## *Double-beam ultrasonic flow meter for direct installation in piping*

# SONOELIS SE8065

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# 1. APPLICATION

The **SONOELIS** double-beam ultrasonic flow meter of the type series **SE8065 for direct installation in piping** is a device for measuring instantaneous flow rate and the total volume of water passed through fully flooded piping. The flow meter includes hardware and software for communication with superordinated control systems. Compared to a single-beam meters, the double-beam principle allows for a higher precision of the flow rate measurement over a wider range of flow rate values.

Ultrasonic flow meter **SONOELIS SE8065** can be installed into existing steel piping with minimum mechanical modifications and relatively low investment costs. The advantages of this solution are particularly noticeable in the cases of large piping diameter where a flow meter sensor installation between flanges is far more expensive than a system using “direct” sensor installation.

# 2. FUNCTION PRINCIPLE

Flow meter **SONOELIS SE8065** uses a single-channel “transit-time” impulse method where the flow rate of the measured liquid is determined from the flight time of the ultrasonic signal between the sensor probes.

Each probe of the two pairs of ultrasonic probes installed into the piping under specified angles operates in turns as a sender and receiver (see Fig. 1].

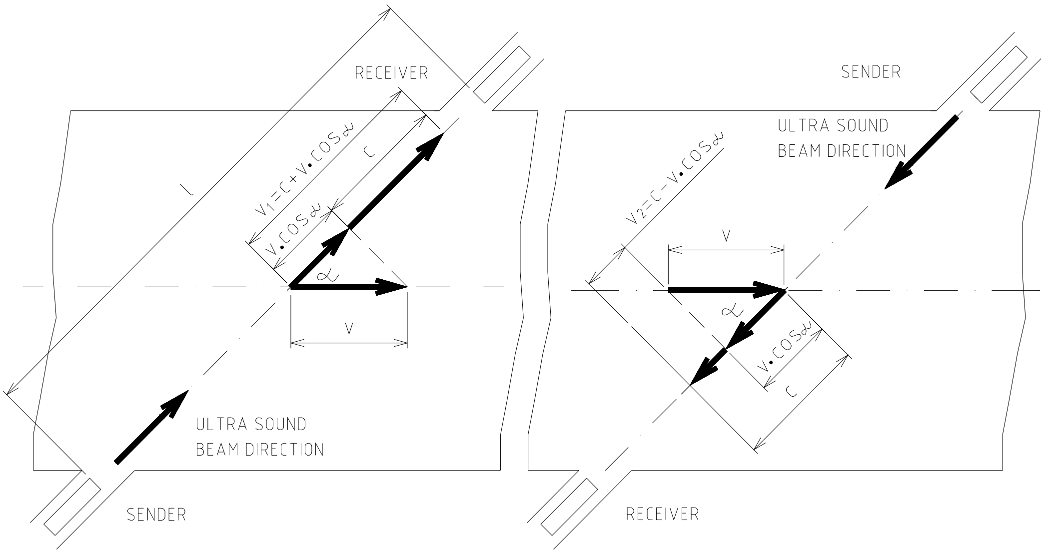



Fig. 1
Principle of flow rate measurement

It holds that ultrasonic ray in a flowing fluid propagates faster in the direction of the flowing fluid than against it. In the flow meter, electronic converter evaluates the differences between the transit (passage) times of ultrasonic signals sent in and against the direction of fluid flow, determines the average flow speed of the fluid and, taking into account the parameters of the meter piping, derives the value of the instantaneous flow rate. The above principle of flow rate measurement using ultrasonic ray can be described by the following equations:

$$v_1 = c + v \cdot \cos\alpha \qquad [1]$$

$$v_2 = c - v \cdot \cos\alpha \qquad [2]$$

$$t_1 = \frac{l}{v_1} \qquad [3]$$

$$t_2 = \frac{l}{v_2} \qquad [4]$$

where

- $v_1$ - ultrasonic ray speed in the direction of fluid flow [m/sec]
- $v_2$ - ultrasonic ray speed against the direction of fluid flow [m/sec]
- $t_1$ - ultrasonic ray passage time in the direction of fluid flow [sec]
- $t_2$ - ultrasonic ray passage time against the direction of fluid flow [sec]
- c - propagation velocity of ultrasonic signal in the measured medium [m/sec]
- l - distance between the face sections of ultrasonic probes [m]
- $v$ - instantaneous value of the average velocity of the flowing medium [m/sec]
- $\alpha$ - angle formed by the measuring ray and the longitudinal axis of the piping [$^o$]

After modification of equations [1] to [4] the average velocity of the medium flowing in the piping can be expressed as follows:

$$v = \frac{1(t_2 - t_1)}{2.t_1.t_2.\cos\alpha} \quad [5]$$

For the flow volume it holds: $q = v.s.k\,(v)$ [6]

where

- s - square section of the meter piping [$m^2$]
- k ($v$) - correction coefficient related to the velocity profile of the medium flowing in the meter piping

**From equations [5] and [6] it follows that the flow rate of the measured medium is independent of either sound propagation velocity in the flowing medium nor the medium pressure or temperature. It only depends on the difference between the passage times of the ultrasonic signal between the ultrasonic probes sent in and against the direction of the flow of the measured medium, and on the mechanical arrangement of the flow meter sensor, i.e. its dimensions and other physical properties.**

For a flow meter installed directly in the existing piping it is therefore necessary to define precisely the dimensions and properties of the meter piping section. After installation of the ultrasonic probes in the piping, all mechanical and physical data on the meter piping need be specified in electronic form and fed into the electronic unit UP 3.10 where the so-called theoretical calibration takes place.

# 3. TECHNICAL DESCRIPTION

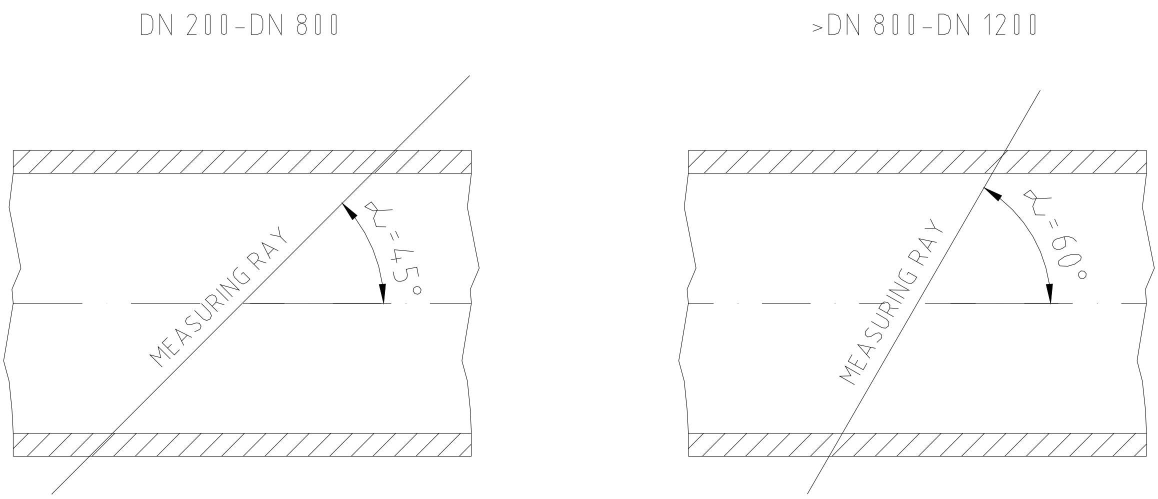
## 3.1. Terminology and symbols used in this manual

| | Symbol |
|---|---|
| **Meter piping**<br>*Meter piping is a section of the piping system complying with the requirements for flow meter installation* | |
| **Flow meter sensor**<br>*Meter piping including ultrasonic probes* | |
| **Length of flow stabilising piping**<br>*To ensure correct function of the flow meter, the flow velocity profile in the meter piping must be stable. This condition is met by ensuring that the flow sensor is located at a spot where there are straight sections of piping of sufficient length at the input and output sides of the meter. The required stabilisation length is given in multiples of the internal diameter of the meter piping.* | |
| **Surface top line**<br>*The surface top line is defined as a section line common to a perpendicular plane placed at the longitudinal axis of the piping and its outer surface.* | $\mathbf{p_v}$ |

| | |
|---|---|
| **Measuring ray**<br>*Measuring ray is ultrasonic signal propagating between the face sections of ultrasonic probes in a line identical with the longitudinal axes of the probes.* | |
| **Surface side line**<br>*The surface side line is defined as a section line common to a horizontal plane placed at the longitudinal axis of the piping and its outer surface.* | $p_b$ |
| **Outer diameter of the meter piping** | $D_o$ |
| **Inner diameter of the meter piping** | $D_i$ |
| **Angle formed by the measuring ray and the longitudinal axis of the meter piping** | $\alpha$ |
| **Ultrasonic probe** | |
| **Welded-on piece to which the ultrasonic probe is attached** | |
| **Welding flange** | |
| **Rectification pin** | |
| **Distance between the face sections of ultrasonic probes** | l |
| **Distance between the outer end faces of the welded-on pieces** | L |
| **Probe sealing thickness** | p |
| **Pipe wall thickness** | t |
| **Length of the ultrasonic probe body** | m |

## 3.2. Equipment description

The ultrasonic flow meter **SONOELIS SE8065** is an electronic device for measuring water flow rate in a fully flooded piping. It consists of electronic control unit UP 3.10 and flow meter sensor including ultrasonic probes US 2.0. The flow meter SE8065 in the standard configuration is suitable for application in piping of nominal sizes DN 200 to DN 1,200; with angle $\alpha$ = 45° for piping sizes up to DN 800 and $\alpha$ = 60° for larger sizes (see the schematic drawings below).




In its basic form, the flow meter includes isolated frequency and impulse outputs. On special request by the customer the flow meter configuration may be extended to include communication line RS 485, isolated current output and, upon installation of a resistor thermometer Pt 100 measuring the temperature of the flowing fluid, the measured fluid volume data can be converted to mass (fluid weight) data. The meter in extended configuration also allows for fluid flow measurement in both directions of flow with the flow direction indication.

The necessary components of the flow meter **SONOELIS SE8065** system with ultrasonic probes installed directly in the existing piping are:

1 pc. Electronic control unit UP 3.10 (Fig. 2)
4 pcs Ultrasonic probe US 2.0 including coaxial cable (the cable length to be specified by the customer; Fig. 3)
4 pcs Welded-on piece (Fig. 4)
4 pcs Welding flange (Fig. 5)
4 pcs Probe sealing
1 pc. Application, installation and service manual
1 pc. Calibration code Es 90 401 D

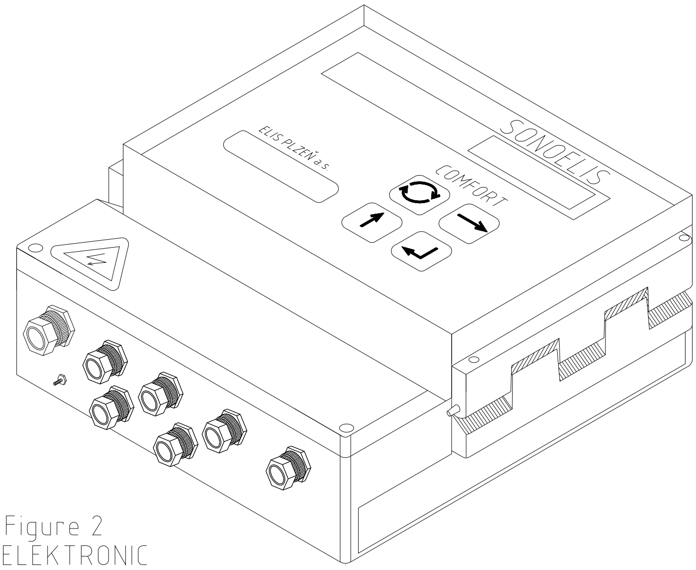



Figure 2
ELEKTRONIC
CONTROL UNIT

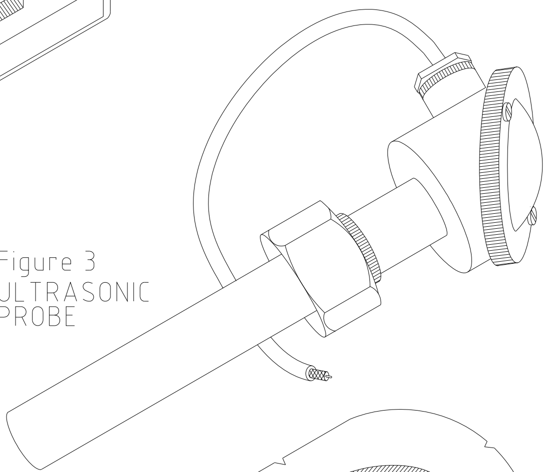


Figure 3
ULTRASONIC
PROBE

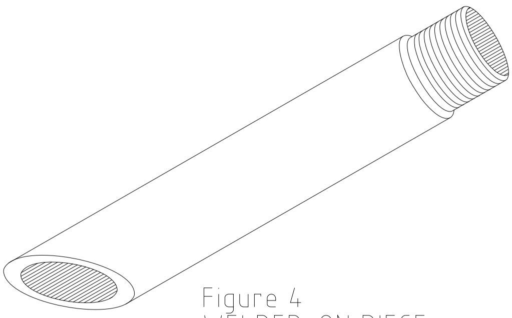


Figure 4
WELDED-ON PIECE

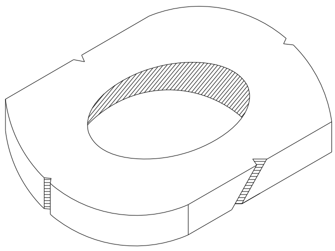


Figure 5
WELDING
FLANGE

In the case of a meter installation by the customer, the delivery kit may include various optional measuring and assembly fixtures, such as:

- 1 pc. Communication cable (see section 7.1)
- 1 pc. Protractor (Fig. 6)
- 1 pc. Protractor holder (Fig. 7)
- 1 pc. Strap piece (Fig. 8)

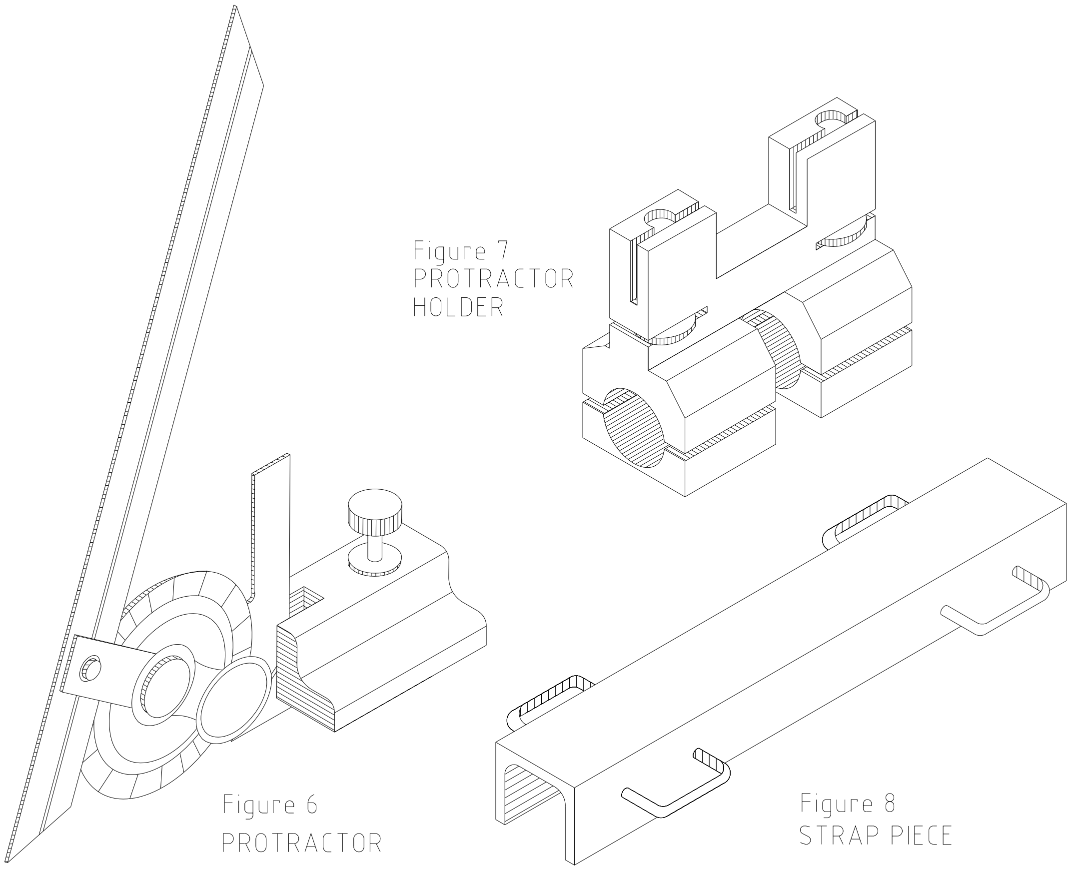


Figure 7
PROTRACTOR
HOLDER

Figure 6
PROTRACTOR

Figure 8
STRAP PIECE

- Parts completing the rectification pin assembly including:

1 pc. Protractor adaptor (Fig. 9)
1 pc. Milling adaptor I including milling tool and nut (Fig. 10)
1 pc. Milling adaptor II (Fig. 11)

- Connecting parts (Fig. 12) as identified in the table below:

| Piping size | Connecting part, L = 250 | Connecting part, L = 450 | Connecting part, L = 850 |
|---|---|---|---|
| DN 200 | 1 | - | - |
| DN 250 | 1 | - | - |
| DN 300 | 1 | - | - |
| DN 350 | - | 1 | - |
| DN 400 | - | 1 | - |
| DN 500 | - | 1 | - |
| DN 600 | - | - | 1 |
| DN 700 | - | - | 1 |
| DN 800 | - | - | 1 |
| DN 900 | - | - | 1 |
| DN 1,000 | - | - | 1 |
| DN 1,200 | - | 1 | 1 |

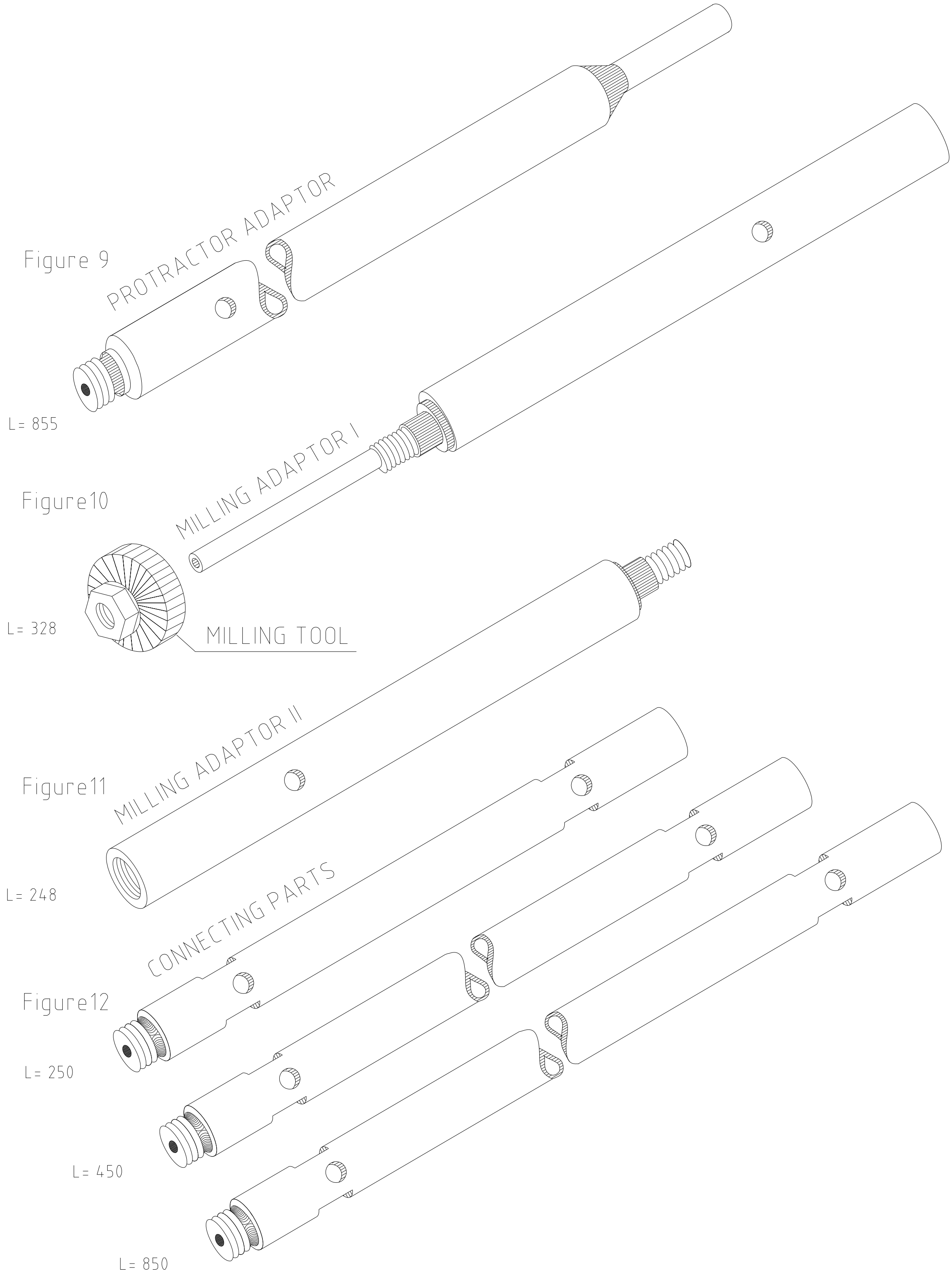


Figure 9
PROTRACTOR ADAPTOR
L= 855
Figure10
MILLING ADAPTOR I
L= 328
MILLING TOOL
Figure11
MILLING ADAPTOR II
L= 248
CONNECTING PARTS
Figure12
L= 250
L= 450
L= 850

## *3.3. Meter design*

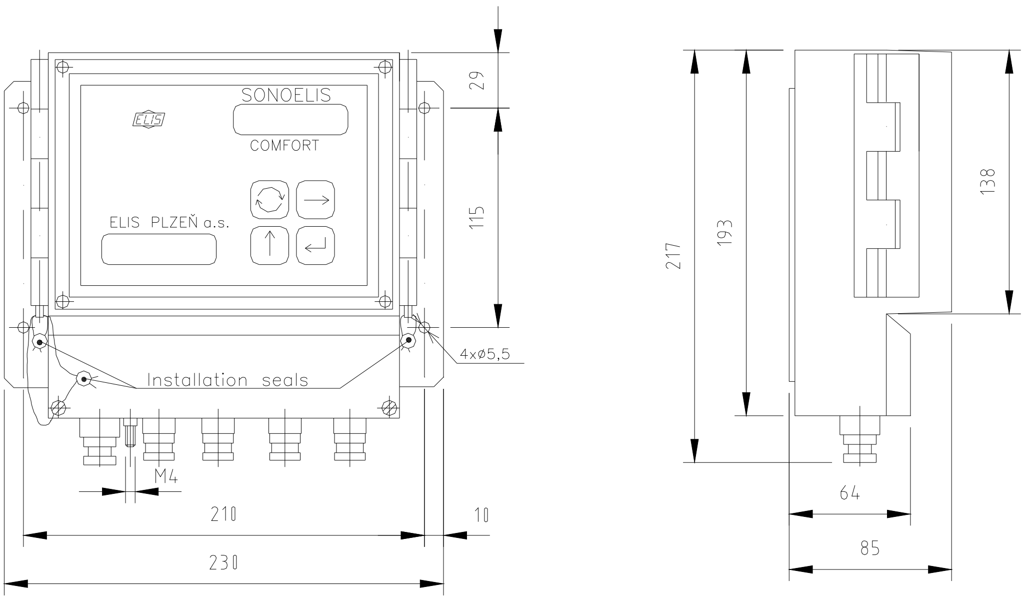
### 3.3.1. Flow meter sensor

The flow meter sensor assembly consists of meter piping and two pairs of ultrasonic probes installed in it.

### 3.3.2. Electronic unit UP 3.10

The electronic accessory of the flow meter is installed in a plastic box designed to be hung on a vertical support plate. On the front part of the box there are: flow meter type designation, series number and trade name, the logo and trade name of the manufacturer, two-line rear-lighted display unit and membrane keyboard including four push-buttons. At the bottom part of the plastic box covered with a removable lid are a terminal strip, grounding bolt and leadthroughs PG9 and PG7 for cables of circular cross-section. Leadthrough PG 9 can accommodate a cable of diameter 6 to 8 mm, PG 7 a cable of diameter 4 to 6 mm. Both the front panel and the bottom lid can be sealed in closed position. Instead of one leadthrough PG 7 it is possible to install a four-pole connector for the RS 485 communication line.

Dimensional sketch of the electronic accessory box




## 4. TECHNICAL PARAMETERS

## *4.1. Flow rate determination*

The basic parameter to be determined prior to installation of a flow meter is the range of flow rate values expected in the given piping.

The flow rate is defined by the following formula:

$$v = \frac{4 \cdot q}{3600 \cdot \pi \cdot D_1^2} \qquad \left[m/s, m^3/hod, m\right]$$

where $D_i$ - inner diameter of the meter piping
$q$ - measured flow rate.

The flow rate of the measured medium in the meter piping should stay within the range of 0.1 to 10 m/sec. Where the given situation allows for such selection, it is recommended that the nominal flow rate $q_p$ should be reached at the flow velocity 4 to 5 m/sec.

## *4.2. Technical specifications*

| | |
|---|---|
| Inner diameter of piping DN | 200 to 1,200 |
| Measuring ray angle $\alpha$ | for DN between 200 and 800 – 45°<br>for DN bigger than 800 and 1,200 – 60° |
| Measurement accuracy | ±1 ÷ 2% of the measured flow rate within the range<br>of 5 to 100 % $q_s$<br>($q_s$ – maximum flow rate at the fluid flow velocity of 10 m/sec) |
| Nominal pressure of the measured liquid PN | max. 40 bar |
| Temperature of the measured liquid | 0 to +150 °C |
| Ambient temperature | +5 to +55 °C |
| Ambient humidity | maximum relative humidity 80 % |
| Storage temperature | -10 to +70°C at relative humidity not exceeding 70 % |
| Protection class<br>- electronic unit UP 3.10 | IP 65 |
| - probe US 2.0 | IP 54 |
| Ultrasonic probes | 4 pcs US 2.0 (manufacturer ELIS PLZEŇ a.s.) |
| Probe installation | Directly in the piping (see the installation manual) |
| Connecting cable to probe US 2.0 | Standard length 8 m |
| | Maximum length 25 m (or more, on prior agreement with the manufacturer/supplier) |
| Differences in cable lengths | Not exceeding 0.1 m |
| Electronic unit UP 3.10<br>- housing dimensions<br>- weight<br>- power supply<br>- back-up power supply<br>- power requirement<br>- line fuse<br>- protection against electric shock according to standard ČSN 332000-4-41 | <br>230 x 217 x 85 mm<br>1,5 kg<br>90 ÷ 260 V, 50/60 Hz<br>Li battery 3 V (lifetime 5 years)<br>6 VA<br>T 250 mA, 250 V<br>automated disconnection from the power supply in the TN-S network |
| Measured flow velocity range | Minimum velocity 0.1 m/sec |
| | Maximum velocity 10 m/sec |
| Data visualisation | 2 x 16-character LC display |
| Outputs<br>Opto-electronically isolated outputs | Impulse output 0.1 to 10,000 l/imp., impulse length 50 ms |
| | Frequency output 0 to 1,000 Hz (corresponding to flow rates 0 to $q_s$) |
| | Switching output 24 V AC/0.1 A |
| | Communication line RS 485 |
| Optional accessories | Isolated current output 0 to 20 mA or 4 to 20 mA (corresponding to flow rates 0 to $q_s$) |
| | Mass flow rate measurement accessory |
| | Equipment for bi-directional measurement including indication of the fluid flow direction |
| | Expanded liquid temperature to +180 °C |
| | Transducer's protection IP 68 |

## 4.3. Communication with external devices

On customer's requirement the ultrasonic flow meter can be equipped with an isolated serial communication line RS 485 of the following parameters:

Data transfer speed 4,800 Bd (or, on customer's request, 1,200, 2,400 or 9,600 Bd); data bit number 8; one stop bit; parity selectable in each data communication direction. The communication data format includes, among other information, all measured or calculated flow values such as instantaneous volume or mass flow rate, aggregate volume or mass of the medium passed through the flow meter or information on the resetting command for the aggregate flow data.

The communication data format is not included in this manual, but it is available to the customer on request.

# 5. GENERAL RULES FOR FLOW METER APPLICATION

The selection of the piping section where ultrasonic probes are to be installed (or, in other words, where the meter piping is to be created) is of utmost importance for the correct functioning and measurement accuracy of the flow meter.

**Recommended lengths of stabilisation piping before and after the meter piping**

| Type of hydraulic disturbance at the input side of flow meter | Required length of stabilisation piping | |
|---|---|---|
| | at the meter input | at the meter output |
| One 90° bend | 10 DN | 3 DN |
| Two 90° bends in the same plane | 15 DN | 3 DN |
| Two 90° bends in two perpendicular planes | 25 DN | 3 DN |
| Valve or pump | 30 DN | 3 DN |

It is recommended to install flow meters before any valves and/or pumps included in the piping system concerned.

# 6. FLOW METER INSTALLATION

## 6.1. Meter assembly and installation

Strict observance of the rules and procedures for the flow meter assembly and installation as given in this manual is necessary in order to assure the best performance of the meter.

To prevent undesirable electromagnetic interference, the minimum distance between the power and signal cables shall be 25 cm. Any connections of signal wires and cables shall be soldered and the soldered joints shall be placed in suitable installation boxes to ensure protection against mechanical and environmental stresses. All cables shall be laid outside the thermal insulation layers on the piping (if any). The connections to thermometer Pt 100, current outputs and the communication system RS 485 shall be done by shielded conductors where the shielding layer shall be connected to the earthing potential on one end of the cable only (at the terminal block X1 of the associated electronic system). Shielded conductors are also recommended for the frequency and impulse output signals where the one-sided earthing shall be done on the side of the superordinated control system.

In the cases where flow measurements are to be performed in operational environments including high-level electromagnetic fields (industrial plants using frequency converters, switching stations, power generation plants etc.), it is recommended to connect the earthing potential bolt of the flow meter electronic system (located at the bottom of the box) with the ultrasonic probes by earthing conductor of a minimum cross-section 4 $mm^2$.

## 6.1.1. Recommended assembly fixtures and tooling

Apart from special measuring and installation fixtures listed in Section 3.2. above, the following standard materials and tooling are required for the flow meter installation:

Abrasive fabric, no. 60
Water level, minimum length 400 mm
Flexible steel rule, length 1,000 mm
Steel rule, length 3 m
Steel measuring band (flat), minimum length 10 m
Slide calliper
Marking awl
Hammer
Centre punch
Steel square 40 x 40 mm, length 0.6 $D_o$
Paper sheet, dimensions 1.1 $D_o$ x 1.8 $D_o$
Drawing kit (set square, drawing pen etc.)
Chalk, white
Spirit marker, black, diameter 1 mm
Fixing rubber ropes
Cover for thread G 1“ on welded-on piece
Half-round file
Steel pin, diameter 7 mm, length 200 mm
“Side” spanner 19 mm, 2 pieces
Calculator with trigonometric and other mathematical functions
Electric welding machine 250 A and accessories
Oxy-acetylene cutting machine including burners
Manual angle grinder and grinding wheel, diameter 125 mm
Electric manual drilling machine, chuck – diameter 12 mm

## 6.1.2. Flow meter installation criteria

### 6.1.2.1. Selection of measuring spot

When selecting the part of the piping where the flow meter sensor is to be installed (see also Section 5), make sure that the surface quality of the piping, in particular any irregularities of shape, deformation, the position and surface finish of welds, whether longitudinal, helical or other, is such that it allows for sufficiently accurate determination of the angle formed by the measuring ray and the longitudinal axis of the piping.

### 6.1.2.2. Necessary room for flow sensor installation

The flow sensor installation in any existing piping (using the fixtures and tooling specified in this manual) requires free room of at least 900 mm to the sides of the welded-on pieces and in the direction of the measuring ray (see Fig. 13).

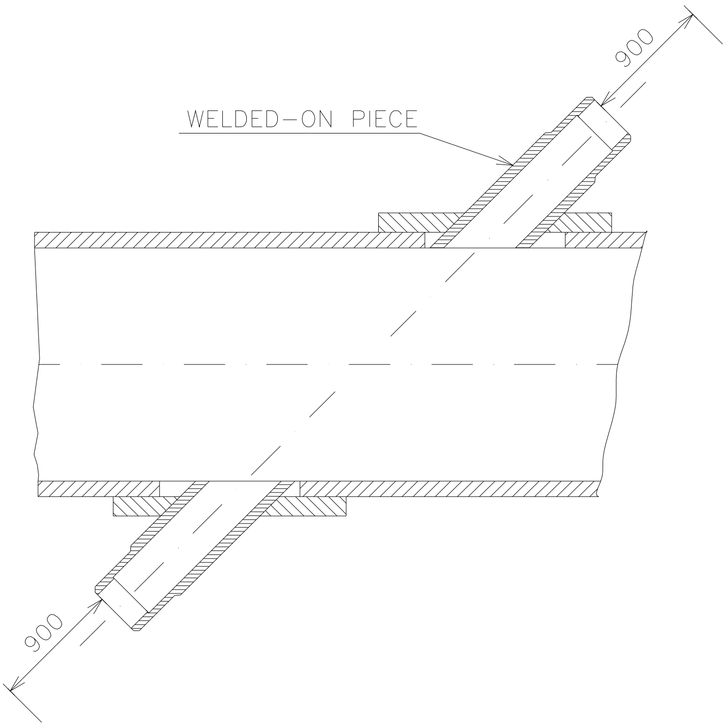



Fig. 13
Required free room around the welded-on pieces

The axes of the ultrasonic rays shall be arranged as shown in Fig. 14.

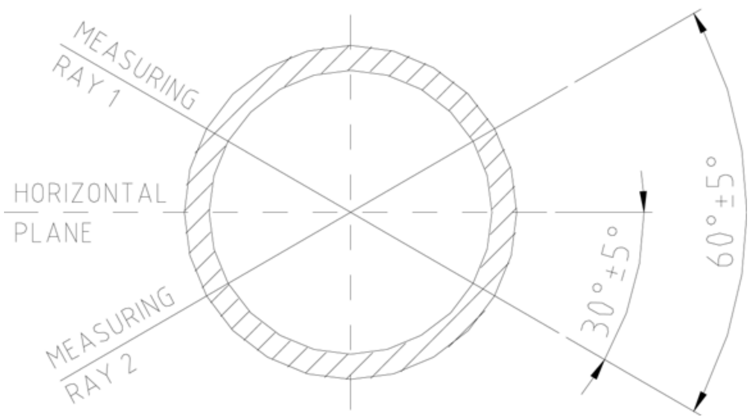



Fig. 14
Arrangement of the ultrasonic rays in the meter piping

The preparatory steps for the ultrasonic sensor installation, determination of the mechanical parameters of the sensor and other installation processes have been designed for application at the customer's plant and operational conditions.

## 6.1.3. Preparatory and measuring operations on meter piping

The surface of the meter piping shall be clean and smooth; any adhering dirt, rough irregularities of shape, corrosion products and traces of paint shall be removed.

### 6.1.3.1. Determination of outer diameter of meter piping

Each of the two optional methods described below can be used:

**Diameter calculation from piping circumference**
This method is suitable for piping of larger diameters. Measure the piping circumference using a flat steel tape.

The outer diameter of the meter piping can then be calculated as follows: $D_o = \frac{O}{\pi}$

where O – piping circumference, being the average value of two circumference measurements taken at the locations where both pairs of the welded-on pieces are to be installed.

**Direct diameter measurement using diameter gauge** Take three diameter measurements, at 120°distance , at each of the two intended positions of both pairs of the welded-on pieces. The outer piping diameter shall then be determined as the average value of all six measurements.

$$D_{o1} = \frac{D1 + D2 + D3}{3} \qquad D_{o2} = \frac{D4 + D5 + D6}{3}$$

$$D_o = \frac{D_{o1} + D_{o2}}{2}$$

where D1 to D6 are the measured values of the outer diameter of the meter piping.

### 6.1.3.2. Marking of surface top line

Water level is considered a tool of sufficient accuracy to define the surface top line on the meter piping (see Fig. 15). The two points on the surface top line ($a_1$, $a_2$) are the points of contact between the piping and water level after the latter has been set in the horizontal position. The distance between the points $a_1$ and $a_2$ is recommended to be selected equal to the piping diameter ( $b = D_0$). Use a steel rule to draw the top surface line $p_v$.

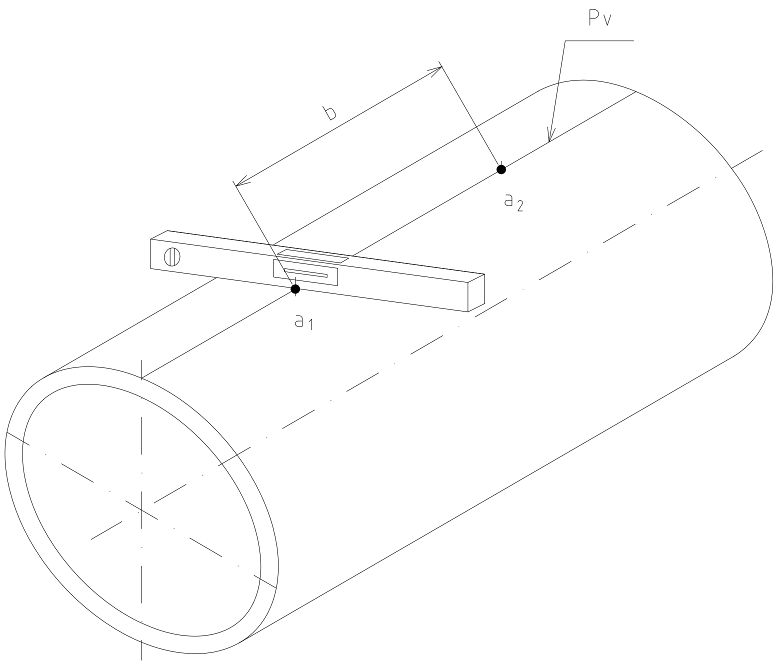



Fig. 15
Marking of surface top line on meter piping

## 6.1.3.3. Laying out of installation points

To measure and mark the key installation points on the piping select and use one of the following two methods:

**Direct method** – Measurements are taken and installation points marked directly on the piping.

**Indirect method** – The installation points are transferred onto the piping by means of a template prepared on drawing paper.

The indirect method is less time-consuming and therefore preferred in most practical situations.

### Direct method

Draw four parallel side surface lines ($p_{b1}$, $p_{b3}$ and $p_{b4}$, $p_{b2}$) at the distances of $\frac{\pi.D_o}{6}$,( i.e. $D_o$ x 0.524) and $\frac{\pi.D_o}{3}$ ($D_o$ x 1.047), left and right of the top surface line (see Fig. 16).

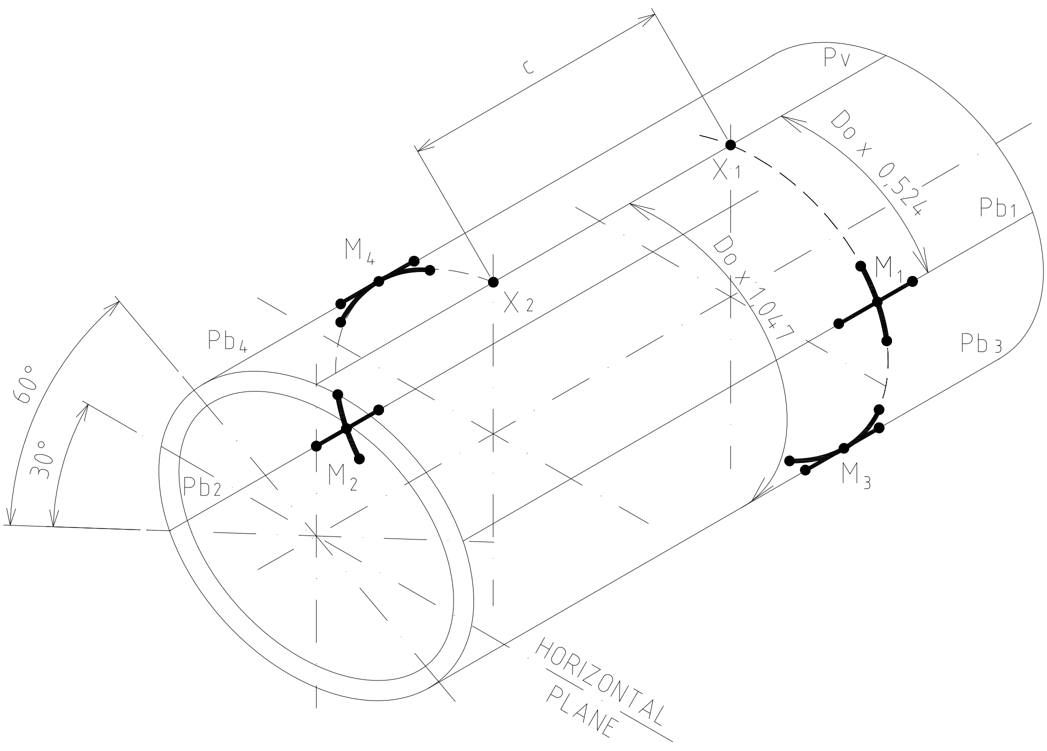



Fig. 16
Laying out of key installation points

On the top surface line $p_v$ mark two points ($X_1$ a $X_2$) at the distance of c. The distance c is defined by the formula $c = \frac{D_o}{tg\alpha}$, from which it follows:

for $\alpha = 45^o$ c = $D_o$,

for $\alpha = 60^o$ c = $D_o$ x 0.5774.

From points $X_1$ and $X_2$ on the top surface line lead perpendicular lines along the piping surface towards the parallel lines $p_{b1}$, $p_{b3}$ and $p_{b4}$, $p_{b2}$. The points of intersection, $M_1$, $M_3$ and $M_4$, $M_2$, are the points where the measuring rays intersect the surface of the meter piping. Points $M_1$, $M_3$ and $M_4$, $M_2$ serve the purpose of accurate setting of the positions of the welding flanges. Define points $M_1$, $M_3$ and $M_4$, $M_2$ by crosses of lines of at least 100 mm each and mark the cross line ends by centre punch dots (see Fig. 16).

**Indirect method**

To prepare a template of installation marks use a paper sheet of minimum dimensions 1.1.$D_o$ x 2.2.$D_o$.

**A.** Draw a centre line ($p_v$) and mark on it the points $X_1$ and $X_2$ at the distance of $\frac{D_o}{tg\alpha}$ (for $\alpha$ = 45° it is $D_o$, for $\alpha$ = 60° the distance of $D_o$ x 0.5774).

**B.** At points $X_1$ and $X_2$ draw parallel lines perpendicular to the central line $p_v$, one on each side, and mark on them points $M_1$, $M_3$ and $M_4$, $M_2$ at the distance of $\frac{\pi . D_o}{6}$ ($D_o$ x 0.7854) and $\frac{\pi . D_o}{3}$ ($D_o$ x 1.047) from the central line $p_v$. Points $M_1$, $M_3$ and $M_4$, $M_2$ shall further be defined by crosses of lines of minimum length of 100 mm (see Fig. 17).

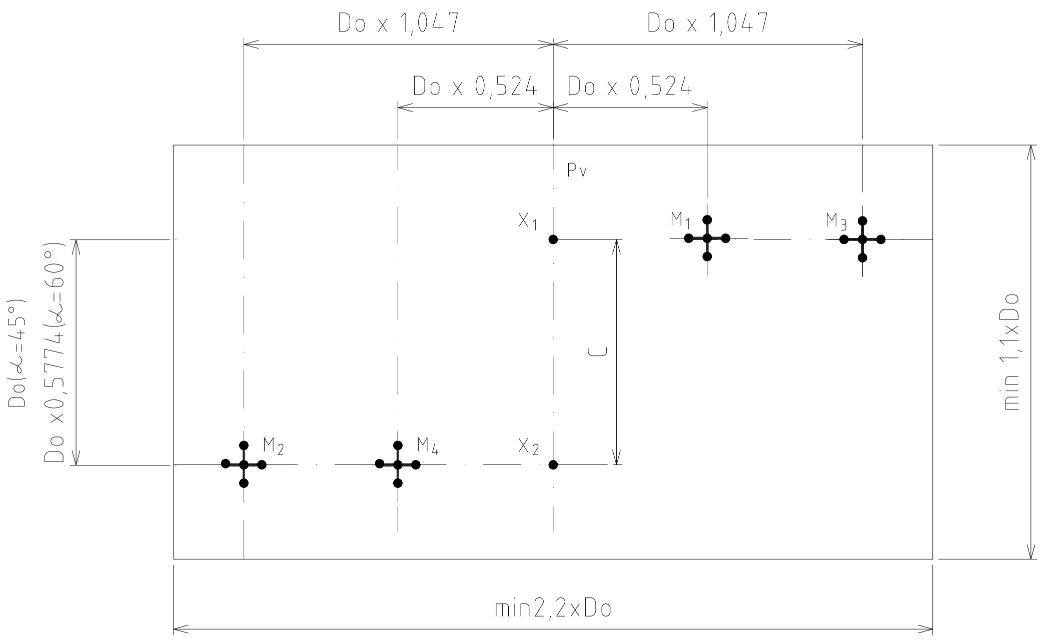



Fig. 17
Paper template

**C.** Lay the paper on the piping so that the central line $p_v$ coincides with the top surface line marked on the meter piping. Then, using a centre punch, transfer all key points including the ends of the cross lines onto the piping.

**D.** Using a drawing awl, mark the crosses defining the points $M_1$ and $M_2$ on the piping surface.

## 6.1.4. Installation of welded-on pieces into the piping

**A.** Using oxy-acetylene machine and burner, cut circular holes in the meter piping of diameter 60 mm with the centres at points $M_1$ through to $M_4$. Prevent the cut-out sections from falling inside the piping; they will be needed to determine the inner diameter of the piping. In the cases of pipe with the wall thickness t in excess of 5 mm (for $\alpha$ = 45°) and t greater then 15 mm (for $\alpha$ = 60°) it is necessary to modify the holes of diameter 60 mm so as the welded-on pieces can be inserted into the piping as shown in Fig. 18. Both the inner and outer edges of the holes shall be smooth and clean.

**B.** The edges of the cut-out sections shall be ground without damaging the surfaces. Then use a slide calliper to determine the thickness of the pipe wall.

**C.** Select one pair of assembly points, e.g. $M_1$ and $M_2$. Slide the welding flanges onto both welded-on pieces and adjust their positions with respect to the setting marks. The insertion depth shall be such that the bottom part of the welded-on piece is flush with the internal surface of the meter piping (see Fig. 18). Mark (on the welded-on piece) the correct depth of insertion of the welded-on piece info the flange.

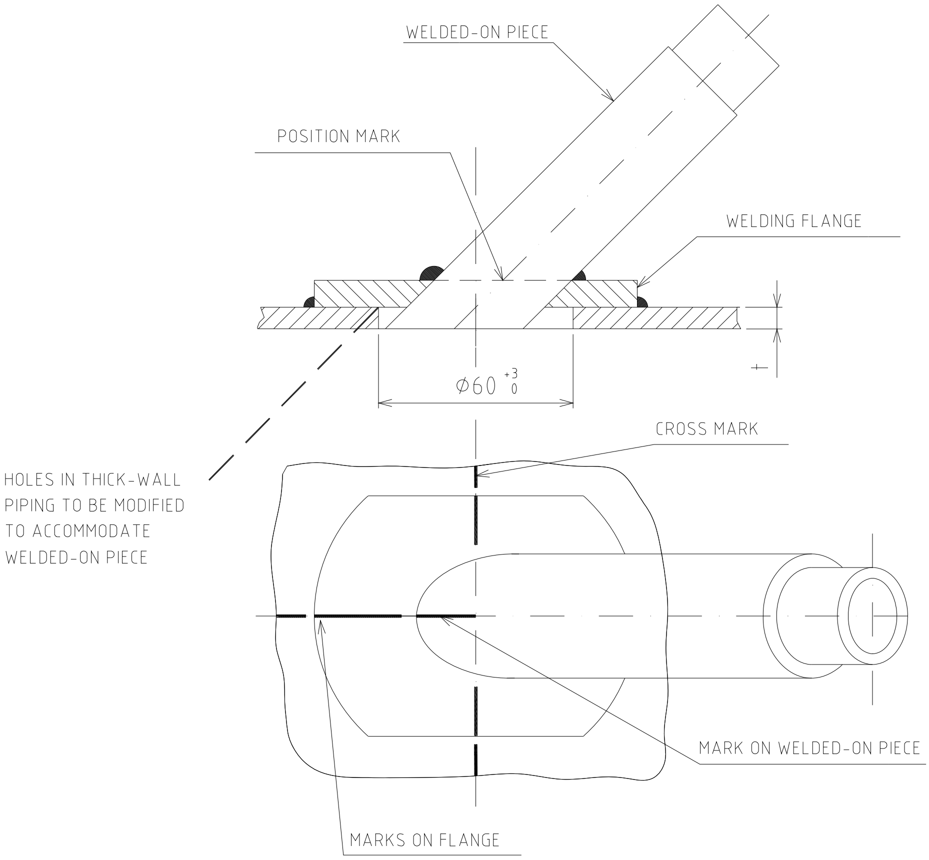



Fig. 18 - Assembly of welded-on pieces

**D.** Assemble the rectification pin of the following component parts: milling adaptor I, connecting parts selected to fit the piping size and protractor adaptor. The parts shall be property tightened together (see Fig. 19).

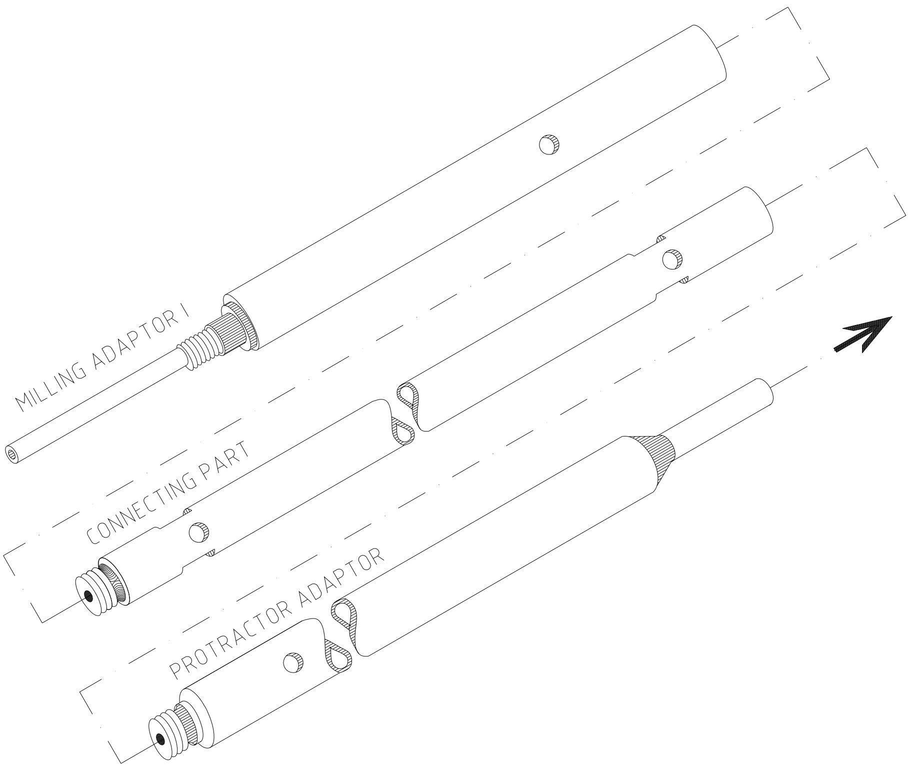



Fig. 19 - Rectification pin assembly

Insert the assembled rectification pin into the holes in the pipe in the direction indicated in Fig. 19.

**E.** From both sides of the meter piping, slide the welding flanges and welded-on pieces on the rectification pin. The flange marks shall be positioned against the cross marks drawn on the pipe. The welded-on pieces shall be set to the desired position with respect to the assembly marks. Check the ease movement of the rectification pin in the welded-on pieces.

**F.** Check the correct position of one of the flanges with respect to the cross mark and fix its position by four light welds; repeat the same with the other flange.

**G.** Check the play of the rectification pin in the welded-on pieces (it shall be easily rotated and moved in the axial direction). Apply fillet weld to fix the positions of the flanges on the piping.

**H.** Set the correct positions of the welded-on pieces in the flanges using the assembly marks and fix the positions by light welds at several spots.

**I.** Check the play of the rectification pin in the welded-on pieces again. Using fillet welds, weld the welded-on pieces to the flanges.

**J.** Repeat the procedure from Section 6.1.4.C onwards for the remaining two pairs of assembly pints ($M_3$ and $M_4$).

**Comment:**
*When performing the welding operations with the welded-on pieces slid on the rectification pin, make sure that the functional parts of the welded-on pieces cannot be damaged by the flying sparks. Protect the welded-on pieces by suitable cover or nut. Should it be found that, at any time during the welding operations, the rectification pin has lost its desired play (free rotation and displacement in the welded-on pieces), the reason for that must be established and the defect removed by slight knocking on the welded-on pieces (with the thread protected).*

**It is recommended to check the play of the rectification pin after each welding operation.**

## 6.1.5. Facing of the seating surfaces on the welded-on pieces

To ensure a perfect alignment of both pairs of the ultrasonic probes, the seating surfaces on the respective welded-on pieces need be end-faced. This is the final assembly operation; insert a milling tool onto the milling adaptor I end of the rectification pin and secure its position by a nut (see Fig. 20).

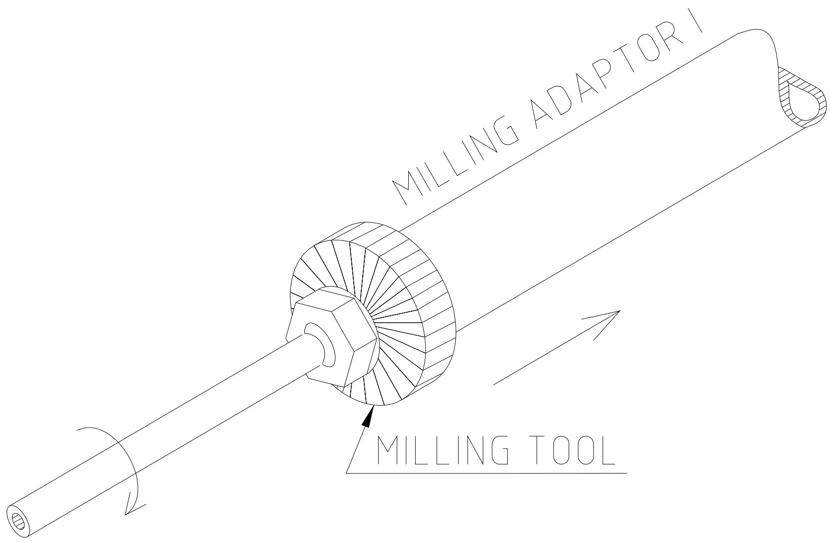



Fig. 20
Facing of the seating surfaces on the welded-on pieces

Grease slightly those parts of the rectification pin that will rotate in the welded-on pieces with vaseline. Using a drilling machine with controlled speed rotate the rectification pin in the clockwise direction and face the seating surface on the welded-on piece. Then remove the rectification pin, insert it into the welding pieces in the opposite direction and face mill the other seating surface.

Should there be insufficient room on the other side, do not remove the rectification pin, but replace the protractor adaptor by the milling adaptor II with a milling tool attached, secure the threads against movement (using the Locktite bonding agent or similar sealing material) and face the inaccessible seating surface by pulling at the rectification pin and rotating it in the counter-clockwise direction (see Fig 21).

After the milling operation, remove the milling tool and nut and leave the rectification pin inserted in the welded-on pieces.

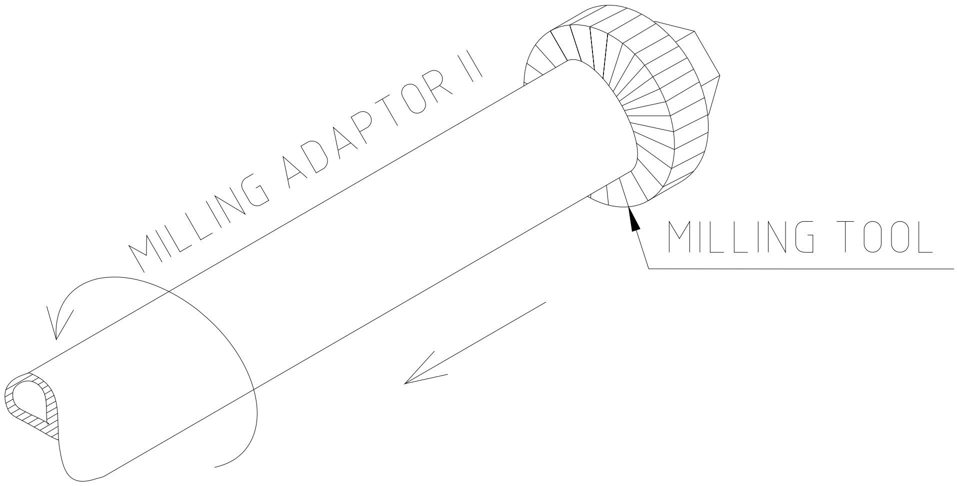



Fig. 21
Facing of the seating surface on an inaccessible welded-on piece

## 6.1.6. Determination of mechanical parameters of the meter sensor

To meet the specified measurement accuracy of the flow meter SONOELIS SE8065, the mechanical parameters of the meter piping need be determined with the precision of 1 ‰.

Example: For piping DN 500, the measurement ray angle $\alpha$ = 45 and the distance between the outer end faces on the welded-on pieces L = 850 mm, the mechanical parameters of the meter piping need by determined with the following precision:

$$\Delta L = \frac{L}{1000} = 0{,}85mm$$

$$\Delta D_1 = \frac{D_1}{1000} = 0{,}5mm$$

Angle $\alpha$ needs be determined with the precision of 0.1° irrespective of the piping diameter.

### 6.1.6.1. Measuring ray angle

**A.** Remove all corrosion products, traces of paint and other undesirable impurities from the piping surface where the strap piece is to be laid. The procedure will be described for one pair of ultrasonic probes corresponding to the surface line $p_{b1}$.

**B.** Place the strap piece onto the piping so that its longitudinal axis is parallel to the side surface line $p_{b1}$ on the piping. Use rubber ropes to hold the strap piece firmly to the piping surface (see Fig. 22).

**C.** Attach a protractor onto the protractor adapter mounted at one of the ends of the rectification pin.

**D.** The angle $\alpha$ measurements (altogether three measurements) shall be performed in the plane defined by the longitudinal axis of the piping and the side surface line $p_{b1}$. Between the measurements knock slightly on the strap piece or move it to the side and back to ensure its correct seating.

**E.** Repeat the same procedure for the other pair of ultrasonic probes and the surface line $p_{b1}$.

**F.** The value of angle $\alpha$ shall be determined as the arithmetic average of all measurements taken.

$$\alpha = \frac{\alpha 1 + \alpha 2 + \alpha 3 + \alpha 4 + \alpha 5 + \alpha 6 + \alpha 7 + \alpha 8 + \alpha 9 + \alpha 10 + \alpha 11 + \alpha 12}{12}$$

where
α1 to α3 are angles formed by the rectification pin and the surface of the meter piping at the first welded-on piece,
α4 to α6 are angles formed by the rectification pin and the surface of the meter piping at the second welded-on piece,
α7 to α9 are angles formed by the rectification pin and the surface of the meter piping at the third welded-on piece,
and
α10 to α12 are angles formed by the rectification pin and the surface of the meter piping at the fourth welded-on piece.

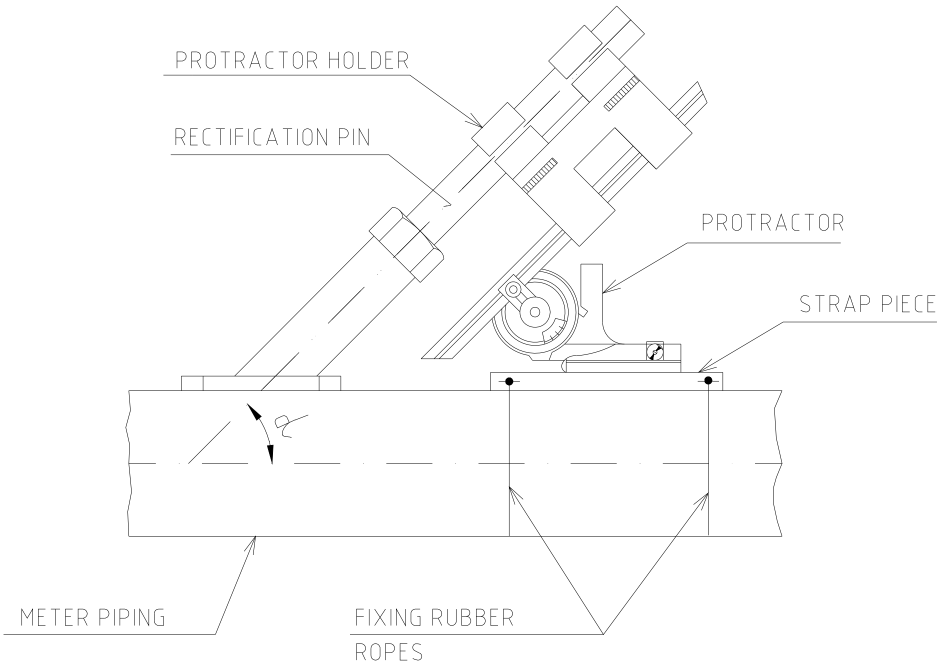



Fig. 22
Determination of the measuring ray angle

### 6.1.6.2. Distance between outer end faces of welded-on pieces

Depending on the given arrangement and room available (the inner diameter of the piping, free room in the vicinity of the welded-on pieces etc.), the distance L between the outer end faces of the welded-on pieces can be determined either by direct measurement using a suitable gauge or a steel rule inserted by means of an auxiliary pin into the welded-on pieces, or indirectly, by making the respective marks on the rectification pin and measuring the distance between the marks after removal of the pin from the welded-on pieces (see Fig. 23).

The auxiliary pin used to insert a steel rule into the meter piping should be of a smaller diameter than the rectification pin. Such pin is not included in the delivery kit.

Measure the distances $L_1$ and $L_2$ between the outer end faces of both pairs of welded-on pieces and determine the final value of L as the arithmetic average of $L_1$ and $L_2$:

$$L = \frac{L_1 + L_2}{2}$$

where $L_1$ – distance between the outer end faces of the first pair of welded-on pieces,
and $L_2$ -distance between the outer end faces of the other pair of welded-on pieces.

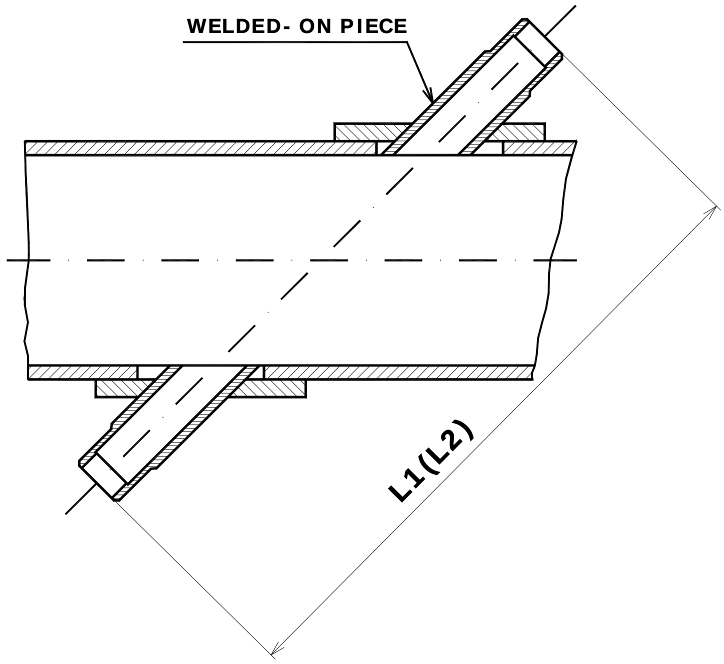



Fig. 23
Determination of distance L

### 6.1.6.3. Inner diameter of meter piping

The meter piping is an integral part of the piping system where the flow measurements are to be performed. The inner diameter $D_i$ shall be determined by calculation as follows:

$$D_i = D_o - 2\,t$$

where t – pipe wall thickness.

The outer diameter of the meter piping $D_0$ was determined using the procedure outlined in Section 6.1.3.1. above.

The pipe wall thickness t is determined by measurements on the cut-out sections acquired when holes were cut in the piping wall for the installation of the welded-on pieces. Each cut-out section shall be measured three times at spots 120° apart. The value of t shall be determined d as the average value of the twelve measurements taken. Regarding treatment of the cut-out sections prior to measurement see Section 6.1.4 - B.

## 6.1.7. Flow meter sensor assembly

The preceding assembly and measurement operations have yielded the following basic sensor parameters necessary to perform the so-called theoretical meter calibration:

- measuring ray angle
- distance between the outer end faces of the welded-on pieces L
- inner piping diameter $D_i$.

Upon finishing the measurement operations, the sensor assembly can be finished. Insert the ultrasonic probes including sealing into the welded-on pieces and tighten the nuts using the torque of 150 Nm.

Connect the coaxial cables from the probes to the terminal block X1 at the bottom part of the electronic control unit (see Fig. 24).

## 6.1.8. External power connection

As shown in Fig. 24, the terminal block and other connectors for connecting external power and electric signals to the electronic control unit UP 3.10 are accessible upon removal of the bottom lid held in position by two M4 bolts.

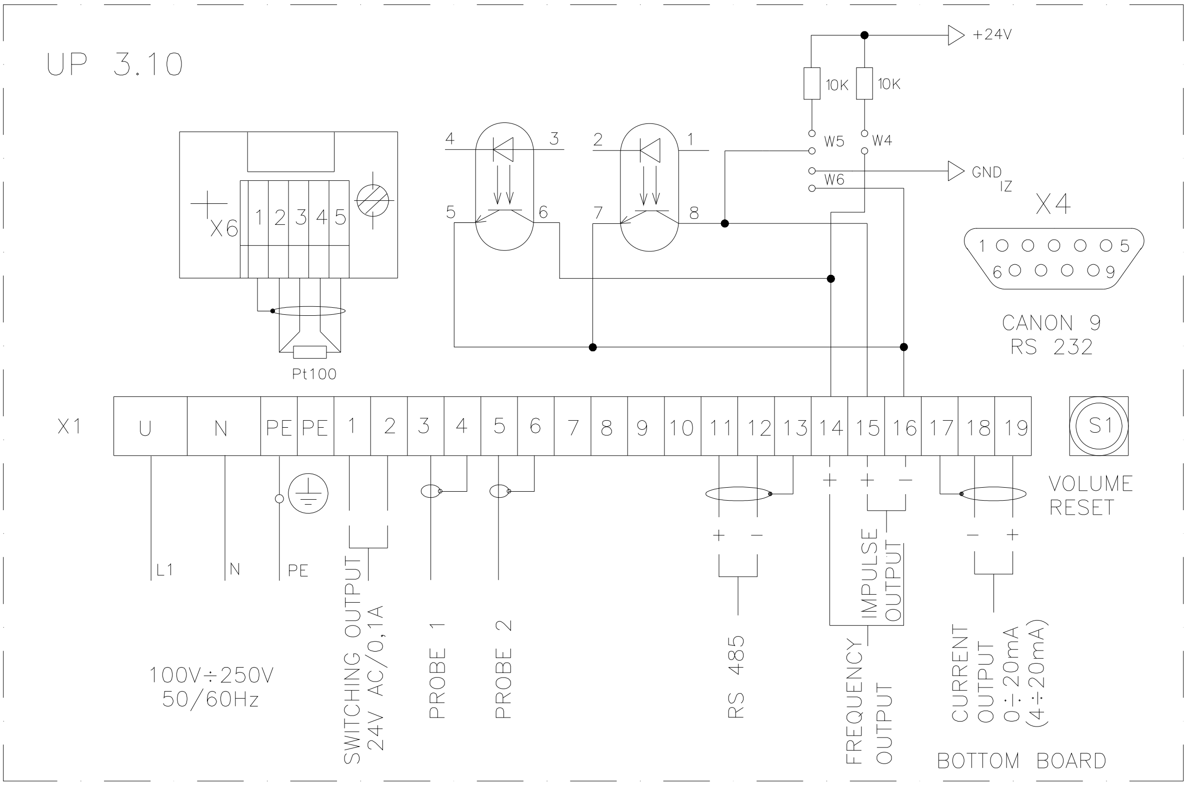



Fig. 24
External power connection to the ultrasonic flow meter SE8065

Make sure that the ultrasonic probes 1 through to 4 are connected to terminal block X1 as shown in Fig. 24. The probe marking is shown in Fig. 25.

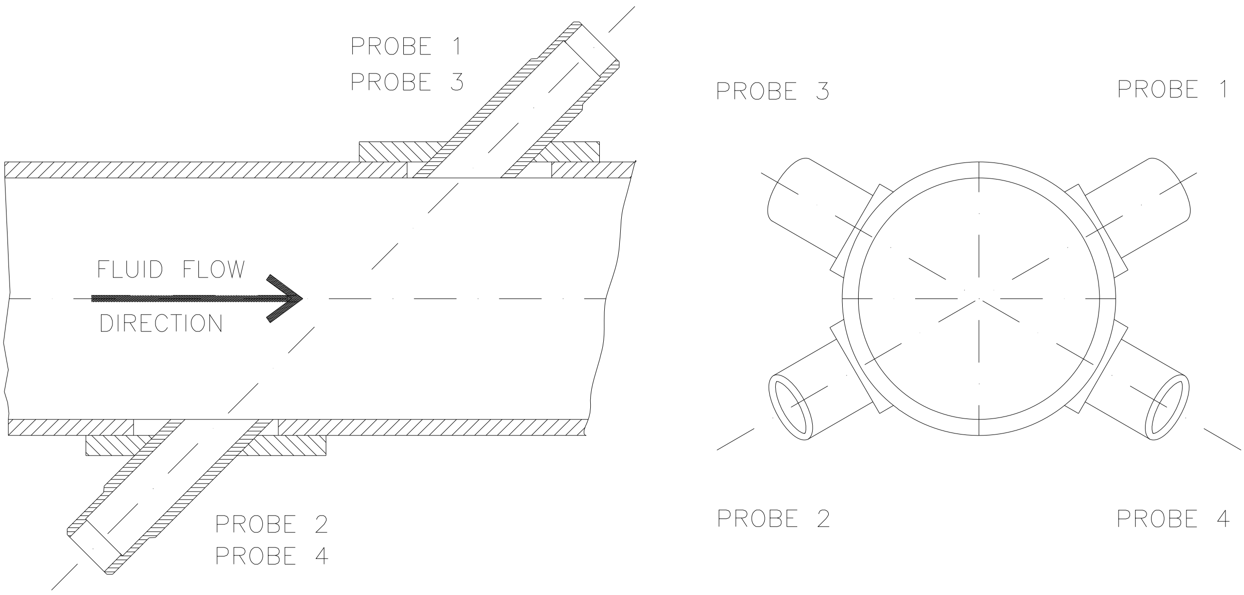



Fig. 25
Ultrasonic probe marking

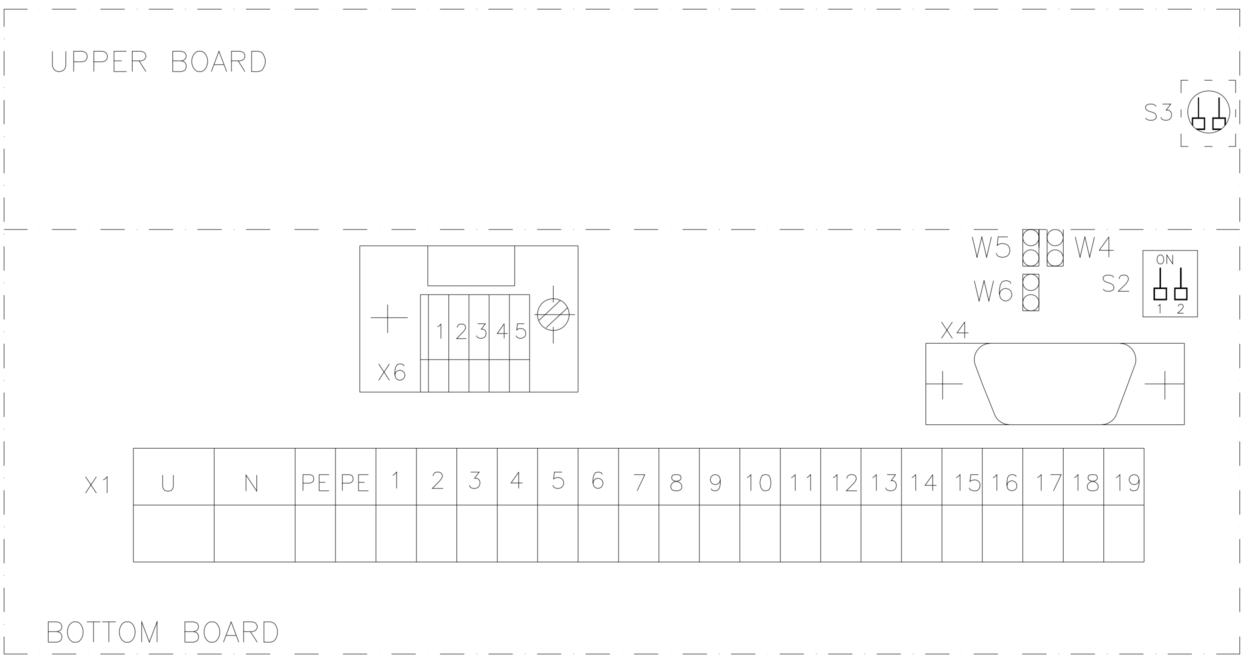
Apart from the ultrasonic probe terminals, the terminal block X1 includes terminals for the supply voltage, meter outputs (the impulse, frequency, current and switching outputs), and the communication interface RS485.

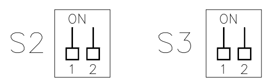
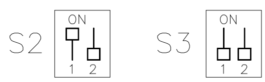
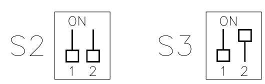
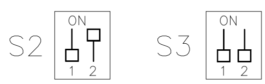
The connector X4 (CANON 9) is used for connecting the communication interface RS232 necessary for theoretical calibration, parameter setting at the manufacturing plant and meter servicing. In the case of a meter configuration facilitating mass flow rate measurement, the terminal block X6 shall accommodate the temperature sensor Pt 100.

By connecting the W4 and W6 pins, the impulse output is activated; by connecting the W5 and W6 pins, the frequency voltage output is activated. If the impulse and/or frequency outputs are used as passive ones (with the W4, W5 and/or W6 pins disconnected), the current passing through the opto-coupler shall not exceed 20 mA. Pushbutton S1 can be used to reset to zero the measured value of the total volume of the fluid passed through the flow sensor; the resetting command can also be sent via the RS 485 communication line. For indication of the flow direction connect to terminals 1 and 2 on the terminal strip X1 a relay coil connected in series with an external power source of 24 VAC/100 mA.

**Locations and functions of switches S2 and S3**

To obtain access to switch S3, push upwards the lock pin on the right-hand side of the box including the electronic control unit UP 3.10 and open the front panel to the left. Switch S3 is located in an opening in the top panel on the right side.




| ***Flow meter function*** | ***Displayed information*** | ***Switch status*** |
|---|---|---|
| Measurement | Instantaneous flow rate |  |
| Measurement | Instantaneous flow velocity |  |
| Programming | EEPROM programming |  |
| Servicing | Servicing |  |

The function „Servicing“ shall be used by the manufacturer and authorised service personnel only.

### 6.1.9. Marking

**System plate** (located at the electronic unit UP 3.10):

Manufacturer, Product type designation, Production series number and production year, List of all system components including the quantity, type designation and production series number for each component

**Electronic unit plate** (located at the electronic unit UP 3.10):

Manufacturer, Product type designation, Production series number and production year, Protection class, Nominal flow rate, Limit flow rates

Calibrated values of output signals: Frequency output, Impulse output, Current output, Communication address

**Flow meter sensor plate** (located at the meter piping):

Assembly/installation organisation, Production series number and production year, Ultrasonic probe type designation, Inner diameter of piping, Angle $\alpha$, Distance between the outer end faces of welded-on pieces, Temperature range of measured fluid, Maximum operational pressure, Nominal flow rate, Flow direction

# 7. SETTING FLOW METER IN OPERATION

## *7.1. Theoretical calibration*

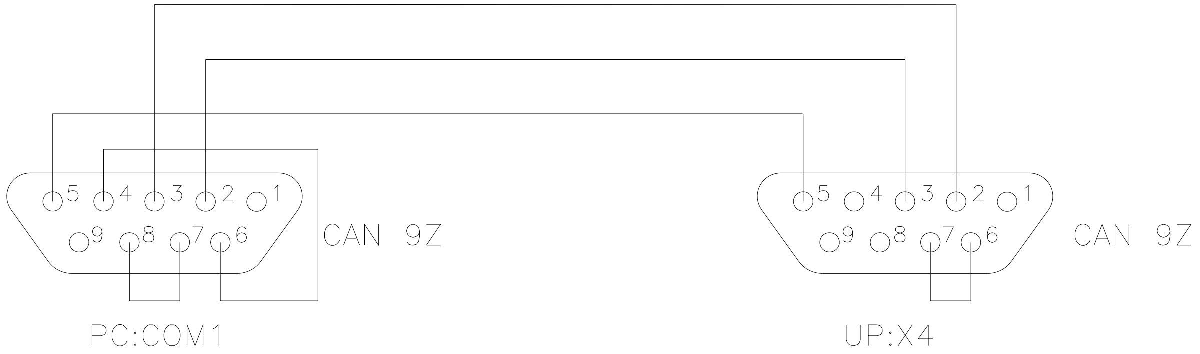
The relationship between flow rate and flow velocity of the given medium is q = f (v).

This rather complex function must take into account the inner diameter of the piping, roughness of the inner surface, viscosity of the measured fluid and the delay of the excitation signal for the ultrasonic probes in passing through the coaxial cable connecting the probes with the electronic control unit of the flow meter.
In practical situations, the so-called theoretical calibration is performed using the program "Flow.exe" where the function q = f (v) is generated for all flow rate values.

**Description of the theoretical calibration**

To use the calibration software WinFlow version 1.1 No. Es 90516D is necessary to use a personal computer or notebook with the following equipment: operating system Windows XT or higher (Windows Vista, Windows 7) and a serial communication port COM.
Connector X4 of evaluating electronics UP 3.10 connect to the COM port of the above mentioned computer through the communication cable supplied by the manufacturer and UP 3.10 connect on the power.

The communication cable:




The switch status configuration (switches S2 and S3 in the electronic unit UP 3.10) shall be set at the "Programming" function – see Section 6.1.8.

Start the program WinFlow.

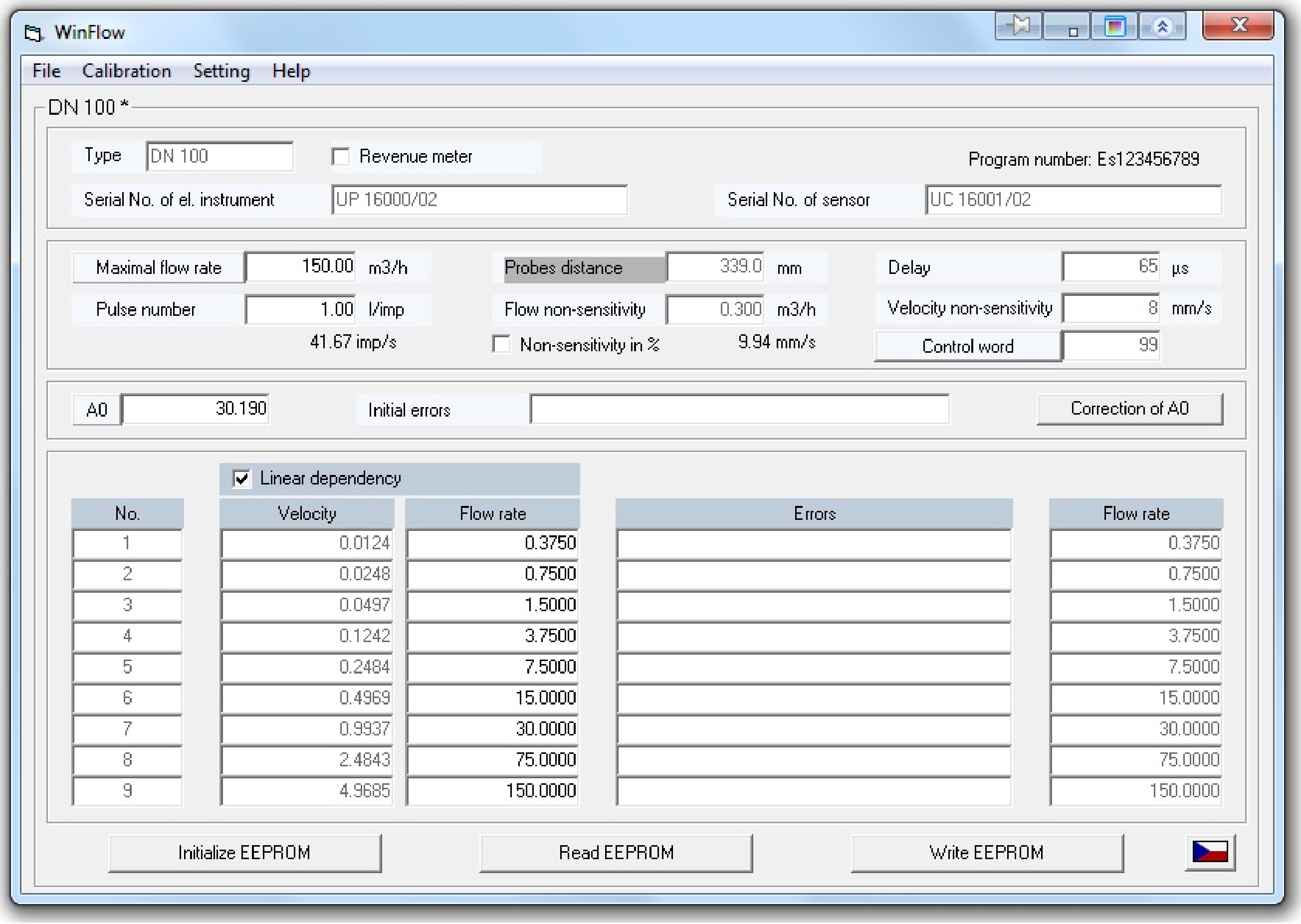



Fig. 26
The picture on the monitor after the program start

The parameter setting of the flow meter in the delivered condition will cover all standard piping sizes. If you click with the mouse at “Read EEPROM“, the table with the preset parameters will be displayed – see Fig. 27.

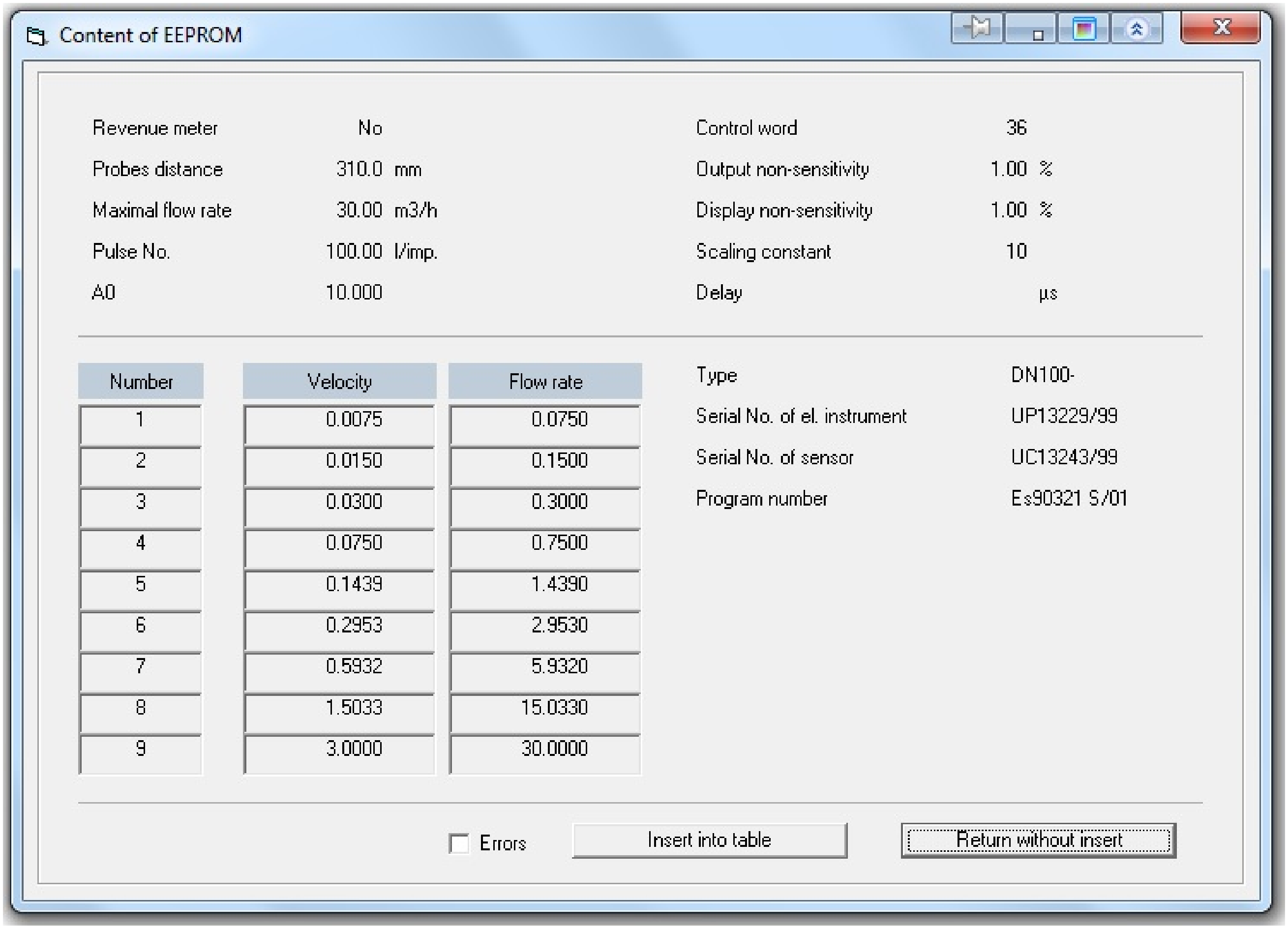



Fig. 27
Reading EEPROM

By click on "Send to a table" are data stored. The table with data of the calibrated flow meter according to the fig. 26 are shown.
By the selecting "Calibration" and "Direct assembly..." from the menu or by pressing the key in combination Ctrl + P the table for the theoretical calibration (see the figure 28) are displayed.

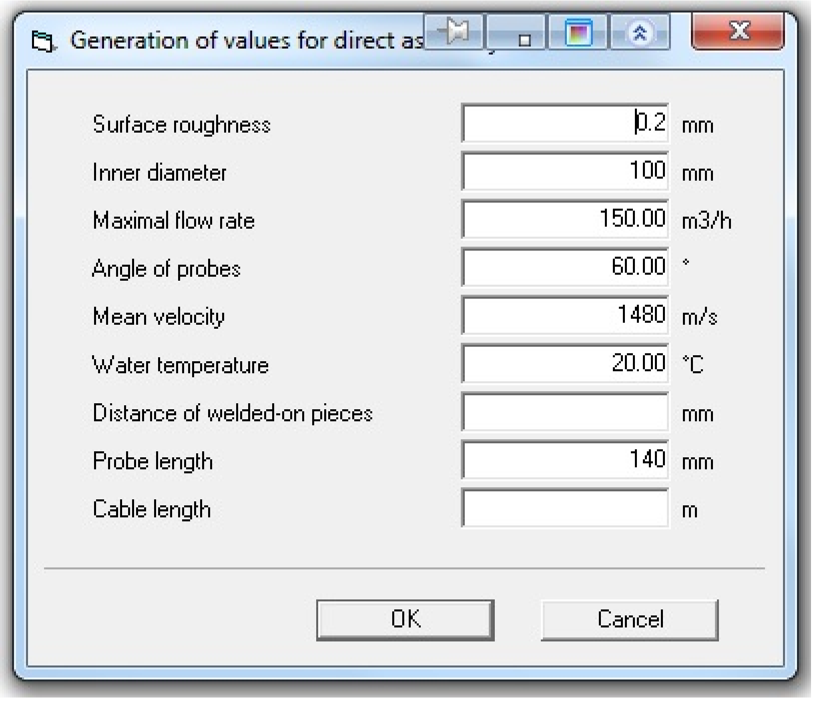



Fig. 28
Table for theoretical calibration

The actual data determined/measured on the flow meter sensor should be entered into the table.
Comments to the data in the table:

| | |
|---|---|
| - Surface roughness: | usually assumed to be 0.2 mm |
| - Inner diameter: | the value of Di – see Section 6.1.6.3. |
| - Maximal flow rate: | the value - see table in chap.14 |
| - Angle of probes: | the value of $\alpha$ – see Section 6.1.6.1. |
| - Mean velocity: | for water 1,480 m/sec |
| - Water temperature: | the average temperature of measured water |
| - Distance of welded-on pieces: | the value of L – see Section 6.1.6.2. |
| - Probe length: | 139 mm |
| - Cable length: | the length of the cables connecting the ultrasonic probes with the electronic control unit |

Press OK to provide the calculation and date transfering to the calibration table acc.to fig.26. After that provide the writing to the EEPROM by clicking on the "Write EEPROM". To check the data, click on "Read EEPROM". This completes the flow meter calibration procedure.

*Note:*
- Program Winflow is described in more details in the manual Es 90559K.

## *7.2. Operational start and control of the meter functions*

After finishing the theoretical calibration, the operator shall change the status of switches S2 and S3 in the electronic unit UP 3.10 into that of Operation/Instantaneous Flow Rate Measurement (see Section 6.1.8).

Very soon (within ten seconds) the meter will adopt the measuring (and data display) mode and the frequency, impulse and isolated current outputs will be operative. The frequency and impulse outputs can be used either in the passive mode (with power supplied from an external source) or in the active mode where each of the output circuits is powered from an internal isolated source. The selection of the output mode of operation is done by connecting or disconnecting the respective W pins (see section 6.1.8. above).

## 7.2.1. Display data

The data on the display include selected measured quantities and information on the flow meter operational status.

### 7.2.1.1. Meter status information

The first three seconds after connecting the meter to the power source the display reads

```
Flow meter
E L I S
```

In the normal operation, the symbol appearing at the last digit position on the second line informs about the current mode of operation of the signal processing electronic unit. The characters used and their meanings are as follows:

| | |
|---|---|
| I | electronic unit initialisation |
| + | measurements in the positive flow direction |
| - | measurements in the negative flow direction |
| C | calculation of measured values, output signal generation and display |
| W | stand-by mode |
| T | data communication (data being sent). |

Under normal operating conditions the above characters regularly replace one another. In the case of an error due to a sensor failure, loss of a sensor signal due to a cable failure, presence of an air bubble or a mechanical particle in the fluid flow, an "R" will appear at the last position on the first line and the "I" and "+" signs will appear in turns at the last position on the second line of the display unit. A failure of the electronic unit will usually be manifested by discontinued regular changes of the system status symbols on the display.

### 7.2.1.2. Display of measured data

Up to three measured quantities can be displayed simultaneously; one on the first line, and the other two in turns on the second line of the display unit. The switching frequency can be selected in terms of the number of measuring cycles per display time of one measured quantity.

Most often the first display line is used to show the volume flow rate (in $m^3$/hod) or the mass flow rate (in metric tons per hour), and the second display line to display the total volume (in $m^3$) or the total mass (in metric tons) alternatively with the fluid temperature in °C. How ever, the customer is free to define other combinations of the data to be displayed and/or to select other optional data units from the software menu available.

## 7.2.2. Review of the measured quantities

Volume flow rate
Relative volume flow rate (in % of $q_s$)
Mass flow rate [T]
Relative mass flow rate (in % of $q_s$) [T]
Volume (aggregate value)
Volume + (volume of the fluid passed in the positive direction) [O]
Volume - (volume of the fluid passed in the negative direction) [O]
Mass (aggregate mass) [T]
Mass + (mass of the fluid passed in the positive direction) [T], [O]
Mass - (mass of the fluid passed in the negative direction) [T], [O]
Temperature [T]
Density [T]
Sound propagation velocity
Fluid flow velocity through the sensor flange
Start of the measurement period (date and time of the last resetting command)
Duration of the measurement period
Duration of a meter error condition
Duration of a power failure period
Date
Time

Comment:
Quantities denoted [T] will only be measured and displayed if the meter configuration includes a thermometer; quantities denoted [O] require that the flow meter has been set for measurements in both fluid-flow directions.

## 7.2.3. Review of the measured quantity units

| Volume flow rate | Mass flow rate | Volume | Mass |
|---|---|---|---|
| $m^3$/hour | t/hour | 1,000 $m^3$ | 1,000 t |
| $m^3$/min | t/min | $m^3$ | t |
| $m^3$/s | t/s | l | kg |
| l/hour | kg/hour | 1,000 bbl | 1,000 tons |
| l/min | kg/min | bbl | ton |
| l/s | kg/s | 1,000 $ft^3$ | lb |
| bbl/hour | tons/hour | $ft^3$ | |
| bbl/min | tons/min | 1,000 gal | |
| bbl/s | tons/s | gal | |
| $ft^3$/hour | lb/hour | | |
| $ft^3$/min | lb/min | | |
| $ft^3$/s | lb/s | | |
| gal/hour | | | |
| gal/min | | | |
| gal/s | | | |

| Temperature | Density | Velocity |
|---|---|---|
| °C | t/$m^3$ | m/s |
| °F | kg/$m^3$ | ft/s |
| | g/$cm^3$ | |
| | tons/$m^3$ | |
| | lb/$ft^3$ | |

**Names of selected units**

| | |
|---|---|
| bbl | American barrel |
| ft | Foot |
| gal | American gallon |
| ton | American ton |
| lb | Pound |
| $m^3$ | Cubic meter |
| l | Litre |

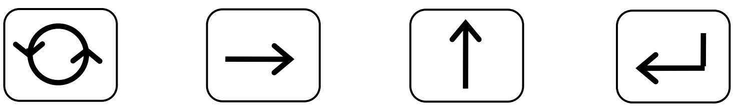
| | |
|---|---|
| s | Second |
| min | Minute |
| hour | Hour |
| °C | Degree Celsius |
| °F | Degree Fahrenheit |
| t | Metric ton |
| kg | Kilogram |

## 7.2.4. Unit conversion table

| | | |
|---|---|---|
| Volume flow rate | 1 $m^3$/hour = | 0.01666667 $m^3$/min<br>0.0002777778 $m^3$/s<br>1,000 l/hour<br>16.66667 l/min<br>0.2777778 l/s<br>6.289387 bbl/hour<br>0.1048231 bbl/min<br>0.001747052 bbl/s<br>35.31467 $ft^3$/hour<br>0.5885778 $ft^3$/min<br>0.009809630 $ft^3$/s<br>264.1708 gal/hour<br>4.402846 gal/min<br>0.07338077 gal/s |
| Mass flow rate | 1 t/hour = | 1.102311 tons/hour<br>0.01837185 tons/min<br>0.0003061975 tons/s<br>2,204.623 lb/hour<br>36.74371 lb/min<br>0.6123952 lb/s |
| Volume | 1 $m^3$ = | 6.289387 bbl<br>35.31467 $ft^3$<br>264.1708 gal |
| Mass | 1 t = | 1.102311 tons<br>2,204.623 lb |
| Density | 1 t/$m^3$ = | 1.102311 tons/$m^3$<br>62.42797 lb/$ft^3$ |
| Temperature | $t_F$ = | 32 + 1.8 $t_C$ |
| Velocity | 1 m/s = | 3.280840 ft/s |

## *7.3. Keyboard control functions*

The four-button keyboard allows for a wide range of the meter functions to be controlled and modified with respect to the requirements of particular operating conditions at the user's plant. The push-buttons T1 to T4 are provided with the following graphic symbols:



**T1** **T2** **T3** **T4**

The push-button control of the meter is shown in a schematic diagram in Fig. 7.3.1 (page 45). The system can be operated in two different modes where the switching-over action between the operation modes and individual functional blocks within a selected mode can be initiated by depressing the push-button the image of which is depicted at the given transition position. From the diagram it follows that a transition from one block to the next one (on the right-hand side) will be done by depressing the T2 button, while a transition to the previous block (next on the left-hand side) by depressing the T3 button. The Zero Reset block can only be activated in the cases of technological meters (the software switch in the “NF” position). In the case of commercial (invoicing) meters, where the switch is in the “F” position, the Zero reset block is missing.

Upon energising, the meter will automatically adopt the display mode with the pre-selected (initial) quantity displayed (see description below). The display mode will also become operative if no push-button has been depressed over the period of 300 measurement cycles (5 minutes for a measurement cycle of 1 s).

Any push-button control actions will not disturb the measuring functions of the meter in any way. A detailed description of individual “block” functions controlled by the push-button unit is given in the following paragraphs.

## 7.3.1. Data display mode

The flow meter in full configuration can measure and evaluate any of the 20 physical quantities listed in section 7.2.2 above. In the data display mode, any of the measured quantities can be displayed. The display format is as follows:
Line 1 – name of the measured quantity in the selected language (Czech, English, German, Spanish, Italian or French);
Line 2 – the measured value in the selected unit system.

Upon switching the power on, the system activates the data display mode whereby the measured value of the pre-selected (“initial”) physical quantity is displayed. Each of the 20 physical quantities available can be selected as the initial one.

If the operator depresses push-button T1, another measured quantity will be displayed (the next on the list in section 7.2.2). Then, unless T1 is depressed again within 5 minutes, the initial quantity will be displayed again.

To leave the Data Display Mode for the Parameter Setting Mode, depress push-button T4 (see Fig. 7.3.2, page 45). Select the desired operating mode (function block) by push-button T1 and confirm the selection by depressing T4 again.

### 7.3.1.1. Volume flow rate

The value of the measured volume flow rate is displayed as a 3- or 4-digit number (this is determined by the manufacturer with respect to the meter application). Provided the flow meter has been set for measurements in both directions of flow, the sign before the reading indicates the flow direction (“+” for the flow direction shown by the arrow sign on the meter body, “-“ for the opposite direction).

### 7.3.1.2. Relative volume flow rate

The displayed reading shows the ratio (in per cent) of the measured volume flow rate to the specified maximum volume flow rate.

### 7.3.1.3. Mass flow rate

The mass flow rate can be measured and the measured data displayed only on condition that the meter configuration includes a thermometer and that the fluid density vs. temperature characteristic is known. For more technical details of the readings see the comments to section 7.3.1.1 above. If a thermometer is not installed, the mass flow rate function block is skipped when selected by push-button T1.

### 7.3.1.4. Relative mass flow rate

See the comments to section 7.3.1.2 above concerning the relative volume flow rate.

### 7.3.1.5. Volume

The aggregate fluid volume passed through the flow sensor during the measurement period, i.e. from the moment the volume data were reset by the reset push-button on the meter, or since the measurement start command from the superordinated control system was received via the RS 485 communication line, or since the data-resetting command was actuated using the T push-buttons as described in section 7.3.2.8 below. The displayed value can have up to 7 digits; higher readings are shown in the form of products of real numbers and appropriate powers of 10 (the "E" format). The reading sensitivity is 0.01 l, the maximum reading is $2.8.10^9$ $m^3$. In the case of bi-directional measurement, the aggregate volume reading is the difference between the volume passed in the positive and the negative direction of the fluid flow. The displayed value includes the polarity sign.

### 7.3.1.6. Volume +

Applicable only in the case of bi-directional measurement. The reading represents the aggregate fluid volume passed in the positive flow direction (see the arrow on the meter body). The reading format and the range of the measured values are as described in section 7.3.1.5 above.

### 7.3.1.7. Volume -

See section 7.3.1.6, for the reverse flow direction.

### 7.3.1.8. Mass

See section 7.3.1.5, for the aggregate mass of the fluid passed through the flow sensor. The reading sensitivity is 0.01 kg.

### 7.3.1.9. Mass +

See section 7.3.1.6, for the aggregate mass flow in the positive direction.

### 7.3.1.10. Mass -

See section 7.3.1.7, for the aggregate mass flow in the reverse direction.

### 7.3.1.11. Temperature

The temperature reading is only available if a thermometer is included in the meter configuration. The reading sensitivity is 0.1°C.

### 7.3.1.12. Density

The fluid density readings are available provided a thermometer has been installed.

### 7.3.1.13. Sound propagation velocity

Velocity of the acoustic signal propagating in the measured fluid.

### 7.3.1.14. Fluid flow velocity

Velocity of the fluid passing through the sensor flange.

### 7.3.1.15. Start of the measurement period

The calendar date, hour and minute when the measurement period commenced (the last resetting of the aggregate flow data).

### 7.3.1.16. Duration of the measurement period

The length of the period (in hours, minutes and seconds) from the measurement start (see section 7.3.1.15) during which the flow meter continuously performed the flow rate measurements.

#### 7.3.1.17. Duration of failure condition

The total duration of the period (s) (in hours, minutes and seconds) from the measurement start during which the meter was energised but could not perform measurements due to a failure condition.

#### 7.3.1.18. Power failure period

The total duration of the period (s) (in hours, minutes and seconds) from the measurement start during which the meter was not energised.

#### 7.3.1.19. Date

The display shows the actual calendar date.

#### 7.3.1.20. Time

The display shows the actual time of the day.

### 7.3.2. Parameter setting mode

When selecting the parameter setting mode (see section 7.3.1), the operator will be requested to enter a four-digit password.

#### 7.3.2.1. Password

The first display line will read

| PASSWORD |
|---|

and the first digit position on the second line will display 0. Depress push-button T3 repeatedly to increase the number by 1 at a time (after 9 will follow 0 again). Select the correct number at the first digit position and then depress push-button T2 to move to the second digit position and repeat the number setting procedure with push-button T3. Progress to the third and fourth digit positions and enter the correct password – a combination of four numbers (see the schematic diagram in Fig. 7.3.3, page 46).

Confirm the entry of the correct password by depressing push-button T4. Provided the password entered is correct, the system will proceed to the language selection block. In the case of an incorrect password the system will request a new password entry. After three consecutive entries of incorrect passwords the system will switch over to the data display mode and will not permit further entry into the parameter setting mode. A new attempt at the password entry is only possible after system de-energising and repeated switching on of the power supply.

Should the operator forget the password, it is possible to use the manufacturer's password supplied with the system (0200). This shall be done as follows: switch off the power, depress and hold push-button T4 and switch the power on again.

The user password can be changed at any time in the parameter setting mode using the procedure described in section 7.3.2.5 below.

#### 7.3.2.2. Meter setting procedures

The meter parameters that can be defined or re-defined in the parameter setting mode include: the language of the messages appearing on the display, units of the displayed quantities, the user password required for entry into the parameter setting mode, the initial measured quantity, specified values of some measured quantities ($q_s$, impulse number – litres per imp., threshold/sensitivity level, and the maximum/limit values of fluid flow rate, volume and temperature), as well as the date, day of the week, time of the day, start of the measurement period and meter zero position (only with the technological meters).

The procedures to be used in setting particular parameters are described below. Upon initialisation of a particular parameter setting mode, the name of the function block concerned will appear on the first line of the display in block letters, e.g.

| LANGUAGE |
|---|

At the same time, the current parameter name or value will appear on the second line. If you wish to pass on to the next parameter, depress T2; by depressing push-button T3 you will return to the previous parameter. Any parameter changes are done using push-button T1, confirmation of the new value by push-button T4. The display will then read

PARAMETER SET

To leave the current parameter setting mode and proceed to another parameter block, depress push-button T2. If you wish to return to the previous block, depress T3. To leave the parameter setting mode completely (and enter the data display mode for the parameter just set), depress push-button T4.

### 7.3.2.3. Language selection

The operator can choose from any of the six languages available (see Fig. 7.3.4, page 46). The language setting mode will be initiated as soon as the system acknowledges the correct user password. The first line on the display will then read

LANGUAGE

or a message to the same effect in the actually defined language. On delivery, the language selected will be Czech unless the customer has specified their required language in the product order. The second display line will identify one of the languages available (e.g. Czech). Depress repeatedly push-button T1 to select the desired language. Upon selecting the language, confirm the setting by depressing push-button T4. The message on the display will inform the operator of completion of the parameter setting in the newly selected language.

### 7.3.2.4. Measuring unit selection

In this parameter setting mode, the desired measuring unit can be associated with each measured physical quantity (see Fig. 7.3.5, page 47). Upon initiating this mode, the first line of the display will read

UNITS

while the name a physical quantity will appear on the second line. Depress repeatedly push-button T1 to select the desired quantity and confirm by depressing T4. The quantity name will then appear on the first line and the second line will display one of the measuring units available. Select the desired unit by T1 and confirm by T4. Depress push-button T3 to access another measured quantity or use T2 to proceed to another parameter to be set.

### 7.3.2.5. New password definition

NEW PASSWORD

In this mode, the operator/user may modify the existing password used to access the parameter setting mode (see Fig. 7.3.6, page 47). Depress push-button T4. The first digit position on the second line will display 0. Set the new password (a combination of four numbers) using the procedure described in section 7.3.2.1 above. Upon final confirmation by depressing push-button T4, the legend Parameter Set will appear on the display. From then on, only the new password will be effective.

### 7.3.2.6. Initial quantity selection

Upon accessing this parameter setting mode, the first line of the display will read

INITIAL QUANTITY

and the second line will give the quantity's name (see Fig. 7.3.7, page 49). Select the desired initial quantity using push-button T1 and confirm the selection by T4.

### 7.3.2.7. Definition of limit values

LIMIT VALUE

Here the operator can set altogether 11 (limit) values of parameters. The detailed description of the procedures concerned is shown in Fig. 7.3.8 on page 50. Select the desired parameter by push-button T1 and confirm the selection by T4. The name of the parameter and the associated measuring unit will then appear on the first line of the display and the second line will show the previously defined limit value (with the exception of the date and time). The limit value unit shall always be the same as that selected for data display. For example, if the volume flow rate is displayed in litres per second, the limit value of volume flow rate shall also be defined in l/s. If the mass flow rate measurement mode is selected and the data are displayed in metric tons, the impulse number shall also be defined in t.

Upon depressing push-button T2, the previously set limit value will disappear from the second line and 0 will be displayed in the first digit position. Use push-buttons T3 and T2 to set the digital value and T1 to insert the division signs (a comma in the position of a decimal point, dot in the date and colon in the case of time).

The day in the week information is to be set as follows:

0 – Sunday
1 – Monday
2 – Tuesday
3 – Wednesday
4 – Thursday
5 – Friday
6 – Saturday

A figure entered may have up to seven digits. The date and time data shall include initial zeroes; e.g. the date of 3 July, 2001 shall be recorded as 03.07.01 and the time 7 minutes past 9 a.m. as 09:07:00. Confirm the selection by depressing push-button T4. In the case of a commercial (invoicing) meter, neither $q_s$, impulse number or sensitivity (low flow cutoff) can be reset by the user as these settings are reserved to the duly authorised testing authority. Therefore, for commercial meters, these parameters will not appear on the list of limit values to be reset.

**List of parameters (limit values, date and time)**

| | |
|---|---|
| Qmax | Maximum (overload) flow rate $q_s$ in the given measuring units |
| ICIS | Impulse number, defining fluid volume or mass (in selected units) per one impulse at the impulse output |
| Date | The actual calendar date |
| Day of the week | The actual day of the week |
| Time of the day | The actual time of the day |
| Low flow cutoff | The flow rate level, in per cent of $q_s$, below which the meter will display and at its outputs indicate zero flow rate |
| Vol. flow limit | Maximum volume flow rate level; where a binary output is associated with this parameter, it will indicate values exceeding this limit |
| Mass flow limit | Maximum mass flow rate; where a binary output is associated with this parameter, it will indicate values exceeding this limit |
| Volume limit | Maximum aggregate volume; where a binary output is associated with this parameter, it will indicate values exceeding this limit |
| Mass limit | Maximum aggregate mass; where a binary output is associated with this parameter, it will indicate values exceeding this limit |
| Temp. limit | Maximum temperature; where a binary output is associated with this parameter, it will indicate values exceeding this limit value. |

*Comment:* The limit values for all the above parameters shall be given in units selected using the procedure described in section 7.3.2.4 above. Should new parameter units be selected, the limit values need be re-defined accordingly; otherwise the meter function would be incorrect.

### 7.3.2.8. Resetting aggregate quantities

Upon entering this mode, the corresponding message will appear on the display (see Fig. 7.3.9, page 50). If resetting of aggregate quantities is not required, depress push-button T2 to access the next parameter-setting block. Confirm your intention to reset the aggregate quantities by depressing T4. The display will then ask

RESET?

At this stage, you can still return to the initial step of the resetting mode by depressing T3. Depress T4 to reset the aggregate readings of the flow volume and flow mass, the operational information (the meter operation time, the error time and power loss time) and define the start of a new measurement period (the date, hour and minute of the same). The system will respond with a confirming message (Parameter Set).

### 7.3.2.9 Meter zero setting

Before leaving the manufacturing plant, every flow meter is carefully set for correct operation. One of the key parameters in this respect is the meter zero. A correctly set meter zero implies that at zero flow rate (or zero fluid flow velocity through the meter sensor) the meter indicates a zero flow rate (zero fluid flow velocity). The setting value (a meter zero shift) is expressed in mm per second. The meter zero shift as identified in the manufacturing plant is stored in the meter memory under the name of initial (in-production) zero setting value.

Meter component ageing and other factors acting over long-term operational periods may result in minor meter zero displacements. To eliminate these, use the automated zero resetting function. However, great care should be taken in employing this function. First of all, the zero flow rate condition shall be ensured (make sure that the closing valve in the piping is not leaking). Only then the zero resetting function may be used.

A detailed description of the zero resetting block is shown in Fig. 7.3.10 on page 50. Upon initiating this function, the operator shall select either the in-production or automated meter zero setting mode. The selection is done by push-button T1, confirmation by T4. When the in-production setting mode is selected, the meter zero is reset using the zero shift value determined in the manufacturing plant.

In the automated zero setting mode, the meter will first ask whether the fluid flow rate through the meter sensor is really zero (the main requirement for a successful zero setting). If it is not so, cancel the setting process using push-button T3. Upon confirmation by push-button T4 the display will show the message “WAIT FOR 100”. The zero setting procedure lasts 100 measuring cycles. The actual number of measuring cycles performed is shown on the second display line.

After 100 measuring cycles the zero displacement is evaluated. If it is smaller than 50 mm/s, the shift value is stored and the display with read “PARAMETER SET”. If the value is greater than 50 mm/s, a notice to this effect is displayed. However, this is highly unlikely; in such as case it is recommended to check again whether the fluid flow has indeed been completely stopped. Use push-button T3 to invalidate the setting and push-button T4 to run the setting procedure anew.

The meter zero setting function is available only with technological flow meters.

### 7.3.2.10. End of parameter setting

At the end of the parameter setting procedure, the display will read

PAR. SETTING END

Depress push-button T4 to access the data display mode. However, should you wish to perform any additional parameter setting action, depress T3 to return to the previous parameter setting function block (see Fig. 7.3.11, page 51).

## *7.4. Automated meter test*

The test shall only be used in extraordinary situations where the meter function is incorrect although all operational conditions are within specified limits. Its purpose is to handle extraordinary situations where the meter function is incorrect although all operational conditions are within specified limits.

Prior to initialising the test, check the correct interconnection between the evaluation electronic unit and the meter sensor, the power supply line, the full sensor flooding and zero flow rate. Then switch off the power, depress push-button S1 (resetting the aggregate volume) and, with S1 depressed, switch on the power again. Upon releasing S1, the display will read

TEST
SENSOR FULL?

Depress and release S1 again, whereby, provided the sensor is fully flooded, the following message will appear on the display:

LIQUID
DOES NOT FLOW?

Check the zero flow rate condition and depress and release S1. The test will continue by checking whether the passage route for the ultrasonic ray in one direction is free. The display will read

TEST
UTS THROUGH.1

If this test is successful, the message "OK" will appear on the display for four seconds, whereby a test of the ray passage route in the other direction will commence.

TEST
UTS THROUGH.2

After successfully passing this test section, the display will show the amplification values associated with the ultrasonic ray passage in both directions; e.g..

UTS THROUGHPUT
D1 = 4,56 D2 = 4,55

Under normal circumstances, the amplification values should be between 4.50 and 4.60, and their difference should not exceed 0.10.

After four seconds, the measurement of the ultrasonic wave propagation velocity will commence. The message on the first display line will read:

UTS RATE

After the velocity measurement, which takes approximately 1 s, the measured value will appear on the second line, e.g.

1510.6 m/s

If the measured value lies within the limits specified for the given fluid, the following message will appear on the display

RATE LIMITS OK
END OF TEST

and, after another 4 seconds, the meter will resume the normal measurement mode.

Should a fault be indicated at the ray passage test stage, the display will show ER instead of OK. After 4 seconds, automated probe cleaning procedure will start and last for 5 minutes. The display will then read

CLEAN.UTSP 5 MIN
11111111 …………...

On the second line is displayed step by step, the actual number of the minute of the cleaning procedure is displayed. Every fourth seconds one numeral is added, the line will be filled up by 15 same numbers within 1 minute, after elapsing this time the displayed numbers disappear and next new numbers start to display for a time 1 minute. After the probe cleaning, another ray passage test is performed. Should even then the test result be negative, the following message will appear on the display:

| |
|---|
| DEFECT<br>END OF TEST |

The meter needs be put out of service and either sent for repair to the manufacturing plant or a service technician be asked to come and repair the meter on site.

Should a fault be indicated at the ultrasonic wave propagation velocity measurement and the measured velocity lie outside the range of physically defined limits (VUTS < 900 m/s, VUTS > 1700 m/s), the probe cleaning procedure will be initiated (unless it has already been performed) and the velocity measurement will be repeated. Should even then the test result be unsatisfactory, the display will read:

| |
|---|
| DEFECT<br>END OF TEST |

and the test sequence will be terminated.

Should the measured velocity lie outside preset limits but within the range of physically possible values, the following message will appear on the display

| |
|---|
| UTS RATE LIMITS<br>ADJUSTMENT |

and the actual limits will automatically be re-adjusted with respect to the measured value. The display will in that case read

| |
|---|
| RATE LIMITS OK<br>END OF TEST |

and, after another 4 seconds, the meter will resume the normal measurement mode.

Should the meter function still be unsatisfactory, it is possible to repeat the tests. In the case of repeated failure to set the meter right, contact the meter manufacturer.

# PUSH-BUTTON CONTROL OF THE FLOW METER FUNCTIONS

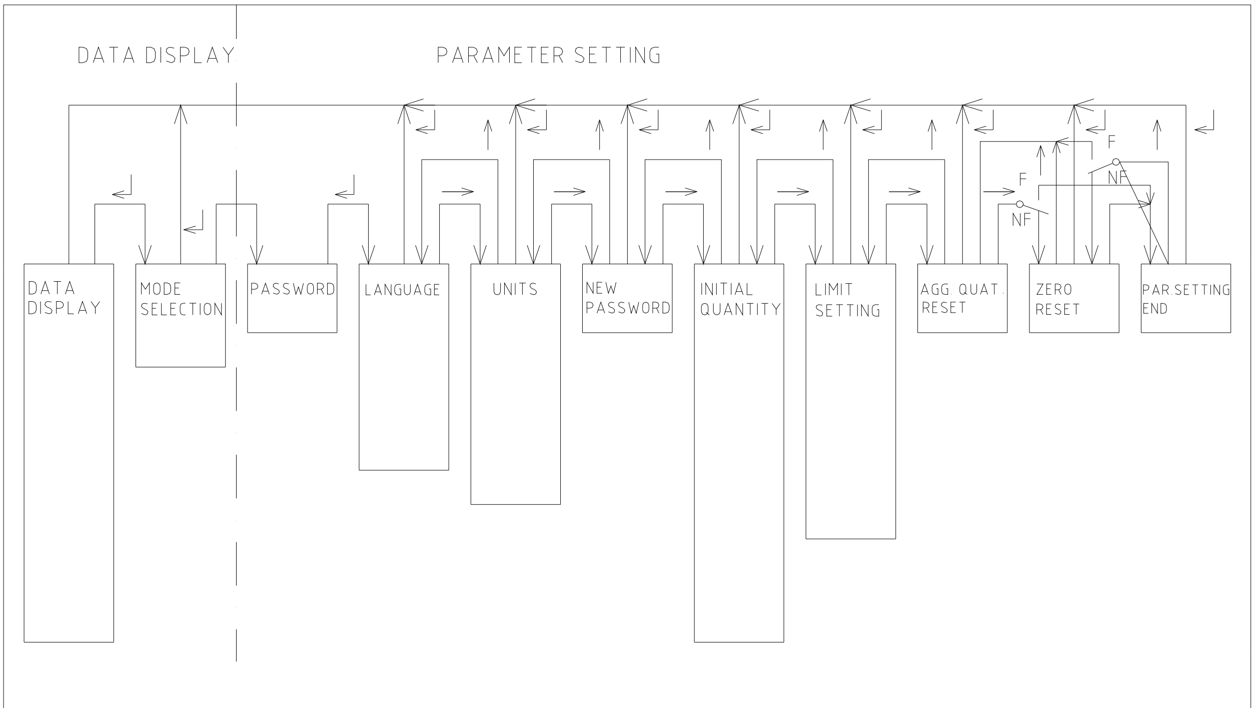



Fig.7.3.1

# DATA DISPLAY

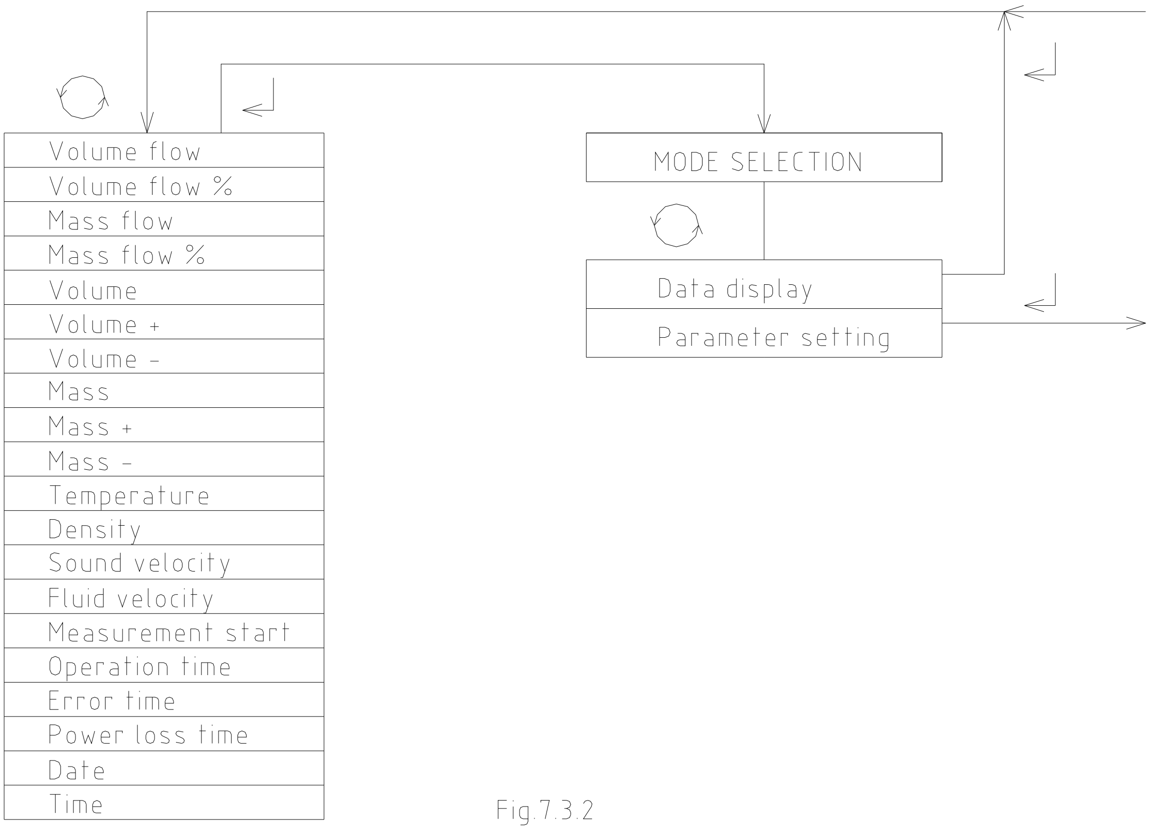



Fig.7.3.2

## PASSWORD ENTRY

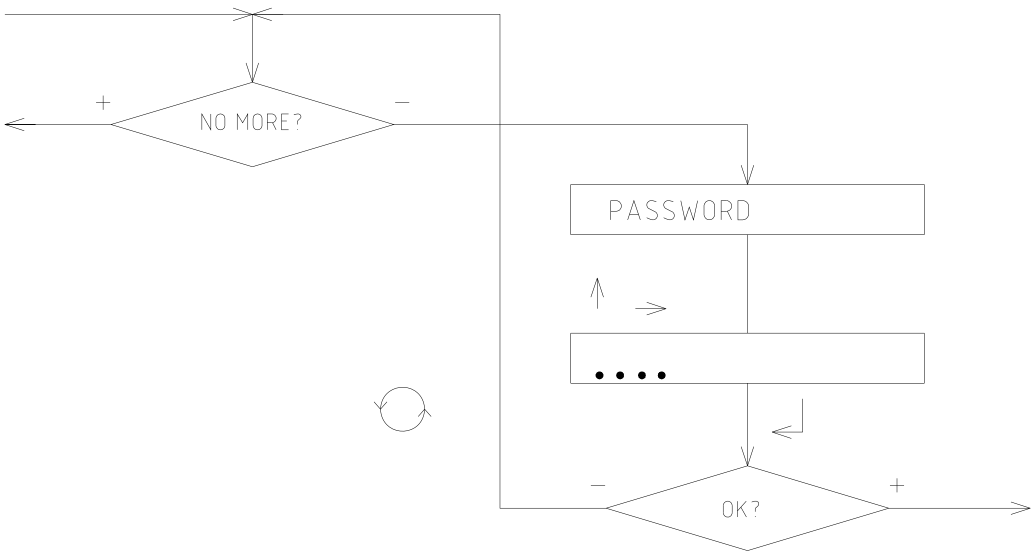



Fig.7.3.3

## LANGUAGE

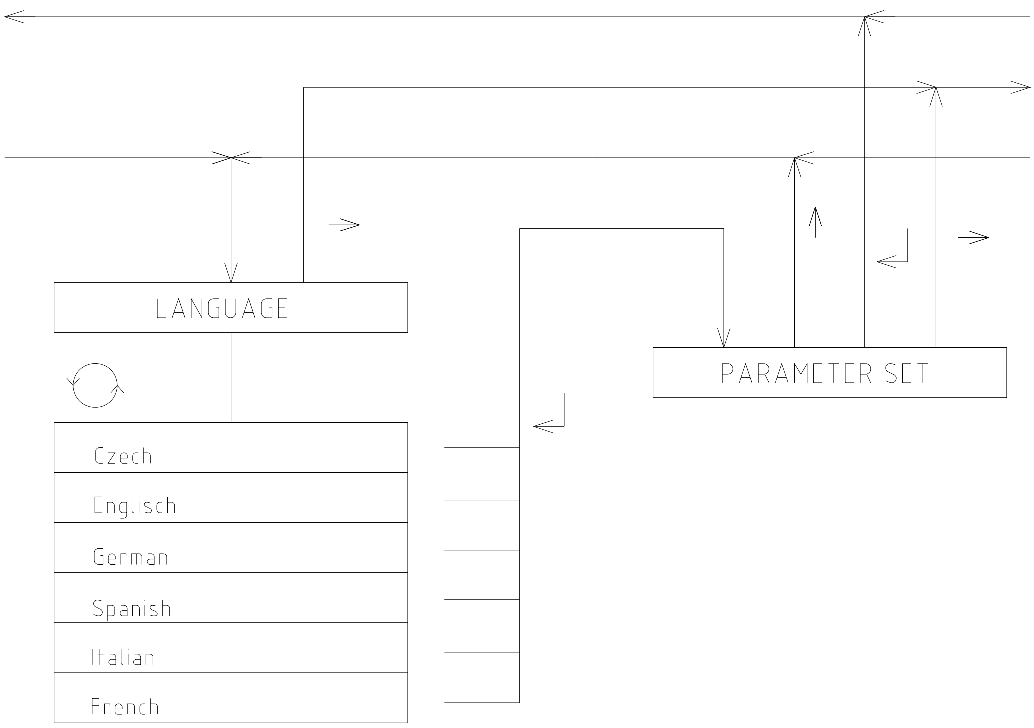



Fig.7.3.4

## MEASURING UNIT SELECTION

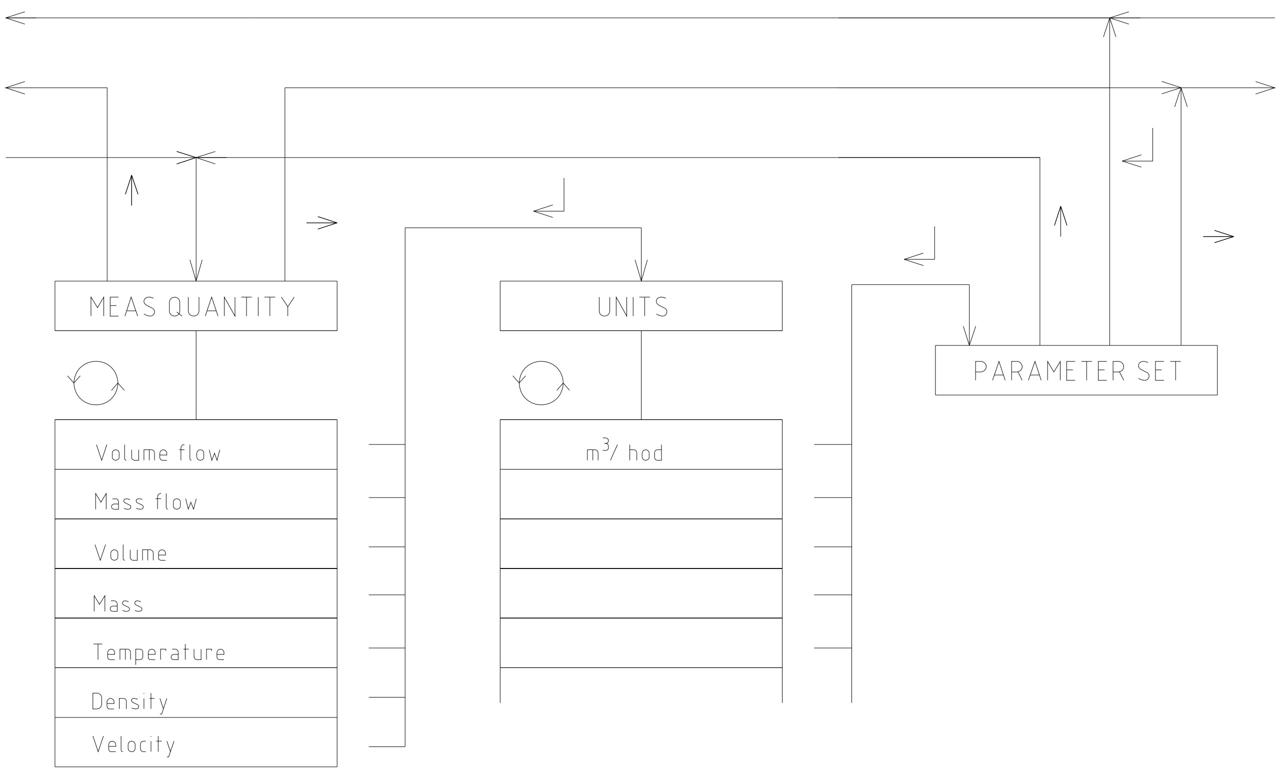



Fig.7.3.5

## NEW PASSWORD DEFINITION

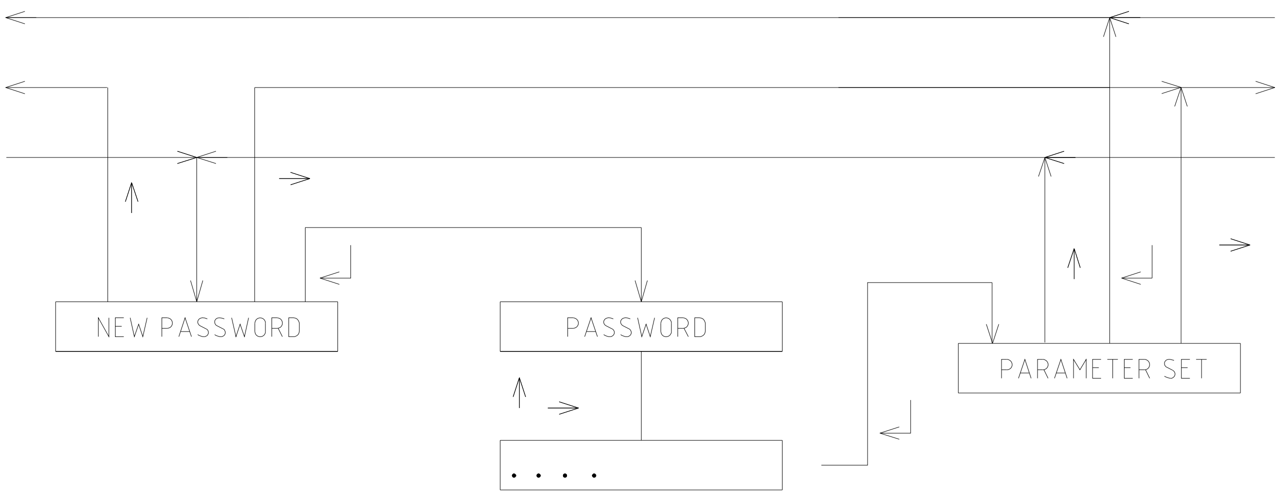



Fig.7.3.6

# INITIAL QUANTITY

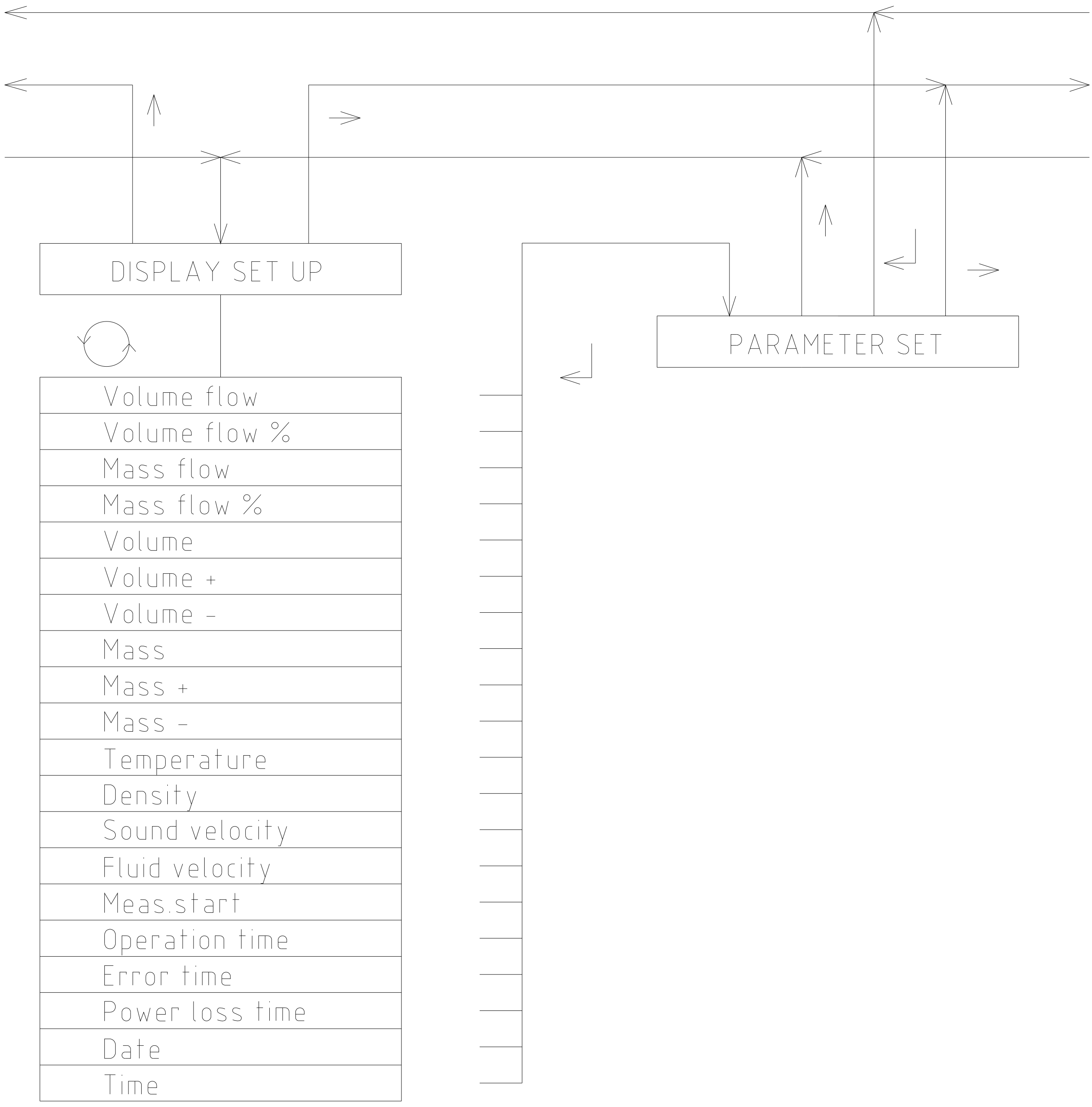



Fig.7.3.7

# DEFINITION OF LIMIT VALUES

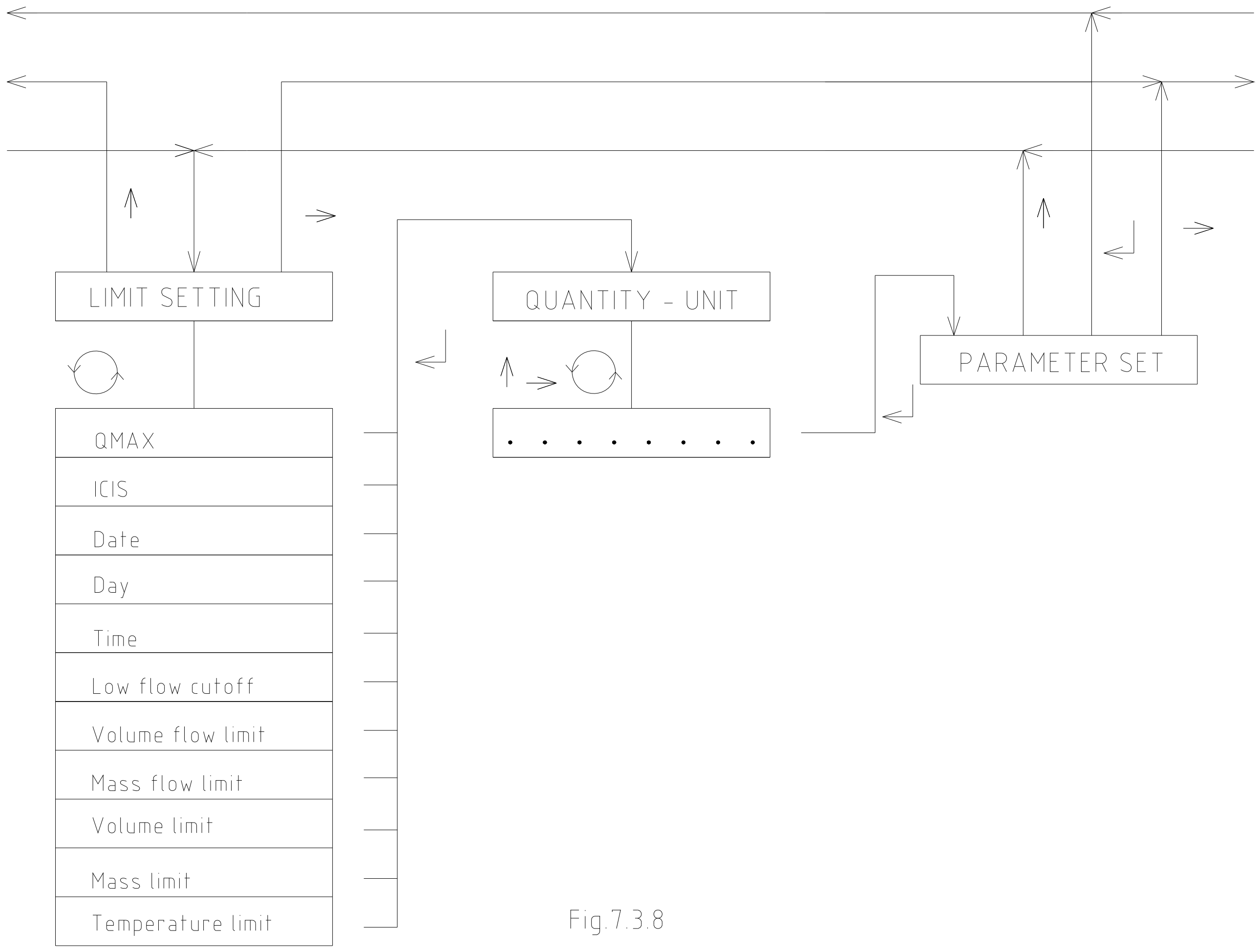



Fig.7.3.8

# RESETTING AGGREGATE VALUES

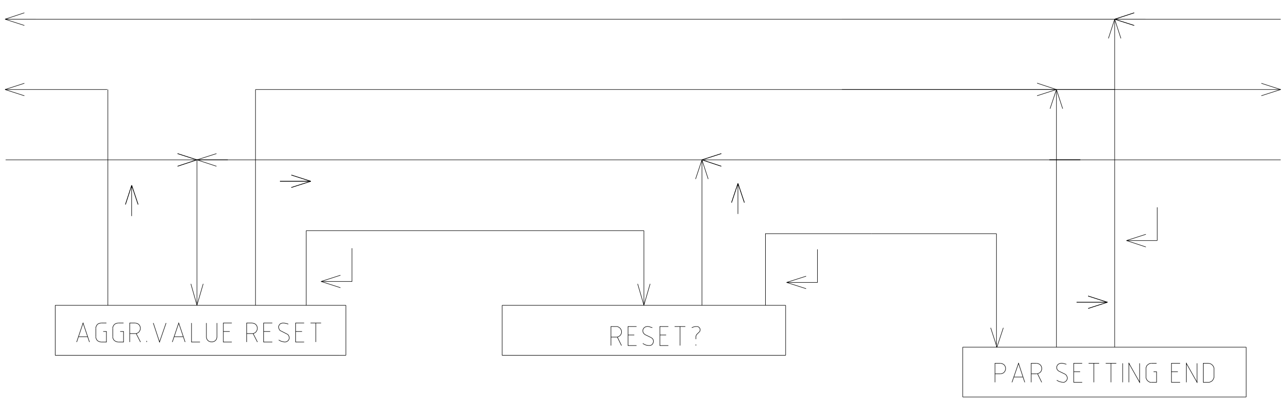



Fig.7.3.9

## METER ZERO SETTING

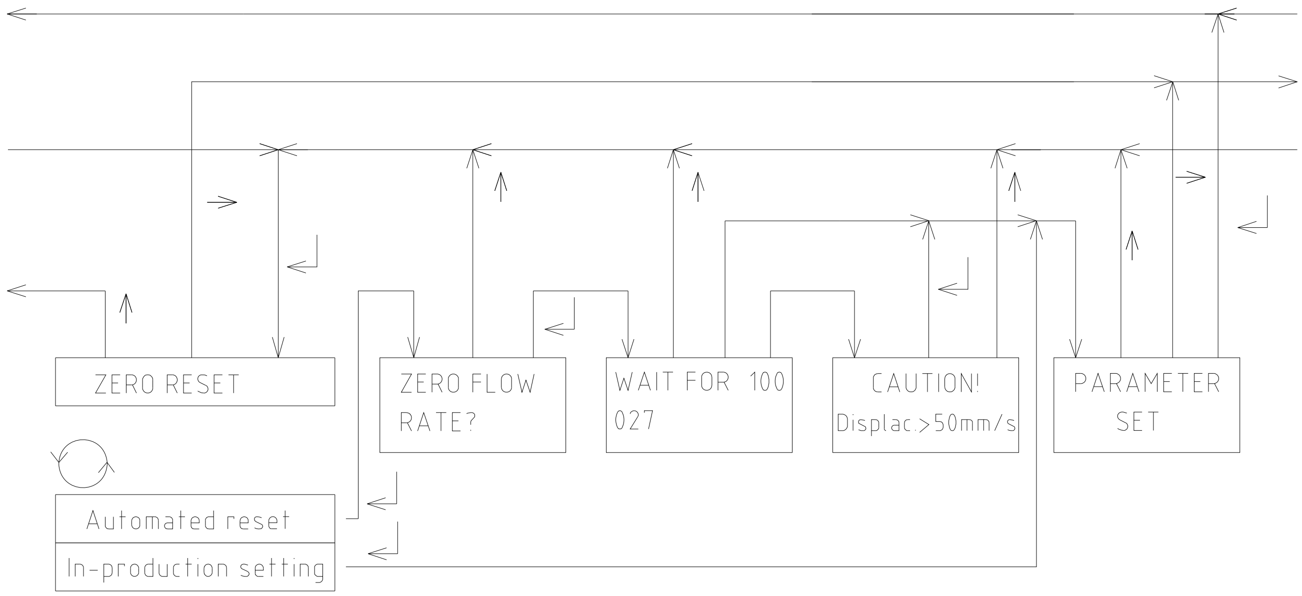



Fig.7.3.10

## PARAMETER SETTING END

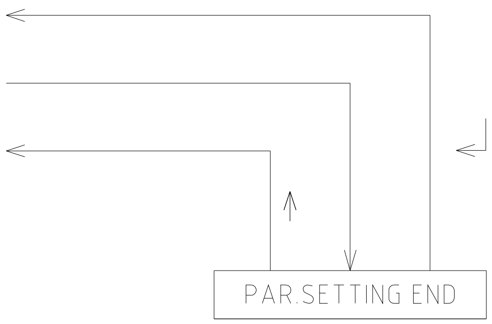



Fig.7.3.11

# 8. SERVICE ACTIVITIES

## 8.1. Warranty services

The product warranty services are understood to include any repair work executed free of charge either on site or at the manufacturer's premises during the product warranty period. Warranty repairs shall concern product defects due to the use of non-standard materials, parts or design errors. Should such defects prove irreparable, the product shall be replaced at no costs to the customer.

Any warranty repairs shall be performed either by the manufacturer (ELIS PLZEŇ a.s.) or other duly authorised distribution agents or service centres.

**The manufacturer's warranty shall not cover**

- products where the installation and/or metrological seals have been removed
- product defects due to incorrect installation
- product defects due to non-standard product use
- product pilferage
- product defects due to circumstances classified as force majeure.

Any requirement for warranty repair shall be submitted in writing (using fax, electronic mail or registered letter) to the official address of the manufacturer. Should the manufacturer establish that the subject product repair does not fall within the warranty conditions, this fact will be made known to the customer in writing and the respective repair costs will be invoiced to the customer. In the case of a commercial meter, the parameters of a repaired product shall be verified at a duly authorised metrological centre.

## 8.2. Post-warranty services

The post-warranty services are understood to include any repair work necessitated by the product defects or deficiencies identified after the warranty period. All such repair work, whether executed at the manufacturer's plant or on site, shall be invoiced and paid for by the customer. In the case of a commercial meter, the parameters of a repaired product shall be verified at a duly authorised metrological centre. Any requirement for post-warranty repair shall be submitted in writing (using fax, electronic mail or registered letter) to the official address of the manufacturer.

# 9. TESTING

On every product, the manufacturer performs a detailed inspection of the product completeness and quality in reference to the respective quality assurance standards. Following this inspection the product is subject to tests performed in compliance with the agreed test specifications. Prior to release from the test station, every product is subject to a test run over a minimum period of 15 hours.

# 10. ORDERING

In ordering a product, the customer shall use the enclosed Product Order Form.

# 11. PACKAGING

The product packaging shall ensure safe domestic and international transport, taking into account the delivery conditions agreed to with the customer. The packaging shall comply with the respective internal standards of the manufacturer (ELIS PLZEN a.s.).

# 12. PRODUCT ACCEPTANCE PROCEDURE

Upon delivery, the goods shall be checked for completeness with respect to the delivery note and subject to visual inspection. A typical scope of delivery includes a complete flow meter system SE8065, a set of assembly and measuring fixtures, application, installation and service manual, product compliance certificate and delivery note.

## 13. WARRANTY CONDITIONS

Unless agreed within the commercial contract between the manufacturer and customer otherwise, the standard product warranty period is 12 months from the date of sale. Within the warranty period all product defects due to material, part of system design faults shall be repaired free of charge. The warranty period shall be extended by the time the product was inoperative due to a warranty repair. Warranty shall not be applicable to any product defects due to incorrect system assembly and/or installation, intentional damage, pilferage, theft or any faults due to circumstances classified as force majeure.

## 14. PRODUCT ORDER FORM

**ELIS PLZEŇ a.s.** **Product Order Form** **SE8065**

| | |
|---|---|
| **Project:** | |
| **Measurement position:** | |
| **Project item:** | |

| Parameters | | | Specified data | Meas. units |
|---|---|---|---|---|
| Minimum flow rate | | | | $m^3$/hour<br>t/hour * |
| Maximum flow rate | | | | $m^3$/hour<br>t/hour * |
| Nominal pressure of measured fluid, PN | | | 6, 10, 16, 25, 40 * | – |
| Nominal inner diameter of piping | | | DN | – |
| Pipe wall thickness | | | | mm |
| Pipe material class | | | | – |
| Type of measured medium | | | | – |
| Length of connecting cables to ultrasonic probes US 2.0 | | | | m |
| Output signal | | impulse | yes no * impulse number | l/imp |
| | | frequency | yes no * | – |
| | | current | yes no * | – |
| Set of assembly and measurement fixtures | | | yes no * | – |
| Optional equipment and functions | | | yes no * | – |
| | current output | | 0 ÷ 20 mA 4 ÷20 mA * | – |
| | mass flow rate information | | yes no * | – |
| | bi-directional flow rate measurement | | yes no * | – |
| | communication interface | | yes no * | – |
| | | - workstation number (1 ÷ 255) | | – |
| | | - group number (1 ÷ 255) | | – |
| Customer's address | | | | |
| Company identification number | | | Tax-payer's identification number | |
| Bank connection | | | | |
| Contact person | | | | |
| Telephone | | | Fax | |

* cross out where inapplicable

Prepared by:

# Manufacturer's address:

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