Flow measurement in gases – What is a standard cubic metre?

Standard volume flow | Mass flow | Calorimetric measurement method

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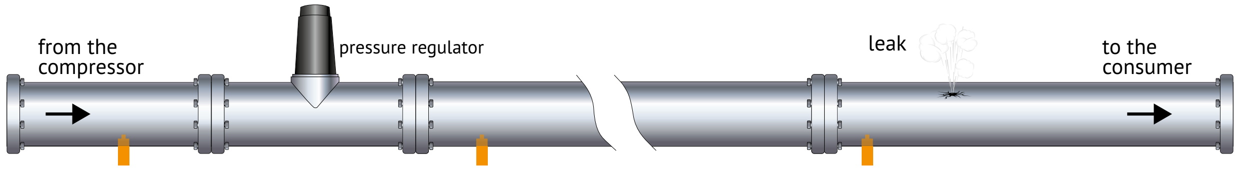


	Measuring point 1	Measuring point 2	Measuring point 3
Pressure	9 bar	7 bar	6 bar
Temperature *(constant)*	25 °C	25 °C	25 °C
Mass flow *(constant)*	10 kg/h	10 kg/h	10 kg/h
Standard volume flow *(constant)*	7,73 Nm^3/h	7,73 Nm^3/h	7,73 Nm^3/h
Operating volume flow	0,95 m^3/h	1,22 m^3/h	1,42 m^3/h

Basics

The measurement of gas flow differs fundamentally from the measurement of liquid flow. This is due to the compressibility of gases. This means that the **volume** of a gas changes depending on **temperature** and **pressure**. This can be described using the following formula:

$p \cdot V / T$ = constant (p: pressure, V: volume, T: temperature)

If the temperature is constant, the formula simplifies to:

$p \cdot V$ = constant

The volume of a gas therefore changes depending on pressure. For example, if pressure is increased by a factor of 8 – from 1 bar to 8 bar – volume is reduced to 1/8 of the original value (from 10 m^3 to 1.25 m^3). In contrast, the volume change of liquids is negligible in practice.

$p_1 \cdot V_1 = 1\text{ bar} \cdot 10\text{ m}^3 = 8\text{ bar} \cdot 1{,}25\text{ m}^3 = p_2 \cdot V_2$

Therefore, when determining a gas quantity, simply stating a volume (e.g. 10 m^3 or 10,000 litres) is not sufficient. Instead, the **mass** of the gas must be specified because the mass of a gas always remains constant. In the above example, the mass of the gas at 1 bar and 10 m^3 is the same as at 8 bar and 1.25 m^3. In practice, the **standard volume** is often specified instead of the mass.

One **standard cubic metre** (Nm^3) of gas is the amount of gas contained in a volume of 1 m^3 at 1,01325 bar and 273,15 K (0 °C). Since the mass remains constant at 1 bar and 8 bar, the standard volume contained is also constant.

The following table shows the mass contained per 1 Nm^3 of commonly used industrial gases:

Air	1,293 kg/Nm^3
Nitrogen	1,250 kg/Nm^3
Oxygen	1,429 kg/Nm^3
Argon	1,784 kg/Nm^3
Carbon dioxide	1,977 kg/Nm^3
Methane	0,717 kg/Nm^3
Hydrogen	0,090 kg/Nm^3

Flow measurement in gases

In a compressed air network where pressure varies across different locations, it becomes clear that measuring operating volume flow in m^3/h is not very meaningful. The example above shows part of a compressed air network with various flow measurement points.

If, for example, a significant leak is detected in the compressed air network and you wish to measure how much valuable compressed air is being unnecessarily lost as a result, it makes sense to measure the **mass flow rate** or **standard volume flow rate directly**. This remains constant at all three measuring points along the continuous pipeline. If, instead, you measure the operating volume flow rate, you will obtain different results at all three measuring points. The reason for this is that the air is more compressed at higher pressures. Consequently, at higher pressures, a lower operating volume flow rate is needed to transport the same mass.

To make the different operating volume flows comparable, it is necessary to additionally measure the prevailing pressure and temperature directly at the measuring points. Only then can the measurement results be meaningfully compared, for example by converting them to standard conditions.

To avoid these additional measurements, the mass flow rate or standard volume flow rate can be measured directly. The following table shows which measurement methods make this possible:

Ultrasonic
no – only operating volume flow measurement

Magnetic-inductive (MID)
no – only operating volume flow measurement

Calorimetric (thermal)
yes – direct mass/standard flow measurement

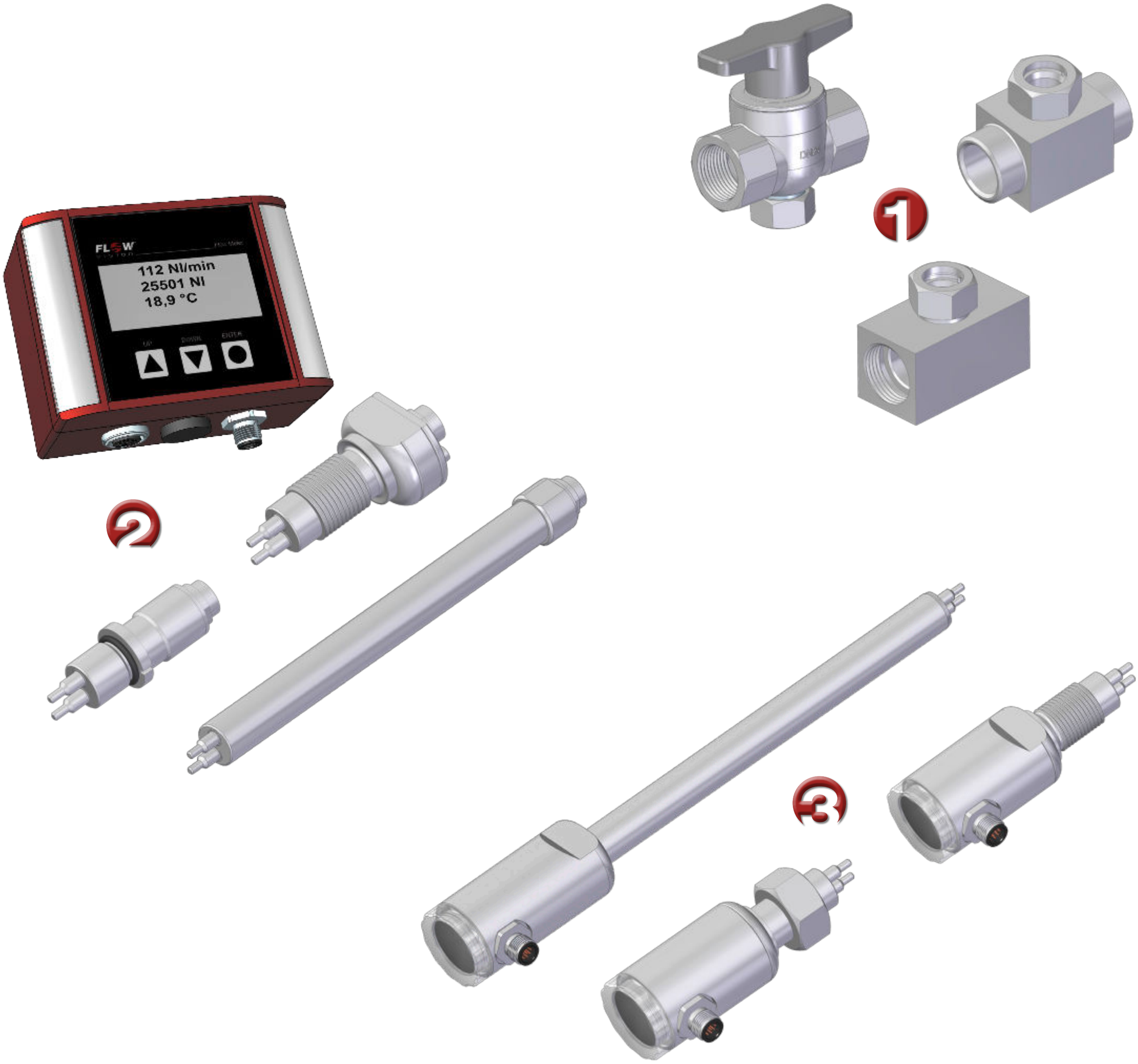
Coriolis
yes – direct mass/standard flow measurement

Vortex
no – only operating volume flow measurement

Differential pressure (orifice plate)
no – only operating volume flow measurement

Turbine
no – only operating volume flow measurement

Variable area
no – only operating volume flow measurement



Our sensors for technical gases

Air | Nitrogen | Oxygen | Argon | Carbon dioxide | Methane | Hydrogen

1 Sensor adapter TP | Ball valve BV
For precise positioning of sensors

2 Calorimetric flow meter PERFLU 5-CA
Sensor separated from control unit | illuminated display | USB
4...20 mA for flow and temperature| pulse output | relay outputs

3 Calorimetric flow meter FVone-NP-CA
Control unit integrated in sensor | USB
4...20 mA for flow and temperature| pulse output | relay outputs

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