Correction Factor for the Rotameter

While a gas volume meter up to a certain pressure (over - or vacuum) always indicate the actual flowing volume, is this not the case by a rotameter. The rotameter is calibrated only at one certain condition (on the ad declared). The Gothe-rotameter was calibrated at a barometric pressure of 1000 mbar, temperature of 293 K and with air (standard condition density 1,293 kg/m³). The add show the volume flow at standard condition. To calculate the actual gas flow through the rotameter you must use a correction factor and the correction to operating condition.

The scale of the rotameter is for air (density NPT: 1.293 kg/m³) at 273K. Correction factors (K) must be used if the temperature and/or pressure and/or the density change:

δ_B: gas density NPT [kg/m³]
δ_E: calibrate density NPT [kg/m³]
b: atmospheric pressure [mbar]
p: operating pressure [mbar]
p_N: NPT-pressure (1013 mbar)
T: NPT temperature (273 K)
t: operating temperature [°C]

To calculate the density: Formula 1+2

$$\delta_{operating} = \delta_N \bullet \frac{(b \pm p) \bullet T}{p_N \bullet (T + t)}$$

$$\delta_N = \delta_{operating} \bullet \frac{p_N \bullet (T + t)}{T \bullet (b \pm p)}$$

Formula 3: to calculate the calibration factor

$$K_\delta = \sqrt{\frac{\delta_E}{\delta_B}}, \quad K_t = \sqrt{\frac{293}{(273+t)}}, \quad K_p = \sqrt{\frac{p}{1000}}$$

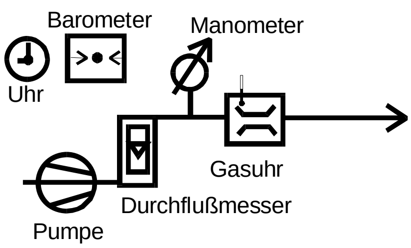
How to use the correction factor:

Formula 4:

$$Volume(gasmeter) = scale(rotameter) \bullet K_\delta \bullet K_t \bullet K_p$$

Formula 5:

$$scale(rotameter) = \frac{volume(gasmeter)}{K_\delta \bullet K_t \bullet K_p}$$



Example 1:

Gas compounds: 20 Vol-% CO_2, 72 Vol-% N_2, 6,5 Vol-% O_2 ,1,5 Vol-% CO

Temperature at the gas meter: 30°C,
stat. pressure at gas meter: +3 mbar, barometric pressure: 1000 mbar,
NPT-density: 1,4074 kg/m³, wished gas flow: 5 m³/h

calculate the density (NPT):

	%-Volume	NPT-density [kg/m³] at 100 %	(%-Vol/100)	%-density
CO_2	20	1,9770	0,15	0,3954
N_2	72	1,2505	0,80	0,9004
O_2	6,5	1,4290	0,035	0,0929
CO	1,5	1,2505	0,015	0,0188
			Density (NPT):	**1,4074**

In standard situations, the flowmeter is in front of the gas meter and behind the gas tight pump. What must indicate the flowmeter if 5 m³/h should flow through the gas meter for isokinetic sampling:

$$scale(rotameter) = \frac{volume(gasmeter)}{K_\delta \bullet K_t \bullet K_p}$$

$$K_\delta = \sqrt{\frac{\delta_E}{\delta_B}} = \sqrt{\frac{1{,}293}{1{,}4075}} = 0{,}959\,, \quad K_t = \sqrt{\frac{t_{cal}}{(T+t)}} = \sqrt{\frac{293}{303}} = 0{,}983\,, \quad K_P = \sqrt{\frac{p}{1000}} = \sqrt{\frac{1003}{1000}} = 1{,}002$$

$$V_{indicated} = V_{desired} \bullet \frac{(b \pm p) \bullet T}{p_N \bullet (T+t)} \bullet \frac{1}{K_\delta} \bullet \frac{1}{K_t} \bullet \frac{1}{K_p} = 5 \bullet \frac{(1000+3) \bullet 273}{1013 \bullet (273+30)} \bullet 1{,}059 = 4{,}72\, m^3/h$$

In this example: At the scale of the rotameter must indicate 4,72 m³/h. , if 5 m³/h on operating condition should flow through the gas meter.

Or:

At the scale at the rotameter is shown 4,72:

$$Volume(gasmeter) = scale(rotameter) \bullet K$$

$$V_{real} = V_{indication} \bullet \frac{p_N \bullet (T+t)}{(b \pm p) \bullet T} \bullet K_\delta \bullet K_t \bullet K_p = 4{,}72 \bullet \frac{1013 \bullet (273+30)}{(1000+3) \bullet 273} \bullet 0{,}945 = 5{,}0\, m^3/h$$

On operating condition flow through the rotameter 5 m³/h if the scale show 4,72 m³/h.

Respect: Disturbances in the ad (dead loss) can happen through pumps in front of the flowmeter (rotary vane- and membrane-pumps). To avoid this, use a pulsation dumper in front of the flowmeter! Calibrate the flowmeter with the gas meter.