GENERAL DESCRIPTION

Meters used in the gas industry fall into two general categories: either positive displacement or inferential. Meters in the positive displace category are diaphragm and rotary. Inferential types include turbine and orifice meters.

Diaphragm and rotary meters measure gas with compartments that alternately fill and empty. A slight pressure drop across the meter causes the meter and its measurement compartments to rotate. Each stroke of the diaphragm meter and each revolution of the rotary meter traps a small volume of gas, delivering it to the meter outlet.

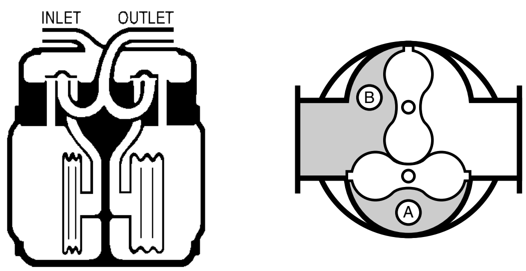

Fig. 1

Turbine meters contain no measurement compartments. Instead, a rotor with multiple blades is placed directly in the gas stream. Gas flows through the meter, passing through the rotor blades, causing the rotor to turn. The rotor rotational speed is proportional to the gas flow rate, which is directly related to the gas velocity at the rotor. This is why turbine meters are sometimes referred to as velocity meters.

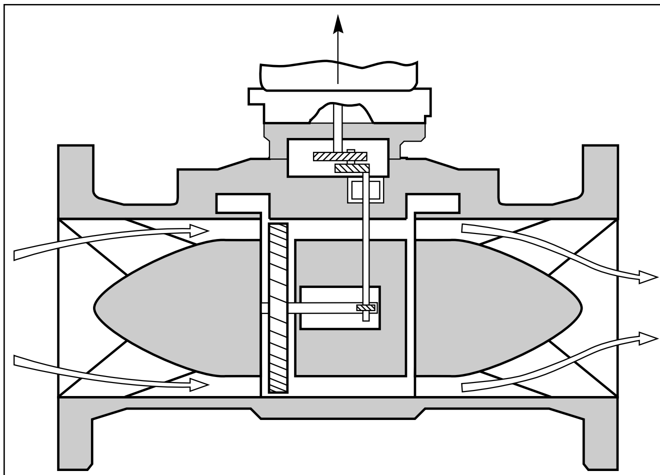

Fig. 2

Turbine meter rotor revolutions are converted to measured volume by means of internal gearing, resulting in meter output shaft revolutions in either cubic feet or cubic meters. In addition to a mechanical output, turbine meters may be also equipped with high frequency pulsers, where each pulse represents a small increment of volume, defined during meter calibration as a "K" factor.

Since turbine meters measure gas by sensing gas velocity, proper installation is essential, to make certain the gas is uniform as it approaches the the measurement rotor.

TYPICAL METER PERFORMANCE

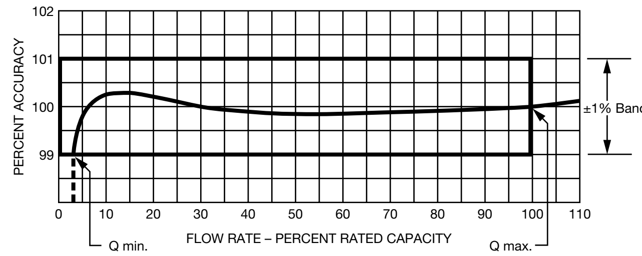

Fig. 3 Typical Gas Turbine Meter, Accuracy Curve

The graph of Fig. 3 shows a typical accuracy curve for the GTS meter. As shown, rated rangeability over the ±1% band is the ratio of maximum flow rate (Q_{max}) to minimum flow rate (Q_{min}). Rangeability of GTS meters becomes greater with increasing line pressures.

METER PRESSURE DROP
(Differential Pressure in Inches W.C.)

Meter Differential Pressure

The approximate differential pressure developed across the turbine meter at operating conditions can be calculated using the following formula.

$$\Delta P = \Delta P_{avg} \times \frac{P_g + P_a}{P_b} \times \frac{G}{0.60} \times \left[\frac{Q}{Q_{max}}\right]^2$$

Example:

Calculate the differential for the following conditions:

6" GTS (ΔP_{avg} = 3.3 in. w.c., Q_{max} = 35,000 ACFH)
G = 0.64, P_g = 60 psig, Q = 27,600 ACFH

$$\Delta P = 3.3 \times \frac{60 + 14.48}{14.73} \times \frac{0.64}{0.60} \times \left[\frac{27,600}{35,000}\right]^2$$

ΔP = 11 in. w.c.

Average Differential Pressures

@ Q_{max} and @ 0.25 psig in inches w.c.

	3" GTS	4" GTS	6" GTS	8" GTS	12" GTS
45° Rotor	4.5	2.4	3.3	1.6	2.1
30° Rotor	N/A	3.9	8.9	3.4	N/A

BASIS OF CAPACITY TABLES

Capacity tables are contained in Sales Bulletin SB 4510 in both English and metric units. The tables include values of Q_{max} and Q_{min} in standard Ft^3/hr. or M^3/hr. units at each gauge pressure listed. Standard capacities are shown for 45° rotor angle. Extended capacities are listed for 30° rotor angle. The top plate of the meter cartridge is labeled 30° or 45° rotor angle.

Maximum Flow Rates at elevated pressure are equal to the base flow rate at 0.25 psig times the pressure factor, times the compressibility ratio "S" and are independent of the specific gravity of the gas being measured.

(A) $Q_{max} @ P_g = Q_{max} @ 0.25 \text{ psig} \times \frac{P_g + P_a}{P_b} \times S$

Where P_g = gauge press., P_a = atmos. press., P_b = base press., S = comp. ratio

Minimum Flow Rates are based on the minimum rotor speed that produces a measurement accuracy within an error band of +/-1%, as shown in Fig. 3.

(B) $Q_{min} @ P_g = Q_{min} @ 0.25 \text{ psig} \times \sqrt{\frac{P_g + P_a}{P_b}} \sqrt{\frac{0.60}{G}} \sqrt{S}$

A temperature factor is not included in equations A & B since it has minimal affect on Q_{min}.

METER SIZING

Base Conditions

English	Metric
P_b = 14.73 psia	101.325 kPa absolute
P_a = 14.48 psia	99.8 kPa absolute
T_b = 60°F + 460 or 520°R	15.56°C + 273, or 288.56K
T_f = Temperature of flowing gas + 460 for °R (or + 273 for K)	

If the required flow rate is given in Standard Cubic Feet (or meters) per hour, (SCFH or SCMH) convert this value to actual Cubic Feet (or meters) per hour, e.g.

$$Q = Q_b \times \frac{P_b}{P_g + P_a}$$

Select the meter with the smallest Q_{max} (@ 0.25 psig or 2.0 kPa) that is larger than Q.

Example: Select the proper meter size to handle 145,000 SCFH at 60 psig, S = 1.009

$$Q = 145{,}000 \times \frac{14.73}{60 + 14.48} \times 1/1.009 = 28{,}421 \text{ ACFH}$$

Choose a 6" GTS with Q_{max} (@ 0.25 psig) = 35,000 CFH (45° rotor).

Rangeability increases with increased gas density which can result from either increased operating pressure or specific gravity of the gas at a particular pressure:

$$\text{Rangeability} = \underset{\text{(@ 0.25 psig or 2.0 kPa)}}{\text{Rangeability}} \times \sqrt{\frac{P_g + P_a}{P_b}} \times \sqrt{\frac{Sp.Gr.}{0.60}} \times \sqrt{S}$$

Example: From above, 6" GTS (Rangeability @ 0.25 psig = 18) P_g = 60 psig Sp.Gr. = 0.64.

$$\text{Rangeability} = 18 \times \sqrt{\frac{60 + 14.48}{14.73}} \times \sqrt{\frac{0.64}{0.60}} \times \sqrt{1.009} = 42 \text{ or } 42{:}1$$

Minimum flow rate, Q_{min} is:

$$Q_{min} = \frac{Q_{max}}{\text{Rangeability}}$$

Example: From above, Q = 35,000 ACFH, Rangeability = 42

$$Q_{min} = \frac{35{,}000}{42} = 833 \text{ ACFH}$$

RECOMMENDED INSTALLATION

GTS Meters in sizes from 4" through 12" have ANSI 150, 300 or 600 flanges, depending on the pressure rating. The 3" GTS bolts between flanges as shown in Fig. 4.

GTX Meters in sizes 4" through 8" have ANSI 150 flanges.

Fig. 4

The 4" through 12" GTS meters are designed for horizontal installations. 3" GTS meters may also be installed in a vertical line, using an optional right-angle index or instrument mount.

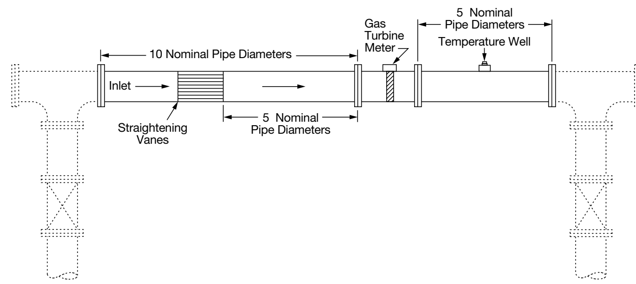

Fig. 5 Recommended Installation

Recommended turbine meter installation requires a minimum of 10 pipe diameters upstream, with straightening vanes located 5 pipe diameters from the meter inlet as shown in Fig. 5. A length of 5 pipe diameters is recommended downstream of the meter. Both inlet and outlet piping should be the same nominal size as the meter.

The purpose of the 10 diameters of straight inlet piping is to remove jetting and swirl from the gas stream before the gas reaches the turbine rotor.

Jetting, shown in Fig. 6, is non-uniform gas velocity within the pipe, and can be caused by an upstream regulator, a valve, an elbow or a misaligned flange gasket. Jetting will cause the meter to over-register since the rotor responds to the higher, not the average velocity, in the pipe. For this reason, temperature wells and pressure taps should be located in the downstream piping. Any pressure tap fitting in the upstream piping should be ground flush with the inside pipe wall.

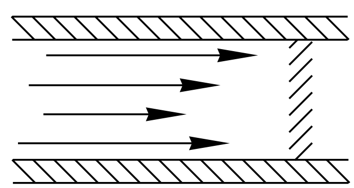

Fig. 6 Jetting

Swirl, Fig. 7, is a condition where the gas velocity is not totally parallel to the axis of the pipe, but has a spiral component. It may be caused by upstream valves, elbows or other fittings. Swirl in the direction of the rotor rotation will cause the turbine meter to over-register and vice-versa.

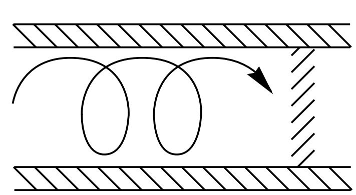

Fig. 7 Swirl

OPTIONAL INSTALLATIONS

The following installations may result in some degradation in meter accuracy, and should only be used where space does not permit the recommended installation shown in Fig. 5.

Short Coupled Installation

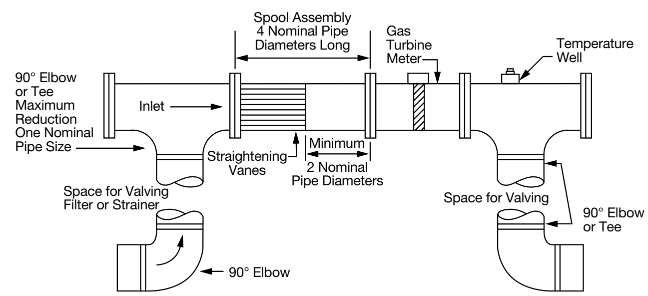

Fig. 8 Short Coupled Installation of an In-Line Gas Turbine Meter (Minimum Lengths)

This configuration uses a minimum of 4 pipe diameters a-head of the meter with straightening vanes a minimum of 2 pipe diameters from the meter inlet, Fig. 8. The meter is connected to vertical risers using a standard tee, as shown, to minimize jetting and to facilitate field proving.

The maximum pipe reduction to the risers is one nominal pipe size. Valving, filters or strainers may be installed in the risers.

Close Coupled Piping

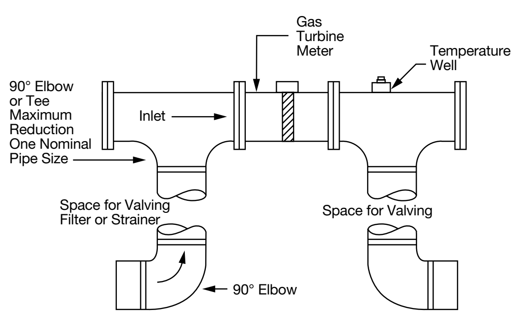

Fig. 9 Close Coupled Installation of an In-Line Gas Turbine Meter with Integral Straightening Vanes

This installation would be used where the available space is critical and design considerations have eliminated jetting and abnormal swirl conditions. The meter is connected to vertical risers using a tee as shown. The maximum pipe reduction to risers is one pipe size. Valving, filters or strainers may be installed in the risers.

STRAINERS or FILTERS – CAUTION

Important: Foreign matter in a pipe line, such as welding slag, can cause SERIOUS damage to turbine meters. Upstream piping must be cleared of all foreign matter before the meter is installed and commissioned.

Strainers are recommended where large particles may be present in the piping. They should be selected to operate with low flow distortion.

Filters are recommended where wide pressure fluctuations and dust are present in the pipe. Monitor the pressure drop across the filter to determine the need to replace the filter element.

OVER-RANGE PROTECTION

Turbine meters can be operated up to 150% of capacity for short periods with no damaging effects. However, line blowdowns can cause severe over-ranging of the turbine rotor, causing possible rotor and/or bearing damage. In those installations where adequate pressure is available, either a critical flow orifice or a sonic nozzle may be installed downstream of the meter. It should be sized to limit the meter to approximately 120% of the meter's rated capacity.

BY-PASS PIPING

By-pass piping will allow the meter to be maintained and calibrated without a service interruption. This should include proper valving relative to the calibration equipment used.

When tees are used in by-pass piping for the purpose of transfer proving, make certain the tee connections are in line with the axis of meter flow and are the same pipe diameter as the pipe to avoid jetting and possible calibration errors.

ADDITIONAL INSTALLATION REMINDERS

Add oil – see Lubrication Section, page 6.

Minimize pipe stresses on the meter.

Make certain piping and gaskets are aligned properly to avoid possible errors caused by jetting.

No welding should be done in the immediate area of the meter.

Where liquids may be present, do not install the meter in the low point in the line.

When installation is complete, pressurize the meter slowly and and bring the meter up to speed gradually. Shock loading by opening valves quickly will usually result in rotor damage. Perform a leak test with a bubble solution or other approved method.

MAINTENANCE

Routine turbine meter maintenance will insure measure-ment accuracy and enhance the service life of the meter.

Turbine meter maintenance consists of:

Lubrication	Inspection
Spin Testing	Cleaning
Repair	Calibration
Proof Adjustment	Cartridge Replacement