AFLOWT

BATTERY POWERED
ULTRASONIC FLOW METER

AFLOWT BUF M

VERSION
BUF-310

OPERATION MANUAL

ISO 9001:2015

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Manufacturer quality management system is certified to ISO 9001:2015

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URL: http://www.aflowt.com

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INTRODUCTION

This document covers battery powered ultrasonic flow meter "AFLOWT BUF M" of BUF-310 version and contains the information about its design, operation and installation.

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
SMC	- 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 Monitor BUF (310) program.

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Validation documents are available on website **www.awlowt.com**.

1. DESCRIPTION AND OPERATION

1.1. Application

1.1.1. AFLOWT BUF M battery powered ultrasonic flow meter of BUF-310 version is designed to measure average volumetric flow rate and volume of bidirectional flows of cold water.

The flow meters may be used as part of metering systems and complexes, in heat metering systems, automatic process control systems in power industry and municipal, etc.

1.1.2. AFLOWT BUF M battery powered ultrasonic flow meter of BUF-310 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 regarding flow direction
- Determining the current value of flow velocity and flow direction
- Output of measurement results to the frequency/pulse or logic output
- Output of measurement data on the indicator, as well as through the M-Bus interface or Wireless M-Bus interface
- Output of measuring, diagnostic, installation, archive and other information via RS-485 serial interface or NFC radio transponder according to ISO 15693
- Archiving of measurement results and setting parameters in energy-independent memory
- Possibility of entering setting parameters by means of software, considering individual features and characteristics of the measurement object
- Automatic control and indication of emergencies and failures, as well as recording of their type and duration in the archives
- Protection of the archival and adjusting data from unapproved access.

1.2 Specifications

1.2.1. Specifications of the flow meter AFLOWT BUF M of BUF-310 version are listed in Table 1.

Table 1

Parameter	Value	Notes
1. Nominal diameter of the pipeline, DN	80	
2. Minimal measured average volumetric flow rate Q_{min}, m^3/h	0.25	
3. Maximal measured average volumetric flow rate Q_{max}, m^3/h	90.0	
4. Sensitivity threshold, m^3/h	0.057	
5. Maximal pressure in the pipeline, MPa	1.6	
6. Properties of working fluid: - temperature, °C - density, kg/m3 - gas occlusion content, % of volume	 0 to 50 700 to 1200 no more than 5	
7. Power supply voltage, V	3.6	see clause 1.2.6
8. Mean time to failure, h	75000	
9. Mean life time, years	12	

1.2.2. The flow meter provides indication of the measured parameter values with the digit specified in clause 1.5.5.1 of this manual.

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

- Universal output in the form of frequency, pulse or logic signal
- logic output
- RS-485 and M-BUS interface
- Wireless M-Bus interface
- NFC interface.

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

- Hourly log – 1440 records (hourly records) – 60 days
- Daily log – 460 records (daily records)
- Monthly log – 48 records (monthly records)
- Mode log – up to 1000 record
- Operating mode log – up to 4000 records.

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

1.2.5. Environmental resistance:

- To climatic influences – the ambient temperature range is from 5 to 50 °C, relative humidity is not more than 80% at temperatures up to 35 °C, without moisture condensation
- To mechanical stress – vibration in the frequency range from 10 to 55 Hz with an amplitude of not more than 0.35 mm

- Atmospheric pressure ranges from 84.0 to 106.7 kPa.

The degree of protection of the flow meter corresponds to the IP67 or IP68. The required degree of protection of the device is determined when ordering.

1.2.6. The power supply of the flow meter is provided from an internal lithium C size battery with a nominal voltage of 3.6 V.

1.2.7. Appearance, overall dimensions and weight are given in Appendix A.

1.3. Metrological characteristics

1.3.1. The limits of permissible error in measuring the average volumetric flow rate, the volume of liquid in any direction of flow do not exceed the values given in table 2.

Table 2

Error formula	Relative error limit value
$\delta = \pm\left(0.95 + \frac{0.1}{v}\right)$	1.0 % at v > 2.00 m/s 1.5 % at v > 0.19 m/s 2.0 % at v > 0.10 m/s 3.0 % at v > 0.05 m/s 4.0 % at v > 0.033 m/s

where v – flow velocity, m/s.

1.3.2. The diagram of real measurement error of the flow meter is shown in Fig.1.

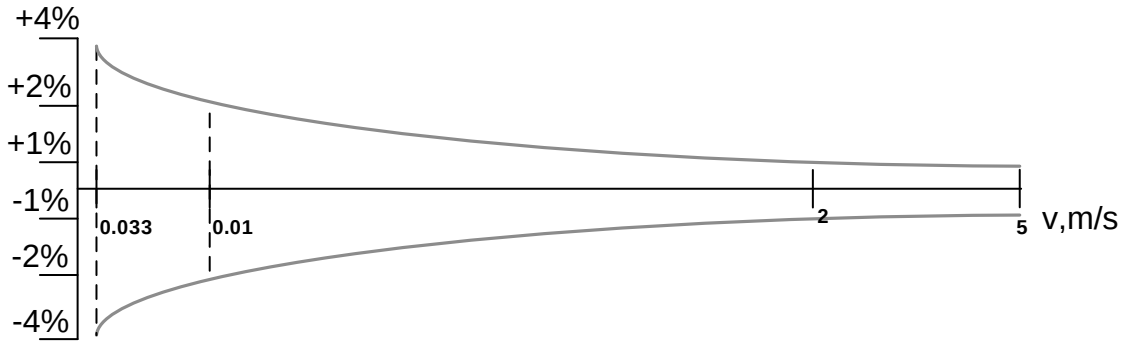


Fig.1. Diagram of real measurement error of the flow meter

1.4. Contents of the delivery package

Items of the delivery package are specified in Table 3.

Table 3

Item	Qty	Notes
1. Flow meter	1	Note 1
2. Installation kit	1	Note 2
3. Passport	1	
4. Operation manual	1	Note 3

NOTES:

1. The size and the protection rating of the flow meter, the types of interfaces are set on request.
2. The required items of the delivery package are specified in the order sheet.
3. Operating documentation and order sheets for this product and other products are available on: **www.aflowt.com**.
4. To connect the device with external devices via RS-485 interface, it is possible to supply a USB signal adapter – RS-232 / RS-485 on request.

1.5. Design and operation

1.5.1. Operation principle

1.5.1.1. 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.

1.5.1.2. The peculiarity of this type of ultrasonic flow meter is alternating supply of electrical probing pulses generated by the secondary converter (SMC) to the converters PEA1 and PEA2 (Fig.2).

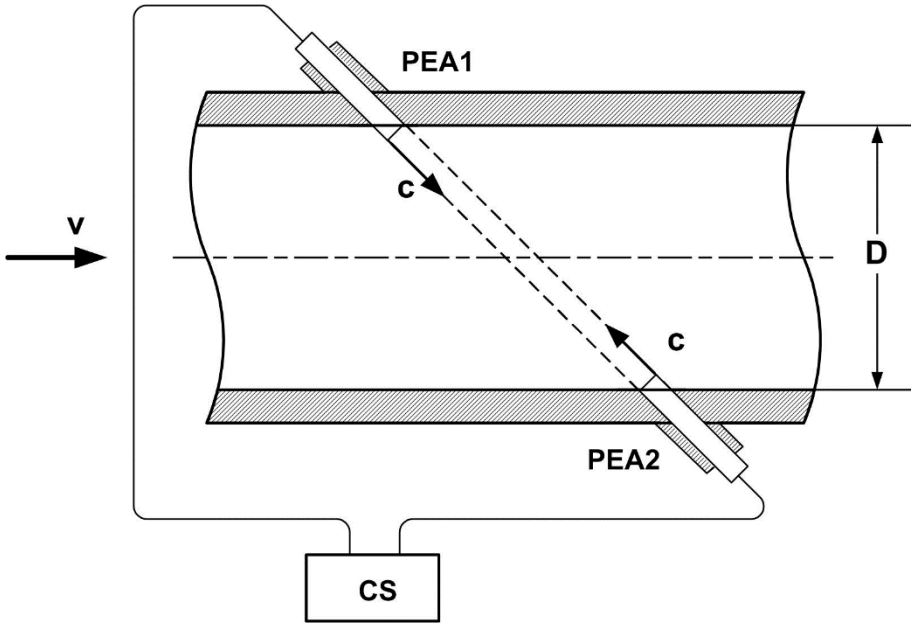


Fig.2. Diagram of the pipeline section with PEA installed

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**.

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

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

where Q_{min} – minimal value of the flow rate at which the measured flow rate value in the flow meter is set to zero, the volume accumulation and pulse output at the universal output stops.

The recommended value of low flow cutoff corresponds to the flow meter's sensitivity threshold.

If $Q > Q_{max}$ condition (where Q_{max} responds to the flow velocity value of 5 m/s) condition is fulfilled, flow measurement continues, but volume accumulation, archiving and pulse output at the universal output stops.

1.5.2. Design

The block diagram of flow meter AFLOWT BUF M of BUF-310 version is shown in Fig.3.

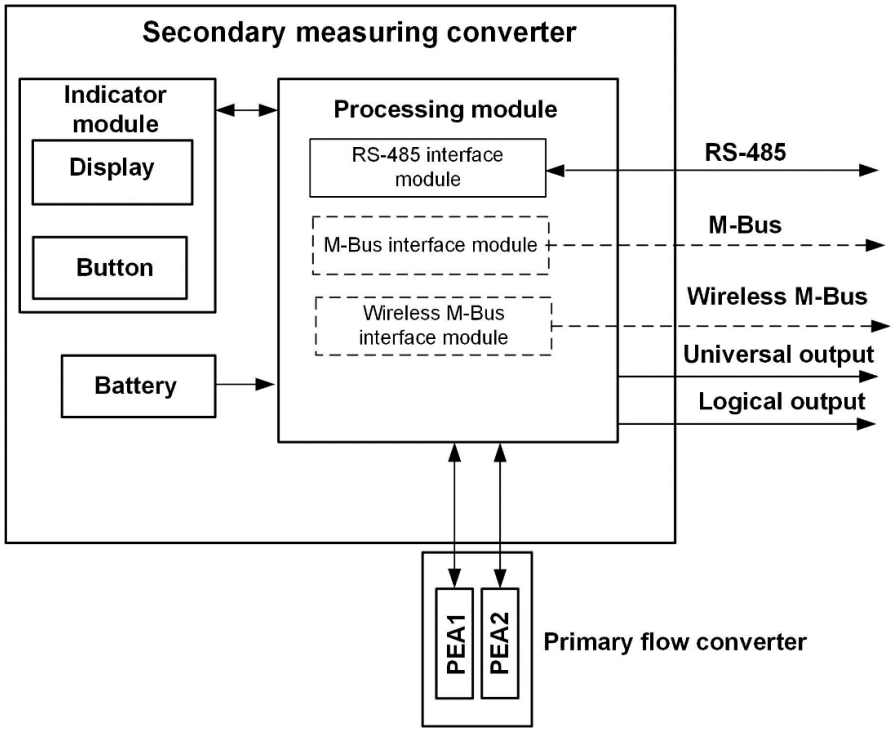


Fig.3. Block diagram of flow meter

The BUF-310 flow meter consists of a primary converter (CP) and a secondary converter.

The primary flow converter is a pipeline section (pipe section with pipe connections for PEA installation and flanges for pipe connection) with two PEAs installed on it (Fig.A.1 of Appendix A).

The PEA operates in two modes: radiation, when the electrical pulse signal from the secondary converter is converted into ultrasonic vibrations, and reception, when the ultrasonic vibrations of the liquid are converted into an appropriate electrical signal.

The secondary converter contains a processing module that acts as a meter and calculator as well as a display module. The processing module controls the electro-acoustic sounding, processes the measurement signals from the PEA and performs the secondary processing of the measurement information and ensures the storage of the measurement results.

External communications of the flow meter are provided by means of universal and logic outputs available on the processing module as well as optional RS-485 serial interface modules, M-Bus interface or Wireless M-Bus interface installed in the processing module.

The measuring information is displayed on a graphical liquid crystal display (LCD) located on the display module. LCD provides output of two lines of alphanumeric information at 16 characters per line. The information output is controlled by means of an optical button located on the front panel next to the LCD.

Before commissioning, the flow meter is set up using a personal computer (PC) via RS-485 interface.

1.5.3. Access levels

1.5.3.1. The flow meter has three levels of access to setting and calibration parameters.

The access levels differ in the information displayed, possibilities to change the setting and calibration parameters of the flow meter and are referred to as WORK, SERVICE and ADJUSTMENT modes.

Mode applications:

- ADJUSTMENT – adjustment and verification mode;
- SERVICE – preparation for operation mode;
- WORK – operation mode (user mode).

Modes differ in the level of access to information and possibilities to change the settings of the flow meter via RS-485 interface.

Maximum rights are granted in ADJUSTMENT mode. The mode allows the user to view all parameters and to modify all configuration settings. Minimum rights are given in WORK mode.

The set of parameters displayed does not depend on the set operation mode.

1.5.3.2. The operation mode is defined by a combination of the presence/absence of a short-circuit using the contact pair jumpers J1 and J2 located on the processing module (see Fig.A.3 of Appendix A).

Correspondence of combinations to operation modes is resulted in table 4, where "+" is presence of contact pair closing, and "-" is absence of closing.

Table 4

Operation mode	Contact pair		Mode application
	J1	J2	
WORK	-	-	Operation
SERVICE	-	+	Preparation for operation
ADJUSTMENT	+	-	Adjustment

1.5.3.3. WORK mode is a flow meter operation mode on the site.

WORK mode allows the user to view the data.

1. With the indicator: current date and time, values of measured parameters (volume flow rate, volumes accumulated during forward and reverse flow direction, as well as their algebraic sum), status line of emergencies and software version number.
2. With RS-485, M-Bus or Wireless M-Bus interfaces:

a) Values of measured parameters: volume flow rate, volumes accumulated in the forward and reverse flow direction, as well as their algebraic sum, fluid velocity, and current velocity of USS

3. With RS-485 interface:

a) The contents of the archives and event log

b) Configuration parameters: current date and time, characteristics of universal and logic outputs

c) Operation parameters:

- Signal processing characteristics (median averaging, arithmetic averaging, etc.)
- Communication parameters via RS-485 interface
- Types of emergency situations.

The WORK mode allows the user to change communication parameters via RS-485 interface (network address of the device, exchange rate from 1200 to 4800 baud).

1.5.3.4. SERVICE mode is a mode of preparation of the flow meter for operation on the site.

SERVICE mode additionally (in relation to WORK mode) allows via RS-485 serial interface to:

a) View:

- The configuration of the pipeline section (base, axial base, nominal diameter)
- Setting parameters for the ultrasonic signal
- Zero offset value and additional USS delay

b) Change:

- Operation modes and parameters of the universal and logic outputs
- Flow and volume measurement units (m^3/h; l/min, m^3, l)
- Device clock readings
- Device clock transition mode to "winter"/"summer" time

c) Adjust LCD contrast, operating time and measurement information update period

d) Start the calculation of conversion factor or pulse weight for the universal output

e) Zero accumulated volumes and archives.

1.5.3.5. ADJUSTMENT mode allows to view and modify all parameters without exception.

Also, ADJUSTMENT mode allows to record the factory number of the device via RS-485 serial interface.

1.5.4. Recording of operation results

1.5.4.1. The results of measurements and calculations are recorded in the internal archives: hourly, daily, monthly, with the depth of the archives, given in clause 1.2.4. Access to the archives is carried out through the RS-485, M-Bus or Wireless M-Bus interfaces and NFC radio transponder.

Hourly, daily and monthly archives are cyclical and have the same structure.

The values of the following parameters are recorded in each record:

- **V+** – total volume in the direct flow direction over the archiving interval, m^3 (l)
- **V-** – total volume in the reverse flow direction over the archiving interval, m^3 (l)
- **ER** – error code
- **ER time** – total time, during which there was no accumulation of volumes in the archive

- **Worktime** – operating time for the archiving interval.

1.5.4.2. Changes in the operating mode of the device are recorded in the mode log, which can contain up to 1000 records.

Each mode log entry records:

- Sequence number of the record
- Name of the set operating mode of the device
- Date and time of mode setting.

1.5.5. Information output

1.5.5.1. Liquid crystal indicator

The list of parameters, which are displayed on the flow meter's indicator, is shown in Table 5.

Table 5

Designation	Parameter	Measurement units (format)	Number of display symbols	
			integral part	fractional part
Time	Current time	**= XX:XX**		
Data	Current date	**XX.XX.XX**		
Q	Current volume flow rate regarding flow direction	**m^3/h, l/min**	up to 4	4
V+	Direct flow volume (cumulative total)	**m^3, l**	up to 9	4
V-	Reverse flow volume (cumulative total)	**m^3, l**	up to 9	4
ΣV	Total volume (cumulative total)	**m^3, l**	up to 9	4
Err	Status bar	**– – – – – –**		
Tw	Total operating time	**XXX:XX h:m**	3	2
Tner	Fault-free operation time	**XXX:XX h:m**	3	2
K1	Calibration factors	**X.XXXXXX**	1	6
P1		**-X.XXXXXX**		
K2		**X.XXXXXX**		
P2		**-X.XXXXXX**		
Soft	Software version number	**XX.XX.XX.XX**		
CRC	Software checksum	**0xA8D9**		

NOTES:

1. The flow rate in the reverse flow direction as well as the negative values of the total volume and the volume of the reverse flow are indicated with a minus.
2. The total volume is defined as the sum of the volumes accumulated in the forward (positive) and reverse (negative) flow direction, considering the sign of the flow direction.
3. An overflow of counters occurs if **V** $> 2\times10^9$ m^3. After the counter is full, the display continues from zero.

In the SERVICE and ADJUSTMENT modes, the indicator is always on. In the WORK mode, the indication is switched on by pressing the button and is switched off after the last pressing it in the interval set in the **Worktime** field in the **Service** tab of the Monitor BUF (310) application.

Switching the indication of the parameters given in Table 5 is performed on the ring by sequential pressing the button located on the front panel of the device.

NOTE. Using the optical button in the flow meters has the following features:

- The button works "slowly", i.e. its touching should last more than 1 s
- The button is triggered when the finger is taken off.

1.5.5.2. RS-485 interface

RS-485 serial interface allows to read out measuring, archival, installation and diagnostic information, to modify setting parameters. RS-485 interface supports ModBus protocol (RTU ModBus and ASCII ModBus)

RS-485 interface provides cable communication in a group of several subscribers, one of which can be a PC, with a communication line length of up to 25 m.

At the time of release from production the network address is recorded in the flow meter – 1. Using switches SK1 and SK2 on the interface module (see Fig.A.3), you can change the network address of the device according to Table 6.

Table 6

Switch position		Network address
SK1	SK2	
1	2	2
2	1	3
1	1	4

When both switches are set to position 2 on the interface, you can set any network address of the device (from 1 to 255).

The RS-485 baud rate and other communication parameters are set programmatically.

1.5.5.3. M-Bus interface

The M-Bus interface complies with EN 13757. The interface allows the readout of measured data, such as: current flow rate, accumulated direct, reverse and total volumes, operating time, as well as the presence of emergencies under the numbers 1 ... 3 (see Table 7).

By default, the flow meter has a network address of 1 and an exchange rate of 2400 baud. The interface is connected via two wires, the polarity of the connection is not important. The M-Bus interface baud rate is set programmatically.

WARNING: Power supply of the flow meter and M-Bus modem from one power source is prohibited.

1.5.5.4. Wireless M-Bus interface

The Wireless M-Bus interface complies with EN 13757-4. The interface allows the transmission of measured and archived data to a receiver (WM-Bus dongle interface box, hub, etc.).

T1 mode is implemented in the protocol: the flow meter works only for transmission without requests from the data acquisition device. The transmission period is 16 seconds and the carrier frequency is 868 MHz.

Each parcel transmits a Wireless M-Bus identifier, which includes the serial number of the flow meter, which determines which metering device (from which consumer/subscriber) received the data.

1.5.5.5. Universal output

The flow meter has a non-isolated universal output that can operate in frequency, pulse and logic modes.

The functions of the universal output, operating modes, output parameters and output disconnection are defined by the software settings.

The diagram of the output terminal stage and the description of its operation are given in Appendix B.

◆ In the frequency mode, a pulse sequence of meander type with a duty cycle of 2 is given to the open output, the frequency of which is proportional to the current value of the flow rate. It is possible to scale the frequency output operation by software setting the **Maximum output frequency** or **Output conversion factor**, as well as the lower and upper flow limit values of **Lower limit by flowrate** and **Upper limit by flowrate**, corresponding to the sequence frequency of 0 Hz and the maximum frequency, respectively. The maximum possible value of **Maximum output frequency** is 1000 Hz in ADJUSTMENT mode and 10 Hz in WORK and SERVICE modes.

Error frequency is pulse sequence frequency (not more than 10 Hz), which will be formed at the output if the measured value of the flow rate exceeds the value of Q_{max} for this DN flow meter. The target value of **Error frequency** must be at least equal to the target value of **Maximum output frequency**. To disable the alarm frequency output function, set **Error frequency** to 0 Hz.

◆ In pulsed operation mode, a pulse burst is given to the open output every second, the number of which, considering **Pulse weigt**, corresponds to the volume value measured in the previous second. The maximum possible pulse repetition rate in the burst (of meander type with a duty cycle of 2) is 1000 Hz in ADJUSTMENT mode and 10 Hz in WORK and SERVICE modes.

◆ For correct operation of the flow meter's universal output there is a procedure of automatic calculation of **KP** parameter (pulse/m^3) in frequency mode and **Pulse weigt parameter** (m^3/pulse) in pulse mode.

KP parameter is calculated based on user-defined values of **Q lower limit**, **Q upper limit** and **Fmax**, **Pulse weigt** parameter is calculated on the basis of defined values of **Q upper limit** and **Pulse width** in the range:

- From 1 to 1000 ms – in ADJUSTMENT mode
- From 100 to 1000 ms – in WORK and SERVICE mode.

◆ In the logic mode, the presence of an event (or its certain condition) at the output corresponds to one level of electrical signal at the output, and the absence of an event (or its other condition) – to another level of signal.

The active signal level (**Active level**), i.e. the level of the signal corresponding to the presence of an impulse (event), is set by setting the **High** or **Low** value in any operation mode. The electrical parameters of the signal levels are given in Appendix B.

When released from production, the typical values of universal output parameters are set: pulse type, passive mode, pulse weight – 0.0025 m^3/pulse.

1.5.5.6. Logic output

The flow meter has a non-isolated logic output. Operation modes, parameters and electrical characteristics of the logic output are similar to those of the operation modes, parameters and electrical characteristics of the universal output in the logic mode.

1.6. Flow meter design

1.6.1. The primary flow converter and the secondary measuring converter form a single design of the flow meter (see Fig.A.1 of Appendix A).

The pipeline section (PS) of the primary converter is made of high-strength plastic PA66-GF30. The ends of the PS are fitted with pipe flanges for connection to the counter flanges.

1.6.2. The plunge PEA used in the flow meter is cylindrical, the end of the PEA has a radiating plane in the form of a disk. The converters are installed in the pipeline section in such a way that the radiating PEA plane is in contact with the liquid to be monitored. The PEAs supplied with CP are designed for pressures up to 1.6 MPa.

1.6.3. PEA and the secondary converter are connected by communication cables hidden inside the enclosure.

1.6.4. The secondary converter is mounted directly on the flow meter's pipeline section. The processing module board is placed in the secondary converter enclosure, and the indication module board with indicator – in the front panel. The modules are connected to each other by a signal loop.

1.6.5. After installation of the interface cable and the universal output, the secondary flow meter converter with IP68 protection is completely filled with Hensel GH 0350 type compound. The design of the device is not disassembled.

1.6.6. The appearance of the flow meter may differ from that given in Appendix A without changing its operational and metrological characteristics.

1.7. Marking and sealing

1.7.1. The marking on the front panel of the SMC contains the designation and name of the flow meter, the manufacturer's trademark and the approval mark of the measuring device type. In addition, the maximum temperature of the liquid to be measured, the supply voltage and the size (DN) of the flow meter are marked on the individual labels.

The factory numbers of the PEA and pipeline section are indicated on their enclosures.

1.7.2. After verification of the flow meter the contact pair of the permission to modify the calibration parameters is sealed. Also, the screws of fixing the protective cover of the processing module are sealed with the manufacturer's seal.

1.7.3. The contact pair of the permission to modify the service parameters can be sealed after the commissioning.

In addition, the cover of the secondary converter can be sealed with two hinged seals to prevent unauthorized access during transport, storage or operation.

2. INTENDED USE

2.1. Operational restrictions

2.1.1. The flow meter should be operated under the conditions of influencing factors and parameters of the controlled medium, which do not exceed the permissible values specified in the operating documentation.

2.1.2. The flow meter can be installed in vertical, horizontal or inclined piping.

2.1.3. Precise and reliable operation of the flow meter is ensured if the following conditions are met at the CP installation site:

- Fluid pressure in the pipeline and its operation modes exclude gas formation and/or accumulation of gas (air)
- The internal volume of PS must be filled with liquid during operation
- Sections of the pipeline up to the flow meter should not contain devices or structural elements that cause changes in the structure of the fluid flow.

2.1.4. Type and composition of the controlled liquid (presence and concentration of suspended solids, foreign liquids, etc.), operation mode and condition of the pipeline should not lead to corrosion and/or deposits that affect the performance and metrological characteristics of the flow meter.

2.1.5. Flow meter should be installed on the site in accordance with the section "Installation of the flow meter" of this manual.

2.1.6. Lightning protection of the device site protects the device from failure in the presence of lightning discharges.

2.1.7. The requirements for the operating conditions and the selection of the installation site given in these operating instructions take into account the most typical factors affecting the operation of the flow meter.

Factors that cannot be predicted, evaluated or checked and which the manufacturer could not consider in the development of the flow meter may exist or occur during its operation.

If such factors occur, they must be eliminated or a different place of operation must be found where these factors do not exist or do not affect the operation of the product.

2.2. Safety measures

2.2.1. The flow meter can be operated by the personnel who have studied the documentation for the product.

2.2.2. When operating the flow meter, dangerous factors are:

- Pressure in the pipeline (up to 1.6 MPa)
- Other dangerous factors related to the nature and characteristics of the facility where the flow meter is operated.

2.2.3. If external damage to the device or communication cables is detected, disconnect the device until a specialist determines that it can be used again.

2.2.4. During installation, commissioning or repair of the flow meter is prohibited to:

- Make connections to the flow meter, switching operation modes when the power supply is on
- Dismantle the flow meter on the pipeline until the pressure is completely relieved in the section of the pipeline where the work is performed
- Use electrical devices and power tools without connecting their enclosures to the protective grounding line, as well as to use the listed devices in a faulty condition.

3. INSTALLATION OF THE FLOW METER

3.1. Transportation

The flow meter must be transported to the installation site in its original packaging.

After transportation to the place of installation at a negative temperature and introduction into the room with a positive temperature, the flow meter should be kept in the package at least 3 hours to avoid moisture condensation.

When unpacking the flow meter, check its completeness in accordance with the passport for this device.

3.2. Installation requirements for the flow meter

3.2.1. To install the device on the site it is necessary to have a free section in the pipeline for installation of the flow meter.

The following conditions must be met at the CP installation site:

- Liquid pressure and pipeline operation modes exclude gas formation and/or accumulation of gas (air)
- The internal volume of the CP must be filled with liquid during operation;
- there are no or minimum pulsations and swirls of liquid.

CP may be installed in horizontal, vertical or inclined piping (Fig.4). The CP (PEA) must not be located at the highest point of the pipe section. The most suitable place for installation, if any, is the upstream or downstream section of the pipeline.

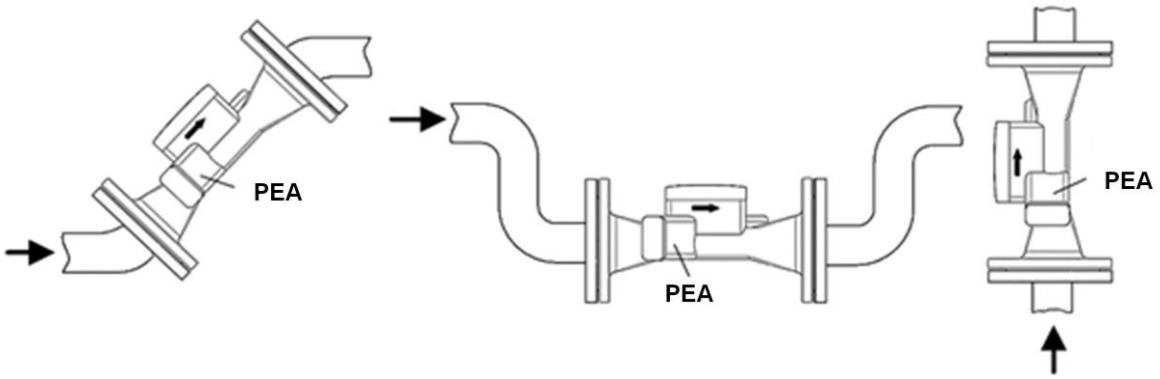


Fig.4. Recommended installation locations for the CP of flow meter

NOTE. If it is not possible to install the flow meter in the recommended places, it is possible to install the device at the top of the pipeline. It is necessary to install an air valve (air vent) at a point above the upper point of the flow meter, for example, in the expansion of the pipeline.

WARNING: Ensure that the air valve is in good working order. Correct operation of the flow meter is possible only when there is no air in the duct.

3.2.2. The difference between the inner diameters of the pipeline and the CP pipeline section at the jointing points must not exceed 0.05·DN.

3.2.3. When installing the CP on a pipeline, it is recommended that the longitudinal plane of PEA (the plane passing through a pair of PEA along the

pipe axis) be positioned at an angle of β = 45°-90° to the vertical plane (Fig.5).

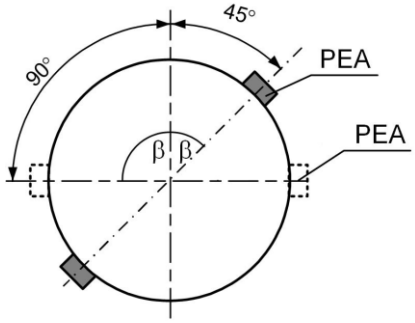


Fig.5. Recommended PEA positions when installing the flow meter

3.3. Requirements for the length of straight sections

3.3.1. If there are hydraulic resistances at the installation site, normal operation of the flow meter is provided by straight sections of the pipeline before the first and after the last one PEA in the stream. The minimum values of the relative length of straight sections for different types of hydraulic resistances are given in Table D.1 of Appendix D.

The length of the straight section L (mm) is determined by the formula:

$$L = N \cdot DN,$$

where N is the relative length expressed by the number of DNs and shown in Table D.1;

DN – nominal diameter of CP, mm.

WARNING: When measuring the reverse flow rate, all PEAs are the first in the flow and the lengths of the straight sections must be determined from this position.

3.3.2. When installed in the pipeline in front of the primary flow straightener converter (Appendix D), the straight input length of the CP can be reduced by up to two times.

3.4. Installation on the pipeline

3.4.1. Before starting work on the pipeline in the place of installation of the flow meter, fix pipe sections that may deviate from the coaxial position after cutting the pipeline with clamps to the fixed supports.

WARNING: Before installing the flow meter it is necessary to drain the liquid and cover the section of the pipeline, where the installation works will be carried out.

3.4.2. A section of the required length is cut out at the selected point of the liquid-free pipeline, and counter flanges of the appropriate diameter are welded to the pipe ends. Ensure the alignment and parallelism of the flanges, between which the CP of flow meter is installed.

3.4.3. The flow meter should be installed in the pipeline, and the direction of the arrow on the CP should coincide with the flow direction or the forward direction for reverse flow. The joints between the flanges are sealed with gaskets and the flanges are bolted together.

WARNING: Do not drop or hit the flow meter during installation. It may result in damage to the installed PEA or SMC.

NEVER remove the PEA from the mounting nozzles.

3.5. Electrical installation of the flow meter

3.5.1. The communication cable of the flow meter is connected to the SMC in the manufacturer. A round cable with an outer diameter from 3.0 to 6.5 mm is used as a communication cable.

3.5.2. External communication cable (SMCs are external devices) must be routed according to the operating conditions of the flow meter.

3.5.3. It is not recommended that the excess part of the cable be wound up with rings.

3.5.4. The external cable is attached to the wall as far as possible. It is recommended to place the cable in a metal or plastic pipe (hose) to protect it from mechanical damage.

DO NOT route the signal cable near power circuits or in the presence of high level electromagnetic interference (e.g. in the presence of a thyristor regulator) without laying it in an earthed steel pipe or metal hose.

WARNING: To ensure the declared degree of protection of the flow meter during installation, the following requirements must be met:

- The seal on the back of the SMC front panel must be clean and undamaged
- Before installing the front panel on the SMC enclosure, check that the seal is evenly positioned in the ring groove provided for it without tension or protrusions, and that it does not fall out when the front panel is turned upside down. Silicone sealant can be used to fix the sealant
- The SMC front panel should be tightened securely with screws after installation
- The cable gland packing nut must be tightened securely.

It is necessary for the signal cable to form a downward U-shaped loop in the vertical plane (Fig.6) to prevent dripping water or condensate from entering the SMC through the cable entry.

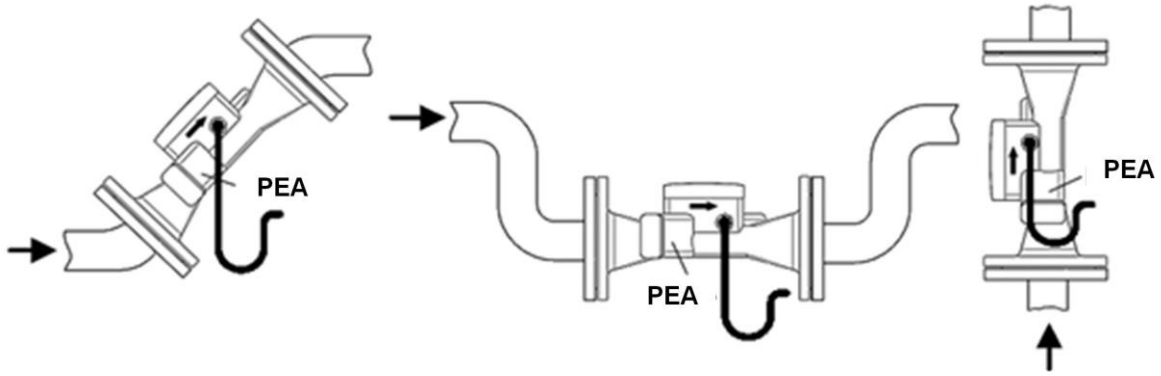


Fig.6. Formation of a U-shaped loop of the signal cable

WARNING: The manufacturer **SHALL NOT BE LIABLE UNDER WARRANTY** for failure to meet the requirements for the declared degree of protection and for leaks through the cable gland.

3.6. Dismantling the flow meter

When dismantling the flow meter:

- Shut off the liquid supply, make sure that there is no pressure in the pipe-line and drain the liquid
- Disconnect the communication cable suitable for the SMC
- Remove the flow meter.

4. OPERATION

4.1. Setting up before operation

4.1.1. The flow meter can be configured and read in the WORK and SERVICE modes via the serial interface using the Monitor BUF (310) service application included in the UBViewer ModBus program. The installation file can be downloaded from the delivery set.

The UBViewer ModBus program works under Windows XP operating systems (Vista, Windows 7, Windows 8, Windows 10). For the installation of the program on the PC, open the installation file and follow the instructions appearing on the monitor.

4.1.2. Before starting the operation, cable the flow meter RS-output and the computer serial port (via RS-232/RS-485 signal adapter) or the computer USB port (via USB-RS-232/RS-485 signal adapter).

Set the flow meter to SERVICE mode by setting a jumper on the corresponding contact pair. Start the "UBViewerProjects" file on the computer from the folder where it was loaded during installation. The UBViewer ModBus menu bar appears on the monitor. Open the "AFLOWT BUF M (310).vpr" file, and the **Monitor BUF (310)** application window will be displayed (Fig.7).

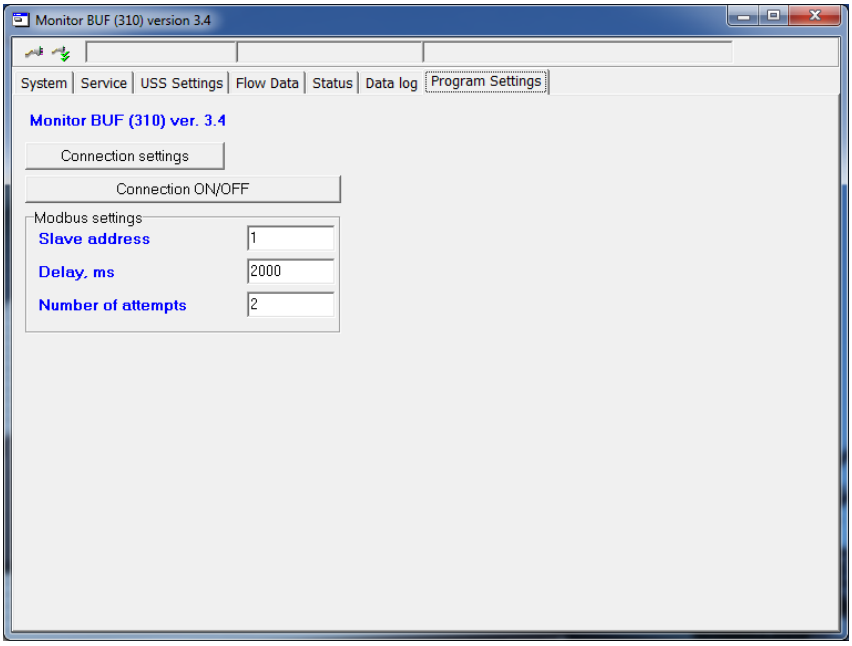


Fig.7. View of the Monitor BUF (310) application window

The **Monitor BUF (310)** application window interface consists of seven tabs divided by function. The contents of the tabs depend on the operating mode of the device. The operating mode is automatically determined when a PC communicates with the flow meter.

To set up the connection parameters, press **Connection settings** button on the **Programm Settings** tab or press the  (Edit parameters of connection with the device) button in the upper left corner of the application window (Fig. 7).

Set the following in the appeared **Data link setting** window (Fig.8):

- The number of the PC COM port to which the signal adapter is connected
- Baud rate (4800 bps).

Other setting parameters are loaded automatically.

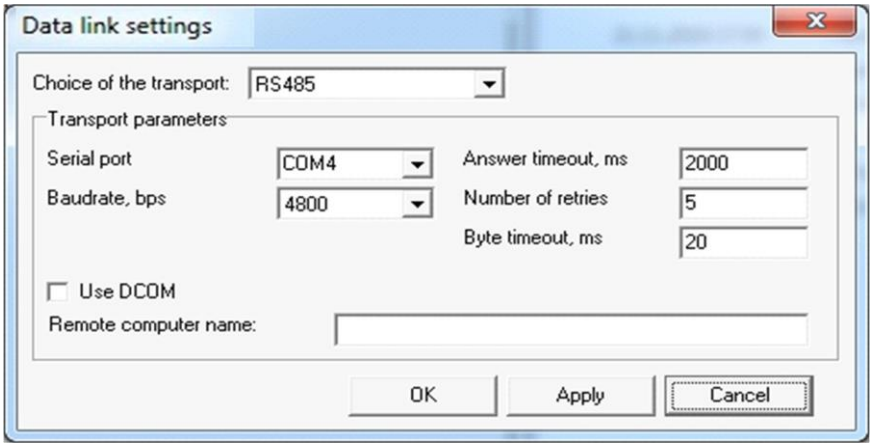


Fig.8. View of the Data link setting window

To set up communication with the flow meter, press the button in the upper left corner of the application window (Fig.7). If the operation is successfully completed, the line to the right of the button should contain the following messages: "**The data link is open**" and "**The command is executed successfully**". The button will change the view to (Close communication channel). Click the **System** button in the command line, the **System** tab will appear in the application window (Fig.9).

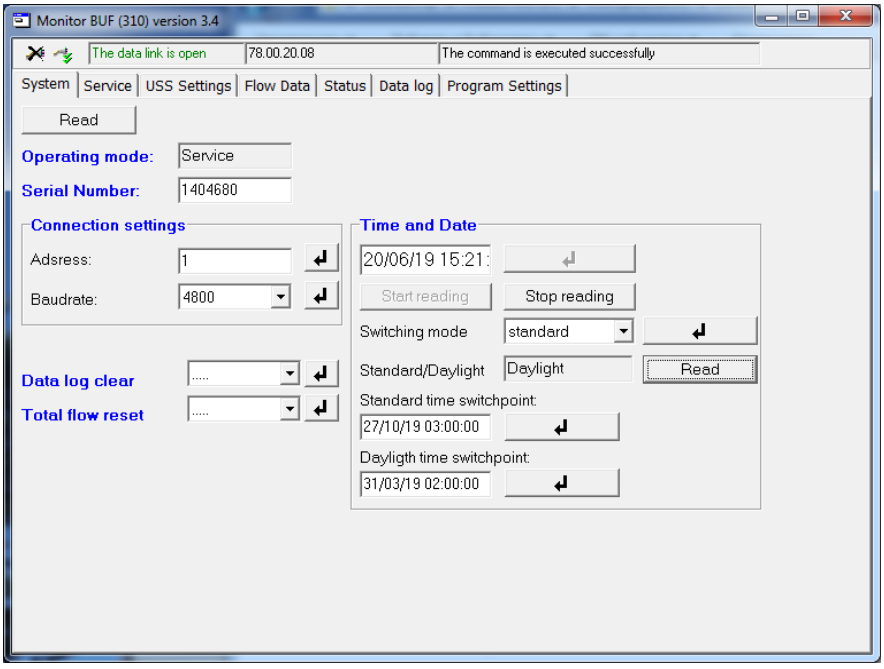


Fig.9. View of the System tab after the PC has been connected to the flow meter

You can adjust the device time, set up communication parameters via the interface, reset archives and volumes, and set the mode of transition to "winter"/"summer" time on the **System** tab.

4.1.3. You can set the USS processing parameters, set the LCD contrast value and operating time and select the measured flow rate dimension on the **Service** tab (Fig.10).

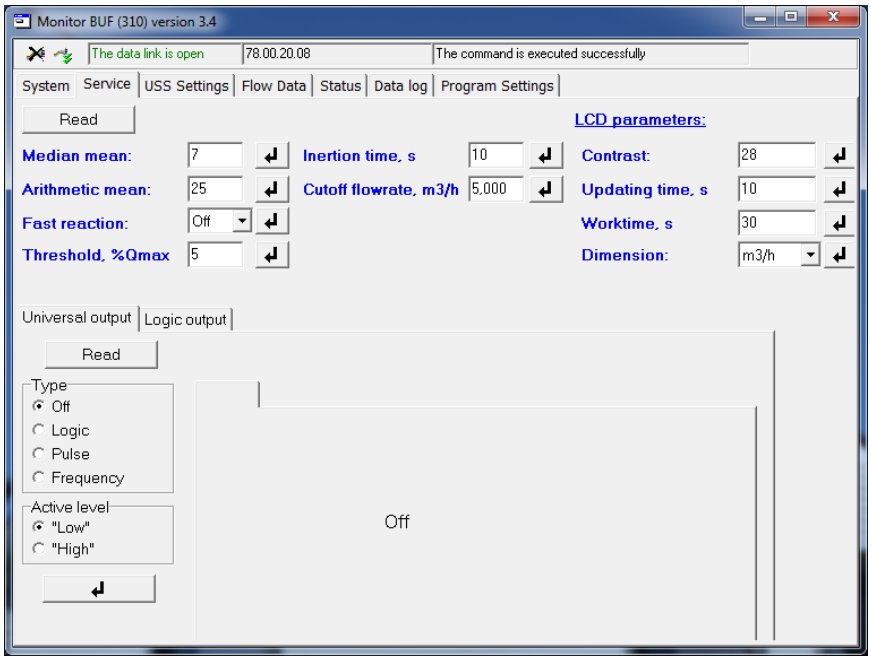
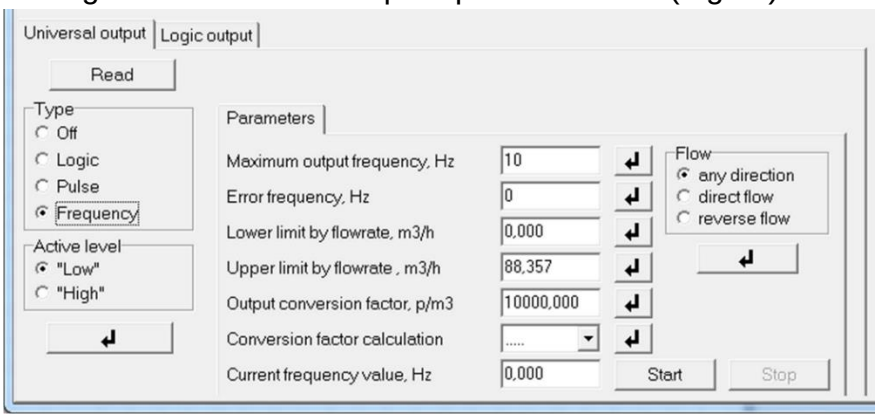


Fig.10. View of the Service tab

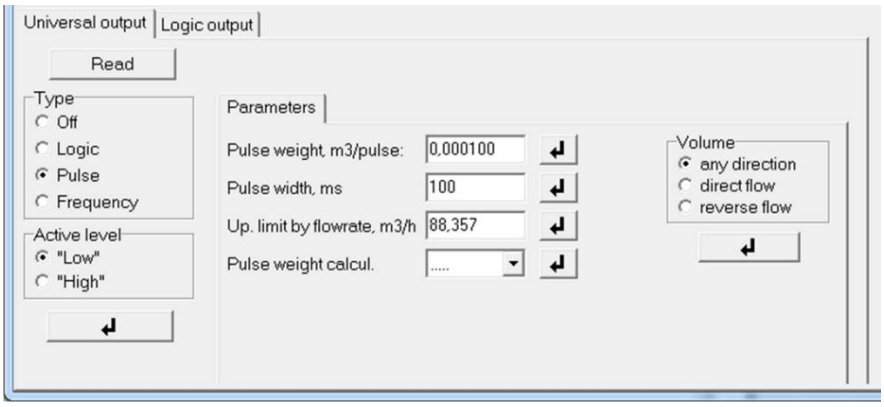
To change the current value of the parameter, type a numeric value in the corresponding field or set a symbolic value from the drop-down list and press the ↵ button.

You can also set the parameters of the universal and logic outputs in the **Service** tab.

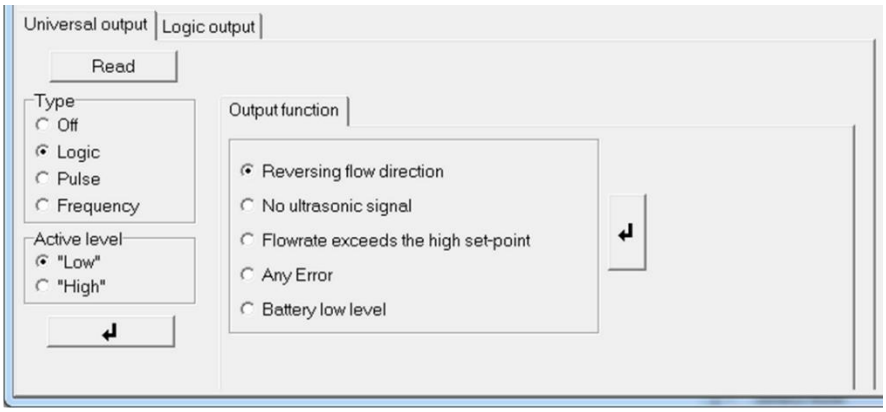
To switch to the setting parameters of universal output operation, set the checkbox ◉ in the additional tab **Universal output** in the line containing the name of the output operation mode (Fig.11).



a) Frequency mode



b) Pulse mode



c) Logic mode

Fig. 11. Configuration parameters for different universal output modes

Configuration parameters of the logic output operation are contained in the additional tab **Logic output**, which has the same appearance as shown in Fig.11.c.

4.1.4. The information contained in the **USS Settings** tab is displayed only in the SERVICE and ADJUSTMENT operating modes and is only available for editing in the ADJUSTMENT mode. In WORK mode, the tab is not available for viewing.

4.1.5. You can view the current values of the measured parameters on the **Flow Data** tab (Fig.12) after pressing the **Start reading** button.

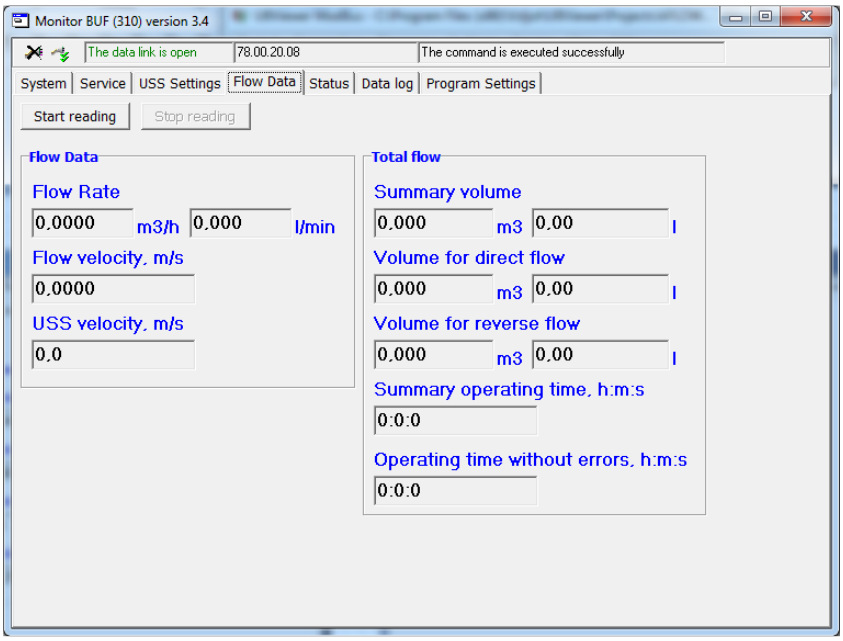


Fig.12. View of the Flow Data tab

4.1.5. The current state of the flow meter (presence/absence of emergencies) is displayed on the **Status** tab after pressing the **Start reading** button (Fig.13).

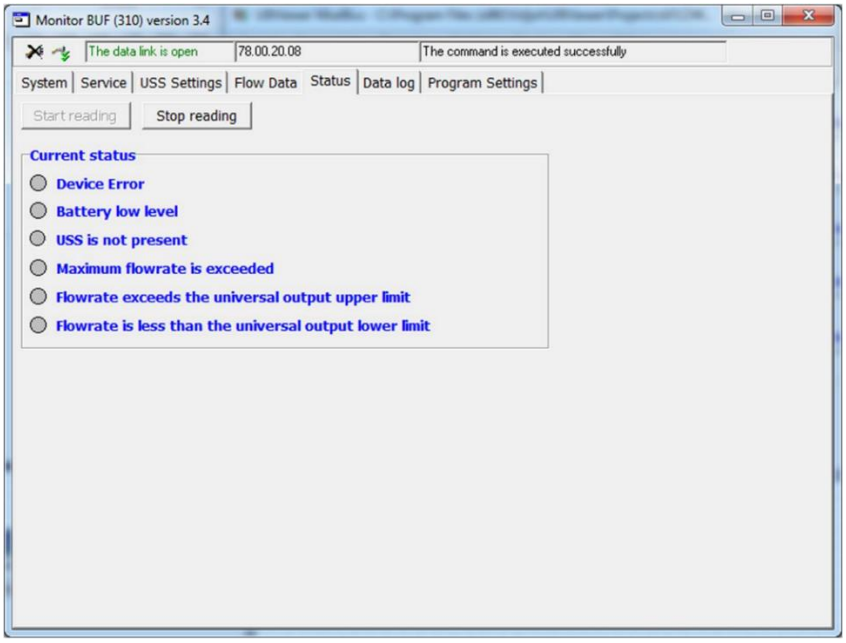


Fig.13. View of the Status tab

4.1.6. To read the archive data, go to the **Data log** tab (Fig.14), select the type of archive (hourly, daily or monthly), set the required interval in the **Date from** and **Time from** fields and press the **Read** button.

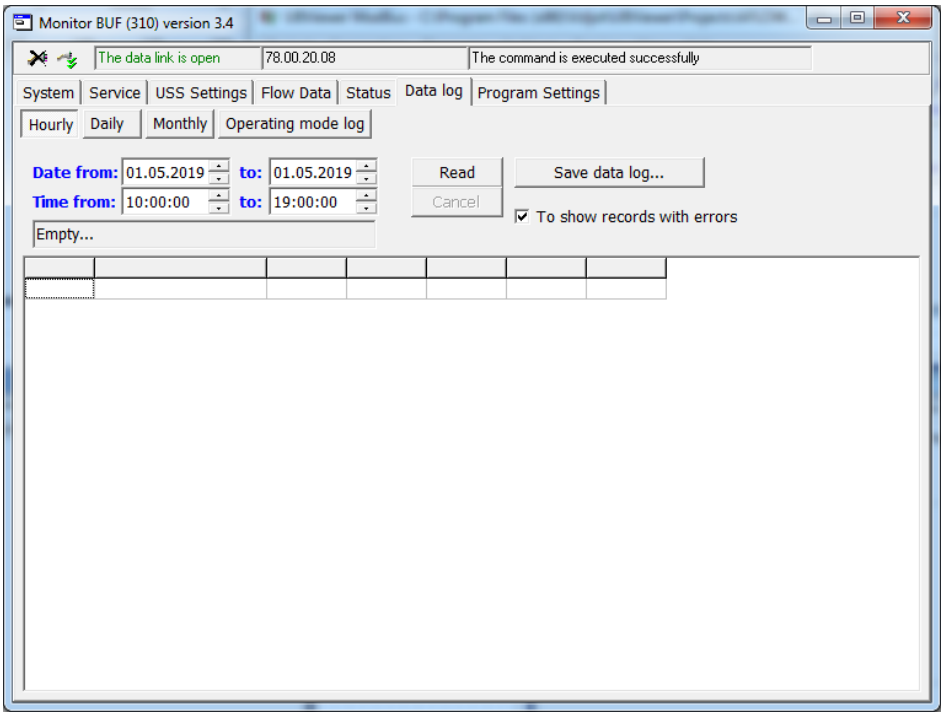


Fig.14. View of the Data log tab

4.1.7. Once the flow meter has been set up:

- close the device communication channel with PC by pressing the  in the upper left corner of the Monitor BUF (310) application window;
- close the Monitor BUF (310) application window;
- set the device to WORK mode: remove the jumper from the contact pair for allowing the modification of service parameters. Seal the contact pair.

4.2. Pre-commissioning

4.2.1. Pre-commissioning shall be performed by representatives of the organization having the right to perform such works or by representatives of the manufacturer.

4.2.2. After the installation of the flow meter, the pipeline is filled with the measured liquid. The flow meter's battery is connected, the flow meter is connected to the computer and adjusted in accordance with the instructions in section 4.1 of this manual.

4.2.3. The flow meter is ready for operation on initial start-up or after a long interruption in operation after:

- A 30-minute flushing of the CP with fluid stream
- A 30-minute warm-up of the flow meter.

4.2.4. When commissioning the flow meter, check:

- The correct connection of the flow meter and the interacting equipment according to the selected connection diagram
- The correctness of the set operating modes of the flow meter's universal and logic outputs.

After commissioning, the SMC enclosure can be sealed to protect against unauthorized access during operation.

4.3. Operating procedure

The flow meter, which has been put into operation, operates continuously in automatic mode. Current values of measured parameters can be read from the flow meter LCD or via RS-485, M-Bus, Wireless M-Bus or NFC interfaces.

5. READING DATA WITH A SMARTPHONE

5.1. Hardware requirements

The ultrasonic flow meter of URSV-310 version provides the possibility of connecting a smartphone based on Android OS of version 4.4 and higher with the support of NFC-V (ISO 15693).

For a list of NFC-enabled phones, see: https://devices.nfc.help/

Communication between the flow meter and smartphone is provided via the AFLOWT BUF monitor application.

5.2. Installing the AFLOWT BUF monitor application

The installation file for the AFLOWT BUF monitor application (apk.) is downloaded from vzljot.ru.

To install the application in Android 7+ versions, provide permission to the file manager as a source of software from an unknown source (see Fig.15):

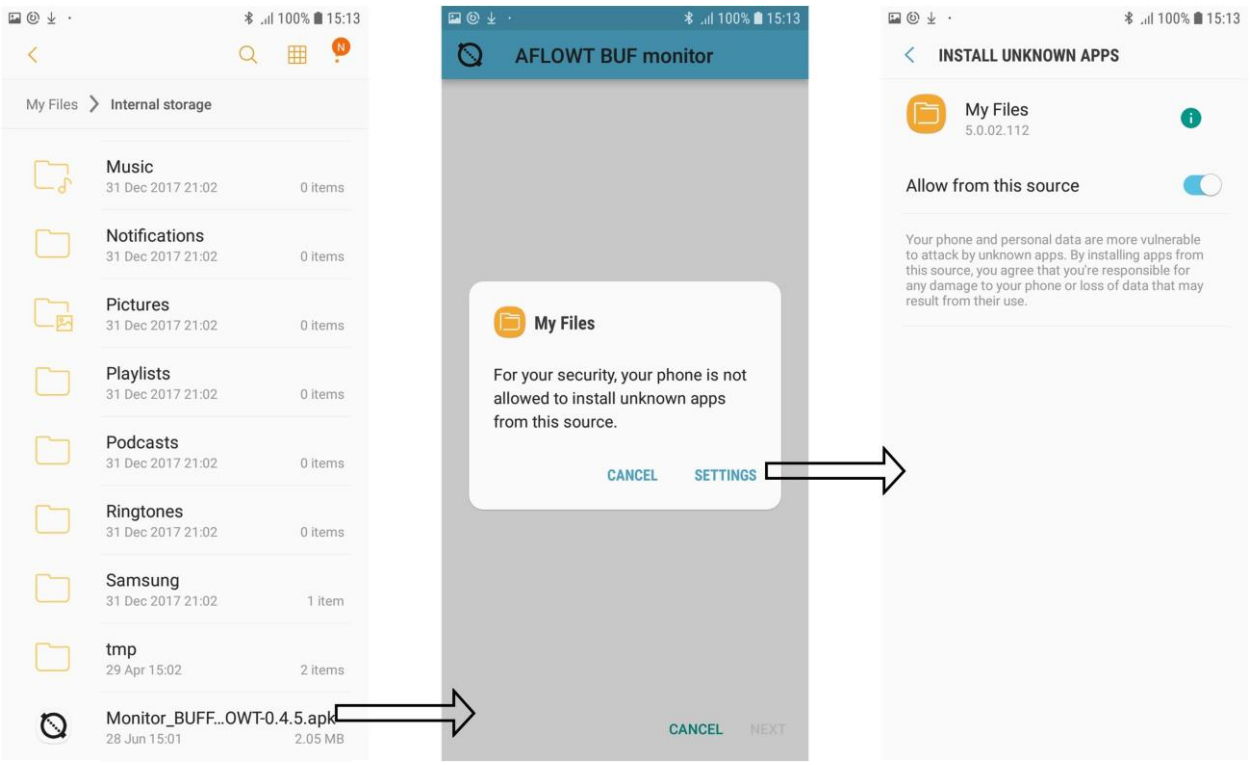


Fig.15. Granting permission to the file manager

Install the downloaded installation file using any file manager on your smartphone.

During the software installing, follow the hints of the system messages that appear on the screen of your smartphone (Fig.16).

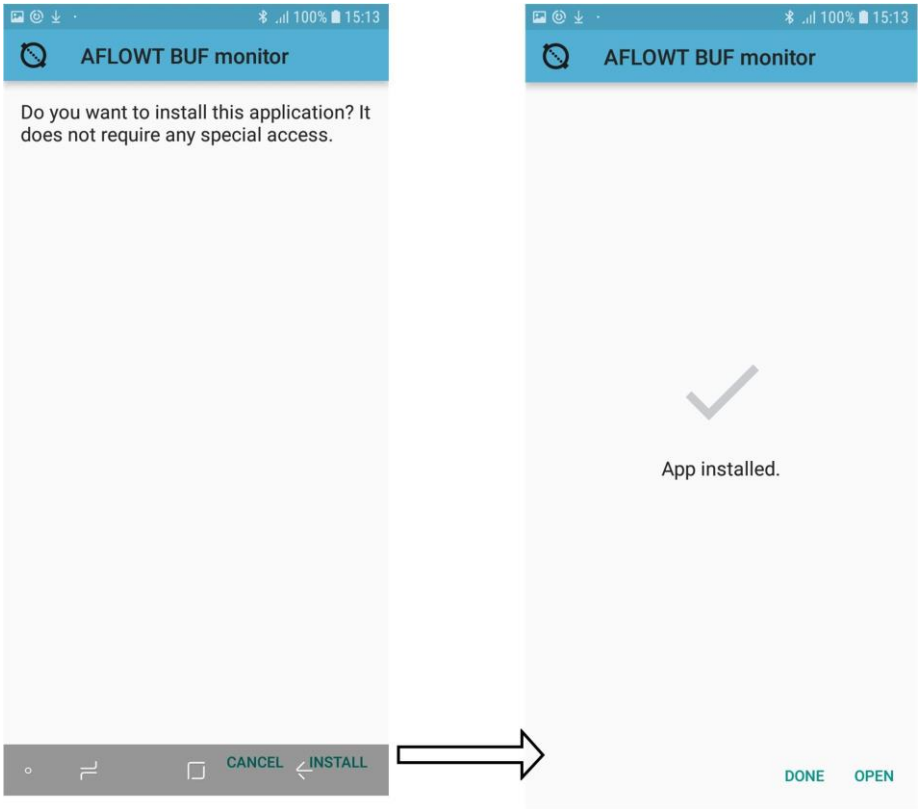


Fig.16. AFLOWT BUF monitor application installation window

When the installation process is complete, the AFLOWT BUF monitor software icon (Fig.17) should appear on the desktop and/or in the application menu.

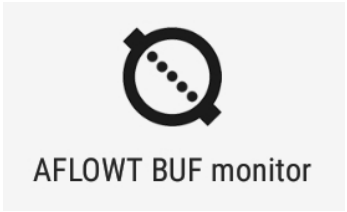


Fig.17. AFLOWT BUF monitor application icon

5.3. Connecting to the flow meter

To use the AFLOWT BUF monitor program, enable the NFC function in the corresponding menu item (Fig.18) in the smartphone settings.

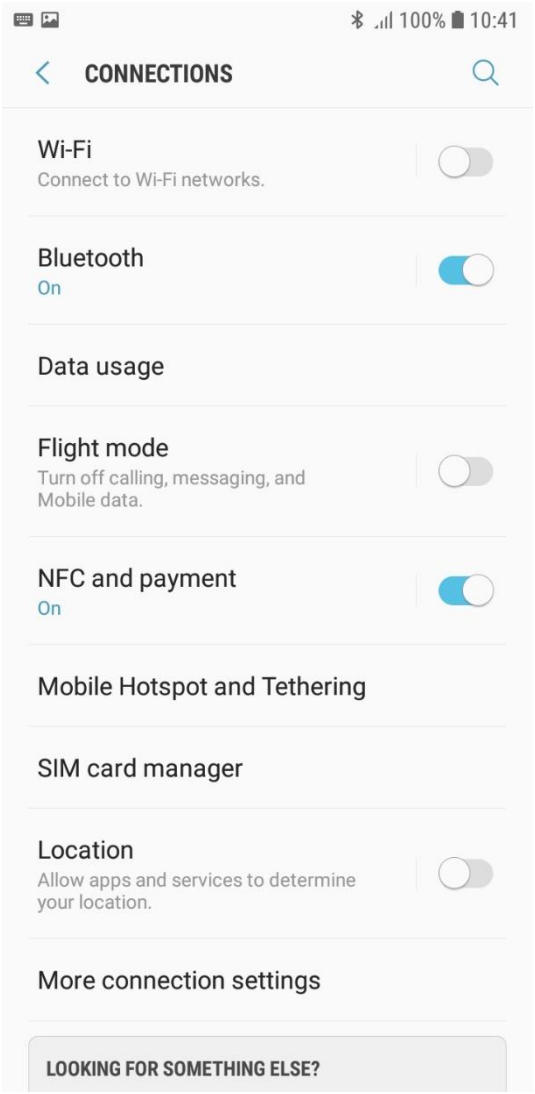


Fig.18. Enabling NFC

After installing the AFLOWT BUF monitor application, the application will request access to the file system of the smartphone at its first start (Fig.19). Otherwise, saving of archives and its further use will be inaccessible.

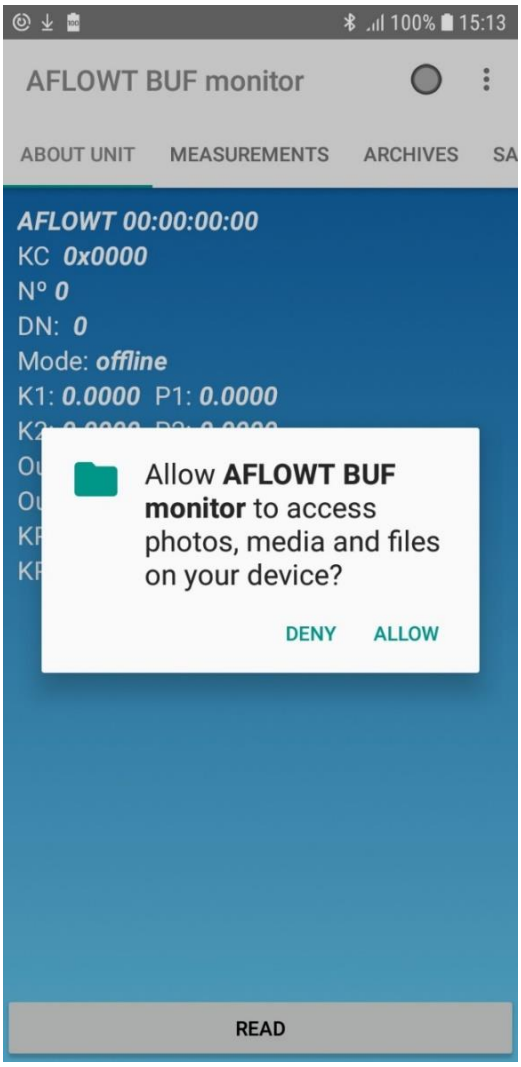


Fig.19. Request for access to the file system

5.4. Reading parameters

The application contains four tabs: **ABOUT UNIT**, **MEASUREMENTS**, **ARCHIVES** and **SAVED DATA** that can be swap sequentially on your smartphone screen by swiping left or right.

When you start reading the parameters by pressing the **READ** button, the progress bar in the form of a rotating circle will be displayed at the top of the screen (Fig.20).

Fig.20. Display of data exchange

A green circle indicates that the data is currently being read or a connection is being maintained.

Yellow circle (Fig.21) – the connection has been established, but now the smartphone is out of the NFC range.

Fig.21. Display of the lack of NFC

5.5. ABOUT UNIT tab

The appearance of the **ABOUT UNIT** tab is shown on Fig.22. You can read the parameter values by pressing the **READ** button.

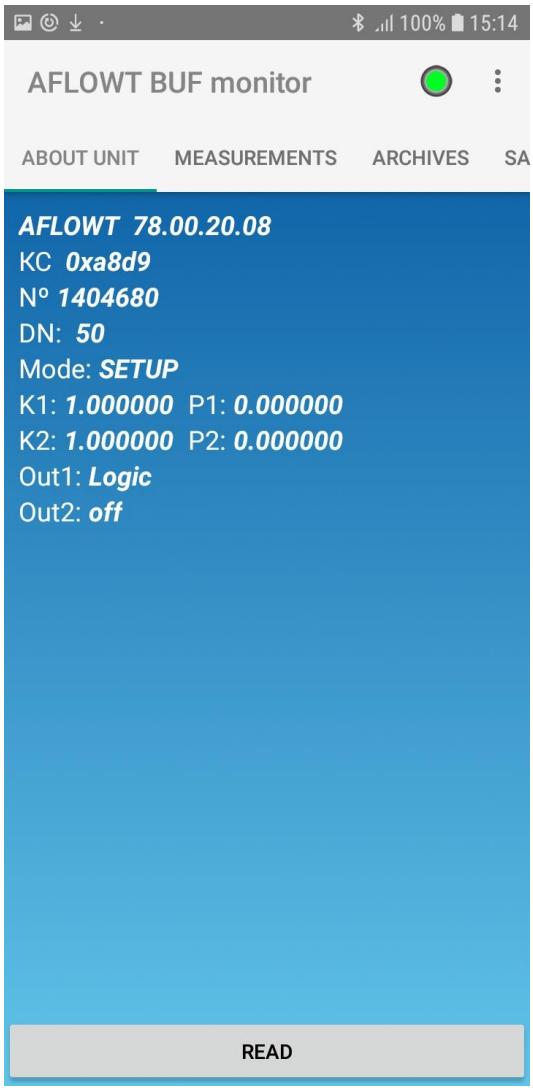


Fig.22. ABOUT UNIT tab window

This tab displays the following parameters: software version of the flow meter, serial number of the flow meter, nominal diameter (DN), operating mode, checksum (CS) of the software, calibration factors, information about the use of universal and logic outputs, values of output factors (if the universal output works in the frequency or pulse mode).

5.6. MEASUREMENTS tab

The appearance of the **MEASUREMENTS** tab is shown on Fig.23.

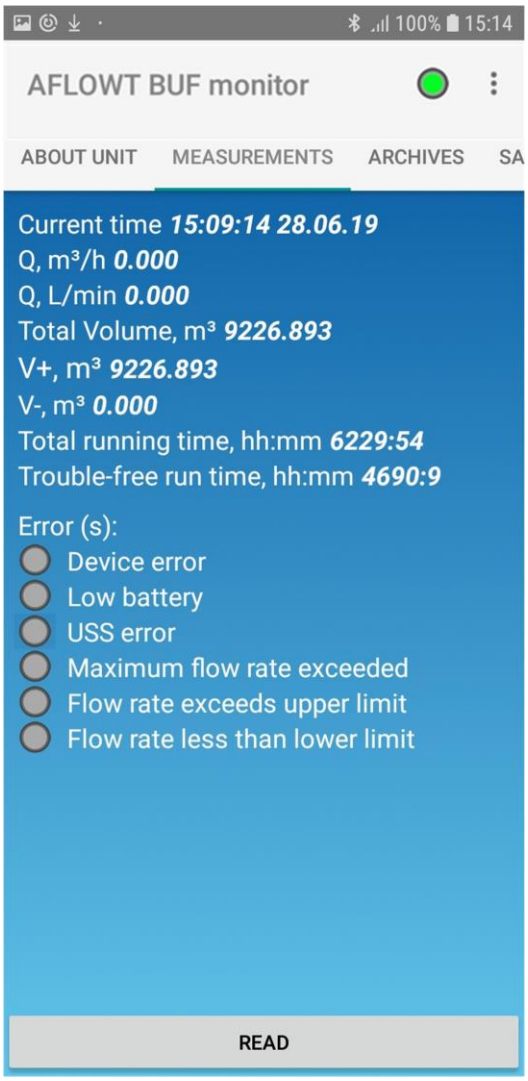


Fig.23. MEASUREMENTS tab

You can read current values by pressing the **READ** button.

The tab displays: the current date and time, the current flow rate value (in m^3/h and l/min), accumulated volumes (direct, reverse and total), total operating time and trouble-free operation time, emergencies.

The total volume is calculated based on the obtained data on V+ and V-.

If there are no errors, all circles to the left of the name of the diagnosed ER are grayed out, and if an error occurs, the corresponding circle changes to red (e.g. Fig.24).

Fig.24. Display of the emergency USS error

5.7. ARCHIVES tab

The monitor allows you to read hourly (last 96 records), daily (last 92 records) and monthly (last 48 records) archives from the flow meter.

The appearance of the **ARCHIVES** tab is shown on Fig.25.

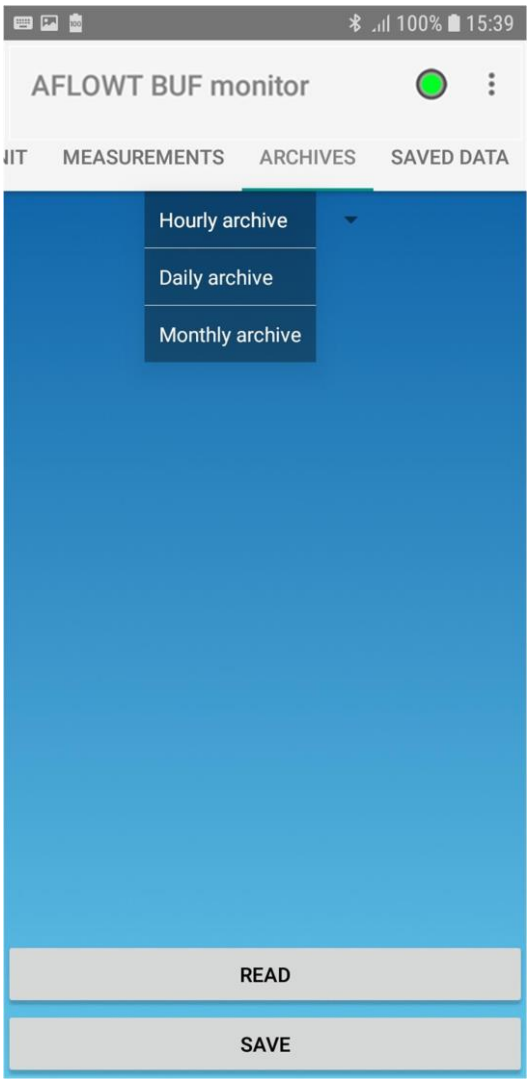


Fig.25. ARCHIVES tab

The tab is used to select the type of archive: hourly, daily or monthly. After that you should press the **READ** button. Thus, the window with records of the chosen archive (Fig.26) opens:

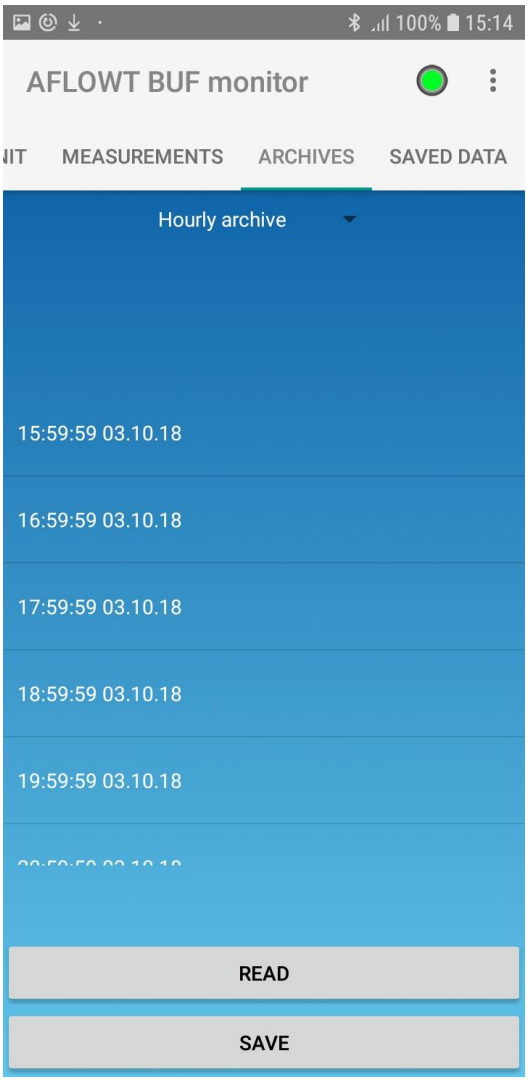


Fig.26. Tab with records of the selected archive

To view a certain record, click on the line with the corresponding date.

To save all records in the file, press the **SAVE** button. You will see a request to confirm that you want to save SMCV files (Fig.27):

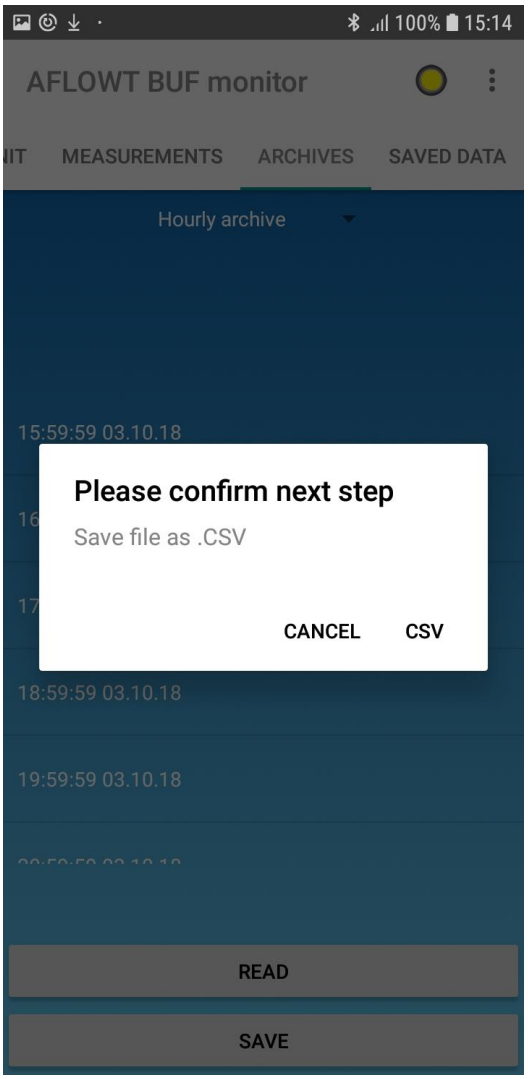


Fig.27. Confirming the file saving

Saving the files is accompanied by the message "**SMCV file was created**" (Fig.28).

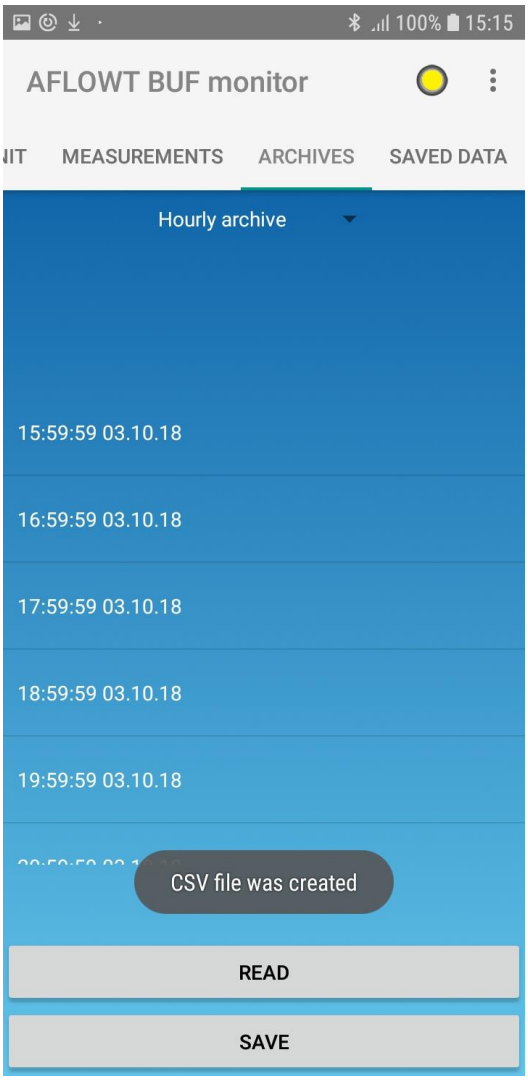


Fig.28. Confirming the file saving

The files are saved to: sdcard \ Aflowt \ monitor \ export.

Depending on the type of smartphone, the path to the saved archive files may differ.

NOTE. The file name is formed with indication of the archive type and time of reading the record from the device (Fig.29):

Fig.29. Saved archive files

A message is displayed on the smartphone screen (Fig.30) when you are finished with the application:

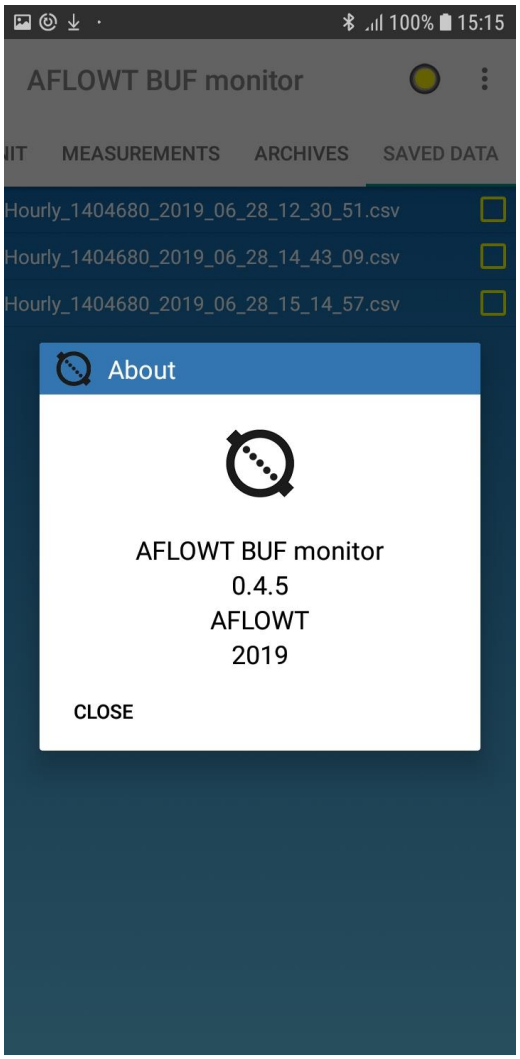


Fig.30. Closing the application

6. MAINTENANCE

6.1. Technical condition monitoring

6.1.1. Commissioned flow meter is recommended to be periodically inspected to check:

- Flow meter performance
- Compliance with operating conditions
- Availability of supply voltage
- Absence of external damage to the flow meter
- Reliability of electrical and mechanical connections.

Inspection frequency depends on operating conditions but should not be less than once a month.

At least once a year, the internal CP channel should be inspected for contamination and/or deposits. A light reddish patina is allowed, which should be removed with a clean soft cloth soaked in water during the maintenance.

If there are any other types of dirt or deposits or if their thickness is significant, the CP surface should be cleaned with water, clean cloths and non-abrasive detergents immediately after removing the flow meter from the pipeline.

The significant contamination on the CP surface in contact with the liquid indicates the unsatisfactory condition of the pipeline.

6.1.2. Failure to comply with the operating conditions of the flow meter specified in clauses 1.2.5 and 2.1, external damage or damage to the internal CP surface may result in failure of the flow meter or exceeding the permissible level of measurement error.

In case of damage of the product or communication cable it is necessary to contact the manufacturer to determine the possibility of its further operation.

6.1.3. The performance of the device is determined by the presence and content of the indication on the flow meter display or on the PC monitor. Possible malfunctions diagnosed by the flow meter are specified in clause 6.2.

6.1.4. Taking into account the operating conditions and the version, the flow meter refers to the products that are repaired by the manufacturer.

6.1.5. The flow meter must be sent for verification or repair with the device passport. The accompanying documents shall contain the sender's postal details, telephone and fax number, as well as the method and address of return delivery.

When sending the device for calibration or repair, clean the internal CP channel from deposits, scale, as well as from the remnants of working fluid after dismantling.

6.2. Troubleshooting

6.2.1. List of possible faults, failures and alarm situations detected by the flow meter and displayedon the LCD with "**X**" character in the "**ERR = - - - - - -**" line is given in Table 7. A sign-position code is read from ***right*** to ***left***.

Table 7

Sign position number	Explanation
1	Devise Error
2	Battery low level
3	USS is not present
4	Maximum flowrate is exceeded
5	Flowrate exceeds the universal output upper limit
6	Flowrate exceeds the universal output lower limit

6.2.2. The same information can be read via the communication interface from the **Status** tab of the "Monitor BUF (310)" program (see section 4.1.5). In the event of a fault, the LED on the corresponding line lights up red.

6.2.3. If **X** symbol is displayed in position 1 or the indicator lights up in red in the **Devise Error** line in the **Status** tab, the flow meter shall be forwarded for repair.

6.2.4. If **X** is displayed in other positions, or the lights are red in other lines of the **Status** tab, 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;
- The universal output conversion factor and flow rate cutoffs are correct; change their values if necessary.

If the above checks are positive, you should contact the device manufacturer to determine the possibility of its further operation.

6.2.5. Past emergencies are recorded in the device archive and can be viewed via the serial interface in the **Data log** tab, selecting the type of archive and time interval. The assignment of the 16-position code in the column of emergency situations of the archive from the 1st to 6th positions (from right to left) corresponds to the one specified in Table 7. The presence of a fault is indicated by the number "1", while the absence is indicated by the number "0".

7. PACKING, STORAGE AND TRANSPORTATION

7.1. The flow meter is packed in a separate container (corrugated carton or wooden box).

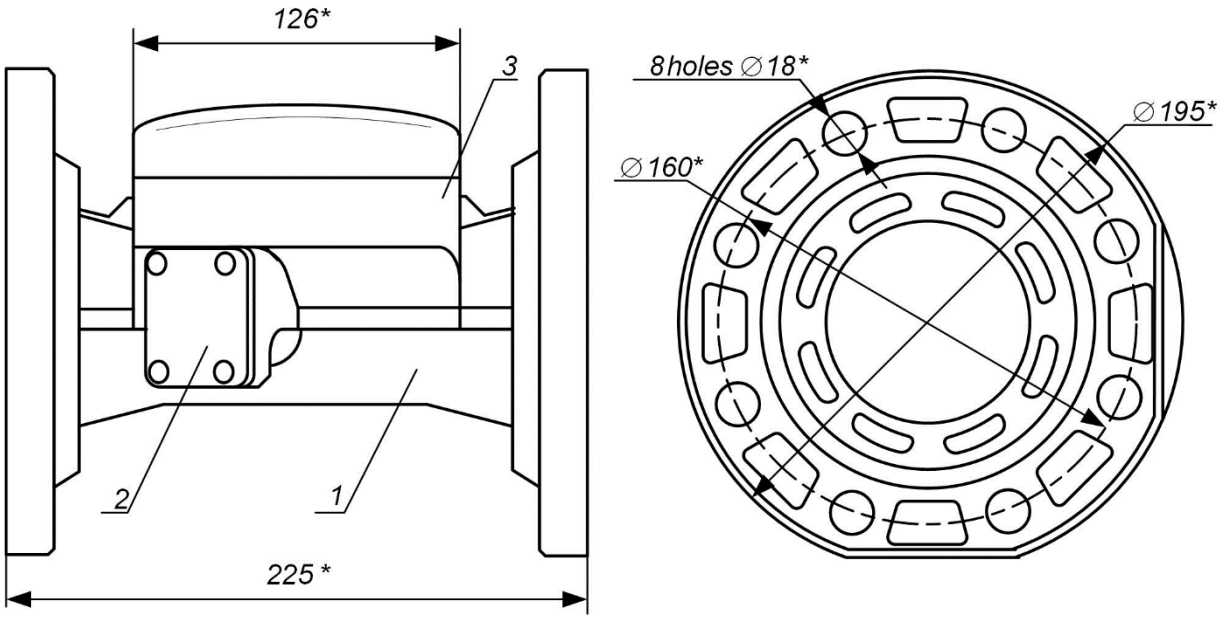
7.2. The flow meter should be kept in the manufacturer's box in a dry heated storeroom. The storeroom should be free from current-conductive dust, acid or alkali fumes and aggressive gases.

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

7.3. 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 +50 °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.

APPENDIX A. Appearance of the flow meter

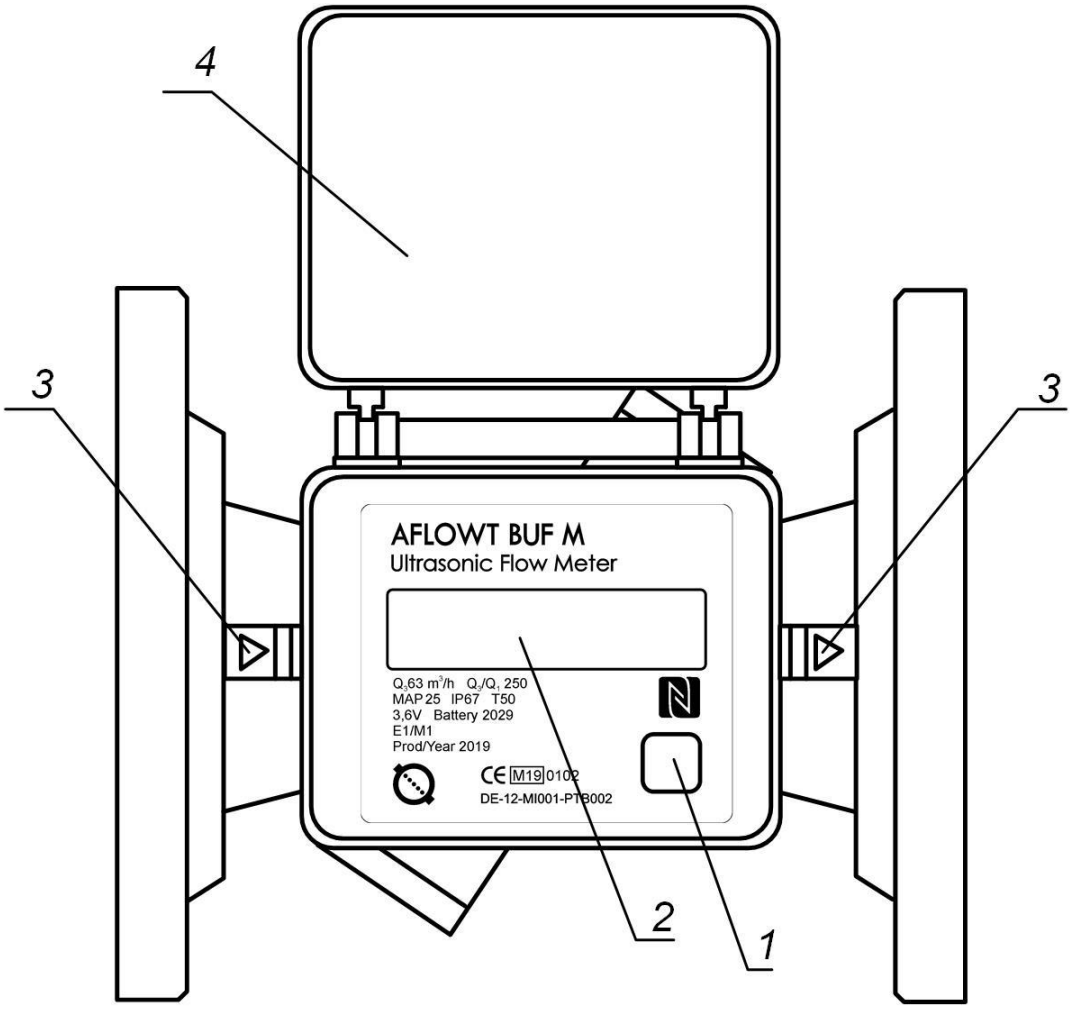


a) front view b) side view

* Reference size

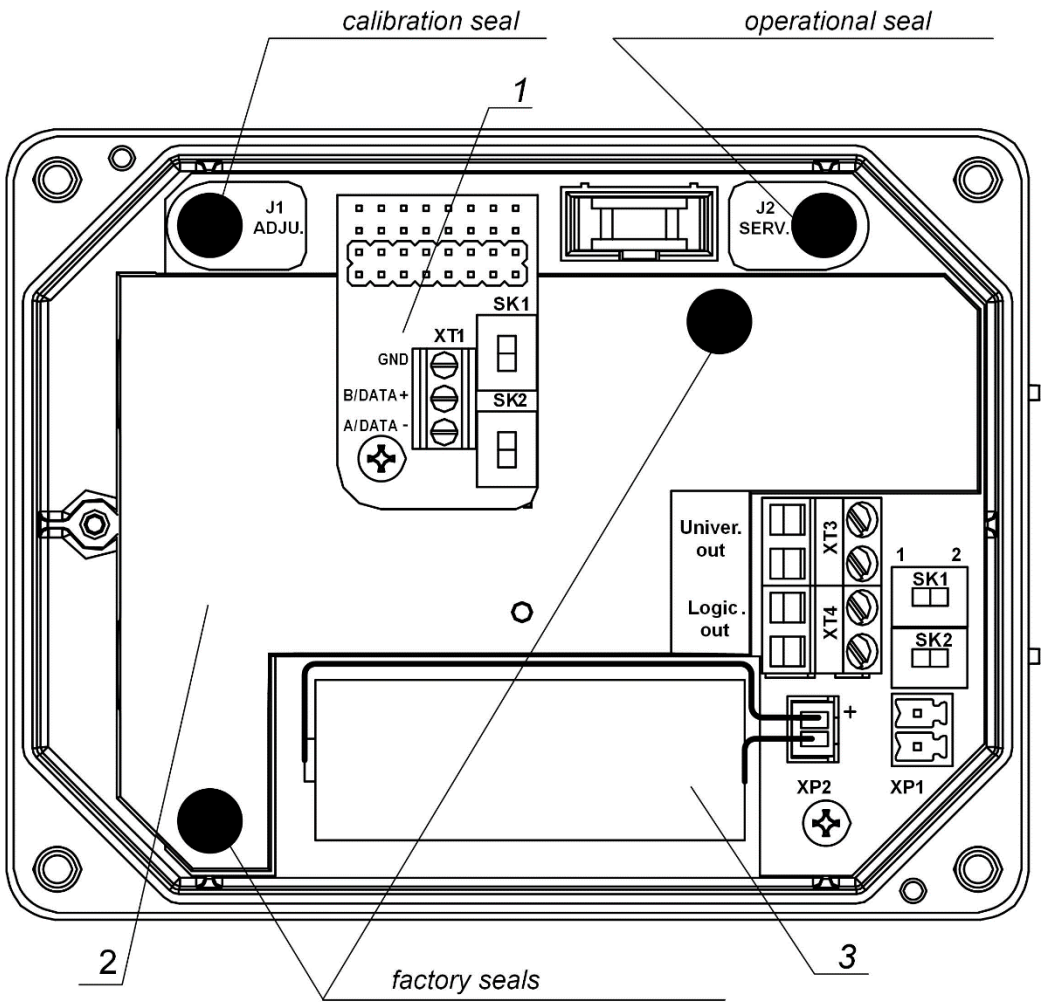
1 – pipeline section; 2 – PEA; 3 – secondary converter.

Fig.A.1. Flow meter AFLOWT BUF M of U-310 version.



1 – button; 2 – LCD; 3 – flow direction indicator; 4 – cover.

Fig.A.2. Flow meter AFLOWT BUF M. Front panel view



1 – RS-485 interface module; 2 – display; 3 – built-in 3.6 V battery;

XT1 – RS-485 interface output connector;

SK1, SK2 – flow meter network address setting switches (on the RS-485 interface module);

XP2 – 3.6 V battery connector;

XT3 – universal output connector;

XT4 – logic output connector;

J1, J2 – contact pairs of the flow meter operation mode;

SK1, SK2 – switches for setting the operating modes of the universal and logic outputs.

Fig.A.3. View of the secondary converter processing module with RS-485 interface module

APPENDIX B. Wiring diagrams

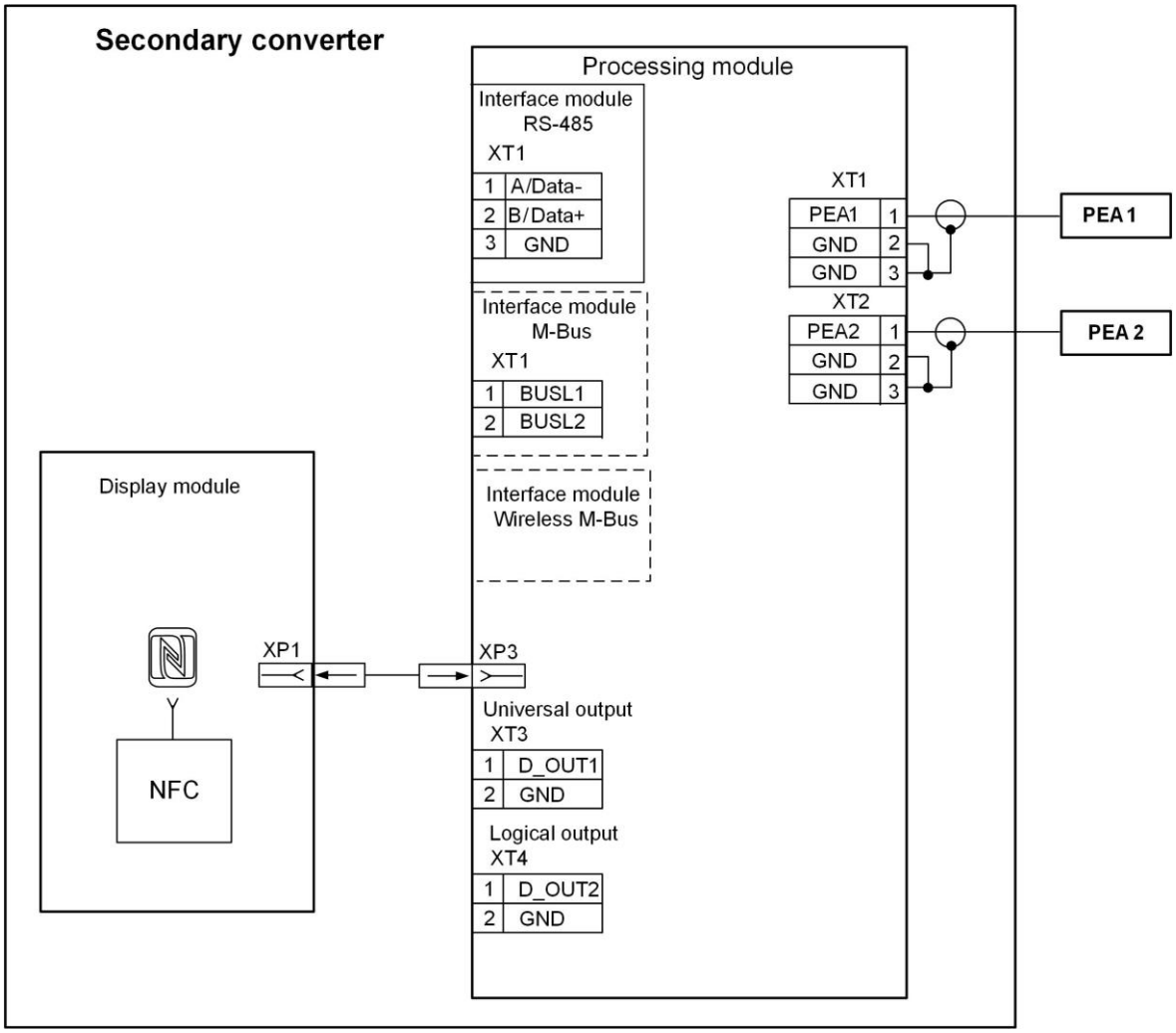


Fig.B.1. AFLOWT BUF M flow meter wiring diagram

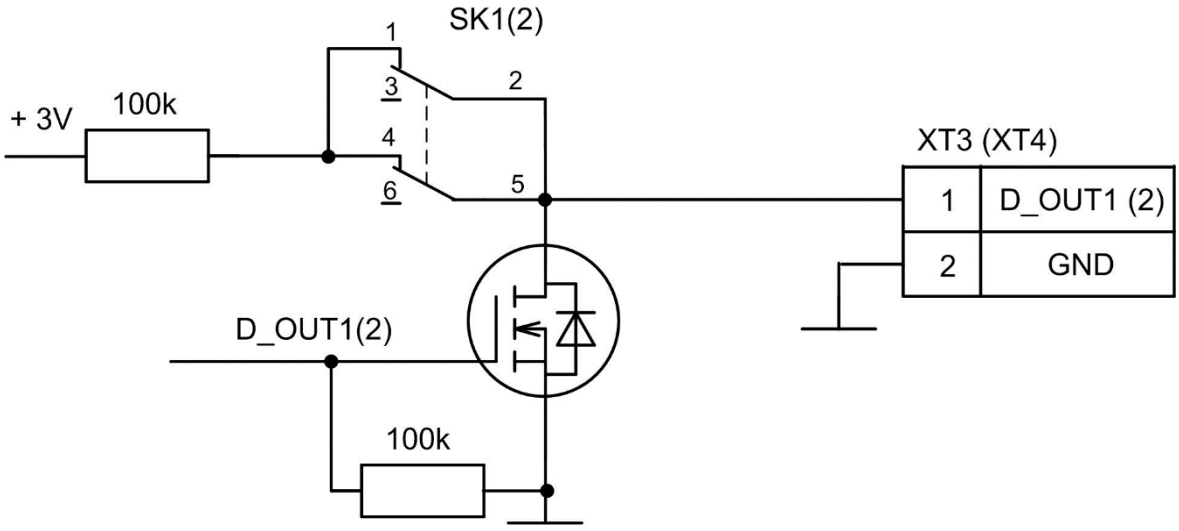


Fig.B.2. Diagram of the terminal stage of the universal and logical outputs

The terminal stage of the universal and logic outputs (Fig.B.2) can be powered either from the internal power supply (active mode) or from an external power supply (passive mode). Typical delivery includes passive operation of the terminal stage.

In the active mode and at the set value of the parameter **Active level** – **Hihg**, the output voltage in the logic mode and the pulse amplitude in the frequency (pulse) mode, depending on the resistance of the load, can be from 1.7 to 3.6 V. If there is no pulse, and the **Low** level is in the logic mode, the output voltage is not more than 0.4 V. Operation of the output in active mode is allowed for a load with a resistance of at least 200 kOhm

The terminal stage is connected to the internal +3.6 V power supply via the SK1 (SK2) switch.

The length of the communication line for the universal and logical outputs is up to 300 m.

APPENDIX C. Parameters available for editing in Monitor BUF (310) application

Table C.1. System tab (Fig.9)

Parameter designation on the PC monitor	Parameter, measurement units	Possible values	Value after initialization
1	2	3	4
Address	Address of the flow meter in the network	**1-247**	**1**
Boudrate	Baud rate in the network of devices	**1200, 2400, 4800**	**4800**
Time and Date	Current device 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	Reset of accumulated archives	**...; start**	**...**
Total flow reset	Zeroing of accumulated volume meters	**...; start**	**...**

Table C.2. Service tab (Fig.10)

Median mean	Number of measurements to determine the median value	**1-21**	**7**
Arithmetic mean	Number of measurements to determine the arithmetic mean	**1-50**	**25**
Inertion time, s	Minimum duration of USS loss not fixed in the archives	**0-255**	**10**
Cutoff flowrate, m^3/h	Minimal flow rate cutoff	**0.000-999.000**	**0.250**
Fast reaction	Dynamic flow measurement mode	**On/Off**	**Off**
Threshold, %Qmax	Criterion for quick installation	**0-100**	**5**
Contrast	Adjusting the indicator contrast	**1-63**	**28**
Updating time, s	Measured information update period on the indicator	**1-30**	**10**
Worktime, s	Time after which the indicator automatically turns off after the last pressing of the button	**1-255**	**30**
Dimention	Flow rate dimension	**m^3/h; l/min**	**m^3/h**

Table C.3. Service / Universal output tab (Fig.11)

Parameter designation on the PC monitor	Parameter, measurement units	Possible values	Value after initialization
Type	Universal output operation mode	**Off** **Logic** **Pulse** **Frequency**	**Off**
Type – Frequency (Fig.11.a)			
Flow	Output assignment (parameter designation)	See Table C.4	**any direction**
Parameters tab			
Maximum output frequency, Hz	Maximum output frequency	**0-10**	**10**
Error frequency, Hz	Output frequency at Q> Q_{max},	**0-10**	**0**
Lower limit by florate, m^3/h	Lower flow rate threshold for universal output in frequency mode	**0-999.999**	Depending on DN
Upper limit by florate, m^3/h	Upper flow rate threshold for universal output in frequency mode	**0-999.999**	Depending on DN
Output conversion factor, p/m^3	Output conversion factor	**0,001- 200000.000**	Depending on DN
Conversion factor calculation	Output conversion factor calculation	**...; Start**	**...**
Current frequency value, Hz	Current frequency value	**0-10**	Corresponds to flowrate value
Active level	Output voltage level when a signal is present (logic unit)	"**Low**" "**High**"	"**Low**"
Type – Pulse (Fig.11.b)			
Volume	Output assignment (parameter designation)	See Table C.4	**any direction**
Parameters tab			
Pulse weight m^3/pulse	Pulse weight	**0.000001-100.0000**	Depending on DN
Pulse width, ms	Pulse width	**1-1000**	**100**
Up. limit by flowrate, m^3/h	Upper flow threshold for universal output in pulse mode,	**0-999.999**	Depending on DN
Pulse weight calcul.	Pulse weight calculation	**...; Start**	**...**
Active level	Output voltage level when a signal is present (logic unit)	"**Low**" "**High**"	"**Low**"

Continuation of table C.3

Parameter designation on the PC monitor	Parameter, measurement units	Possible values	Value after initialization
Type – Pulse (Fig.11.c)			
Output function	Output assignment (parameter designation)	See Table C.4	**Reversing flow direction**
Active level	Output voltage level when a signal is present (logic unit)	"**Low**" "**High**"	"**Low**"

NOTE. The purpose of the logic output is similar to that of the universal output in logic mode.

Table C.4. Possible settings for universal output

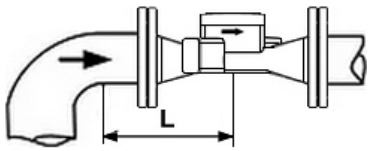
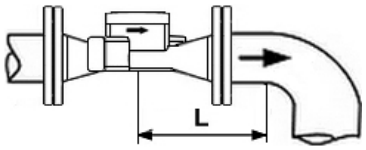
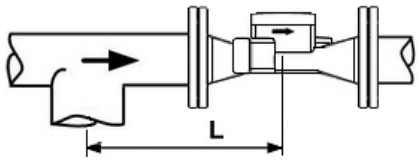
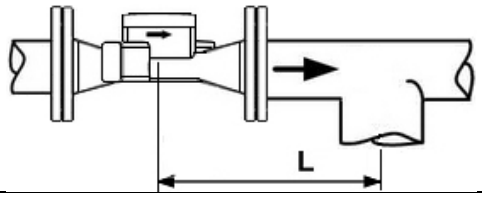
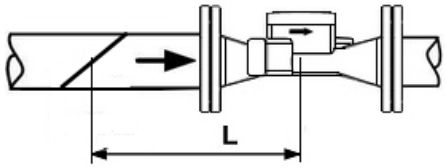
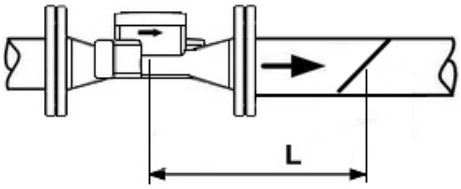
Parameter	Possible output assignments when Type parameter is set			
	off	**frequency**	**pulse**	**logic**
Off	+			
Flow - any direction		+		
Flow - direct flow		+		
Flow - reverse flow		+		
Volume - any direction			+	
Volume - direct flow			+	
Volume - reverse flow			+	
Reversing flow direction				+
No ultrasonic signal				+
Flowrate exceeds the hidh set-point				+
Any Error				+
Battery low level				+

NOTE. The "+" sign shows one of the possible assignments (conditions) of the universal output.

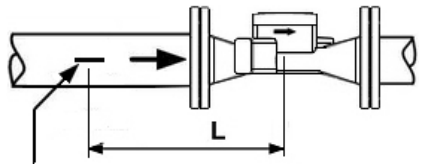
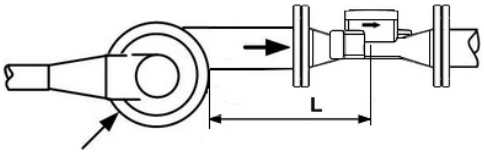
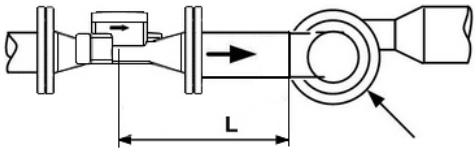
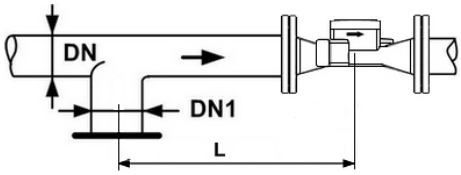
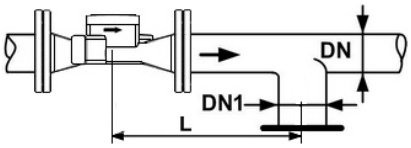
APPENDIX D. Relative length of straight runs

Table D.1 shows the minimum values of the relative length of straight pipe sections for the various types of local hydraulic resistances required for installation of the flow meters.

Table D.1

Type of local hydraulic resistance	Relative length of a straight run, L, minimum
1	2
	10·DN
	3·DN
	10·DN
	10·DN
 Regulating valve	30·DN
 Regulating valve	3·DN

Continuation of table D.1

1	2
 Fully open ball valve *	10·DN
 Pump	30·DN
 Pump	3·DN
 DN1 / DN > 0,1	10·DN
 DN1 / DN > 0,1	3·DN

* - fully open, full port ball valve is not a hydraulic resistance.

If there are several hydraulic resistances in the pipeline, the length of the straight section of the pipeline to the nearest resistance to the PEA must be at least as specified in this table, and the distance from the PEA to each of the other hydraulic resistances must be at least as large as the value given in the table for this type of resistance.

NOTE. If there is no hydraulic resistance in the pipeline, the flow meter should be installed taking into account the lengths of straight sections 3·DN before the flow meter and 2·DN after the flow meter.

APPENDIX E. Flow straightener design

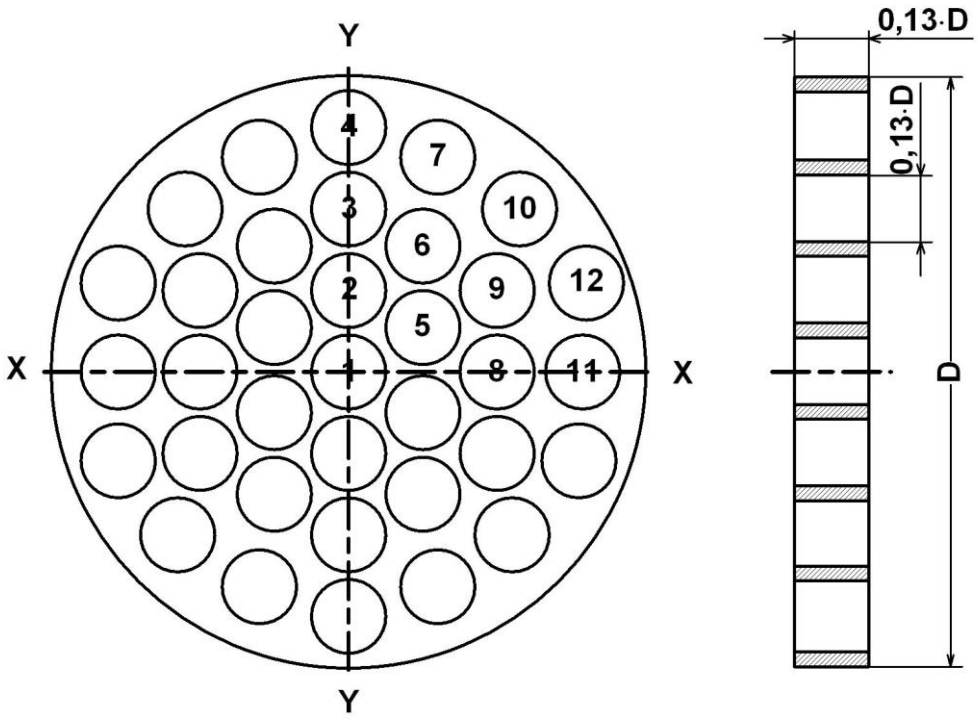
1. Fig.E.1 shows the design of flow straightener of A type that is manufactured according to the following rules:

a) the thickness of the flow straightener board is equal to the diameter of the holes; depending on the material, the board may consist of one or more plates;

b) all hole diameters in the board are the same;

c) holes are more densely distributed in the center of the board and rarer in the periphery;

d) holes on the flow inlet side are chamfered.



D – internal diameter of the pipeline where the flow straightener is inserted.

Fig.E.1. Design of flow straightener of A type

2. To reduce the weight and amount of material, the flow straightener of B type (Fig.E.2) can be used according to the following rules:

a) tubes are inserted into the board holes;

b) length of the tubes is equal to the diameter of the tubes;

c) all hole diameters in the board are the same;

d) holes are more densely distributed in the center of the board and rarer in the periphery;

e) holes on the flow inlet side are chamfered.

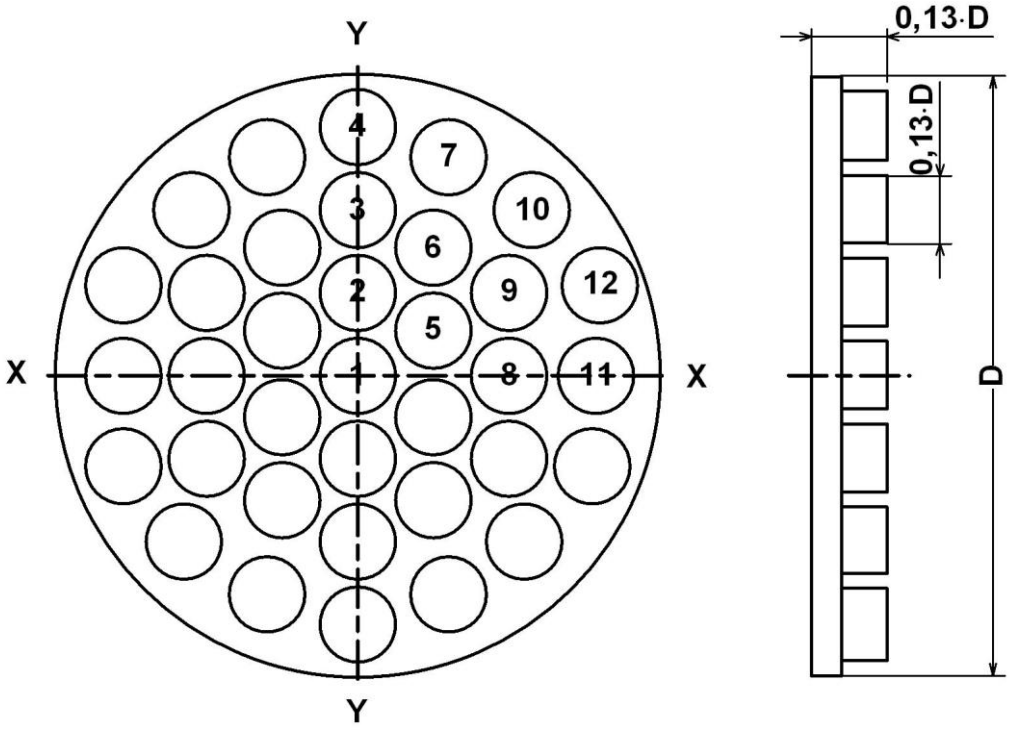


Fig.E.2. Design of flow straightener of B type

3. Hole pattern in the flow straighteners is shown in Table E.1.

Table E.1. Hole coordinates in the flow straighteners of A and B type (D is pipe inner diameter)

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 flow straightener is installed in the pipeline at 1÷2 DN of the pipeline from the local resistance that is the last in the flow. When installing the flow straightener, the required length of the straight section in front of the PEA is defined as the distance from the hydraulic resistance to the PEA.