

**AFLOWT**



**ELECTROMAGNETIC  
FLOW METER**

# **AFLOWT MF**

**Version “Pro-xxxMx”**

**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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This document covers “AFLOWT MF” Electromagnetic Flowmeter of “Pro-xxxMx” model Pro-112MI, -122MI, -212MI, -222MI, -111MA, -121MA, -211MA, -221MA, -112MC, -122MC, -212MC, -222MC hereinafter referred to as the flowmeter and contains information about its operation and design.

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

#### LIST OF ABBREVIATIONS

DN	- Nominal Diameter
MB	- Measuring Block
LCD	- Liquid Crystal Display
PC	- Personal Computer
EMF	- Electromotive force
MF	- Electromagnetic Flowmeter.

Certifying documents can be found online: [www.awlowt.com](http://www.awlowt.com)

## DESIGN VERSIONS

The design versions differ in form factor and functionality of the measuring block, pipe connection type (design of the flow channel), purpose with regard to medium (material of the electrodes and the liner material of the inner surface of the pipe channel).

Product identification corresponding to the type of the measuring block:

**Pro - 1xxMx** – without the display module

**Pro - 2xxMx** – with the display module

Product identification corresponding to the pipe connection type:

**Pro - x1xMx** – connection type – "wafer" (available sizes: DN10-DN150)

**Pro - x2xMx** – connection type – flanged (available sizes: DN20-DN300)

Product identification corresponding to the type of the flow channel lining:

**Pro - xx1Mx** – polyurethane lining of the flow channel

**Pro - xx2Mx** – fluoroplastic lining of the flow channel

Product identification corresponding to the purpose with regard to medium:

**Pro - xxxMI** – standard industry design (for non-aggressive liquids without abrasive additives)

**Pro - xxxMA** – wear proof design (for abrasive liquids);

**Pro - xxxMC** – corrosion resistant design (for aggressive liquids)

# 1. DESCRIPTION

## 1.1. Application

1.1.1. "AFLOWT MF" electromagnetic flowmeter of "Pro-xxxMx" model is designed for measuring average volumetric flowrate and volume of various electrically conductive liquids in a wide range of operating conditions.

"AFLOWT MF" flowmeters can be used in a great variety of applications in power industry, oil, gas and mining industries, municipal engineering as well as in iron and nonferrous, chemical, oil refining, cellulose and paper, food and other industries. The flowmeters can be used as a part of various integrated solutions, metering systems, automatic process control systems etc.

The flowmeters can be installed in both metal, and plastic (metal-plastic) pipes.

1.1.2. Depending on design type and firmware, "AFLOWT MF" flowmeters of "Pro-xxxMx" model perform the following functions:

- Measure 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
- Batching of preset volume of liquid or in the start-stop mode, batching and determining the amount of batched liquid, batching time and flow rate
- Displaying measurement results and emergency conditions
- Outputting of measurement results to current, pulse or logical output
- Storing configuration settings in the Device's non-volatile memory
- Automatic monitoring and displaying alarm conditions and faults
- Transferring measurement, diagnostic, configuration, log data etc. via RS-485 serial interface
- Protecting configuration settings from unauthorized access.

The flowmeter is also capable of monitoring how the pipeline is filled with liquid.

## 1.2. Specifications

1.2.1. The maximum  $Q_{max}$ , and the minimum  $Q_{min}$  flowrate values of measured average volumetric flowrates for various nominal diameters (DNs of the flowmeter's flow channel) are given in Table 1.

**Table 1**

Name of the Parameter	Value												
	10	15	20	25	32	40	50	65	80	100	150	200	300
DN, mm	10	15	20	25	32	40	50	65	80	100	150	200	300
$Q_{max}$ , m <sup>3</sup> /h	2.5	6.3	10.0	16.0	25.0	40.0	63.0	100	160	250	630	1000	2500
$Q_{min.1/10}$ , m <sup>3</sup> /h	0.25	0.63	1.0	1.6	2.5	4.0	6.3	10.0	16.0	25.0	63.0	100	250
$Q_{min.1/80}$ , m <sup>3</sup> /h	0.031	0.078	0.125	0.2	0.312	0.5	0.787	1.25	2.0	3.125	7.87	12.5	31.25
$Q_{min.1/150}$ , m <sup>3</sup> /h	0.016	0.042	0.066	0.106	0.166	0.266	0.42	0.666	1.066	1.666	4.2	6.66	16.66

-  $Q_{min.1/10}$ ,  $Q_{min.1/80}$ ,  $Q_{min.1/150}$  – minimal measured average volumetric flow rate for the flowmeters with measuring range factor of 1:10, 1:80 and 1:150, respectively.

1.2.2. Flowmeter's sensitivity to flow velocity is 0.02 m/s.

1.2.3. Characteristics of the liquid-under-control:

- Specific conductivity – no less than  $5 \cdot 10^{-4}$  S/m
- Flow velocity – up to 10 m/s
- Temperature – from -10 to 150°C with fluoroplastic lining, and from -10 to 70°C with polyurethane lining
- Pipeline pressure – up to 2.5 MPa.

1.2.4. Inputs and outputs of external communications:

- Universal outputs – 2
- Control input – 1
- Current output – 1 (optional)
- RS-485 interface – 1.

1.2.5. Storing of configuration settings:

- User log – up to 1000 records
- Configuration settings registry – up to 8000 records.

When powered off, the flowmeter stores configuration settings for no less than 1 year.

1.2.6. Flowmeter Power Supply:

- Input voltage is a stabilized 22 ... 29 V DC voltages with pulse level of no more than  $\pm 1.0\%$ . The flowmeter can be powered from mains 220 V 50 Hz via optional secondary power source
- Power consumption is no more than 5.0 W.

1.2.7. Operational data:

- Mean time to failure – 75 000 h

- mean life time is 12 years.

1.2.8. Environmental restrictions:

- Ambient temperature, from 5 to 50°C
- Relative humidity shall be no more than 80% at 35°C, without moisture condensation
- Vibrational loads – within the range of 10-55 Hz, with displacement amplitude up to 0.35 mm
- Atmospheric pressure from 66.0 to 106.7 kPa.

Flowmeter protection level shall be IP65.

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

### 1.3. Metrological specifications

1.3.1. Limits of permissible relative error for measurement, indication, logging, storage and transferring the results of average volumetric flowrate and volume measurement for various liquids and for any flow direction do not exceed the following ranges:

- $\pm 0.5\%$  – for flowmeters with flowrate range from  $Q_{\max}$  to  $0.1 \cdot Q_{\max}$  ( $Q_{\min.1/10}$ )
- $\pm 1.0\%$  – for flowmeters with flowrate range from  $Q_{\max}$  to  $0.0125 \cdot Q_{\max}$  ( $Q_{\min.1/80}$ )
- $\pm 2.0\%$  – for flowmeters with flowrate range from  $Q_{\max}$  to  $0.0067 \cdot Q_{\max}$  ( $Q_{\min.1/150}$ ).

1.3.2. Limits of permissible relative error for recording time of totalizer operation are  $\pm 0.1\%$ .



## 1.4. Contents of the delivery package

Items of the delivery package are specified in Table 2.

**Table 2**

Name	Qty	Notes
Flowmeter	1	Notes 1
Secondary DC 24 V power source	1	Optional
Installation kit	1	Notes 2, 3
Passport	1	
Operating documentation: - Operation manual - Installation manual	1	

### Notes

1. Flowmeter's nominal diameter and design type (see section DESIGN VERSIONS) are specified in the purchase order.
2. Socket connectors for power and signal cables are included in the standard supply.
3. Set of fittings can be provided for on-site installation at customer's option either as specified in the purchase order.

Allowable pressure for the supplied set of fittings is 2.5 MPa.

Operating documentation for this product is available on:  
[www.aflowt.com](http://www.aflowt.com).

## 1.5. Design and operation

### 1.5.1. Operating Principle and Arrangement of the Flowmeter

The flowmeter consists of the primary transducer (electromagnetic flow sensor) and secondary converter which is a microprocessor-based electronic measuring block (MB).

MF operation principle is based on measuring electromotive force (EMF) induced in electrically conductive liquid when it flows in magnetic field. The magnetic field is furnished in the flow sensor's inner channel by a special electromagnetic system (see Fig.1)

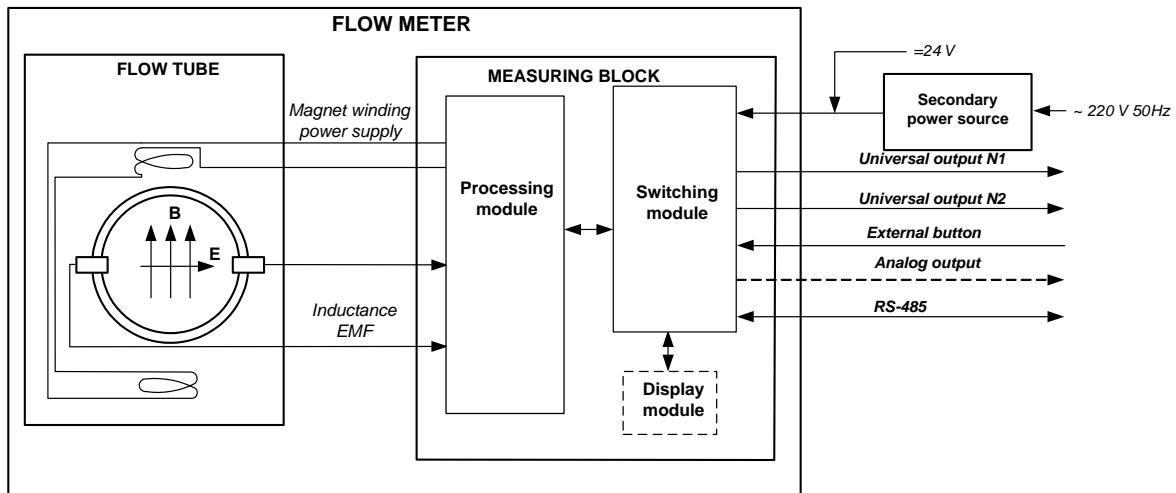


Fig.1. Flowmeter's block diagram

The Electromagnetic Flow Sensor is designed as a hollow magnetotransparent cylinder with solenoid coils located outside. The inside of the cylinder is covered with an electrically insulating material. The induced signal is picked up by two electrodes, which are in conductive contact with the liquid under control.

Inductive electromotive force (EMF)  $E$  is proportional to the mean flow velocity  $v$ , distance between the electrodes  $d$  (which is equal to the sensor's inner diameter), and magnetic field strength  $B$ :

$$E = k \cdot B \cdot d \cdot v,$$

where  $k$  is a linear factor.

$B$  and  $d$  are constants for the flowmeter of a given standard size. The value of electromotive force (EMF) is independent of liquid temperature and viscosity, and also it is independent of conductivity provided that the value of conductivity is no less than specified in the flowmeter's specifications.

Considering the formula for inductive EMF, flow rate  $Q$  is calculated as follows:

$$Q = \frac{\pi \cdot d^2}{4} \cdot v = \frac{\pi \cdot d}{4 \cdot k \cdot B} \cdot E.$$

Volume  $V$  of the liquid passed through the flow sensor during the time interval  $T$  is calculated by the formula:

$$V = \int_0^T Q(t)dt.$$

The measuring block includes processing, communication and display (if applicable) modules.

The processing module:

- Provides power supply for solenoids
- Receives and processes the induced EMF signals, determines average volumetric flow rate
- Totalizes volume and time of operation
- Performs equipment diagnostics
- Stores configuration settings and collected data.

The communication module:

- Generates the sequence of output pulses corresponding to measured average volumetric flowrate (volume)
- Generates output current signal
- Generates flow direction signal, error signal in the form of logic signal
- Receives external control signal
- Provides data exchange with external devices via RS-485 serial interface.

The display module (if present) provides displaying parameters on the LCD display.

Flowmeter's functions depend on design type and are specified in the purchase order.

### 1.5.2. Operating modes

1.5.2.1. The flowmeter operates in three modes:

- VERIFICATION – adjustment and calibration
- SERVICE – start-up procedures
- WORK – operation mode (user mode).

Flowmeter's operating modes are set by placing (removing) jumpers on J1 and J2 terminals, which are located on the board of the MB processing module (see Fig.A.4) 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**

Name of the mode	MB terminal pair		Mode description
	J1	J2	
VERIFICATION	–	+	Adjustment and calibration
SERVICE	+	–	Start-up procedures
WORK	–	–	Operation

1.5.2.2. The modes provide different options for modification of the device's configuration settings. The settings are reconfigured programmatically via RS-485 interface.

In the WORK mode, only the settings which have no effect on the flowmeter's operation can be changed:

- Dose value set for the batching mode
- Serial interface properties
- Display settings.

In the SERVICE mode, in addition to the WORK mode options, the operator can configure the following flowmeter's operational settings:

- Flow cutoffs for measurement
- Settings for the general-purpose and current outputs and the control input
- Settings for the flowrate signal filter and automatic flowrate setup module.

In the VERIFICATION mode, all configuration settings may be changed. Device adjustment during manufacture and after-calibration adjustment are made in this mode.

Configuring the settings in the SERVICE and WORK modes does not affect flowmeter's metrological characteristics and may be performed on-site, if necessary. In the SERVICE and OPERATION modes, adjustment and calibration settings are inaccessible.

All the modes provide options for viewing service and configuration settings.

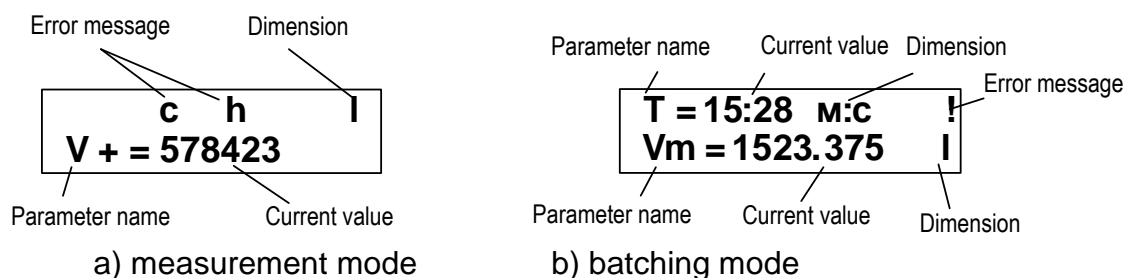
Flowmeter's adjustment for measuring reverse flow is available at customer's option.

### 1.5.3. Displaying results and external connections

#### 1.5.3.1. Displaying results

A two-line character LCD display of the flowmeter shows:

- When measuring (fig.2.a) – codes of ER situations and measurement units (first line), measured parameters and measurement results (second line)
- In the batching mode (fig.2.b) – batching settings and measurement units (first and second lines).



**Fig.2. Flowmeter's display view**

Measurement units and number of displayed digits are given in Table 4.

**Table 4. Displaying measured parameters**

Name	Description	Units	Number of digits (max)		Notes
			integer part	fractional part	
<b>Q</b>	Average volumetric flow rate	l/min m <sup>3</sup> /h	Up to 10	Up to 3	Note 1
<b>V</b>	Total volumetotalized value	l, m <sup>3</sup>	Up to 9	Up to 3	Note 1 Note 2
<b>V+</b>	Forward flow volume totalized value	l, m <sup>3</sup>	Up to 9	Up to 3	Note 2
<b>V-</b>	Reverse flow volume totalized value	l, m <sup>3</sup>	Up to 9	Up to 3	Note 1
<b>t</b>	Time of totalizer operation	hours	Up to 10	-	
<b>Vs</b> <b>Vm</b>	Dose volume: - set value - measured value	l, m <sup>3</sup> l, m <sup>3</sup>	Up to 9 Up to 9	Up to 3 Up to 3	Note 3

Notes

1. Reverse flow flowrate and volume, 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. For unidirectional flowmeters, "Totalized volume" value equals "Totalized volume of forward flow" value.
3. Dose volume set **Vs** and measured **Vm** values are displayed in the batching mode only. One of the other parameters can be displayed along with **Vm** value (see table 5).

**Table 5. Displaying batching parameters**

Line number	Name of the Parameter	Description	Measurement units
1	<b>Q</b>	Average volumetric flow rate	l/min, m <sup>3</sup> /h
2	<b>Vm</b>	Dose volume, measured	l, m <sup>3</sup>
1	<b>Vs</b>	Dose volume, set	l, m <sup>3</sup>
2	<b>Vm</b>	Dose volume, measured	l, m <sup>3</sup>
1	<b>T</b>	Batching time	min, s
2	<b>Vm</b>	Dose volume, measured	l, m <sup>3</sup>

The set of displayed parameters, measurement units, display period and flow cutoff value may be set at the factory on customer request or on site when putting the flowmeter into operation.

By default, the flowmeter is configured to display **Vs / Vm** parameters during batching.

**Indication Period** (the time for one parameter to be displayed in the automatic indication switching mode). This parameter is set programmatically from 1 to 100 s (5 s is a factory set value).

It is possible to switch indication by feeding the corresponding signal to the control input. To do this, select **Menu navigation** item for the control input.

The first line of the display shows characters corresponding to alarm or fault condition in the operation of the pipeline or to the failure of the device (see fig.2a).

Character assignments are specified in section 2.5 of this manual.

### 1.5.3.2. Control input

Functions of the inputs are configurable:

- **Start-Stop batching** – to start and stop batching upon control signal
- **Menu navigation** – to switch over indication upon control signal.

Control input circuit diagrams and control signal characteristics are given in Appendix B.

### 1.5.3.3. Universal outputs

The flowmeter has two galvanically isolated outputs N1 and N2. These outputs are universal regarding both the operation modes (frequency, pulse or logical) and function.

Operating mode, function and parameters of the outputs are configured at the factory (if ordered) or on site (see table 6).

Circuit diagrams of output stages and description of their operation modes are specified in Appendix B.

When working in the pulse and frequency modes, the outputs can be used to output measurement results in the form of square pulse sequence with period-to-pulse duration ratio of 2 and standardized pulse weight. The maximum pulse repetition rate is 500 Hz.

Output conversion constant  $K_p$  (pulse/l) that defines the pulse weight may be set within the range from 0.0001 to 200 000 (minimal increment of 0.0001). To determine  $K_p$  having regard to the maximal flow rate in the pipeline where the flowmeter is installed and frequency characteristics of the input receiving the pulse signal, the following formula may be used:

$$K_p(p/l) \leq \frac{3.6 \cdot F}{Q_m} = \frac{1.8 \cdot 10^3}{Q_m \cdot \tau_i}$$

$Q_{max}$  – maximum operational flowrate in the pipeline, m<sup>3</sup>/h

F – maximum flowmeter's pulse repetition rate permissible for a receiving input, Hz

$\tau_i = \frac{T_i}{2}$  – minimum flowmeter's pulse duration permissible for a receiving input, ms

$T_i$  – pulse repetition period on the flowmeter's output, ms.

**Table 6. Functions of the universal outputs**

Operating mode of the output	Name on the PC's display	Condition for the generating of the signal / changing state on the output
<b>Frequency</b>	<b>Modulo flow</b>	Flowrate for any flow direction
	<b>Direct flow</b>	Flowrate for direct (positive) flow direction
	<b>Reverse flow</b>	Flowrate for reverse (negative) flow direction
<b>Pulse</b>	<b>Modulo volume</b>	Volume for any flow direction
	<b>Direct volume</b>	Volume for direct flow
	<b>Reverse volume</b>	Volume for reverse flow
	<b>Batching stop signal</b>	Stop of the preset batch accumulation
<b>Logic</b>	<b>Reverse flow</b>	Flow direction is changed in the pipeline
	<b>Error Q&gt;Qmax</b>	Q <sub>max</sub> value is exceeded
	<b>Any Error</b>	Any error detected by the flowmeter
	<b>Batcher signal</b>	Batching Start/ Stop
	<b>Reverse flow (inertial)</b>	Flow direction is changed in the pipeline during the heat accounting
	<b>Power ("High" level)</b>	Interruption of power supply
	<b>Empty pipe</b>	Level of the probing signal applied to the electrodes exceeds the preset threshold for the empty pipe
	<b>Error "Flow out of user range"</b>	Value of flowrate falls outside the specified range
	<b>Error Q&gt;Qmax (user)</b>	Current value of the flowrate exceeds the upper limit of the preset operation range
<b>Error Q&lt;Qmin (user)</b>	Current value of the flowrate is lower than the bottom limit of the preset operation range	

The default mode for N1 output is the frequency mode, and the default  $K_p$  values are specified in Table 7 which correspond to a frequency of 500 Hz at  $Q_{max}$  flowrate.

**Table 7.**

DN, mm	10	15	20	25	32	40	50	65	80	100	150	200	300
$K_p$ , p/l	530	230	130	80	50	30	20	10	8	5	2	1	0.5

- ◆ In the frequency mode, frequency is proportional to average volumetric flowrate measured over previous 80 ms.

For the frequency mode,  $K_p$ , **Maximal frequency** and **Error frequency** parameters are configured.

**Maximum frequency** is the frequency of the output signal corresponding to the maximum flowrate in the pipeline. Exceeding **Maximum frequency** of the output signal is identified by the flowmeter as an alarm condition, i.e. the value of  $K_p$  set for this output is incorrect.

**Emergency frequency** is the pulse repetition rate of a pulse sequence (no more than 700 Hz) generated on the output if the measured flowrate exceeds  $Q_{max}$  for a given DN. The value set for **Error frequency** must be no less than the **Maximum frequency** value for the output.

Function of the output in the frequency mode is set by **Modulo flow**, **Direct flow** and **Reverse flow** parameters.

**Modulo flow** – a pulse sequence with pulse repetition rate proportional to the measured flowrate is generated on the output regardless of flow direction. **Direct flow** – the pulse sequence is only generated for forward flow. **Reverse flow** – the pulse sequence is only generated for reverse flow.

- ◆ 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 the previous second.

In the pulse mode, **K<sub>p</sub>** and **Pulse period** are set.

**Pulse period** – the pulse repetition period, may be set from 2 to 1000 ms (which corresponds to the frequencies from 500 to 1 Hz).

To set the function for the output in pulse mode, select **Modulo volume**, **Direct volume**, **Reverse volume** or **Batching stop signal**.

**Modulo volume** – pulses the number of which is proportional to the measured volume are generated on the output regardless of flow direction. **Direct volume** – pulses are generated for direct flow only. **Reverse volume** – pulses are generated for reverse flow only.

**Batching stop signal** – one pulse is generated on the output when batching stops.

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

For the logical mode, **Activity level** i.e. **High** or **Low** signal level is set programmatically when the event is present. Electrical parameters of the corresponding signal levels are specified in Appendix B.

To set the function for the logical output, the following options may be selected:

- **Reverse flow** – signal level on the output is changed without lag when the flow direction is changed
- **Error Q > Q<sub>max</sub>** – Signal level on the output is changed if the actual value of flowrate exceeds Q<sub>max</sub> for a given DN
- **Any Error** – Signal level on the output is changed in case of any alarm situation detected by the flowmeter.
- **Batcher signal** – Signal level on the output is changed at the start and stop of batching
- **Reverse flow (inertial)** – signal level on the output is changed only if period of changing flow direction exceeds the preset lag. **T inertial flow** may be set from 2 to 60 min
- **Power (“High” level)** – **High** signal level is generated on the output if power is applied to the Device, in case of power supply failure output signal is absent



- **Empty pipe** – Signal level on the output is changed if the value of resistance exceeds the threshold specified for the pipe filled with liquid
- **Error “flow out of user range”** – Signal level on the output is changed, if the value of the flowrate falls outside the specified rate
- **Error Q > Q<sub>max</sub> (user)** – Signal level on the output changes, if measured flowrate value exceeds the Q<sub>max</sub> value
- **Error Q < Q<sub>min</sub> (user)** – Signal level on the output changes, if measured flowrate value is lower than the Q<sub>min</sub> value.

#### 1.5.3.4. Current output

The current output of the flowmeter can operate in the range of 4-20 mA. The current output is set by the optional.

Nominal static characteristic of the current output is calculated as follows:

$$Q_v = Q_{lt} + (Q_{ut} - Q_{lt}) \frac{I_{out} - I_{min}}{I_{max} - I_{out}}$$

where **Q<sub>v</sub>** is the measured flowrate, l/min;

**Q<sub>lt</sub>** – specified low setpoint for the current output corresponding to **I<sub>min</sub>**, l/min

**Q<sub>ut</sub>** – specified high setpoint for the current output corresponding to **I<sub>max</sub>**, l/min

**I<sub>out</sub>** – value of output current signal corresponding to the measured flowrate, mA

**I<sub>max</sub>** – maximum operating range for the current output (20), mA

**I<sub>min</sub>** – minimum operating range for the current output (4), mA.

The current output is configured programmatically by setting the operating range, setpoints and function. **Modulo flow** – current proportional to the measured flowrate is generated on the output regardless of flow direction. **Direct flow** – current is generated for direct flow. **Reverse flow rate** – current is generated for reverse flow only.

The following levels can also be generated on the current output:

- 3.2 mA – when flowmeter’s hardware fault takes place (e.g. deadlock), or during flowmeter’s initialization when it is being connected to the external power source (after its successful startup, the output current is set proportionally to the current flowrate)
- 24 mA – when measured flowrate Q<sub>max</sub> is higher and **Error current** is set.

Parameters of the current output and circuit diagram are given in Appendix B.

#### 1.5.3.5. Serial interface

Serial interface RS-485 is used to transfer measurement and configuration data and modify configuration parameters, if accessible.

RS-485 interface supports ModBus (RTU ModBus and ASCII ModBus) protocol and provides cable communication between several stations (one may be a PC) with maximum cable length up to 1200 m.

Data transfer rate (from 9600 to 115200 baud) as well as communication properties are set programmatically. By default, at the factory, the transfer rate is set to 19200 bauds.

#### **1.5.4. Logs**

User log and Configuration settings registry are provided in the flowmeter for storing the configuration settings.

Parameters available for editing in the SERVICE mode are stored in User log. This log can contain up to 1000 records. After log depth is exhausted new records are written over the old ones starting from the first (by the time of recording).

Configuration settings registry is used to store parameters available for editing in the CALIBRATION mode. This log can contain up to 8000 records. After the log depth is exhausted it is impossible to add new records. The lock is released by the manufacturer.

#### **1.5.5. Design**

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

- Wafer connection type (DN10-DN150): flow pipe is fixed by studs between two flanges welded to the pipeline ends where the flowmeter is cut in
- Flanged type (DN20-DN300): the flow pipe's flanges are bolted to the mating flanges of the pipeline.

Depending on application, the inner surface of the flow pipe is lined with fluoroplastic or polyurethane.

For the flowmeter's with fluoroplastic flow pipe, protection rings are installed on the end faces of the flow pipe to protect fluoroplastic lining from damages during mounting and operation. The protection rings ensure alignment of the inner channel of the flow pipe with the mating flanges. Elements of the protection rings provide electrical contact of the flowmeter with the fluid being measured during the installation in plastic (metal-plastic) pipelines.

The measuring block (without the display) contains boards of the processing and communication modules. Modules are placed within the case of the MB and connected with each other through the connector. MB with the display additionally contains in the cover of the front panel the display module connected with the communication module via the signal flexible flat cable. The MB is designed in a metal case. The cover is connected with the case by the lower swivel hinge and fixed to it with screws.

The flow pipe casing and hollow stand fixing the MB are made of metal. It is possible to turn the MB about the stand axis by 90°, 180° or 270° (factory-installed on customer's request).

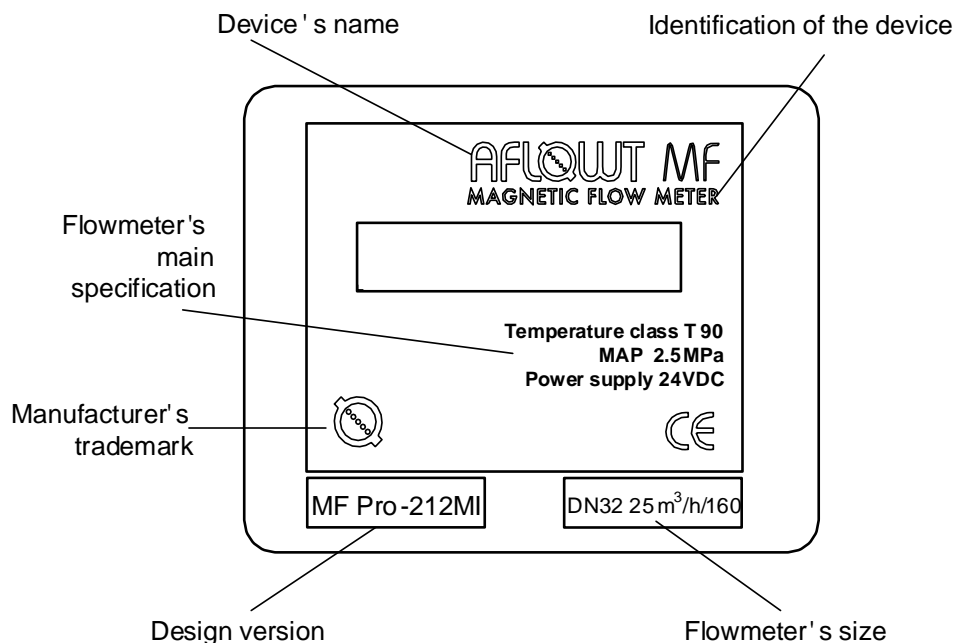
The power supply cable and signal cables are entered into the case via two cables through with M16×1.5 installation thread.

The screw on the MB foundation is used as the flowmeter's grounding terminal. The wires for connection with the pipeline mating flanges are fastened to the screw.

## 1.6. Marking and sealing

1.6.1. The MB front panel bears (see fig.3):

- Name and identification
- Manufacturer's trademark
- Mark of conformity with EU Directives
- Design version
- MF standard size
- MF main specification.



**Fig.3. Flowmeter's marking**

Serial number is indicated on the nameplate located on the MB case. Power cable through on the MB case is marked as "24VDC".

1.6.2. After flowmeter calibration the MB's terminal that allows modification of calibration settings is sealed.

1.6.3. The MB's terminal that allows modification of service settings can be sealed after putting the flowmeter into operation.

Besides this, to protect the device from unauthorized access during operation two fixing screws of the MB's casing cover can be sealed.

## 2. OPERATION

### 2.1. Operating restrictions

- 2.1.1. Environmental restrictions are specified in section 1.2.8.
- 2.1.2. The flowmeter may be mounted into the pipeline installed horizontally, vertically or obliquely. Special filters or dirt traps are not needed.
- 2.1.3. For precision and reliable operation, when choosing its mounting location, the following conditions must be met:
  - No air accumulation in the mounting location
  - Liquid pressure in the pipeline must not be of values that may facilitate gas release
  - Straight pipe runs of appropriate length and DN equal to the flowmeter DN must be provided at the flow channel's input and output. The runs must not include devices or components that may disturb flow structure
  - When the flowmeter is operated, the inner volume of the flow channel must be fully filled with liquid
  - Intensity of external magnetic field (commercial frequency) should not exceed 400 A/m.

**CAUTION!** DO NOT touch the electrodes inside the flow channel at any time when working with the flowmeter.

Mounting considerations, mounting and dismounting instructions, are given in "AFLOWT MF Electromagnetic Flowmeter of the Pro- $\times\times M\times$  model. Installation Manual".

**CAUTION!** If the flow channel is covered with fluoroplastic and the protection rings are removed, **DO NOT** remove the tightening stud (bolt) and clamping plates from the flow channel for more than 10 minutes.

- 2.1.4. Type and composition of medium (suspensions and their concentration, impurity substances, etc.), operating mode and pipeline conditions must not lead to sediments affecting performance and metrological characteristics of the flowmeter.

**To provide proper operation of the flowmeter in pipelines equipped with carbon filters, it is necessary to keep the filters in good condition.**

- 2.1.5. The need for the protective grounding is determined on power supply voltage and environment condition.
- 2.1.6. Lightning protection system for the site where the flowmeter is installed protects it against failures caused by lightning strokes.
- 2.1.7. Mounting location and operating conditions requirements specified in this operating documentation are based on the most typical factors affecting Device's 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 flowmeter in other location.

## 2.2. Selecting standard size

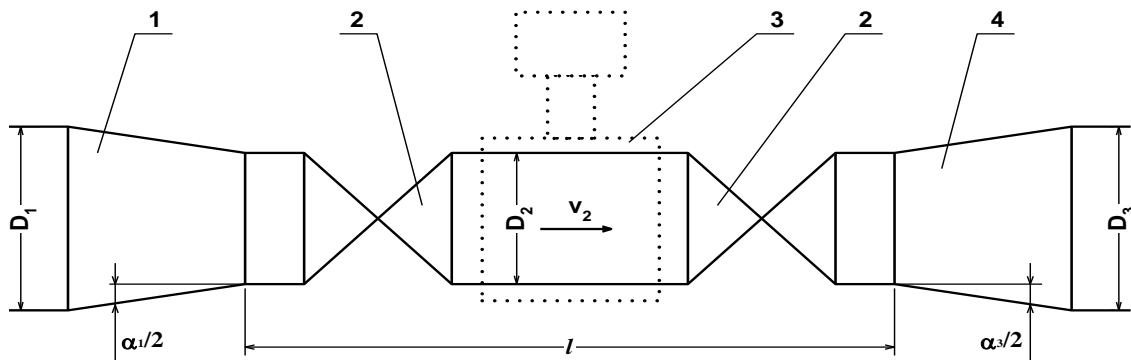
2.2.1. Flowmeter's standard size is selected based on the flowrate range in the pipeline where the flowmeter is installed. If several sizes are suitable, the standard size is selected from the specified limit of pressure losses.

2.2.2. If the selected DN is less than DN of the pipeline where the flowmeter is expected to be installed, you may use pipe reducers (confusor and diffusor).

2.2.3. To evaluate hydraulic losses in the confusor-flowmeter-diffusor system shown in Fig.4 use the following method.

2.2.3.1. The initial values for evaluation of the hydraulic losses:

- |                                               |              |                      |
|-----------------------------------------------|--------------|----------------------|
| - Liquid volumetric flow rate in the pipeline | - Q          | [m <sup>3</sup> /h]; |
| - DN of the inlet duct                        | - D1         | [mm];                |
| - DN of the flowmeter                         | - D2         | [mm];                |
| - DN of the inlet duct                        | - D3         | [mm];                |
| - Confusor taper angle                        | - $\alpha_1$ | [deg.];              |
| - Diffusor taper angle                        | - $\alpha_3$ | [deg.];              |
| - Length of the straight pipe run             | - $l$        | [mm].                |



1 – confusor; 2 – full bore spherical valve; 3 – flowmeter's flow channel; 4 – diffusor.

**Fig.4. Pipeline at the flowmeter mounting location**

2.2.3.2. According to superposition principle, total pressure losses in the confusor-flowmeter-diffusor system -  $h_{hyd}$  are the sum of pressure losses in the confusor  $h_{hyd1}$ , losses in the straight pipe run (length  $l$ )  $h_{hyd2}$  and losses in the diffusor  $h_{hyd3}$ .

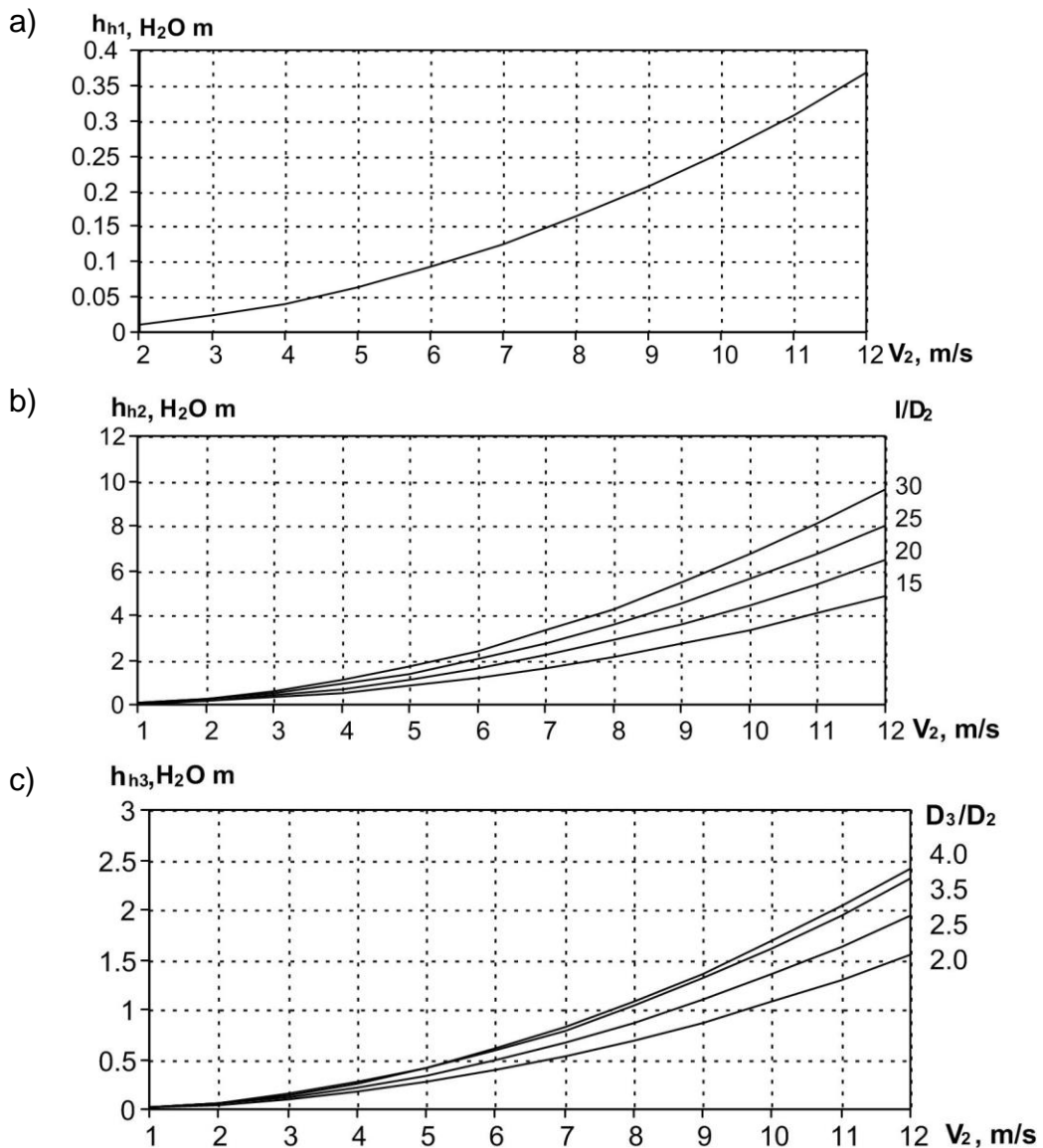
Hydraulic losses in the confusor are determined according to Graph 5a ( $V_2$  is the flow velocity in the straight pipe run). The Graph of hydraulic losses as a function of flow velocity is calculated for confusor taper angle  $\alpha_1 = 20^\circ$ . To determine flow velocity by volumetric flow rate  $Q$  use Graph 6 or the formula:

$$v(\text{m/s}) = \frac{Q(\text{m}^3/\text{h})}{0,9 \cdot \pi \cdot \text{DN}^2(\text{mm})} \cdot 10^3.$$

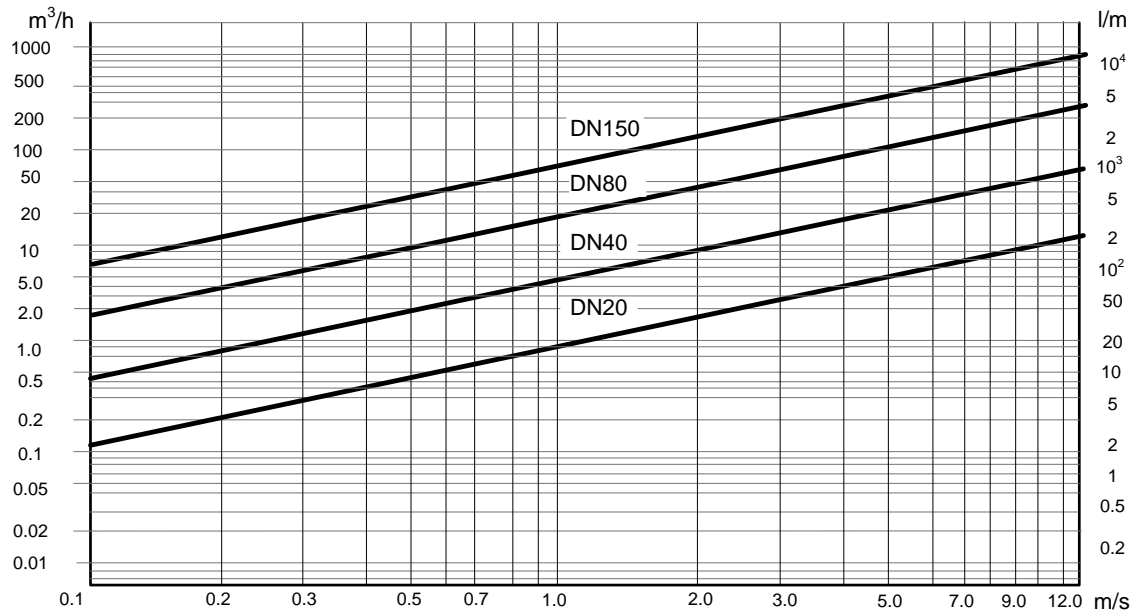
To determine hydraulic losses in the straight pipe run, Graph 5b is used. The Graph of the hydraulic losses as a function of flow velocity corresponds to straight pipe run length-to-diameter ratio 15; 20; 25 and 30.

To determine hydraulic losses in the diffusor, Graph 5c is used. The Graph of hydraulic losses as a function of flow velocity is calculated for diffusor taper angle  $\alpha_3 = 20^\circ$  and corresponds to diffusor's maximal-to-minimal diameter 2.0 2.5 3.5 and 4.0.

NOTE. Specialized software for accurate calculation of hydraulic losses in the confusor-flowmeter-diffusor system can be provided on request.



**Fig.5. Graphs of hydraulic losses in confusor (a), straight run (b), and diffusor (c).**



**Fig.6. Graph of flow rate vs flow velocity for various DNs**

## 2.3. Preparing for operation

### 2.3.1. Safety instructions

2.3.1.1. The flowmeter should only be used by personnel familiar with all operational documentation for the product.

2.3.1.2. When working with the flowmeter, the dangerous factors are as follows:

- AC voltage (RMS value up to 264 V, frequency 50 Hz)
- Pipeline pressure (up to 2.5 MPa)
- Medium temperature (up to 150°C)
- Other installation site-specific factors.

2.3.1.3. Do not use the flowmeter in the pipelines with pressure exceeding 2.5 MPa.

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

- Connect to the flowmeter, switch over modes and replace electronic components, if the flowmeter is powered up
- Remove the flowmeter 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).

2.3.2. When putting the Flowmeter into operation check the following:

- The flow is in the direction of the arrow on the flowmeter's body
- Length of the inlet and outlet straight pipe runs corresponds to flow direction
- The flowmeter and related equipment are connected in accordance with the selected wiring diagram
- The outputs operate in the preset modes

- Power supply voltage corresponds to the specifications.
- 2.3.3. At first power-up or after a long break in operation, the flowmeter becomes operational after:
- The flow channel is washed by medium for 30 minutes
  - The Flowmeter is kept powered for 30 minutes.
- 2.3.4. Seal the flowmeter and bypass gate (if installed) before putting into operation.

## 2.4. Operation procedure

### 2.4.1. Reading Data

After putting into operation the flowmeter works continuously in automatic mode.

Measurement results and flowmeter's working status is read from the display (indication may be switched from automatic to command modes), general-purpose and current outputs or via RS-485 serial interface.

### 2.4.2. Batching

Batching may be set in two ways: batching a doze or start-stop batching.

To batch a doze, you should enter the doze value to the flowmeter. Batching starts when the first signal comes from the control unit or when **Start** command comes via the serial interface, and stops automatically when the specified doze is filled.

In the start-stop mode batching starts when the first signal comes to the control input or **Start** command comes via the serial interface, and stops when the second signal comes to the control input or when **Stop** command comes via the serial interface. To set the flowmeter for work in start-stop mode, the doze value must be set to zero.

Pulse and/ or logical signal applied to the actuator may be generated on general purpose outputs when batching is completed.

### 2.4.3. Setting cutoffs for flowrate measurement

Cutoffs for flowrate measurement are set by the following parameters: **On rising flow**, **On falling flow**, and **Display cutoff**.

The **On rising flow** and **On falling flow** are the flowrate thresholds below which (on increasing or decreasing the flowrate value respectively) volume totalizing, pulse generating and outputting of current signal are stopped. The flowrate value is displayed as zero.

Values for all cutoffs may be set from 0 to  $0.255 \cdot Q_{\max}$  in the increment of  $0.001 \cdot Q_{\max}$ . The factory setting is  $0.002 \cdot Q_{\max}$ .

**Display's cutoff** is the flowrate threshold below which the flowrate value is displayed as zero, however volume totalizing, pulse generating and outputting of current signal continue.



For the reverse (bidirectional) flow, the cutoffs trigger both for positive and for negative flow directions. The flow direction signal also changes according to the preset cutoffs.

#### 2.4.4. Setting **User flow range**

The flowmeter also allows to set the minimum (**User flow range Qmin**) and the maximum (**User flow range Qmax**) values for the operating flow range. Parameter values are set as absolute values in volumetric flowrate measurement units (l/min).

When measured flowrate value is less than **Qmin** or greater than **Qmax**:

- The flowrate measuring and volume totalizing continue
- The alarm condition is registered and character **h** or **l** displayed on the LCD (see Fig.2a).

#### 2.4.5. Settings for the flowrate signal filter and automatic flowrate setup module

The Flowrate signal filter and Automatic flowrate setup module may be included in signal processing. Filter constant and parameters of the Automatic flowrate setup module determine flowmeter's time of response to changes in flowrate.

By default, the value of filter constant is set to 6, and the Automatic flowrate setup module is enabled with standard values of the parameters. Flowrate fixing values against values of filter constant at standard values of the parameters are given in Table 8.

**Table 8**

Constant of flowrate signal filter	Time of fixing flowrate value, s	
	Automatic module on	Automatic module off
<b>0</b>	1	1.5
<b>1</b>	2	3
<b>2</b>	3	6
<b>3</b>	5	12
<b>4</b>	6	24
<b>5</b>	6	48
<b>6</b>	6	96
<b>7</b>	7	192
<b>8</b>	8	384

#### 2.4.6. Setting the pipeline filling monitoring parameters

Functionality allowing the user to monitor how the pipeline is filled with the measured liquid (mains water) is implemented in the flowmeter. When measuring liquids with electrical conductivity differing from that of water, it is recommended to configure the flowmeter's parameters according to the guidelines in Appendix D.

## 2.5. Troubleshooting

2.5.1. The list of possible faults and alarm conditions detectable by the flowmeter and shown in relevant symbols on the LCD is given in Table.9.

**Table 9**

Fault Code, AIS	Event Description
–	Hardware failure <b>Memory</b> message is indicated
<b>!R</b>	Support measurement error
<b>!D</b>	Operating mode, without initialization
<b>!O</b>	Input signal level exceeds the allowed value for several measurement runs in a row
<b>Q</b>	Flowrate value is greater than $Q_{max}$
<b>1</b>	Value of $K_p$ on the output N1 not correct
<b>2</b>	Value of $K_p$ on the output N2 not correct
<b>c</b>	Flowrate value is outside the setpoints set for the current output
<b>h</b>	Flowrate value lower than user defined limit
<b>l</b>	Flowrate value exceeds user defined limit
<b>e</b>	Value of the probing signal exceeds the allowed value (empty tube)

NOTE: Configuration settings registry overflow is only displayed in “Viewer AFLOWT MF-Pro” program.

2.5.2. When flowmeter’s hardware fault or errors with codes **!R**, **!D** and **!O** take place, the flowrate measurement and volume totalizing are stopped. When message **Memory** or characters **!R**, **!D** are displayed the device should be dispatched for repair.

2.5.3. If other symbols are displayed and/ or no measurement data are displayed, check the following:

- Flowmeter and secondary power source input voltage is present and conforms to the specifications
- Power circuits are reliably connected
- Liquid is present and running through the pipeline
- Air is not collected in the Flowmeter's location
- Values of  $K_p$ , setpoints set for the current output, flowrate cutoffs, the lower and upper limits of the measured flowrate range. Modify these 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.

2.5.4. "AFLOWT MF" flowmeter, considering its design and recommended operating conditions should be repaired by authorized dealers or by the manufacturer.

### 3. MAINTENANCE

3.1. It is recommended to make inspections of the flowmeter put into operation on a regular basis at least biweekly, to check that:

- Performance of the Flowmeter complies with the specifications
- Operating conditions are met
- Power supply voltage is present
- No external defects are detected
- Electrical and mechanical parts are reliably connected.

The flowmeter can be inspected more often if required by the operation conditions.

3.2. During device's lifecycle, it is necessary to check the flowmeter inner channel for dirt or/and sediment at least once a year. Slight layer of sediment that can be removed with a soft damp cloth is permissible.

If dirt and/ or sediment of other type or in considerable amount are detected, it is necessary to clean the inner surface of the flow channel with water, clean cloth and non-abrasive detergent immediately after the flowmeter is retrieved from the pipeline.

**When removing dirt an/ or sediment of any type it is strictly forbidden to rinse the flow channel with a jet of liquid or to immerse it in liquid, even partly!**

Considerable amount of dirt and/ or sediment on the inner surface of the flowmeter flow channel which comes in contact with liquid shows that the pipeline is in unsatisfactory condition.

3.3. If the operating conditions of the device specified in section 1.2.8 are not observed, or the inner surface of the flow channel is damaged, this may lead to the device's fault, or the permitted limit of relative measurement error may be exceeded.

Therefore, when the device, its power and communication cables are damaged, contact the Service Center or regional dealer for the information about the device's operability.

The flowmeter is dispatched for the unscheduled calibration if the appropriate report is given by supervising authorities about unsatisfactory operation of the device.

3.4. Before dispatching the flowmeter for calibration or repair, clean the flowmeter inner channel from sediments that formed in the course of operation, and from the residues of liquid.

Mounting and dismounting of the flowmeter is regulated by the Instruction on installation for a given make of the flowmeter.

When the flowmeter is sent for service, the Equipment Certificate must be enclosed.

Please specify post details, phone/fax numbers along with the way and address for redispaching.

## 4. PACKING, STORAGE AND TRANSPORTATION

- 4.1. "AFLOWT MF" flowmeter completed in accordance with the order sheet is packed into a separate container made of corrugated carton or into a wooden box.

The set of fittings for one or several kits is delivered as an assembly or in bulk in a separate box.

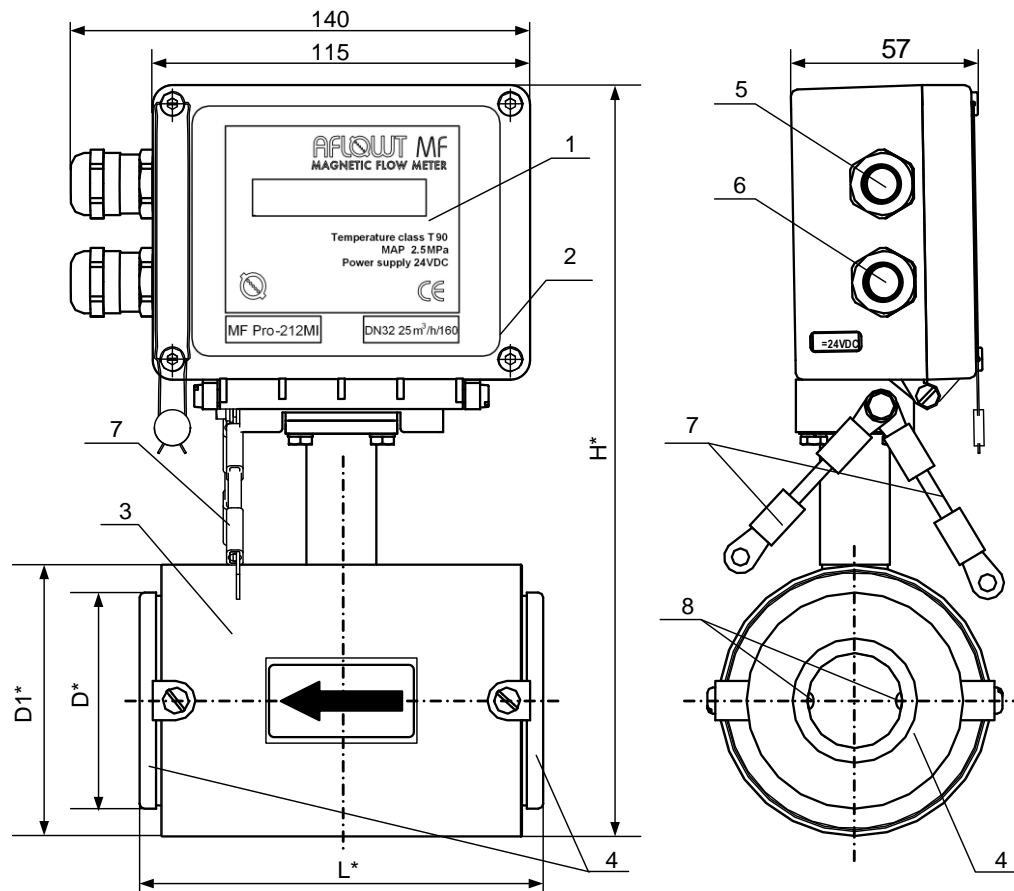
- 4.2. The flowmeter should be kept in the manufacturer's box in a dry heated storeroom. The storeroom should be free from current-conductive dust, acid or alkali fumes and aggressive gases that may damage insulation.

During storage the Flowmeter does not require any special maintenance.

- 4.3. The flowmeter can be transported by road, rail, sea or air (not in unpressurized compartments) provided that the following requirements are met:

- The flowmeter 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 95% at 35°C
- Vibration is within the range of 10-500 Hz with maximum 0.35 mm amplitude or acceleration of 49 m/s<sup>2</sup>
- Impact acceleration does not exceed 98 m/s<sup>2</sup>
- Flowmeters are fixed to prevent damages.

## APPENDIX A. View of components



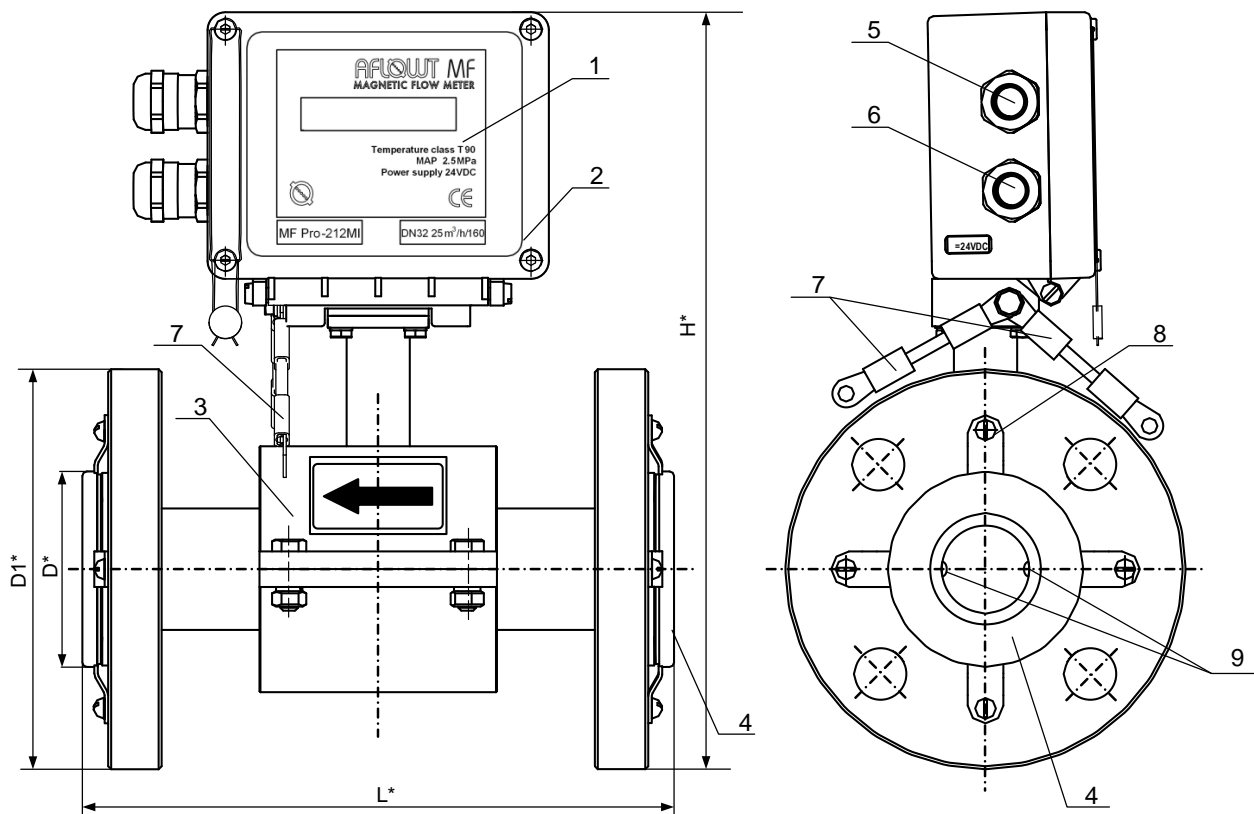
\* - reference dimension

1 – display; 2 – measuring block; 3 – flow sensor (primary flow converter); 4 – protection rings; 5 – signal cable through; 6 – power supply cable through; 7 – wires for connecting the flowmeter case and pipeline; 8 – electrodes.

**Fig.A.1. Pro-212M $\times$  flowmeter with protection rings**

**Table A1. Overall dimensions and weight of Pro- $\times$ 1 $\times$ M $\times$  flowmeters, DN10...DN150 standard sizes**

DN	D*, mm	D1*, mm	L*, mm		H*, mm	Weight, no more than, kg
			with protection rings	without protection rings		
10	34	60	93	85	206	1.19
15	39	60	93	85	206	1.19
20	50	73	114	106	220	1.74
25	57	73	114	106	220	1.79
32	65	83	124	116	230	2.19
40	75	89	134	126	235	2.54
50	87	102	154	147	250	3.39
65	109	121	175	167	267	4.64
80	120	140	175	167	286	5.79
100	149	159	216	208	305	9.49
150	202	219	236	228	365	15.7



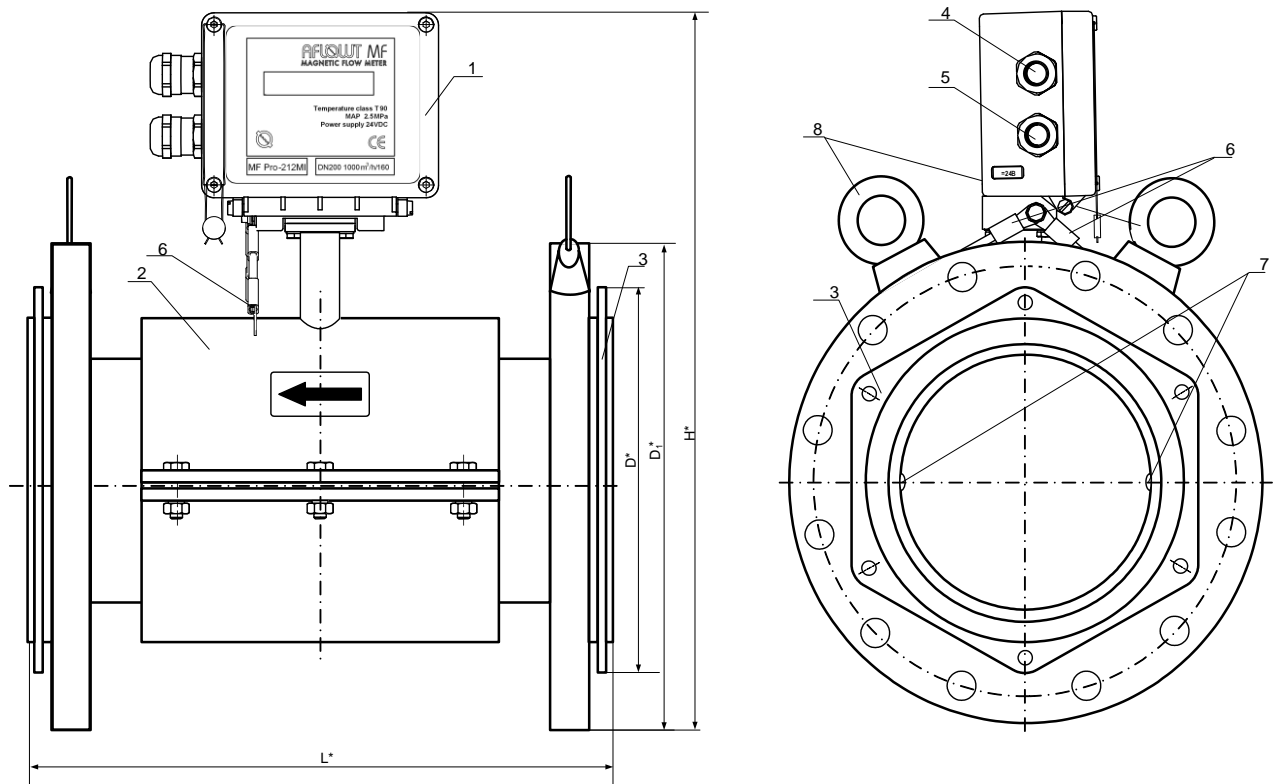
\* - reference dimension

1 – display; 2 – measuring block; 3 – flow sensor (primary flow converter); 4 – protection rings; 5 – signal cable through; 6 – power supply cable through; 7 – wires for connecting the flowmeter case and pipeline; 8 – additional grounding element; 9 – electrodes.

**Fig.A.2. Pro-222M× flowmeter with protection rings**

**Table A.2. Overall dimensions and weight of Pro-×2×M× flowmeters, DN20...DN150 standard sizes**

DN, mm	D*, mm	D <sub>1</sub> *, mm	L*, mm		H*, mm	Weight, no more than, kg
			with protection rings	without protection rings		
20	50	105	158	150	236	3.8
25	57	115	158	150	241	4.0
32	65	135	202	194	257	5.8
40	75	145	202	194	265	7.0
50	87	160	203	195	279	8.9
65	109	180	220	212	299	11.4
80	120	195	230	222	316	14
100	149	230	251	243	343	20
150	202	300	324	316	408	36



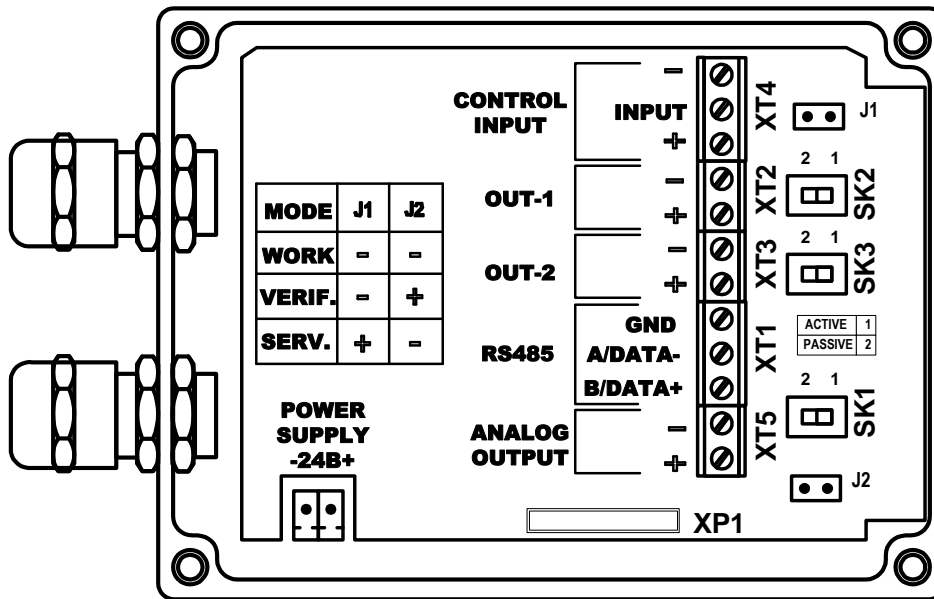
\* - reference dimension

1 – measuring block; 2 – flow sensor (primary flow converter); 3 – protection rings; 4 – signal cable through; 5 – power supply cable through; 6 – wires for connecting the flowmeter case and pipeline; 7 – electrodes; 8 – eye bolts.

**Fig.A.3. Pro-122M× flowmeter, DN200, DN300 standard sizes**

**Table A3. Overall dimensions and weight of Pro-×2×M× flowmeters, DN200, DN300 standard sizes**

DN, mm	D*, mm	D1*, mm	L*, mm		H*, mm	Weight, no more than, kg
			with protection rings	without protection rings		
200	258	358	362	344	464	59.0
300	362	485	514	496	581	120.4



- POWER SUPPLY – DC 24 V power supply connector*
- J1 – terminal used to enable modification of service settings*
- J2 – terminal used to enable modification of calibration settings*
- SK1 – switch used set operation modes for the current output*
- SK2 – switch to set operation mode for output stage, general-purpose output N1*
- SK3 – switch to set operation mode for output stage, general-purpose output N2*
- XP1 – connector for connecting flexible flat cable of display module*
- XT1 – RS-485 terminal block*
- XT2 – general-purpose output N1 terminal block*
- XT3 – general-purpose output N2 terminal block*
- XT4 – control Input terminal block*
- XT5 – current output terminal block.*

**Fig.A.4. View of Measurement Block with Communication Module (cover not shown)**



## APPENDIX B. Schematics of input and outputs

### B.1. General-purpose outputs

To match the MB (see Fig. B.1) output stages to inputs of different types, the output stages are designed to work with either the internal galvanically isolated power source (active mode) or an external power source (passive mode). In standard supply the output stages are in the passive mode.

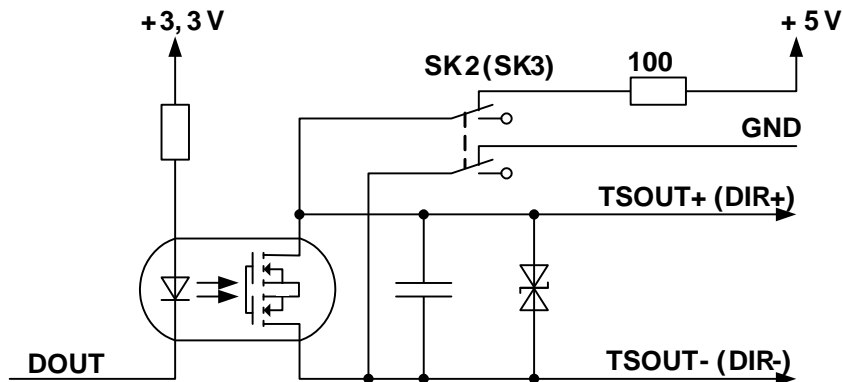


Fig.B.1. Universal outputs, circuit diagram of output stages

Switches SK2 and SK3 on the MB's communication board are used to connect the output stages to the internal power source +5 V.

In the active mode, in case of no pulse and corresponding to the logic **High**, output voltage is 2.4...5.0 V. In the presence of pulse or at logic **Low**, output voltage is maximum 0.4 V. External load resistance shall be of 1 kOhm as a minimum.

In the passive mode, power from an external power source with output DC voltage from 5 to 26 V may be applied. Amplitude of output pulses is limited by supressor's triggering voltage at the level of 15 V. Permissible value of external load current shall not exceed 150 mA.

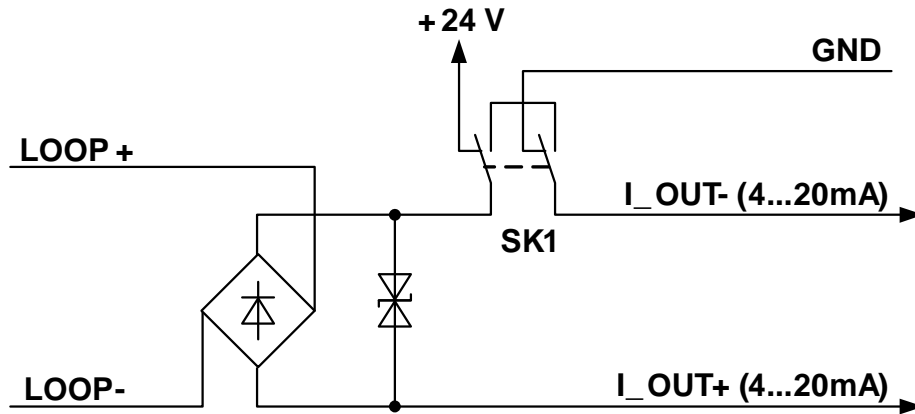
For the universal outputs, length of signal cables should be up to 300 m.

### B.2. Current output

The MB's current output (see Fig. B.2) is designed to work with either the internal galvanically isolated power source (active mode) or an external power source (passive mode). Switch SK1 on the Communication module board is used to switch the current output operation mode. In the passive mode, the allowable range of the external power supply voltage is from 24 to 40 V.

The MB current output can be connected to an external load up to 800 Ohm.

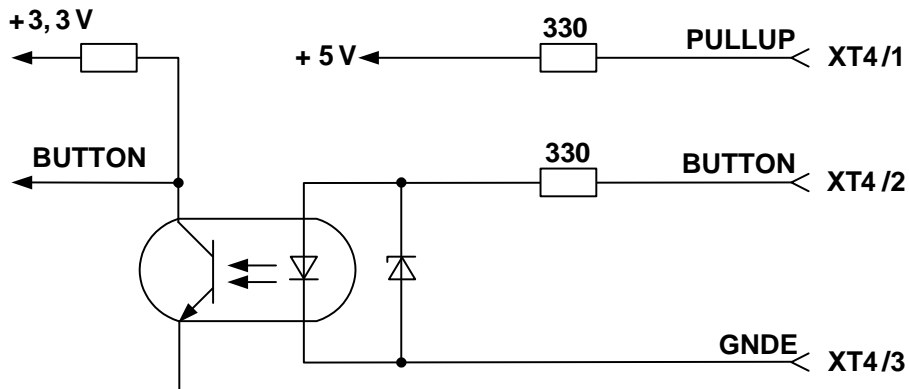
Permissible length of a signal cable connected to the current output depends on the resistance of the corresponding signal circuit. The condition is that the sum of input resistance of a connected input and signal circuit resistance must not exceed the above-specified external load resistance.



**Fig.B.2. Current output circuit diagram**

### B.3. MB Control Input

Circuit diagram for the MB control input is given in Fig. B.3.



**Fig.B.3. Circuit diagram of MB input stage**

As a control signal for XT4/2XT4/3 circuit, (0.5-20) mA current pulse signal is used.

If control signal is not applied, current in the circuit must not exceed 0.2 mA.

Control signal may also be generated on closing XT4/1 and XT4/2 contacts (e.g. by pressing a button) under the condition that external circuit resistance is no more than 100 Ohm.

Galvanic isolation of input circuit is provided in both cases.

## APPENDIX C. Configuring Pipeline Filling Settings

“**Empty tube**” Error in the flowmeter **is diagnosed** when level of the probing signal applied to the electrodes exceeds the threshold stored in the flowmeter based on the results of calibration for the empty pipeline. Signal threshold is calculated as one hundredth of the reference (calibration) signal and represented in percents in “Viewer AFLOWT MF-Pro” program.

When measuring liquids with electrical conductivity differing from that of mains water, it is recommended to modify the triggering threshold as follows:

1. Make sure the pipeline is completely filled with the measured liquid.
2. Switch the flowmeter to SERVICE mode by setting the jumper on the corresponding terminal on MB communication module board (see Fig.A.4).
3. Connect the flowmeter to the PC via RS-485 interface.
4. Launch Viewer AFLOWT MF-Pro application. Navigate to **Measures** tab in **Current values** group, and read value of **Empty pipe detection** parameter (current threshold signal) in nominal units (32, for example).
5. In **Flow measurement settings/ Empty pipe** tab, read **Current EP code** parameter value (probing signal reference value) in nominal units (318, for example).
6. Calculate new threshold value of the signal for the liquid being measured according to the formula:

$$EP = \frac{K_{cur} + 0,5 \cdot (K_{cal} - K_{cur})}{K_{cal}} \cdot 100\%,$$

where EP is the new threshold value of the signal for the empty pipeline, in percents;

Kcal is the reference (calibration) value of the probing signal, in nominal units;

Kcur is the current threshold value of the signal, in nominal units.

7. In **Flow measurement settings/ Empty pipe** tab enter the new threshold value of the signal for the empty pipeline (**Threshold,%** parameter).
8. Switch the flowmeter to WORK mode by removing the previously set jumper from the terminal on the MB communication module board.