AFLOWT

BATTERY POWERED
ULTRASONIC FLOW METER

AFLOWT BUF

VERSION
BUF-311

OPERATION MANUAL

ISO 9001:2008

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Manufacturer quality management system is certified to ISO 9001:2008

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URL: http://www.aflowt.com

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INTRODUCTION

This document covers battery powered ultrasonic flow meter "AFLOWT BUF" of BUF-311 version (the flow meter below) and contains the information about its operation and design.

Due to continuous improvement of product policy actual flow meter’s specifications may differ from the data specified in this manual. However, this will not affect the metrological characteristics and functionality.

LIST OF ABBREVIATIONS

CP	- Primary converter
CS	- Secondary measuring converter
DN	- Nominal diameter
ER	- Error
LCD	- Liquid crystal display
PC	- Personal computer
PS	- Pipeline section
PEA	- Electro-acoustic converter (transducer)
SPS	- Secondary power source
USS	- Ultrasonic signal

NOTE. Words in the text marked in bold, for example, **Low**, correspond to the items displayed on the flow meter's screen or PC display when running "Viewer BUF-311" program.

1. DESCRIPTION AND OPERATION

1.1. Application

1.1.1. "AFLOWT BUF" battery powered ultrasonic flow meter of BUF-311 version is designed to measure average volumetric flow rate and volume of bidirectional flows of cold and hot water.

The flow meters may be used as part of metering systems and automatic process control systems in power industry and municipal engineering applications.

1.1.2. "AFLOWT BUF" battery powered ultrasonic flow meter, BUF-311 version, performs the following functions:

- Measuring average volumetric flow rate in either forward or reverse flow directions
- Totalizing volume of forward and reverse flows independently or calculating their algebraic sum with regard to flow direction
- Determining the current value of flow velocity and flow direction
- Outputting measurement results to the frequency/pulse or logical output
- Logging of measurement data and configuration settings in the internal nonvolatile memory
- Displaying measurement, configuration and history (logged) data on the built-in indicator (LCD) and outputting the data to the external devices via M-BUS interface or RS-485 interface
- Configuring the flow meter according to on-site and process requirements
- Monitoring and indicating alarm conditions (ER, error situations) and faults; recording error and fault types and intervals into the corresponding logs
- Protecting logged data and configuration settings from unauthorized access.

1.2 Specifications

1.2.1. Specifications are listed in Table 1.

Table 1

Parameter	Value										
1. Nominal diameter of the pipeline, DN	32	40	50	65	80	100	125	150	200	250	300
2. Minimal measured average volumetric flow rate Q_{min}, m^3/h	0.11	0.18	0.28	0.48	0.73	1.13	1.77	2.50	4.53	7.10	10.15
3. Measured transient average volumetric flow rate Q_{trans}, m^3/h	0.55	0.9	1.40	2.40	3.60	5.70	8.80	12.7	22.6	35.4	50.9
4. Maximal measured average volumetric flow rate Q_{max}, m^3/h	14.5	22.6	35.4	59.8	90.6	141.5	221.1	318.4	566.0	885.0	1290
5. Sensitivity threshold, m^3/h	0.022	0.036	0.06	0.10	0.15	0.24	0.35	0.54	0.96	1.50	2.16
6. Maximal pressure in the pipeline, MPa	1.6 (2.5 – request)										
7. Temperature of medium, °C	0-90 (130 – request)										
8. Power supply voltage, V	3.6 from a lithium battery										
9. Mean time to failure, h	75000										
10. Mean life time, years	12										

1.2.2. Under normal operating conditions*, the lithium battery keeps the flow meter operational for at least 10 years without changing the battery.

*Normal operating conditions are as follows:

- Ambient temperature from +15 to +35 °C
- For frequency / pulse / logical outputs, maximal operating frequency of no more than 8 Hz
- Logs are read (via interface) not more frequently than once a month
- LCD works no more than 3 min per day.

1.2.3. The flow meter measures average volumetric flow rate at flow velocity ranging from 0.04 to 5.0 m/s. The relation between flow velocity v and flow rate in the pipeline Q is determined by the following formula:

$$v = \frac{Q}{2.83 \times 10^{-3} DN^2},$$

Where Q – average volumetric flow rate, m^3/h;

v – flow velocity, m/s;

DN – nominal diameter of the pipeline, mm.

1.2.4. Limits of permissible relative error for measurement, indication, logging, storage and transferring of average volumetric flow rate and volume measurement results for any flow direction do not fall outside the following ranges:

- From Q_{min} to Q_{trans}: no more than ± 4 %
- From Q_{trans} to Q_{max}: no more than ± 2%.

The real values of the errors no more (see fig.1):

- ± 1.0 % at v > 2.0 to 5.0 m/s
- ± 2.0 % at v > 0.10 to 2.0 m/s
- ± 4.0 % at v > 0.04 to 0.10 m/s.

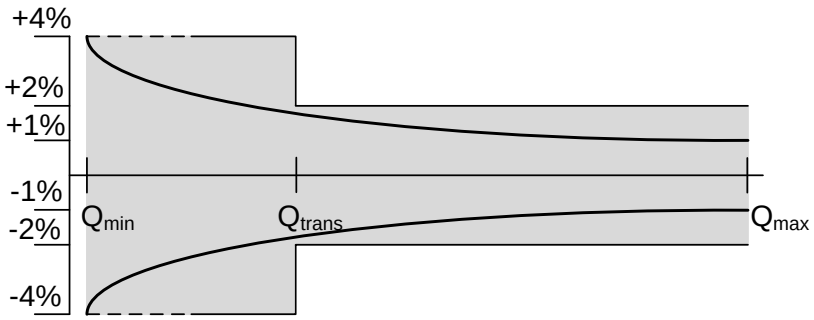


Fig.1. The figure is a real measurement error of the flow meter

1.2.5. The flow meter provides that the results of measurements can be outputted to:

- Universal output in the form of frequency, pulse or logical signal
- M-BUS interface
- RS-485 interface.

1.2.6. The flow meter provides storage of measurement results in the following logs:

- Hourly log – 120 records (hourly records)
- Daily log – 45 records (daily records)
- Monthly log – 48 records (monthly records)
- Opereting mode log – up to 100 records.

When powered off, the flow meter stores measurement results and configuration settings for no less than 1 year.

1.2.7. The flow meter is powered from a built-in D-size lithium battery (3.6V nominal voltage);

1.2.8. The flow meter complies with the following standards:

- Environmental resistance – ambient air temperature range is +5...+65 °C; relative humidity is no more than 80 % at a temperature ≤ 35 °C, without moisture condensation
- Atmospheric pressure from 66.0 to 106.7 kPa.

Protection provided by the enclosure is IP65 (IP67 on request).

1.2.9. View, overall dimensions and weight are given in Appendix A.

1.3. Contents of the delivery package

1.3.1. Items of the delivery package are specified in Table 2.

Table 2

Item	Qty	Notes
1. Battery powered ultrasonic flow meter	1	Note
2. Installation kit	1	
3. Operating documentation:		
- Passport	1	
- Operation manual and dedicated software	1	

NOTE. The required items of the delivery package are specified in the order sheet.

Operating documentation and order sheets for this product and other products are available on **www.aflowt.com**.

1.4. Design and operation

1.4.1. Operation principle

1.4.1.1. The flow meter is designed on the base of a pulse-phase method of ultrasonic flow measurement. Its operation principle is based on measuring the time difference between the time it takes for an ultrasonic signal (USS) to travel through the liquid with the direction of flow and against it.

Regarding the sounding principle, the flow meter utilizes the method of one-time simultaneous sounding. Flow meters of this type have two simultaneously operating signal paths. Each signal path is formed by a transmitting/receiving path of the flow meter consisting of electronic circuitry [Secondary Converter (CS) and communications cables with Electroacoustic Converters (PEAs)] and an acoustic path (PEA – fluid – PEA).

1.4.1.2. PEAs are diametrically (see Fig.2) installed into the measuring section (Pipeline Section, PS) making up together the Primary Converter (CP).

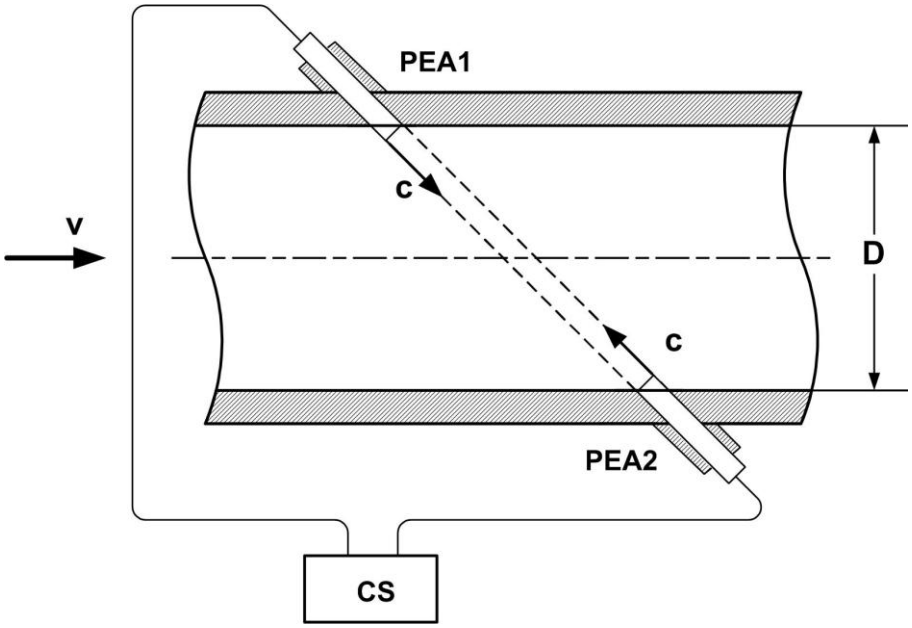


Fig.2. Diagram showing Pipeline Section (PS) with PEAs installed

1.4.1.3. The CS generates electric sounding pulses which simultaneously come to PEA1 and PEA2.

USS generated by one PEA is projected through the liquid flowing in the pipe and is received by the other PEA. Because of liquid flow, a sound wave is shifted, which in turn leads to the difference in upstream and downstream times of USS travel: it takes less time for an ultrasonic signal to travel in the flow direction (from PEA1 to PEA2) than that in the opposite direction (from PEA2 to PEA1). The difference in upstream and downstream time of USS travel through an acoustic path **dT** is proportional to flow velocity of fluid v and, correspondingly, to volumetric flow rate **Q**.

1.4.1.4. The flow rate value is calculated only if the following condition is fulfilled:

$$Q_{min} \leq Q,$$

Where Q_{min} – minimal value of the flow rate, m^3/h;

Q – current value of the flow rate, m^3/h.

The recommended value of low flow cutoff corresponds to the flow meter's sensitivity threshold, m^3/h.

If $Q < Q_{min}$, condition is fulfilled, the measured flow rate values are displayed as zero, volume totalizing and pulse transmission to the universal output are cancelled.

Under $Q > Q_{max}$ condition (where Q_{max} corresponds to the flow velocity value of 5 m/s), the metrological characteristics cannot be ensured. The flow meter measures and displays flow rate values (depending on temperature, liquid density etc.), however, volume totalizing and logging, as well as pulse transmission to the Universal Output, are cancelled.

1.4.2. Design

The flow meter's block diagram is shown in Fig.3.

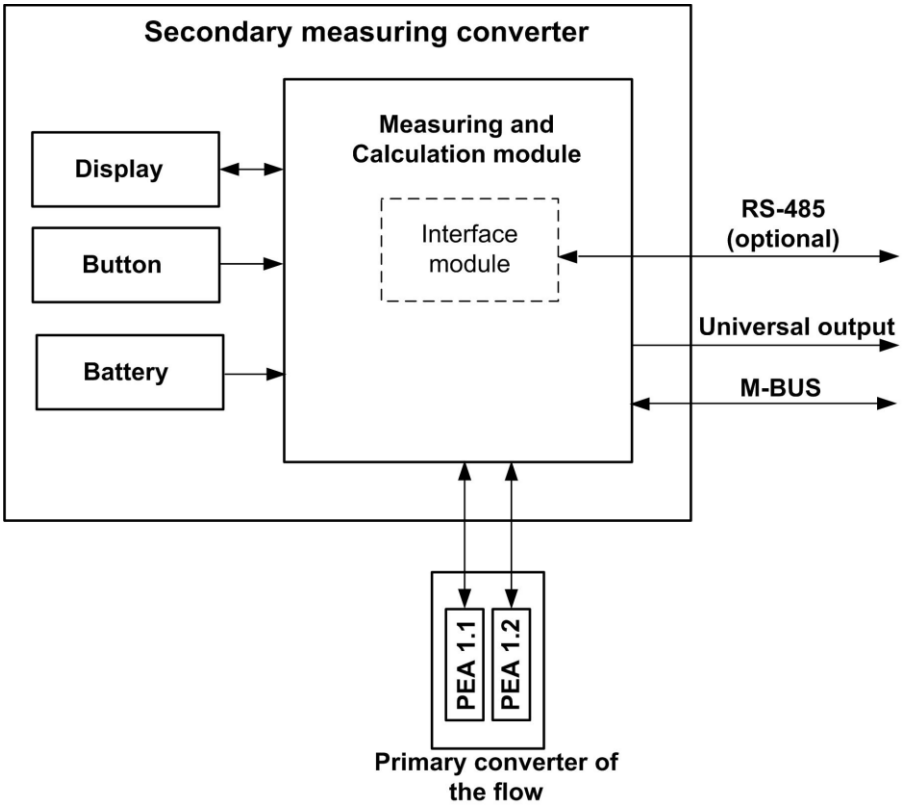


Fig.3. Flow meter's block diagram

BUF-311 flow meter includes the Primary Converter and Secondary Measuring Converter.

The Primary Converter (CP) is a specially designed measuring pipe section with one factory-supplied pair of PEAs installed on it.

Secondary Measuring Converter (CS) includes Measurement and Calculation board, which is responsible for electroacoustic sounding control, primary and secondary processing of measurement results as well as for their storing in the memory.

To provide data exchange with external devices, Measurement and Calculation board is equipped with Universal output, M-BUS output and RS-485 output (optional).

The graphic Liquid Crystal Display (LCD) makes visible measurement data. The LCD displays alpha-numeric data in two lines (16 characters per line). Displayed data is updated with use of the button located near the LCD on the front panel.

1.4.3. Operating modes

1.4.3.1. The flow meter operates in three modes:

- ADJUSTMENT – adjustment and calibration
- SERVICE – start-up procedures
- OPERATION – user mode.

The operating modes differ by level at which the user can access certain data (transferred via RS-485 interface) and modify flow meter's configuration settings.

Maximum rights are granted in ADJUSTMENT mode. The mode allows the user to modify all of the configuration settings. Minimum rights are given in OPERATION mode.

The set of displayed parameters is the same in all operating modes.

Flow meter's work in different operating modes is controlled via RS-485 interface.

1.4.3.2. Flow meter's operating modes are set by placing (removing) jumpers on J1 and J2 terminals, which are located on the board of Secondary Calculation module.

Combinations of jumpers with regard to operating modes are specified in Table 3 ("+" means that the terminal contacts are closed by a jumper, and "-" means that the terminal contacts are opened).

Table 3

Mode	Terminal		Mode description
	J1	J2	
OPERATION	-	-	Operation
SERVICE	-	+	Start-up procedures
ADJUSTMENT	+	-	Adjustment

1.4.3.3. OPERATION mode – flow meter's on-site operation.

In OPERATION mode, the user can view the following parameters:

1. On LCD: the current date and time, the values of the measured parameters (volume flow, amounts accumulated in the forward and reverse direction of flow, as well as their algebraic sum), the status of error situations (ER) and the version number of the software.
2. Via RS-485 or M-Bus:

a) Measurement values of: volumetric flow rate, flow volume totalized for forward and reverse flow and their algebraic sum, velocity of liquid, current value of USS velocity

b) Measurement data and "Mode" logs

c) Configuration settings: current date and time, specifications of output

d) Operation settings:

- Type of signal processing (median averaging, arithmetical averaging etc)
- RS-485 settings
- Types of error situations.

1.4.3.4. SERVICE mode – start-up procedures.

In SERVICE mode, in addition to the above, available in OPERATION mode, the operator can do the following (via RS-485 interface):

a) View:

- Configuration of measuring pipe section (device base, axis base, nominal diameter)
- Settings for ultrasonic signal detection.

b) Modify:

- Settings for flow meter's control via RS-485 interface (network address, baud rate from 1200 to 4800 Baud)
- Settings for battery status monitoring
- Settings and operating modes for universal output
- Measurement units of volumetric flow rate (m^3/h, l/min)
- Reading of built-in real time clock
- Automatic winter/summer time clock settings

c) Adjust LCD contrast and data update period

d) Initiate calculation of output scale factor or pulse weight for Universal output

e) Clear logs.

1.4.3.5. ADJUSTMENT mode allows viewing and modifying all of the settings.

In ADJUSTMENT mode, in addition to the above, available in OPERATION and SERVICE mode, the operator can do the following:

- Calibrate the flow meter
- Enter Device's serial number into the memory.

1.4.4. Displaying measurement results

1.4.4.1. List of displayed parameters is given in Table 4.

Table 4

Displayed	Parameter	Units (format)	Number of displayed symbols	
			Integer part	Fract. part
Time	Current date	XX.XX.XX		
Data	Current date	XX:XX:XX		
Q	Current value of volumetric flow rate with regard to flow direction	(m^3/h) l/min	1-3	4
V+	Totalized volume of forward flow	m^3; l	1-7	0-4
V-	Totalized volume of reverse flow	m^3; l	1-7	0-4
ΣV	Total value of totalized volume	m^3; l	1-7	0-4
Err	Status line	– – – – – –		
Ver	Number of software version	XX.XX.XX.XX		

NOTES:

1. Flow rate and volume of reverse flow and negative values of total volume are indicated by negative sign.
2. Totalized volume is the algebraic (considering the sign of the flow) sum of flow volumes totalized for both forward (positive) and reverse (negative) flows.
3. Counters are overflowed at $\mathbf{V} > 2 \times 10^9$ m^3 and restart from zero.

1.4.4.2. In SERVICE and ADJUSTMENT mode, the LCD is constantly on. In OPERATION mode, measurement results listed in Table 4 cyclically appear on the display on pressing the relevant button. With each pressing of the button, the next parameter is indicated. When no button is pressed during the period specified in the "**Service**" window of Viewer BUF-311 program, the LCD goes off.

1.4.5. External connections

1.4.5.1. RS-485 interface

RS-485 serial interface is used to control the flow meter, read measurement results, data logs, configuration settings, and diagnostic data as well as to modify configuration settings. The RS-485 interface supports ModBus (RTU ModBus and ASCII ModBus).

RS-485 interface supports cable communications among a group of several end users, one of which can be a PC, at a distance of up to 1200 m.

The speed of communication via RS-485 and other communication parameters are set from a PC.

1.4.5.2 M-Bus interface

Interface M-Bus interface complies with the standard EN 60870-5. The interface allows reading of the measured and archived data. Interface connections are made via two wires, the polarity is not important. The rate of exchange via interface M-Bus is set from a PC.

1.4.5.3. Universal output

The flow meter is equipped with 1 galvanically connected output.

Universal output can operate in the frequency, pulse and logical modes. Diagrams of output stages and description of their operation are given in Fig.B.2, see Appendix B of the present manual.

Functions, working modes, specifications of output signals and disconnection of the outputs are specified programmatically (see section 4.1.3). Options available are specified in Table C.2, see Appendix C of the present manual.

Operation modes of Universal output.

- In the frequency mode, measurement results are outputted in the form of square pulse sequence with period-to-pulse duration ratio of 2 and pulse repetition rate proportional to the current flowrate value. The frequency output can be scaled by specifying the values for "**Maximum output frequency**" and "**Output conversion factor**" parameters as well as for "**Lower limit by flowrate**" and "**Up. limit by flowrate**" threshold flowrate values that correspond to zero and maximum frequencies of the output signal. Maximum output fre-

quency value is 1000 Hz for ADJUSTMENT mode and 100 Hz for OPERATION and SERVICE modes.

CAUTION! Please note that the higher the value of maximum frequency, the faster the battery is discharged. The recommended **Fmax** value is 8 Hz.

- In the pulse mode, a burst of pulses is generated on the output within a second, in which the number of pulses (considering **Pulse weight**) corresponds to the flow volume measured over a previous second. Maximum pulse repetition rate permissible in a burst (meander-like, period-to-pulse duration ratio of 2) is 1000 Hz in ADJUSTMENT mode and 100 Hz in SERVICE mode.

CAUTION! Please note that increasing the number of pulses in a burst results in a faster discharge of the battery. It is recommended to set the value of pulse weight so that the number of pulses in a burst does not exceed 8.

To provide correct work of Universal output, the parameters "**Conversion factor calculation**" (pulses/m^3) in the frequency mode and "**Pulse weight calcul.**" (m^3/pulse) in the pulse mode are calculated automatically.

The conversion factor is calculated on the basis of user-specified values set for the "**Lower limit by flowrate**" and "**Upper limit by flowrate**" parameters and "**Maximum output frequency**" parameter. The pulse weight is calculated from the values set for the "**Up. limit by flowrate**" and "**Pulse width**" parameters. The pulse width can be set in the range 1 to 500 ms.

- In the logic mode, one signal level corresponds to "event" (or its state) and the other level corresponds to "no event" (or another state).

Programmatically this means: "**Active level**", i.e. "**Low**" or "**High**" signal level is set when the event is present. Electrical parameters of corresponding signal levels are specified in Appendix B.

The flow meter is delivered preset so that the universal output is disabled.

1.4.6. Logging

1.4.6.1. Measurement results are recorded into the flow meter's internal logs: hourly, daily and monthly logs. Logs are accessed via RS-485 and M-Bus interfaces.

Hourly, daily, and monthly logs are arranged as circular buffers and have the same structure.

Log capacity:

- Hourly log – 120 records (hourly records)
- Daily log – 45 records (daily records)
- Monthly log – 48 records (monthly records).

Format of one record is as follows:

- **V+** – total volume for direct flow over logging interval, m^3 (l)
- **V-** – total volume for reverse flow over logging interval, m^3 (l)
- **Errors** – code of error situation

- **Time of errors** – duration of error situation
- **Operating time** – time of totalizer operation.

1.4.6.2. Modifications made on the operation mode are logged in the Operation mode log with a capacity of 100 records.

Mode log format is as follows:

- Order number of the record
- Name of the active operation mode
- Date and time of activation.

1.5. Design

1.5.1. The Measuring pipe section (PS) with the Secondary converter (CS) installed on it are delivered as an assembly unit.

The design of the flowmeter's depends on the pipe connection type and may be as follows:

- Flanged type (DN32-DN300): PCF flanges are bolted to the mating pipeline flanges (see Fig.A.1 Appendix A);
- Threaded coupling connection type only DN32, DN40 and DN50 (see Fig.A.2).

1.5.2. Electro-acoustic converters

1.5.2.1. PEAs alternately operate in two modes: transmitter mode, in which the electrical pulse signal coming from the CS is transduced into ultrasonic waves, and receiver mode, in which ultrasonic waves in liquid are transduced into the corresponding electrical signal.

1.5.2.2. The flow meter works with built-in PEAs.

The built-in PEAs come in cylindrical case with the transmitting plane in the form of a disk in the flat end. The built-in PEAs are mounted onto the Measuring pipe section so that the transmitting (radiating) plane contacts the medium. Pipeline-PEA contact surface is sealed.

The PEAs and CS are connected by twisted pair cables.

1.5.3. The CS is directly installed on the measuring PS and includes Measurement and Calculation board. The board is placed in the transparent cover of the case (on the front panel, see Fig.A.3). The cables connections with the PEA and the interface cable are entered into the case through cable glands of SKINTOP type.

1.6. Marking and sealing

1.6.1. The marking on the front panel of the CS contains:

- Flow meter's name and designation
- Nominal diameter
- Pulse weight on the universal output
- Maximal pressure
- Case protection
- Minimal, nominal and maximal measured average volumetric flow rate
- Production year

1.6.2. The cap covering J1 terminal, used to enable modification of calibration settings, is sealed after performing calibration (see Fig.A.2, Appendix A).

1.6.3. J2 terminal used to enable modification of flow meter's operation settings is sealed on completing start-up procedures and putting the Device into operation.

1.6.4. To protect the device from unauthorized access during transportation, seals may be hung through the lugs located on the front and rear panels.

2. OPERATION

2.1. Operating restrictions

2.1.1. Environmental restrictions with regard to the factors affecting the performance and characteristics of the controlled medium shall comply with the requirements specified in the operating documentation.

2.1.2. For precision and reliable operation, when choosing CP mounting location, the following conditions must be met:

- Liquid pressure in the pipeline and pipeline's operational characteristics must not be of values that may facilitate gas release and/or gas (air) collection
- When the flow meter is operated, the PS should be fully filled with liquid.

2.1.3. Type and composition of medium (suspensions and their concentration, impurity substances, etc.), operating mode and pipeline conditions must not lead to corrosion and/or sediments affecting the performance and metrological characteristics of the flow meter.

2.1.4. Lightning protection system for the site where the flow meter is located protects the device against failures caused by lightning strokes.

2.1.5. Mounting location and operating conditions requirements specified in this operating documentation are based on the most typical factors affecting flow meter performance.

The external factors that cannot be foreseen, evaluated or tested by the manufacturer during designing may exist or appear on site.

In this case, it is necessary to eliminate these factors or place the flow meter in other location.

2.2. Safety instructions

2.2.1. The flow meter should only be used by the technical staff familiar with all operating documentation for the product.

2.2.2. When working with the flow meter, the dangerous factors are as follows:

- Pipeline pressure
- Liquid temperature
- Other site-specific factors.

2.2.3. On detecting external defects on the device or damages to mains cabling, you must remove power from the device and contact the authorized technician for the information about the device's operability.

2.2.4. In the course of mounting, start-up or repair works you must not:

- Make connections to the flow meter, switch over modes and replace electronic components, if the flow meter is powered up
- Remove the flow meter's components from the pipeline until pressure in the pipeline section worked on is fully released
- Use defective electronic devices and electric tools or use them without proper grounding (neutral earthing).

2.3. Mounting the flow meter

2.3.1. Mounting preparation

2.3.1.1. When mounting the flow meter on site, a free pipeline section should be provided.

2.3.1.2. The flow meter should be transported packed in the manufacturer's box.

After the flow meter has been moved to the mounting location from a cold environment into a warm one (with ambient temperature above zero), it shall be left to stand in the manufacturer's box for at least 3 hours to make sure that no condensation remains inside.

When unpacking the flow meter, check that the delivery package contains all items specified in the Equipment Certificate.

2.3.2. Mounting requirements

2.3.2.1. The requirements for on-site mounting of the flow meter are specified in section 2.1.2.

The CP can be mounted into the pipeline horizontally, vertically, or obliquely (Fig.4). The CP should not be placed at the upper point of the pipeline. The recommended location (if applicable) is at the lower or uprising pipeline section.

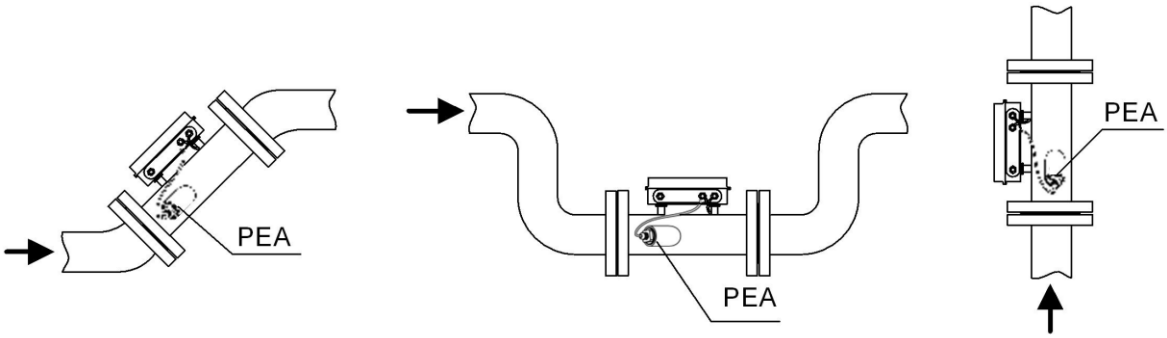


Fig.4. Recommended locations of the CP

NOTE. In case of impossibility of installation of a flow meter in recommended places device installation in the top point of the pipeline is allowed. Installation of the air valve in the point which is above is thus necessary is more true points of flowing part of a flow meter, for example in pipeline expansion.

ATTENTION! It is necessary to watch serviceability of the air valve. Correct work of a flow meter is possible only in the absence of air in the channel.

2.3.2.2. The difference in the internal diameters of the pipeline and measuring Pipe Section (PS) of the CP at link up points should not exceed 0.05 ·DN.

2.3.2.3. When mounting the CP on the pipeline, it should be placed so that the PEA longitudinal axis (the axis that runs through the PEA pair along the pipeline axis) would make an angle with the vertical of β = 45°-90° (Fig.5).

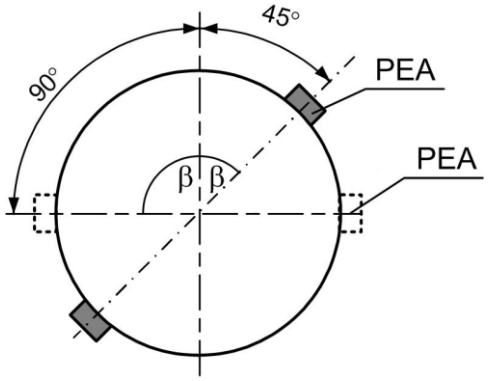


Fig.5. Recommended locations of PEA pair

2.3.3. Length requirements for straight pipe runs

2.3.3.1. For proper operation of the flow meter, before the first and the last PEA with respect to the flow direction, there should be straight pipe runs of corresponding length with the DN equal to the DN of the CP. Table D.1 given in Appendix D shows minimum values of relative length of pipeline straight runs that should be used for typical installations.

The length of the straight pipe run L (mm) is calculated as follows:

$$L = N \times DN,$$

where N is the relative length defined in the number of DNs and specified in Table D.1;

DN – CP nominal diameter, mm.

CAUTION! While measuring the reverse flow, all the PEAs are in upstream position, and the length of the straight pipe runs shall be defined in view of this condition.

2.3.3.2. Any diaphragm or venturi type structure, as well as any valve, refer to the type of hydraulic resistance specified in Appendix D as “control valve”.

2.3.3.3. In case of mounting the straightening vane into the pipeline before the measuring Pipe Section (Appendix E), reduction of straight pipe run length is possible at the inlet of the CP up to two times. In this case, the required length of the straight pipe run is defined on the base of site survey, and the individual measurement technique shall be designed for this structure.

2.3.4. Mounting the flow meter flanged type on the pipeline

2.3.4.1. Before working on the pipeline at the CP mounting location, fix the pipe sections that may tip out of their axes after cutting the pipeline.

CAUTION! Before mounting the flow meter, it is necessary to cut off liquid flow in the pipeline section where the flow meter will be installed, make sure that pressure is released and drain the liquid.

2.3.4.2. Cut a pipe run of the required length at the selected liquid-free pipeline section. Join the flow meter's flanges with the companion flanges provided in the delivery package and bolt them together. Make several tack welds between the cut ends of the pipeline and companion flanges. Then, remove the flow meter and finally weld the flanges to the pipeline.

Alignment of the whole unit and flatness/parallel alignment of the flanges for the CP to be mounted between them must be provided.

2.3.4.3. Mount the flow meter on the pipeline provided that the arrow on the CP points to the flow direction. Put rubberized asbestos fabric gaskets between the mating flanges and bolt the flanges.

CAUTION! IT IS STRICTLY FORBIDDEN to throw the flow meter and hit it while mounting. This can cause damage to the PEAs installed on it. **DO NOT** take the flow meter by the CS case or PEA connection cables. It is **STRICTLY FORBIDDEN** to dismantle PEA from assembly branch pipes. During welding, **PROVIDE** the CS cable and PEA cables with adequate protection from sparks. The welding temperature at the PEA section **SHALL BE** lower than 100 °C.

2.3.5. Mounting the flowmeter with threaded coupling

2.3.5.1. Select the flowmeter's pipeline mounting location observing the rules specified in section 2.3.2.

2.3.5.2. Unscrew grooved nuts and dismount nipple joints which are the parts of flowmeter.

2.3.5.3. Make sure that the simulator is installed into the assembly-welded structure instead of flowmeter, this is necessary to provide alignment between two welded units and to avoid damages to the flowmeter during welding the structure to the pipeline.

Weld conical nozzles to the pipeline butt-to-butt in the same way as to weld the adaptor pipes for the wafer type flowmeters, so that the nozzle axis is perpendicular to the grooved nut plane. Welding works shall be conducted in accordance with the requirements given in section 2.3.4.

CAUTION! When replacing the simulator by the flowmeter after welding, it is recommended to use a compensator to ensure that the threaded couplings are moved apart by the distance of no less than 10 mm. The compensator may be as follows:

- KRK manufactured by JSC "ArmaTreid"
- ARN/HYDRA by Danfoss
- Compensators from "WILLBRANDT" (authorized distributor is "KREOLAIN" company), or similar.

The compensator shall be mounted into the pipeline following the instructions outlined in the corresponding operational (maintenance) documentation.

2.3.5.4. Replace the simulator with the flowmeter. The whole structure is assembled by firm tightening of grooved nuts. When assembling the structure, it is required to install gaskets made of edible material and supplied with the flowmeter, between the nozzles and grooved nuts.

2.3.6. Wiring the flow meter

2.3.6.1. The flow meter's power cable and CS-external devices connection cables (if applicable) are laid in accordance with the flow meter's operating conditions.

2.3.6.2. Communications and network cables are fixed on the wall wherever possible. The network cable is laid separately at a distance of 30 cm as

a minimum from other cables. To avoid mechanical damages, it is recommended to place all cables in metal tubes or sleeves.

With presence of high-level electromagnetic interference (for instance, from a thyristor controller) **IT IS FORBIDDEN** to lay the cables without putting them into properly grounded (neutrally earthed) metal tubes or sleeves.

2.3.6.3. It is recommended not to coil the excessive cables.

2.3.6.4. Prior to connection, cut insulation from cable ends. The cables are directed via cable-through holes and attached to the connectors according to the Wiring diagram given in Fig.B.1, see Appendix B. Refer to Fig.A.2 of Appendix A for orientation of the connectors on the Measurement and Calculation Board.

2.3.7. Dismounting

To dismount the flow meter, do the following:

- Cut off liquid flow in the relevant pipeline section, ensure there is no pressure in the pipeline and drain the liquid
- Disconnect a lithium battery
- Disconnect cables leading to the CS
- Dismount the flow meter.

When the device is dispatched for calibration or repair, the PS and emitting surfaces of built-in PEAs should be cleaned off sediments, residue, scale, etc.

2.4. Putting into operation

2.4.1. Start-up works shall be performed by the manufacturer or by an entity certified for performing works of this type.

2.4.2. The pipeline is filled with liquid to be controlled. Connects a lithium battery and the flow meter is connected to a PC, and configured according to the instructions listed in section 4.1 of the present manual.

2.4.3. At first power-up or after a long break in operation, the flow meter becomes operational after all hydraulic processes in the pipeline related to flow adjustment (draining, flow cut off, etc.) are fully completed.

2.4.4. When putting the flow meter into operation check the following:

- The flow meter and related equipment are connected in accordance with the selected wiring diagram
- Output operates in the preset modes.

After putting the flow meter into operation, two fixing screws accessed from the CS front panel side can be sealed to protect the equipment from unauthorized access.

3. MAINTENANCE

3.1. It is recommended to check on regular basis that:

- Performance of the flow meter complies with the specifications
- Operating conditions are met
- No external defects are detected
- Electrical and mechanical parts are reliably connected.

Check periods depend on operating conditions but should not exceed 1 month.

It is recommended to check the inside of the CP and emitting surfaces of built-in PEAs for sediments, residue, and scale on regular basis (the period depends on operating conditions) and clean it out from all the deposits.

3.2. If the operating conditions specified in sections 1.2.8 and 2.1 are not observed, this may lead to the flow meter's fault, or the permissible limits of relative measurement error may be impaired.

External defects may also lead to deterioration in measurement accuracy. Therefore, when the external defects are detected on the flow meter, power cables or signal cables, contact the Service Center or regional dealer for the information about the device's operability.

3.3. Presence of display indication means that power is applied to the flow meter, the indicated information gives an idea of the flow meter's performance. The list of possible faults indicated by the flow meter is given in section 4.3 of this manual.

Alarm (ER) situations are also indicated by status words. An ER situation is an event characterized by mismatch of measured values and flow meter metrological characteristics, or by impossibility of measurements due to the violation of measurement conditions.

3.4. The flow meter is calibrated in accordance with the respective instructions.

3.5. Regarding the design and operating conditions, the flow meter refers to the devices that should be repaired by authorized dealers or by the manufacturer.

3.6. When the flow meter is sent for service, the Equipment Certificate must be enclosed. Please specify post details, phone/fax numbers along with the way and address for redispatching.

4. CONTROLLING THE FLOW METER

The flow meter is controlled from a PC running "Viewer BUF-311" program. The program is available free of charge.

The interface includes several tabs classified by their function. Contents of the tabs are determined by the flow meter's operation mode. After the flow meter is powered up, the operation mode is detected automatically.

4.1. Configuring before work

4.1.1. Installing the dedicated software and system requirements

BUF-311 program was designed to control the flow meter and handle the measurement data. Viewer BUF-311 works under Windows 98 (Me, 2000, XP, Vista, 7) operating system.

To install Viewer BUF-311 program, create a directory with the same name and copy BUF-311.vpr file to this directory. The program does not require another installation procedure.

4.1.2. Getting started

Connect the serial port of a PC and RS-port of the flow meter RS232/485 or USB-RS232/485 adapter by a cable. Activate SERVICE mode (place a jumper on J2 terminal). The list of parameters to be configured on-site in SERVICE mode is given in Appendix C. Run the BUF-311.vpr file. Wait for the main window shown in Fig.6 to open.

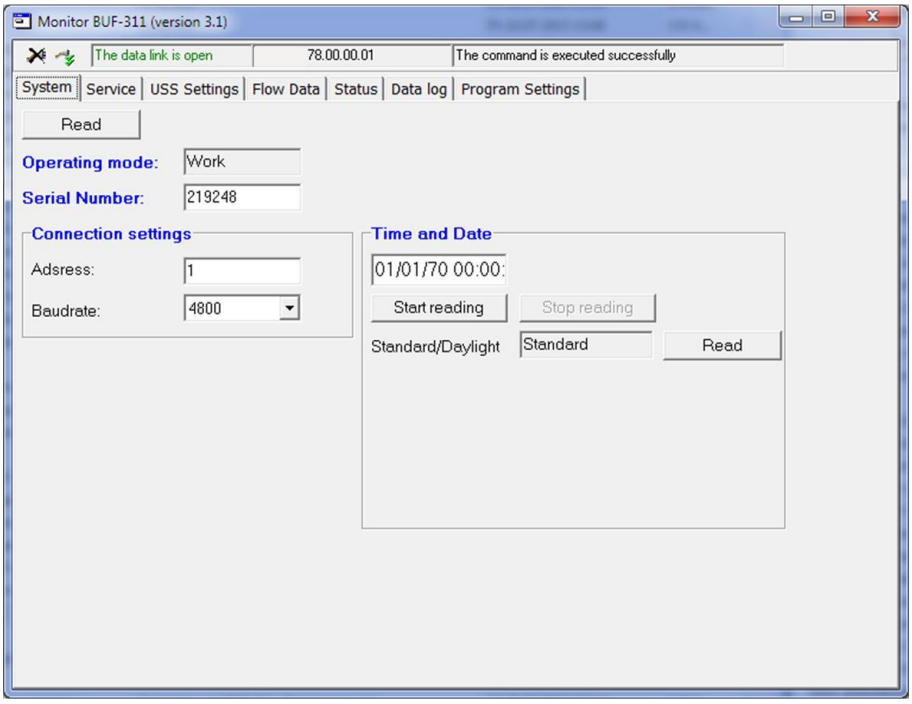


Fig.6. Main window

Click on the leftmost icon in the command line of the main window. By doing so, the connection with the flow meter is established. The window will take the form pictured below (Fig.7).

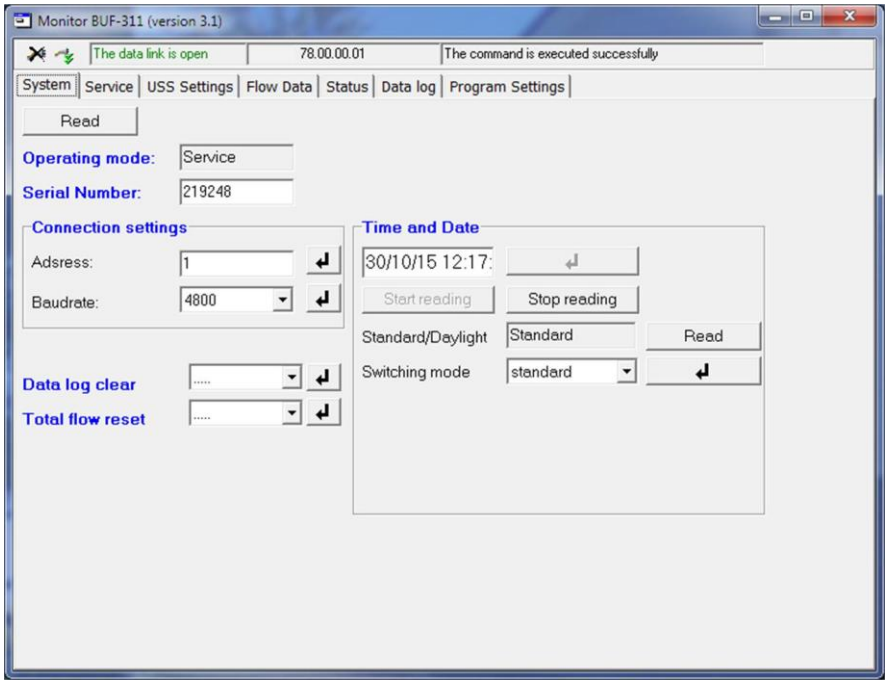


Fig.7. Main window after the connection with the flow meter is established

This tab allows you to set new values for current date and time, establish interface connection between the device and PC, and check/set the winter/summer clock mode (see Table C.1, Appendix C).

4.1.3. Click on the "**Service**" tab. Fig.8 displays the window that will appear.

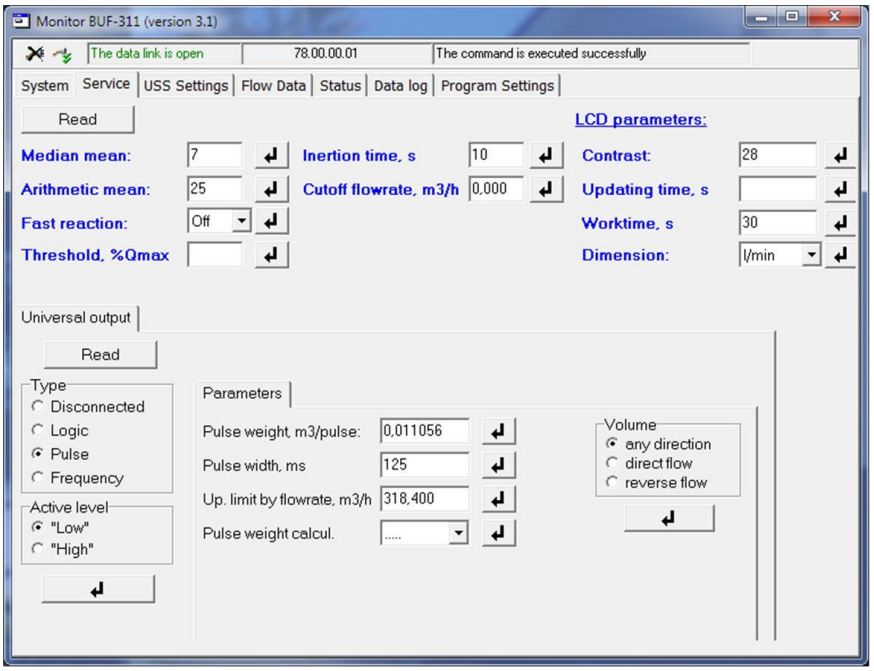


Fig.8. "Service" window

The window allows you to set USS parameters and specify operation settings for the LCD and universal outputs. To activate the parameter, enter the required numeric value or symbol in the corresponding field and press ↵ button.

4.1.4. Click on the "**Flow Data**" tab. Fig.9 displays the corresponding window. Pressing "**Start reading**" button allows you to view measured parameters.

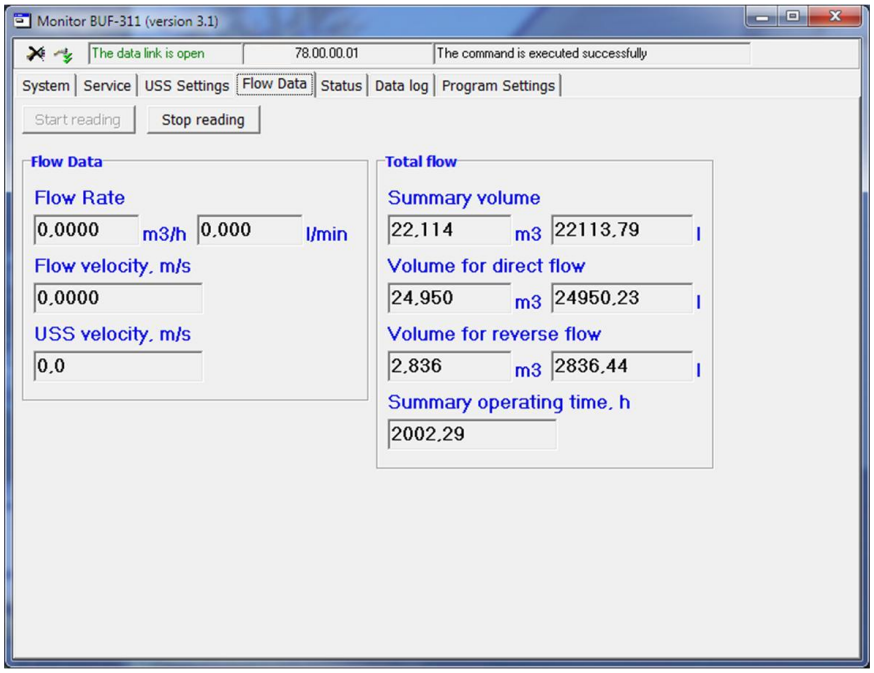


Fig.9. "Flow Data" window

4.1.5. In the "**Status**" tab, on pressing the "**Start reading**" button, the current status of the flow meter is indicated (Fig.10).

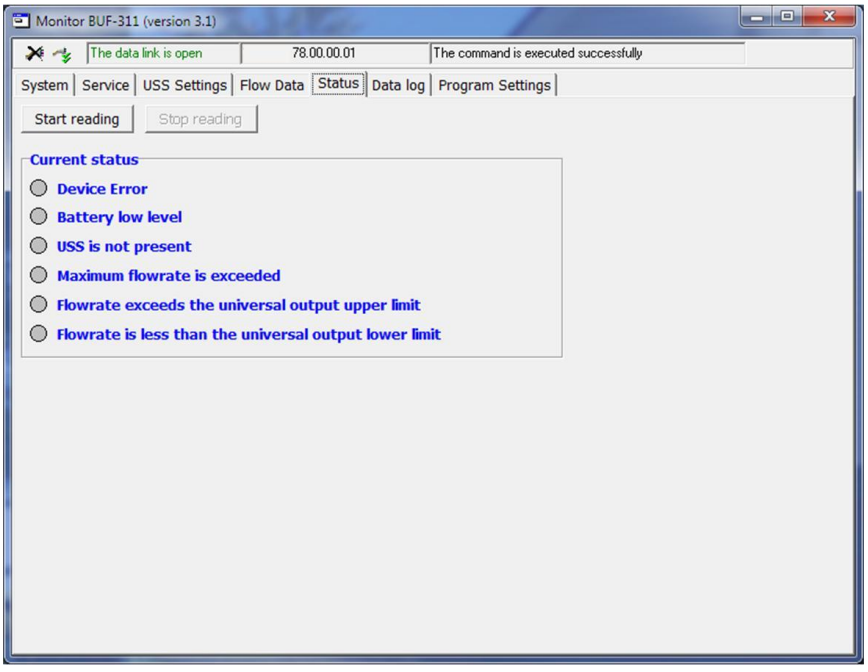


Fig.10. "Status" window

4.1.6. To read the logs, go to the "**Data Log**" tab (Fig.11), select log type (**Hourly**, **Daily** or **Monthly**), set the required interval in "**Date**" and "**Time**" fields and press the "**Read**" button.

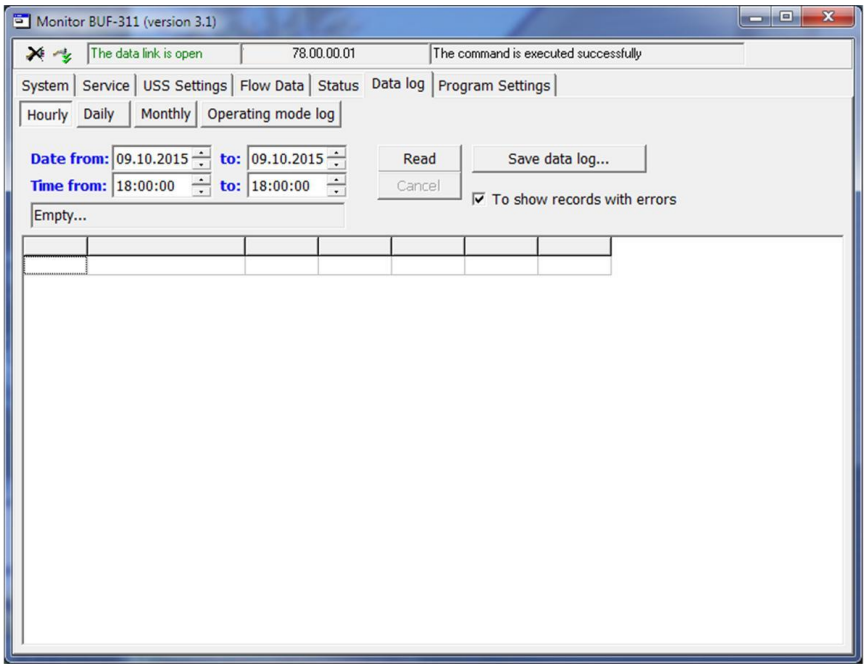


Fig.11. "Data Log" window

4.1.7. If the flow meters are connected in a network, open the "**Program Settinds**" tab (Fig.12).

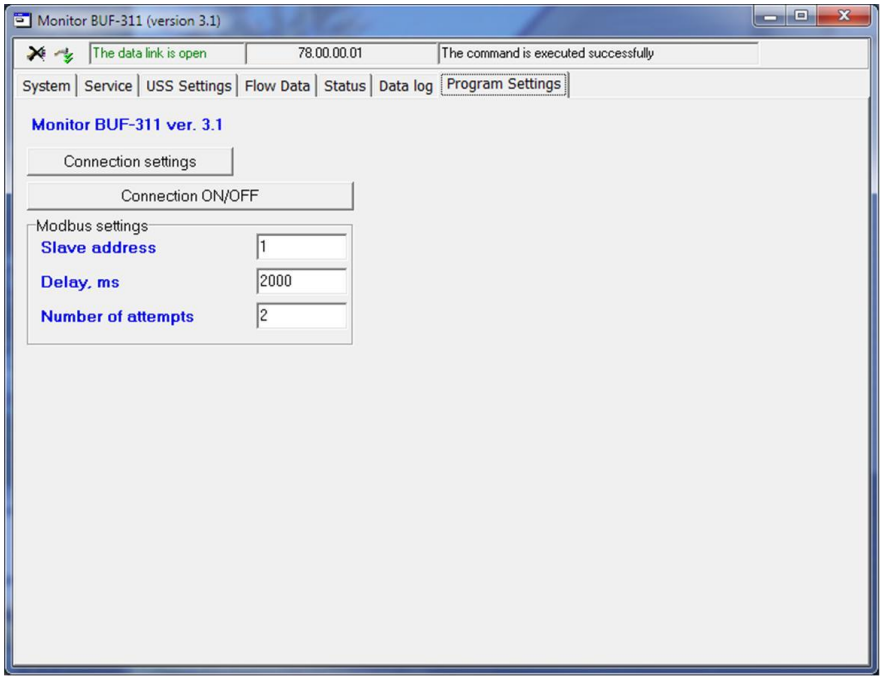


Fig.12. "Program Settings" window

The window options make it possible to establish connection between the networked flow meters via RS-485 interface.

4.1.8. Set the flow meter to OPERATION mode (remove the jumper from J2 terminal). Terminal J2 should be sealed. If necessary, seals may be hung through the lugs located on the front and rear panels of the CS case.

NOTE: In SERVICE and OPERATION modes, the user is not allowed to modify the parameters displayed in the "**USS Settings**" tab.

4.2. Troubleshooting

4.2.1. List of possible faults, failures and alarm situations detected by the flow meter and displayed on the LCD with "**X**" character in the "**ERR = - - - - - -**" line is given in Table 5. A sign-position code is read from ***right*** to ***left***.

Table 5

Sign position number	Explanation
1	Hardware failure
2	Low battery voltage
3	USS not detected
4	Current flowrate value exceeds maximum
5	The current flow rate is above the upper threshold
6	The current flow rate is above the lower threshold

4.2.2. The same information can be read via the communication interface from the **Status** tab of the "Viewer BUF-311" program (see section 4.1.5).

4.2.3. If "**X**" symbol is displayed in position 1, the flow meter shall be forwarded to the manufacturer for repair.

If "**X**" symbol is displayed in position 2, battery replacement is required.

4.2.4. If "**X**" is displayed in other positions and/or in case of no pulses at Universal output, check the following:

- Liquid is present and running through the pipeline
- Air is not collected in the flow meter’s location
- Threshold values for the "**Output conversion factor**" and "**Pulse weight**" as well as for the "**Lower limit by flowrate**" and "**Up. limit by flowrate**" parameters are set correctly. Change the values, if necessary.

If all the requirements listed above are met contact the service centre (regional dealer) or manufacturer for the information about the device’s operability.

5. PACKING, STORAGE AND TRANSPORTATION

5.1. AFLOWT BUF flow meter is packed in a separate container (corrugated carton or wooden box)

5.2. The flow meter should be kept in the manufacturer's box in. a dry heated storeroom. The storeroom should be free from current-conductive dust, acid or alkali fumes and aggressive gases.

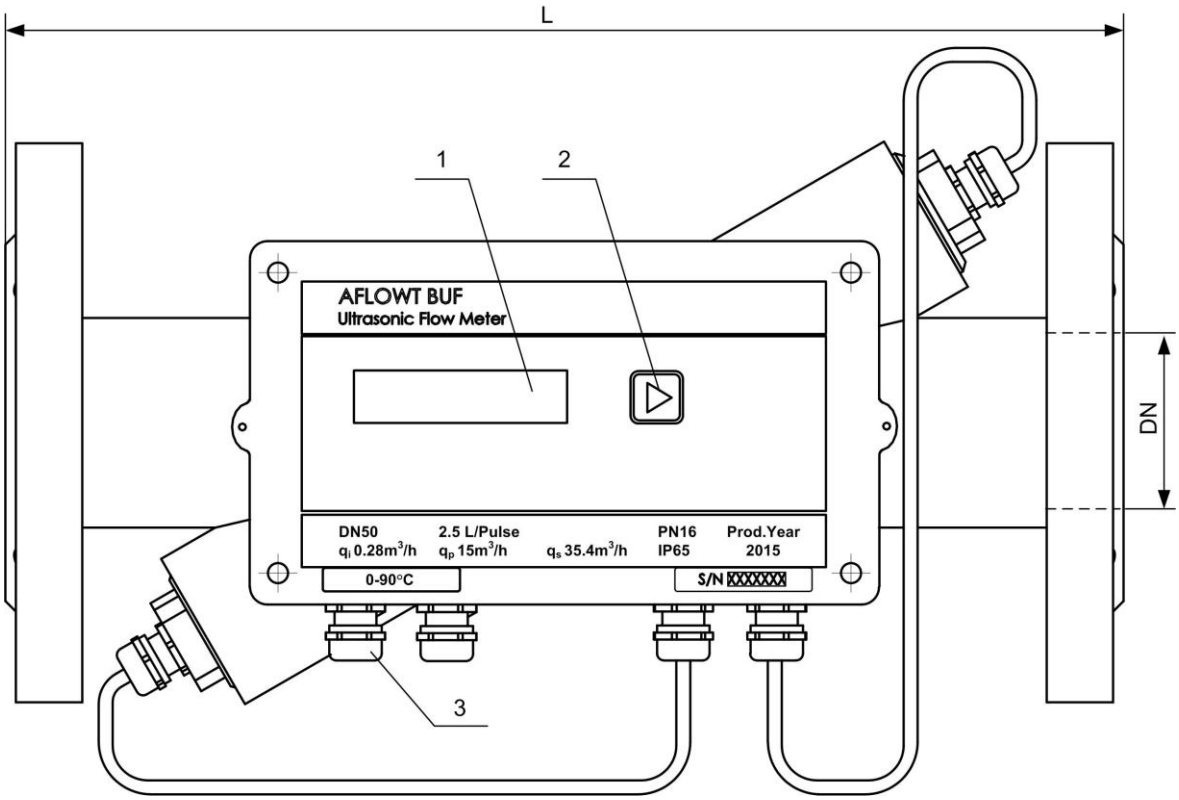
During storage the flow meter does not require any special maintenance.

5.3. The flow meters can be transported by road, rail, sea or air (except for unsealed cargo compartments) provided that the following requirements are met:

- Flow meter is transported packed in the manufacturer’s box
- Protection against moisture is provided
- Temperature is within the range of -25 to +55 °C
- Humidity does not exceed 98 % at +35 °C
- Vibration is within the range of 10-500 Hz with maximum 0.35 mm amplitude or 49 m/s^2
- Impact acceleration does not exceed 98 m/s^2
- Flow meters are fixed to prevent damages.

CAUTION! The flow meter must be stored and transported with the battery disconnected.

APPENDIX A. General view

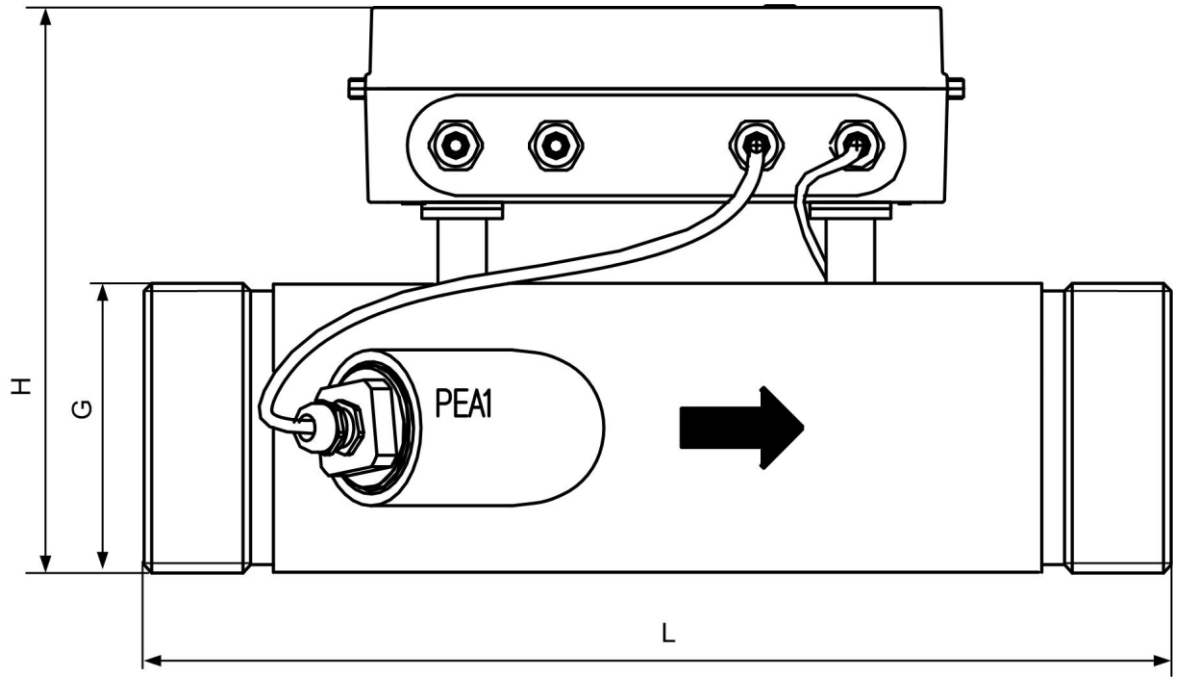


1 – indicator; 2 – button; 3 – cable gland

Fig.A.1. View of flanged flow meter AFLOWT BUF

Table A1. Flow meter's dimensions and weight

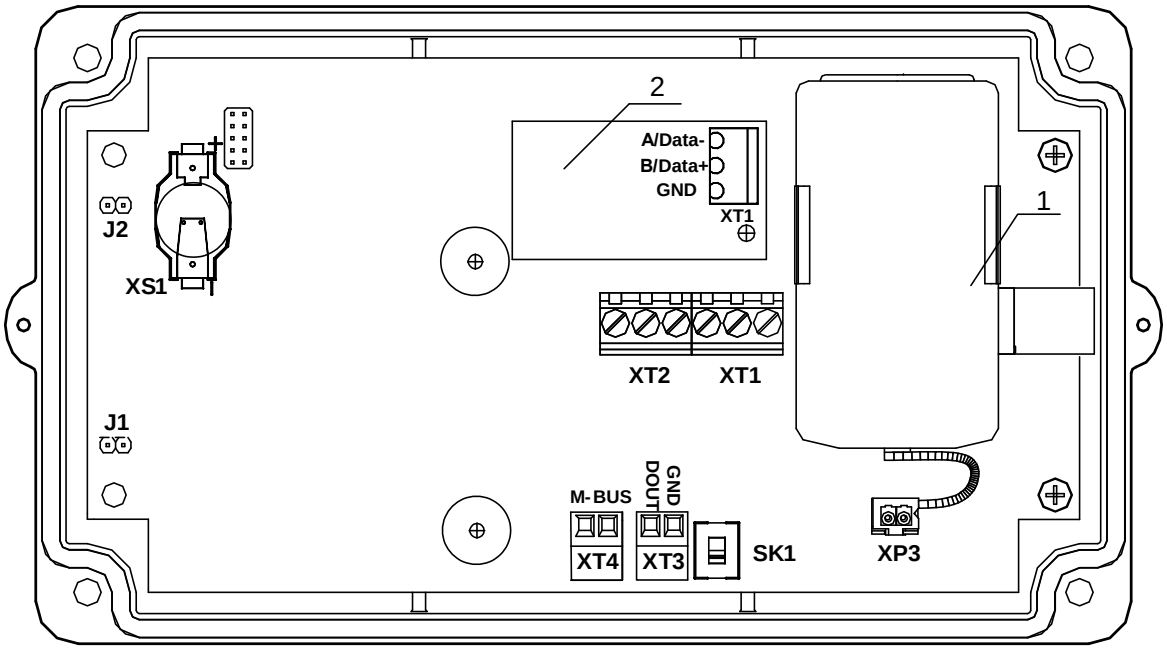
DN, mm	L, mm	Weight, kg	
		PN16	PN25
32	260	4.2	4.5
40	260	7	7.4
50	320	9	9.5
65	320	10.6	11.8
80	320	12.3	14.1
100	320	13.8	18.8
125	320	17.7	24.7
150	320	20.3	30.6
200	450	38.8	46.4
250	450	57.4	62.2
300	450	66.8	76.8



Flowmeter's dimensions and weight

DN, mm	L, mm	H, mm	G, “	Weight, kg
32	260	68	G1 1/2B	3.8
40	260	76	G1 3/4B	6.5
50	320	87	G2 1/2B	8.2

Fig.A.2. View of flow meter AFLOWT BUF with threaded coupling



1 – Battery;

2 – Module RS-485, XT1 – connector for RS-485 interface;

XT1, XT2 – connectors for PEA connection cables, XP3 – connector for battery; XT3 – connector for Universal output; XT4 – connector for M-BUS interface; J1, J2 – terminals used to set operation modes; SK1 – the switch of operation modes.

Fig.A.3. Measurement and Calculation board

APPENDIX B. Wiring diagrams

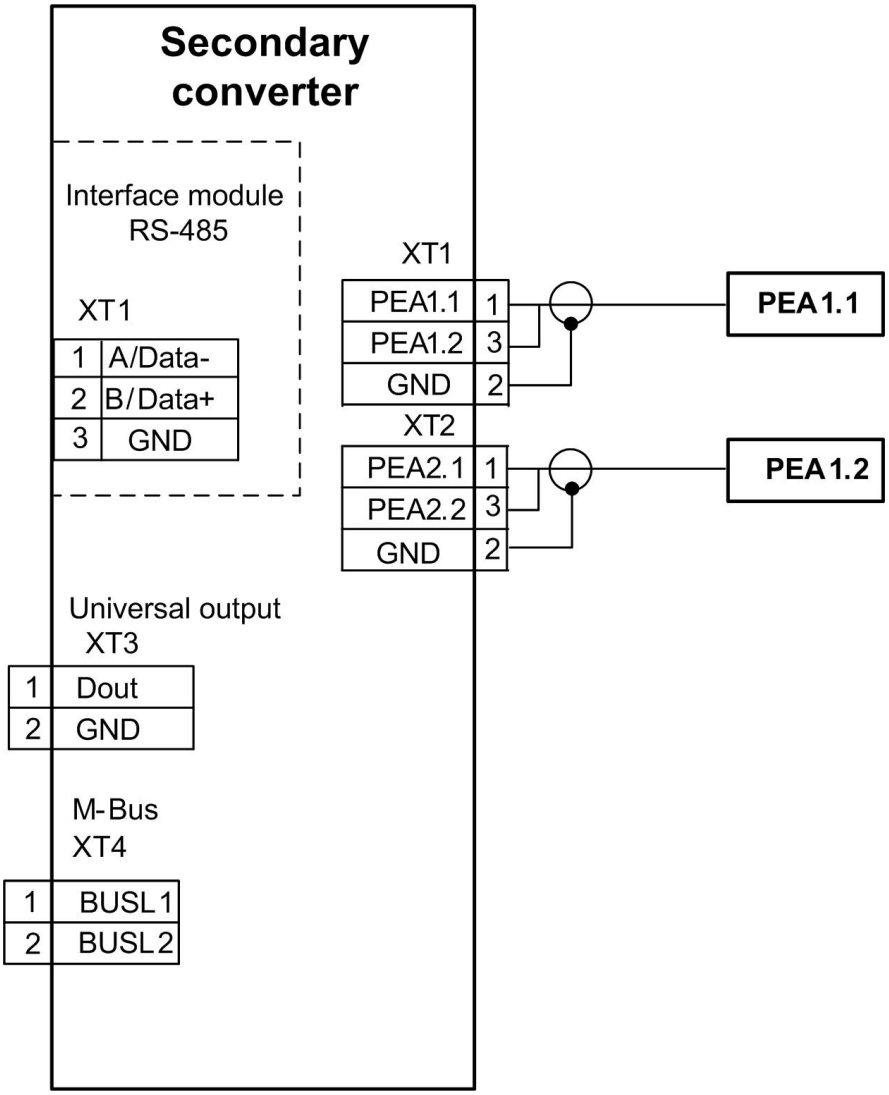


Fig.B.1. BUF Flow meter wiring diagram

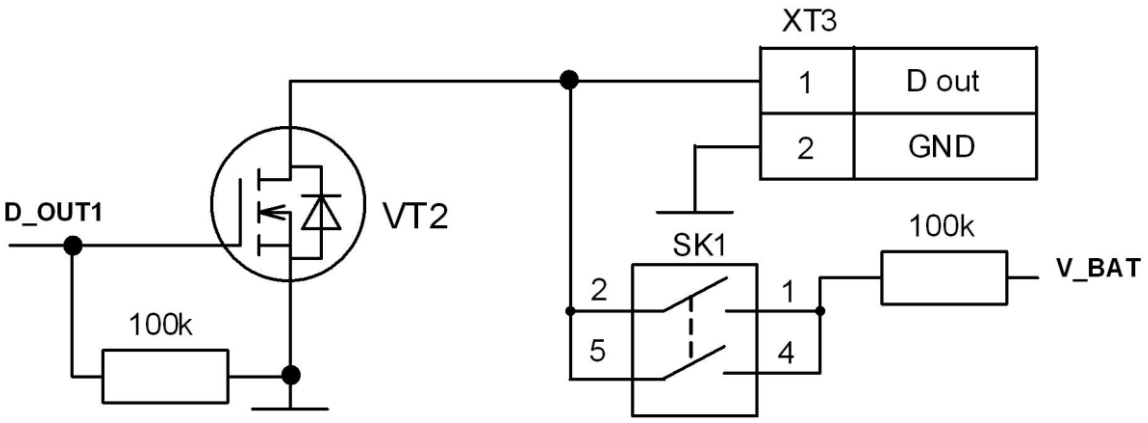


Fig.B.2. Universal output, circuit diagram of output stage

To match output stage to inputs of different types, the output stage of universal output (Fig.B.2) is designed to work with either the internal power source (active mode) or an external power source (passive mode). In standard supply configuration the output stage is in the passive mode.

In the active mode and in case that **Active level** parameter is set to "**High**", output voltage in the logic mode and pulse amplitude in the pulse mode is within 1.7 to 3.6 V. In case of no pulse or at logic "**Low**" the output voltage is no more than 0.4 V. External load resistance shall be 100 kOhm as a minimum.

In the passive mode, power from an external power source with output DC voltage to15 V can be applied. Permissible value of external load current is no more than 100 mA.

The output stage is connected to the internal power source +3.6V with SK1 switch.

For the universal output, length of signal cable should be up to 300 m.

APPENDIX C. Parameters to be set during on-site configuration

Table C.1

Representation of the parameter on PC screen	Parameter Name, measurement units	Possible values	Value after initialization	Notes
1	2	3	4	5
Menu **"System"**				
Address	Flow meter address in the RS-interface network	**1-247**	**1**	
Boudrate	The speed of communication via RS-485	**1200, 2400, 4800**	**4800**	
Time and Date	Current flow meter time and date	**XX/XX/XX** (dd.mm.yy) **XX:XX:XX** (hh:mm:ss)	No changes available	
Switching mode	Clock transition between "Summer" and "Winter" time	**no switch; standard; user**	**standard**	
Data log clear	Clearing logs	**...; start**	**...**	
Total flow reset	Zero setting for volume totalizer	**...; start**	**...**	
Menu **"Service"**				
Median mean	Number of measurements to determine the median value	**1-21**	**7**	
Arithmetic mean	Number of measurements to determine the arithmetic mean value	**1-50**	**25**	
Inertion time, s	Minimal duration of the event recorded to logs	**0-255**	**10**	
Cutoff flowrate, m^3/h	Minimal flowrate cutoff	**0,000-999.000**	see table1	
Fast reaction	Measuring mode dynamic flows	**Off, On**	**Off**	
Threshold, %Qmax	The criterion for quick installation	**0-100**	**5**	
Contrast	LCD contrast setting	**1-63**	**28**	
Updating time	The update period of the measurement data on the display	**1-255**	**10**	
Worktime	Time to turn off the LCD after the last pressing of a button	**1-255**	**30**	
Dimension	Flowrate measurement units	**m^3/h; l/min**	**m^3/h**	

Cont. of Table C.1

1	2	3	4	5
Menu **"Service" / Universal output**				
Type	Operation mode of the output	**Disconnected Logic Pulse Frequency**	**Disconnected**	
Frequency				
Flowrate	Function of the output	See table C.2	**any direction**	
"Parameters"				
Maximum output frequency, Hz	Maximum frequency of output signal	**0-120**	**8**	
Error frequency, Hz	Output signal frequency when Q> Q_{max}	**0-120**	**120**	
Lower limit by flowrate, m^3/h	Flowrate lower threshold for the universal output in the frequency mode	**0-999,999**	**0**	
Upper limit by flowrate, m^3/h	Flowrate upper threshold for the universal output in the frequency mode	**0-999.999**	depending on flow meter's DN	
Output conversion factor, p/m^3	Output scaling factor	**0,010-200000.000**	depending on flow meter's DN	
Conversion factor calculation	Calculation of output conversion factor	**...; start**	**...**	
Current frequency value, Hz	Current frequency value	**0-120**	Corresponds to flowrate value	
Active level	"Logic high" level on the output	**Low; High**	**Low**	
Pulse				
Volume	Function of the output	See table C.2	**any direction**	
"Parameters"				
Pulse weight, m^3/pulse	Pulse weight	**0,000005-100.0000**	depending on flow meter's DN	
Pulse width, ms	Pulse period	**10-1000**	depending on flow meter's DN	
Up. limit by flowrate, m^3/h	Flowrate upper threshold for the universal output in the pulse mode	**0-999.999**	depending on flow meter's DN	
Pulse weight calcul.	Calculation of pulse weight	**...; start**	**...**	
Active level	"Logic high" level on the output	**Low; High**	**Low**	
Logic				
Output function	Function of the output	See table C.2	**Reversing flow direction**	
Active level	"Logic high" level on the output	**Low; High**	**Low**	

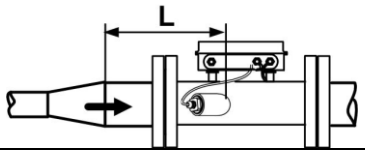
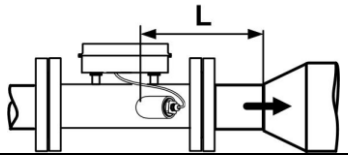
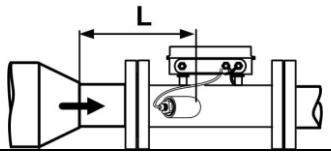
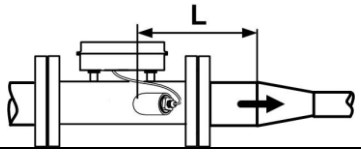
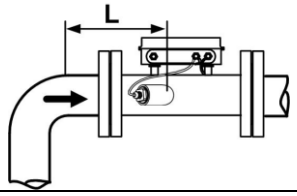
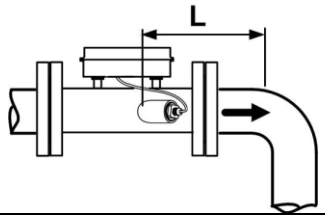
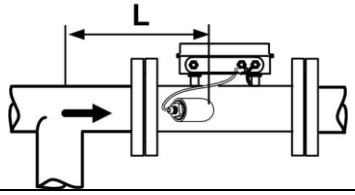
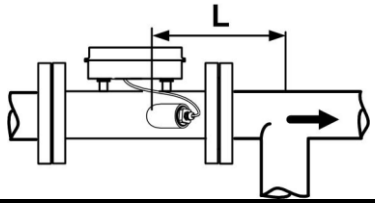
Table C.2. Possible settings for Universal output

Name of the parameter		Possibility to set the function for the output		
		Frequency	**Pulse**	**Logic**
Mode	**Disconnected**	×	×	×
Frequency	**Any direction**	×		
	Direct flow	×		
	Reverse flow	×		
Pulse	**Any direction**		×	
	Direct flow		×	
	Reverse flow		×	
Logic	**Reversing flow direction**			×
	No ultrasonic signal			×
	Flowrate exceeds the high set-point			×
	Any Error			×
	Battery low level			×

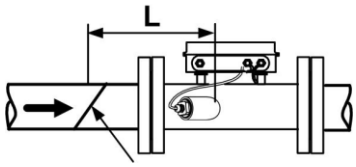
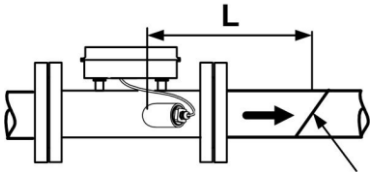
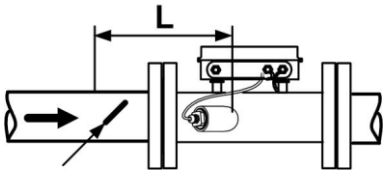
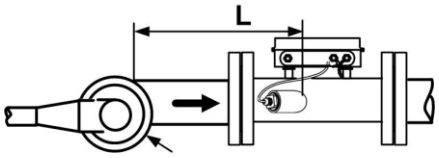
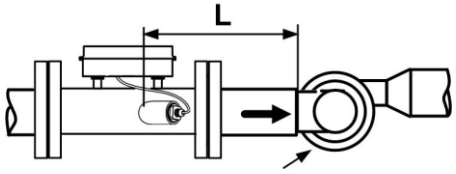
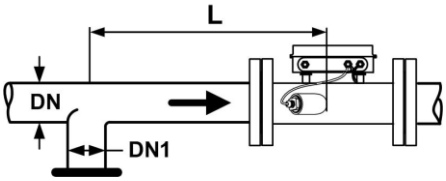
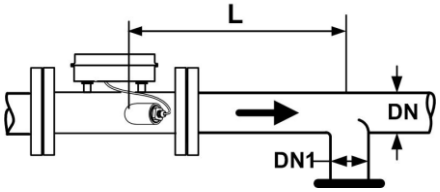
APPENDIX D. Relative length of straight runs

Table D.1 shows minimum values of relative length of pipeline straight runs for type installation depending on the types of local hydraulic resistance.

Table D.1

Type of local hydraulic resistance	Relative length of a straight run, N, minimum
1	2
	10
	3
	10
	3
	10
	3
	10
	10

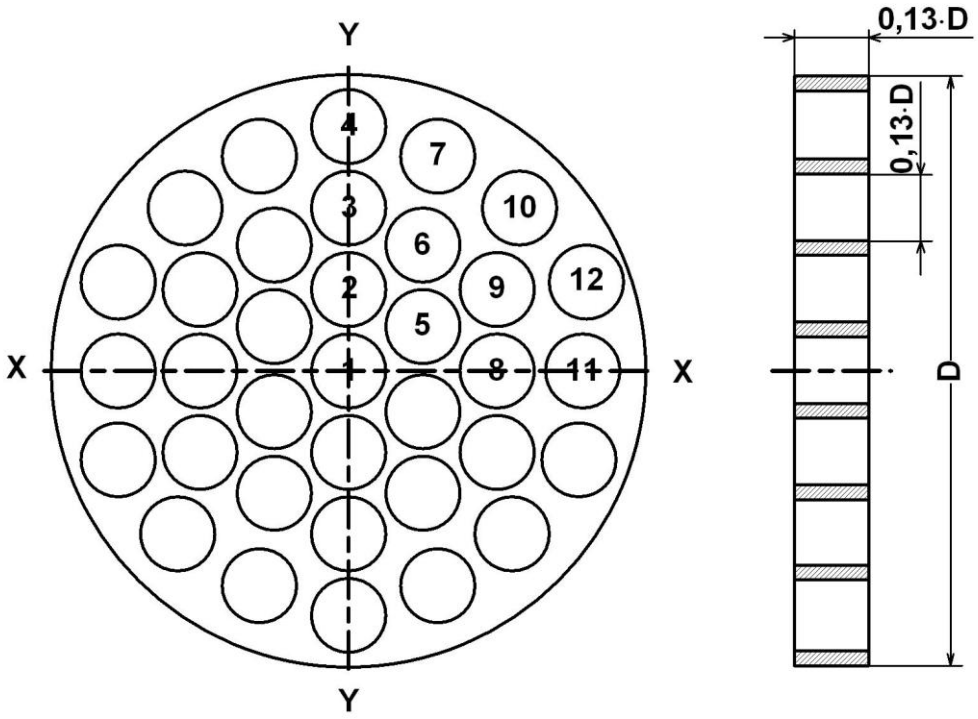
Cont. of Table D.1

1	2
 Control valve	30
 Control valve	3
 Not fully-open globe valve	10
 Pump	30
 Pump	3
 DN1 / DN > 0.1	10
 DN1 / DN > 0.1	3

In case of various types of hydraulic resistance in the pipeline, the length of a pipeline straight run related to the resistance nearest to the PEAs should be no less than the value specified in the table, and the distance from PEAs to other hydraulic resistances should be no less than the value specified in the table for hydraulic resistance of this type.

APPENDIX E. Straightening vane design

1. Fig.E.1 shows the design of type A straightening vane that is manufactured according to the following rules:
   a) Straightening vane plate thickness is equal to the diameter of the holes; depending on material, the plate can be made of one or several sheets
   b) All the diameters of the holes in the plate are equal
   c) Holes are spread more thickly in the center of the plate, and more rarely – at the periphery
   d) Holes have chamfers from the flow inlet site.



D – internal diameter of the pipeline where the straightening vane is inserted.

Fig.E.1. Design of type A flow straightening vane.

2. To lower weight and material quantity, a type B straightening vane (Fig. E.2) can be used; it is manufactured according to the following rules:
   a) Tubes are inserted in the plate holes
   b) Tube length is equal to tube diameter
   c) All the diameters of the holes in the plate are equal
   d) Holes are spread more thickly in the center of the plate, and more rarely – at the periphery
   e) Holes have chamfers from the flow inlet site.

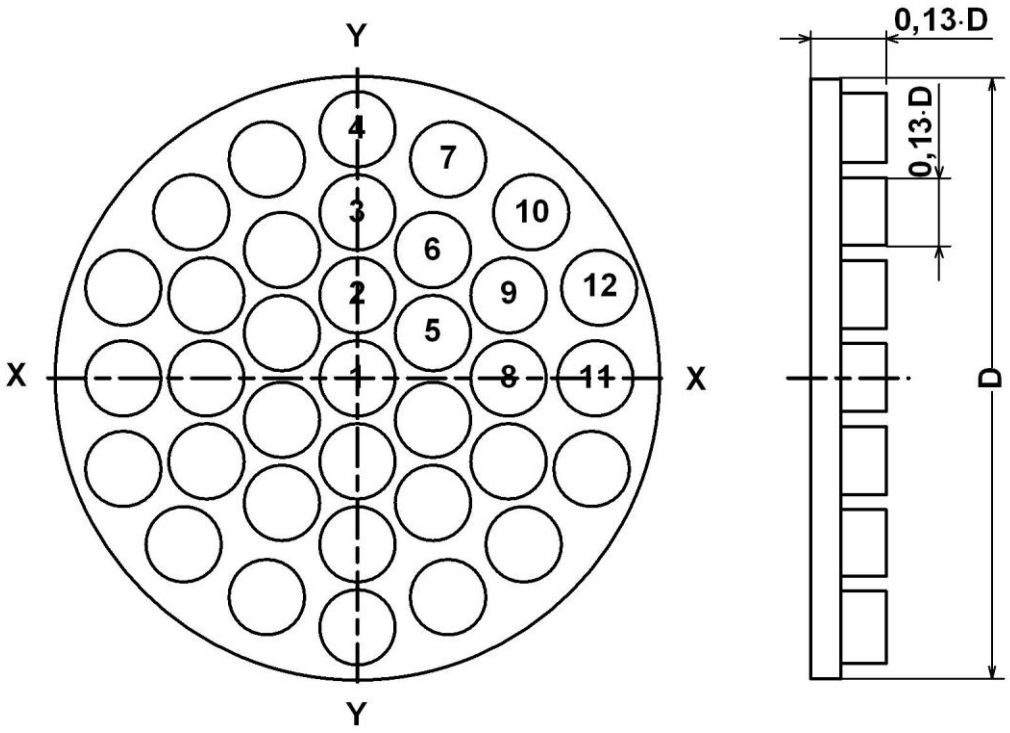


Fig.E.2. Design of type B flow straightening vane.

3. Hole marking in straightening vanes is shown in Table E.1.

Table E.1. Coordinates of the holes in straightening vanes of A and B type (D – pipeline internal diameter)

Item No.	X axis	Y axis
1	0	0
2	0	0.142·D
3	0	0.283·D
4	0	0.423·D
5	0.129·D	0.078·D
6	0.134·D	0.225·D
7	0.156·D	0.381·D
8	0.252·D	0
9	0.255·D	0.146·D
10	0.288·D	0.288·D
11	0.396·D	0
12	0.400·D	0.151·D

4. The straightening vane is installed in the pipeline at a distance of 1÷2 pipeline's DN from the last source of hydraulic resistance with respect to the flow direction. When installing the straightening vane, the length of a straight run before PEA is determined as the distance from the source of hydraulic resistance to PEA.