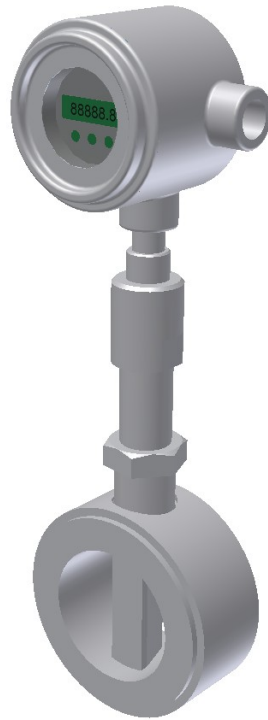


INSTRUMENT MANUAL
MK 8840

VORTEX METERS



August 2010

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1. FUNCTION AND FIELDS OF APPLICATION

The vortex-separation type flowmeters of the series 3340 (further on called simply vortex meters) are suitable for the measurement of volume flow rate of

fluids, gases and vapors

in a wide range of flow, pressure and temperature in closed pipelines, under industrial conditions, outdoors and in explosion dangerous plants.

Main advantages of the vortex meter include:

- it combines the accuracy of turbine meter with the simplicity and reliability of metering orifice, while it has a measuring range which is several times larger than that of the latter one;
- the so called calibration constant used for the determination of the working volume flow rate is practically independent of the properties of the medium to be measured (pressure, temperature, density, viscosity), it depends exclusively on the mechanical dimensions of some non-moving components.

Media most frequently measured by vortex meters:

- drinking water, industrial water,
- solvents, alcohol deviates, chemicals,
- hydrocarbons,
- liquid gases,
- vapors (dry - saturated or overheated - water vapor, other vapors)
- gases (air, natural gas, liquefied petroleum gas, nitrogen, oxygen etc.)

2. SCOPE OF SUPPLY

2.1 Vortex Meter and its Accessories

Unless otherwise provided by the contract of supply the package of the vortex meter of the series 3340 includes the following components:

- | | |
|--------------------------------------|-------|
| • Vortex meter (3340-0-ABC-DE) | 1 pc |
| • Vibration plate assembly | 2 pcs |
| • Sealing for vortex detector | 2 pcs |
| • Instrument Manual | 1 pc |
| • Manufacturer's quality certificate | 1 pc |

2.2 Optional Accessories

- Upstream and downstream pipe sections, reducing and expanding pieces
- Assembled and calibrated measuring section
- Calibration diagram (measured under agreed conditions)
- Cable

3. TECHNICAL DATA

From systems technologic aspect the vortex meter of the series 3340 is a volume flow rate transmitter with frequency output, its input signal provided by the volume flow passing through it, while its output signal consists in an electric pulse series proportional to the volume flow rate. Formulated in a formula:

$$f = K Q \quad [1]$$

where:

f	frequency of the output signal	[Hz]
Q	volume flow rate	[m ³ /s]
K	calibration constant	[pulse/m ³]

Programmable 4-20 mA analog current output and local display of the actual volume flow or totalized volume are also available depending on the last character of Type-code (Chapter 4.3).

3.1 General Data

Type assortment:	See Chapter 4.3
Main dimensions and weights:	See Table 1
Ambient temperature range:	- 50 ... + 60 °C
Relative humidity of the ambient air:	max. 100 %
Climatic construction:	outdoors
Temperature range of the medium:	- 100 ... + 200 °C (special +400°C)
Pressure of the medium:	0 - 32 MPa with flat sealing surface
	0 - 10 MPa with grooved or recessed sealing surface
	0 - 32 MPa with lens profile sealing surface
Pressure stages and test pressure:	in conformity with norm EN 2873
Supply voltage:	15... 30 V DC
Power consumption:	max. 20 mA
Output signal:	See Chapter 4.3 and Figure 3.
Protection:	IP 65
Materials of wetted parts:	1.4541; X12 CrNi177
Overload capacity:	unlimited
Mounting position:	measuring tube: horizontal ± 30 ° neck of the vortex meter: vertical ± 30 °

3.2 Metrological Data

Measuring range:	according to Chapter 4.4
Accuracy:	± 1.5 % of actual value (within the measuring range determined according to Chapter 4.4, calibrated by upstream and downstream pipe sections of the type series 3341 of length as determined in Table 4)
Repeatability:	± 0.25 % of actual value
Additional error:	negligible (Properties of the medium to be measured - its pressure, temperature, physical condition - do only influence limits of the measuring range through the working density and viscosity. Within the measuring range its effect exerted on the calibration constant does not exceed repeatability.)

4. TECHNICAL DESCRIPTION

4.1 Description of the Operation

Under certain circumstances vortices are generated around a body put into the way of a flowing medium. Such phenomena may be observed day by day in the nature, for example seeing a flag fluttering in the wind or hearing the whizzing of a cane or even watching the whirling of the river water around a pier. This phenomenon considered usually harmful in aerodynamics may be very well utilized in metrology. The theoretical and experimental work of the Hungarian physicist Tódor Kármán, also having done a pioneering work in aeromechanics, highly contributed to the discovery of its laws.

If the flow is properly regular (i.e. taking place for a long time in a straight channel of constant cross-section e.g. in a pipe, thus allowing whirls produced by the preceding curves, contractions or expansions to calm down), then vortices separating from the so called vortex generating body will also be regular ones (Fig. 1). In addition, in a very wide flow rate range, quantity (number) of vortices will be in direct ratio to the flow through quantity producing them. Thus the main point of the phenomenon consists in the fact, that vortices divide the flow generating them into equal portions, that is a determined flow through volume belongs to each vortex. This is also proved by the fact that distance (density) of vortices separating from the vortex generating body and moving forward with the flowing medium is a constant determined by the geometrical dimensions. Thus counting the vortices the flow through volume may be detected.

In addition of the regularity of the flow a further condition of the accomplishment of the above described phenomenon is that the flow should be steadily turbulent, i.e. value of the Reynolds-number should exceed 10000.

Formulated the above in formulas:

$$\text{Re} > 10^4 \quad [2]$$

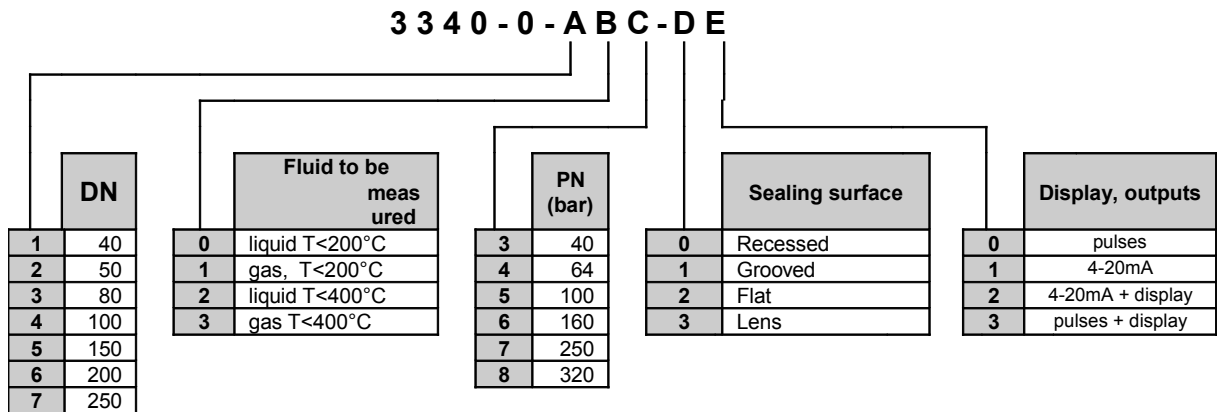
$$\text{Re} = \frac{v \cdot d}{\nu} \quad [3]$$

$$Q = f / K \quad [4]$$

where:	Re	Reynolds-number	[-]
	v	flow rate of the medium	[m/s]
	d	internal diameter of the pipeline	[m]
	ν	kinematical viscosity of the medium	[m ² /s]
	Q	volume flow	[m ³ /s]
	f	frequency of vortices	[Hz]
	K	vortex density	[vortex pair/m ³]

In order to produce electric output signals separation of vortices should be detected. Operation of the vortex detector (Fig. 2) is based on the fact that separating vortices generate a pulsating pressure difference between the flow areas (2,3) on both sides of the vortex generating body (1). The metal plate (4) of special design located in the vortex detector is forced to a vibrating motion of some tenths mm of amplitude synchronous with this pulsating pressure difference. This motion is of course synchronous with the separation of vortices, thus electric pulses (6) of the electromagnetic coil (5) transforming the motion of the vibrating plate into electric pulses will also be synchronous with it. By this way vortices separating from the vortex generating body are transformed into electric pulses by the vortex detector, therefore the calibration constant of the flowmeter expressed in [pulse/m³] will be equivalent to the K vortex density expressed in [vortex pair/m³] of the above formula.

4.3 Type selection



4.4 Determination of the Measuring Range

From below the measuring range of the vortex meters is limited by the turbulence condition referred to in Chapter 4.1 ($Re > 10000$). Using the formulas [2] and [3] the turbulence condition may be described by the following equation:

$$Q_{\min(\text{turb})} = 28274 \nu d = 28274 \eta d / \rho \quad [5]$$

where:

$Q_{\min(\text{turb})}$	lower limit of measuring range determined by the turbulence condition	[m ³ /h]
ν	kinematical viscosity of the fluid	[m ² /s]
d	internal diameter of the pipeline (Table 1)	[mm]
η	dynamic viscosity of the fluid	[Pa.s]
ρ	density of the fluid	[kg/m ³]

The method of detecting vortices requires further restrictions. Table 2 shows measuring limits in water and in normal air. The upper limit indicated for water is also valid for other liquids and, in the same way, the upper limit indicated for normal air is also valid for other media in gaseous or vapor state. Besides turbulence condition (equation [5]) the lower limit is also restricted by the density of the medium, while cavitation in the case of liquids represents a further restriction as regards the upper measuring limit. These will be explained in the following Chapters.

4.4.1 Measuring Range for Liquids

Besides turbulence condition (equation [5]) the lower limit of the measuring range also restricted by the density of the medium in case of liquids, as the vortex energy required for moving the vibrating plate is depending on the volume flow and on the density. the following formula describes the relationship between density and the lower measuring limit in case of liquids:

$$Q_{\min(\rho)} = \frac{Q_{\min(\text{water})}}{\sqrt[3]{\frac{\rho}{998}}} \quad [6]$$

where:	$Q_{\min(\rho)}$ lower measuring limit in liquid of ρ density	[m ³ /h]
	$Q_{\min(\text{water})}$ lower measuring limit in water of 20 °C (see Table 2)	[m ³ /h]
	ρ density of the medium	[kg/m ³]

The upper measuring limit may not exceed the value for water indicated in Table 1. Measuring ranges as a function of the liquid's density are also shown by the diagrams of Fig. 4-10. Q_{\min} curves of the Figures supplied with the parameter of the dynamic viscosity display the turbulence limits calculated from the equation [5].

In case of liquids the upper measuring limit is also restricted by the cavitation. Condition for avoiding cavitation consists in ensuring that the flow does not exceed the value calculated by the following equation:

$$Q_{\max(\text{cav})} = 0.49 d^2 \sqrt{\frac{p - p_s}{\rho}} \quad [7]$$

where:

$Q_{\max(\text{cav})}$	max. flow not yet inducing cavitation	[m ³ /h]
d	internal diameter (Table 1)	[mm]
p	absolute pressure before the meter	[bar]
p_s	saturation pressure of the medium's vapor	[bar]

Summing up:

- the lower measuring limit is equal to the greater one of the two values calculated by the equations [5] and [6];
- the upper measuring limit is equal to the smaller one of the values calculated by the equation [7] respectively indicated in Table 2.

4.4.2 Measuring Range for Gases and Vapors

As in the case of liquids, also the lower measuring limit for gases and vapors is determined by the turbulence condition according to the equation [5] and by the following density condition:

$$Q_{\min(\rho)} = \frac{Q_{\min(\text{air})}}{\sqrt[3]{\frac{\rho}{1,164}}} \quad [8]$$

where:	$Q_{\min(\rho)}$	lower measuring limit for gas or vapor having ρ density	[m ³ /h]
	$Q_{\min(\text{air})}$	lower measuring limit for normal air (Table 2)	[m ³ /h]
	ρ	working density of the gas or vapor	[kg/m ³]

In case of gases and vapors the upper measuring limits are identical to those indicated for normal air (see Table 2). Measuring ranges as a function of the liquid's density are also shown by the diagrams of Fig. 4-10. Curves of the Figures supplied with the parameter of the dynamic viscosity display the turbulence limits calculated from the equation [5].

Summing up:

- the lower measuring limit is equal to the greater one of the two values calculated by the equations [5] and [8];
- the upper measuring limit is equal to the values indicated in Table 2.

4.4.3 Measuring Range for Saturated Dry Water Vapor

Table 3 and Figure 11 show the lower measuring limits in function of the pressure and temperature of the saturated dry water vapor based on the formulas [5] and [8]. The upper measuring limit is equal to the value indicated for normal air in Table 2.

4.5 Pressure Loss

Pressure loss caused by the vortex generating body can be calculated by the following formula:

$$\Delta p = 1.38 \rho Q^2 / d^4 \quad [9]$$

where:	Δp	pressure loss	[bar]
	ρ	working density of the medium	[kg/m ³]
	Q	flow	[m ³ /h]
	d	internal diameter (Table 1)	[mm]

The above relationship indicates direct pressure drop occurring on the meter with a good approximation. A more accurate data taking into consideration pressure drop on the upstream and

downstream pipe sections, too, may be obtained upon consulting with MMG FLOW Ltd. experts with the help of a computer program supported by the factory data base.

5. PRELIMINARY INSTRUCTIONS

5.1 *Unpacking the Vortex Meter and its Accessories*

During unpacking and installation the packing surfaces should be protected with utmost care. After removing the protection cap and the dust cover it should be checked whether eventual unworkmanlike transportation or storage have caused any visible deformation.

ATTENTION !

It is forbidden to lift or move the large flow meters (over ND 100) by the housing of the electronics!!!

5.2 *Preparations before Installation*

For a correct operation complying with specifications of the vortex meters upstream and downstream pipe sections are to be connected to it. Their lengths expressed as a multiple of the diameter are indicated in Table 4 as a function of the pipe fittings located before the measuring section. The following should be observed at the design and preparing of measuring sections:

- Packing surfaces of the pipe sections connecting to the vortex sensor should be adapted to those of the vortex meter (exact dimensions are given in Table 1 as marked in Fig. 12).
- Internal diameter of the upstream and downstream pipe sections and, in case of flat sealing surface, also that of the sealing rings should be identical with value d according to Table 1, respectively it can only be larger than that by value Δ of the same Table.
- At the connections of the pipe sections, sealing rings and vortex meter their eccentricity to each other should not exceed the value e of Table 1. This should be especially observed in case of flat sealing surface.
- Length of the pipe sections should be determined according to Table 4 in dependence of the preceding fittings and armatures.

6. INSTRUCTIONS FOR USE

6.1 *Safety Prescriptions*

- A. Mounting and connection may only be performed in no-voltage state.
- B. The outer diameter of the cable have to ensure a gas-tight closure.
- C. Mechanic fastening and protection against damages of the cable should be ensured.
- D. During assembly of electronic box check the presence of the covering's sealing.
- E. Grounding of the device must be performed by connecting of the upstream and downstream tubes to the external grounding screw of the meter's body.

Now the device may be powered.

6.2 *Preliminary Adjustments*

When installing the upstream and downstream pipe sections prescriptions of Chapter 5.2 should be observed. The vortex meter should be installed into the metering section in a way that the arrow on the side of the meter indicates the flow direction.

ATTENTION !

Sagging of the sealing is inadmissible!!!

6.3 *Electric Connection*

The vortex meter should be connected to the signal processing unit by a plastic insulated screened cable of min. 0.45 mm² cross-section as to Fig. 3.

6.4 Putting into Operation of the Measuring Circuit

When starting a new plant, if possible, disengage the measuring section from the system by the use of a substituting pipe section or a through a bypass until flushing out all contaminants accumulated during pipe assembly (scale, packing tape pieces etc.).

Putting into operation should be performed in the following way:

- Upon installation pressurize the measuring section and check its tightness.
- Turn on the electronic display unit or the supply unit.
- Check the polarity and the value of the supply voltage (Fig. 3, "GND", "+UT").
- Check the zero point of the measuring circuit by fully sectioning out of the meter (no flow and no pressure fluctuation). This can be done by an oscilloscope, frequency meter or the local display. Should the display be other than zero in this state, check correct connection of the cables (Fig. 3) and the grounding of the system (Chapter 6.1 point E.).
- By eliminating the sectioning out produce working flow in the measuring section and check frequency of the pulse output of the vortex meter or the display of the signal processing unit whether they comply with the expectable flow value. Use formula [1] for the calculations.

7. MAINTENANCE

A great advantage of the vortex meter consists in the fact that apart from the periodic replacement of the vibrating plate of the vortex detector they do not require any maintenance. There is a further important advantage that replacement of the vibrating plate does not influence metrological parameters of the meter (calibration constant, accuracy, linearity, measuring range etc.), therefore no recalibration is necessary.

Frequency of the vibrating plate replacement is determined by the working circumstances. Under normal working conditions replacement of the vibrating plate must be performed after 5000 to 8000 working hours in order to ensure proper vortex detection. For determining the optimal replacement period adjusted to the actual circumstances it is expedient to dismount the vibrating plate substituting it by the reserve one after the first 2500 working hours and examine the degree of wear. MMG Ltd. carries out this checking free of charge and proposes an optimal replacement frequency.

Replacement of the vibrating plate should be made as follows (see Fig. 4):

- Disconnect the meter from the power.
- Eliminate pressure and, if necessary, drain the measuring section.
- Carefully clean the outer surface of the measuring body (1) and especially the neck area from any dirt.
- Unscrew the hexagon-head screw (6) by a 41 fork wrench and remove it together with the casing of the electronic unit from the measuring body to the extent as allowed by the cable fastening.
- Remove the vibrating plate assembly (5) with the help of pincers or flat nose pliers. It may happen that the vibrating plate assembly (5) comes out together with the bifurcated chamber (4). In such case disassemble them without damaging the surfaces. Clean the bifurcated chamber (4) and its seat in the body. Check whether the spring (3) is on the bottom of the seat (remove and change also the spring if necessary) then put the bifurcated chamber into its place carefully observing correct positioning of the orientation groove (7) and fitting of the pin (8) located in the measuring body. The bifurcated chamber is properly inserted if it allows a slight axial depression against the spring but can not be turned because of the pin (8) is correctly inserted into the groove (7). If the vibrating plate comes out without the bifurcated chamber, it should be lifted separately and the above procedure performed.
- Now install the new vibrating plate assembly (5). The camber of the plate should be in upward position.
- Replace the sealing ring (2) too, following of the cleaning its seat.
- Put back the neck (3): pull up the locking screw (6) and lay the lower front surface of the neck on the sealing ring (2). Screw in the locking screw (6) and tighten it with min. 100 [Nm] moment.

- Pressurize the system and check the tightness.
- Switch on again the power supply; the measuring circuit is again ready for operation.

Electric parts fitted within the casing [magnetic detector , electronic unit] do not require any maintenance.

8. REPAIR

It is advisable to have repaired the vortex meter even after the guarantee period in the specialized shop of the manufacturer.

9. PACKING, STORAGE, TRANSPORTATION

The vortex meters or the assembled measuring sections together with the accessories as to Chapter 2 are packed in corrugated carton, foam box or wooden case ensuring mechanical fastening, depending on their dimensions.

Storage temperature:	- 50... + 60 °C
Relative humidity:	max. 80 %

Permissible load during transportation confirms to the execution class N2 according to the Standard EN 1635-79.

10. TERMS OF GUARANTEE

According to the Purchase Contract.

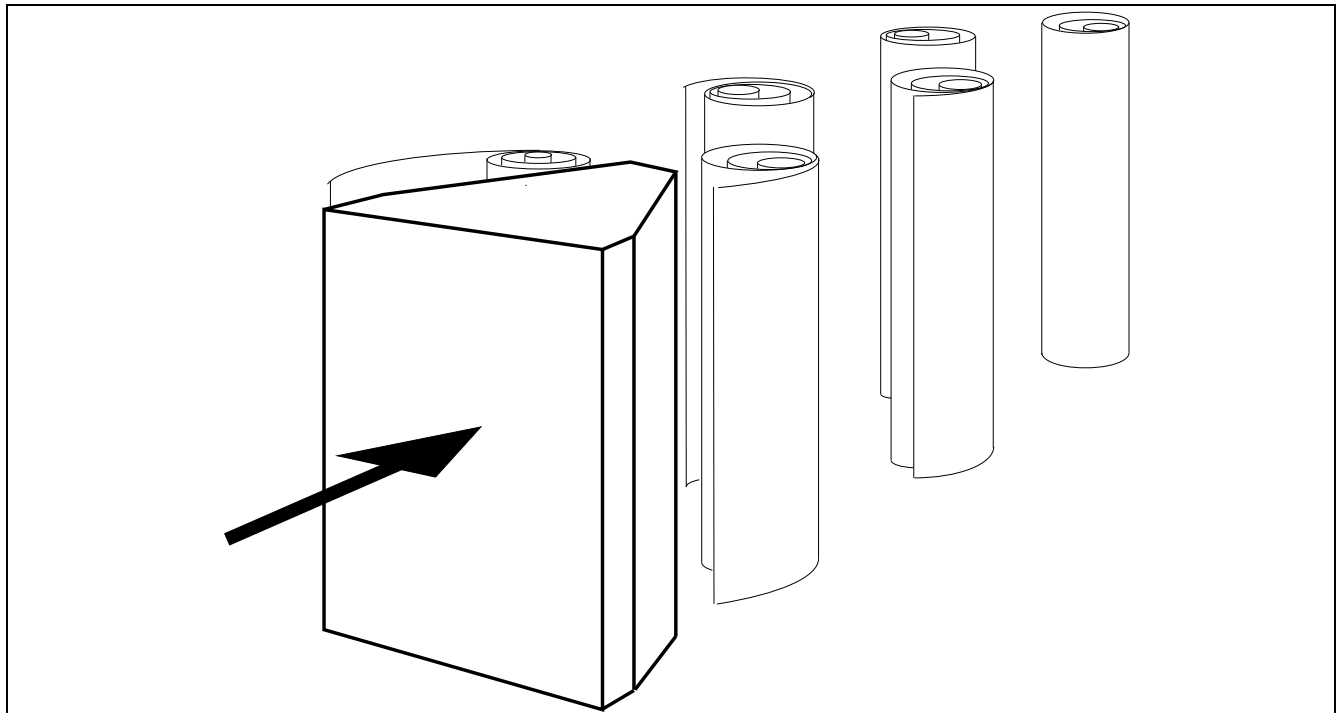


FIGURE 1.

ILLUSTRATION OF VORTICE FORMING

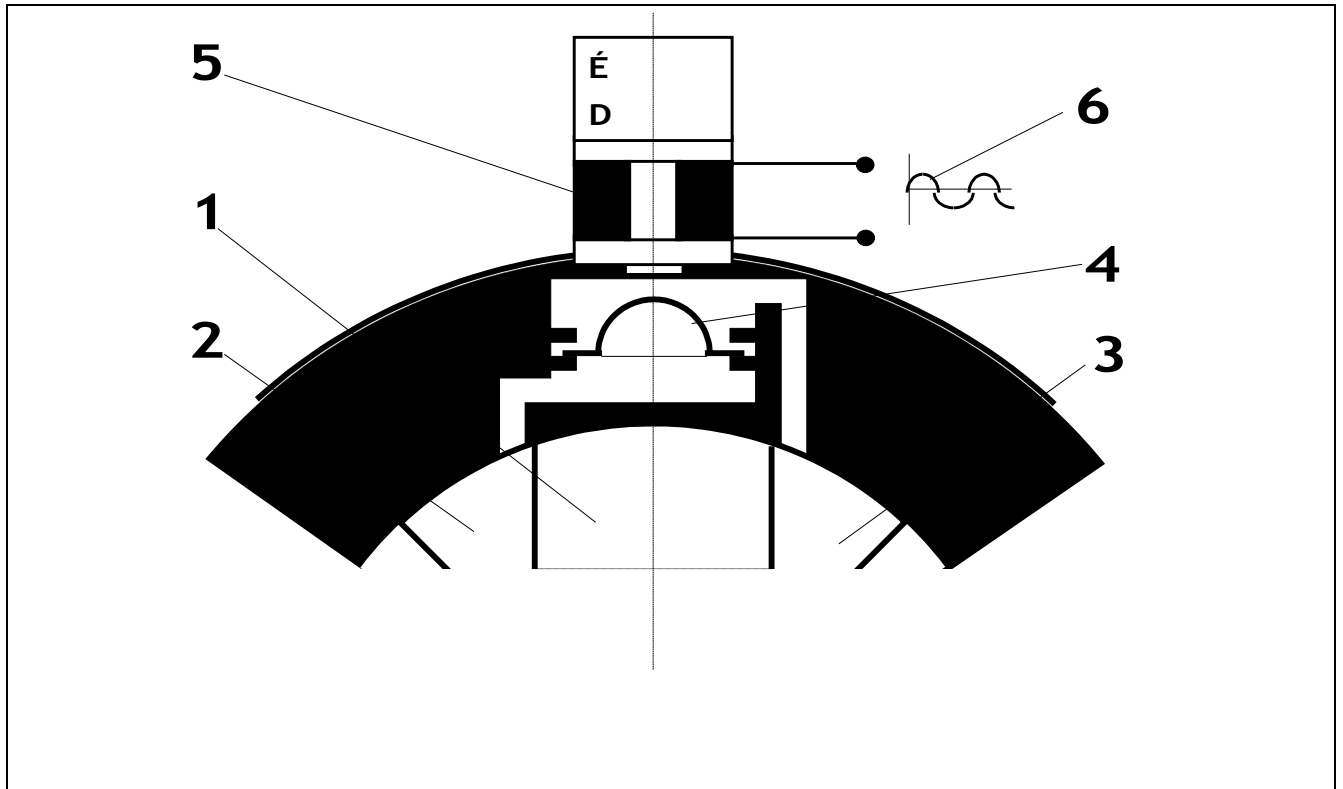


FIGURE 2.

OPERATION PRINCIPLE OF THE VORTEX DETECTOR

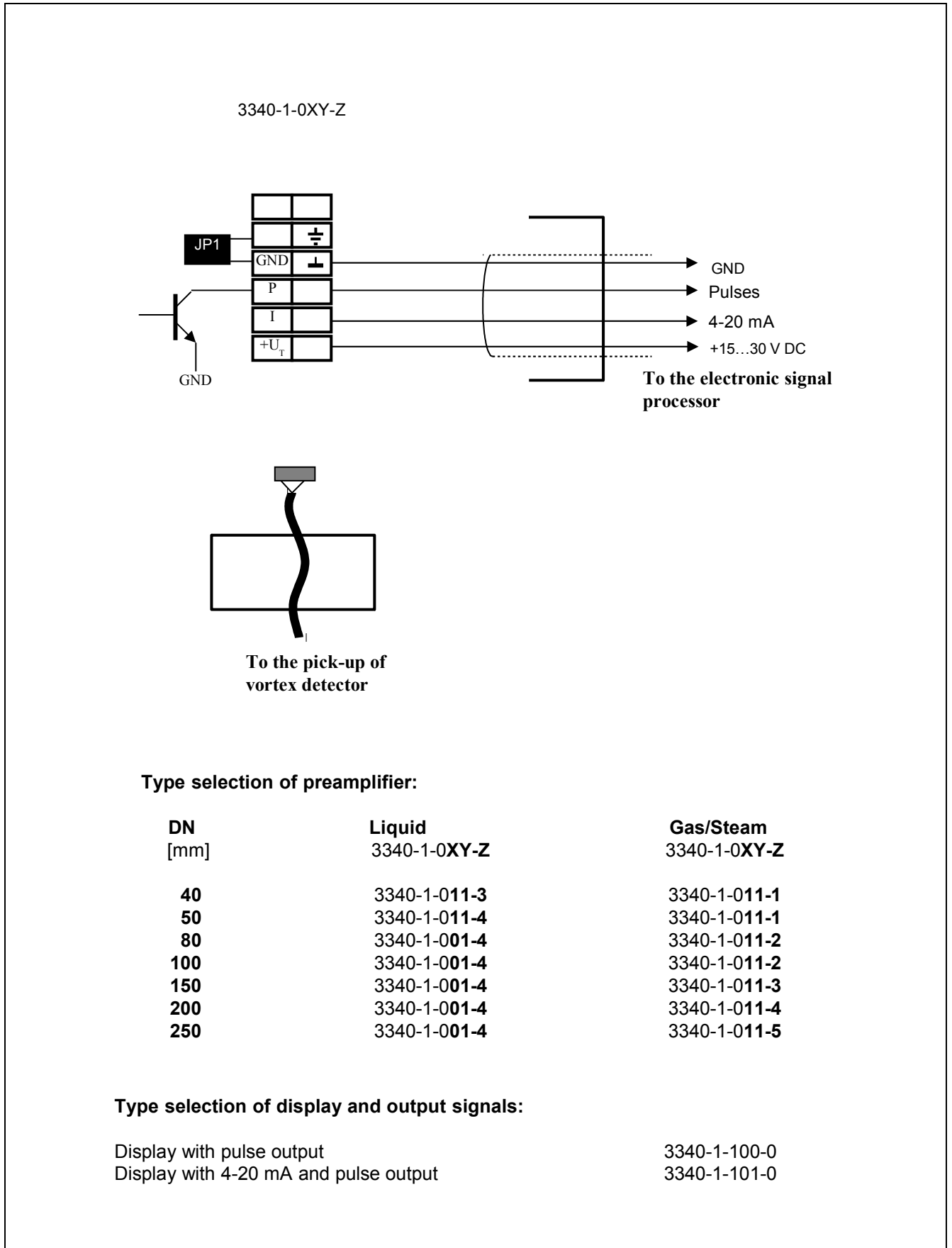


FIGURE 3.

CABLING AND TYPE SELECTION OF THE ELECTRONIC UNIT

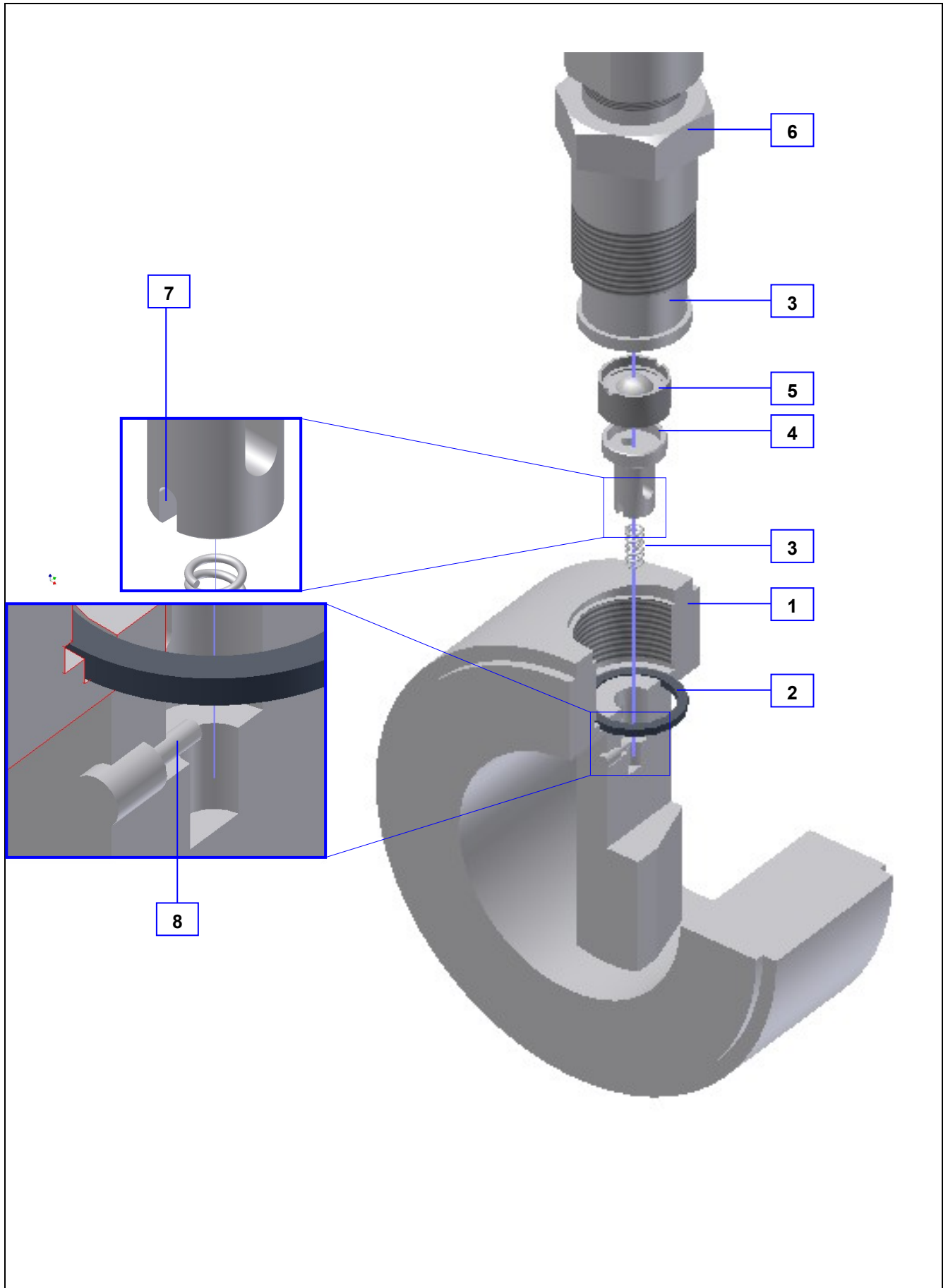


FIGURE 4.

CONSTRUCTION AND REPLACING OF VORTEX SENSOR

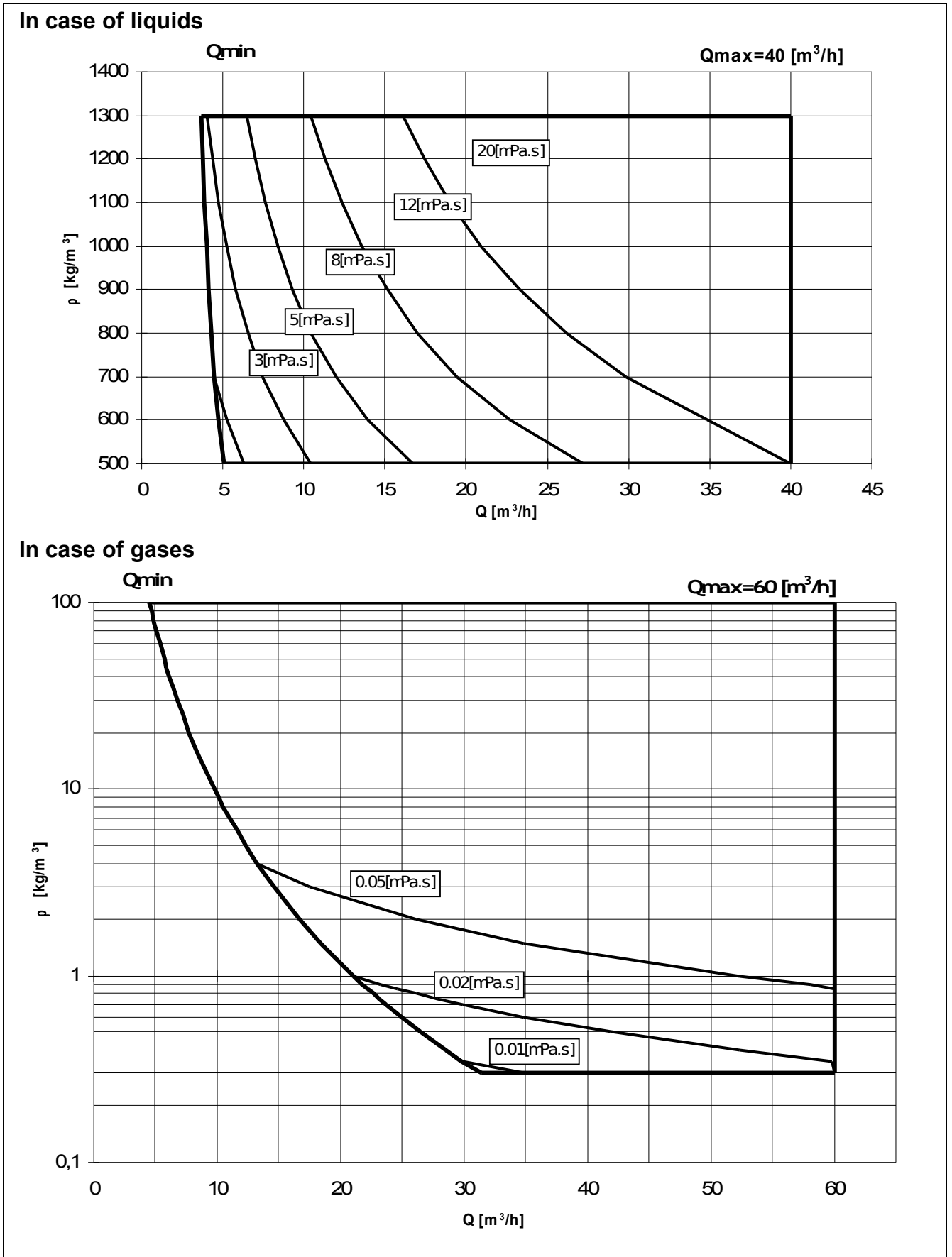


FIGURE 5.

MEASURING RANGES (DN 40)

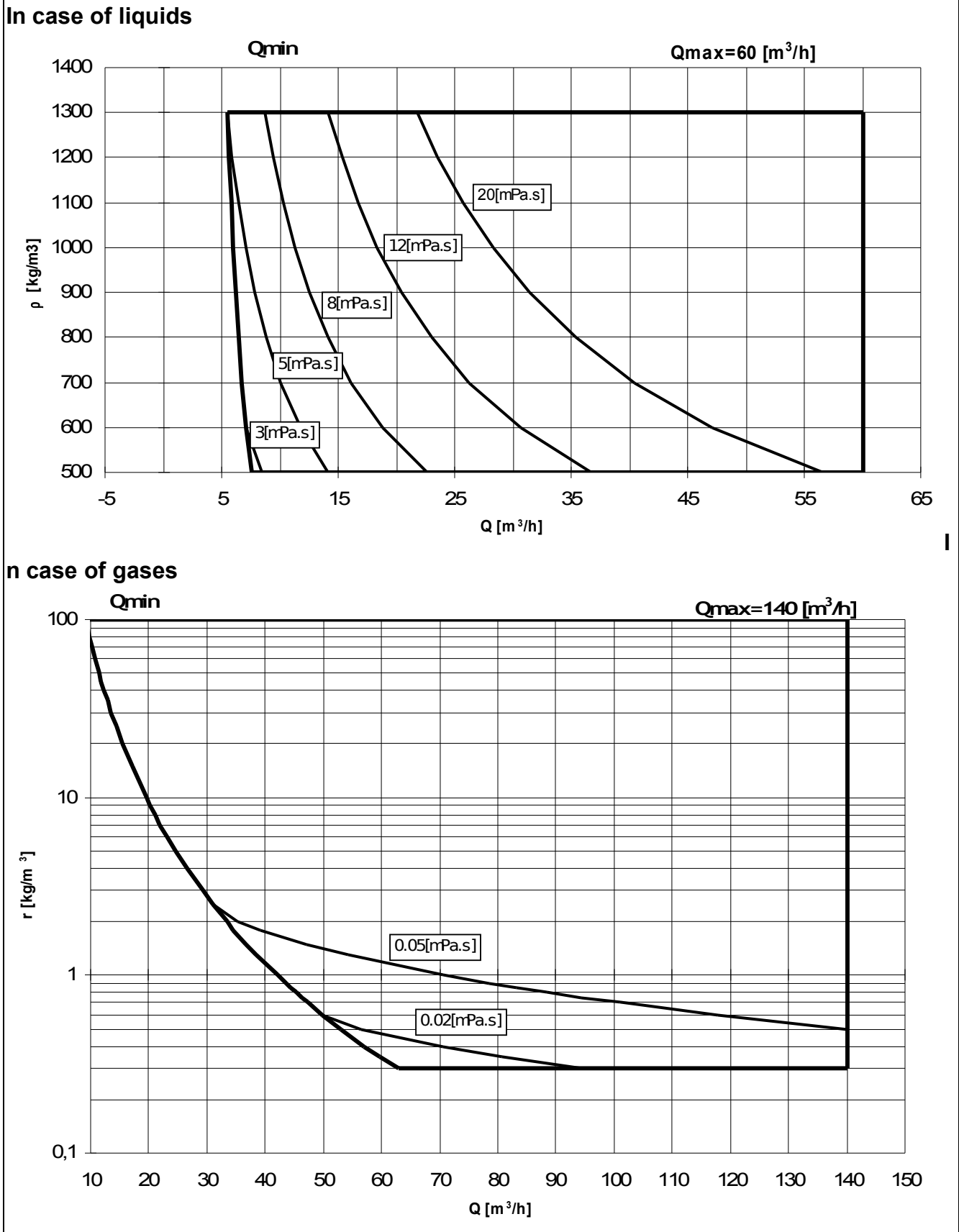


FIGURE 6.

MEASURING RANGES (DN 50)

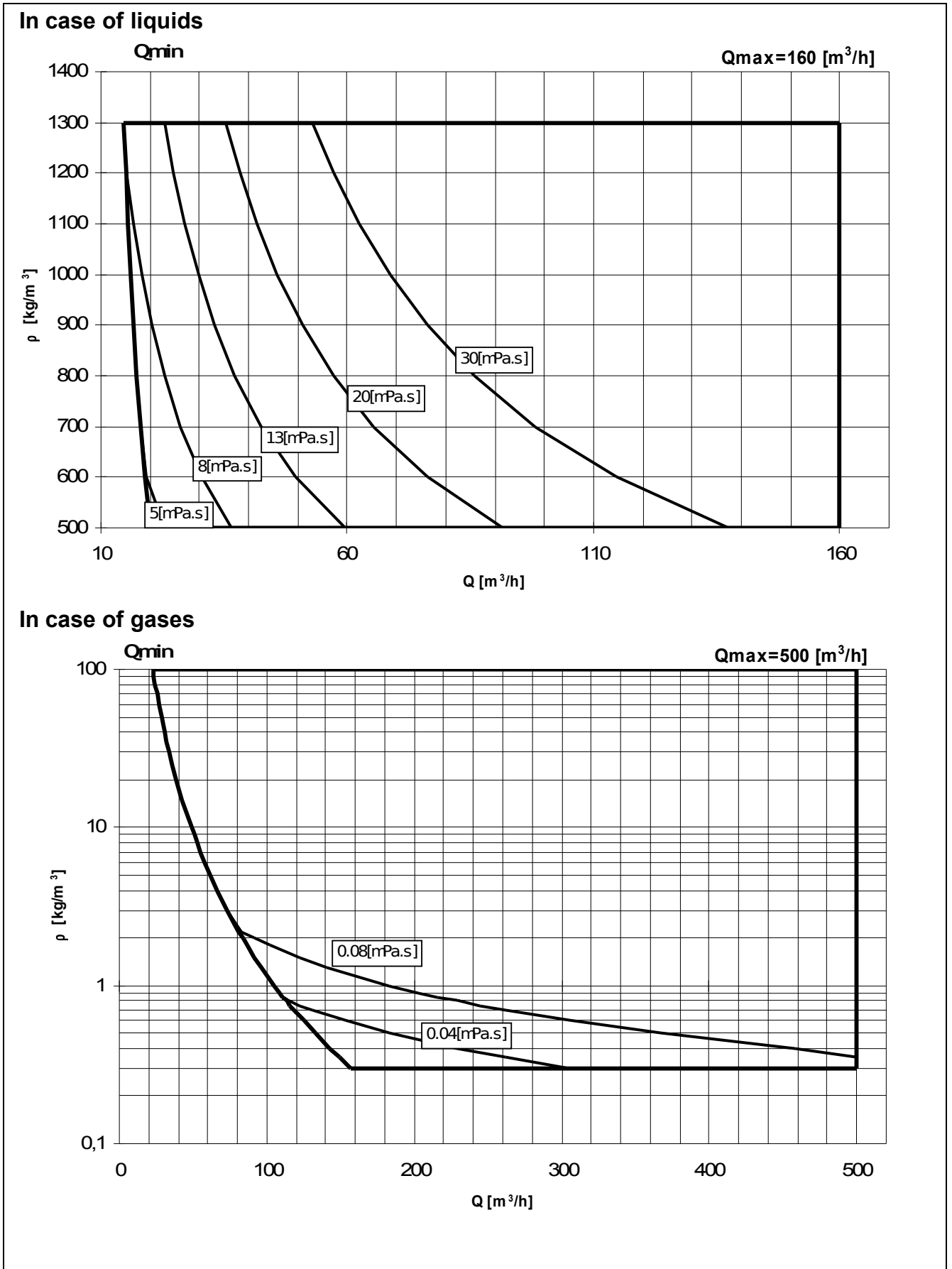


FIGURE 7.

MEASURING RANGES (DN 80)

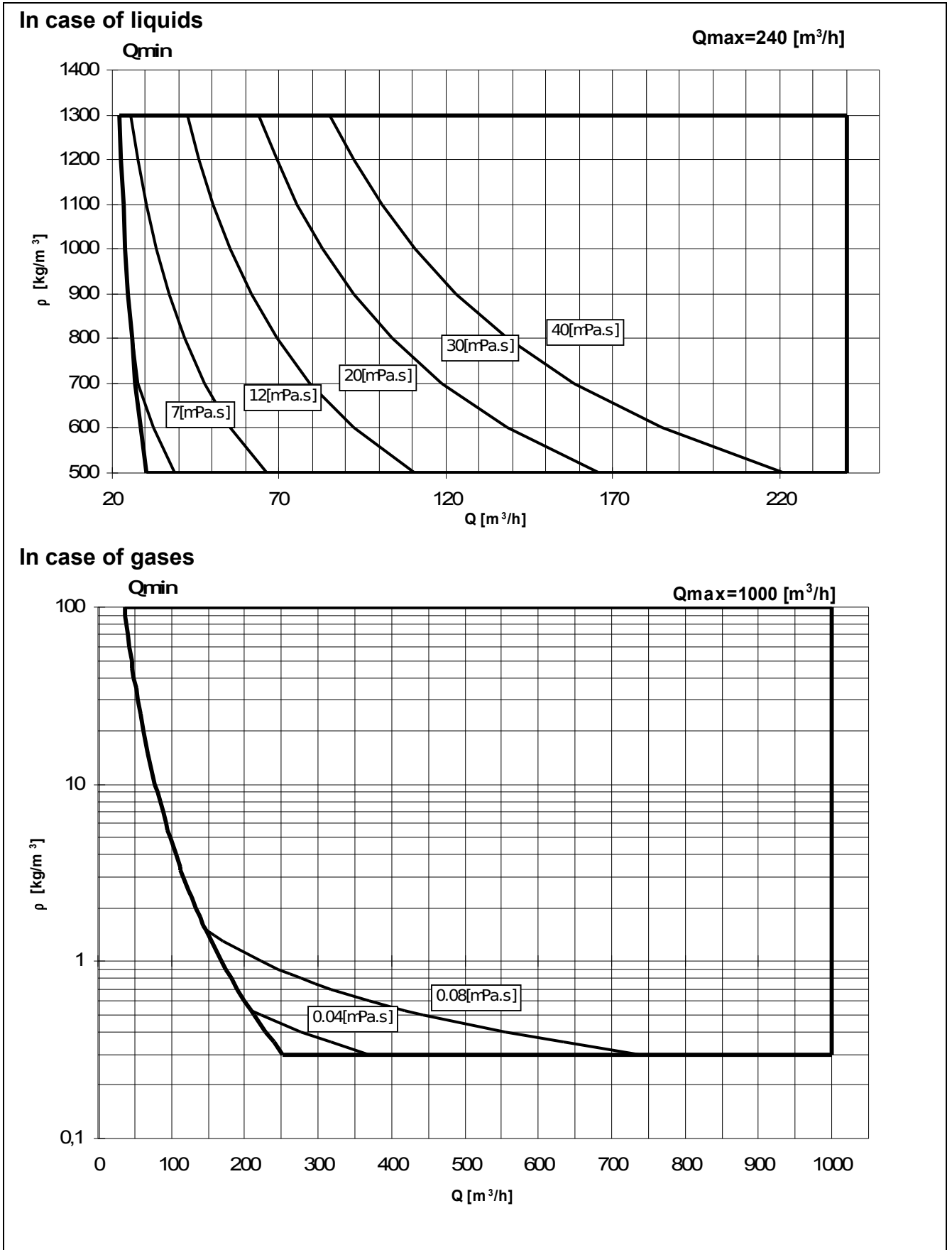


FIGURE 8.

MEASURING RANGES (DN 100)

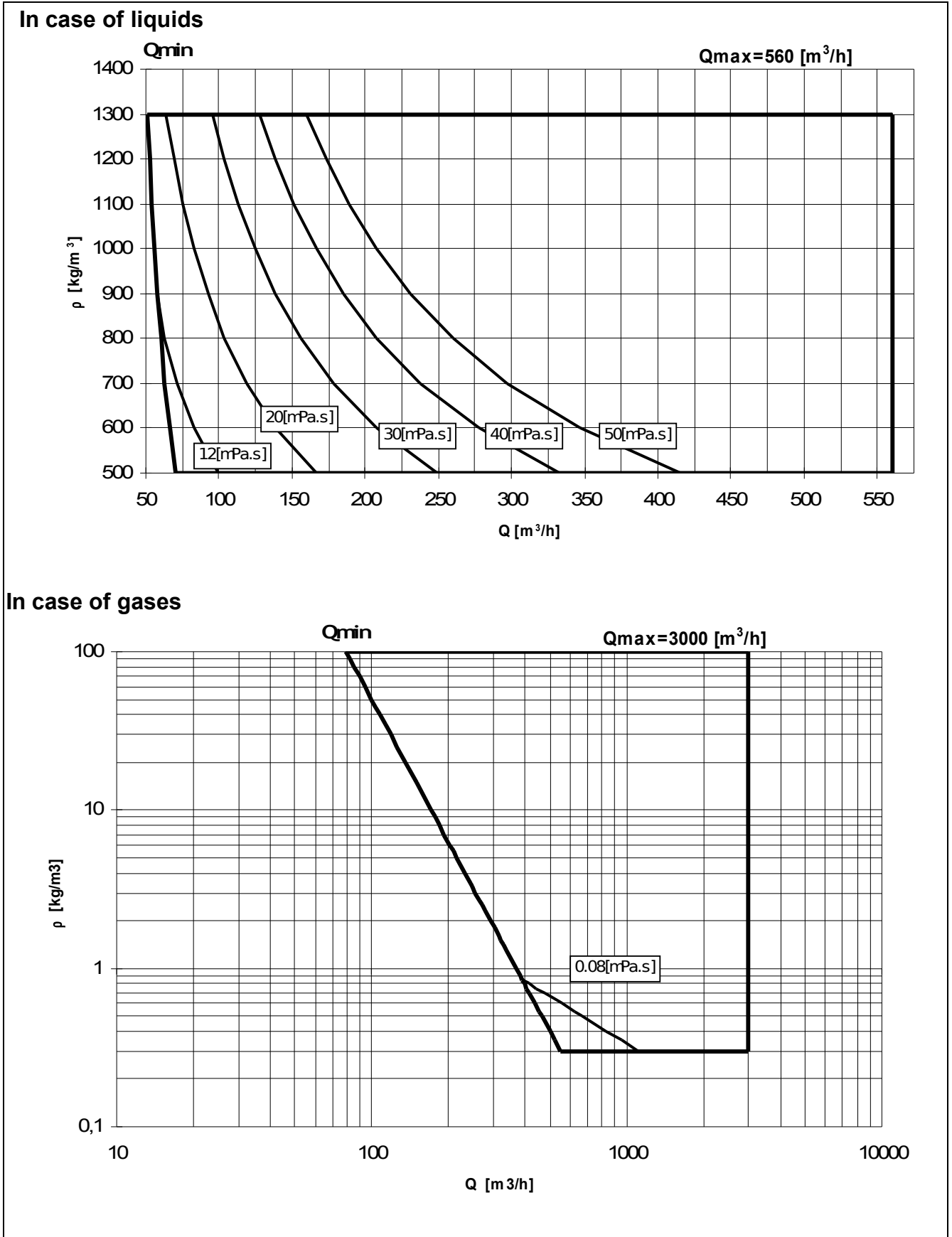


FIGURE 9.

MEASURING RANGES (DN 150)

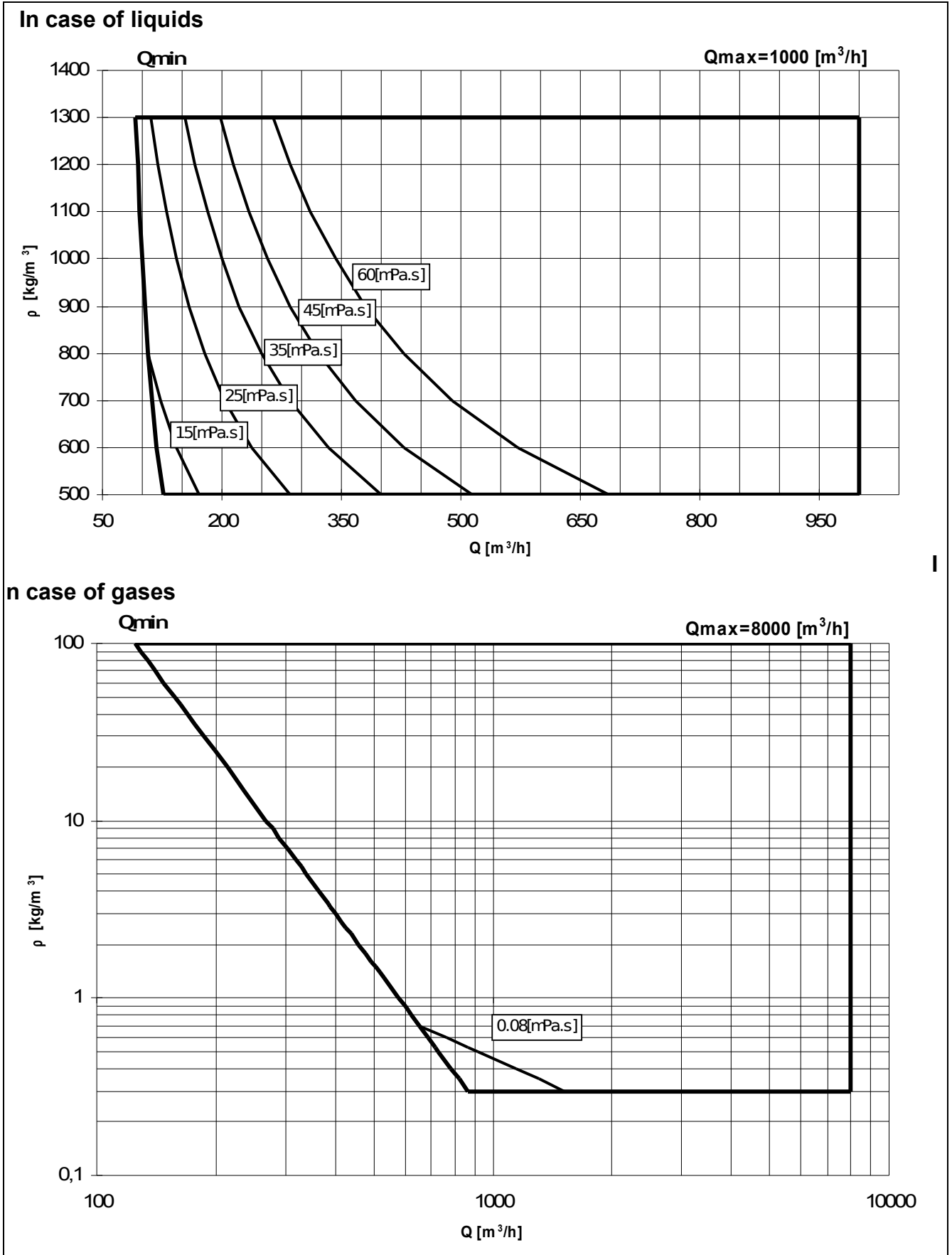


FIGURE 10.

MEASURING RANGES (DN 200)

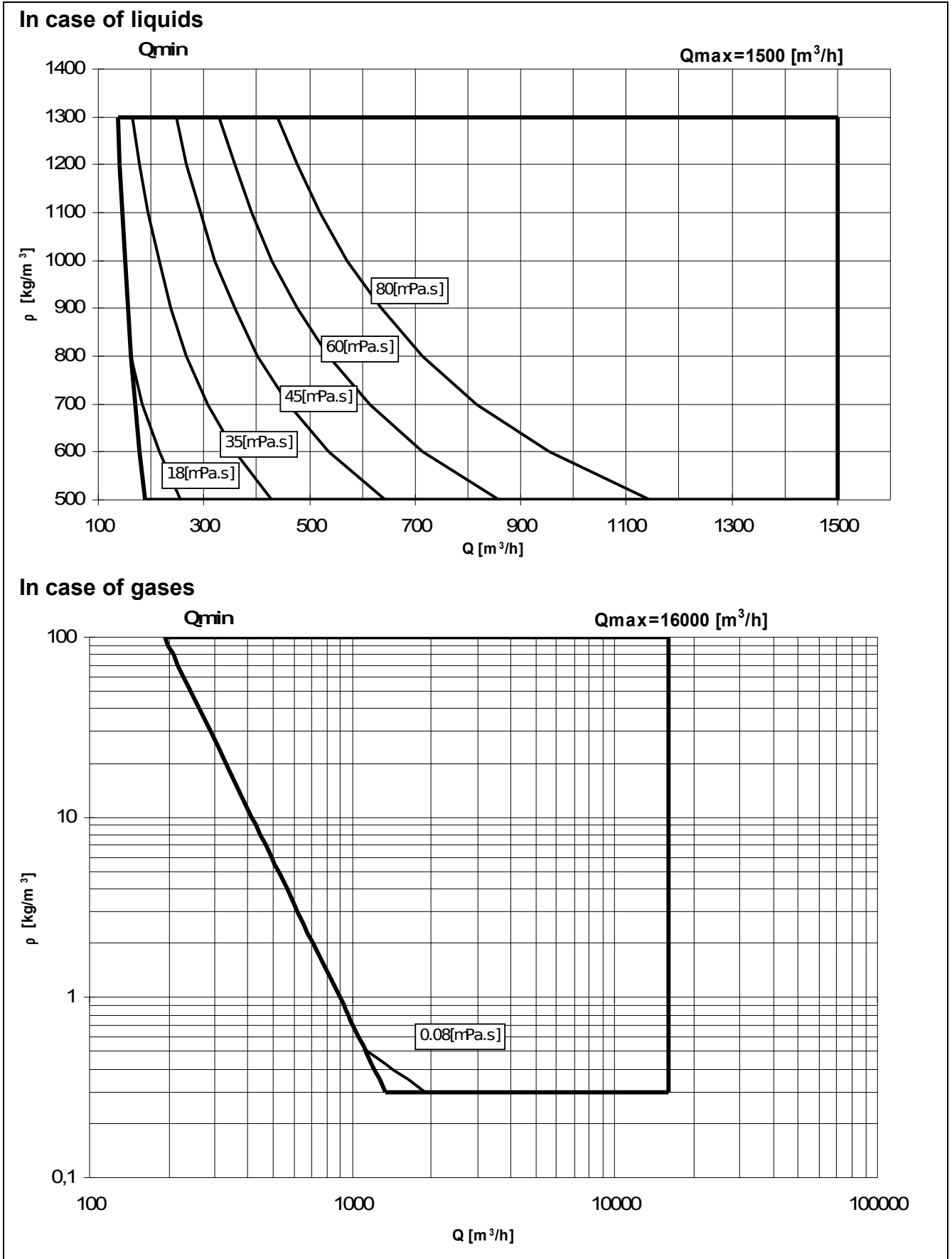


FIGURE 11.

MEASURING RANGES (DN 250)

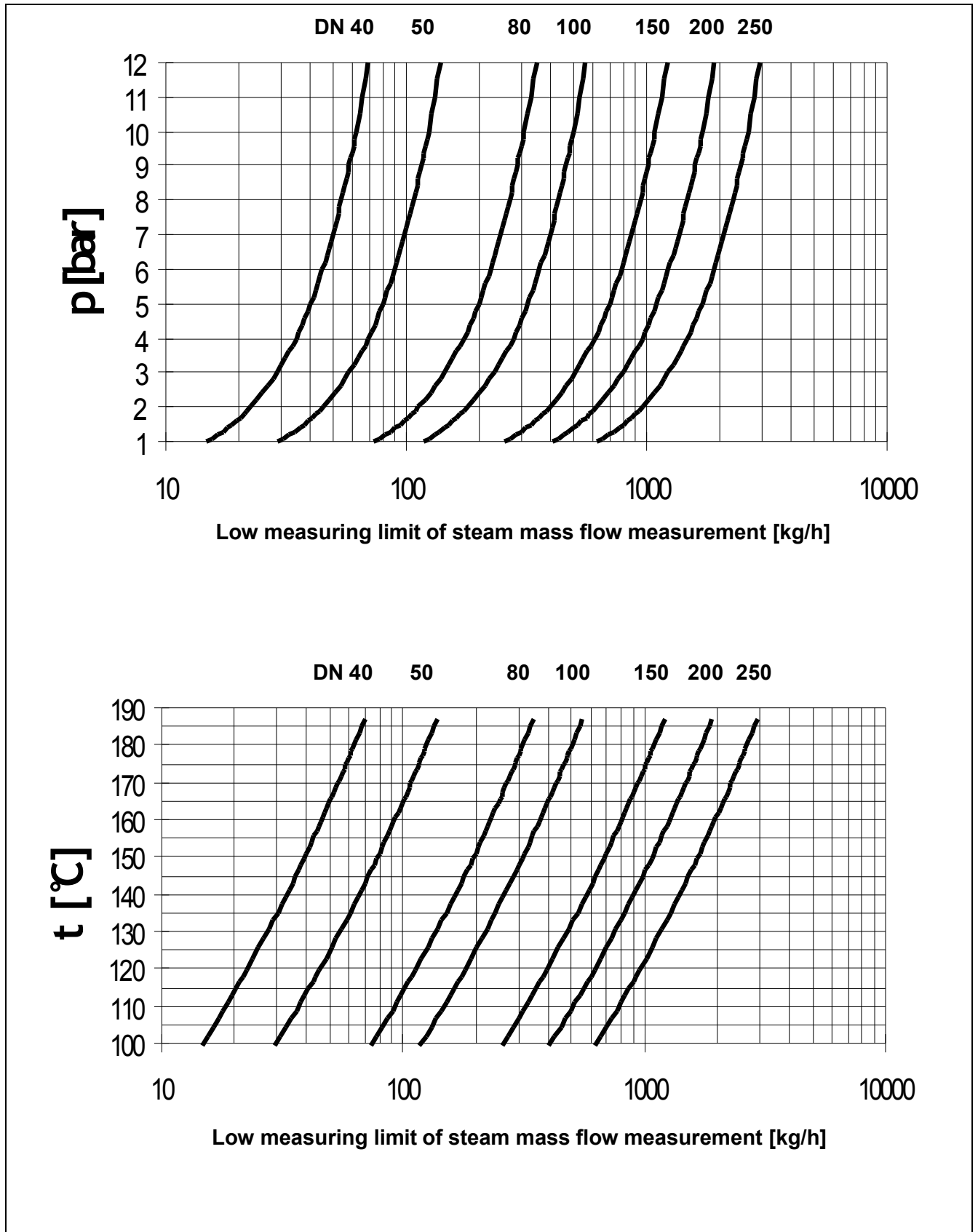


FIGURE 12.

LOW LIMITS OF MEASURING RANGE AT DRY STEAM

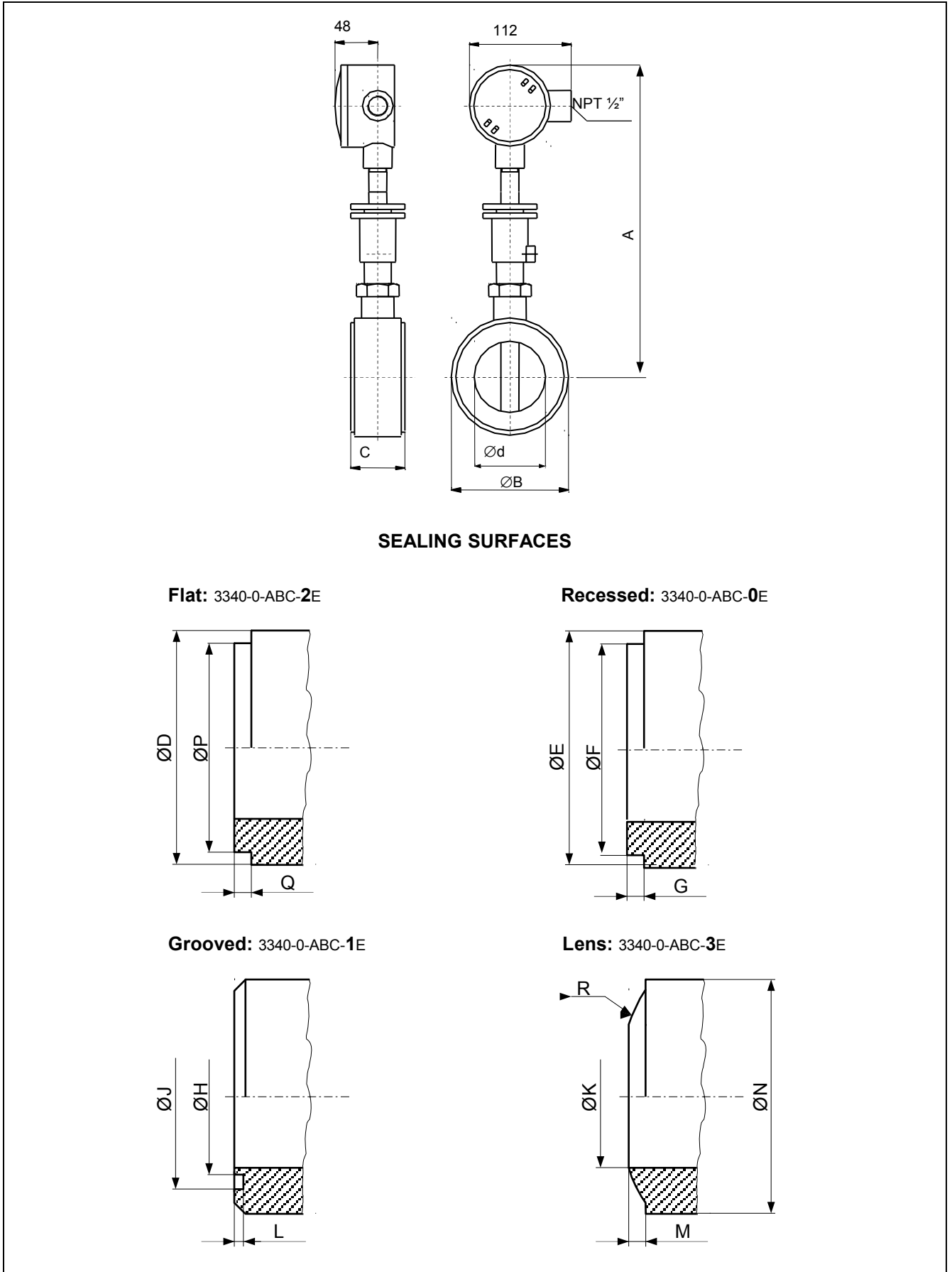


FIGURE 13.

GEOMETRIC DIMENSIONS (SEE VALUES IN TABLE 1.)

TABLE 1. GEOMETRIC DIMENSIONS (MARKINGS ACCORDING TO FIGURE 12.)

DN	[mm]	40	50	80	100	150	200	250
A	[mm]	345	355	370	380	400	430	455
B	[mm]	90	95	130	156	210	265	320
C	[mm]	55	55	60	75	115	150	195
PN		d [mm]						
4	[MPa]	37	50	81	98	147	202	253
6.4	[MPa]	36	50	80	98	145	201	249
10	[MPa]	36	49	79	96	141	194	241
16	[MPa]	36	47	74	95	138	181	225
25	[MPa]	36	45	76	94	136	186	223
32	[MPa]	33	45	73	90	136	170	228
PN		D [mm]						
4	[MPa]	95	110	145	170	230	290	355
6.4	[MPa]	95	110	145	170	230	290	355
10	[MPa]	95	110	145	170	230	290	355
16	[MPa]	95	110	145	170	230	290	355
25	[MPa]	100	115	155	180	250	315	385
32	[MPa]	110	125	180	205	280	350	430
E	[mm]	90	95	130	156	210	265	320
F	[mm]	76	87	120	149	203	259	312
G	[mm]	3	4	4	4.5	4.5	4.5	4.5
H	[mm]	60	72	105	128	182	238	291
J	[mm]	76	88	121	150	204	260	313
K	[mm]	36	47	74	95	138	181	-
L	[mm]	3	3	3	3.5	3.5	4.5	3.5
M	[mm]	7	7	10	10	15	15	-
N	[mm]	90	95	135	150	220	280	-
PN		P [mm]						
4	[MPa]	88	102	138	162	218	280	345
6.4	[MPa]	85	100	135	160	220	275	325
10	[MPa]	85	100	135	160	220	275	325
16	[MPa]	85	100	135	160	220	285	345
25	[MPa]	90	105	145	170	240	305	375
32	[MPa]	100	115	170	195	270	340	420
Q	[mm]	3	3	3	3,5	3,5	3,5	3,5
R	[mm]	73	98	140	160	243	310	-
Δ	[mm]	0.6	0.6	0.8	0.9	1	1.2	1.2
e	[mm]	0.6	0.6	0.8	0.9	1	1.2	1.2
Mass	[kg]	6	6.5	7.5	9.5	12	18	22

- Δ Permissible difference between the internal diameters of the vortex meter and of the connected pipe sections (d may only be less than the internal diameter of the pipe section).
- ε Permissible eccentricity of the axes of the vortex meter and the connecting pipe sections.

TABLE 2. MEASURING RANGES AND CALIBRATION CONSTANTS**Measuring ranges**

DN	water (20 °C-on)		normal air	
	Qmin	Qmax	Qmin	Qmax
[mm]	[m ³ /h]	[m ³ /h]	[m ³ /h]	[m ³ /h]
40	4	40	20	60
50	6	60	40	140
80	16	160	100	500
100	24	240	160	1000
150	56	560	350	3000
200	100	1000	550	8000
250	150	1500	850	16000

Calibration constants

DN	[mm]	40	50	80	100	150	200	250
PN		K [Imp/m ³]						
4	[MPa]	22861	9260	2135	1188	349.14	134.98	69.08
6.4	[MPa]	24819	9260	2216	1188	363.79	137.00	72.46
10	[MPa]	24819	9839	2301	1264	395.63	152.38	79.92
16	[MPa]	24819	11149	2800	1304	422.00	187.62	98.21
25	[MPa]	24819	12702	2585	1346	440.89	172.90	100.88
32	[MPa]	32222	12702	2917	1534	440.89	226.45	94.39

With the calibration constants above the accuracy of the measurement will be $\pm 5\%$ even without calibration. The accuracy of 1.5 % specified in chapter 3.2. can be achieved with the calibration constant determined by factory for each meter individually.

TABLE 3. LOW LIMIT OF MEASUREMENT FOR SATURATED DRY WATER VAPOR

p	t	Q _{min} steam mass flow [kg/h]						
		DN 40	DN 50	DN 80	DN 100	DN 150	DN 200	DN 250
1	99.09	14.63	29.25	73.13	117.01	255.97	402.24	621.64
1.1	101.76	15.52	31.04	77.61	124.17	271.63	426.84	659.67
1.2	104.25	16.38	32.77	81.92	131.08	286.74	450.59	696.36
1.3	106.56	17.22	34.45	86.12	137.78	301.40	473.63	731.98
1.4	108.74	18.04	36.09	90.22	144.35	315.77	496.22	766.88
1.5	110.79	18.83	37.66	94.15	150.63	329.51	517.81	800.24
1.6	112.73	19.61	39.23	98.06	156.90	343.23	539.35	833.55
1.7	114.57	20.37	40.73	101.83	162.92	356.40	560.05	865.53
1.8	116.33	21.10	42.21	105.51	168.82	369.30	580.33	896.88
1.9	118.01	21.83	43.66	109.15	174.64	382.03	600.34	927.80
2	119.62	22.54	45.08	112.70	180.33	394.46	619.87	957.98
2.2	122.65	23.92	47.83	119.58	191.33	418.52	657.68	1016.42
2.4	125.46	25.25	50.50	126.26	202.02	441.91	694.43	1073.22
2.6	128.08	26.54	53.08	132.71	212.33	464.48	729.89	1128.02
2.8	130.55	27.81	55.63	139.06	222.50	486.72	764.85	1182.04
3	132.88	29.03	58.06	145.16	232.25	508.05	798.37	1233.84
3.2	135.08	30.23	60.45	151.13	241.80	528.94	831.19	1284.57
3.4	137.18	31.40	62.79	156.98	251.17	549.43	863.39	1334.32
3.6	139.18	32.53	65.07	162.67	260.27	569.34	894.68	1382.68
3.8	141.09	33.66	67.33	168.32	269.31	589.11	925.74	1430.68
4	142.92	34.76	69.53	173.82	278.10	608.35	955.98	1477.43
4.2	144.68	35.83	71.67	179.17	286.68	627.11	985.46	1522.99
4.4	146.38	36.90	73.80	184.51	295.21	645.78	1014.80	1568.32
4.6	148.01	37.94	75.89	189.71	303.54	664.00	1043.43	1612.57
4.8	149.59	38.97	77.94	194.85	311.76	681.97	1071.67	1656.22
5	151.11	39.98	79.97	199.92	319.87	699.71	1099.55	1699.30
5.2	152.59	40.97	81.95	204.87	327.80	717.05	1126.80	1741.42
5.4	154.02	41.96	83.93	209.82	335.71	734.36	1154.00	1783.45
5.6	155.41	42.93	85.86	214.66	343.45	751.30	1180.61	1824.58
5.8	156.76	43.89	87.78	219.44	351.11	768.04	1206.92	1865.25
6	158.08	44.83	89.67	224.17	358.68	784.61	1232.95	1905.48
6.2	159.36	45.77	91.54	228.86	366.17	801.00	1258.71	1945.28
6.4	160.61	46.70	93.40	233.49	373.59	817.23	1284.21	1984.69
6.6	161.82	47.61	95.21	238.04	380.86	833.13	1309.20	2023.31
6.8	163.01	48.51	97.02	242.54	388.06	848.88	1333.96	2061.57
7	164.17	49.42	98.84	247.09	395.34	864.81	1358.99	2100.25
7.2	165.31	50.30	100.60	251.51	402.41	880.28	1383.29	2137.81
7.4	166.42	51.18	102.36	255.89	409.42	895.61	1407.38	2175.04
7.6	167.51	52.05	104.09	260.23	416.37	910.81	1431.27	2211.96
7.8	168.57	52.92	105.83	264.58	423.33	926.04	1455.20	2248.95
8	169.61	53.76	107.52	268.81	430.10	940.84	1478.46	2284.89
8.2	170.63	54.61	109.22	273.05	436.88	955.67	1501.77	2320.92
8.4	171.63	55.45	110.90	277.25	443.61	970.39	1524.90	2356.67
8.6	172.61	56.28	112.55	281.39	450.22	984.85	1547.62	2391.78
8.8	173.58	57.11	114.21	285.53	456.85	999.36	1570.42	2427.01
9	174.53	57.92	115.84	289.60	463.36	1013.61	1592.81	2461.62
10	179.04	61.93	123.87	309.67	495.48	1083.85	1703.20	2632.22
11	183.2	65.80	131.60	328.99	526.39	1151.48	1809.46	2796.44
12	187.08	69.57	139.14	347.84	556.54	1217.44	1913.12	2956.63

TABLE 4 LENGTH OF THE UPSTREAM AND DOWNSTREAM PIPE SECTIONS

Fitting directly before the upstream pipe section	With flow rectifier	Without flow rectifier
90° elbow, T-piece	15 DN	20 DN
Two leveled 90° elbows	15 DN	25 DN
Two unleveled 90° elbows	15 DN	30 DN
Narrowing	15 DN	20 DN
Widening	20 DN	40 DN
Regulating valve	Only after the measuring section	Only after the measuring section

Downstream pipe section min. 5 ND in each case.

Position of the pressure gauge stub 3D upstream of the meter.

Position of the temperature sensor 2.5D downstream of the meter.

