

Portable Ultrasonic Flowmeter Portalok 7S



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1 Introduction

1.1 Regarding this User Manual

This user manual has been written for the personnel operating the ultrasonic flowmeter Portalok 7S. It contains important information about the measuring instrument, how to handle it correctly, and how to avoid damages.

Read the safety instructions carefully. Make sure you have read and understood this user manual before using the measuring instrument.

All reasonable effort has been made to ensure the correctness of the content of this user manual. However, If you find any erroneous information, please inform us. We will be grateful for any suggestions and comments regarding the concept and your experience working with the measuring instrument.

This will ensure that we can further develop our products for the benefit of our customers and in the interest of technological progress. If you have any suggestions about improving the documentation and particularly this user manual, please let us know so that we can consider your comments for future reprints.

The contents of this user manual are subject to changes without prior notice. All rights reserved. No part of this user manual may be reproduced in any form without EESiFlo's written permission.

1.2 Safety Instructions

The user manual contains instructions that are marked as follows:

Note!	This text contains important information about the use of the measuring instrument.
Attention!	This text contains important instructions which should be observed to avoid damage or destruction of the measuring instrument. Proceed with special caution!

Observe these safety instructions!

1.3 Warranty

The Portalok 7S measuring instrument is guaranteed for the term and to the conditions specified in the sales contract provided the equipment has been used for the purpose for which it has been designed and operated according to the instructions given in this User Manual. Misuse of the flowmeter will immediately revoke any warranty given or implied.

This includes:

- replacement of a component of Portalok 7S with a component that was not approved by EESiFlo
- unsuitable or insufficient maintenance
- repair of Portalok 7S by unauthorized personnel

EESiFlo assumes no responsibility for injury to the customer or third persons proximately caused by the material owing to defects in the product which were not predictable or for any indirect damages.

Portalok 7S is a very reliable instrument. It is manufactured under strict quality control using modern production techniques. If installed as recommended in an appropriate location, used cautiously and taken care of conscientiously, no troubles should appear.

In case of a problem which cannot be solved with the help of this user manual (see chapter 17), contact our sales office giving a precise description of the problem. Specify the type, serial number and firmware version of the measuring instrument.

2 Handling

2.1 First Inspection

The measuring instrument has already been tested thoroughly at EESiFlo. At delivery, ensure that no damage has occurred during transportation.

Check that the specifications of the measuring instrument delivered correspond to the specifications given on the purchase order.

The type and the serial number of the transmitter are shown on the nameplate. The transducer type is printed on the transducers.

2.2 General Precautions

Portalok 7S is a precise measuring instrument and has to be handled with care. To obtain good measurement results and not damage the measuring instrument, it is important that great attention is paid to the instructions given in this user manual, particularly to the following points:

- Protect the transmitter from shocks.
- Keep the transducers clean. Manipulate the transducer cables with caution. Avoid excessive cable bend.
- Make sure to work under correct ambient and operating temperatures. The ambient temperature has to be within the operating temperature range of the transmitter and the transducers.
- Observe the degree of protection.

2.3 Cleaning

- Clean the transmitter with a soft cloth. Do not use detergents.
- Remove traces of the coupling compound from the transducers with a soft paper towel.

3 General Principles

For the ultrasonic measurement of the flow rate, the flow velocity of the medium flowing in a pipe is determined. Further physical quantities (e.g., volumetric flow rate, mass flow rate) are derived from the flow velocity and from additional physical quantities, if necessary.

3.1 Measurement System

The measurement system consists of a transmitter, the ultrasonic transducers with the transducer cables and the pipe on which the measurement is conducted.

The ultrasonic transducers are mounted on the outside of the pipe. Ultrasonic signals are sent through the medium and received by the transducers. The transmitter controls the measuring cycle, eliminates the disturbance signals and analyzes the useful signals. The measured values can be displayed, used for calculations and transmitted.

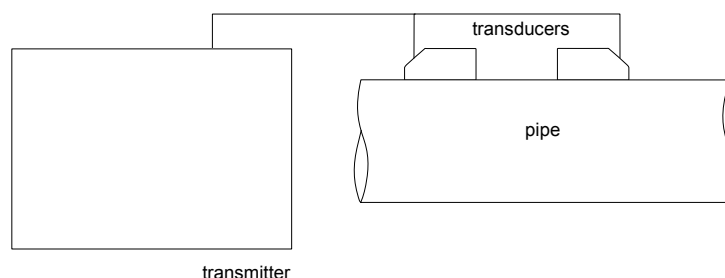


Fig. 3.1: Example of a measurement setup

3.2 Measurement Principle

The flow velocity of the medium is measured using the transit time difference correlation principle (see section 3.2.2).

3.2.1 Terms

Flow profile

Distribution of the flow velocities over the cross-sectional pipe area. For an optimal measurement, the flow profile has to be fully developed and axisymmetrical. The shape of the flow profile depends on whether the flow is laminar or turbulent and is influenced by the conditions in the supply line of the measuring point (see chapter 5).

Reynolds number Re

Coefficient describing the turbulence behavior of a medium in the pipe. The Reynolds number Re is calculated from the flow velocity, the kinematic viscosity of the medium and the inner pipe diameter.

If the Reynolds number exceeds a critical value (usually approx. 2 300), a transition from a laminar flow to a turbulent flow takes place.

Laminar flow

A flow without any turbulence. There is no disruption between the parallel flowing layers of the medium.

Turbulent flow

A flow in which turbulence (swirling of the medium) occurs. In technical applications, the flow in the pipe is mostly turbulent.

Transition range

The flow is partly laminar and partly turbulent.

Transit time difference Δt

Difference of the transit times of the signals in and against the flow direction. The flow velocity of the medium in the pipe is determined from the transit time difference (see Fig. 3.2 and Fig. 3.3).

Sound speed c

Speed of the propagating sound. The sound speed depends on the mechanical properties of the medium and the pipe material. In pipe materials and other solid materials, a distinction is made between the longitudinal and transversal sound speed. For the sound speed of some media and materials see annex C.1.

Flow velocity v

The average value of the flow velocities over the cross-sectional pipe area.

Acoustic calibration factor k_a

$$k_a = c_\alpha / \sin \alpha$$

The acoustic calibration factor k_a is a parameter of the transducer which results from the sound speed c within the transducer and the angle of incidence (see Fig. 3.2). According to Snell's law of refraction, the angle of propagation in the adjoining medium or pipe material is:

$$k_a = c_\alpha / \sin \alpha = c_\beta / \sin \beta = c_\gamma / \sin \gamma$$

Volumetric Flow Rate \dot{V}

$$\dot{V} = v \cdot A$$

The volume of the medium that passes through the pipe per unit time. The volumetric flow rate is calculated from the product of the flow velocity v and the cross-sectional pipe area A .

Fluid mechanics correction factor k_{Re}

With the fluid mechanics correction factor k_{Re} , the measured value of the flow velocity in the area of the sound beam is converted into the value of the flow velocity across the whole cross-sectional pipe area. In case of a fully developed flow profile, the fluid mechanics correction factor only depends on the Reynolds number and the roughness of the inner pipe wall. The fluid mechanics correction factor is recalculated by the transmitter for each new measurement.

Mass flow rate \dot{m}

$$\dot{m} = \dot{V} \cdot \rho$$

The mass of the medium that passes through the pipe per unit time. The mass flow rate is calculated from the product of the volumetric flow rate \dot{V} and the density ρ .

3.2.2 Measurement of the Flow Velocity

The signals are emitted and received by two transducers alternatively in and against the flow direction. If the medium moves, the signals propagating in the medium are displaced with the flow. This displacement causes a reduction in distance for the signal in the flow direction and an increase in distance for the signal against the flow direction in the wedge of the receiving transducer (see Fig. 3.2 and Fig. 3.3). This causes a change in the transit times. The transit time of the signal in the flow direction is shorter than the transit time against the flow direction. This transit time difference is proportional to the average flow velocity.

The flow velocity of the medium is calculated as follows:

$$v = k_{Re} \cdot k_a \cdot \Delta t / (2 \cdot t_{fl})$$

with

- v - flow velocity of the medium
- k_{Re} - fluid mechanics correction factor
- k_a - acoustic calibration factor
- Δt - transit time difference
- t_{fl} - transit time in the medium

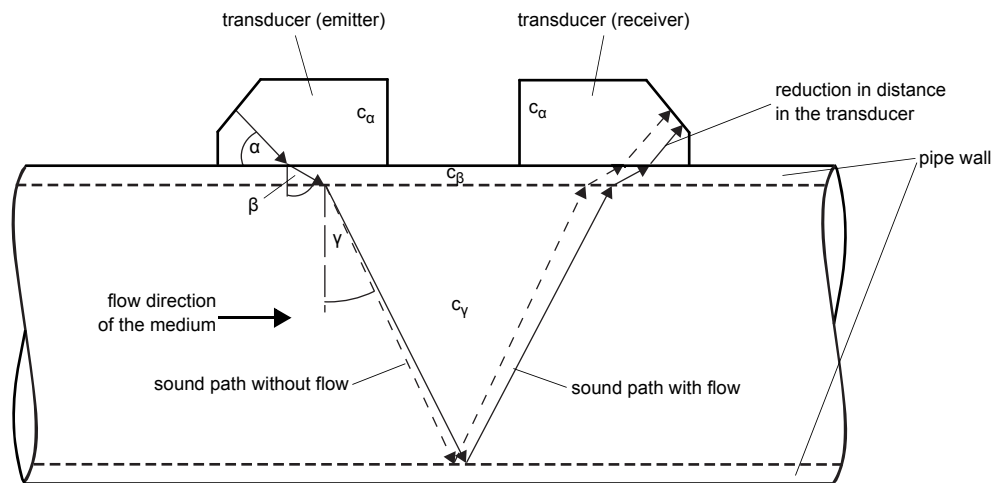


Fig. 3.2: Sound path of the signal in the flow direction

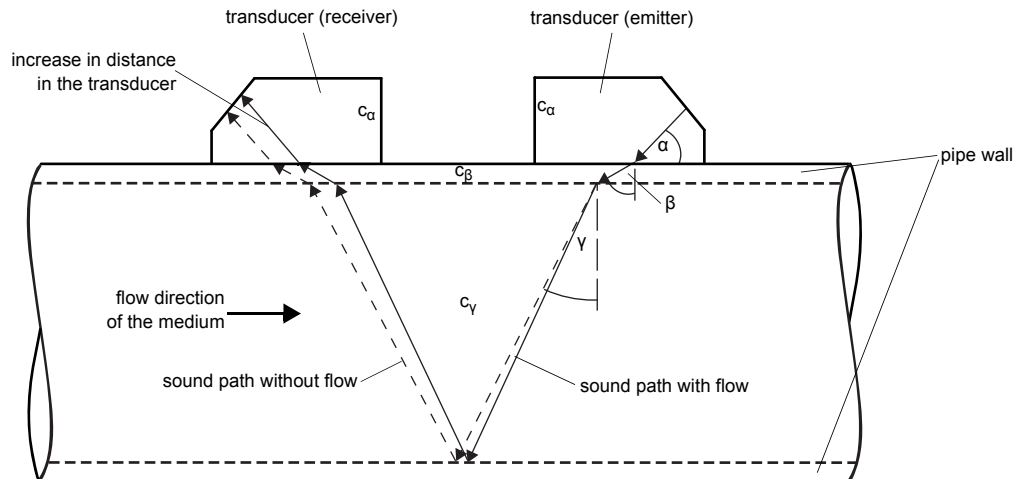
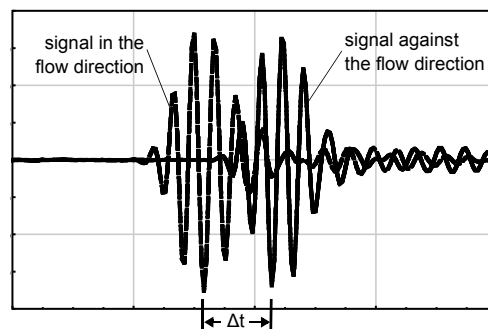


Fig. 3.3: Sound path of the signal against the flow direction

Fig. 3.4: Transit time difference Δt

3.3 Measurement Arrangements

3.3.1 Terms and Definitions

Diagonal arrangement

The transducers are mounted on the opposite sides of the pipe (see Fig. 3.5).

Reflection arrangement

The transducers are mounted on the same side of the pipe (see Fig. 3.6).

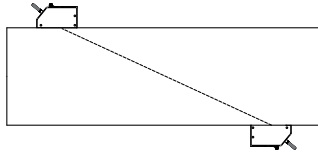


Fig. 3.5: Diagonal arrangement

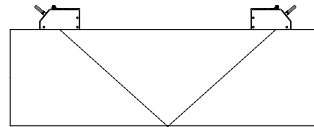


Fig. 3.6: Reflection arrangement

Number of sound paths

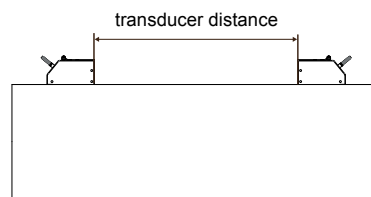
The number of times the ultrasonic signal traverses the liquid before arriving at the receiving transducer. The number of sound paths is:

- odd if the measurement is conducted in the diagonal arrangement (see Fig. 3.5)
- even if the measurement is conducted in the reflection arrangement (see Fig. 3.6).

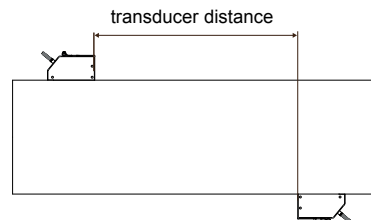
Transducer distance

Distance between the transducers. It is measured between the inner edges of the transducers.

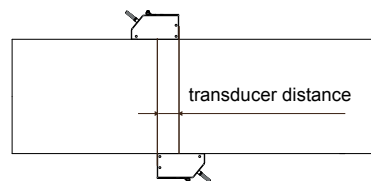
reflection arrangement



diagonal arrangement
(positive transducer distance)



diagonal arrangement
(negative transducer distance)



Sound plane

The plane containing the sound paths (see Fig. 3.7).

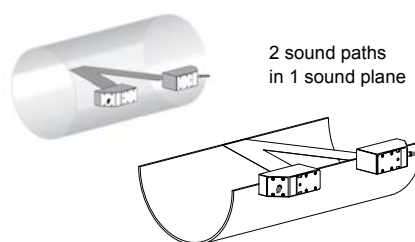
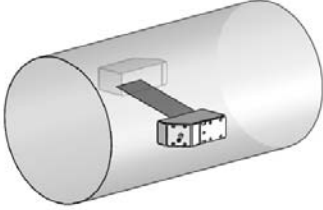
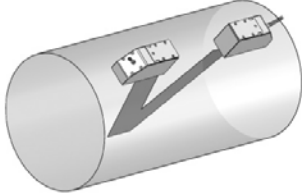


Fig. 3.7: Sound paths in a sound plane

3.3.2 Examples

Diagonal arrangement	Reflection arrangement
<p data-bbox="204 338 387 400">1 transducer pair 1 sound path</p> 	<p data-bbox="850 338 1034 400">1 transducer pair 2 sound paths</p> 

4 Description of the Transmitter

The transmitter Portalok 7S has 1 measuring channel.

The cover has to be opened to access the command panel.

Attention! The degree of protection of the transmitter is only ensured if the cable glands are firmly tightened, the housing is tightly screwed and the cover is closed and latched.

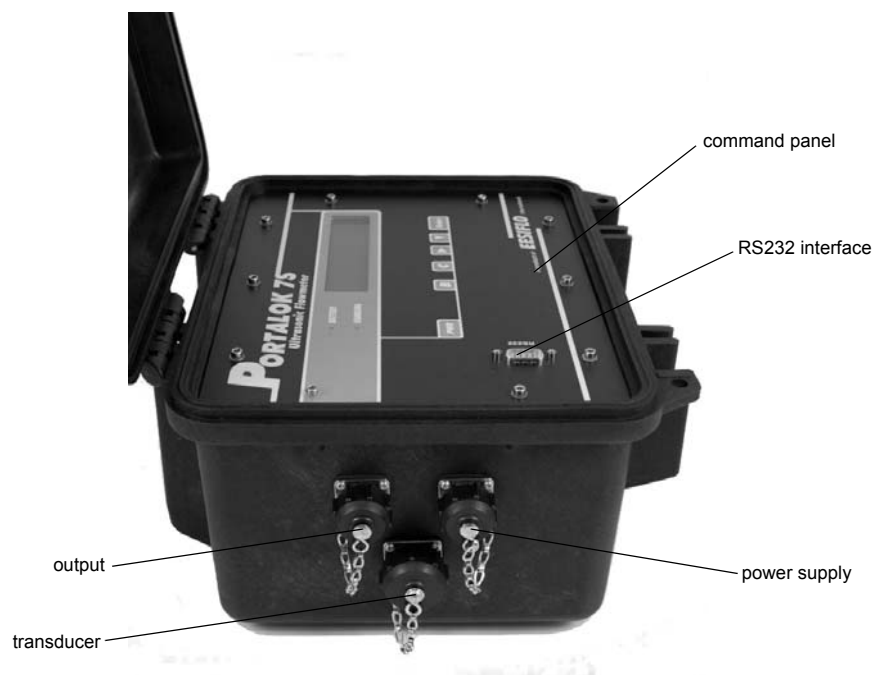


Fig. 4.1: Connections and command panel of the transmitter Portalok 7S



Fig. 4.2: Command panel of the transmitter Portalok 7S



4.1 Keyboard

The keyboard consists of 5 keys.



Tab. 4.1: General functions

PWR	switching the transmitter on/off, switching the backlight on/off Press key PWR briefly to switch on the transmitter or to switch on/off the backlight when the transmitter is on. Press key PWR for 3 seconds to switch off the transmitter.
ENTER	confirmation of selection or entered value
B + C	INIT: Press these two keys while switching on the transmitter to perform an initialization (see section 8.2).
B + C + ENTER	RESET: Press these three keys simultaneously to correct a malfunction. The reset has the same effect as restarting the transmitter. Stored data are not affected.
B	interruption of the measurement and selection of the main menu Be careful not to stop a current measurement by inadvertently pressing key B!



Tab. 4.2: Navigation

	scrolling to the right or up through a scroll list
	scrolling to the left or down through a scroll list

Tab. 4.3: Input of digits

	moving the cursor to the right
	scrolling through the digits above the cursor
C	Moving the cursor to the left. If the cursor is on the left margin: <ul style="list-style-type: none"> • an already edited value will be reset to the value which was stored previously • an unedited value will be deleted. If the entered value is not valid, an error message will be displayed. Press ENTER and enter a correct value.

Tab. 4.4: Input of text

	moving the cursor to the right
	scrolling through the characters above the cursor
C	resetting all characters to the last stored entry

5 Selection of the Measuring Point

Attention! Portalok 7S is must not be used in explosive atmospheres. If the measuring point is within a potentially explosive atmosphere, the danger zone and gases that may be present have to be determined. The transducers and the transmitter have to be appropriate for these conditions.

The correct selection of the measuring point is crucial for achieving reliable measurement results and a high measurement accuracy.

A measurement on a pipe is possible if

- the ultrasound propagates with a sufficiently high amplitude (see section 5.1)
- the flow profile is fully developed (see section 5.2)

The correct selection of the measuring point and thus, the correct transducer positioning guarantees that the sound signal will be received under optimum conditions and evaluated correctly.

Due to the variety of applications and the different factors that influence the measurement, there is no standard solution for the transducer positioning. The correct position of the transducers is influenced by the following factors:

- diameter, material, lining, wall thickness and shape of the pipe
- medium
- gas bubbles in the medium

Avoid measuring points in the vicinity of deformations and defects of the pipe and in the vicinity of welds.

Avoid locations with deposit formation in the pipe.

The ambient temperature at the measuring point has to be within the operating temperature range of the transducers.

Select the location of the transmitter within cable reach of the measuring point.

The ambient temperature at the location has to be within the operating temperature range of the transmitter.

5.1 Acoustic Penetration

The pipe has to be acoustically penetrable at the measuring point. The acoustic penetration is reached when pipe and medium do not attenuate the sound signal so strongly that it is completely absorbed before reaching the second transducer.

The attenuation in the pipe and in the medium depends on:

- kinematic viscosity of the medium
- proportion of gas bubbles and solids in the medium
- deposits on the inner pipe wall
- pipe material

The following requirements have to be met at the measuring point:

- the pipe is always filled completely
- no material deposits in the pipe
- no bubbles accumulate

Note! Even bubble-free media can form gas bubbles when the medium expands, e.g., before pumps and after large increases of the pipe diameter.

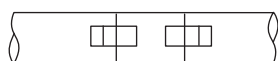
Observe the notes in the following table.

Tab. 5.1: Recommended transducer position

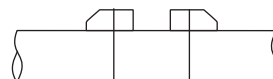
Horizontal pipe

Select a measuring point where the transducers can be mounted on the side of the pipe, allowing the sound waves to propagate in the pipe horizontally. Thus, solid at the bottom or gas bubbles at the top of the pipe will not influence the propagation of the signal.

correct:

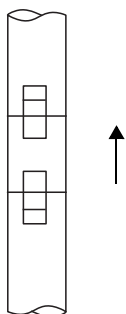


disadvantageous:

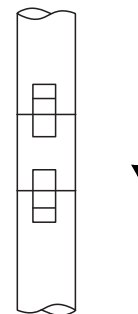
**Vertical pipe**

Select the measuring point at a pipe location where the medium flows upward. The pipe has to be completely filled.

correct:

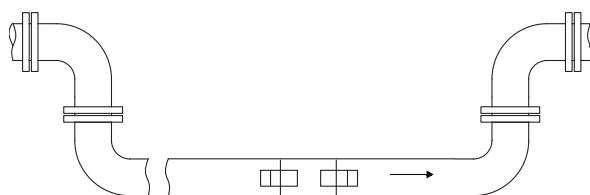


disadvantageous:

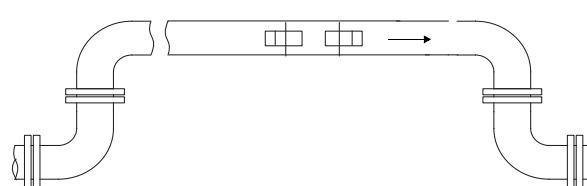
**Free inlet or outlet pipe section:**

Select the measuring point at a pipe location where the pipe cannot run empty.

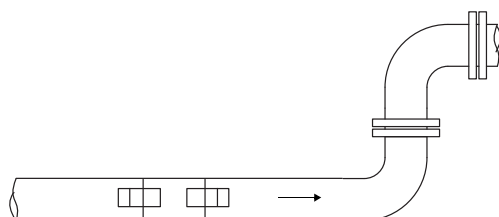
correct:



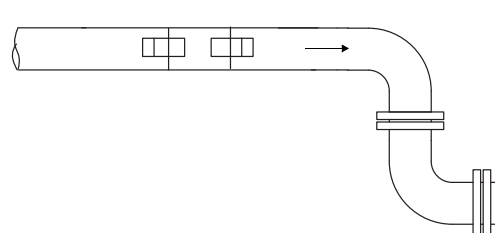
disadvantageous:



correct:



disadvantageous:



5.2 Undisturbed Flow Profile

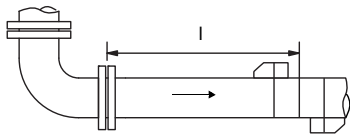
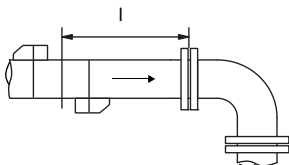
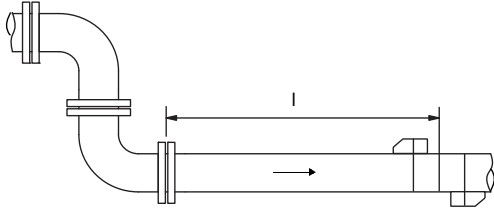
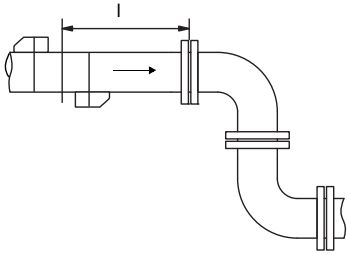
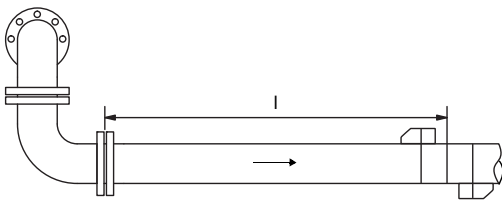
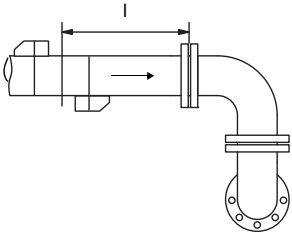
Some flow elements (elbows, slide valves, valves, control valves, pumps, reducers, diffusers, etc.) distort the flow profile in their vicinity. The axisymmetrical flow profile needed for correct measurement is no longer given. A careful selection of the measuring point helps to reduce the impact of disturbance sources.

It is most important that the measuring point is chosen at a sufficient distance from any disturbance sources. Only then it can be assumed that the flow profile in the pipe is fully developed. However, measuring results can be obtained even if the recommended distance to disturbance sources cannot be observed for practical reasons.

Recommended straight inlet and outlet pipe lengths for different types of flow disturbance sources are shown in the examples in Tab. 5.2.

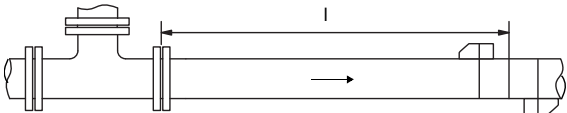
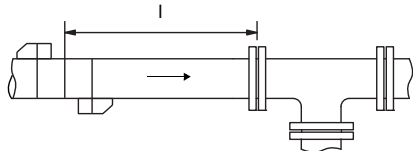
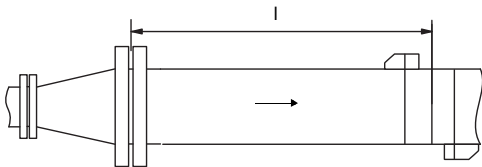
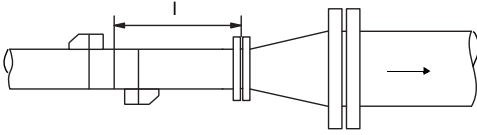
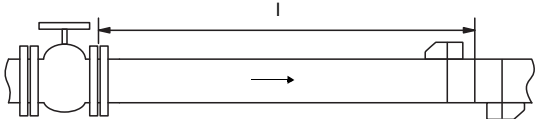
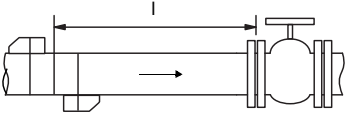
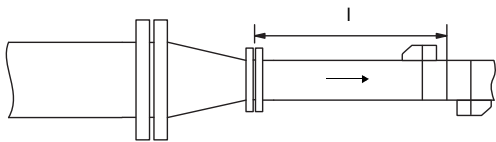
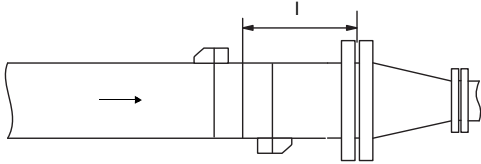
Tab. 5.2: Recommended distance from disturbance sources

D = nominal pipe diameter at the measuring point, l = recommended distance

<p>disturbance source: 90° elbow</p> <p>supply line: $l \geq 10 D$</p> 	<p>return line: $l \geq 5 D$</p> 
<p>disturbance source: 2x 90° elbows in same plane</p> <p>supply line: $l \geq 25 D$</p> 	<p>return line: $l \geq 5 D$</p> 
<p>disturbance source: 2x 90° elbows in different planes</p> <p>supply line: $l \geq 40 D$</p> 	<p>return line: $l \geq 5 D$</p> 

Tab. 5.2: Recommended distance from disturbance sources

D = nominal pipe diameter at the measuring point, l = recommended distance

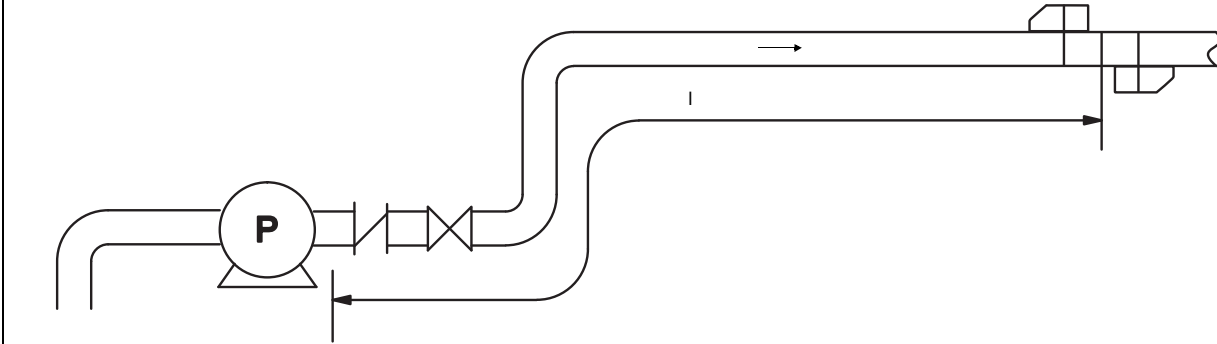
disturbance source: T piece	
supply line: $l \geq 50 D$	return line: $l \geq 10 D$
	
disturbance source: diffuser	
supply line: $l \geq 30 D$	return line: $l \geq 5 D$
	
disturbance source: valve	
supply line: $l \geq 40 D$	return line: $l \geq 10 D$
	
disturbance source: reducer	
supply line: $l \geq 10 D$	return line: $l \geq 5 D$
	

Tab. 5.2: Recommended distance from disturbance sources

D = nominal pipe diameter at the measuring point, l = recommended distance

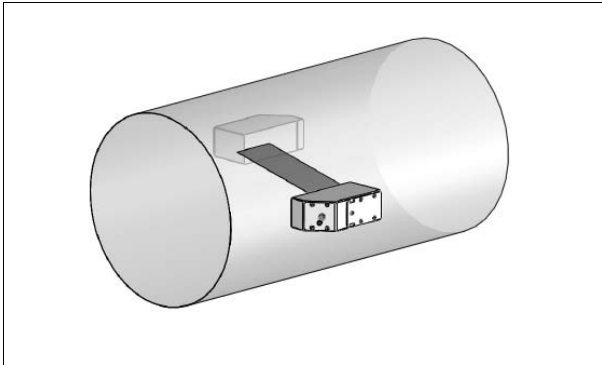
disturbance source: pump

supply line: $l \geq 50 D$



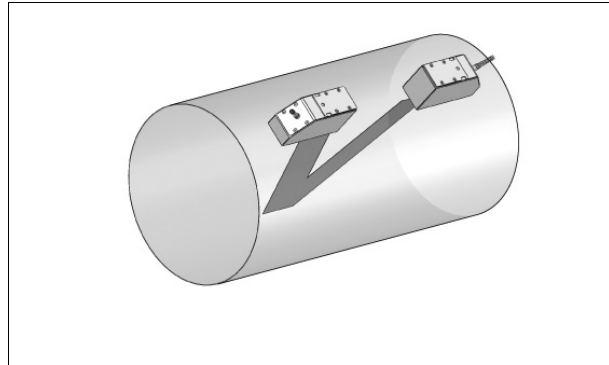
5.3 Selection of the Measurement Arrangement Taking onto Account the Measuring Range and the Measuring Conditions

Diagonal arrangement



- wider flow velocity and sound speed range compared to the reflection arrangement
- use in the presence of deposits on the inner pipe wall or with strongly attenuating media (only 1 sound path)

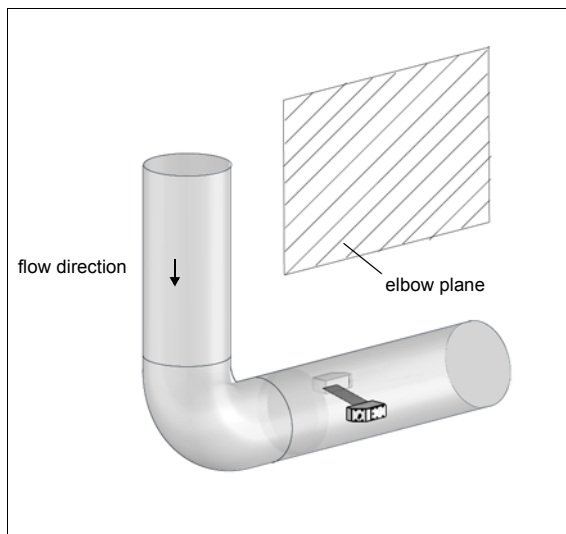
Reflection arrangement



- smaller flow velocity and sound speed range compared to the diagonal arrangement
- transverse flow effects are compensated for because the beam crosses the pipe in 2 directions
- higher accuracy of measurement because the accuracy increases with the number of sound paths

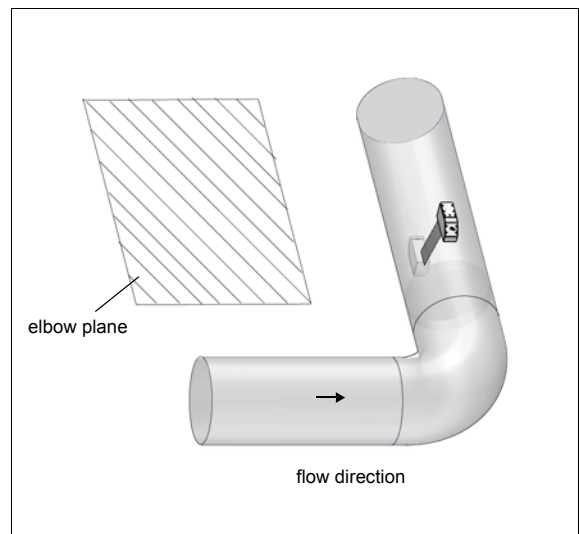
5.4 Selection of the Sound Plane Near an Elbow

On vertical pipes



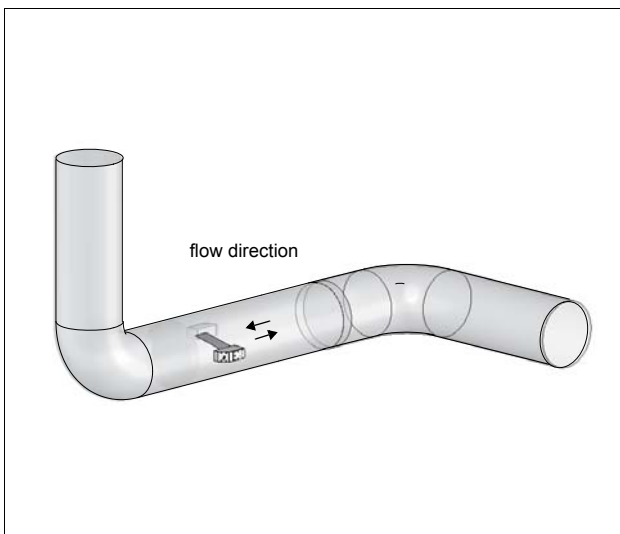
- The sound beam plane (see section 3.3) has an angle of 90° to the elbow plane. The elbow is upstream of the measuring point.

On horizontal pipes



- The sound beam plane (see section 3.3) has an angle of $90^\circ \pm 45^\circ$ to the elbow plane. The elbow is upstream of the measuring point.

With measurements in both directions



- The sound beam plane (see section 3.3) is selected according to the nearest elbow (horizontal or vertical, depending on the pipe orientation - see above).

6 Installation of the Transmitter Portalok 7S

6.1 Location

Select the measuring point according to the recommendations in chapter 5. The ambient temperature has to be within the operating temperature range of the transducers.

Select the location of the flowmeter within cable reach of the measuring point. The ambient temperature has to be within the operating temperature range of the transmitter.

6.2 Connection of the Transducer

It is recommended to run the cables from the measuring point to the transmitter before connecting the transducers to avoid load on the connectors.

Connect the transducer to the transmitter (see Fig. 4.1).

6.3 Power Supply

The transmitter can be operated with the battery (see section 6.3.1) or with the power supply unit (see section 6.3.2).

6.3.1 Power Supply with the Battery

The transmitter has a Li-Ion battery and can be operated independently of the power supply unit.

At delivery, the battery is charged approx. 30 %. The battery does not need to be fully charged before it is used for the first time.

This message will be displayed if the battery is almost empty:



The capacity is sufficient for the display and storing of the current parameter record. A measurement is no longer possible.

Charging the battery

Connect the power supply unit to the transmitter (see Fig. 4.1). Switch on the transmitter. Charging starts automatically. The max. charging time is approx. 8 h.

During the charging process, the ambient temperature should be in the range 0...45 °C (32...113 °F).

A measurement can be made during the charging process. Charging will be stopped automatically when the battery is fully charged.

Storage of the battery

The battery remains in the transmitter. After storage, the transmitter can immediately be operated with the battery.

- charge state: > 30 %
- storing temperature: 12...25 °C (54...77 °F)

State of the battery

The transmitter Portalok 7S has 2 LEDs which indicate the state of the battery.

The state indicator "BATTERY"

- is off when the battery is charged to > 50 %
- is on when the battery is charged to 20...50 %
- blinks when the battery is charged to < 20 %.

The state indicator "CHARGING"

- is off when the transmitter is not connected to the power supply
- is on when the transmitter is connected to the power supply and the battery is fully charged
- blinks when the transmitter is connected to the power supply and the battery is being charged.

6.3.2 Power Supply with the Power Supply Unit

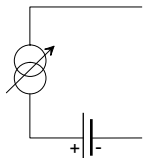
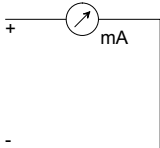
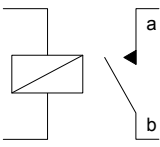
- | | |
|-------------------|---|
| Attention! | <ul style="list-style-type: none"> • Use only the power supply unit supplied by EESiFlo. • The power supply unit is not protected against moisture. Use it only in dry rooms. • The voltage indicated on the power supply unit must not be exceeded. • Do not connect a defective power supply unit to the transmitter. |
|-------------------|---|

- Connect the power supply unit to the transmitter (see Fig. 4.1).

6.4 Connection of the Output

For the connection of the output see Fig. 4.1, Fig. 6.1, Tab. 6.1 and Tab. 6.2.

Tab. 6.1: Circuits of the outputs

output	transmitter internal circuit	connection	external circuit	remark
active current loop		see Fig. 6.1		$R_{\text{ext}} < 500 \, \Omega$
binary output (Reed relay)		see Fig. 6.1		$U_{\text{max}} = 48 \, \text{V}$ $I_{\text{max}} = 250 \, \text{mA}$

The number, type and connections of the outputs are customized.

R_{ext} is the sum of all ohmic resistances in the circuit (e.g., resistance of the conductors, resistance of the amperemeter/voltmeter).

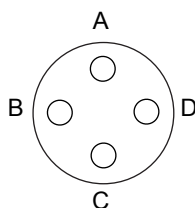


Fig. 6.1: Pin assignment for the connection of the output

Tab. 6.2: Pin assignment for the connection of the output

pin	connection
A (+)	binary output B1 (Reed relay)
B (-)	binary output B1 (Reed relay)
C (+)	current output I1
D (-)	current output I1

6.5 Connection of the Serial Interface

Connect the RS232 cable to the transmitter (see Fig. 4.1 and Fig. 4.2) and the serial interface of the PC. If the RS232 cable cannot be connected to the PC, use an RS232/USB adapter.

7 Installation of the Transducers

7.1 Preparation of the Pipe

- The pipe has to be stable. It has to be able to withstand the pressure exerted by the transducer mounting fixture.
- Rust, paint or other deposits on the pipe absorb the sound signal. A good acoustic contact between the pipe and the transducers is obtained as follows:
- Clean the pipe at the selected measuring point:
 - If present, the paint layer has to be smoothed by sanding. The paint does not need to be removed completely.
 - Remove any rust or loose paint.
 - Use coupling foil or apply a bead of acoustic coupling compound along the center line of the contact surface of the transducers.
 - Observe that there must be no air pockets between the transducer contact surface and the pipe wall.

7.2 Orientation of the Transducers and Transducer Distance

Mount the transducers onto the pipe in such way that the engravings on the transducers form an arrow (see Fig. 7.1). The transducer cables show in opposite directions.

The transducer distance is the distance between the inner edges of the transducers (see section 3.3 and Fig. 7.1)

For the determination of the flow direction see section 9.8.

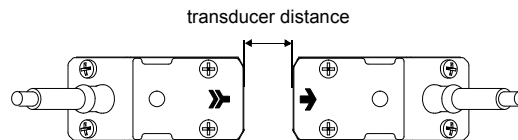


Fig. 7.1: Correct orientation of the transducers and transducer distance

7.3 Installation

Fix the transducers onto the pipe using the supplied mounting hardware.

8 Start-up of the Transmitter

8.1 Switching on

```
EESIFLO
EESXXXX-XXXXXXX
```

Press key PWR to switch on the transmitter. The serial number of the transmitter is displayed for a short time.

Data cannot be entered while the serial number is displayed.

```
>PAR<mea opt sf
Parameter
```

After the transmitter is switched on, the main menu is displayed in the default language. The language of the display can be set (see section 8.5).

8.2 Initialization

During an initialization (INIT) of the transmitter, the settings in the program branches `Parameter` and `Output Options` and some of the settings in the program branch `Special Funct.` are reset to the default settings of EESiFlo.

For INIT-resistant settings, see annex A.

Proceed as follows to execute an initialization:

- While switching on the transmitter: keep keys B and C pressed.
- During the operation of the transmitter: press keys B, C and ENTER at the same time. A RESET is executed. Release key ENTER only. Keep keys B and C pressed.

```
INITIALISATION
-----DONE-----
```

After the initialization has been executed, the message `INITIALISATION DONE` is displayed.

After the initialization, the remaining settings of the transmitter can be reset to the default settings and/or the stored measured values can be deleted.

```
FACTORY DEFAULT?
no                >YES<
```

Select `yes` to reset the remaining settings to the default settings or `no` to keep them at the current settings.

Press ENTER.

If `yes` is selected, the message `FACTORY DEFAULT DONE` will be displayed.

```
Delete Meas.Val.
no                >YES<
```

Select `yes` to delete the stored measured values or `no` to keep them stored.

Press ENTER.

This display will only be indicated if measured values are stored in the data logger.

8.3 Display

8.3.1 Main Menu

```
>PAR<mea opt sf
Parameter
```

The main menu contains the following program branches:

- `par` (Parameter)
- `mea` (Measuring)
- `opt` (Output Options)
- `sf` (Special Function)

The selected program branch is displayed in capital letters and in angle brackets. The complete designation of the selected program branch is displayed in the lower line.

Select a program branch by pressing key  or . Press ENTER.

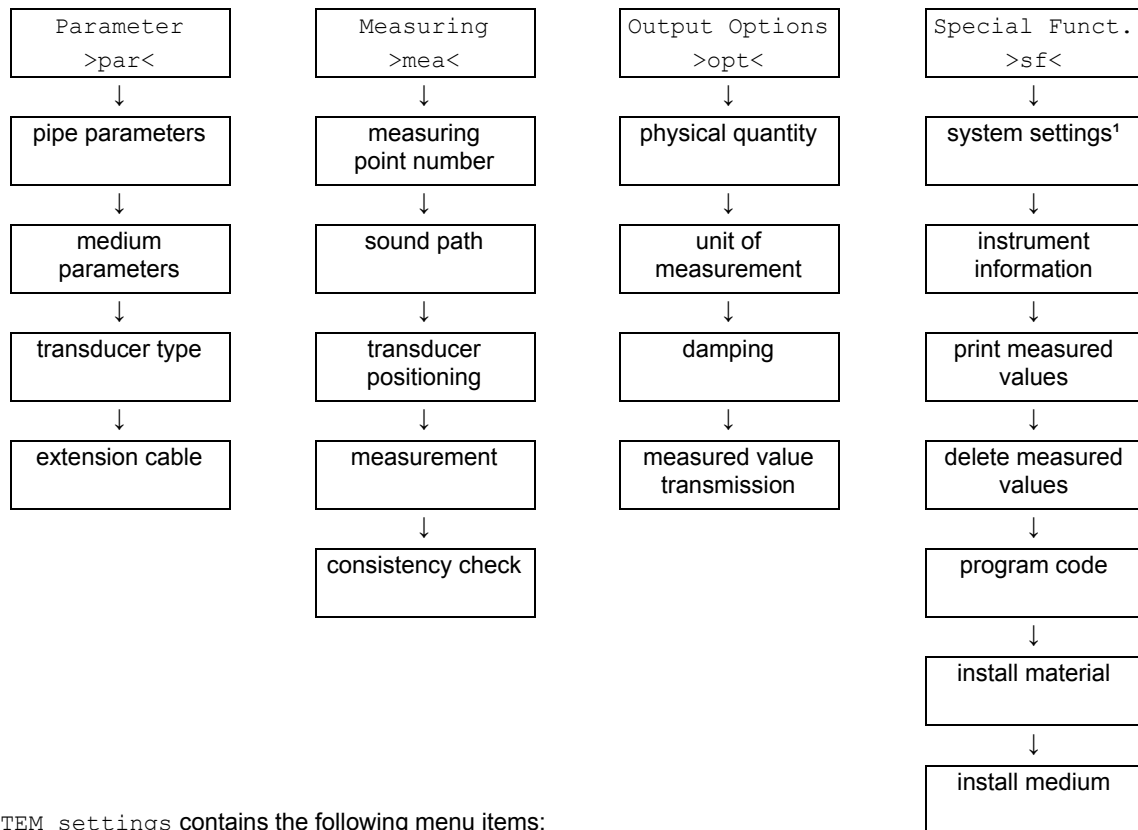
Note! By pressing key B, the measurement will be stopped and the main menu is selected.

Note! In this user manual, all program entries and keys are indicated with typewriter characters (`Parameter`). The menu items are separated from the main menu by a backslash "`\`".

8.3.2 Program Branches

- **Program branch Parameter**
input of the pipe and medium parameters
- **Program branch Measuring**
processing of the steps for the measurement
- **Program branch Output Options**
setting of the physical quantity, the unit of measurement and the parameters for the measured value transmission
- **Program branch Special Funct.**
contains all functions that are not directly related to the measurement

For an overview of the program branches see figure below. For a detailed overview of the menu structure see annex A.



¹ SYSTEM settings contains the following menu items:

- dialogs and menus
- measuring
- outputs
- storing
- serial transmission
- miscellaneous
- set clock
- libraries

8.3.3 Navigation

A vertical arrow ↑ will be displayed if the menu item contains a scroll list. The current list item will be displayed in the lower line.

```
SYSTEM settings↑
Dialogs/Menus
```

Use key and to select a list item in the lower line. Press ENTER.

Some menu items contain a horizontal scroll list in the lower line. The selected list item is displayed in capital letters and in angle brackets.

```
Lining
no          >YES<
```

Press key or to scroll through the lower line and select a list item. Press ENTER.

Some menu items contain a horizontal scroll list in the upper line. The selected list item is displayed in capital letters and in angle brackets. The current value of the list item is displayed in the lower line.

```
R1=FUNC<typ mode
Function:    MAX
```

Press key to scroll through the upper line and select a list item.

Press key to scroll through the lower line and select a value for the selected list item.

Press ENTER.

8.4 HotCodes

A HotCode is a key sequence that activates certain functions and settings:

function	HotCode	see section	deactivation
language selection	9090xx	8.5	
manual input of the lower limit for the inner pipe diameter	071001	11.7	
activation of the SuperUser mode	071049	15.1	HotCode 071049
change of the transmission parameters of the RS232 interface	232-0-	12.2.4	
resetting the contrast of the display to medium	555000	14.4	

```
SYSTEM settings↑
Miscellaneous
```

Select Special Funct.\SYSTEM settings\Miscellaneous.

```
Input a HOTCODE
no          >YES<
```

Select yes to enter a HotCode.

```
Please input a
HOTCODE: 000000
```

Enter the HotCode. Press ENTER.

```
INVALID HOTCODE
hotcode: 000000
```

An error message will be displayed if an invalid HotCode has been entered. Press ENTER.

8.5 Language Selection

The transmitter can be operated in the languages listed below. The language can be selected with the following Hot-Codes:

Tab. 8.1: HotCodes for language selection

909031	Dutch
909033	French
909034	Spanish
909044	English
909049	German

Depending on the technical data of the transmitter, some of the languages might not be implemented.

When the last digit has been entered, the main menu will be displayed in the selected language.

The selected language remains activated when the transmitter is switched off and on again. After an initialization, the default language set by EESIFLo is activated.

9 Basic Measurement

The pipe and medium parameters are entered for the selected measuring point (see chapter 5). The parameter ranges are limited by the technical characteristics of the transducers and of the transmitter.

Note! During the parameter input, the transducers should be connected to the transmitter.

Note! The parameters will only be stored when the program branch `Parameter` has been edited in its entirety.

9.1 Input of the Pipe Parameters

```
>PAR<mea opt sf
Parameter
```

Select the program branch `Parameter`. Press ENTER.

9.1.1 Outer Pipe Diameter/Pipe Circumference

```
Outer Diameter
  100.0      mm
```

Enter the outer pipe diameter. Enter the actual pipe diameter, not the nominal pipe diameter. Press ENTER.

```
Outer Diameter
 1100.0  MAXIMAL
```

An error message will be displayed if the entered parameter is outside of the range. The limit will be displayed.

Example: upper limit 1100 mm for the connected transducers and for a pipe wall thickness of 50 mm.

It is possible to enter the pipe circumference instead of the outer pipe diameter (see section 14.2.1).

If the input of the pipe circumference has been activated and 0 (zero) is entered for the `Outer Diameter`, the menu item `Pipe Circumfer.` will be displayed. If the pipe circumference is not to be entered, press key B to return to the main menu and start the parameter input again.

9.1.2 Pipe Wall Thickness

```
Wall Thickness
   3.0      mm
```

Enter the pipe wall thickness. Press ENTER.

Note! The inner pipe diameter (= outer pipe diameter - 2x pipe wall thickness) is calculated internally. If the value is not within the inner pipe diameter range of the connected transducers, an error message will be displayed.

It is possible to change the lower limit of the inner pipe diameter for a given transducer type (see section 11.7).

9.1.3 Pipe Material

The pipe material has to be selected to be able to determine the sound speed. The sound speed for the materials in the scroll list are stored in the transmitter.

```
Pipe Material  ↑
Carbon Steel
```

Select the pipe material.

If the medium is not in the scroll list, select `Other Material`. Press ENTER.

It can be specified which materials will be displayed in the scroll list (see section 13.5).

When the pipe material has been selected, the corresponding sound speed is set automatically. If `Other Material` has been selected, the sound speed has to be entered.

```
c-Material
  3230.0    m/s
```

Enter the sound speed of the pipe material. Press ENTER.

Note! Enter the sound speed of the material (i.e. longitudinal or transversal speed) which is nearer to 2500 m/s.

For the sound speed of some materials see annex C.1.

9.1.4 Pipe Lining

Lining	
no	>YES<

If the pipe has an inner lining, select `yes`. Press ENTER.

If `no` is selected, the next parameter will be displayed (see section 9.1.5).

Lining	↑
Bitumen	

Select the lining material.

If the material is not in the scroll list, select `Other Material`. Press ENTER.

It can be specified which materials will be displayed in the scroll list (see section 13.5).

If `Other Material` is selected, the sound speed has to be entered.

c-Material	
3200.0	m/s

Enter the sound speed of the lining material. Press ENTER.

For the sound speed of some materials see annex C.1.

Liner Thickness	
3.0	mm

Enter the thickness of the liner. Press ENTER.

Note!

The inner pipe diameter (= outer pipe diameter - 2x pipe wall thickness - 2x liner thickness) is calculated internally. If the value is not within the inner pipe diameter range of the connected transducers, an error message will be displayed.

It is possible to change the lower limit of the inner pipe diameter for a given transducer type (see section 11.7).

9.1.5 Pipe Roughness

The flow profile of the medium is influenced by the roughness of the inner pipe wall. The roughness is used for the calculation of the profile correction factor. As, in most cases, the pipe roughness cannot be determined exactly, it has to be estimated.

For the roughness of some materials see annex C.2.

Roughness	
0.4	mm

Enter the roughness of the selected pipe or liner material.

Change the value according to the condition of the inner pipe wall. Press ENTER.

9.2 Input of the Medium Parameters

Medium	↑
Water	

Select the medium from the scroll list.

If the medium is not in the scroll list, select `Other Medium`. Press ENTER.

It is possible to specify which media will be displayed in the scroll list (see section 13.5).

For the programmed parameters of common media see annex C.3.

If a medium is selected from the scroll list, the menu item for the input of the medium temperature is displayed directly (see section 9.2.4).

If `Other Medium` is selected, the medium parameters have to be entered first:

- average sound speed of the medium
- range around the average sound speed of the medium
- kinematic viscosity
- density

9.2.1 Sound Speed

The sound speed of the medium is used for the calculation of the transducer distance at the beginning of the measurement. However, the sound speed does affect the measuring result directly. Often, the exact value of the sound speed for a medium is unknown. Therefore, a range of possible values for the sound speed has to be entered.

c-Medium	
1500.0	m/s

Enter the average sound speed of the medium. Press ENTER.

This display will only be indicated if `Other Medium` is selected.

c-Medium range	
auto	>USER<

Select `auto` or `user`. Press ENTER.

`auto`: The area around the average sound speed is defined by the transmitter.

`user`: The area around the average sound speed has to be entered.

c-Medium=1500m/s	
range +-150m/s	

Enter the area around the average sound speed of the medium. Press ENTER.

This display will only be indicated if `user` is selected.

9.2.2 Kinematic Viscosity

The kinematic viscosity has an effect on the flow profile of the medium. The entered value and other parameters are used for the profile correction.

Kinem.Viscosity	
1.00	mm ² /s

Enter the kinematic viscosity of the medium. Press ENTER.

This display will only be indicated if `Other Medium` is selected.

9.2.3 Density

The density is used to calculate the mass flow (product of the volumetric flow rate and the density).

Note!	If the mass flow is not measured, press ENTER. The other measuring results will not be affected.
--------------	--

Density	
1.00	g/cm ³

Enter the operating density of the medium. Press ENTER.

This display will only be indicated if `Other Medium` is selected.

9.2.4 Medium Temperature

At the beginning of the measurement, the medium temperature is used for the interpolation of the sound speed and thus, for the calculation of the recommended transducer distance.

During the measurement, the medium temperature is used for the interpolation of the density and the viscosity of the medium.

Medium Temperat.	
20.0	°C

Enter the medium temperature. The value has to be within the operating temperature range of the transducers. Press ENTER.

9.3 Other Parameters

9.3.1 Transducer Parameters

Transducer Type↓	
Standard	

Select `Standard` to use the standard transducer parameters stored in the transmitter. Press ENTER.

This display will only be indicated if no transducers are connected to the transmitter.

9.3.2 Extension Cable

Additional cable	
65.0	m

If the transducer cable has to be extended, enter the additional cable length (e.g., between the junction box and the transmitter). Press ENTER.

9.4 Defining the Measuring Point Number

```
par>MEA<opt sf
Measuring
```

Select program branch `Measuring`. Press ENTER.

```
par>MEA<opt sf
NO DATA!
```

If this error message is displayed, the parameters are not complete. Enter the missing parameters in the program branch `Parameter`.

Optional: If the data logger or the serial interface is activated, the measuring point number has to be entered:

```
Meas.Point No.:
xxx (↑↓←→)
```

Enter the measuring point number. Press ENTER.

If arrows are displayed in the lower line on the right, ASCII text can be entered. If no arrows are displayed, only digits, point and hyphen can be entered.

9.5 Defining the Number of Sound Paths

```
Sound Path
2 NUM
```

A number of sound paths is recommended according to the connected transducers and the entered parameters. Change the value, if necessary.

Press ENTER.

For defining the number of sound paths, see section 3.3.

9.6 Transducer Distance

```
Transd. Distance
54 mm Reflec
```

A value for the transducer distance is recommended. Fix the transducers (see chapter 7). Adjust the transducer distance.

Press ENTER.

Reflec - reflection arrangement

Diagon - diagonal arrangement

The transducer distance is the distance between the inner edges of the transducers (see section 3.3 and Fig. 7.1)

In case of a measurement in diagonal arrangement on very small pipes, a negative transducer distance is possible.

Note!

The accuracy of the recommended transducer distance depends on the accuracy of the entered pipe and medium parameters.

9.6.1 Fine Adjustment of the Transducer Distance

Transd. Distance
54 mm !

If the displayed transducer distance is adjusted, press ENTER.

The measuring for the positioning of the transducers is started.



S=■■■■■■■■
■< >■=54 mm !

The amplitude of the received signal is displayed by the bar graph S .

- Shift a transducer slightly within the range of the recommended transducer distance until the bar graph reaches its max. length.

S=■■■■■■■
Q=■■■■■■■■■■■■■

time= 94.0 μ s
Q=■■■■■■■■■■■■■

The following quantities can be displayed in the upper line by pressing key  and in the lower line by pressing key  :

- ΔL : transducer distance
- t : Transit time of the measuring signal in μs
- S : signal amplitude
- Q : signal quality, bar graph has to have max. length

If the signal is not sufficient for measurement, Q= UNDEF will be displayed.

In case of large deviations, check if the entered parameters are correct or repeat the measurement at a different point on the pipe.

Transd. Distance?
53.9 mm

After the precise positioning of the transducers, the recommended transducer distance is displayed again.

Enter the actual (precise) transducer distance. Press ENTER.

9.6.2 Consistency Check

If a wide range for the sound speed has been entered in the program branch `Parameter` or the exact parameters of the medium are not known, a consistency check is recommended.

The transducer distance can be displayed during measurement by scrolling with key .

$$L = (50.0 \pm 54.0) \text{ mm}$$

The optimum transducer distance (here: 50.0 mm) is displayed in the upper line in parentheses, followed by the entered transducer distance (here: 54.0 mm). The latter value has to correspond to the adjusted transducer distance.

→Adjust transd.
54.5 m3/h

If necessary, scroll in the upper line until \rightarrow Adjust transd. is displayed. Press ENTER. The amplitude of the received signal S is displayed again. Press ENTER to adjust the transducer distance.

The optimum transducer distance is calculated on the basis of the measured sound speed. It is therefore a better approximation than the first recommended value which had been calculated on the basis of the sound speed range entered in the program branch `Parameter`.

If the difference between the optimum and the entered transducer distance is less than specified in Tab. 9.1, the measurement is consistent and the measured values are valid. The measurement can be continued.

If the difference is greater, adjust the transducer distance to the displayed optimum value. Afterwards, check the signal quality and the signal amplitude bar graph (see section 9.6.1). Press ENTER.


Tab. 9.1: Standard values for signal optimization

transducer frequency	difference between the optimum and the entered transducer distance [mm]
M	10
P	10

Transd. Distance?
50.0 mm

Enter the new adjusted transducer distance. Press ENTER.

L=(51.1) 50.0 mm
54.5 m3/h

Press key  again to scroll until the transducer distance is displayed and check the difference between the optimum and the entered transducer distance. Repeat the steps if necessary.

Note!

If the transducer distance is changed during the measurement, the consistency check will have to be repeated.

9.6.3 Value of the Sound Speed

The sound speed of the medium can be displayed during the measurement by pressing key .

If an approximate range for the sound speed has been entered in the program branch `Parameter` and the transducer distance has been optimized afterwards as described in section 9.6.2, it is recommended to write down the sound speed for the next measurement. By doing this, it will not be necessary to repeat the fine adjustment.

Also write down the medium temperature because the sound speed depends on the temperature. The value can be entered in the program branch `Parameter` or a user defined medium can be created for this sound speed (see section 13.2 and 13.3).

9.7 Start of the Measurement

Volume flow
31.82 m3/h

The measured values are displayed in the lower line.

If necessary, scroll in the upper line until `→Adjust transd.` is displayed and press ENTER to return to the fine adjustment of the transducer distance (see section 9.6.1).

The outputs and the serial interface continuously receive the measured values of the measuring channel. The results are displayed according to the currently selected output options. The default unit of measurement of the volumetric flow rate is m³/h. For the selection of the values to be displayed and for the setting of the output options see chapter 10. For further measuring functions see chapter 11.

9.8 Detection of the Flow Direction

The flow direction in the pipe can be detected with the help of the displayed volumetric flow rate in conjunction with the arrow on the transducers:

- The medium flows in the direction of the arrow if the displayed volumetric flow rate is positive (e.g., 54.5 m³/h).
- The medium flows against the direction of the arrow if the displayed volumetric flow rate is negative (e.g., -54.5 m³/h).

9.9 Interruption of the Measurement

The measurement is interrupted by pressing key B if it is not protected by a program code (see section 11.8).

Note!	Be careful not to stop a current measurement by inadvertently pressing key B!
--------------	---

10 Displaying the Measured Values

The physical quantity is set in the program branch `Output Options` (see section 10.1).

During the measurement, the designation of the physical quantity is displayed in the upper line, the measured value in the lower line. The display can be adapted (see section 10.2).

10.1 Selection of the Physical Quantity and of the Unit of Measurement

The following physical quantities can be measured:

- **sound speed**
- **flow velocity**: calculated on the basis of the measured transit time difference
- **volumetric flow rate**: calculated by multiplying the flow velocity by the cross-section of the pipe
- **mass flow rate**: calculated by multiplying the volumetric flow rate by the operating density of the medium

The physical quantity is selected as follows:

```
par mea >OPT< sf
Output Options
```

Select the program branch `Output Options`. Press ENTER.

```
Physic. Quant. ↑
Volume flow
```

Select the physical quantity in the scroll list. Press ENTER.

```
Volume in:      ↑
m3/h
```

For the selected physical quantity (except for the sound speed), a scroll list with the available units of measurement is displayed. The unit of measurement which was selected previously is displayed first.

Select the unit of measurement of the selected physical quantity. Press ENTER.

Press B to return to the main menu. The further menu items of the program branch `Output Options` are for the activation of the measured value transmission.

Note!	If the physical quantity or the unit of measurement is changed, the settings of the outputs will have to be checked (see chapter 16).
--------------	---

10.2 Adjustment of the Display

During the measurement, the display can be adapted as to display two measured values simultaneously (one in each line of the display). This does not affect totalizing, transmission of the measured values, etc.

The following information can be displayed in the upper line:

display	explanation
Mass Flow=	designation of the physical quantity
+8.879 m3	values of the totalizers
full=	date and time at which the data logger will be full, if activated
Mode=	measuring mode
L=	transducer distance
Rx=	alarm state indication if it is activated (see section 16.6.5) and if alarm outputs are activated (see section 16.6).
	status line (see section 10.3)

The measured values of the physical quantity selected in the program branch `Output Options` can be displayed in the lower line:

display	explanation
12.3 m/s	flow velocity
1423 m/s	sound speed
124 kg/h	mass flow rate
15 m3/h	volumetric flow rate

Press key  during the measurement to change the display in the upper line, press key  to change the display in the lower line.


Flow Velocity
* 2.47 m/s

The character * indicates that the displayed value (here: flow velocity) is not the selected physical quantity.

10.3 Status Line

Important data on the ongoing measurement are displayed in the status line. The quality and precision of the ongoing measurement can be estimated.

S3 Q9 c✓ RT F↓

Press key  during the measurement to scroll through the upper line to the status line.


	value	explanation
S		signal amplitude
	0	< 5 %

	9	≥ 90 %
Q		signal quality
	0	< 5 %

	9	≥ 90 %
c		sound speed
		comparison of the measured and the expected sound speed of the medium. The expected sound speed is calculated on the basis of the medium parameters (medium selected in the program branch <i>Parameter</i> , temperature dependence).
	√	ok, is equal to the expected value
	↑	> 20 % of the expected value
	↓	< 20 % of the expected value
R	?	unknown, cannot be measured
		flow profile
		information about the flow profile based on the Reynolds number
	T	fully turbulent flow profile
	L	fully laminar flow profile
F	↑↓	the flow is in the transition range between laminar and turbulent flow
	?	unknown, cannot be calculated
		flow velocity
F		comparison of the measured flow velocity with the flow limits of the system
	√	ok, the flow velocity is not in the critical range
	↑	the flow velocity is higher than the current limit
	↓	the flow velocity is lower than the current cut-off flow (even if it is not set to zero)
	0	the flow velocity is in the offset range of the measuring method
	?	unknown, cannot be measured

10.4 Transducer Distance

L= (51.2) 50.8 mm
54.5 m3/h

By pressing key  during the measurement, it is possible to scroll to the display of the transducer distance.

The optimum transducer distance (here: 51.2 mm) is displayed in parentheses in the upper line, followed by the entered transducer distance (here: 50.8 mm).

The optimum transducer distance might change during the measurement (e.g., due to temperature fluctuations).


A deviation from the optimum transducer distance (here: -0.4 mm) is compensated internally.

Note! Never change the transducer distance during the measurement!

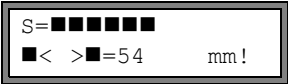
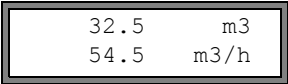
11 Advanced Measuring Functions

11.1 Command Execution during Measurement

Commands that can be executed during a measurement are displayed in the upper line. A command begins with the arrow →. If programmed, a program code has to be entered first (see section 11.8).

Press  until the command is displayed. Press ENTER. The following commands are available:

Tab. 11.1: Commands that can be executed during the measurement

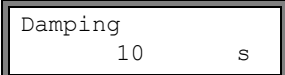
command	explanation
→Adjust transd.	 <p>Select transducer positioning. If a program code is active, the measurement will be continued 8 s after the last keyboard entry.</p>
→Clear totalizer	 <p>All totalizers will be reset to zero.</p>
→Break measure	Stop the measurement and return to the main menu.

11.2 Damping Factor

Each displayed measured value is a floating average of all measured values of the last x seconds, with x being the damping factor. A damping factor of 1 s means that the measured values are not averaged because the measuring rate is approx 1/s. The default value of 10 s is appropriate for normal flow conditions.

Strongly fluctuating values caused by high flow dynamics require a higher damping factor.

Select the program branch **Output Options**. Press ENTER until the menu item **Damping** is displayed.



Enter the damping factor. Press ENTER.

Press B to return to the main menu.

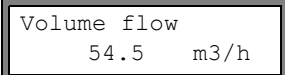
11.3 Totalizers


Total volume or total mass of the medium at the measuring point can be determined.

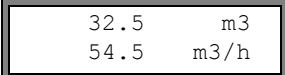
There are two totalizers, one for the positive flow direction, one for the negative flow direction.

The unit of measurement used for totalizing corresponds to the volume or mass unit selected for the physical quantity.

The values of the totalizers can be displayed with up to 11 places, e.g., 74890046.03. For the definition of the number of decimal.

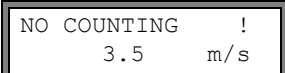


Press key  to scroll through the upper line to the display of the totalizers.



The value of the totalizer will be displayed in the upper line (here: the volume which has passed through the pipe at the measuring point in the positive flow direction after the activation of the totalizers).

Select the command →Clear totalizer in the upper line to reset the totalizers to zero. Press ENTER.



This error message will be displayed if the totalizers are to be activated. The flow velocity cannot be totalized.

Selection of the totalizers for storing

It is possible to store the totalizer for one flow direction or the totalizers for both flow directions. Select `Special Funct.\SYSTEM settings\Storing\Quantity Storage`.

Quantity Storage
one >BOTH<

If `one` is selected, only the totalizer whose value is changing will be stored. This can apply to the totalizer for the positive or the negative flow direction.

If `both` is selected, the values of the totalizers for both flow directions will be stored.
Press ENTER.

When the measurement is stopped

The behavior of the totalizers when the measurement is stopped or after a RESET of the transmitter is set in `Special Funct.\SYSTEM settings\Measuring\Quantity recall`.

Quantity recall
off >ON<

If `on` is selected, the values of the totalizers will be stored and used for the next measurement.

If `off` is selected, the totalizers will be reset to zero.

11.3.1 Overflow of the Totalizers

The overflow behavior of the totalizers can be set:

Without overflow:

- The value of the totalizer increases to the internal limit of 10^{38} .
- if necessary, the values will be displayed as exponential numbers ($\pm 1.00000E10$). The totalizer can only be reset to zero manually.

With overflow:

- The totalizer will be reset to zero automatically when ± 9999999999 is reached.

Select `Special Funct.\SYSTEM settings\Measuring\Quant. wrapping`.

Quant. wrapping
off >ON<

Select `on` to work with overflow. Select `off` to work without overflow. Press ENTER.

Independently of the setting, the totalizers can be reset to zero manually.

Note!

The overflow of a totalizer influences all output channels, e.g., data logger, online transmission of data. The transmission of the sum of both totalizers (the throughput ΣQ) via an output will not be valid after the first overflow (wrapping) of one of the corresponding totalizers.
To signalize the overflow of a totalizer, an alarm output with the switching condition `QUANT.` and the type `HOLD` have to be activated.

11.4 Upper Limit of the Flow Velocity

Single outliers caused by heavily disturbed surroundings can appear among the measured values of the flow velocity. If the outliers are not ignored, they will affect all derived physical quantities, which will then be unsuitable for the integration (e.g., pulse outputs).

It is possible to ignore all measured flow velocities higher than an upper limit. These measured values will be marked as outliers.

The upper limit of the flow velocity is set in `Special Funct.\SYSTEM settings\Measuring\Velocity limit`.

Velocity limit
0.0 m/s

Enter 0 (zero) to switch off the checking for outliers.

Enter a limit > 0 to switch on the checking for outliers. The measured flow velocity will then be compared to the entered upper limit.

Press ENTER.

If the flow velocity is higher than the upper limit,

- the flow velocity will be marked as invalid. The physical quantity cannot be determined.
- "!" will be displayed after the unit of measurement (in case of a normal error, "?" is displayed)

Note!

If the upper limit is too low, a measurement might be impossible because most of the measured values will be marked as "invalid".

11.5 Cut-off Flow

The cut-off flow is a lower limit for the flow velocity. All measured flow velocities that are lower than the limit and their derived values are set to zero.

The cut-off flow can depend on the flow direction or not. The cut-off flow is set in `Special Funct.\SYSTEM settings\Measuring\Cut-off Flow`.

```
Cut-off Flow
absolut  >SIGN<
```

Select `sign` to define a cut-off flow in dependence on the flow direction. Two independent limits are set for the positive and negative flow directions.

Select `absolut` to define a cut-off flow independently of the flow direction. A limit is set for the absolute value of the flow velocity.

Press ENTER.

```
Cut-off Flow
factory  >USER<
```

Select `factory` to use the default limit of 2.5 cm/s (0.025 m/s) for the cut-off flow.

Select `user` to enter the cut-off flow.

Press ENTER.

If `Cut-off Flow\sign` and `user` are selected, two values will have to be entered:

```
+Cut-off Flow
2.5    cm/s
```

Enter the cut-off flow. Press ENTER.

All positive values of the flow velocity that are lower than this limit will be set to zero.

```
-Cut-off Flow
-2.5   cm/s
```

Enter the cut-off flow. Press ENTER.

All negative values of the flow velocity greater than this limit will be set to zero.

If `Cut-off Flow\absolut` and `user` is selected, only one value will have to be entered:

```
Cut-off Flow
2.5    cm/s
```

Enter the cut-off flow. Press ENTER.

The absolute values of all flow velocity values that are lower than this limit will be set to zero.

11.6 Uncorrected Flow Velocity

For special applications, the uncorrected flow velocity might be of interest.

The profile correction for the flow velocity is activated in `Special Funct.\SYSTEM settings\Measuring\Flow Velocity`.

```
Flow Velocity
>NORMAL< uncorr.
```

Select `normal` to display and transmit the flow velocity with profile correction.

Select `uncorr.` to display the flow velocity without profile correction. Press ENTER.

```
PROFILE CORR.
>NO<         yes
```

If `uncorr.` is selected, it has to be confirmed each time the program branch `Measuring` is selected if the profile correction is to be used.

```
FLOW VELOCITY
2.60    m/s
```

If `no` is selected, the profile correction will be switched off.

All physical quantities will be calculated with the uncorrected flow velocity.

During the measurement, the designation of the physical quantity will be displayed in capital letters to indicate that the value is uncorrected.

Press ENTER.

```
PROFILE CORR.
NO         >YES<
```

If `yes` is selected, the uncorrected flow velocity will only be used if the flow velocity is selected as the physical quantity in the program branch `Output Options`.


All other physical quantities (volumetric flow rate, mass flow, rate etc.) will be determined with the corrected flow velocity.

During the measurement, the designation of the physical quantity will be displayed in capital letters to indicate that the value is uncorrected.

Press ENTER.

```
Flow Velocity
*U  54.5    m/s
```

In both cases, the corrected flow velocity can also be displayed.

Press key  to scroll until the flow velocity is displayed. The uncorrected flow velocity is marked with `U`.

Uncorrected flow velocities transmitted to a PC are marked with `uncorr.`

11.7 Change of the Limit for the Inner Pipe Diameter

It is possible to change the lower limit of the inner pipe diameter for a given transducer type.

Enter HotCode **071001**.

DNmin Q-Sensor
15 mm

Enter the lower limit of the inner pipe diameter of the displayed transducer type. Press ENTER to select the next transducer type.

Note!	If a transducer is used below its recommended inner pipe diameter, a measurement might be impossible.
--------------	---

11.8 Program Code

An ongoing measurement can be protected from an inadvertent intervention by means of a program code.

If a program code has been defined, it will be requested when there is an intervention in the measurement (a command or key B).

11.8.1 Defining a Program Code

Special Funct. ↑ Program code

Select Special Funct.\Program code.

Program code -----

Enter a program code with max. 6 digits. Press ENTER.

INVALID CODE ! 909049

An error message will be displayed if a reserved number has been entered (e.g., a Hot-Code for language selection).

A program code will remain valid as long as:

- no other valid program code is entered or
- the program code is not deactivated.

Note!	Do not forget the program code!
--------------	---------------------------------

11.8.2 Intervention in the Measurement



If a program code is active, the message **PROGRAM CODE ACTIVE** will be displayed for a few seconds when a key is pressed.

The input of a program code is interrupted by pressing key C.

If key B is pressed:

INPUT BREAK_CODE CODE: 000000

To stop an ongoing measurement, the complete program code has to be entered (= break code).

Enter the program code with the keys  and . Press ENTER.

INPUT BREAK_CODE INVALID CODE !

If the entered program code is not valid, an error message will be displayed for a few seconds.

If the entered program code is valid, the measurement will be stopped.

If a command is selected:

INP. ACCESS CODE CODE: 000000

To execute a command, it is sufficient to enter the first three digits of the program code (= access code).

Enter the first three digits of the program code with the keys  and . Press ENTER.

At first, 000000 is displayed. If the program code starts with 000, ENTER can be pressed immediately.

11.8.3 Deactivation of the Program Code

Program code -----

Select Special Funct.\Program code.

The program code is deleted by entering "-----". Press ENTER.

If the character "-" is entered less than six times, this character sequence will be used as the new program code.

12 Data Logger and Transmission of Data

The transmitter has a data logger in which the measured values are stored during the measurement (see section 12.1). The measured values are transmitted to a PC via the serial interface directly during the measurement (see section 12.2). For the connection of the serial interface see section 6.5.

12.1 Data Logger

The following data will be stored:

- date
- time
- measuring point number
- pipe parameters
- medium parameters
- transducer data
- sound path (reflection or diagonal arrangement)
- transducer distance
- damping factor
- storage rate
- physical quantity
- unit of measurement
- measured values (physical quantity and input quantities)
- totalizer values
- diagnostic values (if storing of diagnostic values is activated)

In order to store the measured data, the data logger has to be activated (see section 12.1.1).

The available data logger memory can be displayed (see section 12.1.6).

The storing of each measured value will be signaled acoustically. This signal can be deactivated (see section 12.1.3 in Acoustic Signal).

12.1.1 Activation/Deactivation of the Data Logger

```
Store Meas.Data
no          >YES<
```

Select program branch `Output Options`. Press ENTER until the menu item `Store Meas.Data` is displayed.

Select `yes` to activate the data logger. Press ENTER.

12.1.2 Setting the Storage Rate

The storage rate is the frequency at which the measured values are transmitted or stored.

If the storage rate is not set, the storage rate which was selected previously will be used. Min. 4 s is recommended.

```
Storage Rate  ↑
Once per 10 sec.
```

Select a storage rate or `EXTRA`. Press ENTER.

This display will only be indicated if `Store Meas.Data` and/or `Serial Output` are activated.

```
Storage Rate
1          s
```

If `EXTRA` has been selected, enter the storage rate. Press ENTER.

12.1.3 Settings of the Data Logger

Select program branch `Special Funct.\SYSTEM settings\Storing`. It contains the following menu items:

- start of the storing
- ringbuffer
- storage mode
- storing of the totalizers
- storing of the signal amplitude
- storing of the sound speed
- acoustic signal during the storing

Start of the storing

If it is necessary to synchronize the storing of measured values on several transmitters, the starting time of the storing can be set.

```
Start logger  ↑
Promptly
```

Select the starting time of the storing of measured values.

Promptly: Storing will be started immediately.

On full 5 min.: Storing will be started on the next full 5 minutes.

On full 10 min.: Storing will be started on the next full 10 minutes.

On quarter hour: Storing will be started on the next full 15 minutes.

On half hour: Storing will be started on the next half hour.

On full hour: Storing will be started on the next full hour.

Example: current time: 9:06
 setting: On full 10 min.
 Storing will be started at 9:10.

Ringbuffer

The setting of ringbuffer affects the storing of measured values as soon as the data memory is full:

- If the ringbuffer is activated, the available data logger will be halved. The oldest measured values will be overwritten. Only the data logger memory that was free during the activation will be used by the ringbuffer. If more data logger memory is necessary, measured values in the data logger should previously be deleted.
- If the ringbuffer is deactivated, the storing of measured values will be stopped.

```
Ringbuffer
off >ON<
```

Select the behavior of the ringbuffer. Press ENTER.

Storage mode

```
Storage mode
>SAMPLE< average
```

Select the storage mode. Press ENTER.

If `sample` is selected, the displayed measured value will be used for storing and online transmission of data.

If `average` is selected, the average of all values measured during a storage interval will be used for storing and online transmission of data.

Note! The storage mode does not affect the outputs.

Note! Storage mode = average
 The average of the physical quantity will be calculated.
 If the storage rate < 5 s (see section 12.1.2) is selected, `sample` will be used.
 If no average could be calculated over the complete storage interval, the value will be marked as invalid. The ASCII file will contain "???" instead of invalid average values of the physical quantity.

Storing of the totalizers

see section 11.3

Storing of the signal amplitude

```
Store Amplitude
off >ON<
```

If `on` is selected and the data logger is activated, the amplitude of the measured signal will be stored together with the measured values. Press ENTER.

Storing of the sound speed

```
Store c-Medium
off >ON<
```

If `on` is selected and the data logger is activated, the sound speed of the medium will be stored together with the measured values. Press ENTER.

Storing of the diagnostic values

```
Store diagnostic
off >ON<
```

If `on` is selected and the data logger is activated, the diagnostic values will be stored together with the measured values. Press ENTER.

12.1.4 Measurement with Activated Data Logger

- Start the measurement.

```
Meas.Point No.:
xxx (↑↓←→)
```

Enter the measuring point number. Press ENTER.

If arrows are displayed in the lower line on the right, ASCII text can be entered. If digits are displayed, only digits, point and hyphen can be entered.

For the setting of the input mode see section 14.2.2.

If Output Options\Store Meas.Data has been activated and Special Funct.\SYSTEM settings\Ringbuffer is deactivated, this error message will be displayed as soon as the data logger is full.

```
DATA MEMORY
OVERFLOW!
```

Press ENTER.

The error message will be displayed periodically.

The storing will be stopped.

12.1.5 Deleting the Measured Values

```
Special Funct. ↑
Delete Meas.Val.
```

Select Special Funct.\Delete Meas.Val. Press ENTER.

```
Really Delete?
no >YES<
```

Select yes or no. Press ENTER.

12.1.6 Available Data Logger Memory

If the data logger is empty and a measurement is started with one physical quantity without storing the totalizer, approx. 100 000 measured values can be stored. The available data logger memory can be displayed:

```
Special Funct. ↑
Instrum. Inform.
```

Select Special Funct.\Instrum. Inform.. Press ENTER.

```
EESXXXX-XXXXXXXXX
Free: 18327
```


The type and the serial number of the transmitter will be displayed in the upper line.

The available data logger memory will be displayed in the lower line (here: 18 327 additional measured values can be stored). Press key B twice to return to the main menu.

Max. 100 series of measured values can be stored. The number of series of measured values depends on the total number of measured values stored in the previous series of measured values.

The time at which the data logger memory will be full can be displayed during the measurement. All totalizers and other values will be considered.

```
full= 26.01/07:39
54.5 m3/h
```

Press key  during the measurement to scroll through the displays of the upper line.

```
last= 26.01/07:39
54.5 m3/h
```

If the ringbuffer is activated and has overflowed at least once, this display will be indicated.

12.2 Transmission of Data

The measured values can be transmitted to a PC via the serial interface RS232.

12.2.1 Online Transmission of Data

The measured values are transmitted during the measurement. If the data logger is activated, the measured values will also be stored.

Tab. 12.1: Overview online transmission of data

serial interface	transmission of data	see
RS232	terminal program	section 12.2.5

12.2.2 Offline Transmission of Data

The measurement data of the data logger are transmitted.

Tab. 12.2: Overview offline transmission of data

serial interface	transmission of data	see
RS232	terminal program	section 12.2.6

12.2.3 Format of the Measurement Data

Select Special Funct.\SYSTEM settings\serial transmis..

```
SER:kill spaces
off >ON<
```

Select on if the space characters are not to be transmitted. Press ENTER.
The file size will be considerably smaller (shorter transmission time).

```
SER:decimalpoint
'.' >','<
```

Select the decimal marker to be used for floating-point numbers (point or comma). Press ENTER.

This setting depends on the setting of the operating system of the PC.

```
SER:col-separat.
';' >'TAB'<
```

Select the character to be used to separate columns (semicolon or tabulator). Press ENTER.

12.2.4 Transmission Parameters

- the transmitter sends CRLF-terminated ASCII
- max. line length: 255 digits

RS232

- default: 9600 bits/s, 8 data bits, even parity, 2 stop bits, protocol RTS/CTS (hardware, handshake)

The transmission parameters of the RS232 interface can be changed:

Enter HotCode **232-0-** (see section 8.4).

```
>baud<data par st
9600 8bit EVEN 2
```

Set the transmission parameters in the 4 scroll lists. Press ENTER.

- baud: baud rate
- data: number of data bits
- par: parity
- st: number of stop bits

12.2.5 Online Transmission of Data to a Terminal Program

- Start the terminal program.
- Enter the transmission parameters into the terminal program (see section 12.2.4). The transmission parameters of the terminal program and of the transmitter have to be identical.
- Select the program branch `Output Options`. Press ENTER.
- Press ENTER until the menu item `Serial Output` is displayed.

```
Serial Output
no          >YES<
```

Select **yes** to activate the online transmission of data.

- Set the storage rate (see section 12.1.2).
- Start the measurement. The measuring point number will be requested (see section 12.1.4).

```
SEND ONLINE-HEAD
20          mm
```

The measured values are transmitted during the measurement.

12.2.6 Offline Transmission of Data to a Terminal Program

- Start the terminal program.
- Enter the transmission parameters into the terminal program (see section 12.2.4). The transmission parameters of the terminal program and of the transmitter have to be identical.

```
Special Funct. ↑
Print Meas.Val.
```

Select **Special Funct.\Print Meas.Val.** Press **ENTER**.

```
NO VALUES      !
Print Meas.Val.
```

This error message will be displayed if no measured values are stored. Press **ENTER**.

```
Send Header    01
.....
```

This message will be displayed if the measuring signal is sufficient.

```
■■■■■■
.....
```

The progress of the transmission of data is displayed by a bar graph.

```
SERIAL ERROR    !
Print Meas.Val.
```

This error message will be displayed if an error has occurred during the serial transmission. Press **ENTER**. Check the connections and make sure that the PC is ready to receive data.

12.2.7 Structure of the Data

The header is transmitted at the beginning of the measurement. The first 4 lines contain general information about the transmitter and the measurement. The following lines contain the parameters.

Example:	\DEVICE	: EESXXXXX8X27-XXXXXXX
	\MODE	: ONLINE
	DATE	: 2011-01-09
	TIME	: 19:56:52
	Par.Record	
	Meas.Point No.:	: F5050
	Pipe	
	Outer Diameter	: 60.3 mm
	Wall Thickness	: 5.5 mm
	Roughness	: 0.1 mm
	Pipe Material	: Carbon Steel
	Lining	: WITHOUT LINING
	Medium	: Water
	Medium Temperat.	: 38 C
	Fluid pressure	: 11.00 bar
	Transducer Type	: xxx
	Sound Path	: 3 NUM
	Transd. Distance	: -15.6 mm
	Damping	: 20 s
	Full-Scale Val.	: 4.50 m3/h
	Physic. Quant.	: Volume flow
	Unit Of Measure	: [m3/h]/[m3]
	Numb.Of Meas.Val	: 100

The line \DATA will be transmitted next. Afterwards the column titles will be transmitted (see Tab. 12.3) The measured values are transmitted afterwards.

Example: \DATA
 *MEASURE; Q_POS; Q_NEG;

In every storage interval, one data line is transmitted. The line "???" will be transmitted if there are no measured values available for the storage interval.

Example: With a storage interval of 1 s, 10 lines with "???" will be transmitted if the measurement has been re-started after a 10 s interruption for the positioning of the transducers.

The following data columns can be transmitted:

Tab. 12.3: Columns of data

column title	column format	contents
*MEASURE	###000000.00	physical quantity selected in Output Options
Q_POS	+00000000.00	totalizer value for the positive flow direction
Q_NEG	-00000000.00	totalizer value for the negative flow direction
SSPEED		sound speed of the medium
AMP		signal amplitude

Online transmission of data

Columns will be created for all quantities that appear during the measurement.

As the totalizers cannot be activated for the physical quantity flow velocity, these columns will not be created.

Offline transmission of data

During the offline output, columns will only be created if at least one measured value is stored in the series of measured values.

13 Libraries

The internal material database of the transmitter contains parameters for pipe and lining materials as well as for media. It can be extended with user defined materials or media. User defined materials and media will always be displayed in the scroll lists of the program branch `Parameter`.

User defined materials and media can be stored in an integrated coefficient memory (user area). The coefficient memory has to be partitioned first (see section 13.1).

The parameters of user defined materials or media can be entered as follows:

- as constants without the extended library (see section 13.2)
- as constants or temperature and pressure dependent functions by means of the extended library (see section 13.3)

The material and media scroll lists displayed in the program branch `Parameter` can be arranged (see section 13.5). Shorter scroll lists make working more efficient.

13.1 Partitioning of the Coefficient Memory

The coefficient memory can be divided into parts for the following material data:

- material parameters:
 - transversal and longitudinal sound speed
 - typical roughness
- medium parameters:
 - min. and max. sound speed
 - kinematic viscosity
 - density

For the max. number of data sets for each category of these material data see Tab. 13.1.

Tab. 13.1: Capacity of the coefficient memory

	max. number of data sets	occupancy of the coefficient memory in %
materials	13	97
media	13	97

```
Libraries      ↑
Format USER-AREA
```

Select `Special Funct.\SYSTEM settings\Libraries\Format USER-AREA`. Press ENTER.

```
MAXIMAL:      13!
Materials:    15
```

This error message will be displayed if the entered number of data sets for a category of material data exceeds the capacity of the coefficient memory.

```
Format USER-AREA
Materials:      03
```

Enter the number of the user defined materials. Press ENTER.

```
Format USER-AREA
Media:          03
```

Enter the number of the user defined media. Press ENTER.

```
USER AREA:
  52%      used
```

The occupancy of the coefficient memory is displayed for a few seconds.

```
Format NOW?
no          >YES<
```

Select `yes` to start the partitioning. Press ENTER.

```
FORMATTING ...
■■■■■■■ ...
```

The coefficient memory is partitioned accordingly. This procedure takes a few seconds.

```
Libraries      ↑
Format USER-AREA
```

After the partitioning, `Format USER-AREA` is displayed again.

13.1.1 Data Retention During the Partitioning of the Coefficient Memory

When the coefficient memory is repartitioned, max. 8 data sets of each type can be retained.

Example 1: The number of user defined materials is reduced from 5 to 3. The data sets #01 to #03 are retained. The data sets #04 and #05 are deleted.

Example 2: The number of user defined materials is increased from 5 to 6. All 5 data sets are kept.

13.2 Input of Material/Medium Parameters Without the Extended Library

To enter the material/medium parameters as constants, the extended library has to be deactivated.

```
Libraries      ↑
Extended Library
```

Select Special Funct.\SYSTEM settings\Libraries\Extended Library. Press ENTER.

```
Extended Library
>OFF<          on
```

Select off to deactivate the extended library. Press ENTER.

The parameters of a user defined material/medium can be entered now.

The input of a material or a medium is almost identical. Therefore, displays for a medium will only be shown and described in case of differences.

```
Special Funct. ↑
Install Material
```

Select Special Funct.\Install Material or Install Medium. Press ENTER.

```
USER Material
NOT FORMATTED !
```

This error message will be displayed if the coefficient memory does not contain an area for user defined materials/media.

Partition the coefficient memory accordingly (see section 13.1).

```
Install Material
>EDIT<         delete
```

Select edit. Press ENTER.

```
USER Material  ↑
#01:--not used--
```

Select a user defined material/medium. Press ENTER.

```
EDIT TEXT (↑↓←→)
USER MATERIAL  1
```

Change the designation of the material/medium.

The default name for a user defined material/medium is USER MATERIAL N or USER MEDIUM N with N being an integer.

Note! 95 ASCII characters (letters, capital letters, numbers, special characters [!? " + - () > < % * etc.]) are available for the designation of materials/media.
A designation can have max. 16 characters. The input of text is described in section 4.1.

Material parameters

```
c-Material
1590.0         m/s
```

Enter the sound speed of the material. Press ENTER.

For the sound speed of some materials annex C.1.

```
Roughness
0.4           mm
```

Enter the roughness of the material. Press ENTER.

For the typical roughness of some materials see annex C.2.

Medium parameters

```
c-Medium
1500.0         m/s
```

Enter the average sound speed of the medium. Press ENTER.

```
c-Medium range
auto      >USER<
```

Select **auto** or **user**. Press ENTER.

auto: The area around the average sound speed is defined by the transmitter.

user: The area around the average sound speed has to be entered.

```
c-Medium=1500m/s
range    +-150m/s
```

Enter the area around the average sound speed of the medium. Press ENTER.

This display will only be indicated if **user** has been selected.

```
Kinem.Viscosity
1.01    mm2/s
```

Enter the kinematic viscosity of the medium. Press ENTER.

```
Density
1.00    g/cm3
```

Enter the density of the medium. Press ENTER.

13.3 Extended Library

13.3.1 Introduction

If the extended library is activated, it is possible to enter material and medium parameters as a function of the temperature or of the pressure. These data can be entered into the transmitter directly.

Tab. 13.2: Material and medium parameters that can be stored

parameter	parameter is necessary for...
material parameter	
transversal sound speed	flow measurement
longitudinal sound speed	flow measurement
type of sound wave	flow measurement
typical roughness	profile correction of the flow velocity
medium parameter	
sound speed	start of measurement
viscosity	profile correction of the flow velocity
density	calculation of mass flow rate

Enter only the parameters needed for the measuring task.

The dependence of the material/medium parameters on the temperature and pressure can be described

- as constants
- as linear function
- with polynomials of grade 1 to 4
- with customized interpolation functions

In most cases, constants or a linear function are sufficient.

If, e.g., the temperature fluctuations at the measuring point are low compared to the temperature dependence of the material parameters, the linearization or the complete neglect of the temperature dependence will not result in a considerable additional measuring error.

If, however, the process conditions fluctuate strongly and the medium parameters depend strongly on the temperature (e.g., viscosity of a hydraulic oil), polynomials or customized interpolation functions should be used. Contact EESIFLo to find the best solution for the measuring task.

Customized interpolation functions

Some dependencies are only approximated insufficiently by polynomials. A number of customized interpolation functions **Basics: $Y=F(X, Z)$** are available to interpolate multidimensional dependencies $y = f(T, p)$. Contact EESIFLo for more information.

13.3.2 Activation of the Extended Library

```
Extended Library
off                >ON<
```

Select Special Funct.\SYSTEM settings\Libraries\Extended Library. Press ENTER.

Select on to activate the extended library. Press ENTER.

13.3.3 Input of Material/Medium Parameters

The parameters of a user defined material/medium can be entered now.

The input of a material or a medium is almost identical. Therefore, the displays for a medium will only be shown and described in case of differences.

```
Special Funct.  ↑
Install Material
```

Select Special Funct.\Install Material or Install Medium. Press ENTER.

```
USER Material
NOT FORMATTED !
```

An error message will be displayed if the coefficient memory does not contain an area for user defined materials/media.

Partition the coefficient memory accordingly (see section 13.1).

```
Edit Material  ↑
Basics:Y=m*X +n
```

Select the function for the temperature or pressure dependence of the material/medium parameters:

Y=const.: constants

Y=M*X+N: linear function of the temperature

Y=Polynom: $y = k_0 + k_1 \cdot x + k_2 \cdot x^2 + k_3 \cdot x^3 + k_4 \cdot x^4$

Y=F(X, Z): customized interpolation function (only for experienced users or after consultation with EESIFLo)

go back: return to the previous menu item

```
USER Material  ↑
#01:--not used--
```

Select a user defined material/medium.

```
USER MATERIAL  2
>EDIT<         delete
```

Select edit to edit the material/medium parameters or delete to delete the material/medium and to return to the scroll list Edit Material or Edit Medium.

This display will only be indicated if an already existing material/medium has been selected.

```
#2: Input Name:
USER MATERIAL  2
```

Enter the designation of the material/medium. Press ENTER.

The default name for a user defined material/medium is USER MATERIAL N or USER MEDIUM N with N being an integer.

Material parameters

Enter the material's:

- transversal sound speed
- longitudinal sound speed

1...5 values depending on the selected function have to be entered. Press ENTER after each input.

If an already defined material is edited, for each parameter there will be a request whether it is to be edited. Select yes or no. Press ENTER. Change the values, if necessary.

```
Default soundsp.
long.          >TRANS.<
```

Select the type of sound wave to be used for the flow measurement. Press ENTER.

For most materials, a transversal sound wave has to be selected.

```
Roughness
0.4           mm
```

Enter the typical roughness of the material. Press ENTER.

```
Save changes
no            >YES<
```

Select yes to store the entered parameters or no to quit the menu item without storing. Press ENTER.

Medium parameters

Enter the medium's:

- longitudinal sound speed
- kinematic viscosity
- density

Depending on the selected function, 1...5 values have to be entered. Press ENTER after each input.

If an already defined medium is edited, for each parameter of some of the functions there will be a request whether it is to be edited. Select `yes` or `no`. Press ENTER. Change the values, if necessary.

```
Save changes
no          >YES<
```

Select `yes` to store the entered parameters, `no` to quit the menu item without storing. Press ENTER.

13.4 Deleting a User Defined Material/Medium

To delete a user defined material/medium, proceed as follows:

Select `Special Funct.\Install Material` or `Install Medium`. Press ENTER.

If the extended library is activated, press ENTER until the request for deleting is displayed.

```
Install Material
edit          >DELETE<
```

Select `delete`. Press ENTER.

```
USER Material
#01: Polystyrol
```

Select the material/medium to be deleted. Press ENTER.

```
Really Delete?
no          >YES<
```

Select `yes` or `no`. Press ENTER.

13.5 Arrangement of the Material/Medium Scroll List

The materials and media to be displayed in the program branch `Parameter` are arranged in the material scroll list and in the medium scroll list.

Note! User defined materials/media will always be displayed in the scroll lists of the program branch `Parameter`.

```
SYSTEM settings ↑
Libraries
```

Select `Special Funct.\SYSTEM settings\Libraries`. Press ENTER.

```
Libraries      ↑
Material list
```

Select `Material list` to edit the material scroll list or `Medium list` to edit the medium scroll list.

Select `go back` to return to `SYSTEM settings`. Press ENTER.

```
Material list
factory        >USER<
```

Select `factory` if all materials/media of the internal database are to be displayed in the scroll list. An already existing scroll list will not be deleted but only deactivated.

Select `user` to activate the user defined scroll list. Press ENTER.

```
Material list  ↑
>Show list
```

If `user` has been selected, the material or medium scroll list can be edited (see section 13.5.1...13.5.3).

```
Material list  ↑
>End of Edit
```

Select `End of Edit` to stop editing. Press ENTER.

```
Save List      ?
no            >YES<
```

Select `yes` to store all changes of the scroll list or `no` to quit the menu item without storing. Press ENTER.

Note! If the material/medium scroll list is quit by pressing key B before storing, all changes will be lost.

13.5.1 Displaying a Scroll List

```
Material list  ↑
>Show list
```

Select `Show list`. Press ENTER to display the scroll list as in the program branch `Parameter`.

```
Current list=  ↑
Other Material
```

The current scroll list is displayed in the lower line.
Press ENTER to return to the scroll list `Material list` or `Medium list`.

13.5.2 Adding a Material/Medium to the Scroll List

```
Material list  ↑
>Add Material
```

Select `Add Material` or `Add Medium` to add a material/medium to the scroll list. Press ENTER.

```
>Add Material  ↑
Stainless Steel
```

All materials/media that are not contained in the current scroll list will be displayed in the lower line.
Select the material/medium. Press ENTER. The material/medium will be added to the scroll list.

Note! The materials/media are displayed in the order in which they have been added.

13.5.3 Adding all Materials/Media to the Scroll List

```
Material list  ↑
>Add all
```

Select `Add all` to add all materials/media of the database to the current scroll list. Press ENTER.

13.5.4 Removing a Material/Medium from the Scroll List

```
Material list  ↑
>Remove Material
```

Select `Remove Material` or `Remove Medium` to remove a material/medium from the scroll list. Press ENTER.

```
>Remove Material;
Stainless Steel
```

All materials/media of the current scroll list will be displayed in the lower line.
Select the material/medium. Press ENTER. The material/medium will be removed from the scroll list.

Note! User defined materials/media will always be displayed in the scroll lists of the program branch `Parameter`. They cannot be removed.

13.5.5 Removing all Materials/Media from the Scroll List

```
Material list  ↑
>Remove all
```

Select `Remove all` to remove all materials/media from the scroll list. Press ENTER. User defined materials/media will not be removed.

14 Settings

14.1 Time and Date

The transmitter has a battery-powered clock.

14.1.1 Time

```
SYSTEM settings↓
Set Clock
```


Select Special Funct.\SYSTEM settings\Set Clock. Press ENTER.

```
TIME          11:00
ok            >NEW<
```

The current time is displayed. Select `ok` to confirm the time or `new` to set the time. Press ENTER.

```
TIME          11:00
Set Time      !
```

Press key  to select the digit to be edited.

Press key  and C to edit the selected digit. Press ENTER.

```
TIME          11:11
>OK<          new
```

The new time is displayed. Select `ok` to confirm the time or `new` to set the time again. Press ENTER.

14.1.2 Date


After the time has been set, DATE is displayed.

```
DATE 2011-01-25
ok            >NEW<
```

Select `ok` to confirm the date or `new` to set the date. Press ENTER.

```
DATE 2011-01-25
Set Date      !
```

Press key  to select the digit to be edited.

Press key  and C to edit the selected digit. Press ENTER.

```
DATE 2011-01-26
>OK<          new
```

The new date is displayed. Select `ok` to confirm the date or `new` to set the date again. Press ENTER.

14.2 Dialogs and Menus

```
SYSTEM settings↓
Dialogs/Menus
```

Select Special Funct.\SYSTEM settings\Dialogs/Menus. Press ENTER.

Note!

The settings of the menu item `Dialogs/Menus` will be stored at the end of the dialog. If the menu item is quit before the end of the dialog, the settings will not be effective.

14.2.1 Pipe Circumference

```
Pipe Circumfer.
off            >ON<
```

Select `on` if the pipe circumference is to be entered instead of the pipe diameter in the program branch `Parameter`. Press ENTER.

```
Outer Diameter
100.0         mm
```

If `on` has been selected for `Pipe Circumfer.`, the outer pipe diameter will nevertheless be requested in the program branch `Parameter`.

To select the menu item `Pipe Circumfer.`, enter 0 (zero). Press ENTER.

```
Pipe Circumfer.
314.2         mm
```

The value displayed in `Pipe Circumfer.` is calculated on the basis of the last displayed value of the outer pipe diameter.

example: $100 \text{ mm} \cdot \pi = 314.2 \text{ mm}$

```
Pipe Circumfer.
180          mm
```

Enter the pipe circumference. The limits for the pipe circumference are calculated on the basis of the limits for the outer pipe diameter.

Outer Diameter
57.3 mm

During the next scroll through the program branch `Parameter`, the outer pipe diameter that corresponds to the entered pipe circumference will be displayed.

example: $180 \text{ mm} : \pi = 57.3 \text{ mm}$

Note!

The pipe circumference is only edited temporarily. When the transmitter switches back to the display of the pipe circumference (internal recalculation), slight rounding errors may occur.

Example:

entered pipe circumference: 100 mm
displayed outer pipe diameter: 31.8 mm

When the transmitter switches back to the display of the pipe circumference, 99.9 mm will be displayed.

14.2.2 Measuring Point Number

Meas.Point No.:
(1234) > (↑↓←→) <

Select (1234) if the measuring point is to be identified only by numbers, point and dash.
Select (↑↓←→) if the measuring point is to be designated with ASCII characters.

14.2.3 Transducer Distance

Transd. Distance
auto >USER<

recommended setting: `user`

- `user` will be selected if the measuring point is always the same.
- `auto` can be selected if the measuring point changes often.

Transd. Distance?
(50.8) 50.0 mm

In the program branch `Measuring`, the recommended transducer distance will be displayed in parentheses, followed by the entered transducer distance if the recommended and the entered transducer distance are not identical.

Transd. Distance?
50.8 mm

During transducer positioning in the program branch `Measuring`

- only the entered transducer distance will be displayed if `Transd. Distance = user` has been selected and the recommended and the entered transducer distances are identical
- only the recommended transducer distance will be displayed if `Transd. Distance = auto` has been selected.

14.2.4 Error Value Delay

The error value delay is the time after which an error value will be sent to an output if no valid measured values are available.

Error-val. delay
damping >EDIT<

Select `edit` to enter an error value delay. Select `damping` if the damping factor is to be used as the error value delay.

For further information on the behavior of missing measured values see section 16.1.2 and 16.2.

14.2.5 Alarm State Indication

SHOW RELAIS STAT
off >ON<

Select `on` to display the alarm state during the measurement.

For further information on the alarm outputs see section 16.5.

14.2.6 Units of Measurement

It is possible to set the units of measurement for the length, temperature, pressure, density, kinematic viscosity, and sound speed:

Length unit
>[mm]< [inch]

Select `mm` or `inch` as the unit of measurement for the length. Press ENTER.

Temperature
>[°C]< [°F]

Select `°C` or `°F` as the unit of measurement for the temperature. Press ENTER.

```
Pressure
>[bar]<    [psi]
```

Select **bar** or **psi** as the unit of measurement for the pressure. Press ENTER.

```
Density [lb/ft3]
no      >YES<
```

Select **yes** if **lb/ft3** is to be used as the unit of measurement for the density. Press ENTER.

```
Density unit
g/cm3    >kg/m3<
```

Select **g/cm3** or **kg/m3** as the unit of measurement for the density. Press ENTER.

This display will only be indicated if **lb/ft3** has not been selected as the unit of measurement for the density.

```
Viscosity unit
mm2/s    >cSt<
```

Select **mm2/s** or **cSt** as the unit of measurement for the kinematic viscosity. Press ENTER.

```
Soundspeed unit
>[m/s]<    [fps]
```

Select **m/s** or **fps** as the unit of measurement for the sound speed. Press ENTER.

14.2.7 Setting for the Medium Pressure

It is possible to set whether the absolute or the relative pressure will be used:

```
Pressure absolut
off      >ON<
```

Select **on** or **off**. Press ENTER.

If **on** has been selected, the absolute pressure p_a will be displayed/input/output.

If **off** has been selected, the relative pressure p_g will be displayed/input/output.

$$p_g = p_a - 1.01 \text{ bar}$$

```
Fluid pressure
1.00 bar(a)
```

The pressure and its unit of measurement will, e.g., be displayed in the program branch **Parameter**. It will be followed by the selected pressure, indicated in parentheses.

a - absolute pressure

g - relative pressure

Note! All changes will be stored at the end of the dialog.

14.3 Measurement Settings

```
SYSTEM settings↓
Measuring
```

Select **Special Funct.\SYSTEM settings\Measuring**. Press ENTER.

Note! The settings of the menu item **Measuring** will be stored at the end of the dialog. If the menu item is quit before the end of the dialog, the settings will not be effective.

```
Flow Velocity
>NORMAL< uncorr.
```

Select **normal** to display and transmit the profile corrected flow values, **uncorr.** to display and transmit the flow values without flow profile correction. Press ENTER.

For further information see section 11.6.

```
Cut-off Flow
absolut >SIGN<
```

A lower limit for the flow velocity can be entered (see section 11.5).

```
Cut-off Flow
factory >USER<
```

```
Velocity limit
24.0    m/s
```

An upper limit for the flow velocity can be entered (see section 11.4).

Enter 0 (zero) to deactivate the flow velocity check.

```
Quant. wrapping
off     >ON<
```

Select the overflow behavior of the totalizers (see section 11.3.1).


```
Quantity recall
off          >ON<
```

Select **on** to keep the previous totalizer values after a restart of the measurement.
Select **off** to reset the totalizers to zero after a restart of the measurement.

Note!

All changes will be stored at the end of the dialog.

14.4 Setting the Contrast


```
SYSTEM settings↓
Miscellaneous
```

Select **Special Funct.\SYSTEM settings\Miscellaneous** to set the contrast of the display of the transmitter. Press **ENTER** until the menu item **SETUP DISPLAY** is displayed.

```
SETUP DISPLAY
←  CONTRAST  →
```

The contrast of the display is adjusted with the following keys:

 increases the contrast

 reduces the contrast

It is possible to reset the display to medium contrast. Enter HotCode **555000**.

Note!

After an initialization of the transmitter, the display is displayed to medium contrast.

14.5 Instrument Information

```
Special Funct. ↓
Instrum. Inform.
```

Select **Special Funct.\Instrum. Inform.** to display information about the transmitter. Press **ENTER**.

```
EESXXXX-XXXXXXXXX
V x.xx  dd.mm.yy
```

The type and the serial number of the transmitter will be displayed in the upper line.
The firmware version of the transmitter with date is displayed in the lower line.
Press **ENTER**.

15 SuperUser Mode

The SuperUser mode offers the possibility of an advanced analysis of the signal and the measured values as well as the definition of additional parameters adapted to the measuring point, in order to achieve better measuring values or during experimental work. Features of the SuperUser mode are:

- Defaults will not be observed.
- There are no plausibility checks when parameters are being entered.
- There is no check whether the entered parameters are within the limits determined by the laws of physics and technical data.
- The cut-off flow is not active.
- A value for the number of sound paths has to be entered.
- Some menu items that are not visible in the normal the normal mode are displayed.

Attention! The SuperUser mode is intended for experienced users with advanced application knowledge. The parameters can affect the normal measuring mode and lead to wrong measuring values or to a failure of the measurement when a new measuring point is set up.

15.1 Activation/Deactivation

Enter HotCode 071049.

```
SUPERUSER MODE
*IS ACTIVE NOW*
```

It is displayed that the SuperUser mode is activated. Press ENTER. The main menu will be displayed.

Enter HotCode **071049** again to deactivate the SuperUser mode.

```
SUPERUSER MODE
IS PASSIVE NOW
```

It is displayed that the SuperUser mode is deactivated. Press ENTER. The main menu will be displayed.

Attention! Some of the defined parameters are still active after the deactivation of the SuperUser mode.

15.2 Defining the Flow Parameters

In the SuperUser mode, it is possible to define some flow parameters (profile bounds, correction of the flow velocity) for the specific application or measuring point.

```
Measuring      ↑
Calibration
```

Select Special Funct.\SYSTEM settings\Measuring\Calibration. Press ENTER.

15.2.1 Profile Bounds

```
Profile bounds
factory >USER<
```

Select `user` if the profile bounds are to be defined. If `factory` is selected, the default profile bounds will be used and the menu item `Calibration` will be displayed (see section 15.2.2).

Press ENTER.

```
Laminar flow
if R*<      0
```

Enter the max. Reynolds number at which the flow is laminar. The entered number will be rounded to the hundreds. Enter 0 (zero) to use the default value 1 000.

Press ENTER.

```
Turbulent flow
if R*>      0
```

Enter the min. Reynolds number at which the flow is turbulent. The entered number will be rounded to the hundreds. Enter 0 (zero) to use the default value 3 000.

Press ENTER.

```
Calibration ?
>OFF<      on
```

A request is displayed if an additional correction of the flow velocity is to be defined. Select `on` to define the correction data, `off` to work without correction of the flow velocity and return to the menu item `SYSTEM settings`.

For the definition of the correction of the flow velocity see section 15.2.2.

Example: profile bound for the laminar flow: 1 500
 profile bound for the turbulent flow: 2 500
 At Reynolds numbers < 1 500, the flow during the measurement is regarded as laminar for the calculation of the physical quantity. At Reynolds numbers > 2 500, the flow is regarded as turbulent. The range 1 500...2 500 is the transition range between laminar and turbulent flow.

Attention! The defined profile bounds are still active after the deactivation of the SuperUser mode.

15.2.2 Correction of the Flow Velocity

After the profile bounds have been defined (see section 15.2.1), it is possible to define a correction of the flow velocity.

$$v_{\text{cor}} = m \cdot v + n$$

with

v - measured flow velocity

m - slope, range: -2.000...+2.000

n - offset, range: -12.7...+12.7 cm/s

v_{cor} - corrected flow velocity

All quantities derived from the flow velocity will be calculated with the corrected flow velocity. The correction data will be transmitted to the PC or printer during the online or offline transmission of data.

Note! During the measurement, it will not be displayed that the correction of the flow velocity is active.

Calibration ?
 off >ON<

Select **on** to define the correction data, **off** to work without correction of the flow velocity and return to the menu item **SYSTEM** settings.

Slope=
 1.00

If **on** has been selected, enter the slope. If **0.0** is entered, the correction will be deactivated.

Press ENTER.

Offset=
 0.0 cm/s

Enter the offset. Enter **0** (zero) to work without an offset.

Press ENTER.

Example 1: Slope: 1.1
 Offset: -10.0 cm/s = -0.1 m/s
 If a flow velocity $v = 5$ m/s is measured, before the calculation of the derived quantities, it will be corrected as follows:
 $v_{\text{cor}} = 1.1 \cdot 5 \text{ m/s} - 0.1 \text{ m/s} = 5.4 \text{ m/s}$

Example 2: Slope: -1.0
 Offset: 0.0
 Only the sign of the measured values is changed.

Note! The correction data will only be stored when a measurement is started. If the transmitter is switched off without starting a measurement, the entered correction data will be lost.

Attention! The correction of the flow velocity is still active after the deactivation of the SuperUser mode.

15.3 Limit of the Signal Amplification

In order to prevent disturbing and/or pipe wall signals (e.g., if the pipe has run empty) from being interpreted as useful signals, it is possible to define a max. signal amplification. If the signal amplification is greater than the max. signal amplification,

- the flow velocity will be marked as invalid. The physical quantity cannot be determined.
- a hash symbol "#" will be displayed after the unit of measurement (in case of a normal error, "?" is displayed).

Select Special Funct.\SYSTEM settings\Measuring\Miscellaneous. Press ENTER until the menu item Gain threshold is displayed.

```
Gain threshold
Fail if > 90 dB
```

Enter the max. signal amplification. Enter 0 (zero) if no limit of the signal amplification is to be used.

Press ENTER.

```
GAIN=91dB→FAIL!
```

The current value of the signal amplification (GAIN=) can be displayed in the upper line in the program branch Measuring. If the current value of the signal amplification is higher than the max. signal amplification, →FAIL! will be displayed after the current value.

Attention! The limit of the signal amplification is still active after the deactivation of the SuperUser mode.

15.4 Upper Limit of the Sound Speed

When the plausibility of the signal is evaluated, it will be checked if the sound speed is within a defined range. The upper limit used for the evaluation is the greater of the following values:

- fixed upper value, default: 1 848 m/s
- value of the sound speed curve of the medium at the operating point plus offset, default offset: 300 m/s

In the SuperUser mode, the values can be defined for media that are not contained in the data set of the transmitter. Select Special Funct.\SYSTEM settings\Measuring\Miscellaneous. Press ENTER until the menu item Bad soundspeed is displayed.

```
Bad soundspeed
thresh. 2007 m/s
```

Enter the fixed upper limit of the sound speed. Enter 0 (zero) to use the default value of 1 848 m/s.

Press ENTER.

```
Bad soundspeed
offset: +321 m/s
```

Enter the offset. Enter 0 (zero) to use the default value of 300 m/s.

Press ENTER.

Example: fixed upper value of the sound speed thresh.: 2 007 m/s
offset: 600 m/s
value of the sound speed curve at the operating point: 1 546 m/s
As $1\,546\text{ m/s} + 600\text{ m/s} = 2\,146\text{ m/s}$ is greater than the fixed upper value 2 007, this value will be used as the upper limit of the sound speed when the plausibility of the signal is evaluated.

```
GAIN=91dB
SS=1038/2146 m/s
```

It is possible to display the valid range for the sound speed (SS=) in the lower line during the measurement. The second value (here: 2 146 m/s) is the upper limit at the operating point.

Attention! The defined upper limit of the sound speed is still active after the deactivation of the SuperUser mode.

15.5 Detection of Long Measurement Failures

If there are no valid measured value during a long time interval, new increments of the totalizers will be ignored. The values of the totalizers remain unchanged.

In the SuperUser mode, it is possible to set the time interval. Select Special Funct.\SYSTEM settings\Measuring\Miscellaneous. Press ENTER until the menu item Do not total. if no meas. is displayed.

```
Do not total. if
no meas.> 0 s
```

Enter the time. If 0 (zero) is entered, the default value 30 s will be used.

15.6 Number of Decimal Places of the Totalizers

The values of the totalizers can be displayed with up to 11 places, e.g., 74890046.03. In the SuperUser mode, it is possible to define the number of decimal places.

Select Special Funct.\SYSTEM settings\Measuring\Miscellaneous. Press ENTER until the menu item Total digits is displayed.

```
Total digits  ↑
Automatic
```

Select one of the following list items:

Automatic: dynamic adjustment

Fixed to x digit: x decimal places (range: 0...4)

Press ENTER.

Total digits = Automatic

The number of decimal places will be adjusted dynamically. Low values will first be displayed with 3 decimal places. With greater values, the number of decimal places will be reduced.

max. value	display
$< 10^6$	±0.00 ... ±999999.999
$< 10^7$	±1000000.00 ... ±9999999.99
$< 10^8$	±10000000.0 ... ±99999999.9
$< 10^{10}$	±1000000000 ... ±9999999999

Total digits = Fixed to x digit

The number of decimal points is constant. The max value of the totalizer is reduced with each additional decimal place.

decimal places	max. value	max. display
0	$< 10^{10}$	±9999999999
1	$< 10^8$	±9999999.9
2	$< 10^7$	±9999999.99
3	$< 10^6$	±999999.999
4	$< 10^5$	±99999.9999

Note! The number of decimal places and the max. value defined here only affect the display of the totalizers.

For setting the behavior of the totalizers when the max. value is reached see section 11.3.1.

15.7 Manual Reset of the Totalizers

If the manual reset of the totalizers is activated, the totalizers can be reset to zero during the measurement by pressing key C three times, even if a program code is activated.

Select Special Funct.\SYSTEM settings\Measuring\Miscellaneous. Press ENTER until the menu item 3xC clear totals is displayed.

```
3xC clear totals
off >ON<
```

Select on to activate the manual reset of the totalizers, off to deactivate it. Press ENTER.

Note! The manual reset of the totalizers is still active after the deactivation of the SuperUser mode.

Note! If the manual reset of the totalizers is activated, the manual reset function for the alarm outputs (see section 16.6.4) will be deactivated. In order to be able to reset the alarm outputs during the measurement, it will be necessary to deactivate the manual reset of the totalizers.

15.8 Display of the Sum of the Totalizers

The sum of the totalizers for the two flow directions can be displayed in the upper line during the measurement.

Select `Special Funct.\SYSTEM settings\Measuring\Miscellaneous`. Press ENTER until the menu item `Show ΣQ` is displayed.

Show ΣQ
off >ON<

Select `on` to activate the display of the sum of the totalizers, `off` to deactivate it. Press ENTER.

ΣQ 13.2 m3

If the display of the sum of the totalizers is activated, the sum ΣQ can be displayed in the upper line during the measurement.

15.9 Display of the Last Valid Measured Value

If the signal is not sufficient for a measurement, usually `UNDEF` will be displayed. Instead of `UNDEF`, it is also possible to display the last valid measured value.

Select `Special Funct.\SYSTEM settings\Measuring\Miscellaneous`. Press ENTER until the menu item `Keep display val` is displayed.

Keep display val
off >ON<

Select `on` to activate the display of the last valid measured value, `off` to deactivate it. Press ENTER.

15.10 Display During the Measurement

In the SuperUser mode, the following information can be displayed during the measurement besides the normal information (see section 10.2):

display	explanation
t=	transit time of the measuring signal
c=	sound speed
REYNOLD=	Reynolds number
VARI A=	standard deviation of the signal amplitude
VARI V=	standard deviation of the transit time of the measuring signal
dt-norm=	transit time difference standardized to the transducer frequency
	density of the medium

16 Outputs

The outputs have to be installed and activated before they can be used:

- assign the physical quantity (source item) to be transmitted to the output and the properties of the signal
- define the behavior of the output in case no valid measured values are available
- activation of the installed output in the program branch *Output Options*

16.1 Installation of an Output

All outputs are installed in *Special Funct.\SYSTEM settings\Proc. outputs*.

Note! The configuration of an output will be stored at the end of the dialog. If the dialog is quit by pressing key B, the changes will not be stored.

SYSTEM settings;
Proc. outputs

Select *Special Funct.\SYSTEM settings\Proc. outputs*. Press ENTER.

Install Output ↑
Current I1 (✓)

Select the output to be installed. Press ENTER.

The scroll list contains all available outputs. A tick ✓ after a list item indicates that this output has already been installed.

I1 enable
no >YES<

This display will be indicated if the output has not been installed yet. Select *yes*. Press ENTER.

I1 disable
>NO< yes

If the output has already been installed, select *no* to reconfigure it or *yes* to uninstall the output and to return to the previous menu item to select another output. Press ENTER.

I1 Source item ↑
Measuring value

Select the physical quantity (source item) to be transmitted to the output.

If a binary output is configured, only the list items *Limit* and *Impuls* will be displayed.

The source items and their scroll lists are shown in Tab. 16.1.

Tab. 16.1: Configuration of the outputs

source item	list item	output
Measuring value	-	physical quantity selected in the program branch <i>Output Options</i>
Quantity	Q+	totalizer for the positive flow direction
	Q-	totalizer for the negative flow direction
	ΣQ	sum of the totalizers (positive and negative flow direction)
Limit	R1	limit message (alarm output R1)
Impuls	from abs(x)	pulse without sign consideration
	from x > 0	pulse for positive measured values
	from x < 0	pulse for negative measured values
Miscellaneous	c-Medium	sound speed of the medium
	Signal	signal amplitude
	SCNR	ratio useful signal to correlated disturbance signal
	VariAmp	standard deviation of the signal amplitude
	Density	density of the medium

16.1.1 Output Range

I1 Output range↓
4/20 mA

During the configuration of an analog output, the output range is defined. Select a list item or other range... to enter the output range manually.

I1 Output MIN ↓
10.0 mA

If other range... has been selected, enter the values Output MIN and Output MAX. Press ENTER after each input.

I1 Output MAX ↓
11.0 mA

I1 Output MAX ↓
12.0 minimal

This error message will be displayed if the output range is not min. 10 % of the max. output range. The next possible value will be displayed. Repeat the input.
Example: $I_{MAX} - I_{MIN} \geq 2 \text{ mA}$ for a 4...20 mA current output

16.1.2 Error Output

In the following dialog, an error value can be defined which is to be output if the source item cannot be measured, e.g., if there are gas bubbles in the medium:

Tab. 16.2: Error output

error value	result
Minimum	output of the lower limit of the output range
Hold last value	output of the last measured value
Maximum	output of the upper limit of the output range
Other value...	The value has to be entered manually. It has to be within the limits of the output.

Example:

source item: volumetric flow rate

output: current output

output range: 4...20 mA

error value delay t_d (see section 16.2): > 0

The volumetric flow rate cannot be measured during the time interval $t_0...t_1$ (see Fig. 16.1). The error value will be output.

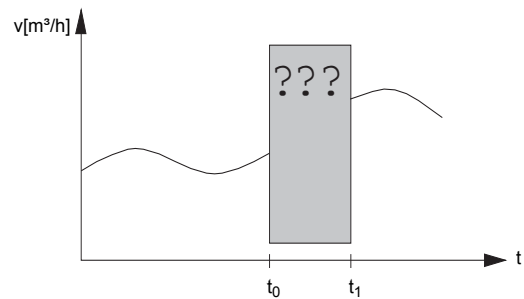
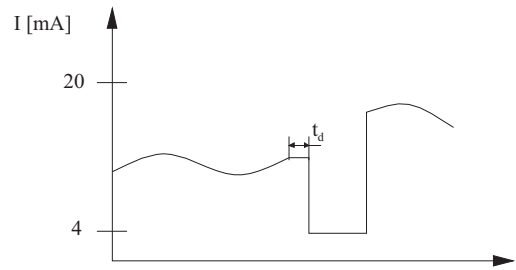
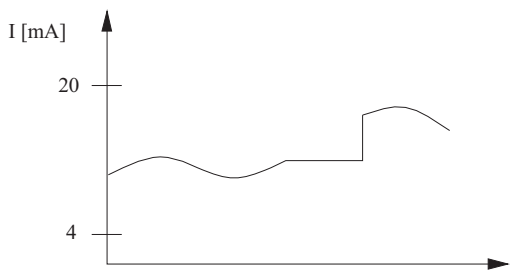
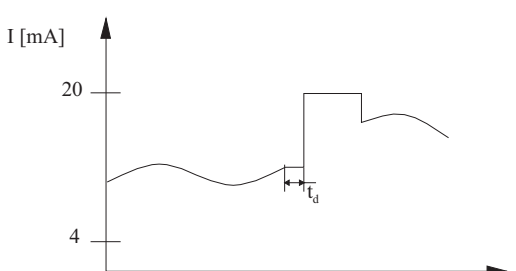
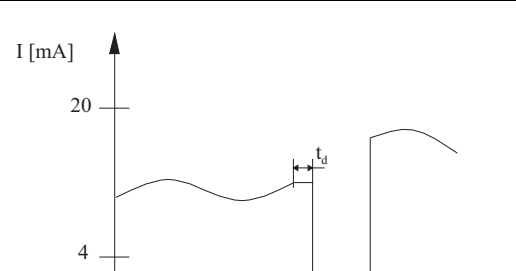


Fig. 16.1: Error output

Tab. 16.3: Examples for the error output

list item for the error output	output signal
<div>Error-value ↓ Minimum (4.0mA)</div>	
<div>Error-value ↓ Hold last value</div>	
<div>Error-value ↓ Maximum (20.0mA)</div>	
<div>Error-value ↓ Other value...</div> <div>error output = 2 mA</div>	

Error-value ↓
Minimum (4.0mA)

Select a list item for the error output. Press ENTER.

Error-value 3.5 mA

If Other value has been selected, enter an error value. It has to be within the limits of the output.
Press ENTER.

Note!

The settings will be stored at the end of the dialog.

I1 active loop
Terminal: -D, C+

The terminals for the connection of the output are displayed (here: -D and C+ for the active current loop).
Press ENTER.

16.1.3 Function Test

The function of the installed output can now be tested. Connect a multimeter with the installed output.

Test of the analog output

```
I1:Output Test
      4      mA
```

The current output is tested in the display. Enter a test value. It has to be within the output range. Press ENTER.

```
I1= 4.0 mA
Again? no >YES<
```

If the multimeter displays the entered value, the output functions correctly.

Press **yes** to repeat the test, **no** to return to the **SYSTEM** settings. Press ENTER.

Test of the binary output

```
B1:Output Test ↑
Reed-Relay OFF
```

Select **Reed-Relay OFF** to test the de-energized state of the output. Press ENTER. Measure the resistance at the output. The value has to be high ohmic.

```
B1=OFF
AGAIN? no >YES<
```

Select **yes**. Press ENTER.

```
B1:Output Test ↑
Reed-Relay ON
```

Select **Reed-Relay ON** to test the energized state of the output. Press ENTER. Measure the resistance at the output. The value has to be low ohmic.

```
B1=ON
AGAIN? no >YES<
```

Select **yes** to repeat the test, **no** to return to **SYSTEM** settings. Press ENTER.

16.2 Error Value Delay

The error value delay is the time interval after which the error value will be transmitted to the output in case no valid measured values are available. The error value delay can be entered in the program branch **Output Options** if this menu item has previously been activated in the program branch **Special Funct..** If the error value delay is not entered, the damping factor will be used.

```
Error-val. delay
>DAMPING< edit
```

Select **Special Funct.\SYSTEM settings\Dialogs/Menus/Error-val. delay**.

Select **Damping** if the damping factor is to be used as the error value delay. Select **Edit** to activate the menu item **Error-val. delay** in the program branch **Output Options**.

```
Error-val. delay
      10      s
```

From now on, the error value delay can be entered in the program branch **Output Options**.

16.3 Activation of the Current Output

Note! An output can only be activated in the program branch `Output Options` if it has previously been installed.

```
Current Loop
I1: no      >YES<
```

Select the program branch `Output Options`. Press `ENTER` until `Current Loop` is displayed. Select `yes` to activate the output. Press `ENTER`.

16.3.1 Measuring Range of the Analog Outputs

After an analog output has been activated in the program branch `Output Options`, the measuring range of the source item has to be entered.

```
Meas.Values
>ABSOLUT<  sign
```

Select `sign` if the sign of the measured values is to be considered for the output.
Select `absolut` if the sign is not to be considered.

```
Zero-Scale Val.
0.00    m3/h
```

Enter the lowest expected measured value. The unit of measurement of the source item will be displayed.

`Zero-Scale Val.` is the measured value that corresponds to the lower limit of the output range as defined in section 16.1.1.

```
Full-Scale Val.
300.00   m3/h
```

Enter the highest expected measured value.

`Full-Scale Val.` is the measured value that corresponds to the upper limit of the output range as defined in section 16.1.1.

Example:
output: current output
output range: 4...20 mA
`Zero-Scale Val.:` 0 m³/h
`Full-Scale Val.:` 300 m³/h
volumetric flow rate = 0 m³/h, corresponds to 4 mA
volumetric flow rate = 300 m³/h, corresponds to 20 mA

16.3.2 Function Test

The function of the installed output can now be tested. Connect a multimeter to the installed output.

```
I1: Test output ?
no      >YES<
```

Select `yes` to activate the output. Press `ENTER`.

```
I1: Test value =
5.00    m3/h
```

Enter a test value. The value has to be indicated on the connected multimeter. Press `ENTER`.

```
I1: Test output ?
no      >YES<
```

Select `yes` to repeat the test. Press `ENTER`.

16.4 Activation of a Binary Output as a Pulse Output

A pulse output is an integrating output which emits a pulse when the volume or the mass of the medium which has passed the measuring point reaches a given value (`Pulse Value`). The integrated quantity is the selected physical quantity. Integration is restarted as soon as a pulse is emitted.

Note! The menu item `Pulse Output` will only be indicated in the program branch `Output Options` if a pulse output has been installed.

```
Pulse Output
B1: no      >YES<
```

Select `yes` to activate the output. Press `ENTER`.

```
Pulse Output
NO COUNTING !
```

This error message will be displayed if the flow velocity has been selected as the physical quantity.

The use of the pulse output is not possible in this case because integrating the flow velocity does not result in a reasonable value.

Pulse Value
0.01 m3

Enter the pulse value. The unit of measurement will be displayed according to the current physical quantity.

When the totaled physical quantity reaches the pulse value, a pulse will be emitted.

Pulse Width
100 ms

Enter the pulse width.

The range of possible pulse widths depends on the specification of the measuring instrument (e.g., counter, PLC) that is to be connected to the output.

The max. flow that the pulse output can work with will be displayed now. This value is calculated on the basis of the entered pulse value and pulse width.

If the flow exceeds this value, the pulse output will not function properly. In this case, the pulse value and the pulse width have to be adapted to the flow conditions. Press ENTER.

16.5 Activation of a Binary Output as an Alarm Output

Note! The menu item **Alarm Output** will only be displayed in the program branch **Output Options** if an alarm output has been installed.

Alarm Output
no >YES<

Select the program branch **Output Options**. Press ENTER until the menu item **Alarm Output** is displayed.

Select **yes** to activate the alarm output. Press ENTER.



16.5.1 Alarm Properties

The switching condition, the holding behavior and the switching function of an alarm output can be defined.

R1=FUNC<typ mode
Function: MAX

Three scroll lists will be displayed:

- func: switching condition
- typ: holding behavior
- mode: switching function

Press key  to select a scroll list in the upper line. Press key  to select a list item in the lower line.

Press ENTER to store the settings.

Tab. 16.4: Alarm properties

alarm property	setting	description
func (switching condition)	MAX	The alarm will switch if the measured value exceeds the upper limit.
	MIN	The alarm will switch if the measured value falls below the lower limit.
	+→- -→+	The alarm will switch if the flow direction changes (sign change of measured value).
	QUANT.	The alarm will switch if totalizing is activated and the totalizer reaches the limit.
	ERROR	The alarm will switch if a measurement is not possible.
	OFF	The alarm is switched off.
typ (holding behavior)	NON-HOLD	If the switching condition is not true anymore, the alarm will return to the idle state after approx. 1 s.
	HOLD	The alarm remains activated even if the switching condition is not true anymore.
mode (switching function)	NO Cont.	The alarm is energized if the switching condition is true and de-energized if idle.
	NC Cont.	The alarm is de-energized if the switching condition is true and energized if idle.

Note! If no measurement is made, all alarms will be de-energized, independently of the programmed switching function.

16.5.2 Setting the Limits

If the switching condition **MAX** or **MIN** is selected in the scroll list **func**, the limit of the output will have to be defined:

R1 Input: ↑
Volume flow

Select in the scroll list **Input** the physical quantity to be used for the comparison. The following list items are available for the alarm output R1:

- selected physical quantity
- signal amplitude
- sound speed of the medium

Press ENTER.

High Limit:
-10.00 m³/h

switching condition: **MAX**

Enter the upper limit. Press ENTER.

The alarm will switch if the measured value exceeds the limit.

Low Limit:
-10.00 m³/h

switching condition: **MIN**

Enter the lower limit. Press ENTER.

The alarm will switch if the measured value falls below the limit.

Example 1: High Limit:: -10 m³/h
volumetric flow rate = -9.9 m³/h
the limit is exceeded, the alarm switches
volumetric flow rate = -11 m³/h
the limit is not exceeded, the alarm does not switch

Example 2: Low Limit:: -10 m³/h
volumetric flow rate = -11 m³/h
the measured value is below the limit, the alarm switches
volumetric flow rate = -9.9 m³/h
the measured value is not below the limit, the alarm does not switch

If the switching condition **QUANT.** is selected in the scroll list **func**, the limit of the output will have to be defined:

Quantity Limit:
1.00 m³

switching condition: **QUANT.**

Enter the limit of the totalizer. Press ENTER.

The alarm will switch if the measured value reaches the limit.

A positive limit will be compared to the totalizer value for the positive flow direction.

A negative limit will be compared to the totalizer value for the negative flow direction.

The comparison will also take place if the totalizer of the other flow direction is displayed.

Note! The unit of measurement of the limit corresponds to the unit of measurement of the selected physical quantity.
If the unit of measurement of the physical quantity is changed, the limit has to be converted and entered again.

Example 1: physical quantity: volumetric flow rate in m³/h
Quantity Limit:: 1 m³

Example 2: physical quantity: volumetric flow rate in m³/h
Low Limit:: 60 m³/h
The unit of measurement of the physical quantity is changed to m³/min. The new limit to be entered is 1 m³/min.

16.5.3 Defining the Hysteresis

A hysteresis can be defined for the alarm output R1 to prevent a constant triggering of the alarm due to small fluctuations of the measured values around the limit.

The hysteresis is a symmetrical range around the limit. The alarm will be activated if the measured values exceed the upper limit and deactivated if the measured values fall below the lower limit.

Example: High Limit:: 30 m³/h
 Hysteresis: 1 m³/h
 The alarm will be triggered at values > 30.5 m³/h and deactivated at values < 29.5 m³/h.

R1 Hysteresis:
 1.00 m³/h

switching condition: MIN or MAX

Enter the value for Hysteresis.

or

Enter 0 (zero) to work without a hysteresis.

Press ENTER.

16.6 Behavior of the Alarm Output

16.6.1 Apparent Switching Delay

Measured values and totalizer values will be displayed rounded to two decimal places. The limits, however, will be compared to the non-rounded measured values. This might cause an apparent switching delay when the measured value changes marginally (less than two decimal places). In this case, the switching accuracy of the output is greater than the accuracy of the display.

16.6.2 Reset and Initialization of the Alarm

After an initialization, the alarm output will be initialized as follows:

Tab. 16.5: Alarm state after an initialization

func	OFF
typ	NON-HOLD
mode	NO Cont.
Limit	0.00

Press key C three times during the measurement to set the alarm output to the idle state. An alarm output whose switching condition is still met will be activated again after 1 s. This function is used to reset an alarm output of the type **HOLD** if the switching condition is no longer met.

By pressing key B, the measurement will be stopped and the main menu selected. The alarm output will be de-energized, independently of the programmed idle state.

16.6.3 Alarm Outputs During Transducer Positioning

At the beginning of the transducer positioning (bar graph display), the alarm output is reset to the programmed idle state.

If the bar graph is selected during the measurement, the alarm output will be reset to the programmed idle state.

An alarm output of the type **HOLD** that has been activated during the previous measurement will remain in the idle state after the transducer positioning if the switching condition is no longer met.

Switching of the alarm into the idle state will not be displayed.

16.6.4 Alarm Output During the Measurement

An alarm output with switching condition **MAX** or **MIN** will be updated max. once per second to avoid humming (i.e. fluctuation of the measured values around the value of the switching condition).

An alarm output of the type **NON-HOLD** will be activated if the switching condition is met. It will be deactivated if the switching condition is no longer met. The alarm will remain activated min. 1 s even if the switching condition is met for a shorter period of time.

An alarm output with the switching condition **QUANT.** will be activated if the limit is reached.

An alarm output with the switching condition **ERROR** will only be activated after several unsuccessful measuring attempts. Therefore, typical short-term disturbances of the measurement (e.g., switching on of a pump) will not activate the alarm.

An alarm output with the switching condition **+→- -→+** and of the type **NON-HOLD** will be activated with each change of the flow direction for approx. 1 s (see Fig. 16.2).

An alarm output with the switching condition **+→- -→+** and of the type **HOLD** will be active after the first change of the flow direction. It can be reset by pressing key C three times (see Fig. 16.2).

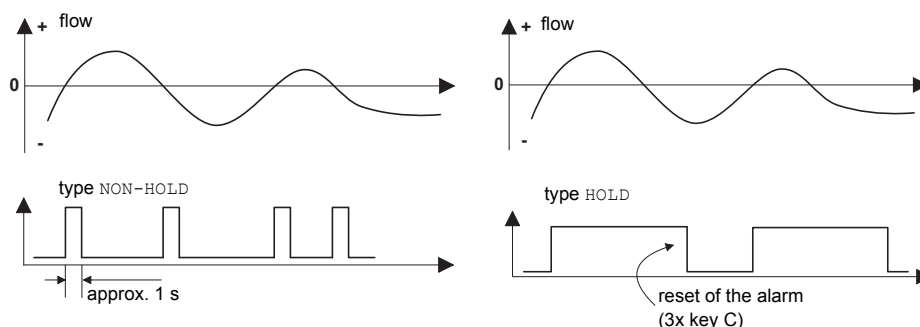


Fig. 16.2: Behavior of a relay when the flow direction changes

If there is an internal adaptation to changing measuring conditions, e.g., to a considerable rise of the medium temperature, the alarm will not switch. An alarm output with the switching condition **OFF** will be set automatically to the switching function **NO Cont..**

16.6.5 Indication of the Alarm State

Note! There is no visual or acoustic indication of alarm output switching.

After the configuration of the alarm output and during the measurement, the state of the alarm can be indicated. This function is activated in the program branch **Special Funct.\SYSTEM settings\Dialogs/Menus**. It is recommended to activate this function if the alarm output have to be reconfigured frequently.

SHOW RELAIS STAT
off >ON<

Select the menu item **SHOW RELAIS STAT**. Select **on** to activate the indication of the alarm state.

If the indication of the alarm state is activated, the state of the alarm output will be indicated after the configuration of the alarm output:

R1=□□□□
C=REPEAT

The indication of the alarm state is structured as follows:

R1 = □ □ □ □, where □ is a pictogram according to Tab. 16.1.

It is possible to repeat the configuration of the alarm output by pressing key C. If the configuration of the alarm output is complete, press ENTER. The main menu will be displayed.

If the indication of the alarm state is activated, it is possible to show the alarm state during the measurement. Press key to scroll through the upper line and to scroll through the lower line until the alarm state is indicated.

Tab. 16.1: Pictograms for the alarm state indication

	func (switching condition)	typ (holding behavior)	mode (switching function)	current state
R1 =				
	OFF	NON-HOLD	NO Cont.	closed
	MAX	HOLD	NC Cont.	open
	MIN			
	+→- -→+			
	QUANT.			
	ERROR			

Example: R1 =

16.6.6 Deactivation of the Output

If the programmed output is no longer required, it can be deactivated. The configuration of a deactivated output is stored and will be available if the output is activated again.

Alarm Output

>NO< yes

Select no in Output Options\Alarm Output to deactivate the output. Press ENTER.

17 Troubleshooting

If any problem appears which cannot be solved with the help of this user manual, contact our sales office and give a precise description of the problem. Specify the type, the serial number and the firmware version of the transmitter.

Calibration

Portalok 7S is a very reliable instrument. It is manufactured under strict quality control, using modern production techniques. If installed as recommended in an appropriate location, used cautiously and taken care of conscientiously, no troubles should appear. The transmitter has been calibrated at the factory and, usually, a re-calibration of the transmitter will not be necessary. A re-calibration is recommended if the contact surface of the transducers shows visible wear.

The transmitter has to be sent to EESIFLo for recalibration under reference conditions.

The display does not work at all or fails regularly

Check the contrast setting of the transmitter (see section 14.4).

Check if the battery is inserted and charged. Connect the power supply. If the power supply is ok, the transducers or an internal component of the transmitter are defective. The transducers and the transmitter have to be sent to EESIFLo for repair.

The message SYSTEM ERROR is displayed

Press key B to return to the main menu.

If this message is displayed repeatedly, write down the number in the lower line. Track down the situations when the error is displayed. Contact EESIFLo.

The transmitter does not react when key B is pressed during the measurement

A program code has been defined. Press key C and enter the program code.

The backlight of the display does not work, but all other functions are available.

The backlight is defective. This problem does not affect the other functions of the display. Send the transmitter to EESIFLo for repair.

Date and time are wrong, the measured values are deleted when the transmitter is switched off

The data backup battery has to be replaced. Send the transmitter to EESIFLo.

An output does not work

Make sure that the outputs are configured correctly. Check the function of the output as described in section 16.1.3. If the output is defective, contact EESIFLo.

It is not possible to manually reset the alarm output by pressing key C three times

The manual reset of the totalizers by pressing key C three times is activated (see section 15.7). This makes it impossible to manually reset the alarm outputs. Deactivate the manual reset of the totalizers.

A measurement is impossible or the measured values substantially differ from the expected values

see section 17.1.

The values of the totalizer are wrong

see section 17.6.

17.1 Problems with the Measurement

A measurement is impossible because no signal is received. A question mark is displayed in the lower line on the right

- Check if the entered parameters are correct, especially the outer pipe diameter, the pipe wall thickness and the sound speed of the medium. (Typical errors: The circumference or the radius was entered instead of the diameter. The inner pipe diameter was entered instead of the outer pipe diameter.)
- Make sure that the recommended transducer distance was adjusted when mounting the transducers.
- Make sure that an appropriate measuring point has been selected (see section 17.2).
- Try to establish better acoustic contact between the pipe and the transducers (see section 17.3).
- Enter a lower value for the number of sound paths. The signal attenuation might be too high due to a high medium viscosity or deposits on the inner pipe wall (see section 17.4).

The measuring signal is received but no measured values can be obtained

- An exclamation mark "!" in the lower line on the right indicates that the defined upper limit of the flow velocity is exceeded and, therefore, the measured values are marked as invalid. The limit has to be adapted to the measuring conditions or checking has to be deactivated (see section 11.4).
- If no exclamation mark "!" is displayed, a measurement at the selected measuring point is not possible.

Loss of signal during the measurement

- If the pipe had run empty: Was there no measuring signal afterwards? Contact EESIFLO.
- Wait briefly until acoustic contact is reestablished. The measurement can be interrupted by a temporarily higher proportion of gas bubbles and solids in the medium.

The measured values substantially differ from the expected values

- Wrong measured values are often caused by wrong parameters. Make sure that the entered parameters are correct for the measuring point.
- If the parameters are correct, see section 17.5 for the description of typical situations in which wrong measured values are obtained.

17.2 Selection of the Measuring Point

- Make sure that the recommended min. distance to any disturbance source is observed (see chapter 5, Tab. 5.2).
- Avoid measuring points with deposit formation in the pipe.
- Avoid measuring points in the vicinity of deformations and defects on the pipe and in the vicinity of welds.
- Measure the temperature at the measuring point and make sure that the transducers are suitable for this temperature.
- Make sure that the outer pipe diameter is within the measuring range of the transducers.
- When measuring on a horizontal pipe, the transducers have to be mounted on the side of the pipes.
- A vertical pipe always has to be filled at the measuring point and the medium should flow upward.
- No gas bubbles should form (even bubble-free media can form gas bubbles when the medium expands, e.g., upstream of pumps and downstream of great cross-section enlargements).

17.3 Maximum Acoustic Contact

Observe the instructions in chapter 7.

17.4 Application Specific Problems

The entered sound speed of the medium is wrong

The entered sound speed is used to calculate the transducer distance and is therefore very important for the transducer positioning. The sound speeds stored in the transmitter only serve as orientation.

The entered pipe roughness is not appropriate

Check the entered value. The state of the pipe should be taken into account.

Measurements on porous pipe materials (e.g., concrete or cast iron) are only possible under certain conditions

Contact EESIFLO.

The pipe lining may cause problems during the measurement if it is not firmly attached to the inner pipe wall or consists of an acoustically absorbing material

Try measuring on a liner free section of the pipe.

Highly viscous media strongly attenuate the ultrasonic signal

Measurements on media with a viscosity $> 1000 \text{ mm}^2/\text{s}$ are only possible under certain conditions.

A higher proportion of gas bubbles or solids in the medium scatter and absorb the ultrasonic signal and therefore attenuate the measuring signal

A measurement is impossible if the value is $\geq 6 \%$. If the proportion is high but $< 6 \%$, a measurement is only possible under certain conditions.

The flow is in the transition range between laminar and turbulent flow where flow measurement is difficult

Calculate the Reynolds number of the flow at the measuring point. Contact EESIFLO.

17.5 Large Deviations of the Measured Values

The entered sound speed of the medium is wrong

A wrong sound speed can result in the ultrasonic signal that is reflected directly on the pipe wall being mistaken for the measuring signal that has passed through the medium. The flow calculated on the basis of the wrong signal by the transmitter is very small or fluctuates around zero.

There is gas in the pipe

If there is gas in the pipe, the measured flow will always be too high because both the gas volume and the liquid volume are measured.

The defined upper limit of the flow velocity is too low

All measured flow velocities that are greater than the upper limit will be ignored and marked as invalid. All quantities derived from the flow velocity will also be marked as invalid. If several correct measured values are ignored, the totalizer values will be too low.

The entered cut-off flow is too high

All flow velocities below the cut-off flow are set to zero. All derived quantities are also set to zero. The cut-off flow (default: 2.5 cm/s) has to be set to a low value in order to be able to measure at low flow velocities.

The entered pipe roughness is not appropriate

The flow velocity of the medium is outside the measuring range of the transmitter

The measuring point is not appropriate

Select another measuring point to check whether the results are better. Because pipes are never rotationally symmetric, the flow profile is affected. Change the transducer position according to the pipe deformation.

17.6 Problems with the Totalizers

The values of the totalizer are too high

See `Special Function\SYSTEM settings\Measuring\Quantity recall`. If this menu item is activated, the values of the totalizer will be stored. The totalizer will continue with this value at the start of the next measurement.

The values of the totalizer are too low

One of the totalizers has reached the upper limit and has to be reset to zero manually.

The sum of the totalizers is not correct

See `Special Function\SYSTEM settings\Measuring\Quant. wrapping`. The sum of both totalizers (throughput) transmitted via an output is not valid after the overflow (wrapping) of one of the totalizers.

17.7 Data Transmission

The file with the transmitted measuring data contains meaningless strings

The transmission parameters of the transmitter and the transmission program are not identical. Adjust the transmission parameters of the transmitter (see section 12.2.4) and of the terminal program.

A Menu Structure

		INIT-resistant
Program Branch Parameter		
<div>>PAR< mea opt sf Parameter</div>	main menu: selection of the program branch Parameter	
<div>Outer Diameter 100.0 mm</div>	input of the outer pipe diameter	
<div>Pipe Circumfer. 314.2 mm</div>	input of the pipe circumference This display will only be indicated if Special Funct.\SYSTEM settings\Dialogs/Menus\Pipe Circumfer. is activated and Outer Diameter = 0 has been entered.	
<div>Wall Thickness 3.0 mm</div>	input of the pipe wall thickness range: depends on the connected transducers default: 3 mm	
<div>Pipe Material ↑ Carbon Steel</div>	selection of the pipe material	
<div>c-Material 3230.0 m/s</div>	input of the sound speed of the pipe material range: 600...6553.5 m/s This display will only be indicated if Other Material has been selected.	
<div>Lining no >YES<</div>	selection whether the pipe is lined	
<div>Lining ↑ Bitumen</div>	selection of the lining material This display will only be indicated if Lining = yes has been selected.	
<div>c-Material 3200.0 m/s</div>	input of the sound speed of the lining material range: 600...6553.5 m/s This display will only be indicated if Other Material has been selected.	
<div>Liner Thickness 3.0 mm</div>	input of the liner thickness default: 3 mm	
<div>Roughness 0.4 mm</div>	input of the roughness of the inner pipe wall range: 0...5 mm default: 0.1 mm (for steel as pipe material)	
<div>Medium ↑ Water</div>	selection of the medium	
<div>c-Medium 1500.0 m/s</div>	input of the average sound speed of the medium range: 500...3500 m/s This display will only be indicated if Other Medium has been selected.	
<div>c-Medium range auto >USER<</div>	selection of the range of the sound speed auto: The area around the average sound speed is defined by the transmitter. user: The area around the average sound speed has to be entered.	

	INIT-resistant
<div>c-Medium=1500m/s range +-150m/s</div>	input of the range around the average sound speed of the medium This display will only be indicated if Other Medium has been selected.
<div>Kinem.Viscosity 1.00 mm²/s</div>	input of the kinematic viscosity of the medium range: 0.01...30 000 mm ² /s This display will only be indicated if Other Medium has been selected or no data set for the selected medium is stored in the transmitter.
<div>Density 1.00 g/cm³</div>	input of the operating density of the medium range: 0.01...20 g/cm ³ This display will only be indicated if Other Medium has been selected.
<div>Medium Temperat. 20.0 °C</div>	input of the medium temperature default: 20 °C (68 °F)
<div>Transducer Type↑ Standard</div>	selection of the transducer type
<div>Additional cable 65.0 m</div>	input of the length of an extension cable
Program Branch Measuring	
<div>par >MEA< opt sf Measuring</div>	main menu: selection of the program branch Measuring
<div>Meas.Point No.: xxx (↑↓←→)</div>	input of the measuring point number This display will only be indicated if Output Options\Store Meas.Data and/or Serial Output are activated.
<div>PROFILE CORR. >NO< yes</div>	activation/deactivation of the flow profile correction This display will only be indicated if Special Funct.\SYSTEM settings\Measuring\Flow Velocity = uncorr. has been selected.
<div>Transd. Distance 54 mm Reflex</div>	display of the transducer distance to be adjusted between the inner edges of the transducers
Program Branch Output Options	
<div>par mea >OPT< sf Output Options</div>	main menu: selection of the program branch Output Options
<div>Physic. Quant. ↑ Volume flow</div>	selection of the physical quantity
<div>Volume in: ↑ m³/h</div>	selection of the unit of measurement for the physical quantity
<div>Damping 10 s</div>	input of the duration over which a floating average of the measured values has to be determined range: 1...600 s
<div>Store Meas.Data no >YES<</div>	activation of the data logger

		INIT-resistant
<div>Serial Output no >YES<</div>	activation of the measured value transmission to a PC or a printer via the serial interface	
<div>Storage Rate ↑ Once per 10 sec.</div>	selection of the storage rate for storing measured values in the data logger This display will only be indicated if Output Options\Store Meas.Data and/or Serial Output are activated.	
<div>Storage Rate 1 s</div>	Input of the storage rate if Storage Rate = EXTRA has been selected range: 1...43 200 s (= 12 h)	
Current Loop		
<div>Current Loop I1: no >YES<</div>	activation of a current output This display will only be indicated if the current output has been installed in Special Funct.\SYSTEM settings\Proc. outputs.	
<div>Meas.Values >ABSOLUT< sign</div>	selection whether the sign of the measured values is to be considered for the output This display will only be indicated if Current Loop is activated.	
<div>Zero-Scale Val. 0.00 m3/h</div>	input of the lowest/highest measured value to be expected for the current output The values are assigned to the lower/upper limit of the output range. These displays will only be indicated if Current Loop is activated.	
<div>Full-Scale Val. 300.00 m3/h</div>		
<div>Error-val. delay 10 s</div>	input of the error value delay, i.e. of the time interval after which the value entered for the error output will be transmitted to the output if no valid measured values are available This display will only be indicated if Special Funct.\SYSTEM settings\Dialogs/Menus/Error-val. delay = EDIT has been selected.	
Pulse Output		
<div>Pulse Output B1: no >YES<</div>	Activation of a Pulse Output This display will only be indicated if a pulse output has been installed in Special Funct.\SYSTEM settings\Dialogs/Menus\Proc. outputs.	
<div>Pulse Value 0.01 m3</div>	input of the pulse value (value of the totalizer at which a pulse will be emitted) This display will only be indicated if Pulse Output is activated.	
<div>Pulse Width 100 ms</div>	input of the pulse width range: 80...1000 ms This display will only be indicated if Pulse Output is activated.	
Alarm Output		
<div>Alarm Output no >YES<</div>	activation of an alarm output This display will only be indicated if an alarm output has been installed in Special Funct.\SYSTEM settings\Proc. outputs.	
<div>R1=FUNC<typ mode Function: MAX</div>	Selection of the switching condition (func), the holding behavior (typ) and the switching function (mode) of the alarm output. This display will only be indicated if Alarm Output is activated.	
<div>R1 Input: ↑ Volume flow</div>	selection of the physical quantity to be monitored This display will only be indicated for R1 if Alarm Output is activated.	

	INIT-resistant
<div>High Limit: -10.00 m3/h</div>	input of the upper limit of the physical quantity to be monitored This display will only be indicated if Alarm Output has been activated and MAX has been selected as the switching condition.
<div>Low Limit: -10.00 m3/h</div>	input of the lower limit of the physical quantity to be monitored This display will only be indicated if Alarm Output has been activated and MIN has been selected as the switching condition.
<div>Quantity Limit: 1.00 m3</div>	input of the limit for the totalizer of the physical quantity to be monitored This display will only be indicated if Alarm Output has been activated and QUANT. has been selected as the switching condition.
<div>R1 Hysteresis: 1.00 m3/h</div>	input of the hysteresis for the lower or upper limit This display will only be indicated if Alarm Output has been activated and MIN or MAX has been selected as the switching condition.
Program Branch Special Funct.	
<div>par mea opt >SF< Special Funct.</div>	main menu: selection of the program branch Special Funct.
SYSTEM settings	
<div>Special Funct. ↑ SYSTEM settings</div>	selection of Special Funct.\SYSTEM settings
SYSTEM settings\Set Clock	
<div>SYSTEM settings↓ Set Clock</div>	selection of the displays for the input of the date and the time
SYSTEM settings\Libraries	
<div>SYSTEM settings↓ Libraries</div>	selection of the displays for the management of the material and medium scroll lists
SYSTEM settings\Libraries\Material list	
<div>Libraries ↑ Material list</div>	selection of the displays for the arrangement of the material scroll list (pipe and lining materials)
SYSTEM settings\Libraries\Medium list	
<div>Libraries ↑ Medium list</div>	selection of the displays for the arrangement of the medium scroll list
SYSTEM settings\Libraries\Format USER-AREA	
<div>Libraries ↑ Format USER-AREA</div>	selection of the displays for the partitioning of the coefficient memory for the storing of user defined material and medium properties
<div>Format USER-AREA Materials: 03</div>	input of the number of user defined materials
<div>Format USER-AREA Media: 03</div>	input of the number of user defined media

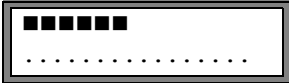
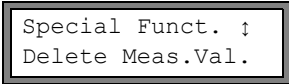

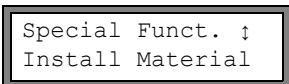
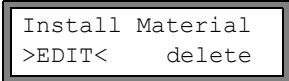
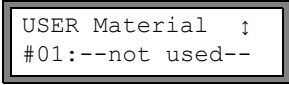
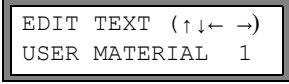
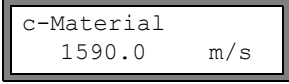
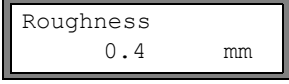
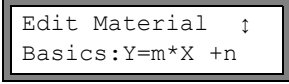
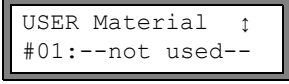
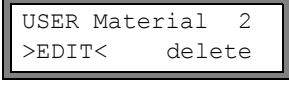
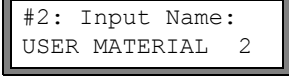
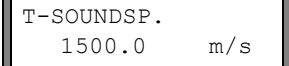
		INIT-resistant
<div>USER AREA: 52% used</div>	display of the occupancy of the coefficient memory	
<div>Format NOW? no >YES<</div>	confirmation of the selected partition	
<div>FORMATTING ... ■■■■■■■■ ...</div>	the coefficient memory is being partitioned	
SYSTEM settings\Libraries\Extended Library		
<div>Libraries ↑ Extended Library</div>	selection of the displays for the activation of the extended library	
<div>Extended Library off >ON<</div>	activation of the extended library	x
SYSTEM settings\Dialogs/Menus		
<div>SYSTEM settings; Dialogs/Menus</div>	selection of the displays for the activation/deactivation or setting of the menu items in the other program branches	
<div>Pipe Circumfer. off >ON<</div>	activation of the menu item for the input of the pipe circumference in the program branch <i>Parameter</i>	x
<div>Meas.Point No.: (1234) >(↑↓←→)<</div>	selection of the input mode for the measuring point number in the program branch <i>Measuring</i> : (1234): digits, point, hyphen (↑↓←→): ASCII editor	x
<div>Transd. Distance auto >USER<</div>	setting for the display for the input of the transducer distance in the program branch <i>Measuring</i> : <ul style="list-style-type: none"> • <i>user</i>: only the entered transducer distance will be displayed if the recommended and the entered transducer distances are identical • <i>auto</i>: only the recommended transducer distance will be displayed recommended setting: <i>user</i>	x
<div>Error-val. delay damping >EDIT<</div>	selection of the error value delay <ul style="list-style-type: none"> • <i>damping</i>: The damping factor will be used. • <i>edit</i>: The menu item for the input of the error value delay in the program branch <i>Output Options</i> will be activated. 	x
<div>SHOW RELAIS STAT off >ON<</div>	activation of the display of the alarm state during the measurement	x
<div>Length unit >[mm]< [inch]</div>	selection of the unit of measurement for the length	x
<div>Temperature >[°C]< [°F]</div>	selection of the unit of measurement for the temperature	x
<div>Pressure >[bar]< [psi]</div>	selection of the unit of measurement for the pressure	x

		INIT-resistant
<div>Pressure absolut off >ON<</div>	selection if the absolute pressure p_a or the relative pressure p_g is to be used	x
<div>Soundspeed unit >[m/s]< [fps]</div>	selection of the unit of measurement for the sound speed	x
<div>Density [lb/ft³] no >YES<</div>	selection if lb/ft ³ is to be used as the unit of measurement for the density	x
<div>Density unit g/cm³ >kg/m³<</div>	selection of the unit of measurement for the density This display will only be indicated if lb/ft ³ has not been selected as the unit of measurement for the density	x
<div>Viscosity unit mm²/s >cSt<</div>	selection of the unit of measurement for the kinematic viscosity	x
SYSTEM settings\Measuring		
<div>SYSTEM settings↓ Measuring</div>	selection of the displays for the settings of the measurement	
SYSTEM settings\Measuring\Miscellaneous		
<div>Compare c-fluid no >YES<</div>	activation of the display for the difference between the measured and the expected sound speed of a selected reference medium during the measurement	x
<div>Flow Velocity normal >UNCORR.<</div>	selection whether the flow velocity is displayed and transmitted with or without profile correction	x
<div>Velocity limit 0.0 m/s</div>	input of an upper limit of the flow velocity range: 0.1...25.5 m/s 0 m/s: no detection for outliers All measured values that are greater than the limit will be marked as outliers.	x
<div>Cut-off Flow absolut >SIGN<</div>	selection of the input of a lower limit for the flow velocity: <ul style="list-style-type: none"> absolut: independent of the flow direction sign: dependent on the flow direction 	x
<div>Cut-off Flow factory >USER<</div>	activation of the input of a lower limit of the flow velocity: <ul style="list-style-type: none"> factory: the default limit of 2.5 cm/s will be used user: input of a limit 	x
<div>+Cut-off Flow 2.5 cm/s</div>	input of the cut-off flow for positive measured values range: 0...12.7 cm/s (0.127 m/s) default: 2.5 cm/s (0.025 m/s) This display will only be indicated if Cut-off Flow = sign and Cut-off Flow = user has been selected.	x
<div>-Cut-off Flow -2.5 cm/s</div>	Input of the cut-off flow for negative measured values range: -12.7...0 cm/s default: -2.5 cm/s This display will only be indicated if Cut-off Flow = sign and Cut-off Flow = user has been selected.	x

		INIT-resistant
<div>Cut-off Flow 2.5 cm/s</div>	<p>Input of the cut-off flow for the absolute value of the measured values range: 0...12.7 cm/s default: 2.5 cm/s</p> <p>This display will only be indicated if Cut-off Flow = absolut and Cut-off Flow = user has been selected.</p>	X
<div>Gain threshold Fail if > 90 dB</div>	<p>Input of the max. signal amplification. range: 0...255 0: no limit of the signal amplification</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>Bad soundspeed thresh. 2007 m/s</div>	<p>Input of the fixed upper limit of the sound speed. range: 0...3 000 m/s 0: the default value 1 848 m/s is used</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>Bad soundspeed offset: +321 m/s</div>	<p>Input of the offset. range: 0...900 m/s 0: the default value 300 m/s is used</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>Quant. wrapping off >ON<</div>	<p>activation of the overflow of the totalizers</p>	X
<div>Quantity recall off >ON<</div>	<p>activation of the taking-over of the totalizer values after a restart of the measurement</p>	X
<div>Do not total. if no meas.> 0 s</div>	<p>input of the time interval without any valid measured values after which the transmitter recognizes a long measurement failure 0: the default value 30 s is used</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>Total digits ↓ Automatic</div>	<p>input of the number of decimal places for the totalizers: Automatic: dynamic adjustment Fixed to x digit: 0...4 decimal places</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>3xC clear totals off >ON<</div>	<p>Activation of the manual reset of the totalizers. This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>Show ΣQ off >ON<</div>	<p>Activation of the display of the sum of the totalizers. This display will only be indicated if the SuperUser mode is activated.</p>	X
<div>Keep display val off >ON<</div>	<p>activation of the display of the last valid measured value This display will only be indicated if the SuperUser mode is activated.</p>	X
Special Funct.\SYSTEM settings\Measuring\Calibration		
<div>Profile bounds factory >USER<</div>	<p>definition of the profile bounds factory: the default profile bounds is used user: the profile bounds can be defined</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	

		INIT-resistant
<div>Laminar flow if R*< 0</div>	<p>Input of the max. Reynolds number at which the flow is laminar. range: 0...25 500 (rounded to hundreds) 0: the default value 1 000 is used</p> <p>This display will only be indicated if the SuperUser mode is activated and <code>Profile bounds = user</code> is selected.</p>	
<div>Turbulent flow if R*> 0</div>	<p>input of the min. Reynolds number at which the flow is turbulent. range: 0...25 500 (rounded to hundreds) 0: the default value 3 000 is used</p> <p>This display will only be indicated if the SuperUser mode is activated and <code>Profile bounds = user</code> is selected.</p>	
<div>Calibration ? >OFF< on</div>	<p>request if an additional correction of the flow velocity is to be defined on: the correction data can be defined off: no correction of the flow velocity will be used</p> <p>This display will only be indicated if the SuperUser mode is activated.</p>	
<div>Slope= 1.00</div>	<p>input of the slope for the correction formula. range: -2.000...+2.000 0: no correction</p> <p>This display will only be indicated if the SuperUser mode is activated and <code>Calibration = on</code> is selected.</p>	
<div>Offset= 0.0 cm/s</div>	<p>input of the offset. range: -12.7...+12.7 cm/s 0: no offset</p> <p>This display will only be indicated if the SuperUser mode is activated and <code>Calibration = on</code> is selected.</p>	
SYSTEM settings\Proc. outputs		
<div>SYSTEM settings↓ Proc. outputs</div>	selection of the displays for the setting of the outputs of the transmitter	
<div>Install Output ↓ Current I1</div>	selection of the output to be installed	
SYSTEM settings\Storing		
<div>SYSTEM settings↓ Storing</div>	selection of the displays for the storing of measured values in the data logger	
<div>Start logger ↓ Promptly</div>	selection the starting time of the storing of measured values	X
<div>Ringbuffer off >ON<</div>	setting of the overflow behavior of the data logger	X
<div>Storage mode sample >AVERAGE<</div>	<p>selection of the sample mode</p> <ul style="list-style-type: none"> sample: storing and online transmission of the displayed measured value average: storing and online transmission of the average of all measured values of a storage interval 	X
<div>Quantity Storage one >BOTH<</div>	<p>setting of the storing behavior of the totalizers</p> <ul style="list-style-type: none"> one: the value of the totalizer that is currently displayed will be stored both: one value for each flow direction will be stored 	X

		INIT-resistant
<div>Store Amplitude off >ON<</div>	activation of the storing of the signal amplitude The value will only be stored if the data logger is activated.	x
<div>Store c-Medium off >ON<</div>	activation of the storing of the sound speed of the medium The value will only be stored if the data logger is activated.	x
<div>Store diagnostic off >ON<</div>	activation of the storing of diagnostic values	x
SYSTEM settings\serial transmis.		
<div>SYSTEM settings; serial transmis.</div>	selection of the displays for the formatting of the serial transmission of measured values	
<div>SER:kill spaces off >ON<</div>	activation of the serial transmission of data with/without blanks	x
<div>SER:decimalpoint '.' >','<</div>	selection of the decimal marker for floating point numbers	x
<div>SER:col-separat. ';' >'TAB'<</div>	selection of the character for column separation	x
SYSTEM settings\Miscellaneous		
<div>SYSTEM settings; Miscellaneous</div>	selection of the display for the setting of the contrast and input of a HotCode	
<div>Input a HOTCODE no >YES<</div>	confirmation that a HotCode has to be entered	
<div>Please input a HOTCODE: 000000</div>	input of a HotCode	
<div>SETUP DISPLAY ← CONTRAST →</div>	setting of the contrast of the display	
Instrum. Inform.		
<div>Special Funct. ↑ Instrum. Inform.</div>	selection of the displays for information about the transmitter	
<div>EESXXXX-XXXXXXXXX V x.xx dd.mm.yy</div>	display of the type, serial number and firmware version with the date (dd - day, mm - month, yy - year)	x
Print Meas.Val.		
<div>Special Funct. ↑ Print Meas.Val.</div>	selection of the displays for the transmission of stored measured values to a PC	
<div>Send Header 01</div>	start of the transmission of measured values This display will only be indicated if the data logger contains measured values and the transmitter is connected to a PC via a serial cable.	

		INIT-resistant
	display of the data transmission progress	
Delete Meas.Val.		
	selection of the displays for the deleting of stored measured values	
	confirmation for the deleting of measured values This display will only be indicated if measured values are stored in the data logger.	
Install Material		
	selection of the displays for the input of the pipe and lining materials	
Install Material with Special Funct.\SYSTEM settings\Libraries\Extended Library = off		
	selection whether a user defined material is to be edited or deleted	
	selection of a user defined material	
	input of a designation for the selected material	
	input of the sound speed of the material range: 600...6553.5 m/s	
	input of the roughness of the material	
Install Material with Special Funct.\SYSTEM settings\Libraries\Extended Library = on		
	selection of the function for the temperature and pressure dependence of the material properties	
	selection of a user defined material	
	selection whether the user defined material is to be edited or deleted This display will only be indicated if the selected material already exists.	
	input of a designation for the selected material	
	input of the constants for the transversal sound speed of the material The number of constants depends on the function selected above.	

	INIT-resistant
<div>L-SOUNDSP. 1500.0 m/s</div>	input of the constants for the longitudinal sound speed of the material The number of constants depends on the function selected above.
<div>Default soundsp. long. >TRANS.<</div>	selection of the sound wave type for the flow measurement
<div>Roughness 0.4 mm</div>	input of the roughness of the material
<div>Save changes no >YES<</div>	confirmation that the changes are to be stored This display will only be indicated if a new material has been entered or the properties of an existing material have been changed.
Install Medium	
<div>Special Funct. ↑ Install Medium</div>	selection of the displays for the input of media
Install Medium with Special Funct.\SYSTEM settings\Libraries\Extended Library = off	
<div>Install Medium >EDIT< delete</div>	selection whether a user defined medium is to be edited or deleted
<div>USER Medium ↑ #01:--not used--</div>	selection of a user defined medium
<div>EDIT TEXT (↑↓←→) USER MEDIUM 1</div>	input of a designation for the selected medium
<div>c-Medium 1500.0 m/s</div>	input of the sound speed of the medium range: 500.0...3500.0 m/s
<div>c-Medium=1500m/s range +-150m/s</div>	input of the range around the average sound speed of the medium range: 50...999 m/s
<div>Kinem.Viscosity 1.01 mm²/s</div>	input of the kinematic viscosity of the medium range: 0.01...30 000.00 mm ² /s
<div>Density 1.00 g/cm³</div>	input of the operating density of the medium
Install Medium with Special Funct.\SYSTEM settings\Libraries\Extended Library = on	
<div>Edit Medium ↑ Basics:Y=m*X +n</div>	selection of the function for the temperature and pressure dependence of the medium properties
<div>USER Medium ↑ #01:--not used--</div>	selection of a user defined medium
<div>USER MEDIUM 2 >EDIT< delete</div>	selection whether the user defined medium is to be edited or deleted This display will only be indicated if the selected medium already exists.

		INIT-resistant
<div>#2: Input Name: USER MEDIUM 2</div>	input of a designation for the selected medium	
<div>SOUNDSPEED 1500.0 m/s</div>	input of the constants for the longitudinal sound speed of the medium The number of constants depends on the function selected above.	
<div>VISCOSITY 1.0 mm2/s</div>	input of the kinematic viscosity of the medium	
<div>DENSITY 1.0 g/cm3</div>	input of the operating density of the medium	
<div>Save changes no >YES<</div>	confirmation that the changes are to be stored This display will only be indicated if a new medium has been entered or the properties of an existing medium have been changed.	
Program Code		
<div>Special Funct. ↑ set program code</div>	selection of the displays for the input of a program code	
<div>set program code -----</div>	defining a program code	
<div>INPUT BREAK_CODE CODE: 000000</div>	input of the break code (= program code)	
<div>INP. ACCESS CODE CODE: 000000</div>	input of the access code (= the first three digits of the program code)	

B Units of Measurement

Length/Roughness	
unit of measurement	description
mm	millimeter

inch	inch
------	------

Temperature	
unit of measurement	description
°C	degree Celsius

°F	degree Fahrenheit
----	-------------------

Pressure	
unit of measurement	description
bar (a)	bar (absolute)
bar (g)	bar (relative)

psi (a)	pound per square inch (absolute)
psi (g)	pound per square inch (relative)

Density	
unit of measurement	description
g/cm ³	gram per cubic centimeter
kg/cm ³	kilogram per cubic centimeter

Sound speed	
unit of measurement	description
m/s	meter per second

Kinematic viscosity	
unit of measurement	description
mm ² /s	square millimeter per second

1 mm²/s = 1 cSt

Flow velocity	
unit of measurement	description
m/s	meter per second
cm/s	centimeter per second

in/s	inch per second
fps (ft/s)	foot per second

Volumetric flow rate		Volume (totalized)
unit of measurement	description	unit of measurement
m ³ /d	cubic meter per day	m ³
m ³ /h	cubic meter per hour	m ³
m ³ /min	cubic meter per minute	m ³
m ³ /s	cubic meter per second	m ³
km ³ /h	1000 cubic meters per hour	km ³
ml/min	milliliter per minute	l or m ³ *
l/h	liter per hour	l or m ³ *
l/min	liter per minute	l or m ³ *
l/s	liter per second	l or m ³ *
hl/h	hectoliter per hour	hl or m ³ *
hl/min	hectoliter per minute	hl or m ³ *
hl/s	hectoliter per second	hl or m ³ *
Ml/d (Megalit/d)	megaliter per day	Ml or m ³ *

bb1/d	barrel per day	bb1
bb1/h	barrel per hour	bb1
bb1/m	barrel per minute	bb1
USgpd (US-gal/d)	gallon per day	gal
USgph (US-gal/h)	gallon per hour	gal
USgpm (US-gal/m)	gallon per minute	gal
USgps (US-gal/s)	gallon per second	gal
KGPM (US-Kgal/m)	kilogallon per minute	kgal
MGD (US-Mgal/d)	million gallons per day	Mg
CFD	cubic foot per day	cft**
CFH	cubic foot per hour	cft
CFM	cubic foot per minute	cft
CFS	cubic foot per second	aft***
MMCFD	million cubic feet per day	MMCF
MMCFH	million cubic feet per hour	MMCF

* Selection with HotCode 007027, firmware version V5.91 or higher

** cft: cubic foot

*** aft: acre foot

1 US-gal = 3.78541 l

1 bbl = 42 US-gal = 158.9873 l

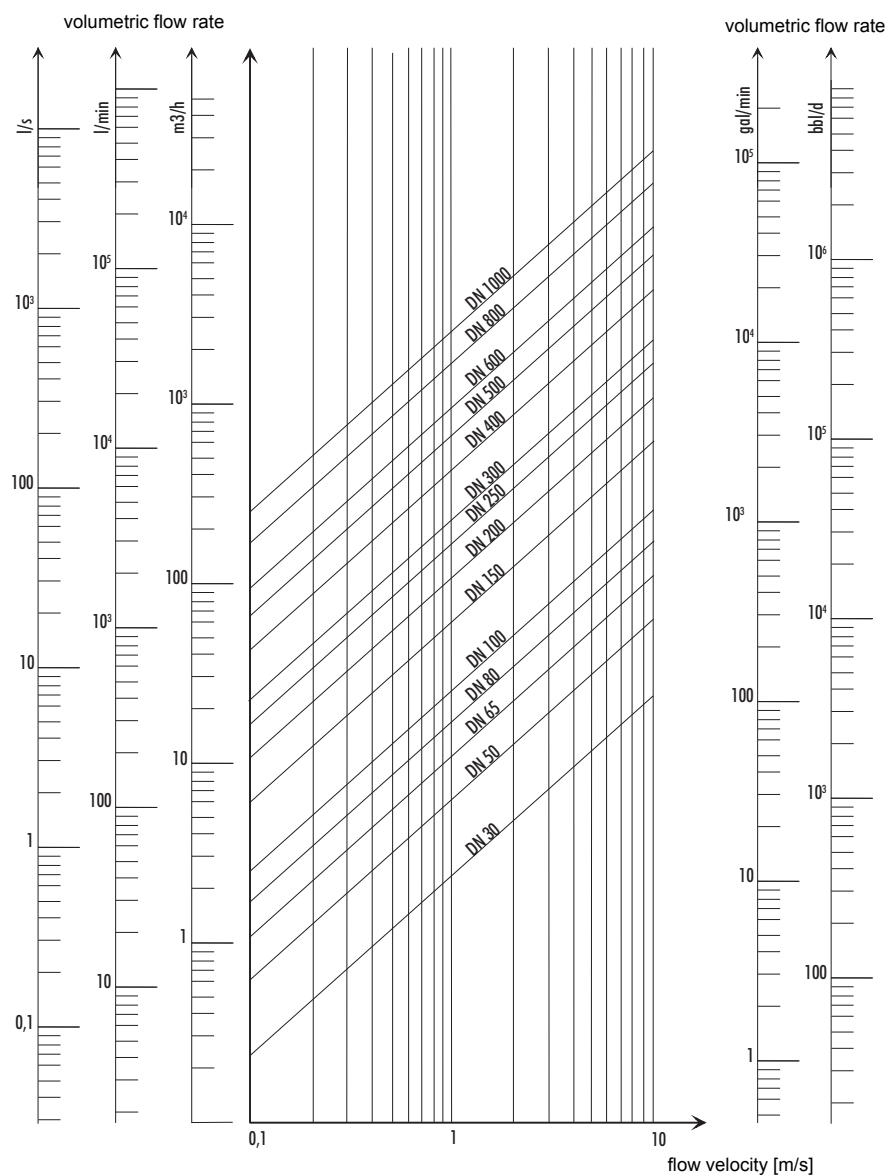
Mass flow rate		Mass (totalized)	
unit of measurement	description	unit of measurement	
t/h	metric ton per hour	t	
t/d	metric ton per day	t	
kg/h	kilogram per hour	kg	
kg/min	kilogram per minute	kg	
kg/s	kilogram per second	kg	
g/s	gram per second	g	

lb/d	pound per day	lb	
lb/h	pound per hour	lb	
lb/m	pound per minute	lb	
lb/s	pound per second	lb	
klb/h	kilopound per hour	klb	
klb/m	kilopound per minute	klb	

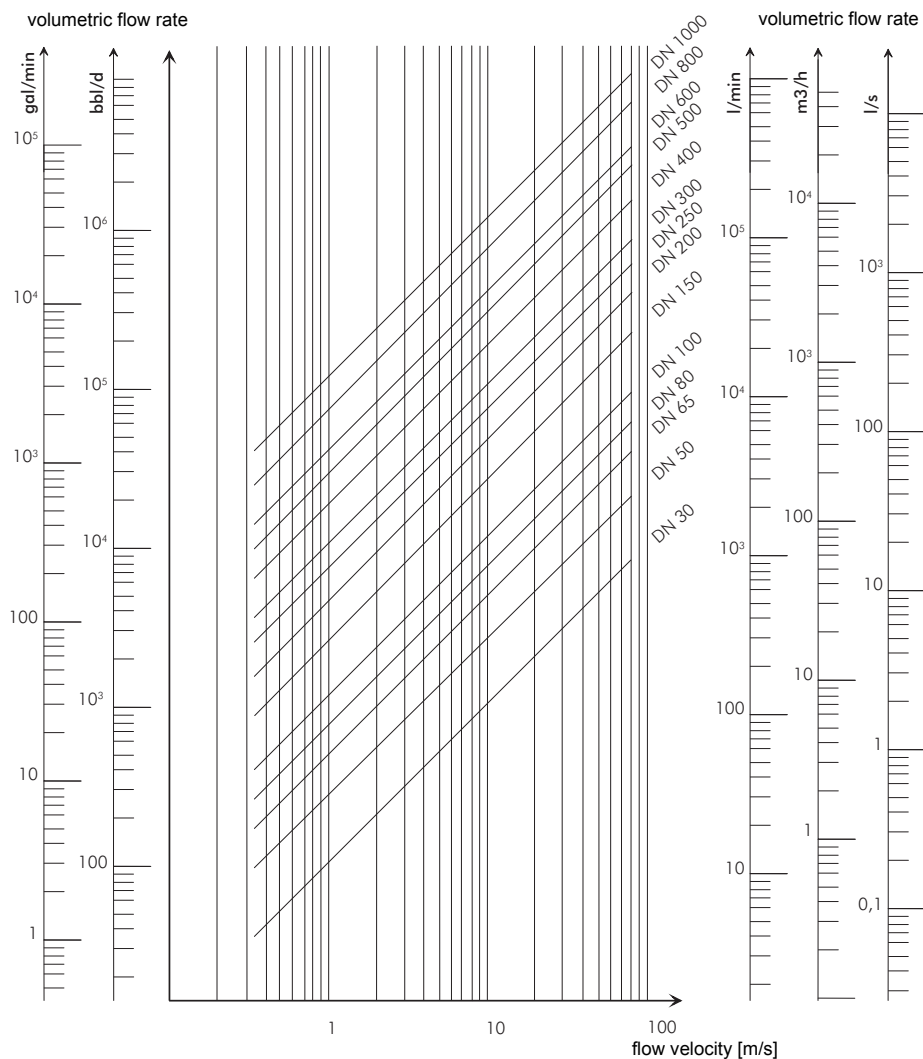
1 lb = 453.59237 g

1 t = 1000 kg

Flow Nomogram (Metrical)



Flow Nomogram (Imperial)



C Reference

The following tables provide assistance for the user. The accuracy of the data depends on the composition, temperature and processing of the material. EESIFLO does not assume liability for any inaccuracies.

C.1 Sound Speed of Selected Pipe and Lining Materials at 20 °C (68 °F)

The values of some of these materials are stored in the internal database of the transmitter. Column c_{flow} shows the sound speed (longitudinal or transversal) used for the flow measurement.

material (display)	explanation	c_{trans} [m/s]	c_{long} [m/s]	c_{flow}
Carbon Steel	carbon steel	3 230	5 930	trans
Stainless Steel	stainless steel	3 100	5 790	trans
DUPLEX	duplex stainless steel	3 272	5 720	trans
Ductile Iron	ductile cast iron	2 650	-	trans
Asbestos Cement	asbestos cement	2 200	-	trans
Titanium	titanium	3 067	5 955	trans
Copper	copper	2 260	4 700	trans
Aluminium	aluminum	3 100	6 300	trans
Brass	brass	2 100	4 300	trans
Plastic	plastic	1 120	2 000	long
GRP	glass-reinforced plastic	4 600	2 300	long
PVC	polyvinyl chloride	-	2 395	long
PE	polyethylene	540	1 950	long
PP	polypropylene	2 600	2 550	trans
Bitumen	bitumen	2 500	-	trans
Acrylic	acrylic glass	1 250	2 730	long
Lead	lead	700	2 200	long
Cu-Ni-Fe	alloy of copper, nickel, and iron	2 510	4 900	trans
Grey Cast Iron	gray cast iron	2 200	4 600	trans
Rubber	rubber	1 900	2 400	trans
Glass	glass	3 400	5 600	trans
PFA	perfluoroalkoxy	500	1 185	long
PVDF	polyvinylidene fluoride	760	2 050	long
Sintimid	Sintimid	-	2 472	long
Teka PEEK	Teka PEEK	-	2 534	long
Tekason	Tekason	-	2 230	long

The sound speed depends on the composition and the manufacturing process of the material. The sound speed of alloys and cast materials fluctuates strongly. The values only serve as an orientation.

C.2 Typical Roughnesses of Pipes

The values are based on experience and measurements.

material	absolute roughness [mm]
drawn pipes of non-ferrous metal, glass, plastics and light metal	0...0.0015
drawn steel pipes	0.01...0.05
fine-planed, polished surface	max. 0.01
planed surface	0.01...0.04
rough-planed surface	0.05...0.1
welded steel pipes, new	0.05...0.1
after long use, cleaned	0.15...0.2
moderately rusted, slightly encrusted	max. 0.4
heavily encrusted	max. 3
cast iron pipes:	
bitumen lining	> 0.12
new, without lining	0.25...1
rusted	1...1.5
encrusted	1.5...3

C.3 Properties of Water at 1 bar and at Saturation Pressure

medium temperature [°C]	medium temperature [°F]	medium pressure [bar]	density [kg/m ³]
0	32	1	999.8
10	50	1	999.7
20	68	1	998.3
30	86	1	995.7
40	104	1	992.3
50	122	1	988.0
60	140	1	983.2
70	158	1	977.7
80	176	1	971.6
90	194	1	965.2
100	212	1.013	958.1
120	248	1.985	942.9
140	284	3.614	925.8
160	320	6.181	907.3
180	356	10.027	886.9
200	392	15.55	864.7
220	428	23.20	840.3
240	464	33.48	813.6
260	500	46.94	784.0
280	536	64.20	750.5
300	572	85.93	712.2
320	608	112.89	666.9
340	644	146.05	610.2
360	680	186.75	527.5
374.15	705	221.20	315.5

* at constant pressure