master reads out the measured values via the auto-scan buffer of the measuring device

6.6 Operating options

6.6.1 Operating program "FieldCare"

FDT-based plant asset management tool from Endress+Hauser. It can configure all intelligent field devices in your plant and supports you in managing them. By using status information, it also provides a simple but effective means of checking their health. The Proline flow measuring devices are accessed via a service interface or via the service interface FXA193.

6.6.2 Device description files

The device description files that suit the individual operating tools are listed in the following table.

Operation via service protocol:

Valid for measuring device software: 3.06.XX **Software release:** 10.2010	→ "DEVICE SOFTWARE" function
Operating program/device driver	**How to acquire:**
FieldCare/DTM	▪ www.endress.com → Download ▪ CD-ROM (Endress+Hauser order number 56004088) ▪ DVD (Endress+Hauser order number 70100690)

Tester/simulator	**Sources for obtaining measuring device descriptions**
Fieldcheck	Update by means of FieldCare with the Flow Communication FXA193/291 DTM in the Fieldflash Module

Note!
The Fieldcheck tester/simulator is used for testing flowmeters in the field. When used in conjunction with the "FieldCare" software package, test results can be imported into a database, printed out and used for official certification. Further information is available from your Endress+Hauser sales center.

6.7 Hardware settings

6.7.1 Hardware write protection, switching on and off

A jumper on the I/O board provides the means of switching hardware write protection on or off. When the write protection is switched on, it is **not** possible to write to the device parameters via Modbus communication.

⚠ Warning!
Risk of electric shock. Exposed components carry dangerous voltages. Switch off the power supply before you remove the cover of the electronics compartment.

1. Switch off the power supply.
2. Remove the I/O board → 🖹 85
3. Configure the hardware write protection accordingly with the aid of the jumpers (see Figure).
4. Installation is the reverse of the removal procedure.

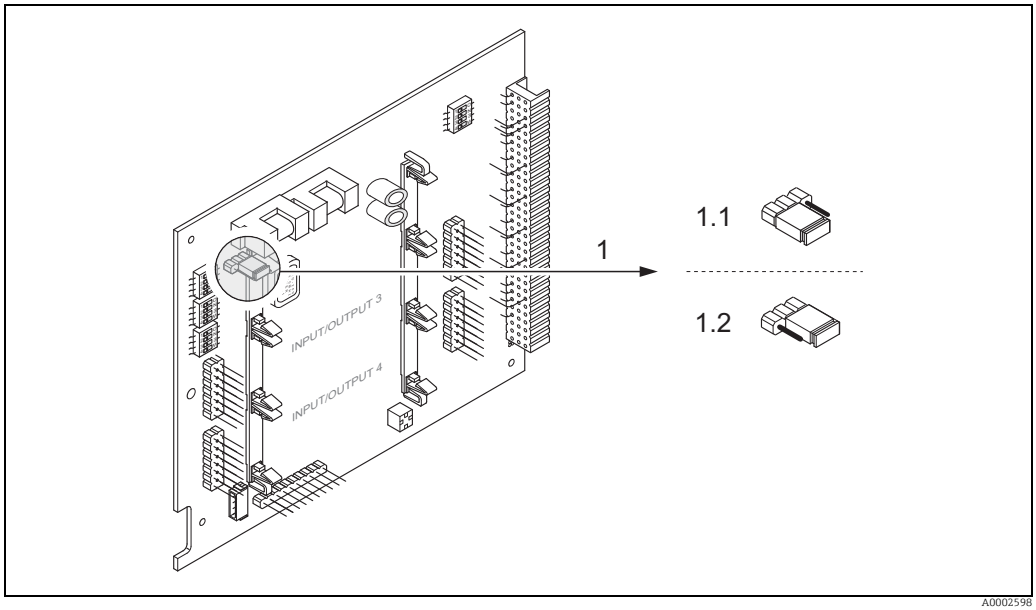


Fig. 34: Switching write protection on and off with the aid of a jumper on the I/O board

1 Jumper for switching write protection on and off
*1.1 Write protection switched on (factory setting) = it is **not** possible to write to the device parameters via Modbus communication*
1.2 Write protection switched off = it is possible to write to the device parameters via Modbus communication

6.7.2 Configuring the measuring device address

The measuring device address must always be configured for a Modbus slave. The valid measuring device addresses are in the range from 1 to 247. Each address can only be assigned once in a Modbus RS485 network. If an address is not configured correctly, the device is not recognized by the Modbus master. All measuring devices are delivered from the factory with the measuring device address 247 and with the "software addressing" address mode.

Addressing via local operation

More detailed explanations for addressing the measuring device via the local display → 🖹 52.

Addressing via miniature switches

Warning!
Risk of electric shock. Exposed components carry dangerous voltages. Switch off the power supply before you remove the cover of the electronics compartment.

1. Loosen the Allen screw (3 mm) of the securing clamp.
2. Unscrew cover of the electronics compartment from the transmitter housing.
3. Remove the local display (if present). To do so, loosen the set screws of the display module.
4. Set the position of the miniature switches on the I/O board using a sharp pointed object.
5. Installation is the reverse of the removal procedure.

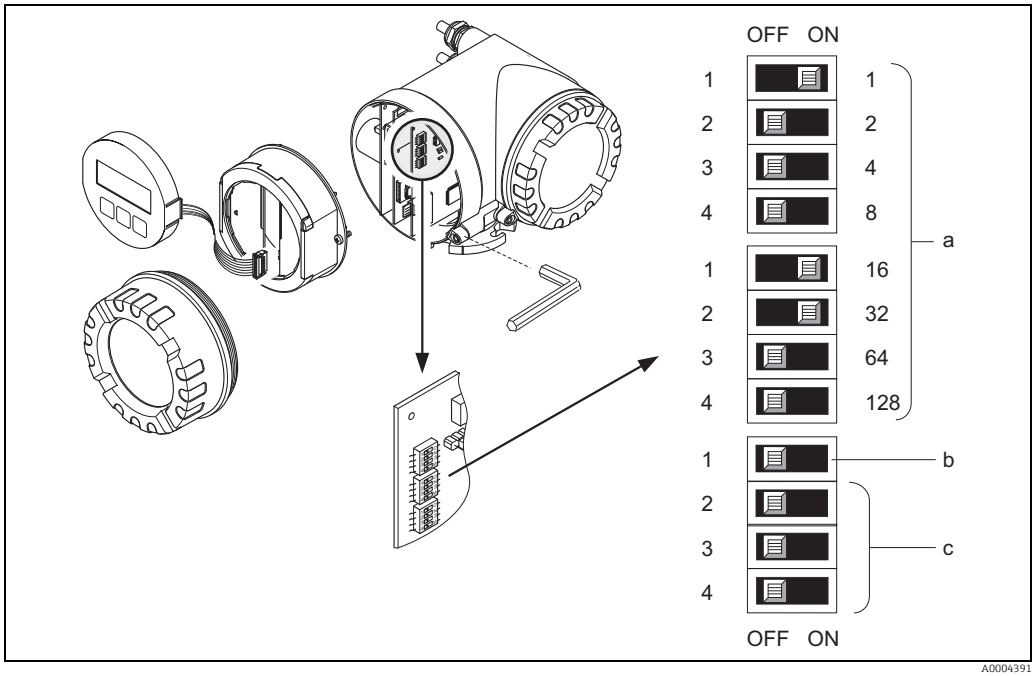


Fig. 35: Addressing with the aid of miniature switches on the I/O board

a Miniature switches for setting the measuring device address (illustrated: 1 + 16 + 32 = measuring device address 49)
b Miniature switches for the address mode (method of addressing):
- *OFF = software addressing via local operation or operating program (factory setting)*
- *ON = hardware addressing via miniature switches*

c Miniature switches not assigned

6.7.3 Configuring the terminating resistors

It is important to terminate the Modbus RS485 line correctly at the start and end of the bus segment since impedance mismatch results in reflections on the line which can cause faulty communication transmission.

Warning!
Risk of electric shock. Exposed components carry dangerous voltages. Switch off the power supply before you remove the cover of the electronics compartment.

The miniature switch for termination is located on the I/O board (see Figure):

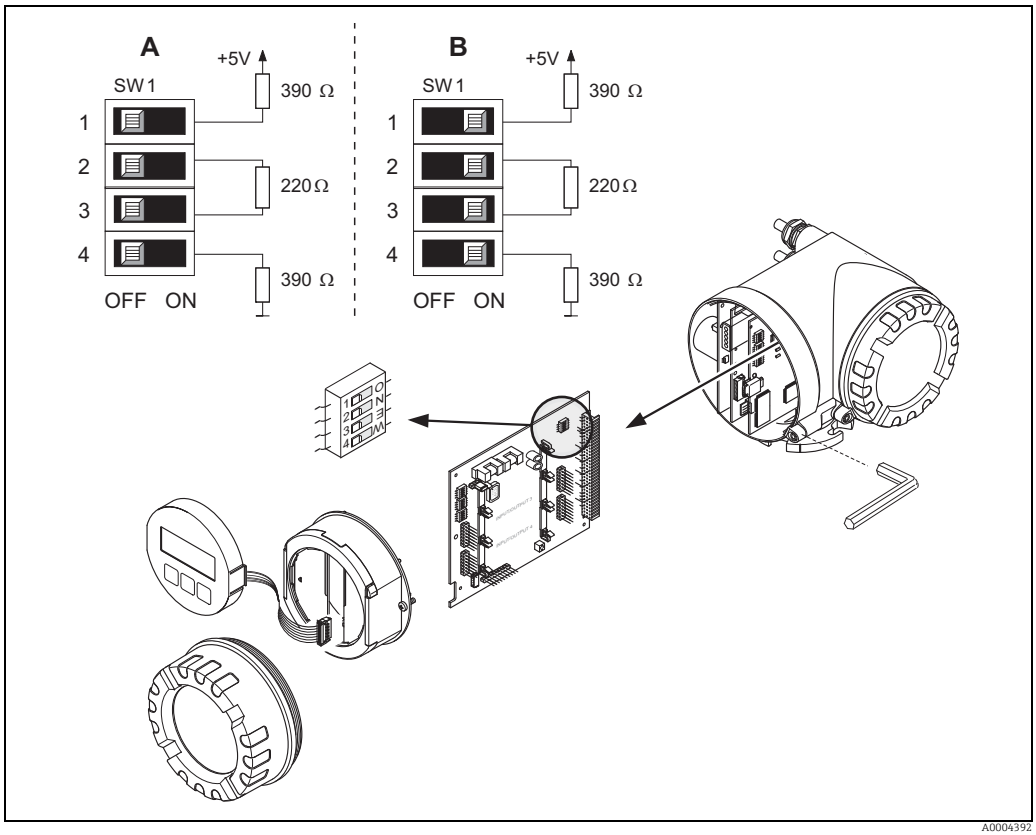


Fig. 36: Configuring the terminating resistors

A = Factory setting
B = Setting at the last transmitter

Note!
It is generally recommended to use external termination since if a measuring device that is terminated internally is defect, this can result in the failure of the entire segment.

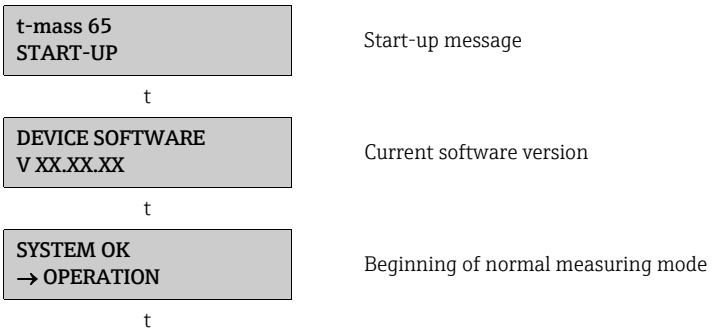
7 Commissioning

7.1 Function check

Perform all the final checks before putting the measuring point into operation:
- Checklist for "Post-installation check" → 27
- Checklist for "Post-connection check" → 33

7.2 Switching on the measuring device

Only switch on the supply voltage once all the final checks have been performed. The measuring device is now operational.
The measuring device performs a number of power on self-tests. As this procedure progresses the following sequence of messages appears on the local display:



Normal measuring mode commences as soon as start-up completes.
Various measured values and/or status variables appear on the display (HOME position).

Note!
If start-up fails, an error message indicating the cause is displayed.

7.3 Quick Setup

All important device parameters for standard operation can be configured quickly and easily by means of the Quick Setup menu, especially for devices that have been delivered with factory default settings.

Note!
If the measuring device has been ordered with customer-specific settings then the Quick Setup is not necessary. Check that the parameterization protocol on the CD delivered with the device matches your required data.

7.3.1 Quick Setup "Commissioning"

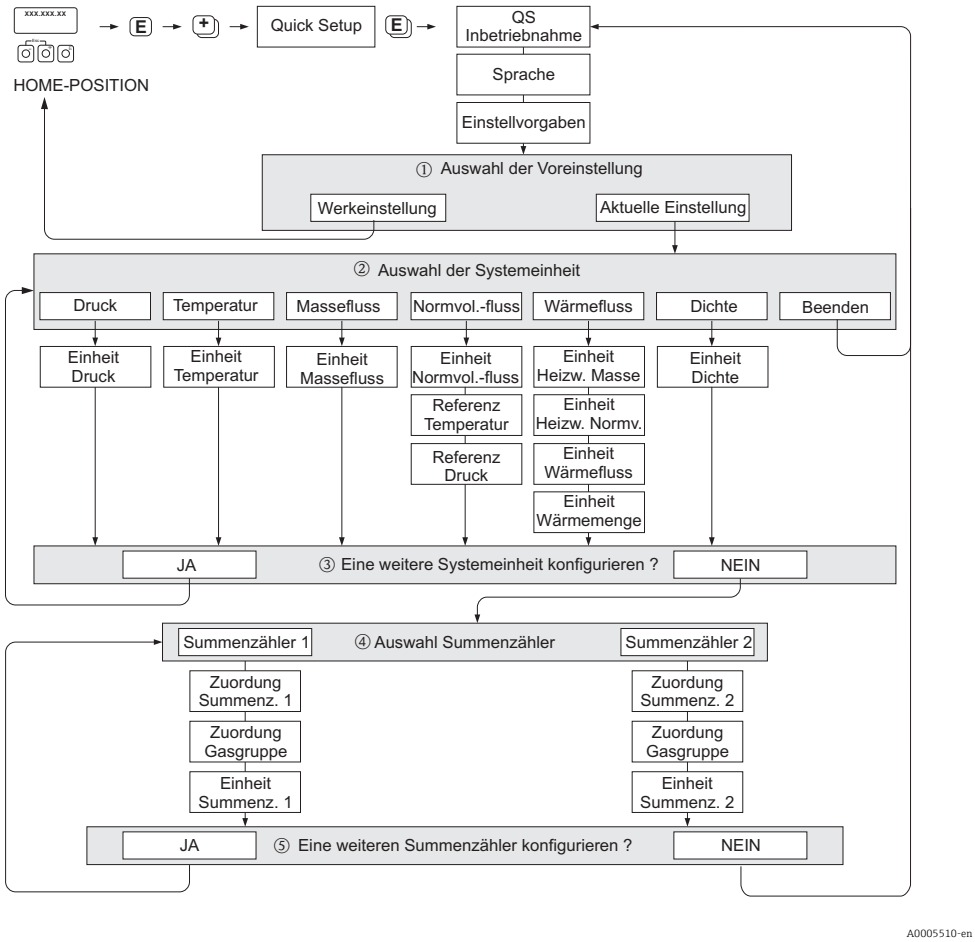


Fig. 37: QUICK SETUP COMMISSIONING - menu for straightforward configuration of the major measuring device functions

Note!
The display returns to the QUICK SETUP cell if you press the ESC key combination ( ) during programming of a parameter anywhere in the menu. The configuration settings already made remain valid, however.

QUICK SETUP - COMMISSION

Use the + or − key at the prompt "QS-COMMISSION NO" and the device access code entry appears. Enter the device access code "65" and press E; programming is enabled. The prompt "QS-COMMISSION NO" appears. Use the + or − key to change NO to YES and press E.

LANGUAGE

Use the + or − key to select the required language and continue with E.

PRE-SETTING.

① Select ACTUAL SETTINGS to continue programming the measuring device and go to the next level or select DELIVERY SETTINGS to reset the measuring device. The measuring device restarts and returns to the Home position.

- ACTUAL SETTINGS are the parameters currently programmed in the measuring device
- DELIVERY SETTINGS are the programmed parameters (factory settings plus customer-specific settings) originally delivered with the measuring device

SYSTEM UNITS.

Select required system unit function and carry out parameterization or select QUIT to return to the QUICK SETUP function if no further programming is required.

② Only units not yet configured in the current setup are available for selection in each cycle.

③ The YES option remains visible until all the units have been configured.
NO is the only option displayed when no further units are available.

SELECTION TOTALIZER.

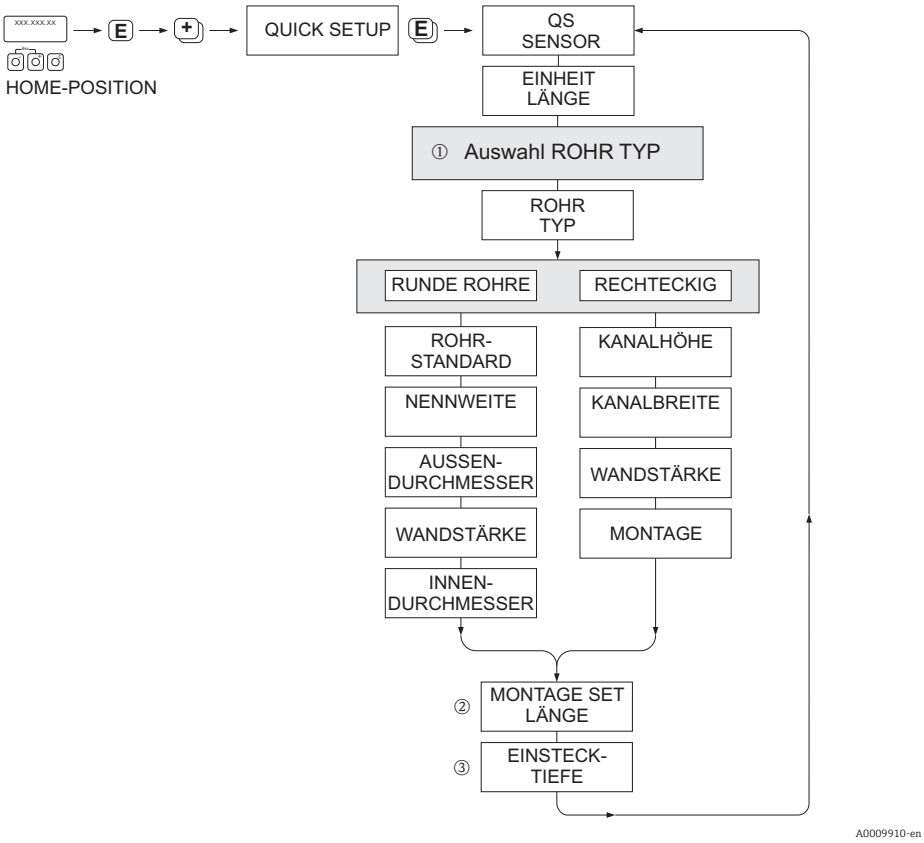
④ Select a totalizer and assign a flow variable, gas group and unit.

⑤ Select a second totalizer or select "NO" to exit.

7.3.2 Quick Setup "Sensor"

It is essential that the insertion sensor is setup according to the actual pipe or duct and then installed at the calculated insertion depth. This Quick Setup guides the user systematically through the procedure to setup the sensor.

Note!
The QUICK SETUP SENSOR function is not available for flanged type sensors.



PIPE TYPE

① ▪ CIRCULAR
  – in case that the pipe is of a standard type, then parameterize functions PIPE STANDARD and NOMINAL DIAMETER
  – In case that the pipe is a non-standard type, then select OTHERS in the function PIPE STANDARD and parameterize the functions WALL THICKNESS and OUTER DIAMETER.
  – The function INTERNAL DIAMETER displays the calculated internal diameter and is read only.
▪ RECTANGULAR
  – Enter the INTERNAL HEIGHT, INTERNAL WIDTH and WALL THICKNESS of the duct
  – Select the MOUNTING orientation of the sensor: HORIZONTAL or VERTICAL

MOUNTING SET LENGTH

② Enter the measured length of the mounting set (including the compression fitting) → 🖹 19.

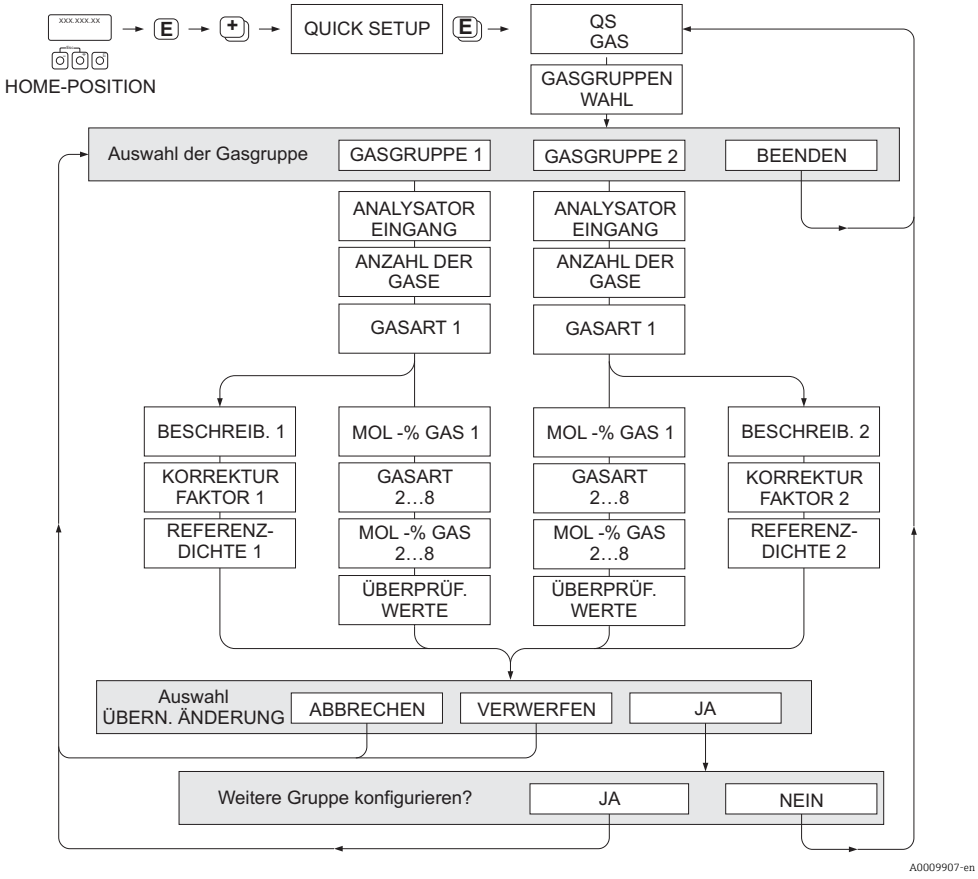
INSERTION DEPTH

③ This function calculates the insertion depth value for the mounting of the sensor → 🖹 19.
This function is read only.

Press E to save settings and return to QUICK SETUP SENSOR group.

7.3.3 "Gas" Quick Setup menu

The device can be setup with 1 or 2 individual gas groups in memory. This means that up to 2 different gas flow streams (e.g. nitrogen and argon) can be measured in a single pipe with one flowmeter.
In the case of 2 gas groups being used, a digital input can be assigned to switch between the gas groups or, alternatively, the switch can be done manually via a function in the device software. Furthermore, a programmed gas mixture can be dynamically updated, via a signal from a gas analyzer.



Programming a gas group

The measuring device allows flexible change of the gas group parameters, independent of the original factory setup and calibration.

A gas group can be programmed as:
- one single gas or
- one gas mixture (of up to 8 components)

A single gas can be:
- selected from a list of standard gases or
- setup for other suitable types of gases, such as Ozone, using manual correction factors and the option called SPECIAL GAS. This requires application evaluation at the factory - In this case, please contact your Endress+Hauser sales center for clarification.

Setting or viewing the active gas group

The active measuring group can be set via 2 methods:

1. Digital input: the status input can be configured to switch between the two groups. Select option GAS GROUP (see "Description of Device Functions" manual BA00116D/06).
2. Manual switch: go to the function SELECT GROUP and simply select 1 or 2 and then exit using ESC (keys simultaneously). No save function is necessary.

Note!
The Quick Setup Gas function is not available if an in-situ calibration function has been performed on the measuring device as the in-situ calibration curve refers to the sensor power at each recorded flow point. Therefore, the programmed gas settings become redundant.→ 72

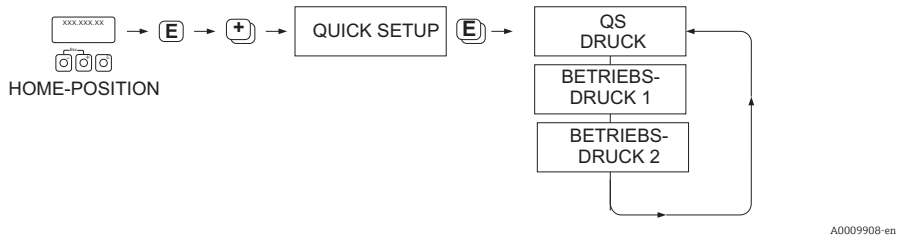
Performing the Quick Setup

1. GAS GROUP
   Use the + or − key to select the required GAS GROUP. and continue with E.
   - Set the ANALYZER INPUT to ON if a gas compensation input is being used → 67
   - select the NUMBER OF GASES in the group from 1 to 8
   - select the GAS TYPE from the choose list.
   - enter the MOLE % for each GAS TYPE (only if NUMBER OF GASES is 2 and more).
   - The error message CHECK VALUES appears if the total mixture % does not equal 100%. Go back and check the mixture settings.
2. SAVE CHANGES?
   - Select YES to save the settings in GAS GROUP 1 or 2 and activate the last gas group selected. Press E to continue or
   - Select CANCEL to save the entered settings in buffer memory but not activate them for measurement. If this function is selected, then it will be necessary to come back to this gas group and save it at a later stage.
   - Select DISCARD to clear the last changes and return to CONFIGURE GROUP to make new settings.
3. ANOTHER GAS GROUP?
   - Select YES to continue to the CONFIGURE GROUP function. Use the + or − key to select the desired GAS GROUP and proceed as per the above instructions.
   - Select NO to exit to the Quick Setup.

Note!
More detailed information on the GAS GROUP programming can be found in the separate "Description of Device Functions" manual (BA00116D/06/... see chapter GAS).

7.3.4 "Pressure" Quick Setup menu

The individual process pressure for every gas group can be programmed with this Quick Setup. If only one gas group is being used, then only the function PROCESS PRESSURE 1 needs to be programmed, PROCESS PRESSURE 2 can remain with default settings.

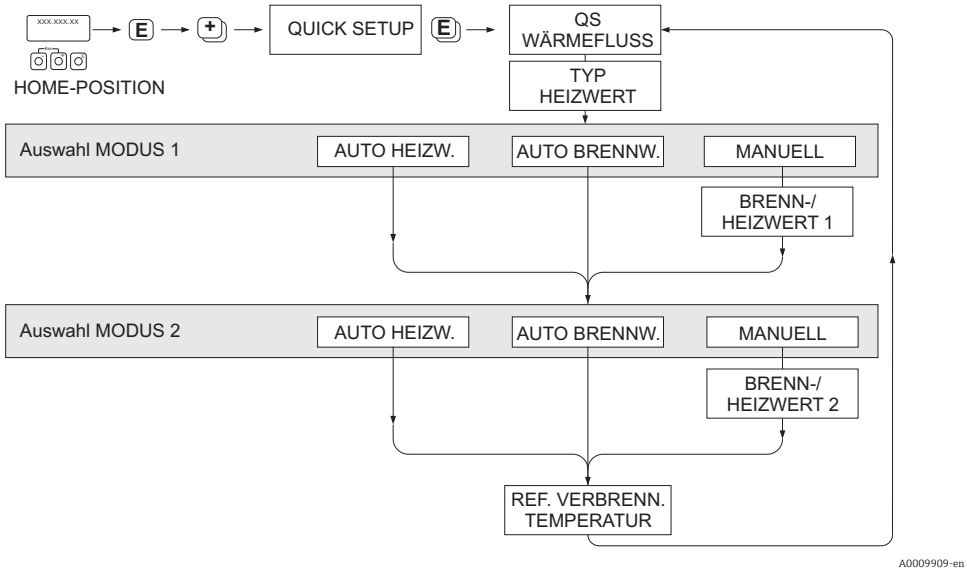


Note!

- The measuring device operates with absolute pressure only. All gauge pressure must be converted to absolute pressure.
- If a pressure compensating input is being used, then the input signal value overrides the manually programmed value. The pressure input value applies to both gas groups. i.e. 2 independent pressure values are no longer possible.
- The Quick Setup Gas function is not available if an in-situ calibration function has been performed on the measuring device as the in-situ calibration curve refers to the sensor power at each recorded flow point. Therefore, the programmed pressure settings become redundant → 72.

7.3.5 "Heat Flow" Quick Setup menu

The measuring device can calculate and output the heat of combustion of common fuel gases such as methane, natural gas, propane, butane, ethane and hydrogen.
This Quick Setup menu can be used to program the method to calculate the net calorific value or gross calorific value. The measuring device can be configured to give two independent heating value outputs and totalized values. For example, the pipeline has either natural gas or propane running at separate times and the heating value is required for both gases.



Calculation mode 1 and 2

- The heating value for CALCULATION MODE 1 corresponds to the settings in the function GAS GROUP 1.
- The heating value for CALCULATION MODE 2 corresponds to the settings in the function GAS GROUP 2.

Note!
- If only one gas group is used, then leave mode 2 as default settings.
- The units of measure are selected in the system units section → 56.

Auto Gross

The gross heating value (or higher heating value) is the total heat obtained by complete combustion at constant pressure of a volume of gas in air, including the heat released by the water vapor in the combustion products (gas, air and combustion products taken at reference cumbustion temperature and standard pressure).

Auto Net

The net heating value (or lower heating value) is determined by subtracting the heat of vaporization of the water vapor from the higher heating value. This treats any water formed as water vapor. The energy required to vaporize the water therefore is not realized as heat.

Manual

This function allows entry of a user-specific heating value if the required value is different from the value in the following table.

Gas	Formula	Net/lower heating value		Gross/upper heating value	
		[Mj/kg]	MBtu/lb	[Mj/kg]	MBtu/lb
Hydrogen	H_2	119.91	51.56	141.78	60.97
Ammonia	NH_3	18.59	7.99	22.48	9.67
Carbon Monoxide	CO	10.1	4.34	10.1	4.34
Hydrogen Sulphide	H_2S	15.2	6.54	19.49	8.38
Methane	CH_4	50.02	21.51	55.52	23.87
Ethane	C_2H_6	47.5	20.43	51.93	22.33
Propane	C_3H_8	46.32	19.92	50.32	21.64
Butane	C_4H_{10}	45.71	19.66	49.51	21.29
Ethylene	C_2H_4	47.16	20.28	50.31	21.63

* According to ISO Standard 6976:1995(E) and GPA Standard 2172-96

Reference combustion temperature

The following reference temperatures are used:

Country	reference combustion temperature
Austria, Belgium, Denmark, Germany, Italy, Luxembourg, The Netherlands, Poland, Russia, Sweden, Switzerland	25 °C
Brazil, China	20 °C
France, Japan	0 °C
Australia, Canada, Czech Republic, Hungary, India, Ireland, Malaysia, Mexico, South Africa, Great Britain	15 °C
Slovakia	25 °C
USA, Venezuela	60 °F

7.3.6 Quick Setup "Communication"

To establish serial data transfer, various arrangements between the Modbus master and Modbus slave are required which have to be taken into consideration when configuring various functions. These functions can be configured quickly and easily by means of the Communication Quick Setup. The configuration options for the parameters are explained in detail in the table that follows.

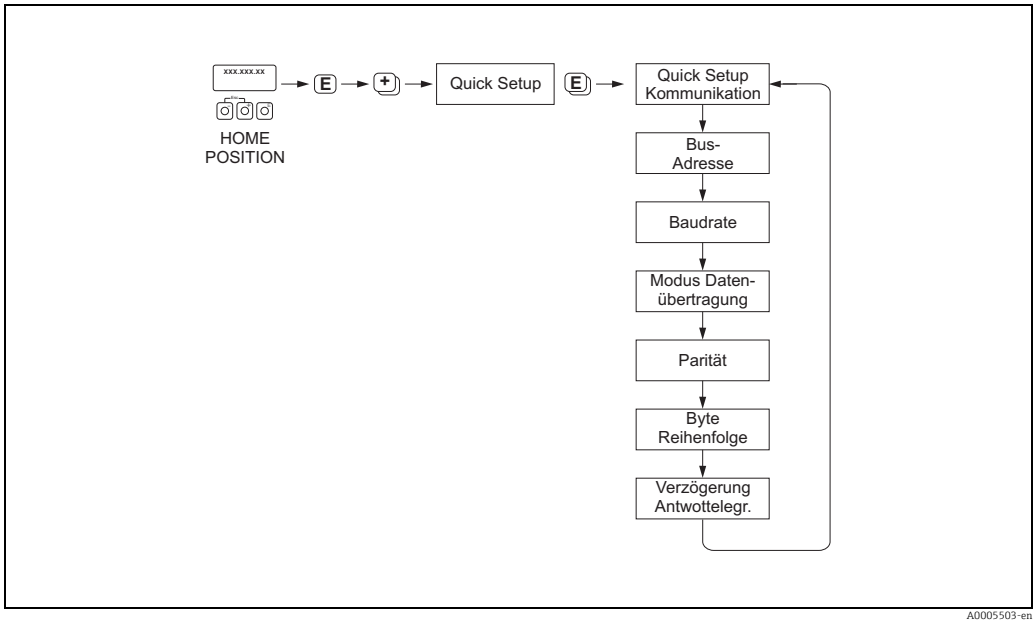


Fig. 38: Quick Setup Communication

Note!
The parameters described in the following table can be found in the function group COMMUNICATION (see "Description of Device Functions" manual, BA00116D/06).

Functions of the Quick Setup "Communication"

SETUP COMMUNICATION	YES → After E is pressed by way of confirmation, the Quick Setup menu calls up all the subsequent functions in succession.
FIELDBUS ADDRESS	For entering the measuring device address. **User entry** 1 to 247 **Factory setting:** 247
BAUDRATE	For selecting the baud rate. **Options:** 1200 BAUD 2400 BAUD 4800 BAUD 9600 BAUD 19200 BAUD 38400 BAUD 57600 BAUD 115200 BAUD **Factory setting:** 19200 BAUD
TRANSMISSION MODE	For selecting the data transfer mode. **Options:** RTU ASCII **Factory setting:** RTU
PARITY	For selecting whether no parity bit or an even or odd parity bit should be ?transmitted. **Options:** EVEN ODD NONE/STOP BITS 2 NONE/STOP BITS 1 **Factory setting:** EVEN
BYTE ORDER	Select the byte transmission sequence for the Integer, Float and String data types: **Options:** 0 - 1 - 2 - 3 3 - 2 - 1 - 0 2 - 3 - 0 - 1 1 - 0 - 3 - 2 **Factory setting:** 1 - 0 - 3 - 2 Note! The transmission sequence must suit the Modbus master.
DELAY TELEGRAM REPLY	For entering a delay time after which the measuring device replies to the request telegram of the Modbus master. This allows communication to be adapted to slow Modbus masters: **Options:** 0 to 100 ms **Factory setting:** 10 ms

7.3.7 Data backup/transmission

Using the T-DAT SAVE/LOAD function, you can transfer data (device parameters and settings) between the T-DAT (exchangeable memory) and the EEPROM (device storage unit).

This is required in the following instances:
- Creating a backup: current data are transferred from an EEPROM to the T-DAT.
- Replacing a transmitter: current data are copied from an EEPROM to the T-DAT and then transferred to the EEPROM of the new transmitter.
- Duplicating data: current data are copied from an EEPROM to the T-DAT and then transferred to EEPROMs of identical measuring points.

Note!
For information on installing and removing the T-DAT → 84

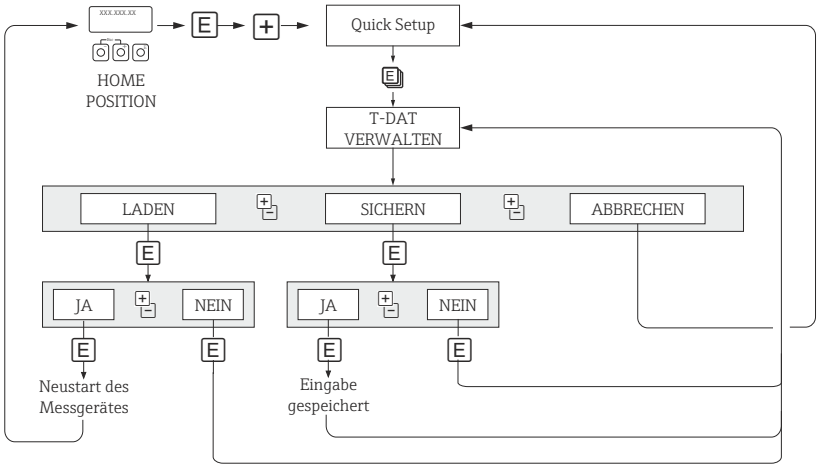


Fig. 39: Data backup/transmission with T-DAT SAVE/LOAD function

Information on the LOAD and SAVE options available

LOAD:
Data are transferred from the T-DAT to the EEPROM.

Note!
- Any settings already saved on the EEPROM are deleted.
- This option is only available, if the T-DAT contains valid data.
- This option can only be executed if the software version of the T-DAT is the same or newer than that of the EEPROM. Otherwise, the error message "TRANSM. SW-DAT" appears after restarting and the LOAD function is then no longer available.

SAVE:
Data are transferred from the EEPROM to the T-DAT

7.3.8 Gas compensation input

The flowmeter can read the composition of the gas from the gas analyzer and automatically update the first two gas components (e.g. GAS TYPE 1 and 2) in the programmed gas mixture. This provides a more accurate measurement in case of varying compositions. For example: varying methane and carbon dioxide components in a biogas application.

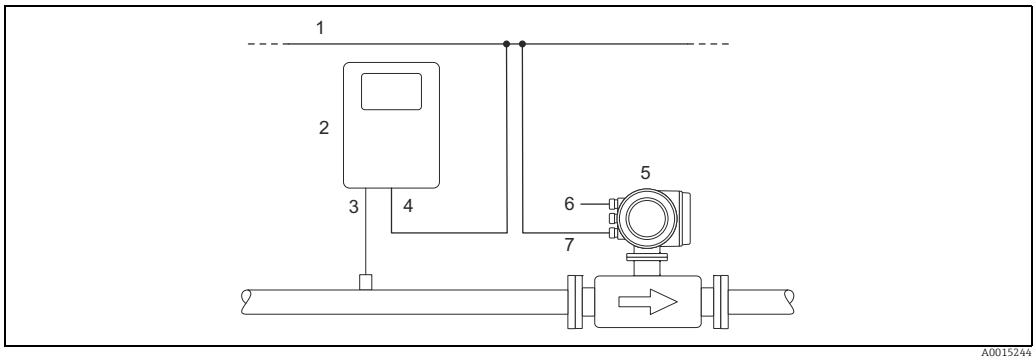


Fig. 40: Gas mixture compensation using a gas analyzer

1 Fieldbus
2 Gas analyzer
3 Gas detector
4 Gas analyzer output
5 t-mass
6 Power supply
7 Input/output

Performing the Quick Setup

1. GAS GROUP
   - Use the + or − key to select the required GAS GROUP and continue with E.
   - Set the ANALYZER INPUT to ON if a gas compensation input is being used (see BA00116D/06 "Description of Device Functions").
   - Select the NUMBER OF GASES in the group from 1 to 8.
   - select the GAS TYPE from the choose list.
   - Enter the "MOLE %" value for each GAS TYPE.

   The error message CHECK VALUES appears if the total mixture % does not equal 100% → Go back and check the mixture settings.
2. SAVE CHANGES?
   - Select YES to save the settings in GAS GROUP 1 or 2 and activate the last gas group selected. Press E to continue or
   - Select CANCEL to save the entered settings in buffer memory but not activate them for measurement. If this function is selected, then it will be necessary to come back to this gas group and save it at a later stage.
   - Select DISCARD to clear the last changes and return to CONFIGURE GROUP to make new settings.
   - Exit the function using ESC (press ⊡ keys simultaneously)
3. ANOTHER GAS GROUP?
   - Select YES to continue to the CONFIGURE GROUP function. Use the + or − key to select the desired GAS GROUP and proceed as per the above instructions.
   - Select NO to exit to the Quick Setup.

Check or note the following points:
- Check that the function GAS → ANALYZER INPUT is set to ON (function group GAS → 59).
- Check the actual % value of the main gas component being transmitted from the analyzer: Go to the function MOLE % GAS 1 in the function group PROCESS PARAMETER.
- A gas group must contain at least 2 gas types (e.g. methane 60%, carbon dioxide 40%).
- By default, the first gas fraction is then updated continuously by the gas chromatograph and the content of the other gases is calculated dynamically

If the value is present and updating then the system is working correctly.

Note!
More detailed information on the GAS GROUP programming can be found in the separate "Description of Device Functions" manual (BA00116D/06/... see chapter GAS).

7.4 Adjustment

7.4.1 Zero point adjustment

Calibration takes place under reference operating conditions. (→ 95).
Consequently, the zero point adjustment is generally **not** necessary!
At zero flow conditions, the output of most thermal mass flow devices has a strong dependency on the process pressure. The effect on the true zero point of the device, by the static line pressure, is dependant on the gas type and the application demands and in many cases the use of the low flow cut-off function is adequate to zero the device output.

With some gases and/or a combination of high pressures, zero point adjustment must be performed under process conditions so that the measuring device can measure smaller values.

Therefore, the zero point adjustment is advisable in the following special cases:
- To achieve highest measuring accuracy with very small flow rates.
- Under process or operating conditions where the gas properties (heat capacity and thermal conductivity) will change e.g. Hydrogen and Helium.

Preconditions for a zero point adjustment

Note the following before you perform a zero point adjustment:
- A zero point adjustment can be performed only with gases that contain no solid contents or condensate.
- The adjustment is performed with the process gas at zero flow and at operating pressure. This can be achieved, for example, with shutoff valves upstream and/or downstream of the sensor or by using existing valves and gates.
  - Normal operation → valves 1 and 2 open
  - Zero point adjustment *with* pump pressure → Valve 1 open / valve 2 closed
  - Zero point adjustment *without* pump pressure → Valve 1 closed / valve 2 open

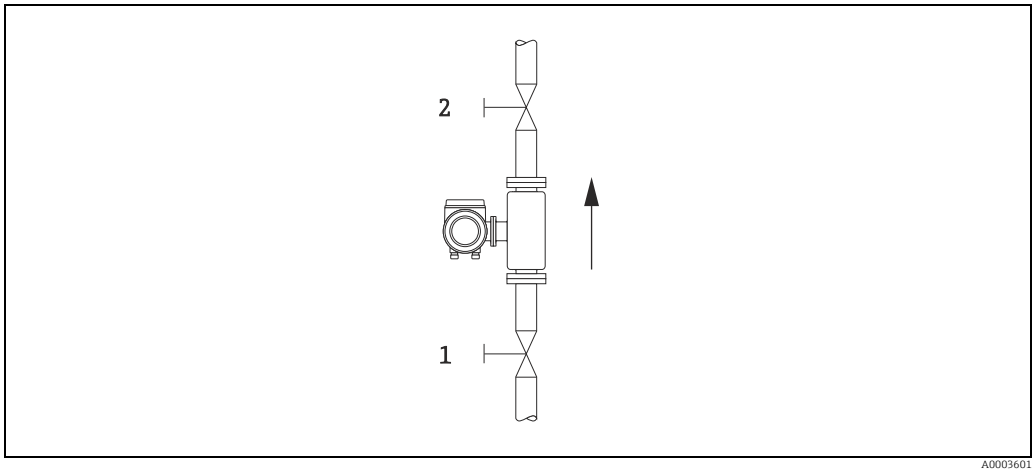


Fig. 41: Zero point adjustment and shut-off valves

Caution!
You can view the currently valid zero point value using the ZERO POINT function in the SENSOR DATA group (see the "Description of Device Functions" manual, BA00116D/06).

Performing a zero point adjustment

1. Operate the system until operating conditions have settled.
2. Stop the flow (v = 0 m/s).
3. Check the shut-off valves for leaks.
4. Check that operating pressure is correct.
5. Using the local display/operating program, select the ZEROPOINT ADJUSTMENT function in the function matrix:
   PROCESS PARAMETER → ZEROPOINT ADJUSTMENT
6. When you press + or − you are automatically prompted to enter the access code if the function matrix is still disabled. Enter the code (factory setting = 65).
7. Use + or − to select START and press E to confirm. The zero point adjustment now starts and is completed within a few seconds.

   ✎ Note!
   If the flow in the pipe is unstable, the following error message may appear on the display "ZERO ADJUST FAIL". The zero point adjustment has failed. The preconditions need to be stabilized before attempting a new adjustment.
8. Back to the HOME position:
   – Press and hold down Esc key (−+) for longer than three seconds or
   – Repeatedly press and release the Esc key (−+).

Resetting a zero point adjustment

The currently stored zero point can be reset to the original factory value by using the RESET option within ZERO POINT ADJUST.
Use + or − to select RESET and press E to confirm. The zero point adjustment is now reset.

7.5 Data storage device (HistoROM)

At Endress+Hauser, the term HistoROM refers to various types of data storage modules on which process and measuring device data are stored. By plugging and unplugging such modules, device configurations can be duplicated onto other measuring devices to cite just one example.

7.5.1 HistoROM/S-DAT (sensor-DAT)

The HistoROM/S-DAT is an exchangeable data storage device in which all sensor relevant parameters
are stored, i.e., pipe type, diameter, serial number, flow conditoner, zero point.

7.5.2 HistoROM/T-DAT (transmitter-DAT)

The HistoROM/T-DAT is an exchangeable data storage device in which all transmitter parameters and settings are stored.
Storing of specific parameter settings from the EEPROM to the HistoROM/T-DAT and vice versa has to be carried out by the user (= manual save function). For detailed information → 🖹 66.

8 Maintenance

Generally, the flowmeter requires no special maintenance work, particularly if the gas is clean and dry.

Warning!
Hazardous area approvals may demand that the device be returned to an Endress+Hauser sales center (→ 6) for service or that work can only be carried out by a qualified Endress+Hauser service person. Please contact your Endress+Hauser sales center if you have any questions.

8.1 External cleaning

When cleaning the exterior of measuring devices, always use cleaning agents that do not attack the surface of the housing and the seals.

8.2 Pipe cleaning

The sensor is capable of withstanding clean in place (CIP) processes using heated liquids or steam (SIP), within the maximum specified temperature limits. However the sensor measurement will be adversely affected during the cleaning cycle and a settling down period will be required after the cycle to allow the process and sensor temperatures to re-stabilize.

Note!
The POSITIVE ZERO RETURN function maybe activated to set the current output to zero flow during such cycles. See "Description of Device Functions" manual for more information.

Caution!
Do not use a pipe cleaning pig.

8.3 Sensor cleaning

For gases that do carry impurities, it is recommended that the sensor be routinely inspected and cleaned to minimize any potential measuring errors due to contamination or build-ups. The frequency of inspection and cleaning will depend upon the application and expected measurement performance.
Cleaning is performed by applying a non-filming or oil-free type cleaning fluid to a soft brush or cloth and gently wiping over the surface until all build-ups and contaminants are removed.

Caution!
- Use care not to bend the sensing elements of the transducer during cleaning.
- Do not use abrasive materials or fluids corrosive to the sensor materials and seals.

Sensor-specific information:
- t-mass F:
  Removal of the transducer requires specialist knowledge, tools and parts. The process seal also may need to be tested and re-qualified. This procedure must be carried out by an Endress+Hauser sales center.
- t-mass I:
  When removing the measuring sensor, observe the safety guidelines in chapter → 19.

8.4 Replacing seals

Under normal circumstances, fluid wetted seals of the sensor do not require replacement. Replacement is necessary only in special circumstances, for example if aggressive or corrosive fluids are incompatible with the seal material.

Sensor-specific information:
- t-mass F:
  The sensor contains o-rings seals and a bushing. In case of failure, the device must be returned to an Endress+Hauser sales center for inspection and repair (→ 🖹 6).
- t-mass I:
  The transducer is welded to the insertion tube and has no exchangeable seals. The compression fitting contains wetted seals (ferrules) and a bonded seal is used on the G 1 A thread version.

Caution!
Do not reuse gaskets after removing sensors.
Use only original parts from Endress+Hauser. The compression fitting and gasket seals are deliverable as spare parts. The seal ring can be replaced easily on site

8.5 In-situ calibration

The t-mass flowmeters are designed to support in-situ calibration using a reference meter signal, thus saving time and cost by reducing the need for factory re-calibration.
Pre-requirements for in-situ calibration with adjustment:

1. Stable gas composition (operation with one gas group only; without gas analyzer input)
2. Stable pressure and temperature (without pressure compensation input)
3. Mass flow reference
   a. mass flow reference meter, mounted in the measurement or bypass pipe, providing a mA signal to t-mass or
   b. manual entry of known mass flow reference values. For example, the display value from the reference meter or a derived value from a pump curve)
4. Ability to control the flow range over a minimum of 5 control points

This function can only be activated with a special Endress+Hauser service code.
For specific applications, contact your Endress+Hauser sales center.

8.6 Recalibration

For thermal meters, the interval between calibrations is dependent on the application since calibration drift is predominantly caused by contamination of the sensor surface.
If the gas is not clean (i.e. contains particulates), then gentle cleaning of the sensor elements can be effective at regular intervals. The cleaning interval will depend upon the nature and extent of the contamination.

Determination of recalibration intervals:
- If the measurement is critical, then a calibration audit should be undertaken by performing recalibration checks once per year for a period of 2 years. Increase that period to twice per year if the application gas is not clean and dry.
  Depending on the results of the audit, the next recalibration check interval can be increased or decreased accordingly.
- For non-critical applications and or where the gas is clean and dry, a recalibration interval of every 2 to 3 years is recommended.

9 Accessories

Various accessories, which can be ordered separately from Endress+Hauser, are available for the transmitter and the sensor. Your Endress +Hauser sales center can provide detailed information on the specific order code.

9.1 Device-specific accessories

Accessories	Description	Order code
Mounting boss	Mounting boss for the t-mass insertion version	DK6MB - *
Cable remote version	Connecting cable for the remote version	DK6CA - *
Mounting set for transmitter	Mounting set for remote version. Suitable for: – Wall mounting – Pipe mounting – Installation in control panel Mounting set for aluminum field housing: Suitable for pipe mounting (¾" to 3")	DK6WM - *
Hot tap, process pressure	Low-pressure version: Mounting kit with process connection, ball valve, safety chain and sensor connection. Insertion or extraction of sensor under process pressure (max. 4.5 barg (65 psig)).	DK6HT-***
	Medium-pressure version: Mounting kit with process connection, ball valve, sensor connection and extractor assembly. Insertion or extraction of sensor under process pressure (max. 16 barg (235 psig)).	
Cold tap, atmospheric pressure	Mounting kit with sensor connection, ball valve and weld socket. Insertion or extraction of sensor in unpressurized pipes (atmospheric pressure). In the absence of a measuring device, the mounting kit enables pipe resealing in order to resume the process.	DK6ML-***
Flow conditioner	▪ t-mass F: DN25 to 100 (1 to 4") ▪ t-mass I: DN 80 to 300 (3 to 12")	DK6ST-*** DK7ST-***
Graphic data manager Memograph M	The graphic data manager Memograph M provides information on all the relevant process variables. Measured values are recorded correctly, limit values are monitored and measuring points analyzed. The data are stored in the 256 MB internal memory and also on an SD card or USB stick. The mathematics channels which are optionally available facilitate continuous monitoring, e.g. of specific energy consumption, boiler efficiency and other parameters which are necessary for efficient energy management.	RSG40 - **********

9.2 Service-specific accessories

Accessory	Description	Order code
Applicator	Software for selecting and sizing Endress+Hauser measuring devices: ▪ Calculation of all the necessary data for identifying the optimum flowmeter: e.g. nominal diameter, pressure loss, accuracy or process connections ▪ Graphic illustration of the calculation results Administration, documentation and access to all project-related data and parameters over the entire life cycle of a project. Applicator is available: ▪ Via the Internet: https://wapps.endress.com/applicator ▪ On CD-ROM for local PC installation.	DKA80 - *

Accessory	Description	Order code
Fieldcheck	Tester/simulator for testing flowmeters in the field. When used in conjunction with the "FieldCare" software package, test results can be imported into a database, printed and used for official certification. Further information is available from your Endress+Hauser sales center.	50098801
FieldCare	FieldCare is Endress+Hauser's FDT based Plant Asset Management Tool. It can configure all intelligent field devices in your plant and supports you in managing them. By using status information, it also provides a simple but effective means of checking their health.	Please refer to the product page of the Endress+Hauser Internet page: www.endress.com
FXA193	The FXA193 service interface connects the device to the PC for configuration via FieldCare.	FXA193 – *

10 Trouble-shooting

10.1 Trouble-shooting instructions

Always start troubleshooting with the following checklist if faults occur after commissioning or during operation. The routine takes you directly to the cause of the problem and the appropriate remedial measures.

Check the display	
No display visible and no output signals present.	1. Check the supply voltage → Terminals 1, 2 2. Check device fuse → 🖹 90 85 to 260 V AC: 0.8 A slow-blow / 250 V 20 to 55 V AC and 16 to 62 V DC: 2 A slow-blow / 250 V 3. Measuring electronics defective → order spare parts → 🖹 84
No display visible, but output signals are present.	1. Check whether the ribbon-cable connector of the display module is correctly plugged into the amplifier board → 🖹 84. 2. Display module defective → order spare parts → 🖹 84 3. Measuring electronics defective → order spare parts → 🖹 84
Display texts are in a foreign language.	Switch off the power supply. Press and hold down both the ⊟+ keys and switch on the measuring device. The display text will appear in English (default) and is displayed at maximum contrast.
Measured value indicated, but no signal at the current or pulse output	Measuring electronics defective → order spare parts → 🖹 84

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Error messages on display
Errors that occur during commissioning or measuring are displayed immediately. Error messages consist of a variety of icons. The meanings of these icons are as follows (example): – Type of error: **S** = System error, **P** = Process error – Error message type: ϟ = Fault message, **!** = Notice message – **FLOW LIMIT** = Error designation, e.g. measured flow has exceeded the maximum limit. – **03:00:05** = Duration of error occurrence (in hours, minutes and seconds) – **#422** = Error number ☝ Caution! ▪ See the information on → 🖹 38. ▪ The measuring device interprets simulations and positive zero return as system errors, but displays them as a notice message only.

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Faulty connection to Modbus master	
No connection can be made between the Modbus master and the device. Check the following points:	
Supply voltage Transmitter	Check the supply voltage → Terminals 1, 2
Device fuse	Check device fuse → 🖹 90 85 to 260 V AC: 0.8 A slow-blow / 250 V 20 to 55 V AC and 16 to 62 V DC: 2 A slow-blow / 250 V
Fieldbus connection	Modbus RS485: Check data line Terminal 26 = B (RxD/TxD-P) Terminal 27 = A (RxD/TxD-N)
Network structure	Check permissible fieldbus length and number of spurs.

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Faulty connection to Modbus master (continued)	
Fieldbus address	Check fieldbus address: make sure there are no double assignments.
Bus termination	Has the Modbus RS485 network been terminated correctly? Each bus segment must always be terminated with a bus terminator at both ends (start and finish). Otherwise there may be interference in communication.

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System or process error messages
System or process errors which occur during commissioning or operation can be displayed in ACTUAL SYSTEM CONDITION function via local display or by using the operating program FieldCare.

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Other error (without error message)	
Some other error has occurred	Diagnosis and rectification → 🖹 80

10.2 System error messages

Serious system errors are **always** recognized by the flowmeter as "Fault message", and are shown as a lightning flash (ϟ) on the display! Fault messages immediately affect the operation. Simulations and positive zero return, on the other hand, are classed and displayed as "Notice messages".

Caution!
In the event of a serious fault, a flowmeter might have to be returned to the manufacturer for repair. Important procedures must be carried out before you return a flowmeter to Endress+Hauser. → 🖹 91.Always enclose a duly completed "Declaration of contamination" form. You will find a preprinted blank of this form at the back of this manual.

Note!
Also observe the information on the following pages: → 🖹 38

Modbus communication **Register: 6859 Data type: Integer**	**Register: 6821 Data type: String (18 byte)**	**No.**	**Device status message (local display)**	**Cause**	**Rectification (spare part → 🖹 84)**
Response to a fault message: The value "NaN" (not a number) is transmitted to the Modbus master instead of the current measured value.		**Onsite display** S = System error ϟ = Fault message (with an effect on the current operation) ! = Notice message (without any effect on the current operation)			
1	SYSTEM OK	-	*There is no error present in the device*		
No. # 0xx → Hardware error					
2	CRITICAL FAIL.	001	S: CRITICAL FAIL. ϟ: # 001	Serious device error	Replace the amplifier board.
3	AMP HW-EEPROM	011	S: AMP HW EEPROM ϟ: # 011	Amplifier: Defective EEPROM	Replace the amplifier board.
4	AMP SW-EEPROM	012	S: AMP SW EEPROM ϟ: # 012	Measuring amplifier: Error when accessing data of the EEPROM	Replace the amplifier board.
6	AMP SW-ROM/RAM	014	S: AMP SW-ROM/RAM ϟ: # 014	Amplifier: Defective ROM/RAM	Replace the amplifier board.
7	SENSOR HW-DAT	031	S: SENSOR HW DAT ϟ: # 031	Sensor DAT: 1. HistoROM/S-DAT is defective. 2. HistoROM/S-DAT is not plugged into the amplifier board or is missing.	1. Replace the S-DAT. Check the spare part set number to ensure that the new, replacement DAT is compatible with the measuring electronics. 2. Plug the HistoROM/S-DAT into the amplifier board → 🖹 85
8	SENSOR SW-DAT	032	S: SENSOR SW DAT ϟ: # 032	Sensor DAT: Error accessing the calibration values stored in the HistoROM/S-DAT.	1. Check whether the HistoROM/S-DAT is correctly plugged into the amplifier board.→ 🖹 85 2. Replace the S-DAT if it is defective. Before replacing the DAT, check that the new, replacement DAT is compatible with the measuring electronics. Check the: – Spare part set number – Hardware revision code 3. Replace measuring electronics boards if necessary.
11	SENS HW-ROM/RAM	035	S: SENS HW-ROM/RAM ϟ: # 035	Sensor: Defective ROM/RAM	Replace the remote amplifier board.
12	SENS SW-ROM/RAM	036	S: SENS SW-ROM/RAM ϟ: # 036	Sensor: Defective ROM/RAM	Replace the remote amplifier board.

Modbus communication Register: 6859 Data type: Integer	Register: 6821 Data type: String (18 byte)	No.	Device status message (local display)	Cause	Rectification (spare part → 🖹 84)
14	TRANSM. SW-DAT	042	S: TRANSM. SW-DAT ϟ: # 042	Sensor DAT: Error accessing the calibration values stored in the HistoROM/T-DAT.	1. Check whether the HistoROM/T-DAT is correctly plugged into the amplifier board.→ 🖹 85 2. Replace the T-DAT if it is defective. Before replacing the DAT, check that the new, replacement DAT is compatible with the measuring electronics. Check the: – Spare part set number – Hardware revision code 3. Replace measuring electronics boards if necessary.
15	A/C COMPATIB.	051	AC COMPATIB. ϟ: # 051	The I/O board and the amplifier board are not compatible.	Use only compatible modules and boards. Check the compatibility of the modules used. Check the: – Spare part set number – Hardware revision code
19	SENSOR DEFECT	070	S: SENSOR DEFECT ϟ: # 070	Flow sensors are likely to be defect, measurement is no longer possible.	Contact your Endress+Hauser sales center.
No. # 1xx → Software error					
22	CHECKSUM TOT.	111	S: CHECKSUM TOTAL ϟ: # 111	Totalizer checksum error	1. Restart the measuring device 2. Replace the amplifier board if necessary.
23	A/C SW COMPATI	121	S: A/C SW COMPATI ϟ: # 121	Due to different software versions, I/O board and amplifier board are only partially compatible (possibly restricted functionality). ✎ Note! – This message is only listed in the error history. – Nothing is displayed on the display.	Module with lower software version has either to be actualized by FieldCare with the required software version or the module has to be replaced.
No. # 2xx → Error in DAT/no communication					
25	LOAD T-DAT	205	S: LOAD T-DAT !: # 205	Transmitter DAT Data backup (downloading) to HistoROM/T-DAT failed, or error when accessing (uploading) the calibration values stored in the HistoROM/T-DAT.	1. Check whether the HistoROM/T-DAT is correctly plugged into the amplifier board.→ 🖹 85 2. Replace the T-DAT if it is defective. Spare parts→ 🖹 84 Before replacing the DAT, check that the new, replacement DAT is compatible with the measuring electronics. Check the: – Spare part set number – Hardware revision code 3. Replace measuring electronics boards if necessary.
26	SAVE T-DAT	206	S: SAVE T-DAT ϟ: # 206	HistoROM/S-DAT is not fitted to amplifier board.	Check whether the HistoROM/S-DAT is correctly plugged into the amplifier board → 🖹 85
27	S-DAT NO HW	211	S: S-DAT NO HW ϟ: # 211	HistoROM/S-DAT is not fitted to amplifier board.	Check whether the HistoROM/S-DAT is correctly plugged into the amplifier board → 🖹 85
30	COMMUNIC.AMP.	251	S: COMMUNIC. SENS ϟ: # 251	Internal microprocessor communication fault on the amplifier board.	Remove the amplifier board.
31	COMMUNIC.I/O	261	S: COMMUNICAT. I/O ϟ: # 261	No data reception between amplifier and I/O board or faulty internal data transfer.	Check the BUS contacts

Modbus communication Register: 6859 Data type: Integer	Modbus communication Register: 6821 Data type: String (18 byte)	No.	Device status message (local display)	Cause	Rectification (spare part → 🖹 84)
No. # 3xx → System limits exceeded					
50	DIFF TEMP LO	372	S: DIFF. TEMP. LOW ϟ: # 372	The measured sensor differential temperature is below limit value.	Reduce the flow rate or consider replacing the instrument with a suitable size for the application if possible.
57	FLUIDTEMP.MIN	381	S: FLUIDTEMP.MIN. !: # 381	The minimum fluid temperature limit for the transducer has been exceeded.	Increase the process gas temperature. Caution! In case of severe temperature exposure, the transducer may be damaged.
58	FLUIDTEMP.MAX	382	S: FLUIDTEMP.MAX. !: # 382	The minimum fluid temperature limit for the transducer has been exceeded.	Reduce the process gas temperature. Caution! In case of severe temperature exposure, the transducer may be damaged.
Application error					
66	SW.-UPDATE ACT	501	S: SW.-UPDATE ACT !: # 501	New amplifier or communication (I/O module) software version is loaded. Currently no other functions are possible.	Wait until process is finished. The device will restart automatically.
67	UP-/DOWNL. ACT	502	S: DOWN UPLD. ACT !: # 502	Up- or downloading the device data via configuration program. Currently no other functions are possible.	Wait until process is finished.
No. # 6xx → Simulation mode active					
69	POS.ZERO-RET.	601	S: POS. ZERO RET. ! # 601	Positive zero return active. ☝ Caution! This message has the highest display priority.	Switch off positive zero return
94	SIM.STATUS IN1	671	S: SIM.STATUS IN 1 !: # 671	Simulation status input active	Switch off simulation
98	SIM.FAILSAFE	691	S: SIM. FAILSAFE !: # 691	Simulation of response to error (outputs) active	Switch off simulation
99	SIM. MEASURAND	692	S: SIM. MEASURAND !: # 692	Simulation of measuring variables (e.g. mass flow)	Switch off simulation
100	DEV.TEST ACT.	698	S: DEV. TEST ACT. !: # 698	The measuring device is being checked on-site via the test and simulation device (FieldCheck).	–

10.3 Process error messages

Note!
Observe the information on the following pages: → 38 and → 75.

Modbus communication Register: 6859 Data type: Integer	Register: 6821 Data type: String (18 byte)	No.	Device status message (local display)	Cause	Rectification
Response to a fault message: The value "NaN" (not a number) is transmitted to the Modbus master instead of the current measured value.		**Onsite display** P = Process error ϟ = Fault message (with an effect on the current operation) ! = Notice message (without any effect on the current operation)			
1	SYSTEM OK	-	*There is no error present in the device*		
59	FLOW LIMIT	422	P: FLOW LIMIT ϟ: # 422	The measured flow has exceeded the maximum limit.	Reduce the flow rate or replace the instrument with a suitable size for the application.
65	ZERO-ADJ. N.OK	731	P: ZERO-ADJ. N.OK ϟ: # 731	The saved zero point is inaccurate possibly due to unstable process or flow conditions.	Make sure that zero point adjustment is carried out at "zero flow" only (v = 0 m/s) → 69

10.4 Process errors without messages

Symptoms	Rectification
Note! You may have to change or correct certain settings of the function matrix in order to rectify faults. The functions outlined below, such as DISPLAY DAMPING, for example, are described in detail in the "Description of Device Functions" manual.	
Displayed measured value fluctuates even though flow is steady.	1. Increase value of the TIME CONSTANT setting → CURRENT OUTPUT function group. 2. Increase value of the DISPLAY DAMPING setting → USER INTERFACE function group. 3. The inlet and outlet lengths must be observed. See installation conditions → 15 4. Consider the use of a flow conditioner. See installation conditions → 16 5. Relocate the meter to a point where there is less flow disturbance
Device displays flow with no actual flow present.	1. The low flow cut off value is programmed too low. Increase value of the ON VALUE LOW FLOW CUT OFF setting → PROCESS PARAMETERS function group (Factory setting = 1% of 20mA value). 2. Check for leaks in the pipe line downsteam of the sensor. 3. Reduce or eliminate pressure pulsations in the line.
Device displays flow with no actual flow present - but with high static line pressure and thermally conductive gases present (e.g. Hydrogen, Helium, etc.). Line pressure is typically > 5 bar / 75 psi	Start the ZERO POINT ADJUST function → PROCESS PARAMETERS function group. See Zero Point Adjust function → 69 Note! Process preconditions are required before starting this function.

Symptoms	Rectification
Device displays zero flow but flow is present.	1. The INSTALLATION FACTOR may have a wrong setting = 0 ® PROCESS PARAMETERS function group (factory setting = 1.0). 2. The LOW FLOW CUT OFF setting may be too high. Adjust the function ON VALUE LOW FLOW CUT OFF to a lower value → PROCESS PARAMTERS function group (factory setting 1% of calibrated 20mA value). 3. The ZERO POINT ADJUST function may have been incorrectly carried out with flow present. RESET the zero point adjustment if necessary → PROCESS PARAMETERS function group.

Symptoms	Rectification
Device displays incorrect flow value.	1. Check the basic parameters of the device → 🖹 55 Especially: – Gas – Process pressure – Reference pressure and reference temperature – Flow units – Output assignment 2. Check the installation conditions (Post-installation check → 🖹 27) a. The inlet and outlet lengths must be observed → 🖹 15. b. Consider the use of a flow conditioner if the necessary inlet requirements cannot be met → 🖹 16. c. t-mass F: Check for diameter mismatch between the flanges and check the gasket alignment → 🖹 13. t-mass I: Check the sensor orientation and insertion depth. → 🖹 19. d. If the measures above cannot rectify the problem, the INSTALLATION FACTOR → PROCESS PARAMETER function group (factory setting = 1.0) must be configured in such a way that the flow rate displayed matches the anticipated flow rate. 3. The flow rate maybe too high (i.e. above sensor calibration range) 1. Check the measuring range that the Endress+Hauser Applicator program uses. 2. Check if the inverted plus sign "+" is shown on the display? If yes, reduce the velocity if possible. 4. The flow rate maybe too low 1. Check the measuring range that the Endress+Hauser Applicator program uses. 2. Increase the velocity if possible. 5. Check the condition of the transducer 1. Are the measuring elements bent? If yes, replacement is necessary. 2. Are build-ups present? If yes, clean the sensors (transducer cleaningSensor cleaning → 🖹 71). 3. Has corrosion occurred? If yes, replacement is necessary. 6. Check if the gas is wet? Is condensate present on the sensors? If so: 1. For horizontal pipes: Mount the sensor at 135° → 🖹 14 2. Install a condensate trap or filter upstream of the flowmeter 7. Check if heating devices are used upstream of the flowmeter causing possible temperature profile effects ? If so: 1. Relocate the flowmeter further downstream or 2. Install a flow conditioner upstream of the flowmeter
The fault cannot be rectified or some other fault not described above has occurred. In such cases, your Endress+Hauser sales center can help.	The following options are available for tackling problems of this nature: **Request the services of an Endress+Hauser service technician** If our service representative is contacted to have a service technician sent out, please be ready with the following information: – Brief description of the fault – Nameplate specifications : Order code and serial number → 🖹 7 **Returning measuring devices to Endress+Hauser** The procedures on → 🖹 6 must be carried out before you return a flowmeter requiring repair or calibration to Endress+Hauser. Always enclose a duly completed "Declaration of contamination" form with the flowmeter. You will find a pre-printed "Declaration of contamination" at the back of this manual. **Replace transmitter electronics** Components in the measuring electronics defective → order replacement → 🖹 84

10.5 Response of totalizers and Modbus communication to errors

Note!
The failsafe mode of totalizers can be customized by means of various functions in the FAIL-SAFE MODE function. You will find detailed information on these procedures in the "Description of Device Functions" manual.

Positive zero return can be used to interrupt the evaluation of the flow measurement variables or reset measured value transmission via Modbus communication to "0", for example when measuring has to be interrupted while a pipe is being cleaned. This function takes priority over all other device functions. Simulations, for example, are suppressed.

Response of totalizers and Modbus communication to errors		
	System/process error is present	**Positive zero return is activated**
Caution! System or process errors defined as "Notice messages" have no effect whatsoever on the measurement operation. See the information on → 🖹 75		
Totalizer	STOP The totalizers are paused until the error is rectified. ACTUAL VALUE Fault is ignored, i.e. the totalizer continues to count according to the current flow value. HOLD VALUE The totalizers continue to count the flow in accordance with the last valid flow value (before the error occurred).	Totalizer stops
Modbus RS485	In the event of fault message, the value "NaN" (not a number) is transmitted instead of the current measured value.	No effect on Modbus communication. The value "0" is outputted for the mass flow and corrected volume flow.

10.6 Spare parts

The previous sections contain a detailed trouble-shooting guide. → 🖹 75
The measuring device, moreover, provides additional support in the form of continuous self-diagnosis and error messages.
Fault rectification can entail replacing defective components with tested spare parts. The illustration below shows the available scope of spare parts.

Note!
You can order spare parts directly from your Endress+Hauser sales center by providing the serial number printed on the transmitter's nameplate. → 🖹 7

Spare parts are shipped as sets comprising the following parts:
- Spare part
- Additional parts, small items (threaded fasteners, etc.)
- Installation instructions
- Packaging

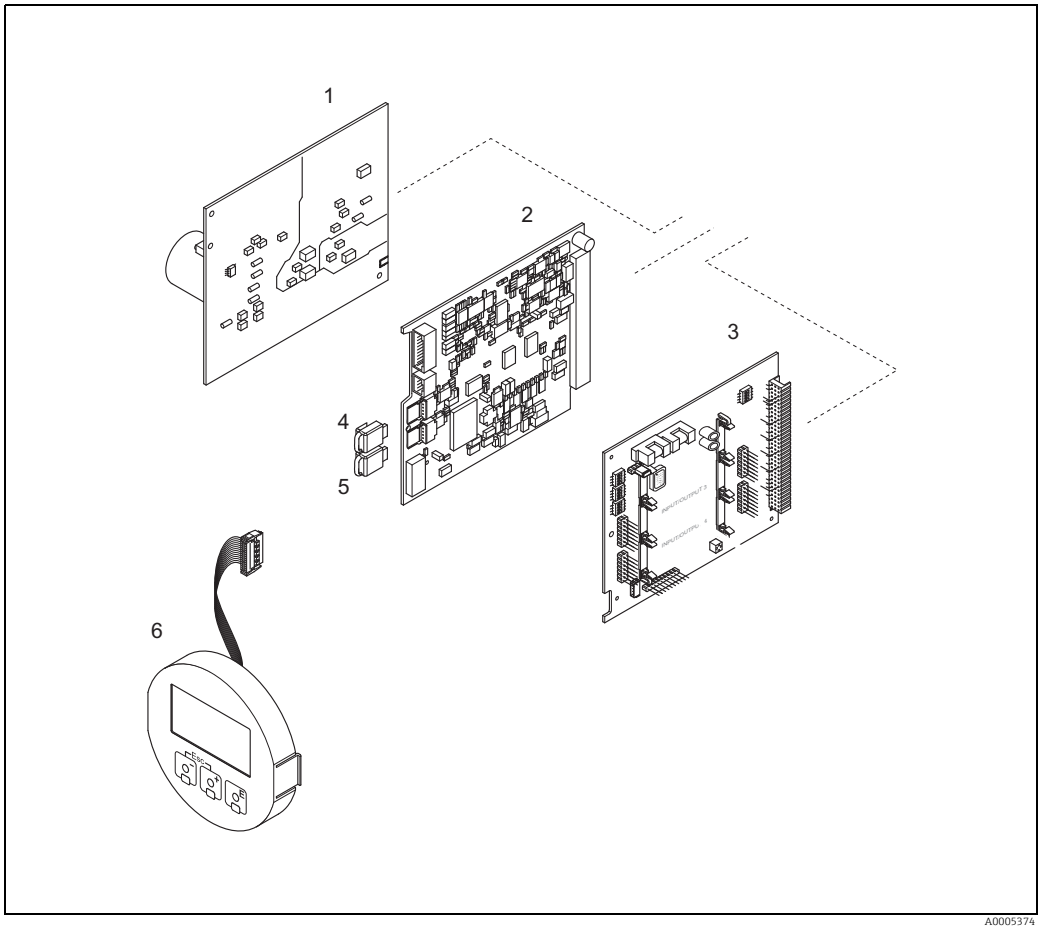

Fig. 42: Spare parts for transmitter 65 (field and wall-mount housings)

1 Power unit board (85 to 260 V AC, 20 to 55 V AC, 16 to 62 V DC)
2 Amplifier board
3 I/O board (COM module)
4 HistoROM/S-DAT (sensor data memory)
5 HistoROM/T-DAT (transmitter data memory)
6 Display module

10.6.1 Removing and installing printed circuit boards

Field housing

Warning!
- Risk of electric shock. Exposed components carry dangerous voltages. Switch off the power supply before you remove the cover of the electronics compartment.
- Risk of damaging electronic components (ESD protection). Static electricity can damage electronic components or impair their operability. Use a workplace with a grounded working surface purposely built for electrostatically sensitive devices!
- If you cannot guarantee that the dielectric strength of the measuring device can be maintained during the following steps, then an appropriate inspection test must be carried out in accordance with the manufacturer's specifications.
- When connecting Ex-certified measuring devices, see the notes and diagrams in the Ex-specific supplement to these Operating Instructions. Please do not hesitate to contact your Endress+Hauser sales center if you have any questions.

Caution!
Use only original Endress+Hauser parts.

Removal and installation → 🖻 43:

1. Unscrew cover of the electronics compartment from the transmitter housing.
2. Remove the screws (1.1) and remove the cover (1) from the electronics compartment.
3. Disconnect the display ribbon cable (1.2) from the amplifier board.
4. Remove power supply board (3) and I/O board (5):
   Insert a thin pin into the hole (2) provided for the purpose and pull the board clear of its holder.
5. Remove amplifier board (4):
   - Disconnect the plug of the sensor signal cable (4.1) including HistoROM/S-DAT (4.2) and HistoROM/T-DAT (4.3) from the board.
   - Disconnect the plug of the excitation current cable (4.2) from the board carefully, i.e. without moving it to and fro.
   - Insert a thin pin into the hole (2) provided for the purpose and pull the board clear of its holder.
6. Installation is the reverse of the removal procedure.

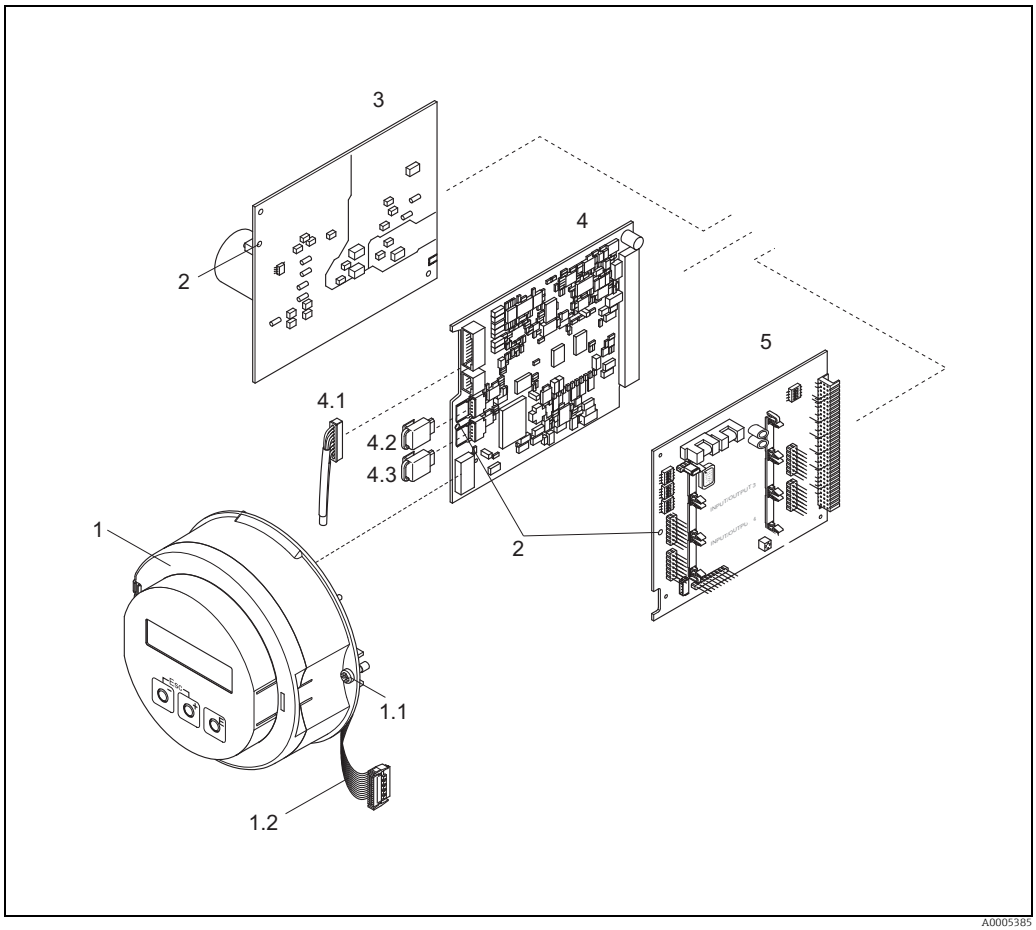

Fig. 43: Field housing: removing and installing printed circuit boards

1 Electronics compartment cover with local display
1.1 Screws of electronics compartment cover
1.2 Ribbon cable (display module)
2 Aperture for installing/removing boards
3 Power unit board
4 Amplifier board
4.1 Signal cable (sensor)
4.2 HistoROM/S-DAT (sensor data memory)
4.3 HistoROM/T-DAT (transmitter data memory)
5 I/O board

Wall-mount housing

Warning!
- Risk of electric shock. Exposed components carry dangerous voltages. Switch off the power supply before you remove the cover of the electronics compartment.
- Risk of damaging electronic components (ESD protection). Static electricity can damage electronic components or impair their operability. Use a workplace with a grounded working surface purposely built for electrostatically sensitive devices!
- If you cannot guarantee that the dielectric strength of the measuring device can be maintained during the following steps, then an appropriate inspection test must be carried out in accordance with the manufacturer's specifications.
- When connecting Ex-certified measuring devices, see the notes and diagrams in the Ex-specific supplement to these Operating Instructions. Please do not hesitate to contact your Endress+Hauser sales center if you have any questions.

Caution!
Use only original Endress+Hauser parts.

Removal and installation → 44:

1. Remove the screws and open the hinged cover (1) of the housing.
2. Loosen the screws securing the electronics module (2). Then push up electronics module and pull it as far as possible out of the wall-mount housing.
3. Disconnect the sensor signal cable plug (7.1) including HistoROM/S-DAT (7.2) and HistoROM/T-DAT (7.3) from amplifier board (7).
4. Remove the cover (4) from the electronics compartment by removing the screws.
5. Disconnect the ribbon cable plug (3) of the display module from amplifier board (7).
6. Remove the boards (6, 7, 8):
   Insert a thin pin into the hole (5) provided for the purpose and pull the board clear of its holder.
7. Installation is the reverse of the removal procedure.

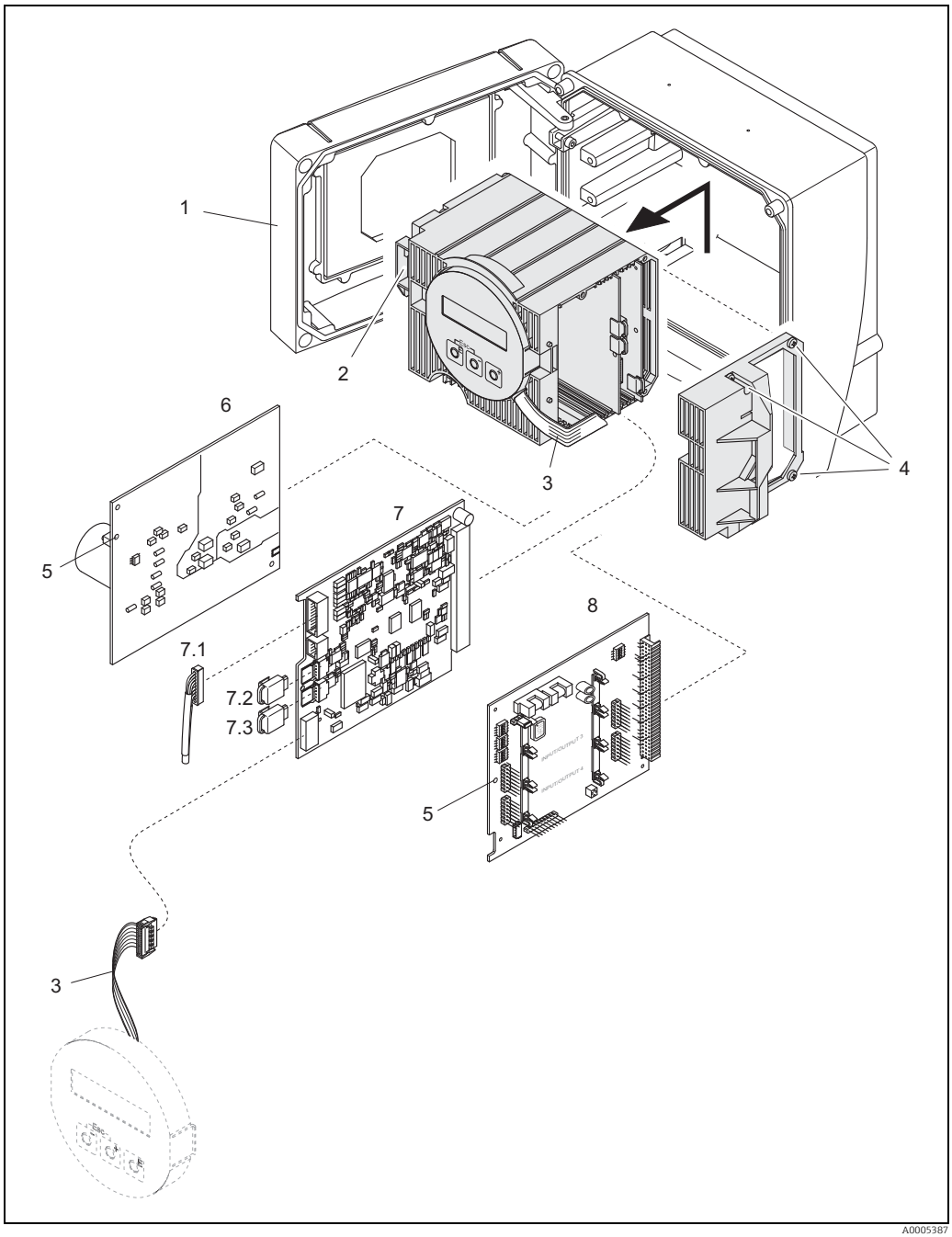

Fig. 44: Field housing: removing and installing printed circuit boards

1 Housing cover
2 Electronics module
3 Ribbon cable (display module)
4 Screws of electronics compartment cover
5 Aperture for installing/removing boards
6 Power unit board
7 Amplifier board
7.1 Signal cable (sensor)
7.2 HistoROM/S-DAT (sensor data memory)
7.3 HistoROM/T-DAT (transmitter data memory)
8 I/O board

Electronics housing sensor remote version

Warning!
- Risk of damaging electronic components (ESD protection). Static electricity can damage electronic components or impair their operability. Use a workplace with a grounded working surface purposely built for electrostatically sensitive devices!

- If you cannot guarantee that the dielectric strength of the measuring device can be maintained during the following steps, then an appropriate inspection test must be carried out in accordance with the manufacturer's specifications.
- When connecting Ex-certified measuring devices, see the notes and diagrams in the Ex-specific supplement to these Operating Instructions. Please do not hesitate to contact your Endress+Hauser sales center if you have any questions.

Caution!
Use only original Endress+Hauser parts.

Removal and installation → 45:

1. Remove the safety screw (1) and remove the cover (2) from the electronics compartment.
2. Disconnect the sensor cable plug (3).
3. Disconnect the remote cable from the terminal block (4).
4. Remove the two screws (5) from the printed circuit board
5. Remove printed circuit board (6)
6. Installation is the reverse of the removal procedure.

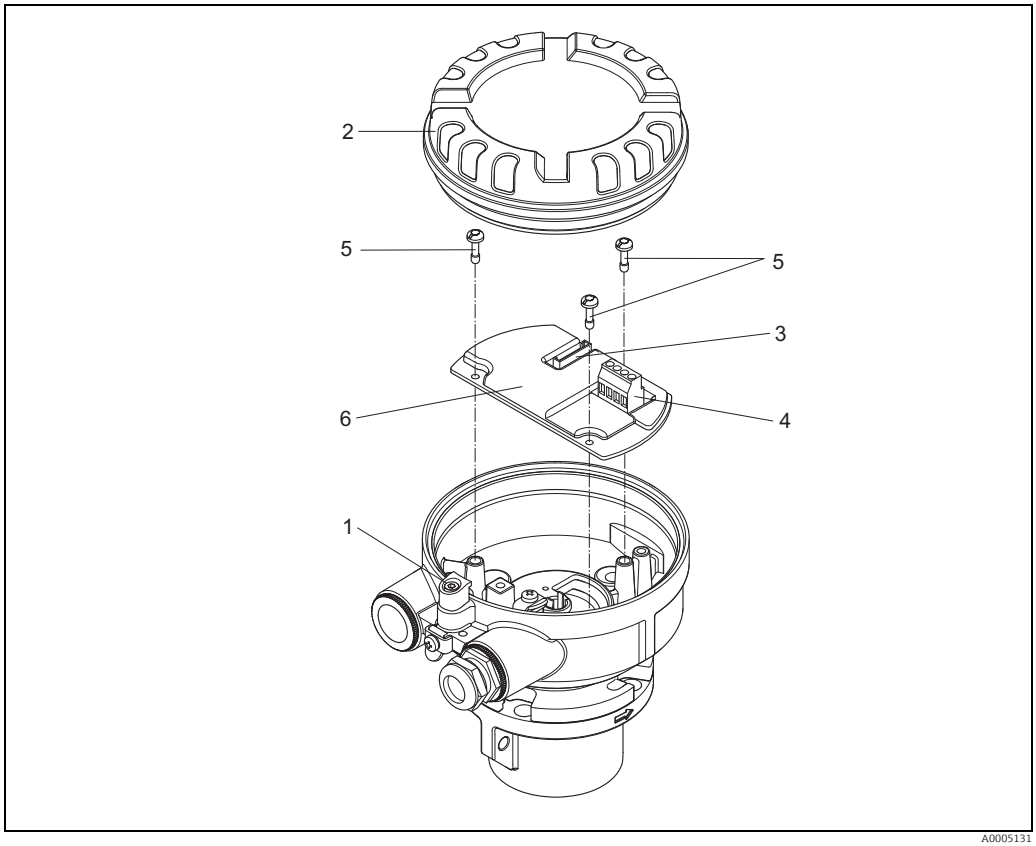

Fig. 45: Electronics compartment of the sensor housing remote version: removing and installing printed circuit board

Wire colors (when supplied by Endress+Hauser):
Terminal no. 41 = white; 42 = brown; 43 = green; 44 = yellow

10.6.2 Replacing the device fuse

Warning!
Risk of electric shock. Exposed components carry dangerous voltages. Switch off the power supply before you remove the cover of the electronics compartment.

The main fuse is on the power unit board.
The procedure for replacing the fuse is as follows:

1. Switch off the power supply.
2. Remove the power unit board → 📄 85
3. Remove the protection cap (1) and replace the device fuse (2).
   Only use the following fuse type:
   – Power supply 20 to 55 V AC / 16 to 62 V DC → 2.0 A slow-blow / 250 V; 5.2 x 20 mm
   – Power supply 85 to 260 V AC → 0.8 A slow-blow / 250 V; 5.2 x 20 mm
   – Ex-rated devices → see the Ex documentation.
4. Installation is the reverse of the removal procedure.

Caution!
Use only original Endress+Hauser parts.

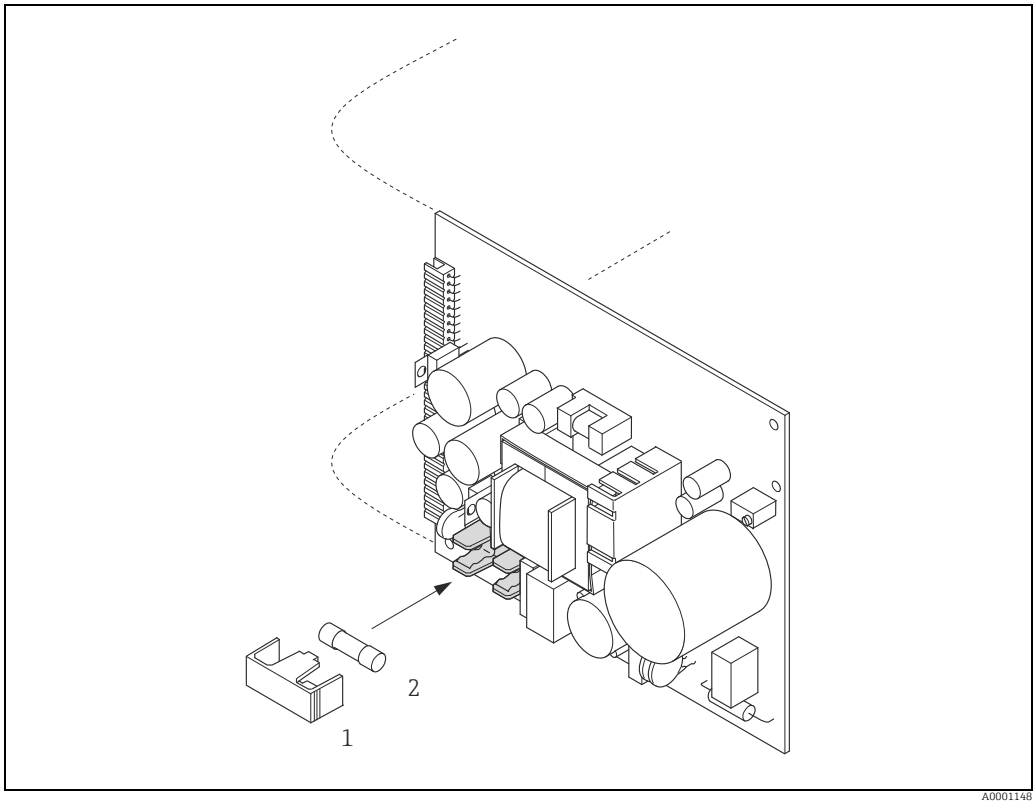

Fig. 46: Replacing the device fuse on the power unit board

1 Protective cap
2 Device fuse

10.7 Return

The measuring device must be returned if it is in need of repair or a factory calibration, or if the wrong measuring device has been delivered or ordered. According to legal regulations Endress+Hauser, as an ISO-certified company, is required to follow certain procedures when handling returned products that are in contact with the medium.
To ensure swift, safe and professional device returns, please read the return procedures and conditions on the Endress+Hauser website at www.services.endress.com/return-material

10.8 Disposal

10.8.1 Disassembling the measuring device

1. Switch off the device.
2. WARNING! Danger to persons from process conditions! Beware of hazardous process conditions such as pressure in the measuring device, high temperatures or aggressive fluids.

Carry out the mounting and connection procedure described in the "Mounting the measuring device" and "Connecting the measuring device" sections in the logically reverse order. Observe the safety instructions.

10.8.2 Disposing of the measuring device

Warning!
Hazardous fluids present a risk to humans and the environment!
- Ensure that the measuring device and all cavities are free of fluid residues that are hazardous to health or the environment, e.g. substances that have permeated into crevices or diffused through plastic.

Note the following when disposing of the device:
- Observe applicable national regulations.
- Separate and recycle the device components based on the materials.

10.9 Software history

Note!
Up or downloading a software version normally requires a special service software.

Date	Software version	Changes to software	Documentation
10.2010	3.06.XX	Software expansion: – second gas group in memory – gas heat flow and heat quantity – variable gas fraction input – revised diagnostics – Fieldcheck compatibility New functionalities: – Quick Setups for gas, pressure, heat flow and sensor – additional pressure units – system units for calorific value, heat flow and quantity heat – process pressure for gas group 1 + 2 – status input assignment for gas group – assignment of heat flow to display, totalizer and outputs – totalizer units for quantity heat flow – assignment of gas groups to outputs and totalizer – selection special gas with correction factors and reference density – insertion depth calculator – time stamping for process and system errors	71123865/13.10
02.2006	3.02.XX		71021612/02.06

11 Technical data

11.1 Applications

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11.2 Function and system design

Measuring principle

Mass flow measurement by the thermal dispersion principle.

Measuring system

The "t-mass 65" measuring device consists of the following components:
- t-mass 65 transmitter
- t-mass F, t-mass I sensor

Two versions are available:
- Compact version: transmitter and sensor form a single mechanical unit.
- Remote version: transmitter and sensor are installed separately.

11.3 Input

Measured variable

- Mass flow
- Gas temperature
- Gas heat flow

Measuring range

The measuring range is dependent upon:
- Gas
- Pressure
- Temperature
- Cross-sectional area of pipe or duct
- Use of flow conditioner (t-mass F sensor)

Please refer to Applicator, the Endress+Hauser sizing and selection software, for calculation of the measuring range.

Special applications

High gas velocities (>70 m/s)
In the event of high gas velocities, it is advisable to read in the process pressure dynamically or to enter the pressure very precisely as a velocity-dependent correction is performed.

Light gases

- Due to the very high thermal conductivity of hydrogen (H_2) (9 times that of air) and the fact that hydrogen is the lightest of all gases, it can prove very difficult to reliably measure this gas. Depending on the application, the flow rates of hydrogen are often particularly slow and the flow profiles are not sufficiently developed. It is not unusual for the flows to be in the laminar range, whereas a turbulent flow regime would be required for optimum measurement.
- Despite loss of accuracy and linearity in hydrogen applications with low flow rates, the t-mass 65 measures with good repeatability and is therefore suitable for monitoring flow conditions (e.g. leak detection).
- A linear, reliable measured value is difficult to obtain in applications with light gases with a Reynolds number below RE 4000. While this can be improved by making a special adjustment in the lower flow range, a loss of accuracy and linearity should be expected. It is advisable to contact your Endress+Hauser sales center if your application involves media with Reynolds numbers below RE 4000.

- When mounting, please note that the recommended upstream distances should be doubled for very light gases such as helium and hydrogen. → 📄 15

Input signal

Status input (auxiliary input)

U = 3 to 30 V DC, R_i = 3 kΩ, galvanically isolated. Switch level: ±3 to ±30 V DC, independent of polarity
Configurable for: reset totalizers, positive zero return, reset error messages

11.4 Output

Output signal

MODBUS RS485:

- MODBUS device type: slave
- Address range: 1 to 247
- Functions codes supported: 03, 04, 06, 08, 16, 23
- Broadcast: supported with the function codes 06, 16, 23
- Physical interface: RS485 in accordance with standard EIA/TIA-485
- Baudrate supported: 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 Baud
- Transmission mode: RTU or ASCII
- Parity: NONE, EVEN, ODD
- Response time:
  Direct data access = typically 25 to 50 ms
  Auto-scan buffer (data area) = typically 3 to 5 ms

Signal on alarm

If an error occurs, the value NaN (not a number) is output for the measured values.

Low flow cut off

Switch points for low flow cut off are programmable.
Factory setting = 1% of 20 mA Value

Galvanic isolation

All circuits for inputs, outputs and power supply are galvanically isolated from each other.

11.5 Power supply

Electrical connections

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Supply voltage

85 to 260 V AC, 45 to 65 Hz
20 to 55 V AC, 45 to 65 Hz
16 to 62 V DC

Power consumption

- AC: 85 to 260 V = 18.2 VA; 20 to 55 V = 14 VA ; (including sensor)
- DC: 8 W (including sensor)

Switch-on current:
- Max. 8 A (<5 ms) at 24 V DC
- Max. 4 A (<5 ms) at 260 V AC

Power supply failure

Lasting min. 1 power cycle:
- EEPROM/HistoROM/T-DAT saves measuring system data if the power supply fails.
- HistoROM S-DAT is an exchangeable data storage chip with sensor specific data: (pipe type, nominal diameter, serial number, flow conditioner, zero point, etc).
- Totalizer stops at the last value determined

Potential equalization

No measures necessary.
For measuring devices in hazardous areas please refer to the additional Ex documentation.

Cable entry

Power supply and signal cables (inputs/outputs):
- Cable entry M20 × 1.5 (8 to 12 mm (0.31 to 0.47 in))
- Threads for cable entries, ½" NPT, G ½"

Connecting cable for remote version:
- Cable entry M20 × 1.5 (8 to 12 mm (0.31 to 0.47 in))
- Threads for cable entries, ½" NPT, G ½"

Cable specifications (remote version)

→ 🖹 30

11.6 Performance characteristics

Reference conditions

- Traceable to National Standards
- Accredited according to ISO/IEC 17025
- Air-controlled to 24 °C ± 0.5 °C (75.2 °F ± 0.9 °F) at atmospheric pressure
- Humidity-controlled < 40% RH

Maximum measured error

t-mass 65F and t-mass 65I
±1.5 % of reading for 100 % to 10 % of range (at reference conditions)
±0.15 % of full scale for 10 % to 1 % of range (at reference conditions)

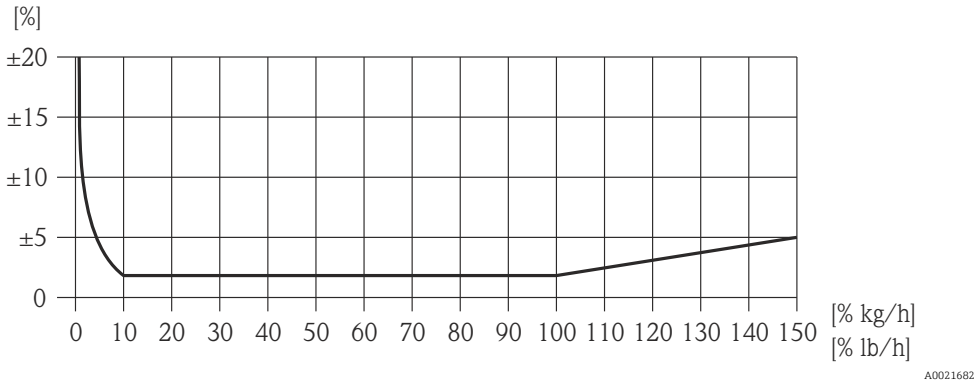

Fig. 47: Maximum measured error (% mass flow) as % of full scale value, see next table

Order code for "Calibration flow" (not verified)	Performance characteristics	Description
G	Q = 100 to 150 %: ±1.5 to ±5 % of the current measured value increasing linearly as expressed in the following equation: $\pm 1.5 \pm (X_n\text{-}100) \times 0.07$[% o.r.] (100 % < X_n ≤ 150 %; X_n = current flow in % o.f.s.) Q = 10 to 100 % of full scale value [1)] ±1.5 % o.r. Q = 1 to 10 % of full scale value [1)] ±0.15 % o.f.s. (all data under reference conditions)	Factory calibration: The measuring device is calibrated and adjusted on an accredited and traceable calibration rig and its accuracy is certified in a calibration report (3 control points).

Order code for "Calibration flow" (not verified)	Performance characteristics	Description
H	Q = 100 to 150 %: ±1.5 to ±5 % of the current measured value increasing linearly as expressed in the following equation: $\pm 1.5 \pm (X_n\text{-}100) \times 0.07$[% o.r.] (100 % < X_n ≤ 150 %; X_n = current flow in % o.f.s.) Q = 10 to 100 % of full scale value [1)] ±1.5 % o.r. Q = 1 to 10 % of full scale value [1)] ±0.15 % o.f.s. (all data under reference conditions)	Factory calibration + flow conditioner[2)]: The measuring device is calibrated and adjusted on an accredited and traceable calibration rig with a flow conditioner and its accuracy is certified in a calibration report (3 control points).
K	Q = 100 to 150 %: ±1.5 to ±5 % of the current measured value increasing linearly as expressed in the following equation: $\pm 1.5 \pm (X_n\text{-}100) \times 0.07$[% o.r.] (100 % < X_n ≤ 150 %; X_n = current flow in % o.f.s.) Q = 10 to 100 % of full scale value [1)] ±1.5 % o.r. Q = 1 to 10 % of full scale value [1)] ±0.15 % o.f.s. (all data under reference conditions)	5-point, traceable ISO/IEC17025: The measuring device is calibrated and adjusted on an accredited and traceable calibration rig and its accuracy is certified in a Swiss Calibration Services (SCS) calibration report (5 control points), which confirms traceability to the national calibration standard.
L	Q = 100 to 150 %: ±1.5 to ±5 % of the current measured value increasing linearly as expressed in the following equation: $\pm 1.5 \pm (X_n\text{-}100) \times 0.07$[% o.r.] (100 % < X_n ≤ 150 %; X_n = current flow in % o.f.s.) Q = 10 to 100 % of full scale value [1)] ±1.5 % o.r. Q = 1 to 10 % of full scale value [1)] ±0.15 % o.f.s. (all data under reference conditions)	5-point, traceable ISO/IEC17025 + flow conditioner[2)]: The measuring device is calibrated and adjusted on an accredited and traceable calibration rig with a flow conditioner and its accuracy is certified in a Swiss Calibration Services (SCS) calibration report (5 control points), which confirms traceability to the national calibration standard.

1. The full scale value depends on the nominal diameter of the device and the maximum flow capacity of the calibration rig. The full scale values are listed in the following section.
2. A flow conditioner is also supplied.

Repeatability ±0.5 % of reading for velocities above 1.0 m/s (0.3 ft/s)

Response time

Typically less than 2 seconds for 63 % of a given step change (in either direction).

Influence of medium pressure (Pressure co-efficient)

Air: 0.35 % per bar (0.02% per psi) of process pressure change

11.7 Installation

Installation section → 🖹 11

11.8 Environment

Ambient temperature range

Standard: −20 to +60 °C (−4 to +140 °F)
Optional: −40 to +60 °C (−40 to +140 °F)

Note!
- Install the device in a shady location. Avoid direct sunlight, particularly in warm climatic regions. (A protective sun cover is available on request)
- At ambient temperatures below −20 °C (−4 °F) the readability of the display may be impaired.

Storage temperature

−40 to +80 °C (−40 to +176 °F), recommended +20 °C (+68 °F)

Degree of protection

Standard: IP 67 (NEMA 4X) for transmitter and sensor

Shock resistance

According to IEC 60068-2-31

Vibration resistance

Acceleration up to 1 g, 10 to 150 Hz, following IEC 60068-2-6

Electromagnetic compatibility (EMC)

To IEC/EN 61326 and NAMUR recommendation NE 21

11.9 Process

Medium temperature range

Sensor

t-mass F:
−40 to +100 °C (−40 to +212 °F)

t-mass I:
−40 to +130 °C (−40 to +266 °F)

Seals t-mass F

O-rings:
Viton FKM −20 to +100 °C (−4 to +212 °F)
Kalrez −20 to +100 °C (−4 to +212 °F)
EPDM −40 to +100 °C (−40 to +212 °F)

Bushing:
PEEK −40 to +100 °C (−40 to +212 °F)

Seals t-mass I

Bonded seals:
Kalrez −20 to +130 °C (−4 to +266 °F)
EPDM −40 to +130 °C (−40 to +266 °F)
Nitrile −35 to +130 °C (−31 to +266 °F)

Ferrule:
PEEK, PVDF −40 to +130 °C (−40 to +266 °F)

Note
We recommend special materials (Alloy and PVDF) for aggressive media (e.g. chlorine or ozone). Please contact your Endress+Hauser sales center for clarification.

Media

The following media and media mixtures can be measured. A mixture can consist of up to 8 components from the following list.

AIR	ETHANE	METHANE
AMMONIA	ETHYLENE	NEON
ARGON	HELIUM 4	NITROGEN
BUTANE	HYDROGEN NORMAL	OXYGEN
CARBON DIOXIDE	HYDROGEN CHLORIDE	PROPANE
CARBON MONOXIDE	HYDROGEN SULFIDE	XENON
CHLORINE	KRYPTON	

Note
Other media (e.g. ozone) available on request. Contact your Endress+Hauser sales center for clarification.

Pressure-temperature ratings

Note!
An overview of the pressure-temperature ratings for the process connections is provided in the Technical Information

Flow limit

See "Measuring range" section → 🖹 93.
The velocity in the measuring tube should not exceed 130 m/s (427 ft/s), (in air).

Pressure loss

Negligible (without flow conditioner).
Refer to Applicator for the precise calculation → 🖹 73

Medium pressure range (nominal pressure)

t-mass F:
−0.5 to 40 barg (−7.25 to 580 psig)

t-mass I:
−0.5 to 20 barg (−7.25 to 290 psig)

Limiting medium pressure range (nominal pressure)

The material load diagrams (pressure-temperature ratings) for the process connections are provided in the separate "Technical Information" document for the particular measuring device. This can be downloaded as a PDF file at www.endress.com.
A list of the "Technical Information" documents: → 🖹 103

Hot tap, process pressure

The Hot tap for mounting and removal at process pressure may only be used with non-toxic, innocuous gases classified as "Group II" in accordance with European Directive 67/548/EEC Art. 2.

Medium pressure version
Max. process pressure: 20 barg (290 psig)
Max. extraction press: 16 barg (230 psig)
Max. extraction temperature: +50 °C (+122 °F)
Min. sensor length: 435 mm (17 in)

Low pressure version
Max. process pressure: 20 barg (290 psig)
Max. extraction press: 4,5 barg (65 psig)
Max. extraction temperature: +50 °C (+122 °F)
Min. sensor length: 335 mm (13 in)

Cold tap, atmospheric pressure

Cold tap for mounting and removal at atmospheric pressure
Max. process pressure: 20 barg (290 psig)
Max. extraction pressure: 1 bar(a) (14.5 psia)
Max. extraction temperature: +50 °C (+122 °F)
Min. sensor length: 335 mm (13 in)

11.10 Mechanical construction

Design / dimensions

Dimensions and the fitting lengths of the transmitter and sensor are provided in the separate "Technical Information" document on the device in question. This can be downloaded as a PDF file from www.endress.com.
A list of the "Technical Information" documents: → 🖹 103

Weight

- Wall-mount housing of remote version: 5 kg (11 lb)

Weight (SI units)

t-mass F* / DN	15	25	40	50	80	100
Compact version	7.5	8.0	12.5	12.5	18.7	27.9
Remote version	5.5	6.0	10.5	10.5	16.7	25.9

Weight dimensions in [kg]
* For flanged versions, all values (weight) refer to measuring devices with EN/DIN PN 40 flanges.

t-mass I / sensor length [mm]	235	335	435	608
Compact version	6.4	6.6	7.0	7.4
Remote version	4.4	4.6	5.0	5.4

Weight dimensions in [kg]

Weight (US units)

t-mass F* / DN [inch]	½"	1"	1½"	2"	3"	4"
Compact version	16.5	17.6	27.5	27.5	41.2	61.5
Remote version	12.1	13.2	23.1	23.1	36.7	57.1

Weight dimensions in [lb]
* For flanged versions, all values (weight) refer to measuring devices with "Cl 150" flanges.

t-mass I / sensor length [inch]	9.25"	13.2"	17.1"	24.0"
Compact version	14.1	14.5	15.4	16.3
Remote version	9.7	10.1	11.0	11.9

Weight dimensions in [lb]

Materials

Transmitter housing
- Compact housing: powder coated die-cast aluminum
- Wall-mount housing: powder coated die-cast aluminum
- Remote field housing: powder coated die-cast aluminum

Connection housing, sensor (remote version)
Powder coated die-cast aluminum

t-mass F sensor

Measuring tube:
- In contact with medium:
  - DN 15 to 25 (½ to 1"): stainless cast steel CF3M-A351
  - DN 40 to 100 (1 ½ to 4"): 1.4404 (316/316L)
- Not in contact with medium:
  - 1.4301 (304)

Flanges (process connections):
Stainless steel 1.4404 (316L/316)

Transducer:
- 1.4404 (316L)
- Alloy C22, 2.4602 (N06022)

Transducer elements:
- 1.4404 (316L) or
- 1.4404 (316L)
- Alloy C22, 2.4602 (N06022)

Bushing:
PEEK GF30, PVDF

O-rings:
EPDM, Kalrez 6375, Viton FKM

t-mass I sensor

Insertion tube:
- Sensor length 235 (9"), 335 (13"), 435 (17"), 608 (24")
- 1.4404 (316/316L)
- Special lengths and full Alloy C22 versions on request

Transducer:
- 1.4404 (316L)
- Alloy C22, 2.4602 (N06022)

Protection guard:
1.4404 (316L)

Compression fitting:
1.4404 (316/316L)

Ferrule:
PEEK 450G, PVDF (on request)

Bonded seals:
EPDM, Kalrez 6375, Nitrile and 316/316L (outer ring)

Hot tap, process pressure

Lower tube section:
1.4404 (316/316L)

Upper tube section:
1.4404 (316/316L)

Ball valve:
CF3M and CF8M

Seal:
PTFE

Cold tap, atmospheric pressure

Lower tube section:
1.4404 to EN 10272 and 316/316L to A479

Upper tube section:
1.4404 to EN 10216-5 and 316/316L to A312

Ball valve:
CF3M and CF8M

Seal:
PTFE

Process connections

For both the flanged and insertion meters it is possible to have wetted parts degreased for oxygen service. Further information is available from your Endress+Hauser sales center.

t-mass F:
Flanges according EN 1092-1, JIS B2220 and ASME B16.5

t-mass I:
G 1A or 1" MNPT thread

11.11 Operability

Display elements

- Liquid crystal display: illuminated, two lines with 16 characters per line
- Selectable display of different measured values and status variables
- At ambient temperatures below −20 °C (−4 °F) the readability of the display may be impaired.

Operating elements

- Local operation with three keys (−, +, E)
- Quick Setup menus for straight forward commissioning

Languages

English, German, French, Spanish, Italian, Dutch, Norwegian, Finnish, Swedish, Portuguese, Polish, Czech

11.12 Certificates and approvals

CE mark

The measuring system is in conformity with the statutory requirements of the applicable EC Directives. These are listed in the corresponding EC Declaration of Conformity along with the standards applied.
Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.

C-Tick mark

The measuring system meets the EMC requirements of the Australian Communications and Media Authority (ACMA).

Ex approval

Information about currently available Ex versions (ATEX, FM, CSA etc.) is available from your Endress+Hauser sales center. All explosion protection data are given in a separate documentation which is available upon request.

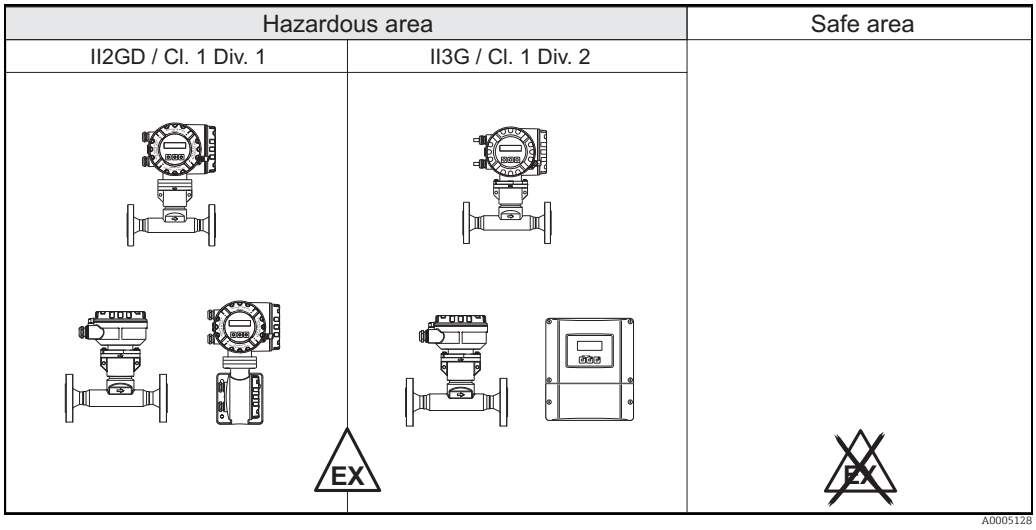

Fig. 48: Example of t-mass devices in the hazardous area (Example t-mass 65F)

PROFIBUS DP/PA certification

The flowmeter has passed all the test procedures implemented and has been certified and registered by the PNO (PROFIBUS User Organization). The device thus meets all the requirements of the following specifications:

- Certified in accordance with PROFIBUS Profile Version 3.0 (device certification number: available on request)
- The device can also be operated in conjunction with other-make certified devices (interoperability).

Pressure measuring device approval

- With the identification PED/G1/x (x = category) on the sensor nameplate, Endress+Hauser confirms conformity with the "Essential safety requirements" of Appendix I of the Pressure Equipment Directive 97/23/EC.
- Devices with this identification (with PED) are suitable for the following types of fluid: Fluids of Group 1 and 2 with a steam pressure of greater than, or smaller and equal to 0.5 bar (7.3 psi).
- Devices without this identification (without PED) are designed and manufactured according to good engineering practice. They correspond to the requirements of Art. 3, Section 3 of the Pressure Equipment Directive 97/23/EC. Their application is illustrated in Diagrams 6 to 9 in Appendix II of the Pressure Equipment Directive 97/23/EC.

Oxygen service

For oxygen applications with the order code for "Surface cleaning" option B "Certified and cleaned of oil and grease"
We certify that the wetted parts of the flow sensor have been degreased in accordance with British Oxygen Company (BOC) specification 50000810 and BS-IEC-60877:1999. After final degreasing there shall be less than 100 milligram/m² (0.01 milligram/cm²) of oil/grease contamination on the degreased surface of the component.

Other standards and guidelines

- BS IEC 60877:1999
  Procedures for ensuring the cleanliness of industrial-process measurement and control equipment in oxygen service.
- EN 60529
  Degrees of protection by housing (IP code)
- EN 61010-1
  Protection Measures for Electrical Equipment for Measurement, Control, Regulation and Laboratory Procedures.
- IEC/EN 61326
  "Emission in accordance with requirements for Class A".
  Electromagnetic compatibility (EMC- requirements).
- EN 91/155/EEC
  Safety Data Sheets Directive.
- ISO/IEC 17025
  General requirements for the competence of testing and calibration laboratories.
- ISO 14511
  Measurement of fluid flow in closed conduits - Thermal mass flowmeters.
- NAMUR NE 21
  Electromagnetic compatibility (EMC) of industrial process and laboratory control equipment.
- NAMUR NE 43
  Standardization of the signal level for the breakdown information of digital transmitters with analogue output signal.
- NAMUR NE 53
  Software of field devices and signal-processing devices with digital electronics

11.13 Ordering information

The Endress +Hauser sales center can provide detailed ordering information and information on the extended order code.

11.14 Accessories

Various accessories, which can be ordered separately from Endress+Hauser, are available for the transmitter and the sensor → 73

11.15 Documentation

- Technical Information t-mass 65F, 65I (TI00069D/06)
- Description of Device Functions t-mass 65 (BA00114D/06)
- Supplementary documentation on Ex-ratings: ATEX, FM, CSA, IECEx, NEPSI
- Flow measuring technology (FA00005D/06/)

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