Küppers Elektromechanik GmbH
Flow Meters
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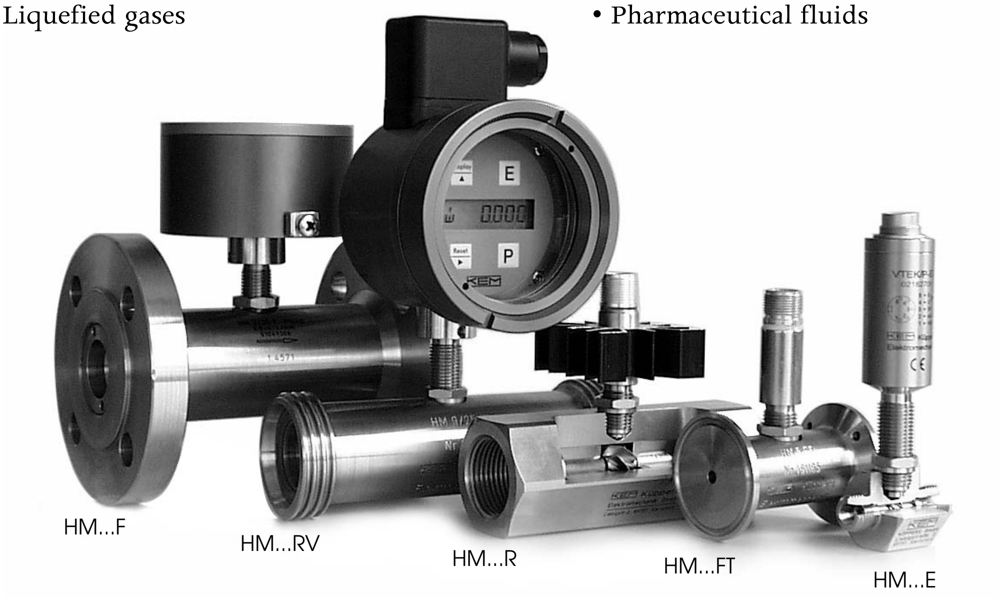
HM Series
Turbine Flow Meters

Application

Turbine flow meters (hereinafter referred to as turbines) are used for the precise measurement of instantaneous flow rates and flow quantities of low-viscosity fluids such as:

- Tap and demineralised water
- Fuels
- Liquefied gases
- Light fuel oil
- Solvents
- Pharmaceutical fluids



Individual datasheets are available for each type.

Principle

Turbine flow meters are *mediate volume transmitters* similar to a Woltmann's Sail Wheel. The volume passing through the tube is measured by the mean velocity of the streaming fluid. Flow rectifiers ensure a laminar flow in the axial direction of the wheel.

A light-weight turbinewheel carried concentrically in the tube body is rotated by the fluid. The RPM of the turbinewheel is directly proportional to the mean flow velocity within the tube diameter and corresponds to the volume flow over a wide range.

Principle (continued)

The following equation applies (excluding mechanical and hydraulic loss):

Equation 1

$$Q = c \cdot 2\pi \cdot r \cdot A \cdot n \cdot \cot\alpha$$

Q = Flow rate
c = Correction factor
r = Mean radius of blades
A = Effective area
n = RPM
α = Angel between blade and wheel axle with $r = r$ mean

An inductive pickup or a carrier-frequency pickup is screwed into the turbine flow meter. The pickup will detect the RPM of the turbinewheel through the non-magnetic turbinebody without magnetic drag and without coming into contact with the measuring medium. The turbinewheel is made from stainless steel and has sufficient magnetic conductibility.

With carrier-frequency pickups each passing of a rotor blade will influence the *electric* field of the pickup. The frequency of the amplitude modulation of the carrier corresponds to the rpm of the turbinewheel.

With inductive pickups each passing of a rotor blade will influence the *magnetic* field of the pickup. The change in magnetic flux induces a voltage in the pickup. The frequency of the sinusoidal alteration corresponds to the RPM of the turbinewheel.

After amplifying and transforming the pickup signal a squarewave pulse signal is available. The number of pulses per time unit is in proportion with the instantaneous flow rate.

Equation 2

$$\frac{n}{Q} = K\left(\frac{n}{\upsilon}\right)$$

n = RPM
Q = Instantaneous flow
K = Pulses per volume unit
ν = Kinematic viscosity

The ideal K-factor, which is to be derived from equation 1, really is a function of geometrical dimensions, flow velocity and kinematic viscosity. The turbine design provides a sufficiently constant K-factor over a certain velocity range. Considering calculating factors, equation 3 can be derived from equation 2:

Equation 3

$$Q = \frac{f \times 60}{K} \text{ l/min}$$

Q = Instantaneous flow
f = Frequency in Hz
K = K-factor in pulses/ltr.

Calibration

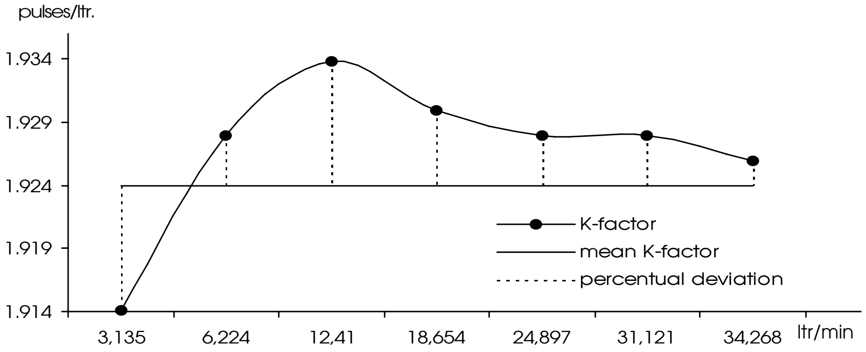
All turbines are calibrated before they leave our factory, and individual calibration records are supplied with the meters. Calibrations are performed on our volumetric calibration rigs or, on special request, in our DKD calibration laboratory. It is possible to calibrate at different viscosities. Therefore visosity variations in an application may be compensated by using the prevailing viscosity. Comparative measurements with our DKD lab ensure that calibration results have a valid relationship to nationally recognized standards.

During calibration the volume of a tank determined as accurate as ± 0.01 % is filled with a constant flow passing through the turbine flow meter. The output pulses of the turbine flow meter are added electronically and calculated for a volume unit to receive the K-factor in pulses per litre. Strictly speaking this K-factor applies only for a certain flow velocity or flow volume respectively. For the application of turbine flow meters, however, it is necessary to know the linear measuring range, i. e. the range with a constant K-factor. This range is determined by successively repeating the filling process at constant frequency intervals and different flow velocities. These individual measurements will result in the calibration curve from which the average K-factor can be drawn. The average K-factor applies for the entire measuring range.

Example

Turbine HM 9
3 up to 30 ltr./min

$$K_{mean} = \frac{K_{max} + K_{min}}{2}$$



Accuracy

Linearity corresponding to actual flow
It defines the max. percentual difference between a specific K-factor and the average K-factor.
Linearity ususally amounts to ±0.15% up to ±1% within the linear measuring range of the turbine flow meter. The linearity range of hydrodynamic flow meters as turbine flow meters depends on the Reynold's number of the measuring medium and the nominal diameter of the turbine flow meter.
As viscosity increases linearity deteriorates and the linear measuring range will be smaller at low flow velocities (cf. diagram next page). The influence of viscosity decreases with increasing nominal diameters.

Repeatability
It gives the percentual difference between two measuring results at identical flow rates. It usually amounts to 0.05 up to 0.1%. Only with small turbine flow meters below 9 mm diameter will repeatability increase to 0.2 %.

Advantages of KEM Turbines

Fast response time and high resolution
The turbinewheel's low moment of inertia allows a fast acceleration from standstill up to full number of revolutions within 5 to 50 msec. For that reason rapidly rising flow rates and pulsating flows may be detected. The resolution can amount to as much as 109,000 pulses per litre (see page 8).

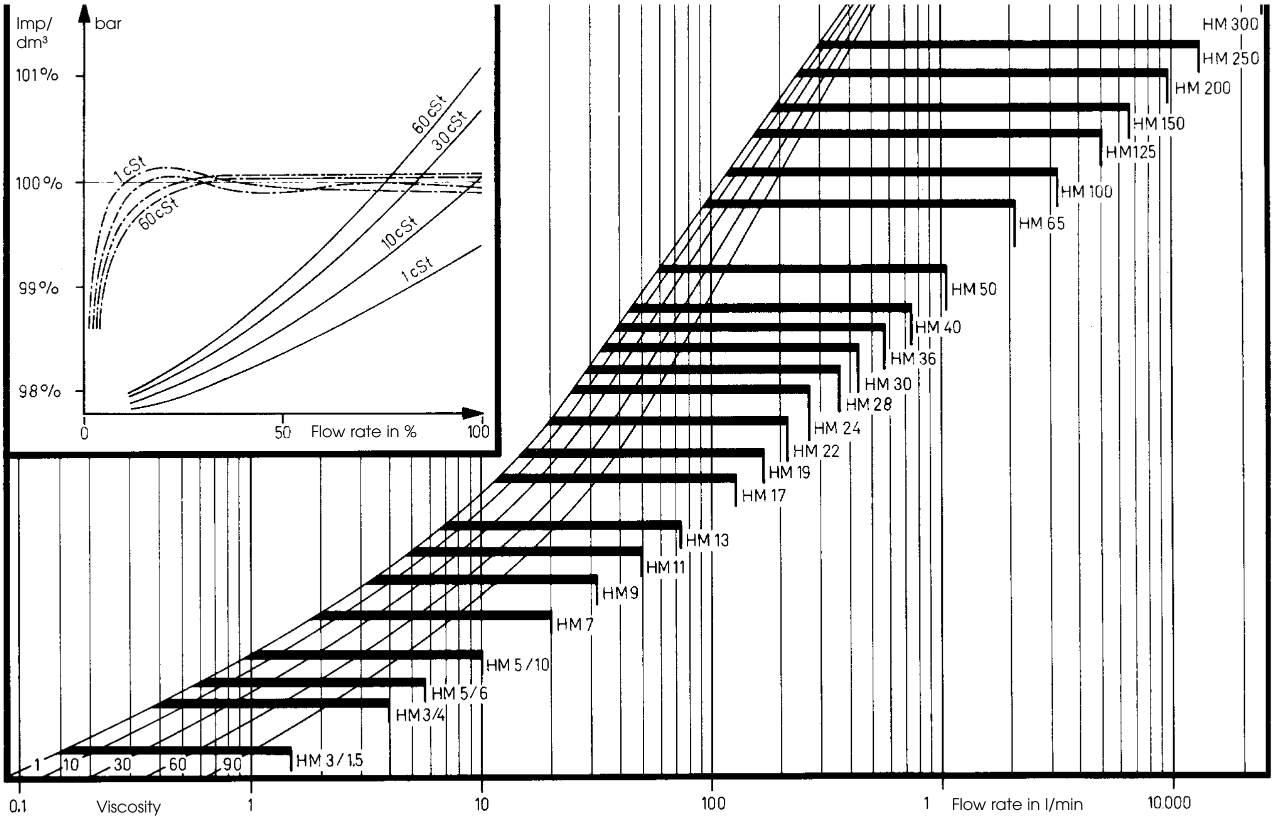
Wide temperature range from –273 up to +350°C
Standard turbine flow meters: –20 up to +120°C.
Special models for cryogenic liquids: –273°C
Special models with high-temperature pickups: up to +350°C

High Pressure Resistance and Low Pressure Drop
KEM turbines are available for pressures up to 630 bars and up to 4,000 bar using high-pressure adapters or BASF high-pressure flanges. A major advantage over other flow meters can be found in the low pressure drop figures. These depend on viscosity and turbine size and have to be observed at very low working pressures only (cf. diagrams page 6 and 7).

Resistant to contamination with solids
Turbine wheel and bearings are designed in a way that solids are flushed through the turbine with the medium. Furthermore the twist of flow in this area has a self-cleaning effect preventing solids from blocking the turbine.

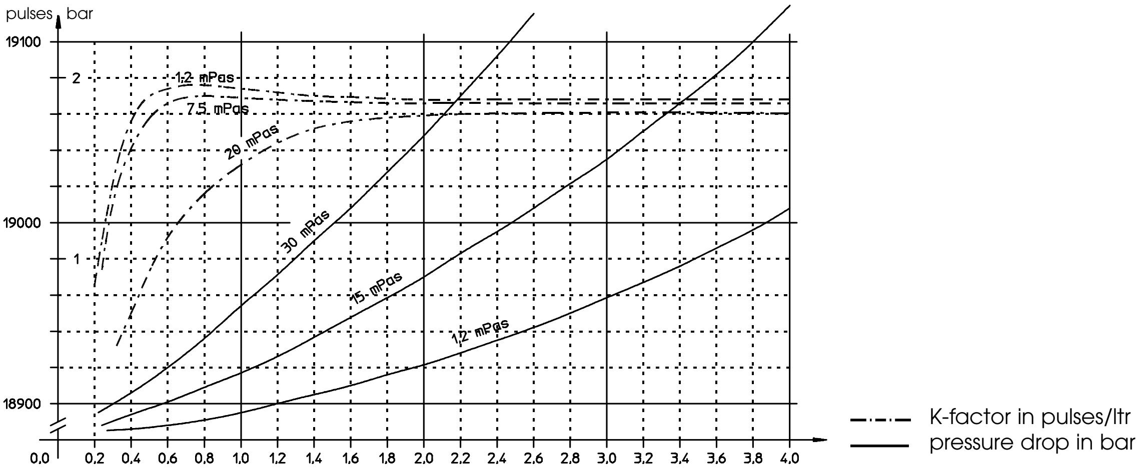
Measuring ranges for turbines at different viscosities

K-Factor/Pressure drop

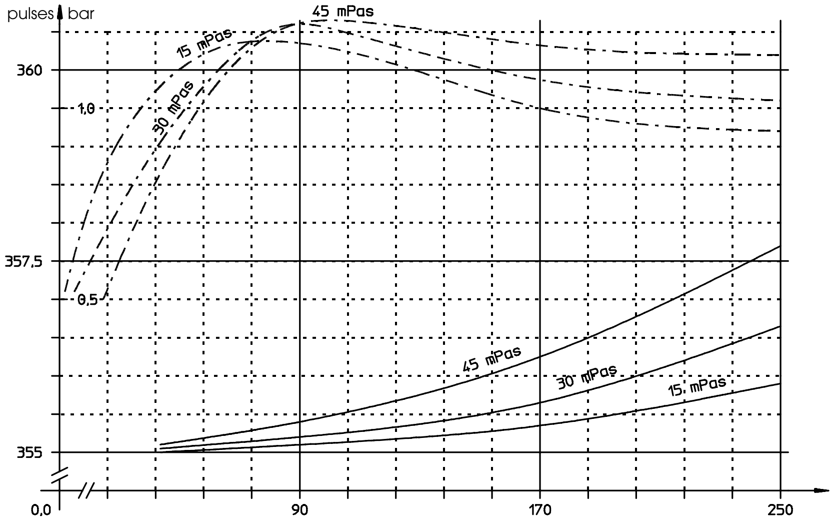


Pressure drop and K-factor at different viscosities

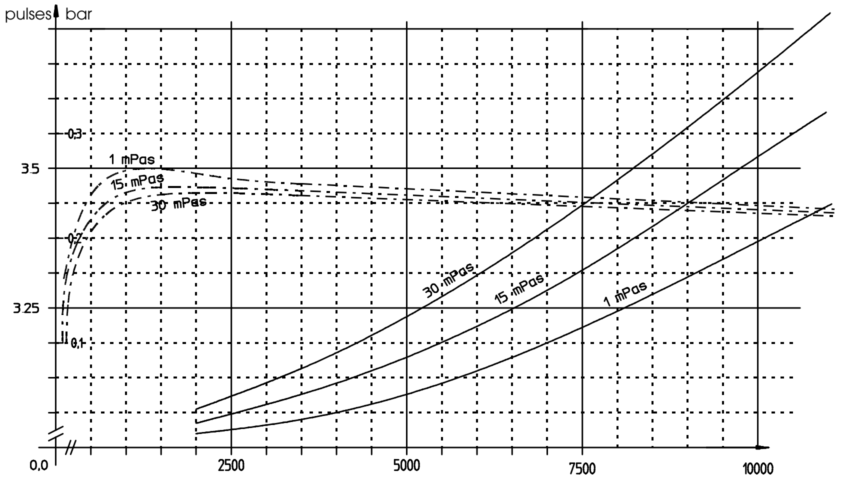
HM 3E/4



HM 24 (1")

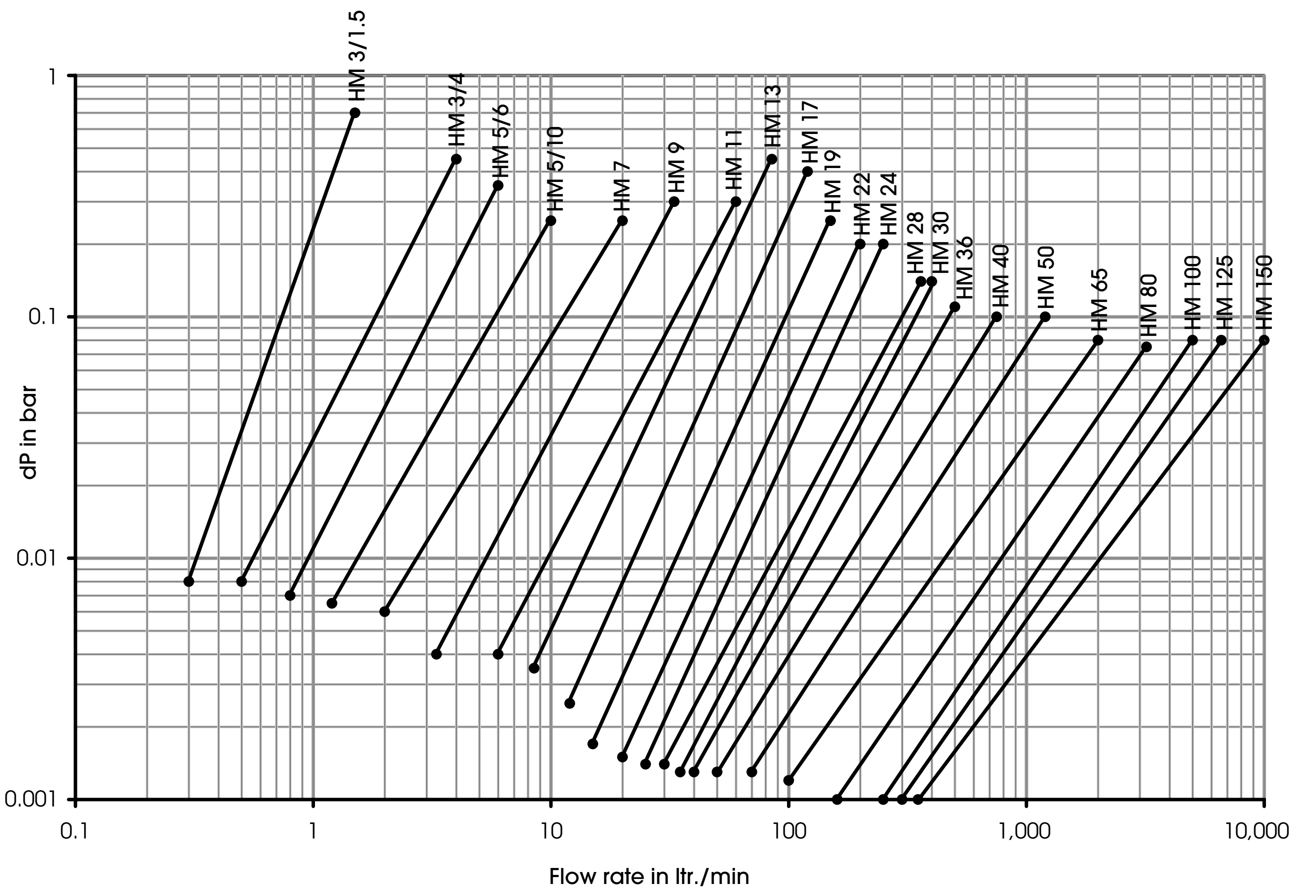


HM 150 (6")



Pressure drop

Diagram for water, 1 mm²/s, 20 °C



Turbine flow meters for special applications

Different designs are available in accordance with the application. Individual datasheets are available.

Fluid food:	HM...RV with dairy connections as per DIN 11851
Pharmaceutical fluids:	HM...FT with »Tri-Clamp« connections
High pressure rates:	HM...FHD with BASF flanges up to 4,000 bar HM...NS with Nova-Swiss threads
Small flow rates:	HM 9 EP with sapphire bearings
Alternative connections:	HM....E with Ermeto threads HM...F with flanges as per DIN or ANSI HM....R with female inch-type threads

Technical Data

Type	Measuring range			Average K-factor*		Frequency*		Output signal
dia	ltr./min			pulses/ltr.		in Hz. 0 up to max		mVss
HM 9 EP	0.03	to	0.8	139,000		1,970		0.5 to 5
HM 3/1.5	0.3	to	1.5	32,000	32,500	1,000	1,000	0.5 to 5
HM 3/4	0.5	to	4	24,000	19,000	1,250	1,250	0.5 to 5
HM 5/6	0.8	to	6	17,800	17,800	1,740	1,780	1.0 to 10
HM 5/10	1.2	to	10	11,000	11,000	1,750	1,750	1.0 to 10
HM 7	2.0	to	20	5,200	5,200	1,800	1,800	1.5 to 15
HM 9	3.3	to	33	1,900	4,200	1,080	2,200	1.7 to 17
HM 11	6.0	to	60	1,300	2,730	1,350	2,700	2.0 to 20
HM 13	8.5	to	85	900	1,900	1,300	2,600	2.5 to 25
HM 17	12	to	120	380	840	800	1,650	2.7 to 27
HM 19	15	to	150	310	650	925	1,600	2.9 to 30
HM 22	20	to	200	217	450	800	1,600	3.1 to 31
HM 24	25	to	250	170	362	800	2,000	3.8 to 40
HM 28	30	to	360	155	320	960	2,000	4.0 to 42
HM 30	35	to	400	130	270	860	1,850	4.1 to 45
HM 36	40	to	500	60	135	600	1,200	4.3 to 48
HM 40	50	to	750	105	110	1320	1,400	4.5 to 52
HM 50	70	to	1,200	65		1400		6.0 to 64
HM 65	100	to	2,000	25		850		10 to 80
HM 80	160	to	3,200	11		615		15 to 100
HM 100	250	to	5,000	7		560		20 to 120
				pulses/m³				
HM 125	300	to	6,600	4,500		495		30 to 125
HM 150	350	to	10,000	3,400		420		35 to 140
HM 200	430	to	13,400	415		134		40 to 150

The wheel's axial pitch is halved for viscosities from 8 mm²/s onwards, therefore pulse rates will double for dia 9 up to 36. All K-factors and output signals are average values. Exact specifications can be taken from individual calibration records.

Linearity: each ±0.5% at 1 cSt

Materials

Stainless steel as per DIN (AISI)

Component	Standard material	Special material
Body	1.4305 (1.4571 with flange versions)	1.4571 (316 Ti)
Internal parts	1.4305 (303)	1.4571 (316 Ti)
Wheel	1.4122 (303)	1.4460 (329)
Bearing	Tungsten carbide	Tungsten carbide or teflon

Website
http://www.kem-kueppers.com

Küppers Elektromechanik GmbH
Flow Meters and Electronics: Design • Manufacture • Distribution