Flowmeters: Making the Right Choice

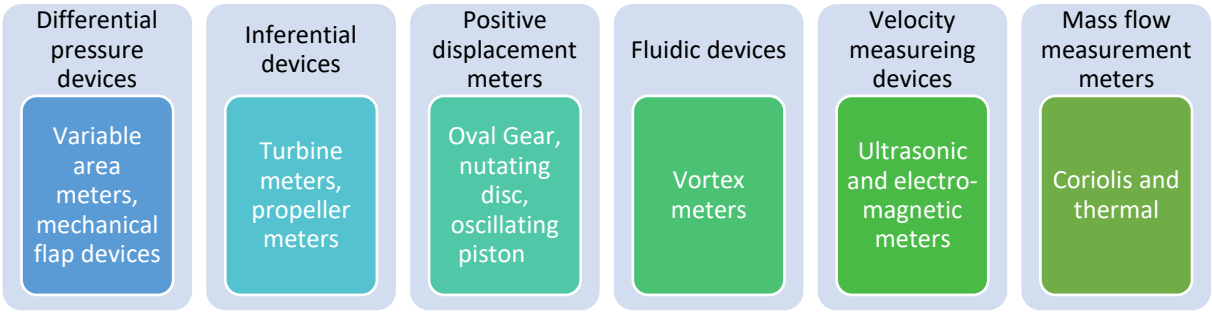
Flowmeters are essential measurement devices across industry and considering all the parameters at the outset is crucial in selecting the right one for the job, says Trevor Forster, Managing Director of Titan Enterprises.

Flowmeter sales in all sectors increase year on year as more control is required throughout the industrial landscape. In response, innovation in flow meter technology continues to progress to meet the needs of growing demands and applications.

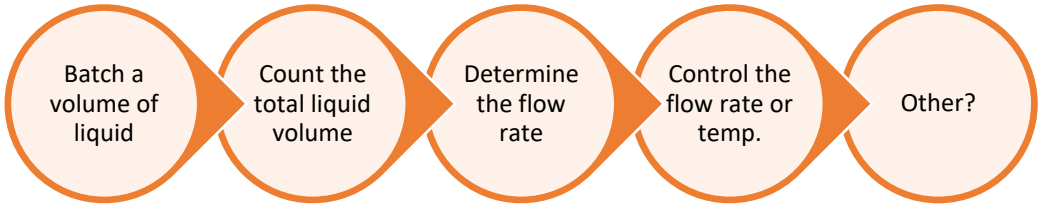
The basic physical techniques that flowmeters work to are well established; it's the latest technology and materials that are applied which give the wide variety of choices in the market.

Although what we discuss here is directed at liquid flow meters, the considerations are applicable to gases and two-phase flow measurement as well.

Flowmeters fall into six broad groups:



At the outset, the question to start with is: "What will using a flowmeter enable me to achieve?"

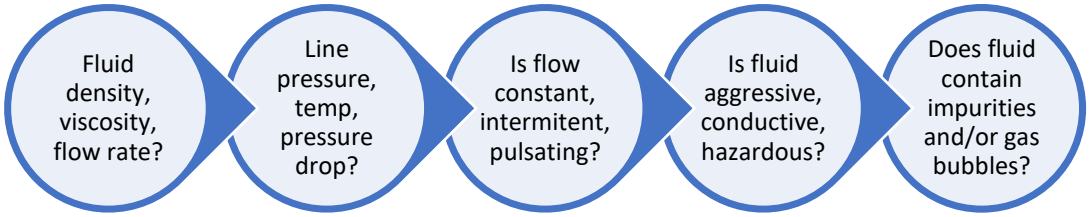


Defining what the flowmeter must achieve is often a moving target and considering all the parameters required for the process and environment is key to ensuring the flow meter chosen is suitable for the process application.

Parameters that Combine to Determine the Choice of Flowmeter

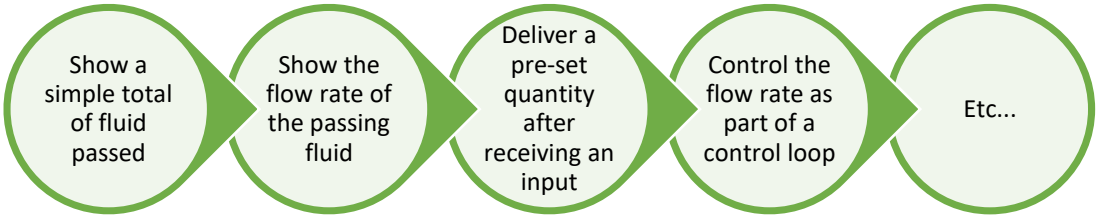
1. Fluid Type

The properties and process characteristics of the fluid will determine the technologies available and acceptable solutions.



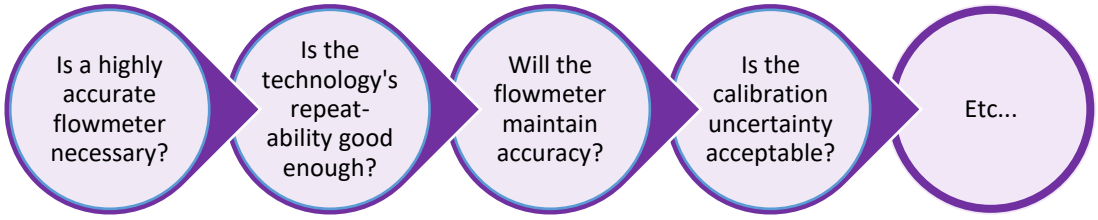
2. Measurement Task

The flowmeter output and interface requirements will be determined by what you want the flow meter to do:



3. Flow Measurement Performance

Both the mechanical properties of the flow meter and the physical properties of the liquid combine to influence the performance of the flow measurement device. Determining the required level of performance for the flow meter will help to pin-down the suitable flowmeter types available. Ask yourself:

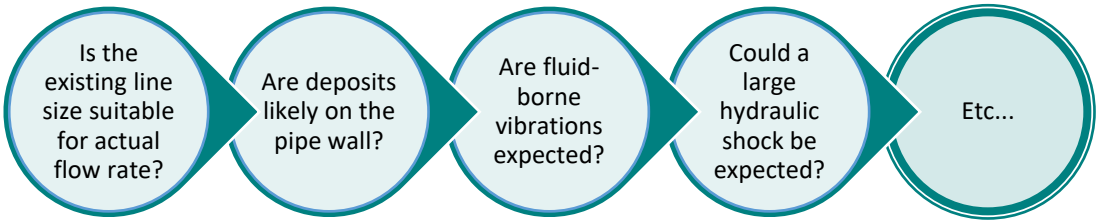


4. Installation and Operational Limitations

Poor installation can easily compromise flowmeter performance. Pipework configurations, electrical installation, pumps and other equipment introduced into the pipework that impact flow, will all have

a bearing on flowmeter performance. Manufacturers specify the ideal installation requirements for each type of flowmeter and any variation from this will negate the stated performance characteristics.

Always read the flowmeter specification and installation instructions to avoid potential installation and operational issues. Ask yourself:



5. Cost of Ownership

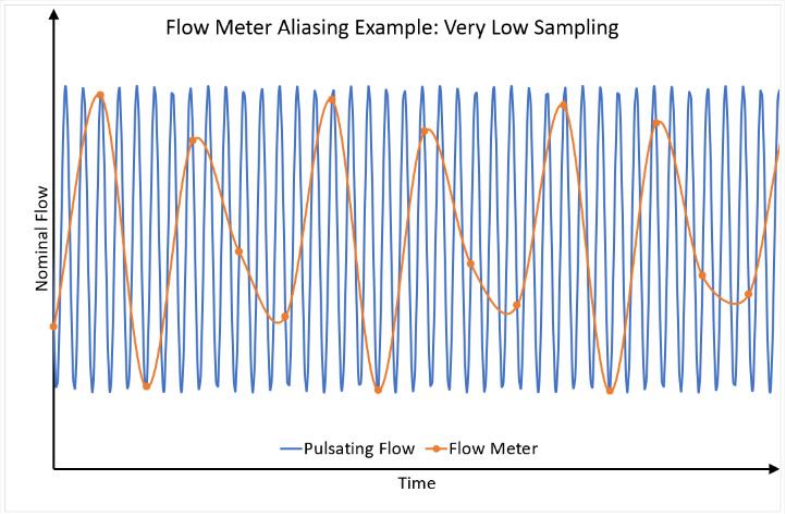
The cost of ownership is not simply the purchase price but includes the cost of any repair outside of the warranty period, performance loss resulting from measurement uncertainty, the power or equipment cost of running the flowmeter, and any additional wiring requirements. Investigation into the following will give a broader picture above the simple purchase cost:

Influencing the Decision

As only certain flowmeter technologies will suit certain application conditions, the liquid properties will often be the prime determinant in choice of flow measurement device. The five sets of points raised above are intertwined and determining one parameter may lead to a compromise in another.

Although a hygienic meter could be used within a simple cooling water circuit, it would be overkill when a standard electromagnetic flow measurement device might be the perfect solution. Similarly, a turbine meter is unlikely to be suitable for a viscous oil, particularly if the temperature, viscosity and therefore the Reynolds number, constantly change. Adding the other possible variations, the window of options quickly closes.

Electronic-based meters may not perform well with pulsating flows as there could be aliasing between the meter's cycle time and the pulsations, causing drastic reading errors. Positive displacement flow meters would provide a better outcome where pulsating flows are integral to the process. The graph below illustrates that if sampling is much lower than the pulsations, a random scatter of the flow will be observed, seemingly following no pattern at all.



Aggressive liquids offer their own set of problems and flowmeters such as ultrasonic and Coriolis, can withstand the effects of these type of fluids. Vortex shedding meters do not perform well at low Reynolds numbers and positive displacement meters perform poorly at high ones. Ultrasonic and Coriolis meters do not require conductive fluids, yet for electromagnetic meters it is fundamental to their operation.

The meter function may not always be clear-cut. A sight-flow, ball-in-tube, meter may be perfect for a moulding machine water flow where no extra instrumentation is required, and the process has wide operational parameters. However, for a precision medical moulding, full control over the mould temperature and therefore cooling water flow rate, may be critical for high tolerance plastic mouldings.

Flowmeter performance is an interesting point. Depending on the application, one user may require it to be as absolute as possible, whereas another would be happy with 'about right'. But performance costs: the higher the performance required, generally the higher the cost of the flowmeter. Determine the actual process requirements before choosing a flowmeter purely on performance.

Very small flowmeters generally have no special plumbing requirements but with many flow measurement technologies the installation effects can be catastrophic. To demonstrate, take a turbine meter with two pipe elbows upstream of the meter. By rotating the elbows into differing upstream configurations the turbine could be stopped and indeed made to spin backwards. When plant requirements are prioritised as opposed to the fluidic ones, low flows in oversize pipes are often seen. This occurs where pipe size rather than measured flow rate is used to determine flow meter size.

PERFORMANCE COSTS: THE HIGHER THE PERFORMANCE REQUIRED, GENERALLY THE HIGHER THE COST OF THE FLOWMETER. DETERMINE THE ACTUAL PROCESS REQUIREMENTS BEFORE CHOOSING A FLOWMETER PURELY ON PERFORMANCE

Selecting the Flowmeter to Suit the Application

The following table highlights the different types of flow meter and their suitability for various process applications.

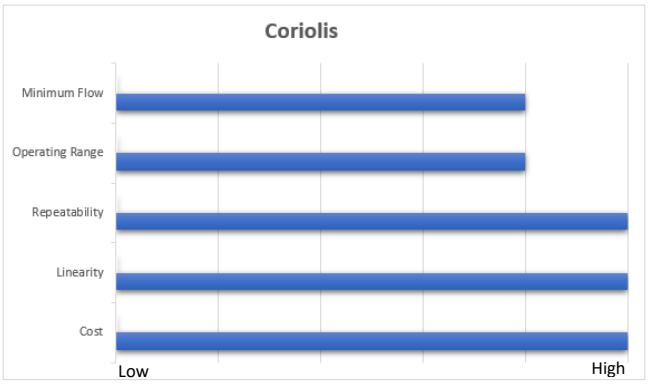
Each flow meter type has its own strengths and weaknesses, each performing optimally under different conditions.

Flow Meter requirement	Orifice plate	Averaging pitot tube	Variable area	Spring loaded	Axial turbine	Pelton wheel	Insertion turbine	Oval gear	Gear	Helical screw	Electromagnetic	Clamp-on ultrasonic	Coriolis	Thermal	Ultrasonic
Small water pipes	●	x	✓	●	x	✓	x	✓	x	x	✓	●	✓	●	✓
Large water pipes	✓	✓	x	✓	✓	x	✓	x	x	x	✓	✓	✓	x	x
Dirty water & slurries	●	x	x	●	x	x	✓	x	x	x	✓	✓	✓	x	✓
Low viscosity fluids	✓	✓	✓	✓	✓	✓	✓	✓	x	x	✓	✓	✓	✓	✓
High viscosity fluids	●	●	x	x	x	x	x	✓	✓	✓	●	✓	✓	✓	✓
Very low flows	x	●	✓	x	x	✓	x	✓	✓	✓	✓	x	✓	✓	✓
High accuracy	x	●	x	x	✓	●	●	✓	✓	✓	✓	●	✓	●	✓
Pulsating flow	x	●	x	●	x	x	x	✓	✓	✓	●	●	●	✓	✓
Contorted pipework	x	●	✓	x	x	●	x	✓	✓	✓	●	●	✓	✓	✓
Wide dynamic range	x	●	x	x	x	●	●	✓	✓	✓	✓	✓	✓	✓	✓
Low pressure drop	x	✓	●	x	●	●	✓	●	x	●	✓	✓	✓	●	✓
Low maintenance	✓	✓	✓	●	x	x	x	●	x	●	✓	✓	✓	●	✓
Low purchase price	✓	●	✓	✓	●	✓	✓	●	●	x	●	●	x	x	●

Green: Suitable/good Yellow: Possible/questionable Red: Unsuitable/poor

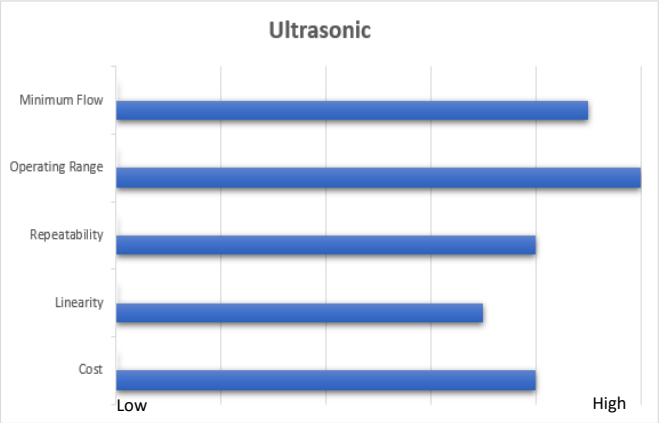
MASS FLOW METERS

Mass Flow Meters - specifically the Coriolis - measure mass flow directly and can meter down to low flow rates. They work based on when a fluid is in motion, any change in direction will produce a reaction in the system. This reaction is proportional to the mass of the fluid being accelerated. They are viewed by many as close to the perfect flow measuring device, delivering excellent accuracy and overall performance. However, Coriolis type meters can be very expensive.



VELOCITY FLOW METERS

Velocity Flow Meters include Ultrasonic and Electromagnetic flow meters, both of which use full pipe bores, measure the liquid velocity and are inherently bi-directional. For large pipes a multipath meter will give superb velocity information. Add in measurements or tables for the other fluid variables and an ultrasonic flowmeter is the perfect device for these large conduits. For medium size tubes a clamp-

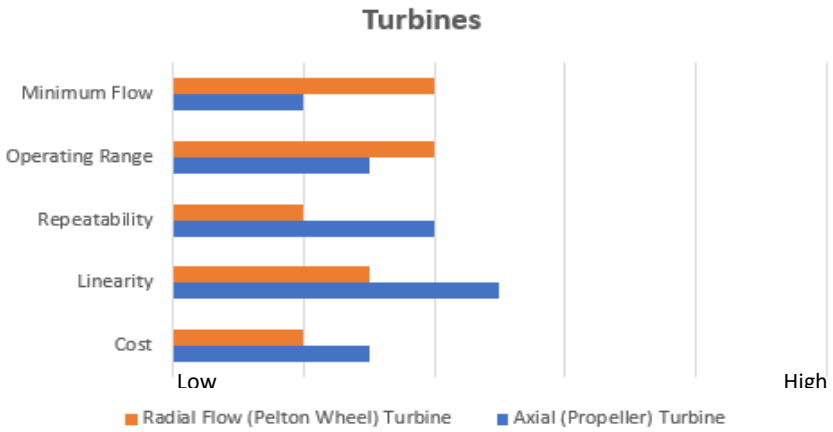


on ultrasonic meter will give flow readings with no additional pressure drop to the system, although set-up and calibration is required for really accurate readings. For tubes down to 1mm bore, in-line volumetric meters are available with excellent accuracy when using the latest available technology. Such ultrasonic flow meters are independent of Reynolds numbers and can therefore operate from laminar flow up to turbulent flow. This makes them highly commercial being able to accurately measure liquids ranging from water to high viscosity oils. As through-flow devices, they can also be tolerant to impurities in the system which would cause havoc to meters with moving parts.

The Electromagnetic meters are highly accurate and reliable, making them ideal for any conductive liquid. Electromagnetic meters can be used successfully with aggressive and contaminated liquids and are also reasonably priced.

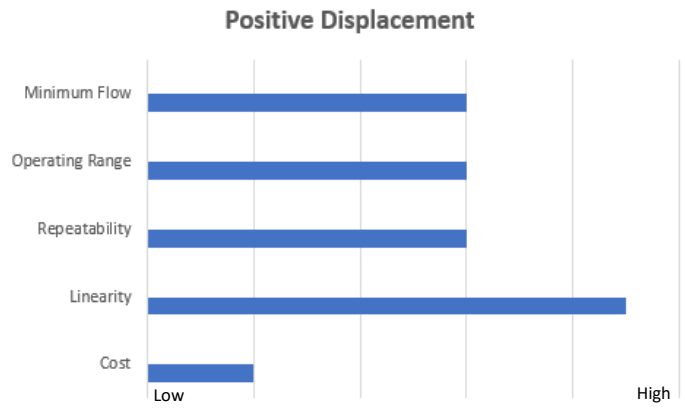
INFERENTIAL FLOW METERS

Inferential flow meters have been an industry standard for many years. Turbine flow devices are the most common and give great accuracy under known operating parameters but work best in turbulent flow with high Reynolds numbers. Potential issues arise when operating at the lower end of their operating range in variable fluid conditions. For small pipes the Pelton wheel devices work well but the same Reynolds number qualifier is required to maintain the performance. Turbine flowmeters are economic but do require clean homogenous fluids. External instrumentation is often required adding to the apparent meter installation cost. The larger dynamic range and the ability to meter very low flows, make the turbine meters ideal for beverage dispensing or other low-flow dosing processes.



POSITIVE DISPLACEMENT METERS

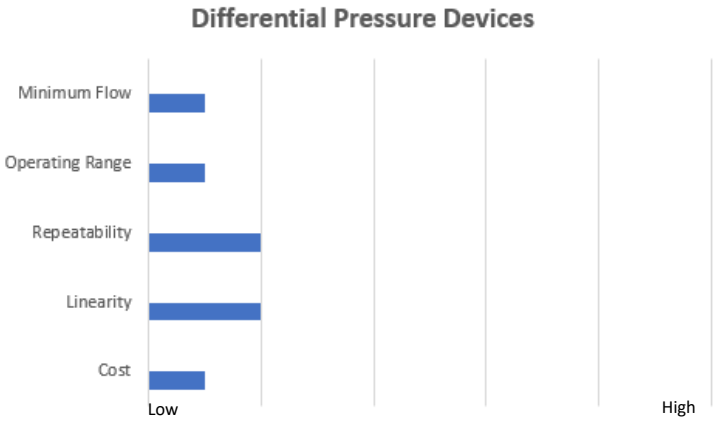
Positive displacement meters are a large family of devices, ranging from the domestic water meter through to highly accurate, sophisticated products for high viscosity liquids. Therefore, the price and specification range is enormous.



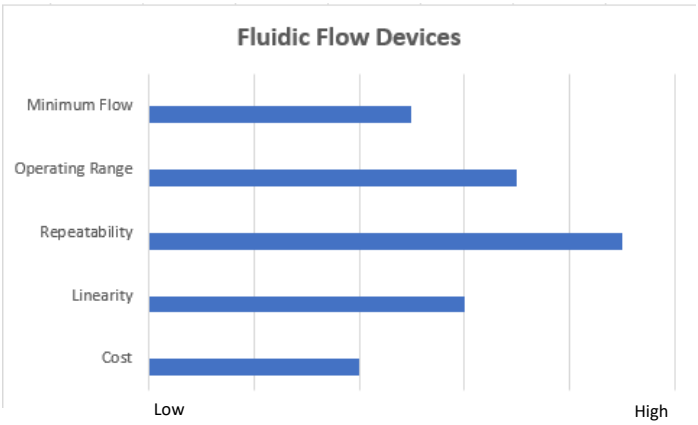
These type of flowmeters – oval gear, nutating disc, oscillating piston – have the same basic mode of operation, taking a discrete volume of liquid and passing it from the inlet to the outlet without loss or slippage. These too require clean fluids as any contaminant will cause extra friction and potentially stop the device entirely. Typically, pulse output devices require additional external instrumentation.

DIFFERENTIAL PRESSURE DEVICES

The appeal of d**ifferential pressure devices** is obvious: simple, usually reliable, and relatively inexpensive. As a technology, they can handle a wide range of operating conditions from laminar flow through to the most turbulent. The most common method using this principle is with an orifice plate, a hole in the bore of the pipe that creates an obstruction to flow. The square root of the pressure differential is proportional to the flow rate.



FLUIDIC FLOWMETERS



Fluidic flowmeters use the physical properties of moving liquids. These devices, like the vortex shedding meter, require high Reynolds numbers so are rarely used for very low flows or in small pipes.

Available technologies that measure flow successfully are many and the user must always perform due diligence on the chosen supplier and technology. In addition to meter cost, consider the device's entire lifespan and service plan as well as potential savings in plant operation. The right flowmeter for the job is the one that will perform the task required, with satisfactory accuracy, at an acceptable

fully installed cost. An expensive product accurately measured could feasibly add up to a 2% saving over a year. Plant down-time is possibly the greatest overhead so a reliable flowmeter with a very low failure rate can be cost-efficient over the plant's life ■