BELL Flow Systems
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COMMON

INDUSTRIAL QUANTOMETER

Manual

Note: Common reserves the right, to modify the gas meters without changing the request concerning accuracy and security.

1. Design and Function

1.1. Description

The industrial quantometer CPT serve for the volume measurement of flowing gases. They were developed by the company COMMON in close co-operation with the oil and gas industry. The standard version is appropriate for the gases in table 1 for pressure rates up to 20 bar. The operating pressure amounts to thus 0 to p_{max} the appropriate pressure rate of the meter.

Table 1. List of appropriate gases for the measurement with industrial quantometers in standard version

Gas	Symbol (chemical formula)	Density ρ_n* [kg/m³]	Density relating to air
Argon	Ar	1,78	1,38
Ethylene	C_2H_4	1,26	0,98
Butan	C_4H_{10}	2,71	2,09
Ethan	C_2H_6	1,36	1,06
Natural gas	-	~0,83	~0,64
Helium	He	0,18	0,14
Carbon dioxide	CO_2	1,97	1,53
Carbon monoxide	CO	1,25	0,97
Air	-	1,29	1,00
Methan	CH_4	0,72	0,55
Propane	C_3H_8	2,01	1,56
Nitrogen	N_2	1,25	0,97
Hydrogen	H_2	0,09	0,07

*(ρ_n at 1,01325 bar and 273,15 K)

The gas meters are specified by the following parameters:
Nominal size DN, maximal operating pressure p_{max}, as well as maximum flow Q_{max} and minimum flow Q_{min} under operating pressure and operating temperature.
The admissible error between Q_{max} and Q_{min} under operating conditions is designed according to the margins of error of turbine gas meters as per EEC guideline for volume gas meters. The minimum flow results from the calibration of the meter.

1.2. Function

The measurement principle of the quantometer is based on the proportionality of the linear gas rate for the rotating speed of the turbine wheel in the defined annular space of the measuring cartridge. This area of the gas meter was designed according to the laws of the mechanical measuring technique of liquids and gases. Counter sums up the passed gas volume and brings it to the display.

1.3. Meter sizes

The standard sizes of the COMMON industrial quantometers are arranged in table 2.

Table 2. Standard sizes of the industrial quantometers CPT

DN		G-Size	maximum flow Q_{max}	minimum flow Q_{min}	Measurement range	NF1 – NF4 Counter head pulse rate - U_a m³/Imp.	HF1 – HF2 Counter head m³/Imp.	HF3 Turbine wheel m³/Imp.
mm	inch		[m³/h]	[m³/h]				
50	2	40	65	6	1:10	0,1	1,84929E-04	6,10862E-06
		65	100	10			3,69858E-04	1,01810E-05
80	3	100	160	8	1:20	1	9,24645E-04	2,34947E-05
		160	250	13			1,18519E-03	3,26246E-05
		250	400	20			2,12954E-03	5,86196E-05
100	4	160	250	13	1:20	1	7,22932E-04	3,40498E-05
		250	400	20			1,44586E-03	5,95871E-05
		400	650	32			2,58587E-03	1,06569E-04
150	6	400	650	32	1:20	1	2,58587E-03	1,06569E-04
		650	1000	50			4,57365E-03	1,50792E-04
		1000	1600	80		10	7,75761E-03	2,55766E-04

1.4. Dimensions

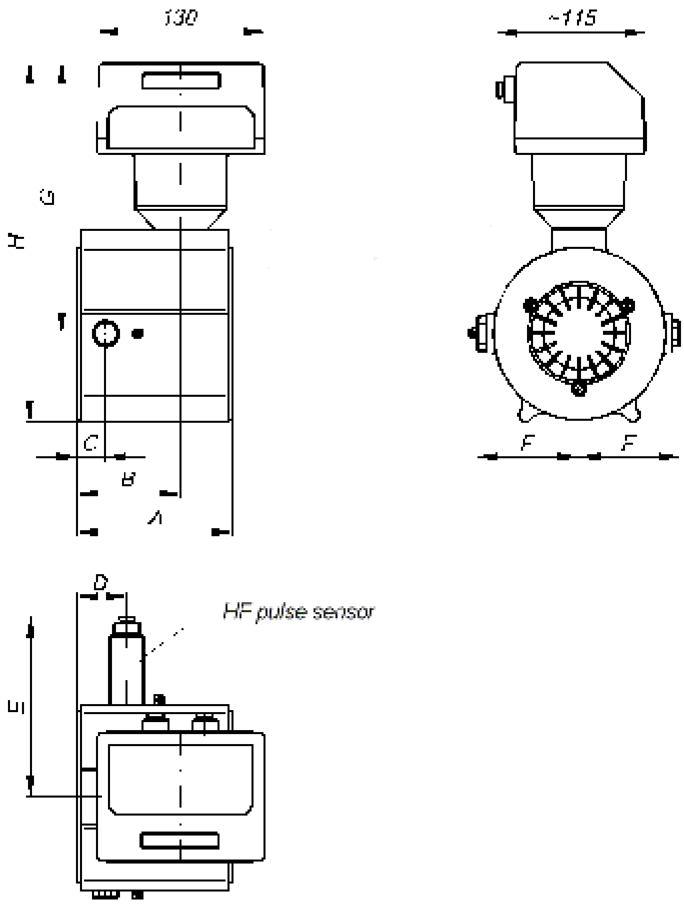


figure 1: External dimensions of the industrial quantometer CPT

The external dimensions of the industrial quantometers can you take from the table 3. An allocation of the parameters takes place according to the figure 1. The dimensions are to be considered when planning from measuring systems.

Table 3. Dimensions and weights of the industrial quantometer CPT

DN		Pressure rate	A	B	C	D	E	F	G	H	Weight
mm	inch		mm	mm	mm	mm	mm	mm	mm	mm	kg
50	2	PN10/16 ANSI150	100	65	18	32	140	65	199	252	3,6
80	3		120	80	21	38	150	77	211	278	5,3
100	4		150	100	29	53	165	91	225	305	7,4
150	6		180	127	50	76	190	116	243	351	11,6

1.5. Construction

The industrial quantometer consists of 4 main components:

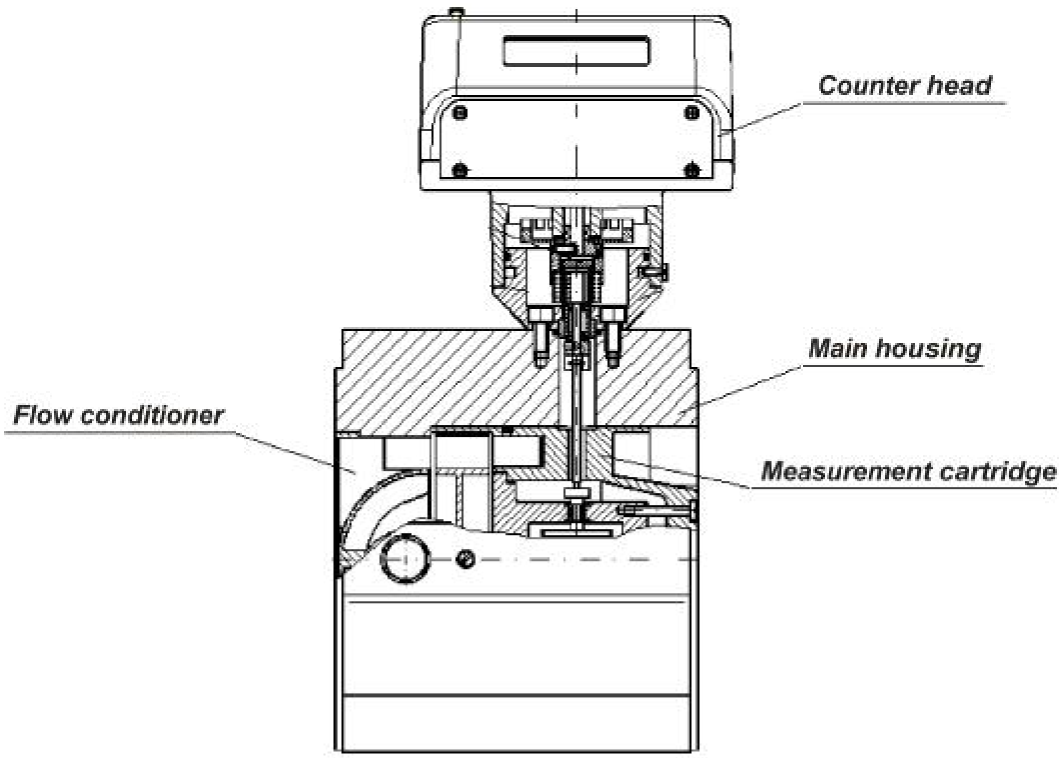


Figure 2: Sectional view of the industrial quantometers CPT

1.5.1. Main housing

The main housing is manufactured from extruded aluminium.
The dimensions and weights of the meters are indicated in table 3.
The housing of the meter owns no flanges. The installation of the meter will be done between DIN or ANSI flanges the pipe installation, by using of long bolt screws. For detecting of the operating pressure at the meter, is at the front side one p_r - connecting piece in form of a tapped hole M 12 x 1,5 available.

1.5.2.Measuring cartridge

The measuring cartridge contains the turbine wheel, which is hold by self lubricated ball bearings on the main shaft. The rotating motion of the main shaft will be reduced by gear wheels and transferred to the magnetic coupling.
A direct detecting of the rotating motion of the turbine wheel as high frequency impulse is additionally possible by the optional installation of one HF sensor.

1.5.3. Counter head

The transfer of the angular momentum from the main housing loaded by pressure into the counter head is made by a gas tight magnetic coupling. In the counter heading a further reduction of the rotating speed of the waves is made by snail and gear wheels up to the drive of the 8-digit roll counter. A gear set is to be implemented changeable to realise an adjustment of the roll counter.
To pick up electrical impulses is given a possibility by up to two HF Namur sensors, up to two NF Namur sensors and up to two NF Reed contacts. As standard, each counter is equipped with one NF Reed contact. The electrical connection, to take the impulses from the counter head can take place over up to two sockets, whereby one socket is installed as standard. The output signals of the HF sensors in the counter operate adjustment-independently proportionally to the optionally HF sensor on the turbine wheel of the meter.

1.5.4. Flow conditioner

The quantometer has an integrated flow conditioner on the upstream site. To fulfil the requirements for the stated accuracy of the meter in the gas installation, a straight and undisturbed upstream pipe of minimal 5 x DN in front of the meter has to be planned.

1.6. Materials

All by the construction of the industrial quantometers CPT used materials guarantee the necessary stability and corrosion resistance. The meters are material-technically checked before distribution. Appropriate certificates in accordance with DIN EN 10204 can be requested.
The meter bodies are manufactured from aluminium. They are galvanised and outside coated with varnish paint.
The integrated flow conditioner is manufactured from plastic.
The turbine wheel, the measuring cartridge, the meter body, as well as the oil pump are manufactured from aluminium alloys.
Moved parts like shafts, snails or bearings consist of stainless steel.
Gear and snail wheels are manufactured from plastic.
The transparent parts like counter displays consist of polycarbonates.

1.7. Measurement and pulse outputs

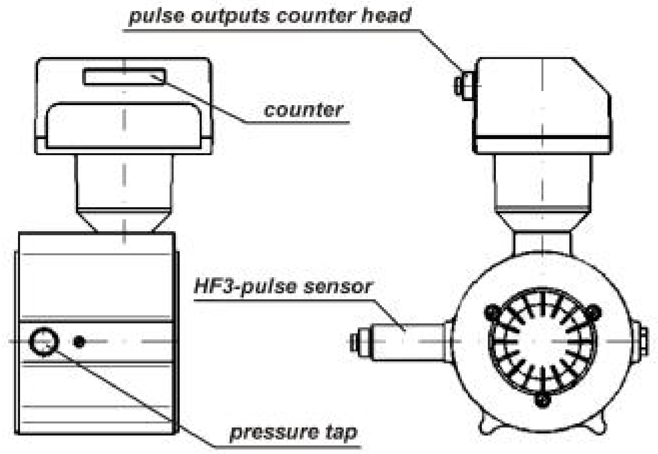


Figure 3: Measurement outputs of the industrial quantometer CPT

1.7.1. Counter head

The mechanical 8-digit roll counter head is the main counter of the industrial quantometer CPT. It displays the passed gas volume at operating pressure and operating temperature. Depending of the meter size, the display value corresponds to the lowest place 0.01 m³ up to 1 m³. The counter head is rotatable around 345°, so that it is configurable into almost all directions, in order to ensure a good readability in all installations.

1.7.2. NF-Reed-Contact

In the counter head Reed-Contacts (NF1 and NF2) are available depending upon execution up to two, whereby one Reed-Contact NF1 is equipped as standard. They are adjusted like the mechanical roll counter and output pulses, which are in direct relation to the mechanical display. This type of contacts is electric potential free and has a high long-term reliability. Mostly by Reed-Contacts battery powered devices are connected such as volume correctors or tariff devices. You find a representation of the position as well as the connection possibilities in the figures 6 and 7, as well as the specification of the pulse values in table 2. The technical data please take from the paragraph: „Technical data of the Reed-Contacts“.

1.7.3. NF-NAMUR-Pulse sensor

NF-NAMUR pulse generators are optionally possible up to two slot initiators (NF3 and NF4) in the counter head They are adjusted like the mechanical roll counter and the Reed-Contacts and output pulses, which are in direct relation to the mechanical display. The use of such active pulse generators is possible due to increased requirement of electric power consumption generally only with line power devices. Thus however pulses can be transferred over larger distances up to approximately 200 m surely. You find a representation of the position as well as the connection types in the figures 6 and 7 as well as the specification of the pulse values in table 2. The technical data please take from the paragraph: „Technical data of the NAMUR-Pulse sensors“. All pulse generators are certified for hazard areas and possess a EEx conformance certificate.

1.7.4. HF-NAMUR-Pulse sensor

HF NAMUR pulse generators are optionally possible in the counter heading (HF1 and HF2) and at the turbine wheel (HF3). The quantometer can be equipped with these sensors according to demand of the customer. The output signals are in fixed relation to the rotation of the turbine wheel and can not be changed by the adjustment gear wheels. They serve generally the control of line powered volume correctors, flow computers or data storage devices. The pulses can be transferred over larger distances up to approximately 200 m surely. The specifications in the table 2 are approximate values, whereby the exact impulse values of an each sensor and meter are determined during the calibration and can deviate from the indicated value in table 2. The technical data please take from the paragraph: „Technical data of the NAMUR-Pulse sensors“. All pulse generators are certified for hazard areas and possess an EEx conformance certificate.

1.7.4.1.HF1 and HF2

This both pulse sensors are positioned in the counter head. There existing reference wheel generates the pulses in up to two approximation initiators (see fig.4). You find a representation of the position as well as the connection possibilities in the figures 6 and 7.

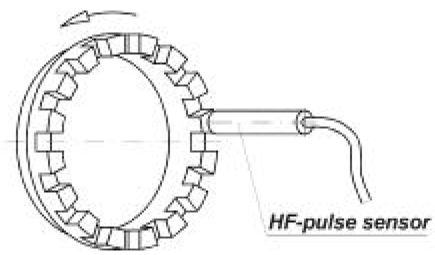


Figure 4: Representation of the HF-pulse sensors HF1 and HF2 in the counter head

1.7.4.2. HF3

The pulse sensors HF3 is positioned in the meter body (see fig.3). The pulses of the turbine wheel are generated by the sensors HF3.
The sensor is an approximation initiator and possess a separate plug (see fig.5).

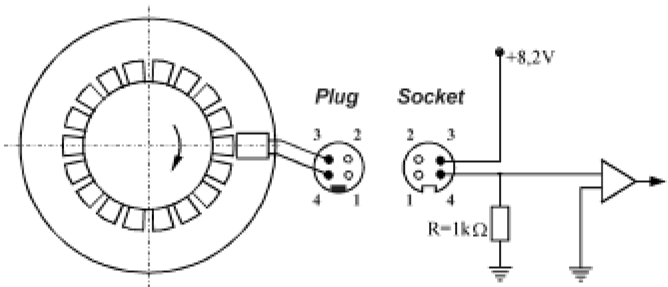


Figure 5: Pattern of the connector of the HF pulse sensor HF3 in the meter body

1.7.5. Link specification of the electrical pulse sensors

Whether a pulse sensor is available and which impulse value of these possesses, you can take from the pulse generator sign of the industrial quantometer (fig.13).

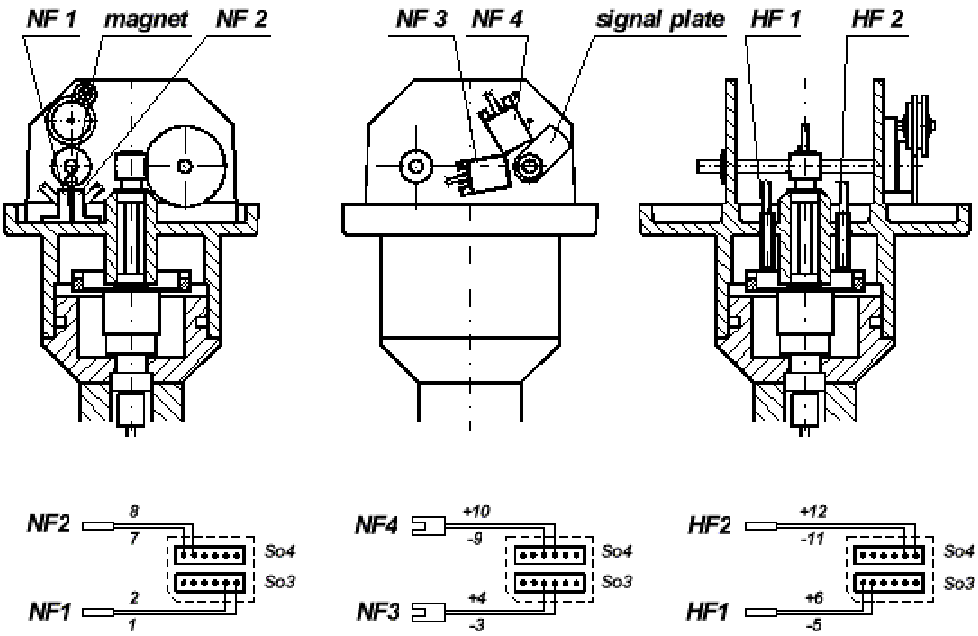
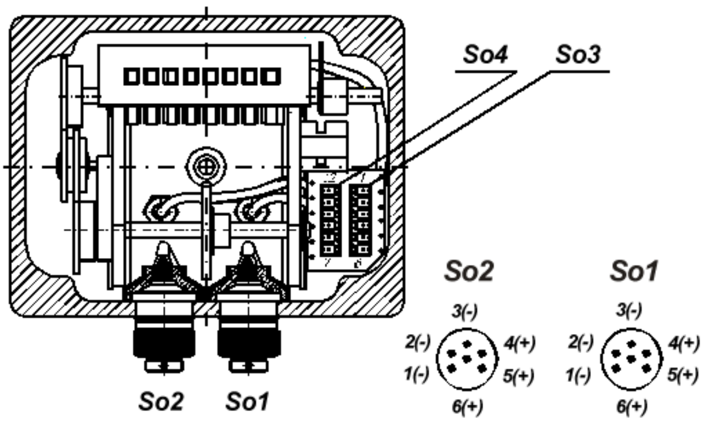


Figure 6: Position of the NF and HF pulse sensors in the counter head of the quantometer CPT



			Socket 3						Socket 4					
			NF1		NF3		HF1		NF2		NF4		HF2	
	Pin	Polarity	1	2	3	4	5	6	7	8	9	10	11	12
Socket 1	1	–	**x**		x									
	4	+		**x**		x								
	2	–			**x**				x		x		x	
	5	+				**x**				x		x		x
	3	–					**x**							
	6	+						**x**						
Socket 2	1	–			x				**x**					
	4	+				x				**x**				
	2	–			x				x		**x**		x	
	5	+				x				x		**x**		x
	3	–					x						**x**	
	6	+						x						**x**

x - Standard connection of the complete version
x - Alternative connections

Figure 7: Diagram of connections of the pulse sensors in the counter head of the quantometer CPT

1.7.5.1. Pulse sensors in the counter head

The position and the connectors of the possible pulse generators in the counter head are represented in the figures 6 and 7. The standard version contains only the NF Reed contact NF1. All other sensors can be installed on customer's request. The connection of the electrical pulses to the installation for clients is made by the sockets So1 and So2, whereby So2 is installed optionally with more than 3 sensors or on customer's request in the counter head. The electrical connection to the socket is to be implemented over a plug of the company Tuchel with the designation C091 31 H006 100 6. An information plate (see fig.14) of the electrical specification of the socket is positioned on the rear side of the counter head.

1.7.5.2. Pulse sensors in the meter body

The position of the optionally pulse generator in the meter body is represented in the figure 3. The detection of the electrical impulses is made by the respective plug at the sensor. The electrical connection could be realised to the 4-pin plug by a coupling socket of the company Tuchel with the designation C091 31 D004 100 2. An equipment of the meter with this sensor has to be required in the meter order. A retrofitting can be done by the manufacturer only, or executed by assigned technical personnel.

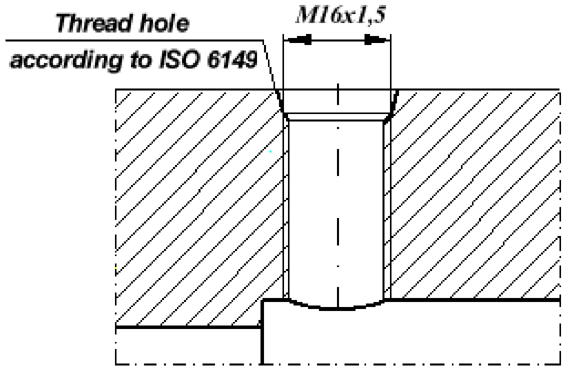


Figure 8: Assembly hole for the HF-pulse sensor HF3 in the meter body

1.7.5.3. Technical data of the Reed-Contacts

The Reed-Contacts are passive sensors and used for low-frequency output signals only. They have the following technical data:

max switching voltage	24 V
max switching current	100 mA
contact resistance	0,15 Ω
max switching frequency	500 Hz

1.7.5.4.Technical data of the NAMUR-Pulse sensors

The NAMUR-Pulse generators are active sensors and used for low or high frequency output signals. They have the following technical data:

supply voltage	8,2 V
supply current inactive (low)	< 1,2 mA
supply current active (high)	> 2,1 mA
load resistance	1 kΩ
max switching frequency	5 kHz

The circuitry of the electrical connection is represented in figure 9 and the output signals which can be expected in figure 10.

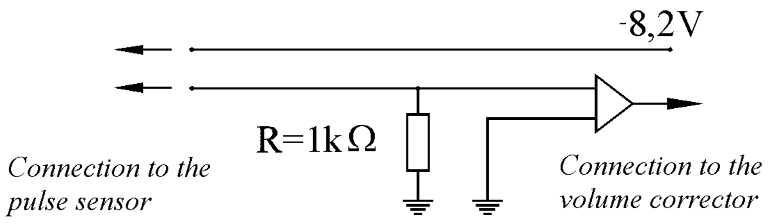
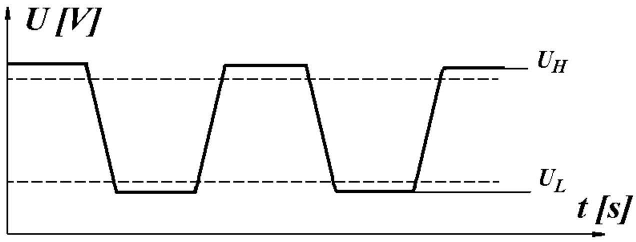


Figure 9: Diagram of connections of the inductive NAMUR initiators



inactive state: U_L < 1,2 V, active state: U_H > 2,1 V

Figure 10: Output signals of the inductive NAMUR initiators

1.7.6. Pressure measurement

The measurement of the operating pressure of the quantometer can be done by the reference measuring tap p_r. This is available at the front side of the meter (see fig.3). In that way it will take place at the front without attention of the installation position. The thread dimensions for the connection of a screw connector is represented in the figure 11.

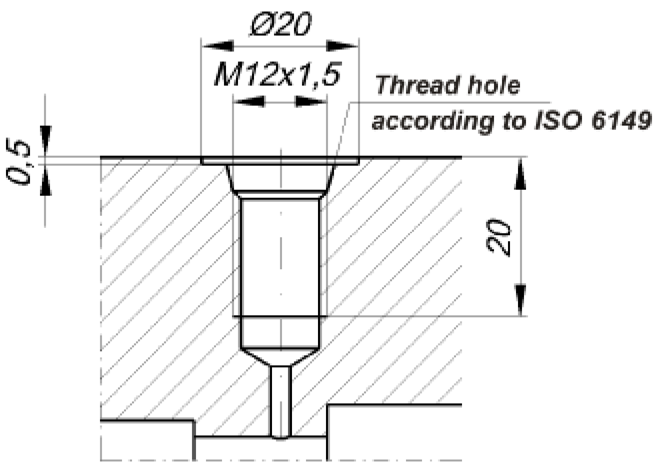


Figure 11: Dimensions of the reference measuring tap

1.8. Designation and signs

The technical basic parameters of the industrial quantometer are noted on the type plate (fig.12). It is equipped on the front of the counter head.
The specification concerning pulse outputs and their value can be taken from the pulse generator sign on the top side of the counter head (fig.13).
The flow direction is indicated by arrows (fig.15) on the front and rear side of the meter body.
The marking of the pressure measuring point takes place at the meter body according to the representation in figure 16. In similar manner also the pulse generator HF3 is marked.

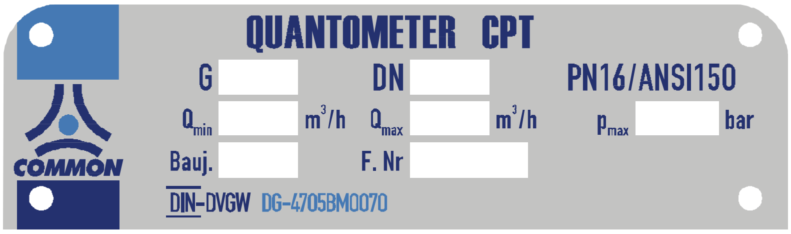


Figure 12: type plate

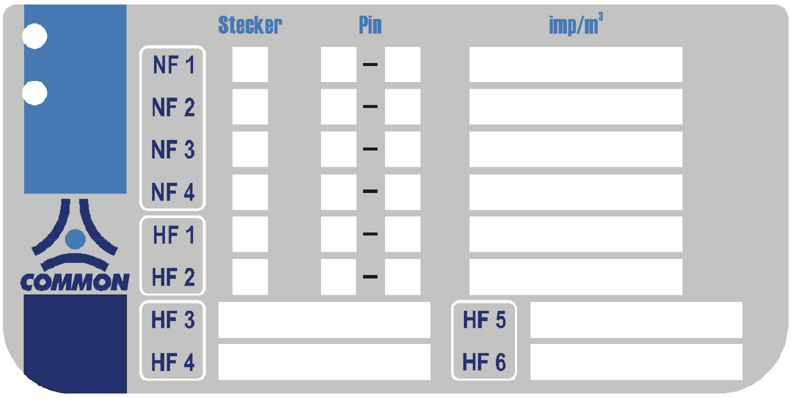


Figure 13: Pulse sensor sign

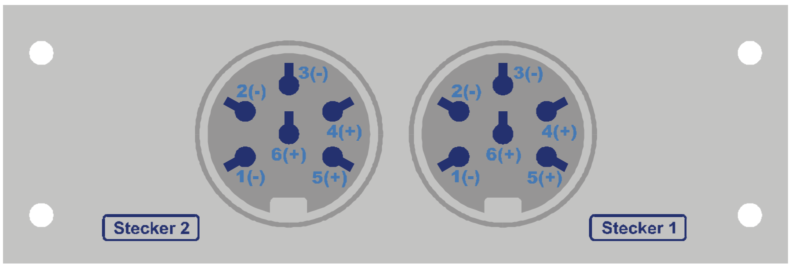


Figure 14: Sign for the connector identification of the pulse generators in the counter head

Figure 15: Arrow on the meter body for the specification of the flow direction

Figure 16: Information designation for the pressure measurement

2. Measuring values

The gas volume, which flows through a quantometer, is displayed by the counter concerning the operating or line conditions pressure, temperature and compressibility only. In order to determine a comparable value independently to the respective operating conditions for accounting purposes, a conversion of the volume to standard conditions V_n is used. The standard volume determines itself from the following calculation:

$$V_n = \frac{V_b}{k} * \frac{p_b}{p_n} * \frac{T_n}{T_b} \approx \frac{V_b}{Z} * \frac{273 * (p_ü + 1)}{(t + 273)} \qquad (1)$$

where $k = Z/Z_n$

Definition:

V_b	– operating volume [m³/h]	T_b	– standard gas temperature abs. [K] (273,15 K)
V_n	– standard volume [m³/h]	T_n	– operating gas temperature abs. [K]
p_b	– operating pressure at the meter [bar]	k	– compressibility factor k (constant or calculation by GERG 88)
$p_ü$	– operating over pressure at the meter [bar]		
p_n	– standard pressure [bar] (1,01325 bar)	Z	– real gas factor
t	– operating gas temperature [°C]	Z_n	– real gas factor (standard condition: $Z_n \cong 1$)

The operation volume V_b of a measuring period determines itself from the difference of the counter statuses of the quantometer the at the beginning and to the end of the period. The operation over pressure $p_ü$ is determined on the reference pressure point p_r of the meter as average value. The operation gas temperature t can be measured by a temperature sensor in the down stream pipe of the meter in accordance with PTB test rules Volume 20. The compressibility factor is determined by using the gas quality, at systems up to 10 bar as constant or at higher pressures than variable over calculation methods in accordance with G 486.

3. Measuring accuracy

Each real measurement is falsified by measurement inaccuracies. These errors can be divided at the quantometer in two substantial categories:

1. Error by the physical characteristics of the measurement principle.
2. Error by the installation-conditioned influence of the gas flow.

3.1. Error of the measurement principle

The measuring characteristic of quantometers is represented in figure 17. Dependence to the EWG guideline of volume gas meters the margins of error are determined on the following values:

$Q_t - Q_{max}$ $\leq \pm 1{,}5$ %

$Q_{min} - Q_t$ $\leq \pm 3$ %

where at quantometers $Q_t = 0{,}2\ Q_{max}$

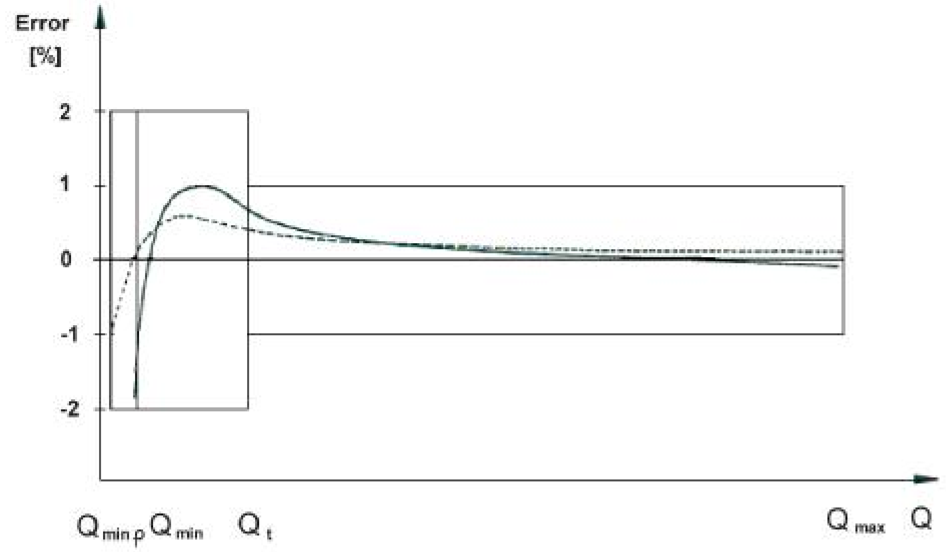


Figure 18: Error characteristic of a quantometer
¾ ¾ ¾ Low pressure error curve; - - - - - - High pressure error curve

The measurement range of the COMMON quantometers is indicated in table 2. As more highly the operating pressure rises, becomes the error curve more flatter (see fig.17) and the minimum flow Q_{min} becomes more smaller within the admissible limits of error. Thus a larger measuring range can be obtained with higher operating pressures, which could be up to a relation of 1:50.
The on density depending minimum flow value $Q_{min,\rho}$ can be calculated according to the following relation:

$$Q_{min,\rho} = Q_{min} * i_\rho = Q_{min} * \sqrt{\frac{\rho_w}{\rho}} = Q_{min} * \sqrt{\frac{\rho_w * 1{,}013}{\rho_g * (p + p_a)}} \approx 1{,}1 * \frac{Q_{min}}{\sqrt{\rho_g * (p + p_a)}} \qquad (2)$$

Definition:
$Q_{min,\rho}$ – minimum flow value under operating pressure [m³/h]
Q_{min} – minimum flow value according to table 2 [m³/h]
i_ρ – coefficient
ρ_w – density of the gas of the verification [kg/m³]
ρ – density of the operation gas with operating pressure [kg/m³]
ρ_g – density of the operation gas with atmospheric pressure according to table 1 [kg/m³]
p – gas overpressure in front of the quantometer [bar]
p_a – atmospheric pressure [bar]

The figure 18 shows a diagram to the determination of $Q_{min,\rho}$ with determined operating pressure. Based on the operating pressure and the temperature it has to be determined the density. In dependency of this density values, the coefficient i_ρ can be determined from the right page of the diagram. Under help of the formula in the diagram (fig.18) it is possible to calculate the appropriate $Q_{min,\rho}$ under operating pressure by using the Q_{min} value from table 2.

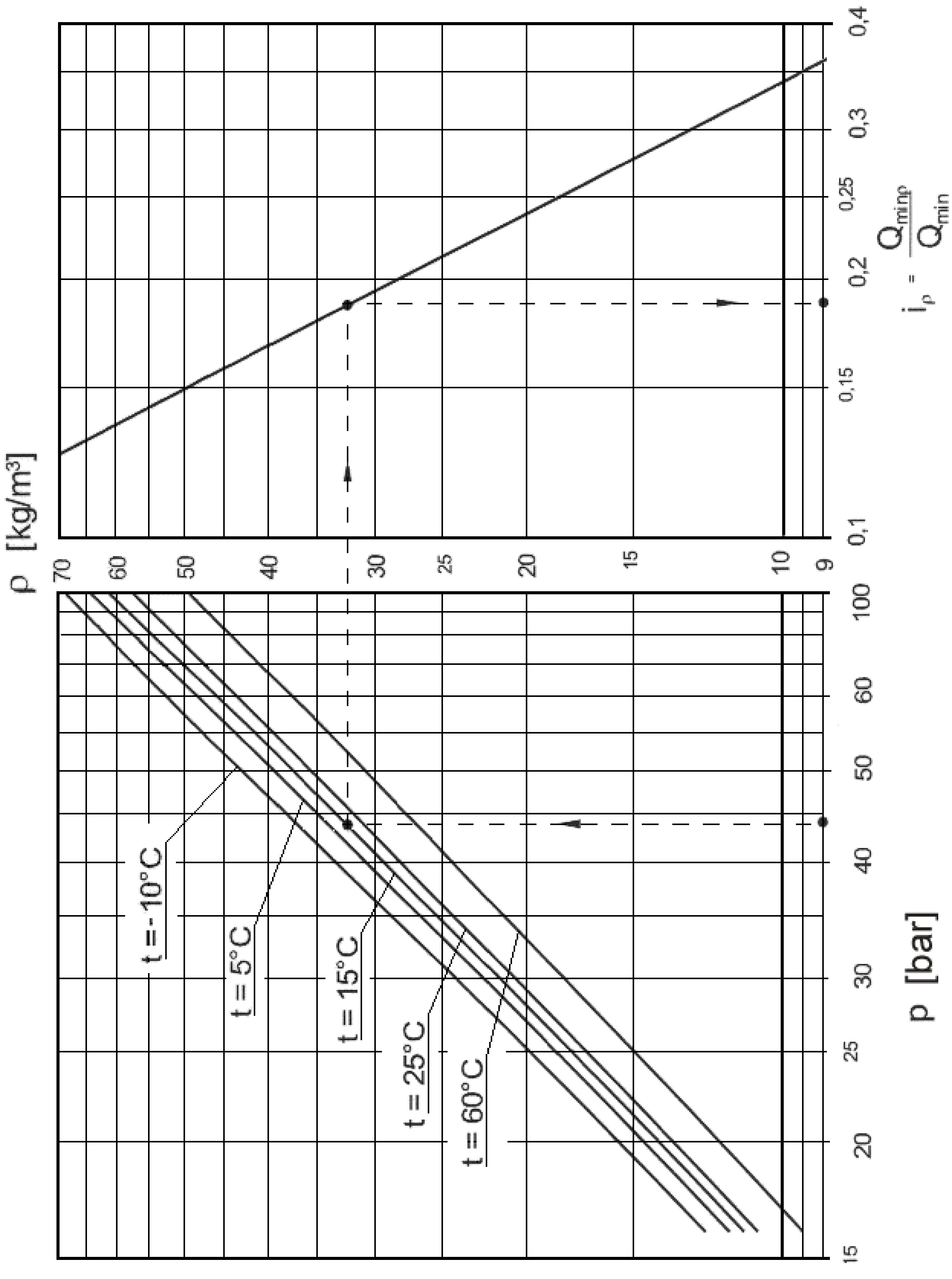


Figure 18: *Diagram for the determination of the Q_{min} - value at defined operating pressure and operating temperature*

3.2. Error of the installation

Quantometers are inferential gas meters and therefore dependent on the direction, distribution and the homogeneity of the gas flow.
The integrated flow conditioner allows with an upstream pipe length of 5xD a measurement, mainly free of perturbations. An elimination of perturbations can be obtained with a COMMON flow conditioner PS, installed in the upstream pipe.
In the case of pulsating or intermittent gas flows, which cause a run after of the turbine wheel of over 1% in relation to the operation flow, a quantometer without special add-on modules is not suitable. In these cases volume measuring instruments should be used, as for example the COMMON rotary gas meters CGR.

4. Pressure loss

The gas meter causes an inevitable pressure loss. This is limited by the maximum value according to DIN 33800. The pressure loss values of the individual nominal sizes at a gas density $\rho_0 = 1 kg/m^3$, that can be taken from the diagram of the figure 19.
The real pressure loss Δp_{re} is calculated according to the following formula:

$$\Delta p_{re} = \frac{\rho}{\rho_0} * \frac{p_a + p}{p_a} \Delta p \qquad (3)$$

Definition:
ρ – gas density according to table 1
ρ_0 – reference gas density ($\rho_0 = 1 kg/m^3$)
Δp – pressure loss for gas density ρ_0 (Abb.19)
Δp_{re} – operating pressure loss
p – gas over pressure in front of the meter
p_a – atmospheric pressure ($p_a = 1 bar$)

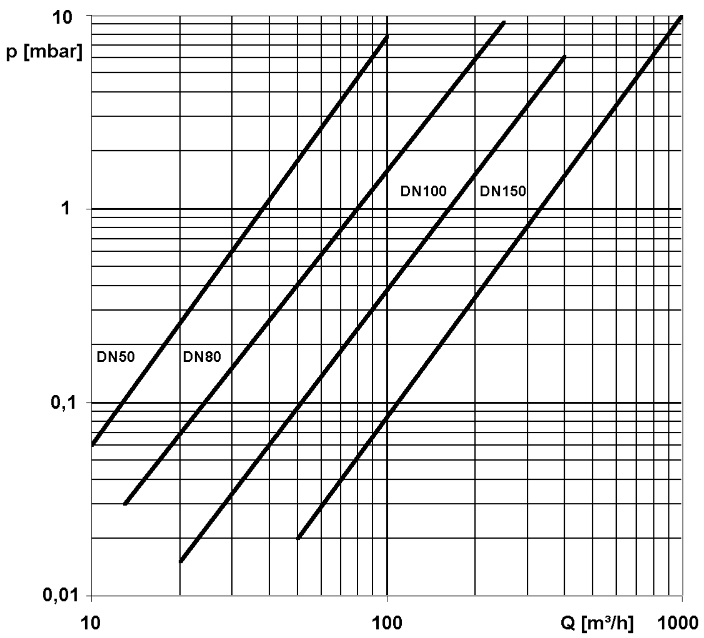


Figure 19: Pressure loss diagram of the quantometer CPT of a density $r_0 = 1 kg/m^3$

5. Transport and storage

The quantometer CPT is a precise measuring instrument and is to handle with the utmost caution.
The following points are to be considered:
During transportation the meter is not to be thrown or to expose strong vibrations.
The meter is to be transported and to be stocked in the appropriate installation position.
The gas meter should be transported in the original packaging up to the place of work.
Removing from fabrication catches and transportation covers is only recommendable at the installation place.
A raising of the quantometer at the counter head is not admissible.
It is to be paid attention to as dry a storage as possible. The meter is to be protected against precipitation and other humidity.
It is to be made certain that by the transportation and by remove of the packing no seal is damaged or is removed.
For mentioned above transport damages the manufacturer does not take over a warranty.

6. Installation

Before the gas meter is installed, it should be checked again, if the meter meets the requirements of the gas measuring system. Very important is the check of the pressure rate PN of the installation, the maximum installation pressure p_{max} and maximum the flow rate Q_{max} under operating conditions, as well as the right flow direction.
The preferred position for the installation of the quantometer is an horizontal installation. The counter head has to be above in each case. A vertical installation has to be adapt by the production. Specially the flow direction from down upward is to be avoided and possible only by special manufacturing.
The gas meter has not to be installed at the deepest point of the installation, because otherwise condensate or contamination can settle in the meter and thus the function and measuring accuracy can be affected.
The installation of quantometers should take place in closed rooms or cabinets if possible. In open air installations the meter has to be protected by suitable measures from precipitation, contamination or direct sun exposure. The area of application is with a gas temperature between -10°C and +60°C. The lowest ambient temperature has to be not lower than -25°C.
The installation, into which the quantometer has to be installed, should be conceived according to the technical guideline TR G 13, because otherwise by the manufacturer no warranty for the adherence of the error limits can be given. To adherence the measuring accuracy, normally an upstream pipe distance of 5 x DN is sufficient. It is to be made certain too, that the gas flow does not indicate an intermittent or pulsating character, which can cause a tracking error of $\geq$1%.
In order to achieve a very high measuring accuracy of the gas meter, the company offers also complete meter runs with upstream and downstream pipe and a COMMON flow straighter. This flow straighter is a Sprenkle Flow conditioner according to DIN EN ISO 5167-1. The pressure loss thus increased is to be inferred from the paragraph of the same name.
The installation of the gas meter has to take place without tension into the piping. With larger meters the pipe installation, or if necessary the meter, is to be supported. It is to be made

certain that the meter is to be built concentrically into the piping and no seals loom into the piping.
It has to be paid attention of possible contamination of the gas, which can damage the meter and cause an influence of the measuring accuracy strongly. If possible, a filter has to be installed in front of gas meter, which has a fineness of minimal 10µm. In the starting phase a start sieve is recommendable, which avoids a damage of the meters by welding or installation pollution. This is to be removed however after some time again from the pipe installation, in the case of contamination which were held back by the start sieve, will generate a flow disturbance, which can have an influence on the measuring accuracy. The manufacturer of the quantometers does not take responsibility for damage to the gas meter, which from insufficient filtering or contamination in the piping results.
The connection of volume correctors and add-on modules has to take place using the prescribed plug connectors (paragraph "link specification of the electrical pulse generators").

7. Putting into operation

During the admission of the quantometer with operating pressure largest caution is required, because by the difference of pressure for pressure-free subsequent installation briefly large gas flows can occur, which can load then the gas meter over the permitted flow and destroy the measuring cartridge. Filling the pipe installation by the installed quantometer should be avoided. You find an example of the structure of a measuring system in figure 20.

– case a bypass in the installation is available, is before opening the valves 1 and 2 pre and behind the gas meter the following piping through to open the valve 4, to be filled. Afterwards over a needle valve 5, if it is available, or by very slow opening of input valve 1 the meter can be set under operating pressure. After it the output valve 2 is only to open slowly. As last step may not be forgotten to close the valves 4 and 5 again.
– with absence of the bypass at first the meter is by slow opening of the output valve 2 to connect with that follows installation. Afterwards very slowly and carefully the input valve 1 is to be opened, whereby the danger of the brief overload is very large here.
– for the purpose of the disassembly the meter installation has to be emptied. If a bypass is available, the valve 4 is to open as the first one. The meter has to be separated from the gas flow by slowly close from the input valve 1 and the output valve 2. Afterwards the gas meter is to be emptied over the bleed valve 3 slowly.

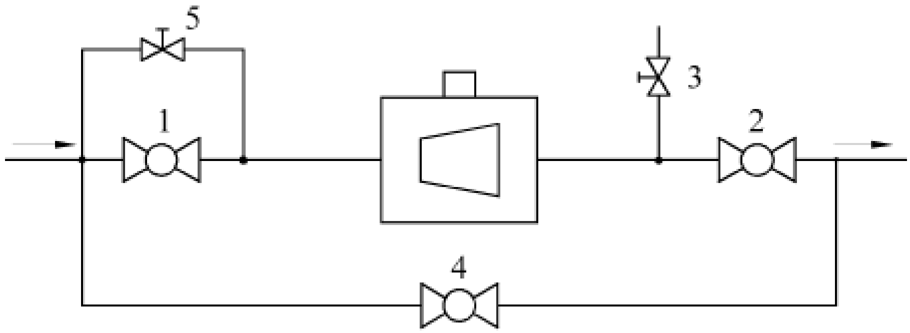


Figure 20: Pattern of a measuring system with bypass

8. Maintenance and lubrication

Quantometers have to be serviced from instructed technical personnel only. Strong operation noises or jerky run point on a damage of the gas meter.
The industrial quantometer require no lubrication. The bearings of the main shaft of the turbine wheel are self lubricated.

9. Seals

The seal positions can be taken from the figure 21.

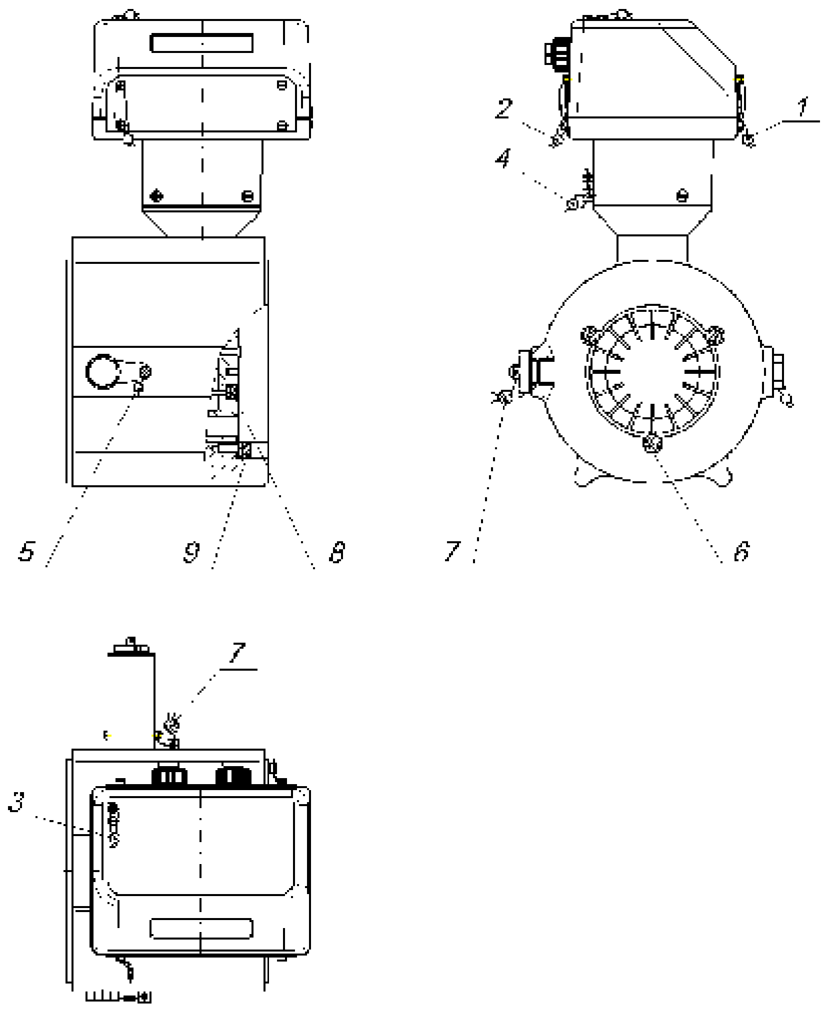


Figure 21: Seal positions of the quantometer CPT

If a seal was damaged or removed, the guarantee goes out for the measurement accuracy of the meter.
Seals for add-on modules are not marked. At special information it is pointed out, that blind screw connections which are not be used by sensors, can be sealed too.