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A master distributor of flow measurement products

How to Select a Flowmeter

This page was written primarily to assist a user in the selection of a meter design from those offered by Controls Warehouse. Meter operation or design is not discussed. The sole intent is to provide practical guidelines on meter selection.

A. The line size… choosing by line size can be a serious mistake
B. Flow range… same size meters can have totally different flow ranges
C. Foreign matter and cleanliness… meter choices and mesh sizes for strainers
D. Chemical service… the materials inside the meter should be evaluated
E. Connections for high pressure meters
F. Viscosity -- meter derating factors and some limits
G. Accuracy and repeatability… repeatability is the more important parameter
H. Lubricity and capillary sealing… when a turbine meter is required
I. Gas flow measurement… ACFM vs. SCFM (actual cubic feet per minute vs. standard cubic feet per minute)
J. Gas flow measurement -- Pressure and temperature compensation

The Line Size

In general, it is a bad idea to select a flowmeter on the basis of line size. From practical experience we know that there are specific applications where the existing lines are frequently oversized. For these applications a meter should never be selected with the primary consideration being the line size. These are:

a. Waste water lines
b. Any compressed gas, especially compressed air and natural gas
c. Any gravity drain application
d. Oil burner fuel lines
e. Steam lines

Flow range… same size meters can be different

Meters of the same line size can have widely different flow ranges. This is frequently seen on small oil meters used for burner service.

An example would be an 800 HP boiler with a 3/4" oil line to the burner and at high fire is burning about 4 GPM.

If one selects a 3/4” potable water positive displacement meter on the basis of the 3/4" line size, they will get a meter ranged for 3/4 to 30 US GPM. By contrast a 3/4" electromagnetic meter, the range is min/max/peak of 8/265/400 GPH (0.13/4.42/6.67 GPM).

The morale of the story - don't buy on the basis of line size alone!

A second major mistake is to assume that different meter designs have the same flow range. For example:
A 1" oval gear meter is typically has a range of 4 to 40 GPM whereas a
1" positive displacement design has a typically has a range of 5 to 50 GPM and a
1" axial turbine meter has a 2 to 75 GPM range.

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Foreign matter & Cleanliness

Use a magnetic or ultrasonic flowmeter if you have fibers, silt, bits of matter coming from a cleaning process, biological matter, anything that can get into bearings, wrap around something, cause damage by impact (turbine rotor blades) or erosion.

Strainers - remember that what counts is the mesh of the strainer, not the fact that a customer has a strainer body in place ahead of the meter.

Guidelines

For 1" and smaller positive displacement meters	40 mesh
For 1/8" & 1/4" oil meters	felt
For oval gear meters under 1/2"	80 mesh
For oval gear meters over 1/2"	60 mesh
Precision turbines meters	60 mesh
Turbine meters	40 mesh
Bulk meters	10 mesh
Irrigation meters	use sealed bearings
Magnetic meters	use grounding ring
Ultrasonic meters	not required
Vortex shedder meters	not required

Chemical service

It is a mistake to specify a body material for a chemical service meter and not be equally specific about the internal working parts. We are commonly requested to quote a 316 stainless steel (SS) positive displacement meter (PD) with no mention of the desired internals. Most 316 SS PD meters have Kynar® PVDF (polyvinylidene fluoride) working parts. PVDF has a wide range of compatibility, but there are some fluids, especially acids at higher temperatures which will attack it.

We offer a very wide range of materials in our turbine meters. A turbine meter can be machined from any material which will retain dimensional stability, typically we offer 304 SS and 316 SS, Chlorinated Polyvinyl Chloride (CPVC), Polypropylene (PP), PVDF, Polychlorotrifluoroethylene (Kel-F), Teflon® (PTFE), Hastelloy® B & C, Titanium, Tantalum, Monel and Inconel.

Never assume that a plastic bodied meter will work for you just because you are using plastic lines. PVC and CPVC can handle chemicals which melt a plastic bodied flow meter in seconds. Plastic bodied meters designed for water service are made of polyacetals and polycarbonates, not PVC. They cannot handle low pH fluids and, in some cases, will be attacked by solvents. The market for domestic water meters is the largest single meter market in the world. The volumes are huge and the meters are optimized for water service, they are not general-purpose design meters. If you need a meter to measure chemicals, buy a chemical meter, not a water meter.

If the viscosity is right, consider our liquid turbine flow metering solutions. They have the best selection of body and internal materials of any product we offer.

These magnetic flowmeters are available with a PTFE liner and a variety of electrode materials.

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High Pressure

We have positive displacement (PD) meters which are available in 2500 and 5000 PSIG bodies, but only with NPT ends.

For meters with high pressure fittings, i.e. 30 deg. flare, Autoclave, Grayloc® clamp connectors, SAE Code 61 and 62 flanges, consider the use of our liquid turbine flow metering solutions.

Viscosity

There are many ways to measure viscosity and consequently many ways to express it. Most flowmeters use centipoise (cP) or centistokes (cSt) to define pressure drops. If you need help in converting viscosity numbers provide us with the specific gravity (Metric, i.e. cP or cSt) or density (English).

Flowmeters react differently to viscosity changes, plus remember that most viscosities will drop with increasing temperature or velocity (thixotropic fluids).

Magnetic and ultrasonic flowmeters - are immune to viscosity considerations. Almost all other meters are affected by viscosity.

Positive displacement meter - If a magnetic or ultrasonic meter is not suitable, a PD meter is your best choice. PD meters will work over wide viscosity ranges, with minimal accuracy shifts. It is a rare PD meter which will show greater than a +1.5% accuracy shift with increasing viscosity. However, the pressure drop rises quickly as viscosity goes up.

To reduce the pressure drop you choose a larger meter. To get the proper size meter you must de-rate the maximum recommended flow statement in the literature. Many derating curves are in the literature, but as a rule of thumb you can:

Take the maximum continuous flow rating and multiply it by:

500 cP	multiply by 0.7
1000 cP	multiply by 0.55
2000 cP	multiply by 0.4
4000 cP	multiply by 0.3
10000 cP	multiply by 0.2

Turbine meters

It is recommended to stay below 20 cP viscosity on meters 1" and under. On larger meters as the viscosity goes up try to size the meter so that the flow rate is at the upper end of the meter curve. Always avoid low flow rates at the bottom of the meter curve. If you must use a turbine meter under higher viscosity conditions, you can because the turbine meter is repeatable in nature, however, you need to add a "linearizer" to compensate for the drop off in low end performance. Another option is to have a viscosity calibration done by the manufacturer in the field, or by an outside flow lab. Our policy is to shift to a different meter design which does not have this problem, however, we do offer linearizers.

Vortex shedding meters

One should always stay below 20 cP viscosity.

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Rotameters (Variable area meters)

Rotameters come in a variety of sizes and materials, but they all have a tapered tube and a float. The "float" is the thing that rises and falls inside the tapered tube. As the float rises the area of the annular orifice between the float OD and the tube ID increases, thus rotameters are a particular form of variable area meter. For each tube you are offered a selection of float materials, of different weights. This gives you as many different flow ranges as there are floats.

The viscosity handling characteristics vary with the float design. Ball floats have no viscosity immunity at all and are only found on small meters. Cylindrical floats have large "drag" surface with little immunity. Sharp-edged floats, 1" and larger have the maximum immunity to viscosity.

Practical viscosity limits using sharp edged floats:

1/2" size	10 cP
3/4" size	15 cP
1" size	20 cP
1.5" size	40 cP
2" size	60 cP

Accuracy and Repeatability requirement

Accuracy is defined as the percentage of full-scale range (% FS) and the percent rate, which is the percentage of actual flow rate.

For example: if the % FS is rated for 100 GPM at 1% FS accuracy then at 100 GPM it is 100 (1 GPM), at 50 GPM it is 50 (1 GPM) and at 10 GPM it is 10 (1 GPM).

Percent Rate example: if a meter is rated for 100 GPM at 1% of rate accuracy then at 100 GPM it is 100% (1 GPM). At 50 GPM it is 50% (0.5 GPM). At 10 GPM it is 10% (0.1 GPM).

With the exception of oval gear meters, most PD meters are rated as % FS.

It is not fair to rigorously apply the mathematical interpretation of % FS. In the above example, at 10 GPM we have an error of 10% of actual flow. The actual error is never stated; but you can apply some intuition and get reasonable results. For example, if the meter has a 10:1 turndown range (maximum flow divided by minimum flow = 10), the bottom end of the meter curve is probably straying up to 1.5% to 2.0% of actual range accuracy. PD meters with better low-end accuracies will have greater than 10:1 turndown statement and in some cases will provide specific statements on low end accuracies.

Alternatively, some meters will define accuracy's as a function of turndown or specific flow spans. An alert manufacturer will give you an interpretation of his accuracy rather than let you assume 10% and larger errors.

For truly precise measurement, accuracy doesn't matter. Repeatability is what counts. If you look at our precision electronic turbine literature you will see that accuracy is not even given. In a mechanical meter, you can change the register gear train ratio and make the meter give you any reading you want. In an electronic meter with a pulse output, the display will have a "K-Factor Divider", which allows you to make the display say anything you want. Accordingly, what really matters is how well the flow meter repeats itself. Flowmeter repeatability specifications run from 0.01 up to 0.3% and are always 5 to 10 times better than the accuracy statement.

Certain meter designs are inherently very accurate and the accuracy becomes a selling point. Magnetic flowmeters are 0.15% or 0.2% accurate of rate with turndown ranges of up to 1000:1.

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Lubricity (oiliness) & Capillary sealing

Mechanical meters are tried and true devices, but they need to be applied with some concern given to the fluid characteristics. A mechanical meter which has an oscillating piston, nutating disc (wobble plate) or similar measuring element is termed a positive displacement meter. However, what makes it "positive" is capillary sealing between the measuring element and the side wall or the meshing components. If you are dealing with a low viscosity fluid, i.e. alcohol, toluene, MEK, etc. you lack the viscosity to develop a good capillary seal. This will manifest itself in leakage around the measuring element. This leakage can be substantial. In general, the larger the meter, the greater the mass of the measuring element and the greater the leakage.

A positive displacement meter has moving parts which touch, typically, the ball in the middle of a nutating disc, a piston sliding across a partition plate, etc. If the fluid is very dry in nature, like alcohol, MEK, acetone, etc., it does not provide any lubrication to the parts which touch. PD meters can develop substantial frictional loading which increases pressure drop and destroys low flow rate performance.

It is common for mass produced positive displacement water meters for municipalities to have carbon impregnated working parts.

If you have a non-lubricating fluid use a turbine, vortex shedder, magnetic or ultrasonic flow meter. The turbine bearings would typically be PTFE sleeves or ball bearings with PTFE inserts.

We have a problem with companies who want to batch these types of solvents using mechanical meters in order to avoid using electricity and explosion proof housings. We understand the desire, an explosion proof housing for an electronic batcher is very expensive. The meters are typically 1.5" and 2" stainless steel positive displacement meters with batching registers and integral valves. These meters have lots of mechanical loading, the register, the valve, etc., and when we add the frictional drop of a non-lubricating fluid, they have huge 10 to 20% errors at low flows. The fluid is of such a low viscosity that a capillary seal never forms, allowing the fluid to squirt through all the gaps between parts.

There are ways to get around this and provide good service using a mechanical oval gear meter (which costs more). See our discussion on oval gear meter designs in another paper.

Gas flow measurement

Very important - never size the meter by line size. A meter responds to what it sees, which is actual flow, not flow at STP.

SCFM - Gas flow rate at standard temperature 70°F and pressure. PSI Absolute pressure is measured relative to a full vacuum. The pressure of a vessel completely void of any air molecules would be 0 PSIA, while average atmospheric surface pressure (at sea level) is roughly 14.7 PSIA.

ACFM - Gas flow rate at the actual temperature and pressure.

Gas and compressed air lines are almost always oversize and demand careful sizing based on line size, flow rate, pressure and temperature. Let's say that you have 400 SCFM at 15 PSIG. Unless temperature is specified we assume 70°F.

The formula for conversion is:

ACFM = SCFM x ((14.7/(14.7 + PSIG)) x ((F + 460)/530)

an example:

ACFM = 400 x ((14.7/(14.7 + 15) x ((70 + 460)/530)) = 198 ACFM

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Contact us for assistance in selecting a liquid turbine flow meter.

Gas flow measurement and Pressure/Temperature Compensation

In the above example, let us assume that the pressure is not regulated at 15 PSIG, but varies from 13 to 15 PSIG depending on the load (in other words, the pressure regulator can't keep up with the demand volume and the pressure is varying).

At 15 PSIG, the ACFM is:
ACFM = (400 x (14.7/29.7)) = 198 ACFM

At 13 PSIG, the ACFM is:
ACFM = (400 x (14.7/27.7)) + 212 ACFM

The error, in a system calibrated for 15 PSIG is:
((212 - 198)/198) x 100 = 7% error

Bottom line, a pressure compensated system is required.

This is a normal situation and the need for a compensated system should be evaluated every time a gas application is under consideration.