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## 1 Principle of Operation

The principles of operation of the Variable Area Flowmeters are described in the VDI/VDE-Guideline 3513 as follows:

The Variable Area Flowmeter is an instrument for measuring the flow of liquids and gases in pipelines. It includes a vertical tube through which the fluid flows whose diameter increases from the bottom to the top and a float which can move vertically in the tube.

As the flow increases this float moves to a higher position until its resistance to the fluid flow is balanced by the float's buoyed weight in the fluid, a value which is constant and independent of the flowrate.

The position of the float is a measure of the flowrate. The flowrate values can be read on a scale.

## 2 Basic Design

In its simplest construction, a Variable Area Flowmeter consists of the measurement elements (see Fig. 2-1). Float (1), meter tube (2), flowrate scale (3), fittings (5), flanged or threaded, for mounting in the pipeline and O-Rings (7) to provide the seals.

The float movement is restricted by the float stops (4) and a protective housing (6) surrounds the meter tube.

The flowrate scale for flowmeters with glass meter tubes is preferably applied directly on the meter tube. Variable Area Flowmeters generally have a 1: 12.5 measurement range which corresponds to 8 to 100 %.

If the mechanical, thermal or chemical resistance properties of the glass meter tube are not adequate for certain applications, metal meter tubes can be utilized. The float position, which is a measure of the instantaneous flowrate, is indicated external to the metal meter tube by a transmission system (see Fig. 2-2).

Converters can be incorporated to convert the flowrate values to a current output signal (0/4...20 mA) for flow control, remote flow indication or recording applications. Alarm values can also be indicated and signaled.

The Specification Sheets for the individual Variable Area Flowmeter designs include the flow range tables in addition to the design features, specifications, material availability and dimension information. The flow range tables list the maximum flowrate for the individual meter tube sizes and for the meter tube - float combinations which are available.

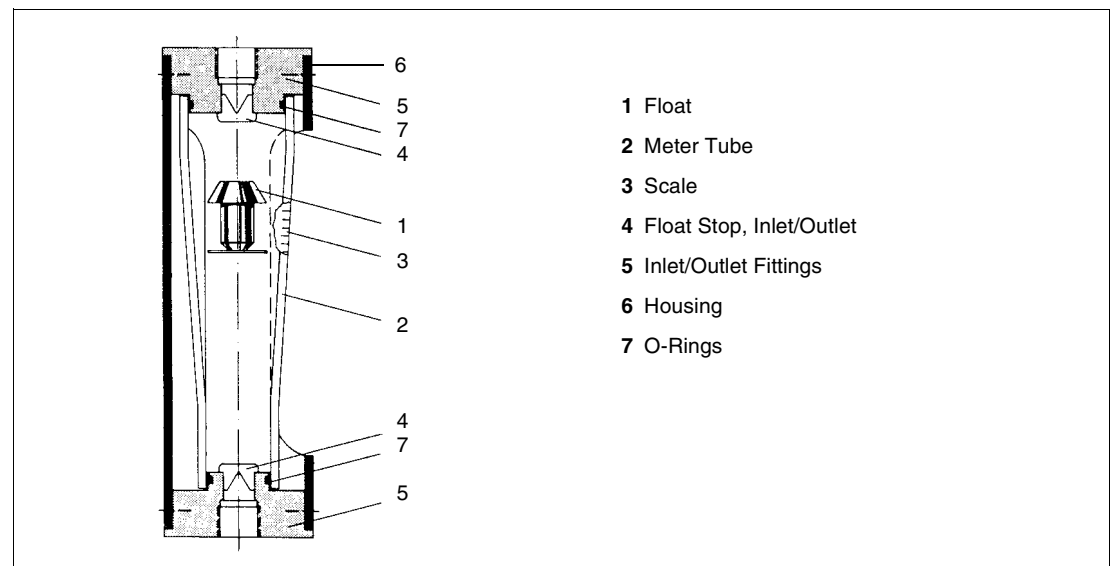


Fig. 2-1: Basic Construction, Glass Tube Flowmeter

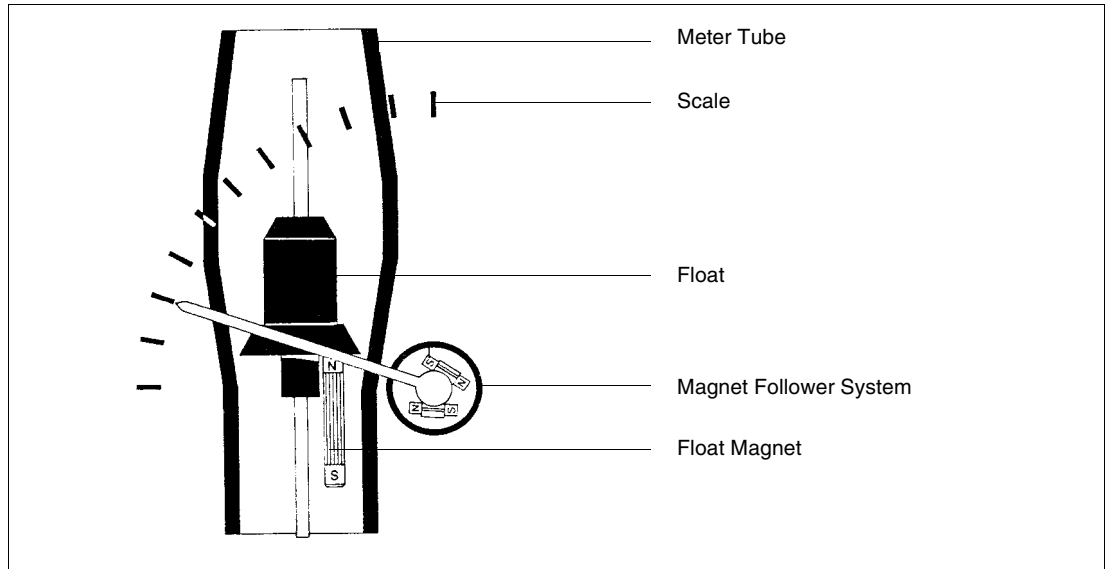


Fig. 2-2: Basic Construction, Armored Metal Tube Flowmeter

The flowrates listed flow range tables are based on floats made of 304 [1.4301] stainless steel (density  $\rho_f = 8.02 \text{ g/cm}^3$ ) and for liquids, on water (density  $\rho = 1 \text{ g/cm}^3$ , viscosity  $\eta = 1 \text{ mPas}$ ) while for gases the ranges listed are based on air at normal conditions ( $t_n = 0 \text{ }^\circ\text{C}$ ;  $p_n = 1.013 \text{ bar}$ ).

### 3 Determination of the Meter-Float Combination

The precision manufacture of the meter tubes and the floats permits use of the simplified calculations based on Guideline VDI/VDE 3513 Calculation of Volume or Mass Flowrate.

An ABB software program **Flow Select** is available for selecting an appropriate flowmeter type for a specific application. The program **FlowCalc** can be used to select the optimal instrument using the actual operating conditions which exist in the application. Both of these programs are available upon request.

### 4 Viscosity Influence (1/2" to 2")

The geometric design of the floats assures operation independent of over wide ranges of viscosity. That is, within these ranges the viscosity of the fluid can vary without affecting the flowrate measurements. The Viscosity Immunity Ceiling is listed in the column VIC in the flow range tables for these Variable Area Flowmeters.

If the VIC value calculated for the application is less than or exactly equal to the VIC value listed in the flow range tables, there is no viscosity effect on the measurements.

$$VIC = \eta \cdot \sqrt{\frac{(\rho_f - 1) \cdot 1}{(\rho_{f1} - \rho_1) \cdot \rho_1}}$$

- $\eta$  = Dynamic viscosity of the fluid [mPas]
- $\rho_f$  = Density of the float used for the table ( $\rho = 7,92 \text{ g/cm}^3$ )
- $\rho_{f1}$  = Density of the float actually used
- $\rho_1$  = Density of the fluid

If a VIC number higher than the value listed in the Table 4-1 is calculated, the scale for the flowmeter must be created for specific fluid viscosity at the factory.

Table 4-1 provides a means to correct the values listed for gases whose operating conditions deviate from the normal conditions (same operating conditions) used during the calibration.

**Example:**

A specific flowmeter, which was calibrated for air, normal density 1.293 kg/m<sup>3</sup> is to be used for Nitrogen, normal density 1.25 kg/m<sup>3</sup>. Read the factor 1.02 (heavy border) from the intersection of the Air column and the Nitrogen row. The flowrate values indicated by this flowmeter are to be multiplied by this factor.

**Note:**

New normal density larger: Factor < 1

New normal density smaller: Factor > 1

If the operating temperature and/or the operating pressure changes, the multiplication factors for the correction should be changed using the following equations:

Normal or weight units

Actual volume units

$$K_p = \sqrt{\frac{p_2}{p_1}}$$

$$K_p = \sqrt{\frac{p_1}{p_2}}$$

$$K_t = \sqrt{\frac{t_1}{t_2}}$$

$$K_t = \sqrt{\frac{t_2}{t_1}}$$

K<sub>p</sub> = Correction Factor for pressure

K<sub>t</sub> = Correction Factor for temperature

p<sub>1</sub> = 1.013 bar + calibration pressure in bar

p<sub>2</sub> = 1.013 bar + new operating pressure in bar

t<sub>1</sub> = 273 K + calibration temperature in °C

t<sub>2</sub> = 273 K + new calibration temperature in °C

**Calculation of the Correction Factors for Liquid Density Changes**

**Volume Flowrate**

**Mass Flowrate**

$$K_F = \sqrt{\frac{(\rho_{f1} - \rho_2) \cdot \rho_1}{(\rho_{f1} - \rho_1) \cdot \rho_2}}$$

$$K_F = \sqrt{\frac{(\rho_{f1} - \rho_2) \cdot \rho_2}{(\rho_{f1} - \rho_1) \cdot \rho_1}}$$

K<sub>F</sub> = Correction Factor

ρ<sub>f1</sub> = Density of the float being used

ρ<sub>1</sub> = Density of the calibration liquid

ρ<sub>2</sub> = Density of the new liquid

4.1. Normal Density Correction Table for Volume Units (Meter Tube Sizes 1/2" to 2")

Gas																							
existing	Normal Density kg/m <sup>3</sup> for 0 °C and 1013 mbar																						
new		Acetylene	Ammonia	Ammonia diss.	Argon	Butane	Chlorine	Natural Gas	Helium	Carbon Dioxide	Carbon Monoxide	Krypton	Air	Methane	Neon	Propane	Propylene	Oxygen	Sulfur Dioxide	Nitric Oxide	Nitrous Oxide	Nitrogen	Hydrogen
Acetylene	1.17	1	0.81	0.566	1.23	1.51	1.66	0.84	0.39	1.3	1.04	1.79	1.05	0.78	0.88	1.32	1.28	1.11	1.58	1.07	1.3	1.04	0.28
Ammonia	0.77	1.232	1	0.697	1.52	1.86	2.04	1.04	0.48	1.6	1.27	2.2	1.3	0.96	1.08	1.62	1.58	1.36	1.95	1.32	1.6	1.27	0.34
Ammonia diss.	0.374	1.77	1.43	1	2.18	2.67	2.93	1.5	0.69	2.3	1.83	3.16	1.86	1.38	1.55	2.32	2.26	1.96	2.8	1.89	2.3	1.83	0.49
Argon	1.78	0.81	0.66	0.458	1	1.22	1.34	0.68	0.32	1.05	0.84	1.45	0.85	0.63	0.71	1.06	1.04	0.9	1.28	0.87	1.05	0.84	0.22
Butane	2.67	0.66	0.54	0.374	0.816	1	1.1	0.56	0.26	0.86	0.66	1.18	0.57	0.52	0.58	0.87	0.85	0.73	1.05	0.71	0.86	0.68	0.18
Chlorine	3.214	0.603	0.49	0.341	0.74	0.91	1	0.51	0.235	0.78	0.62	1.08	0.63	0.47	0.53	0.79	0.77	0.67	0.95	0.65	0.78	0.62	0.17
Natural Gas	0.83	1.19	0.963	0.67	1.46	1.79	1.97	1	0.46	1.54	1.23	2.12	1.25	0.93	1.04	1.56	1.52	1.31	1.88	1.27	1.54	1.23	0.33
Helium	0.178	2.56	2.08	1.45	3.16	3.87	4.25	2.16	1	3.34	2.65	4.6	2.7	2.0	2.24	3.37	3.28	2.83	4.06	2.74	3.34	2.65	0.71
Carbon Dioxide	1.98	0.77	0.624	0.435	0.948	1.16	1.27	0.65	0.3	1	0.79	1.37	0.8	0.6	0.67	1.01	0.98	0.85	1.22	0.82	1.0	0.79	0.21
Carbon Monoxide	1.25	0.967	0.785	0.547	1.19	1.46	1.6	0.82	0.38	1.26	1	1.73	1.02	0.76	0.85	1.27	1.24	1.07	1.53	1.04	1.26	1.0	0.27
Krypton	3.74	0.56	0.454	0.316	0.69	0.845	0.927	0.47	0.22	0.73	0.58	1	0.6	0.44	0.49	0.73	0.72	0.62	0.89	0.6	0.73	0.58	0.15
Air	1.293	0.95	0.77	0.54	1.17	1.44	1.58	0.8	0.37	1.24	0.98	1.7	1	0.75	0.83	1.25	1.22	1.05	1.5	1.02	1.24	0.98	0.26
Methane	0.717	1.28	1.04	0.72	1.58	1.93	2.12	1.08	0.5	1.66	1.32	2.3	1.34	1	1.12	1.68	1.63	1.41	2.02	1.37	1.66	1.32	0.35
Neon	0.9	1.14	0.925	0.645	1.41	1.72	1.89	0.96	0.44	1.48	1.18	2.04	1.2	0.8	1	1.5	1.46	1.26	1.8	1.22	1.48	1.18	0.31
Propane	2.019	0.761	0.618	0.43	0.94	1.15	1.26	0.64	0.295	0.99	0.79	1.36	0.8	0.6	0.66	1	0.97	0.84	1.2	0.81	0.99	0.79	0.20
Propylene	1.915	0.78	0.634	0.44	0.96	1.18	1.296	0.66	0.305	1.02	0.81	1.4	0.82	0.61	0.69	1.03	1	0.86	1.24	0.84	1.02	0.81	0.22
Oxygen	1.43	0.905	0.734	0.51	1.12	1.37	1.5	0.76	0.35	1.18	0.93	1.62	0.95	0.71	0.79	1.19	1.16	1	1.43	0.97	0.118	0.93	0.21
Sulfur Dioxide	2.93	0.632	0.513	0.36	0.78	0.95	1.05	0.53	0.245	0.82	0.65	1.13	0.66	0.5	0.55	0.83	0.81	0.7	1	0.68	0.82	0.65	0.25
Nitric Oxide	1.34	0.93	0.76	0.53	1.15	1.41	1.55	0.79	0.36	1.22	0.96	1.67	0.98	0.73	0.82	1.23	1.2	1.03	1.48	1	1.22	0.96	0.174
Nitrous Oxide	1.98	0.77	0.624	0.435	0.948	1.16	1.27	0.65	0.3	1.0	0.79	1.37	0.8	0.6	0.67	1.01	0.98	0.85	1.22	0.82	1	0.79	0.25
Nitrogen	1.25	0.967	0.785	0.547	1.19	1.46	1.6	0.82	0.38	1.26	1.0	1.73	1.02	0.76	0.85	1.27	1.24	1.07	1.53	1.04	1.26	1	0.27
Hydrogen	0.089	3.36	2.94	2.05	4.47	5.48	6.01	3.05	1.41	4.72	3.75	6.5	3.81	2.84	3.18	4.76	4.64	4.01	5.74	3.88	4.72	3.75	1

Table 4-1: Normal Density Correction Table



## 5 Definition of Operating Pressure for Variable Area Flowmeters

The term „Operating Pressure“ is defined as the pressure which exists in the meter tube of the flowmeter. This pressure is usually identical to the pressure immediately downstream of the flowmeter. The pressure drop through the flowmeter can be ignored.

### 5.1 Locations for a Needle Valve

The locations for a needle valve, at the inlet or the outlet, is immaterial when metering liquids. Due to the compressible nature of gases, it is generally recommended that the needle valve be located at the outlet of the flowmeter when metering gases. This assures that the pressure in the meter tube remains constant and is independent of back pressure variations. If the back pressure remains constant then the needle valve can be installed in the flowmeter inlet. For measurements at atmospheric pressure, the needle valve **must** be installed in the inlet of the flowmeter.

Additionally, for gas measurements, the actual location for the needle valve (in-/outlet side) must always be considered when determining the operating pressure. As a result of the density changes of the compressed gas due to pressure changes, the upward forces acting on the float and thereby the indication of the flowrate values also change. In order to assure that the operating pressure in the region of the meter tube always remains constant, a control valve should be installed as follows (see Fig. 5-1).

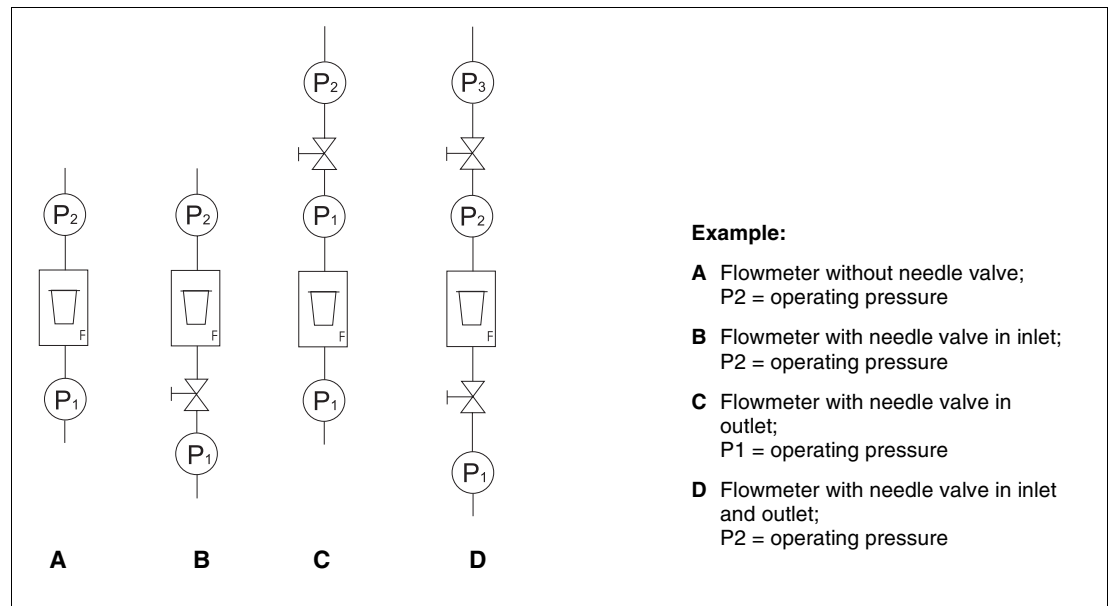


Fig. 5-1: Location of the Needle Valve

## 6 Floats

### 6.1 Ball floats

are used for metering smaller flowrates in sizes 1/16" to 3/8". In order to provide maximum versatility in changing flow ranges in a single meter tube size, ball floats made of a variety of materials with differing densities are available.

### 6.2 Floats with tail guides

used in combination with beadguide meter tubes and percent scales represent the standard Variable Area Flowmeter design. The float type „GSVT“ is largely independent of viscosity effects and is available in a variety of materials and weights. Flowrates approximately 25% to 30% higher can be measured by reversing the float head „GNSVT“. This float geometry is not suitable for fluids with higher viscosities. The VIC values listed in the flow range tables must be observed. The float is guided by the metering edge and the tail guide at the three ribs in the beadguide meter tube.

### 6.3 Low pressure drop floats

were developed especially for metering gases at low pressures and assure an extremely low pressure drop through the flowmeter. They are used in combination with the beadguide metering tubes.

### 6.4 Pole guided floats

in conjunction with plain tapered meter tubes have a hole drilled through their length axis and are guided by a pole rigidly positioned in the meter tube.

### 6.5 Floats Type „BL“ . . .

are especially suitable for high flowrates in the smaller sizes. They are guided by the three ribs in the beadguide meter tubes.

### 6.6 Tapered floats

are used only in cylindrical tubes with an orifice. The guide rods, a part of the float, move in guide elements attached to the tube to center and guide the float. A magnet in the float transmits the float position to an externally mounted indicator.

### 6.7 Floats with guide rods

in tapered metal meter tubes operate similar to the float position transmission and guide system described above. They are essentially viscosity insensitive and are available with the float head geometries previously described (see Chap. 6.2). The wide variety of different meter tube - float - scale combinations which are available provide approximately 100,000 possible Variable Area Flowmeter designs available for quoting.

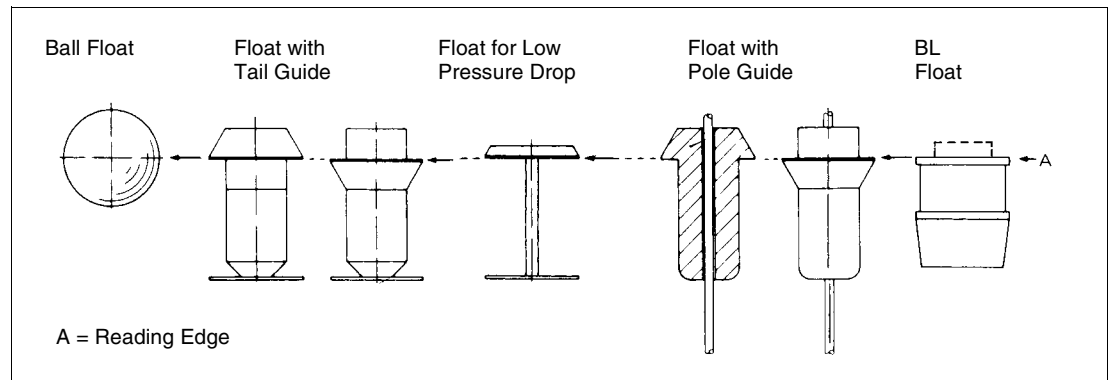


Fig. 6-1: Float Shapes

## 7 Meter Tubes

### 7.1 Glass Meter Tubes

#### 7.1.1 Tri-flat meter tubes sizes 1/16" to 1/4"

are used in the smallest sizes. The tubes expand conically in the flow direction and contain three flats which are parallel to the central axis of the meter tube. The ball float is guided by these three flats over the entire flow range and the minimal space between the float and flats in the meter tube assures readability of the float position even in cloudy fluids. The float is guided exactly in the middle of the meter tube.

#### 7.1.2 Plain tapered meter tubes sizes 1/2" to 1/4"

are also used with ball floats (see Chap. 6.1) for metering smaller flowrates. Their accuracy is not as high as the tri-flat meter tubes and are therefore only utilized for simple applications. The ball floats are centered in the plain tapered meter tubes by the flowing fluid.

#### 7.1.3 Plain tapered meter tubes sizes 1/2" to 2"

are usually only used for extreme operating conditions (pressure shocks, vibrating pipelines, etc.). In the size 2", higher flow range end values are possible because flow area is greater than in the beadguide meter tubes. The float is guided by a pole guide in the plain tapered meter tubes (see Chap. 6.4).

#### 7.1.4 Beadguide meter tubes sizes 1/2" to 2"

are the standard in this size range. This meter tube type incorporates three ribs which are parallel to the center axis of the meter tube and perform the same functions as the flats described in Chap. 7.1.1 for the tri-flat meter tubes. They guide the float over the entire flow range. Here also the minimal space between the float reading edge and the beadguides assures readability of the float position even in cloudy fluids. They are used together with the float shapes described in Chap. 6.2 and Chap. 6.3.

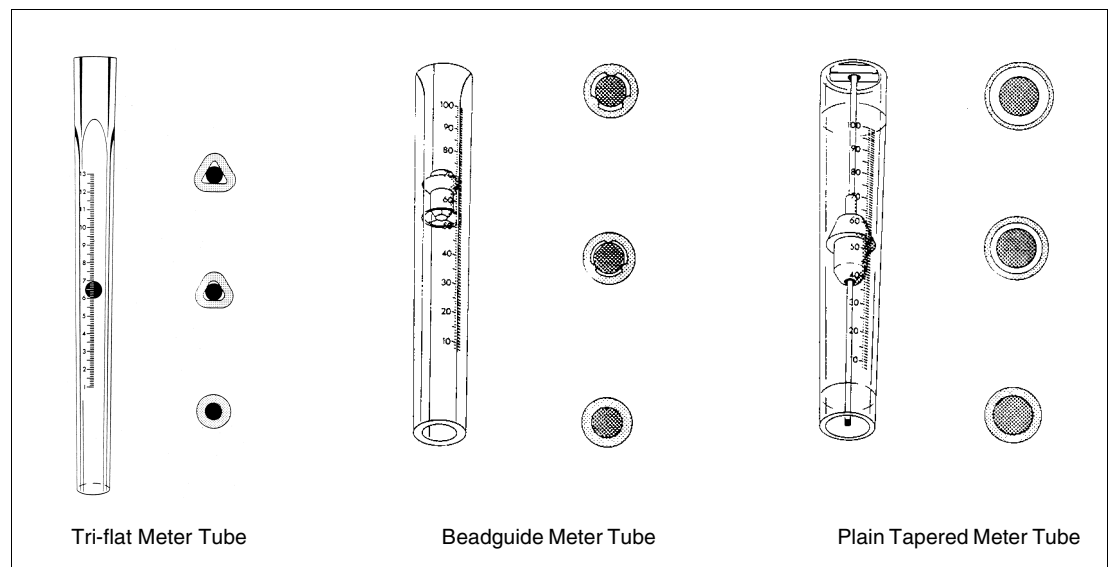


Fig. 7-1: Meter Tube Designs

### 7.2 Metal Meter Tubes

#### 7.2.1 Plain tapered meter tubes

with guide elements rigidly attached to the meter tubes in combination with the floats described in Chap. 6.7 are the standard elements of our all metal, armored flowmeter program. The float position is transmitted to the indicator by a magnet follower system.

## 8 Scales

### **Diameter Ratio Scale Dt/Df**

The diameter ratio scale is a linear representation of the ratio between the effective internal meter tube diameter (Dt) and the float diameter (Df). It can be used universally for both liquids and gases and is particularly advantageous when operating conditions vary. A flowrate table is included at no cost for converting the scale indications into flowrate values. Conversions to other operating conditions can be readily made using our Calculation Program **FlowCalc**. This scale type is the standard for the tri-flat meter tubes with a ball floats.

### **Percent Scale**

The linearized percent scale is the standard scale for all other Variable Area Flowmeters, predominantly the beadguide and plain tapered meter tubes (see Chap. 7.1.3). It indicates a percentage value based on maximum flowrate and extends over a range from 8 to 100%. Knowledge of the operating conditions, the physical characteristics of the fluid and the geometric design of the float can be used to readily calculate or convert the maximum flowrate value. Each percent scales provides the guaranteed accuracy.

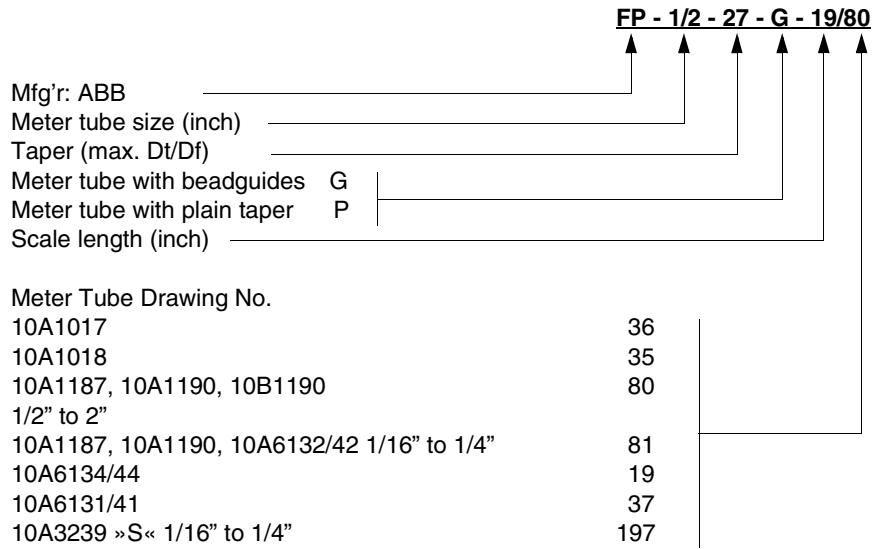
### **Direct Reading Scale**

This scale indicates the volume or mass flowrate per unit of time directly (e.g. l/h Hydrogen, cm<sup>3</sup>/min H<sub>2</sub>O). It is valid only for exactly defined operating conditions. The universal applicability of the meter tubes is somewhat limited by the use of direct reading scales.

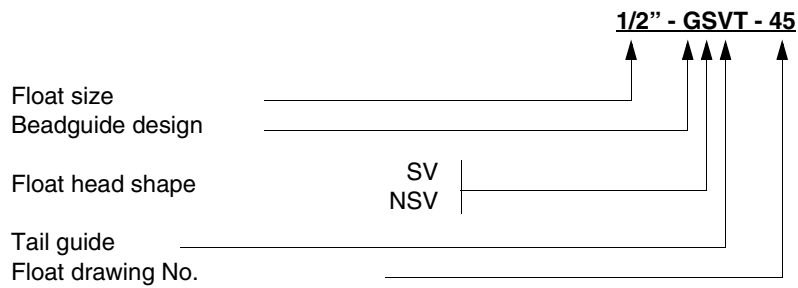
### **Millimeter Scale**

This scale is usually only used when a fixed flowrate is to be reproduced and the actual flowrate value plays a subordinate role. For applications with viscous fluids this scale may be considered as universal.

### 9 Glass Meter Tube Designations



### 10 Float Designations



### 11 Ball Float Designations

Type			
<b>Material</b>	<b>Density (g/cm<sup>3</sup>)</b>		
Glass (black)	2.28 (only 1/4", 3/8")	<b>CD</b>	
Glass (black)	2.53 (only 1/16", 1/8")	<b>BG</b>	
Sapphire (red)	3.98	<b>SA</b>	
Stainless steel 304 [1.4301]	8.02	<b>SS</b>	
Carboloy	14.95	<b>CA</b>	
Tantalum	16.6	<b>TA</b>	
<b>Size</b>			
1/16"			<b>16</b>
1/8"			<b>18</b>
1/4"			<b>14</b>
3/8"			<b>38</b>

## 12 Accuracy Classes

The accuracy specifications for the Variable Area Flowmeters are defined by the various Accuracy Classes in the VDE/VDI Guideline 3513, Pg. 2, in which an error range is assigned for each Accuracy Class. The maximum allowable error is the sum of the following partial errors.

- 1st. Partial error: 3/4 of the value assigned for the Accuracy Class is the error in percent of rate
- 2nd. Partial error: 1/4 of the value assigned for the Accuracy Class is the error in percent of full scale

The total error can be calculated for a specific flowrate in % of rate as follows:

$$E = (3/4M + 1/4E) \cdot K/M$$

M = Measured value in flowrate units

E = Scale end value in flowrate units

K = Value for the Accuracy Class per VDI/VDE 3513/2

E = Total error in % of rate.

Flowrate in %	Accuracy Class				
	1	1.6	2.5	4	6
	Total Error in % of Rate				
100	1.000	1.600	2.500	4.000	6.000
90	1.028	1.644	2.569	4.111	6.167
80	1.063	1.700	2.656	4.250	6.375
70	1.107	1.771	2.768	4.429	6.643
60	1.167	1.807	2.917	4.667	7.000
50	1.250	2.000	3.125	5.000	7.500
40	1.375	2.200	3.438	5.500	8.250
30	1.583	2.533	3.958	6.333	9.500
20	2.000	3.200	5.000	8.000	12.000
10	3.250	5.200	8.125	13.000	19.500

## 13 Allowable Operating Pressures for Glass Meter Tubes when Metering Gases

The assurance of the safety of personnel and the environment is an important quality hallmark of the ABB measurement instruments. ABB meets the challenges of the new safety regulations. To protect from dangerous splinters should a meter tube accidentally burst, our glass meter tube flowmeters for metering gases incorporate a protective component (protection cap or protection tube). The protective component also provides protection from direct external mechanical effects.

### 13.1 Laboratory Flowmeter Series 10A1017/18

Model	Max. Allowable Operating Pressure (bar)
10A1017	0.5
10A1018	0.5

#### Comments

- Listed max. allow. operating pressure for 20 °C fluid temperature and 20 °C ambient temperature
- Max. fluid temperature: 0...95 °C
- Is shipped without protective component

**13.2 Glass Meter Tube Flowmeter Series 10A1187, 10A1190**

Flowmeter Size	Meter Tube Size	Max. allow. Operating Pressure (bar)	
		Standard Design	Alarm Design
1/4"	1 1/16"...1/4"	30	–
1/2"	1/2"	17	17
3/4"	3/4"	13	13
1"	1"	10	10
1 1/2"	1 1/2"	4	4
2"	2"	2	2

**Comments**

- Listed max. allow. operating pressure for 20 °C fluid temperature and 20 °C ambient temperature
- Max. ambient temperature: 40 °C
- Max. fluid temperature: 0...100 °C
- For fluid or ambient temperatures above 30 °C the max. allow. operating pressure is reduced by 1.05 %/1 °C (see Fig. 13-1)

**13.3 Glass Tube Flowmeter Series 10A2700**

Flowmeter Size	Meter Tube Size	Max. allow. Operating Pressure (bar)
1/4"	1/16"...1/4"	6,0
3/4" <sup>1)</sup>	1/2"...1"	0,5
1 1/2"	1 1/2"...2"	1,0

**Comments**

- Listed max. allow. operating pressure for 20 °C fluid temperature and 20 °C ambient temperature
- Max. fluid temperature: 0...150 °C

<sup>1)</sup> Meter tube sizes 1/2" and 3/4" max. 5 bar with PC-Protective Tube

**13.4 Purgemeter Series 10A3239S**

Flowmeter Size	Meter Tube Size	Max. allow. Operating Pressure (bar)
1/4"	1/16"	18
	1/8"	18
	1/4"	18

**Comments**

- Listed max. allow. operating pressure for 20 °C fluid temperature and 20 °C ambient temperature
- Max. ambient temperature: 40 °C
- Max. fluid temperature: 0...80 °C
- For fluid or ambient temperatures above 30 °C the max. allow. operating pressure is reduced by 1.05 %/1 °C (see Fig. 13-1)

**13.5 „Purgemaster“ Series 10A6100**

Flowmeter Size	Scale Length	Max. allow. Operating Pressure (bar)
1/4"	38/70	18
	100/130	18
	250	18

**Comments**

- Listed max. allow. operating pressure for 20 °C fluid temperature and 20 °C ambient temperature
- Max. ambient temperature: 40 °C
- Max. fluid temperature: 0...100 °C
- For fluid or ambient temperatures above 30 °C the max. allow. operating pressure is reduced by 1.05 %/1 °C (see Fig. 13-1)

**13.6 Glass Meter Tube Flowmeter for Bypass Metering Series 10B1197**

Flowmeter Size	Max. allow. Operating Pressure (bar)
1/2"	17

**Comments**

- Listed max. allow. operating pressure for 20 °C fluid temperature and 20 °C ambient temperature
- Max. ambient temperature: 40 °C
- Max. fluid temperature: 0...100 °C
- For fluid or ambient temperatures above 30 °C the max. allow. operating pressure is reduced by 1.05 %/1 °C (see Fig. 13-1)

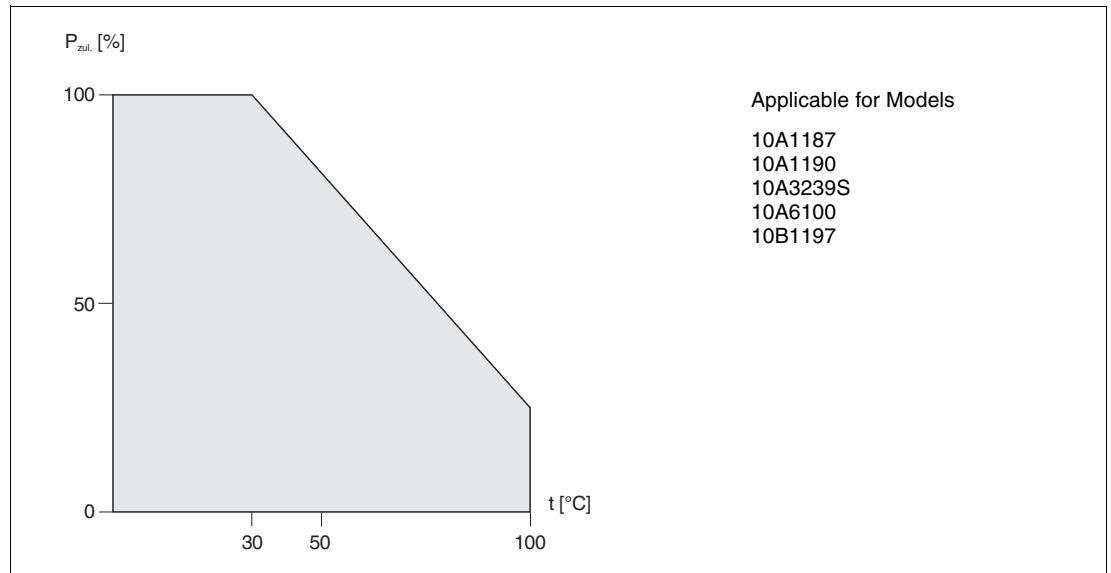


Fig. 13-1: Allowable Operating Pressure as a Function of the Temperature



**Warning**

The flowmeters should only be operated with protective cap or protective tube installed in front of the glass meter tube. It is essential that the maximum allowable operating conditions be observed (see Instruction Bulletin for Installation and Start-up).

**Note:**

The allowable operating pressure values are static pressure values. Selection and installation recommendations for Variable Area Flowmeters are to be observed. Proper handling and operation of the flowmeter (see Instruction Bulletin) and observing the specified allowable operating conditions are the exclusive responsibility of the user.



## 14 Material Selections for Variable Area Flowmeters

This selection does not claim to be complete, however it does offer ease when selecting materials. At the present time these recommendations are based on laboratory tests by the material manufacturers or upon repetitive applications in practice. When in doubt the material recommendations should be obtained from the manufacturer since he has the most experience. Not included are the ball floats sizes 1/16" to 1/4". If a glass meter tube is suitable for the application, then the assumption that a ball float made of glass or sapphire should also be suitable can be made.

Fluid	Concentration in %	Temperature in °C	Fittings							Floats						O-Rings			Meter Tube	Meter Tube for All Metal Flowmeters		
			304[1.4301]/Brass	Bronze	1,4301/Steel	316Ti [1.4571]	PVC/40 °C	Hastelloy C	PVDF/PTFE	316Ti [1.4571]	PVC/40 °C	1,4301	Hastelloy C	Hastelloy B	Titanium	PVDF/PTFE	Buna-N	Viton-A		Ethylene Propylene	Glass	316Ti [1.4571]
Acetaldehyde						x						x						x	x	x		
Acetone			x		x							x	x					x	x	x		
Acetylene			x		x							x	x					x	x	x		
Acrolein						x						x					a.A.		x	x		
Ethane			x		x							x	x					x	x	x		
Äthancarbonsäure						x						x						x	x	x		
Äthanolamin					x	x						x	x					x	x	x		
Ether, Methyl, Ethyl			x		x							x	x					x	x	x		
Ethyl Acetate					x	x						x	x					x	x	x		
Ethyl Acrylate					x	x						x	x					x	x	x		
Ethyl Ether			x		x							x	x					x	x	x		
Ethyl Alcohol			x		x							x	x					x	x	x		
Ethyl Cellulose					x	x						x	x					x	x	x		
Ethylene			x		x							x	x					x	x	x		
Ethylene Chlorohydrin					x	x						x	x					x	x	x		
Ethylene Chloride					x	x						x	x					x	x	x		
Ethylene Diamine						x						x						x	x	x		
Ethylene Dichloride						x						x						x	x	x		
Ethylene Glycol					x	x						x	x					x	x	x		
Ethylene Oxide					x	x						x	x					x	x	x		
Caustic potash, see Calcium Hydroxide																						
Caustic Soda, see Sodium Hydroxide																						
Alaun, see Kalialaun																						
Alcohol			x			x						x	x					x	x	x		
Aluminium Sulfate						x	x					x	x					x	x	x		
Formic Acid	0-100	80				x								x				x	x	x		
Ammonia gas					x	x	x					x	x	x				x	x	x		
Ammonia solution	1	25			x	x	x					x	x	x				x	x	x		
Ammonia liquid						x						x						x	x	x		
Ammonium Chloride							x						x					x				
Ammonium Hydroxide					x	x						x	x					x	x	x		
Ammonium Carbonate					x	x						x	x					x	x	x		

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Fluid	Concentration in %	Temperature in °C	Fittings						Floats						O-Rings			Mess- rohr	Meter Tube for All Metal Flowmeters				
			304[1.4301] Brass	Bronze	1,4301/ Steel	316Ti [1.4571]	PVC/40 °C	Hastelloy C	PVDF/PTFE	316Ti [1.4571]	PVC/40 °C	1,4301	Hastelloy C	Hastelloy B	Titanium	PVDF/PTFE	Buna-N		Viton-A	Ethylene Propylene	Glass	316Ti [1.4571]	Hastelloy C
Ammonium Nitrate						x													x		x		
Ammonium Phosphate						x													x		x		
Ammonium Sulfate						x													x		x		
Amyl Acetate						x												x		x	x		
Amyl Alcohol			x		x	x				x								x		x	x		
Amyl Chloride			x		x					x	x							x		x		x	
Aniline					x	x				x	x							x		x	x		
Antichlor, see Sodium Thiosulfate																							
Mahic acid						x												x		x	x		
Argon			x		x					x	x	x						x		x	x		
Asphalt										x											x		
ATE-Brake Fluid			x							x	x							x		x	x		
Barium Chloride																		x	x				x
Barium Hydroxide					x	x				x	x							x		x	x		
Barium Nitrate						x				x								x		x	x		
Barium Sulfide						x				x								x		x	x		
Benzaldehyde					x					x	x								x		x	x	
Benzine			x		x					x	x							x		x	x		
Benzoic Acid						x				x									x		x	x	
Benzol			x		x					x	x								x		x	x	
Acrid salt, see Manganese Sulfate																							
Prissic Acid						x				x									x		x	x	
Blood						x				x									x		x	x	
Borax					x					x	x								x		x	x	
Boron Chloride					x					x	x								x		x	x	
Boric Acid						x				x									x		x	x	
Bromine gas																			x	x			x
Bromwasserstoffsäure																			x	x			x
Bunker C Oil										x												x	
Butadiene			x		x					x	x									x		x	x
Butane			x		x					x	x									x		x	x
Butane, lliquid			x		x					x	x									x		x	x
Butyric acid						x				x										x		x	x
Butyl Acetate			x		x					x	x									x		x	x
Botyl Alcohol			x							x	x									x		x	x
Butylene			x							x	x									x		x	x

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Fluid	Concentration in %	Temperature in °C	Fittings						Floats						O-Rings			Meter Tube	Meter Tube for Ganzmetall-Durchflussm.			
			304[1.4301]/ Brass	Bronze	1,4301/ Steel	316Ti [1.4571]	PVC/40 °C	Hastelloy C	PVDF/PTFE	316Ti [1.4571]	PVC/40 °C	1,4301	Hastelloy C	Hastelloy B	Titanium	PVDF/PTFE	Buna-N	Viton-A	Ethylene Propylene	Glass	316Ti [1.4571]	Hastelloy C
Calcium Bisulfite						x	x		x		x				x			x				x
Calcium Chloride		40				x	x		x		x			x	x			x				x
Calcium Chloride		>40					x				x			x	x			x				x
Calcium Hydroxide				x	x			x		x					x			x	x			
Calcium Hypochloride							x	x						x		x		x				x
Carbonic Acid					x			x									x	x	x			
Chlorine (dry gas)				x						x						x		x	x			
Chlorine (liquid)				x			x	x		x				x		x		x				x
Chlorine (wet gas)							x	x		x				x		x		x				x
Chlorine Dioxide (dry gas)				x				x		x			x	x		x		x				x
Chlorine line	3	30				x				x				x		x		x				x
Chloroform			x	x	x			x		x						x		x	x		x	
Chlorine Water		20				x	x		x		x			x		x		x				x
Hydrochloric Gas (HCL-Gas)					x	x		x		x				x	x			x				x
Chromic Acid	50	40				x	x		x		x → @ 20 %			x		x		x				x
Chromic Acid, pure, SO3-free	10-50				x			x								x		x	x			
Condopal			x					x		x						x		x	x			
Condorid-S					x	x		x	x						x			x	x			
Cyclohexane				x	x			x		x						x		x	x			
Cyclohexanol				x	x			x		x					x			x	x			
Cyclohexanole				x	x			x		x							x	x	x			
Cyclopropane			x	x	x			x		x					x			x	x			
Steam								x														x
Diacetone			x	x	x			x		x								x	x	x		
Diacetone Alcohol			x	x	x			x		x								x	x	x		
Diethylene Glycol				x	x			x		x					x			x	x			
Diboran					x			x								x		x	x			
Dibutylphtalate					x			x									x	x	x			
Dichlormethane					x			x								x		x	x			
Diese Oil, light				x				x		x					x			x	x			
Diisopropylekton					x			x									x	x	x			
Dimethylether, see Ether, Methyl																						
Diphenyl				x				x		x						x		x	x			
Jet Fuel JP 1 & 4			x	x	x			x		x						x		x	x			
Ferric-II-Chloride						x	x		x		x			x	x			x				x
Ferric-III-Chloride						x	x		x		x			x	x			x				x







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Fluid	Concentration in %	Temperature in °C	Fittings							Floats						O-Rings			Meter Tube	Meter Tube for All Metal Flowmeters		
			304[1.4301] Brass	Bronze	1.4301/ Steel	316Ti [1.4571]	PVC/40 °C	Hastelloy C	PVDF/PTFE	316Ti [1.4571]	PVC/40 °C	1.4301	Hastelloy C	Hastelloy B	Titanium	PVDF/PTFE	Buna-N	Viton-A	Ethylene Propylene	Glass	316Ti [1.4571]	Hastelloy C
Sodium or Trisodium Phosphate					x	x													x	x		
Sodium Silicate (water glass)					x	x													x	x		
Sodium Sulfate					x	x													x	x		
Sodium Sulfide					x	x													x	x		
Sodium Sulfite					x														x	x		
Sodiumthiosulfat						x													x	x		
Sodium Hydroxide	0-20	20			x	x													x	x		
Caustic Soda	> 20	20			x	x													x	x		
Caustic Soda	> 20	> 20																			x	
Neon			x		x	x													x	x		
Nickel Chloride							x												x			x
Nickel Sulfate						x													x			
Nitrobenzol						x													x			
Sulphurate Oil						x													x			
Ölsäure						x													x			
Oleum, see Sulfuric Acid																					x	x
Olive Oil			x			x													x			
Oxalic Acid, cold						x													x			
Ozone						x	x												x	x		
Palmin acid						x	x												x			
Paraffine			x			x	x												x			
Pectin						x													x			
Pentan			x			x													x			
Perchlorethylene			x			x	x												x			
Petroleum			x			x	x												x			
Vegatable Oil						x	x	x											x			
Phenol, see Carboic Acid						x													x			
Phenylamine						x													x			
Phosgene						x															x	
Phosphinic acid						x													x			
Phosphorous, liquid						x															x	
Phosphoric Acid						x													x			
Pikin acid						x													x			
Propane (gas)			x			x	x												x			
Propane, liquid						x	x												x			
Propylene			x			x	x												x			

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Fluid	Concentration in %	Temperature in °C	Fittings							Floats							O-Rings			Meter Tube	Meter Tube for Ganzmetall-Durchflussm.		
			304[1.4301]/Brass	Bronze	1,4301/Steel	316Ti [1.4571]	PVC/40 °C	Hastelloy C	PVDF/PTFE	316Ti [1.4571]	PVC/40 °C	1,4301	Hastelloy C	Hastelloy B	Titanium	PVDF/PTFE	Buna-N	Viton-A	Ethylene Propylene		Glass	316Ti [1.4571]	Hastelloy C
Propylene Oxide						x				x							x		x	x			
Pyrid					x	x				x		x					x		x	x			
Salicylic Acid						x				x							x		x	x		x	
Nitric Acid	< 50					x	x			x	x				x		x		x	x		x	
Nitric Acid, concentrated.						x				x							x		x	x			
Nitric Acid, fuming		20			AL/95.5%					x	AL/95.5%				x	x				x		x	
Hydrochloric Acid							x			x		x				x		x		x		x	
Brine	50-65									x			x			x	x		x			x	
Oxygen			x		x	x				x		x					x		x	x			
Sea Water				x			x			x					x	x			x			x	
Silicone Oil						x				x							x		x	x			
Skydrol 500 B & C/7000			x		x	x				x		x						x	x	x			
Soda, see Sodium Carbonate																							
Soy Oil						x				x		x				x			x	x			
Spaltglas					x	x				x		x				x			x	x			
Spinning Bath Solution													x			x						x	
Sulfitebase						x											x		x	x			
Sulfur, molten										x													
Sulfur Chloride, dry						x				x							x		x	x			
Sulfur Dioxide, dry					x	x	x			x	x	x						x	x	x			
Sulfur Dioxide, wet							x			x		x			x				x			x	
Sulfur Dioxide, liquid					x	x				x		x						x	x	x			
Sulfur Hexafluoride gas			x			x	x			x	x	x						x	x	x			
Sulfurous Acid	20-30					x	x			x	x				x		x		x	x			
Sulfuric Acid	≤ 90						x			x		x			x		x		x			x	
Sulfuric Acid	90-95						x	x		x		x			x		x		x			x	
Sulfuric Acid	96	20					x			x		x			x		x		x			x	
Sulfuric Acid	98 conc.	20			x	x	x			x	x	x	x		x		x		x	x		x	
Hydrogen Sulfide, dry					x	x	x			x	x							x	x	x			
Hydrogen Sulfide, wet						x				x								x	x	x			
Starch						x				x		x				x			x	x			
Stearic Acid						x				x		x				x			x	x			
Nitrogen			x		x	x				x	x	x				x			x	x			
Nitrogen Dioxide						x				x						x			x	x			
Nitrogen Monoxide			x			x				x		x				x			x	x			
Stickstoffoxydul, see Laughing Gas																							







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