Small Bore Meters

Selecting Liquid Flowmeters Below Half Inch Bore

An illustrated guide to identifying the ideal small bore liquid flowmeter

A Technical Briefing for designers, specifiers and users of flow measurement.

Produced by Titan Enterprises Ltd

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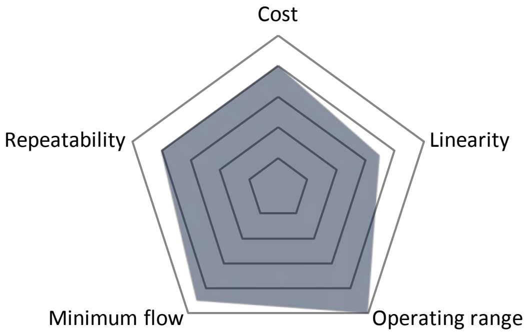
Introduction

Small bore flowmeters offer very different challenges to larger diameter meters. As the flows are lower, less energy is available in the liquid to convert to mechanical movement. The liquid is often running in the laminar flow region and viscosity and boundary layer effects become very important. Generally speaking the smaller the meter the harder it is to make an accurate inline measuring device but the easier it is for the user to check the performance.



ormance Charts

n this briefing we have produced some graphics representing the ve performance and desirability of each type of meter on five neters; Cost, Linearity, Operating range, Minimum flow and atability. The scales are arbitrary with the outer pentagon being the performance level. A perfect performing meter for these low flows d be shown by colour filling the outer pentagon at all five points.

y potential application, different factors may take priority so within this ng we have listed the ten dominant technologies and ordered each neter for each meter to allow comparisons to be easily made. For nple the variable area meter is the cheapest so it is rated as 10, the num, for cost but only 1 for accuracy as they are typically the worst performer.

The Coriolis is the most accurate of the selection so it is rated 10 for accuracy but it is also the most expensive so it is rated 1 for cost. The colour block effectively "points" at the devices best features. The thermal meter is capable of the lowest flows so is rated 10 for "minimum" etc.

Ultrasonic Flowmeters

Ultrasonic flowmeters appear to be the ideal solution to low flows. They do not interfere with the flow, can measure most types of liquid, do not require liquid conductivity and have good turndowns.

The latest versions due in production early 2010 will meter flows down to 1 mL/minute and below -- with excellent accuracy. Some low flow versions already exist but with limited performance due to the sensor inefficiencies and limitations in the signal processing.

Clamp-on meters are rarely used in pipe sizes below 1". The existing (below 1") devices are also affected by the fluid viscosities, liquid velocity profiles and have quite small operating ranges; the latest technology will negate these problems and offers a more commercial solution with turndowns approaching 500:1 at ±1.5% of reading over the whole range - all at competitive prices.

This makes these devices Reynolds numbers independent and can therefore operate from laminar flow right up to turbulent flow; in other terms, accurately measuring liquids ranging from water to high viscosity oils. Being through-flow devices they can also be tolerant to impurities in the system which would cause havoc to meters with moving parts.

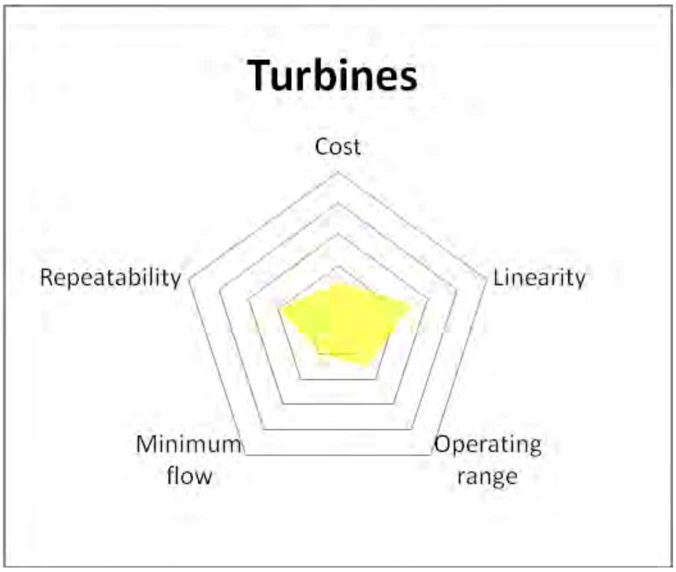
Variable Area

Probably the commonest small bore flow indicator is the variable area flowmeter or "rotameter" as seen in industry, many laboratories and hospitals. This is a simple plastic or glass tube with a shaped float or ball that rises up a tube, whose cross sectional area changes up its length, hence the name variable area meter.

The flow of the fluid "lifts" the float and its height in the tube is an indication of flow rate. Some systems use springs to counter the fluid forces and this makes the devices less dependent on gravity and they can be mounted in any orientation. The displacement can also be sensed remotely which is essential with opaque fluids.

Turbines

Small traditional axial turbines are very rare as these "propeller" type meters usually rely on turbulent flow, fully developed velocity profiles and consistent, very low friction bearings. They are also extremely sensitive to changes on the surfaces of the turbine and are only used in specialised applications.



Several alternatives are available where the turbine has plain blades completely in line with the flow unlike the "angled" blades in a traditional turbine. An upstream fixed helical screw rotates the fluid and this spinning fluid rotates the turbine. Because these devices are usually moulded, tight tolerances can be maintained and the entire meter can be made from thermo-plastics.

The rotors are very light and the forces imparted by the fluid "spinner" are somewhat larger than can be usually extracted from a normal axial turbine. These give better range ability and overall performance however the bearings are still a crucial component being small and often plastic they are subject to wear and contamination from small particles. Temperature changes affect not only the fluid properties but the internal geometry of the meters themselves and this family of devices are not very suitable for applications with wide temperature ranges or fluids which change characteristics with temperature. Ideally they should be calibrated on a fluid at the same viscosity and temperature as the product being metered.

Pelton Wheel

So called Pelton wheel or radial flow turbines act in a similar way to an old water wheel but within an enclosed chamber. Many domestic water meters around the world work in this way. The power available from this arrangement is considerably more than the propeller type meters and they are therefore capable of much lower flows. However, great care must be taken to ensure good linearity over the flow range and, in addition, the pressure drop is quite high.

Pelton Wheel turbines are viscosity sensitive and will give erroneous readings if the fluid properties change significantly. Bearings can be stronger but this is necessary due to the higher forces involved. Very low friction devices of this type are used for the smallest flows but rarely have long service lives.

Positive Displacement

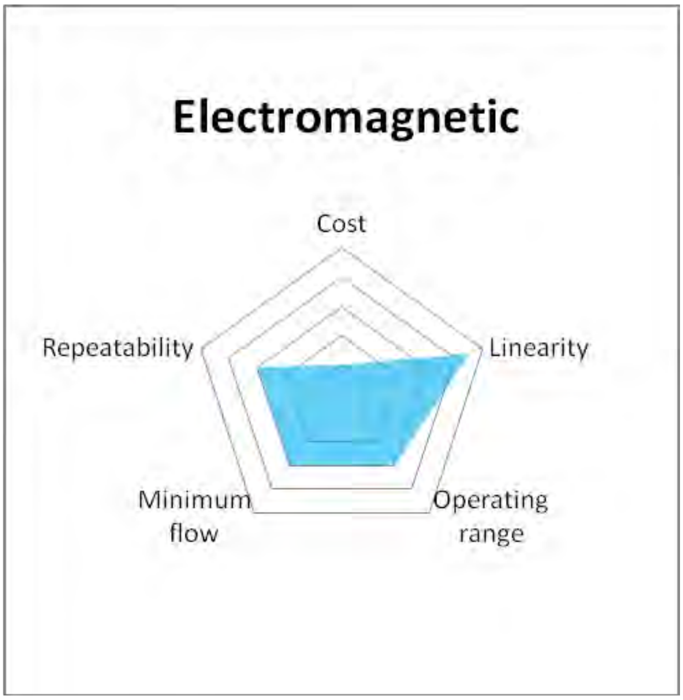
Some manufacturers make positive displacement (PD) meters for small bore pipes including the domestic water meter. There are many differing types of PD meters and generally these are very successful in small sizes providing that the fluid is slippery and viscous. As for metering water, only a handful of suppliers make meters suitable for water as its lubricating properties are very poor.

Other low viscosity liquids such as solvents or the myriad of water based solutions also present problems. Modern low friction plastics have helped, but these meters do insist on clean liquids for effective performance and even the small particles that sometimes get into domestic water systems can stop this type of device.

Most oil meters fall into the Positive Displacement category as the properties of the product and the meter measuring it are totally compatible.

Electromagnetic

Electromagnetic meters use Faraday's law of electromagnetic induction– a conductor moving in a magnetic field will generate an emf at 90° to the magnetic field, the amplitude of the emf being proportional to the velocity of the conductor.



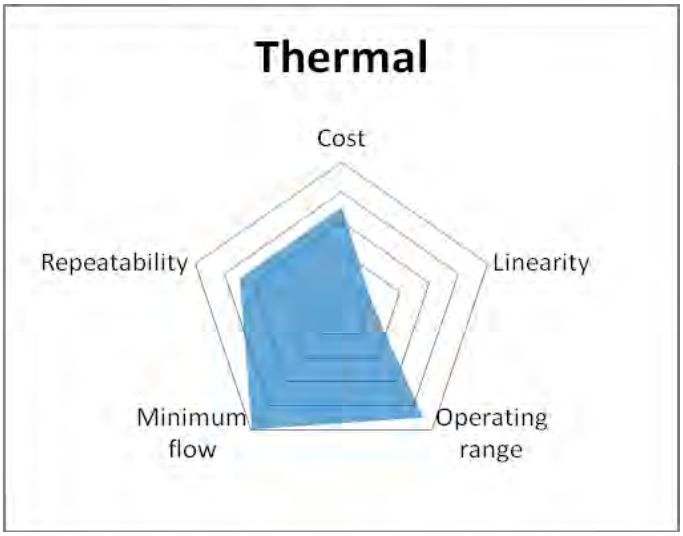
The fluid is the conductor and therefore the Electromagnetic meter is limited to fluids that can conduct electricity, however modern meters can measure flows in liquids with quite low conductivities.

In practice an alternating magnetic field is placed across the pipe with electrodes on the centre line between the two field generators. As the fluid flows through this variable magnetic field an alternating voltage is induced at the probes, which enables the flow-induced emf to be distinguished from electrochemical potentials on the electrodes.

These meters are now made in quite small sizes down to 3mm bores. They are tolerant of impurities and can measure below 0.3M/S i.e. below 0.12 litres per minute.

Thermal

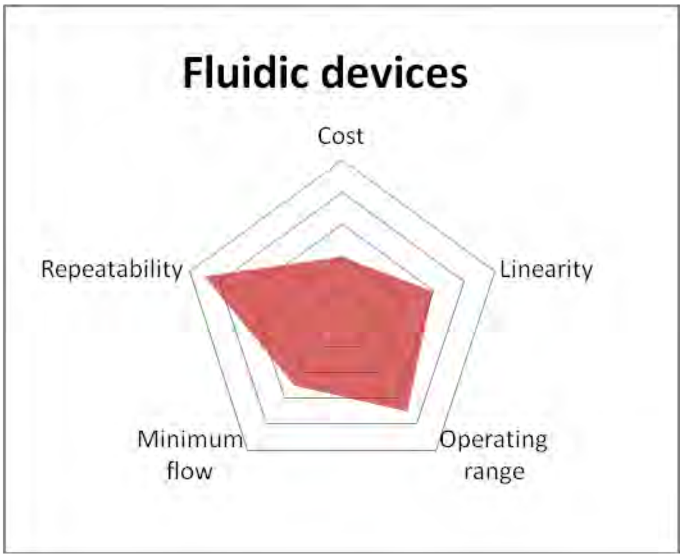
Thermal meters inject energy into the system and are therefore capable of detecting extremely low flows down to micro-litres per minute. A small thermal element puts heat into the fluid and the dispersal of this energy is registered and converted into a flow reading.



Response time is slow for these extremely low flow devices and the accuracy is not up to the standard of other products mentioned in this article. The slightly larger devices perform better with improved linearity and response times. Ideally these meters should be calibrated for the liquid being metered at the operating temperature.

Fluidic Devices

There are a number of meters that use the physical properties of moving liquids, these are called fluidic devices and include such things as vortex shedding meters, fluidic oscillators and laminar flow elements.



The vortex shedding meters require quite high Reynolds numbers and are not often used for very low flows or in small pipes.

Laminar flow devices are inherently linear as the pressure drop across an element is directly proportional to flow rate - providing the Reynolds number of the fluid is kept below the turbulent region. Small flows are attainable with these devices and ranges of up to 50:1 are possible with the correct pressure measurement system.

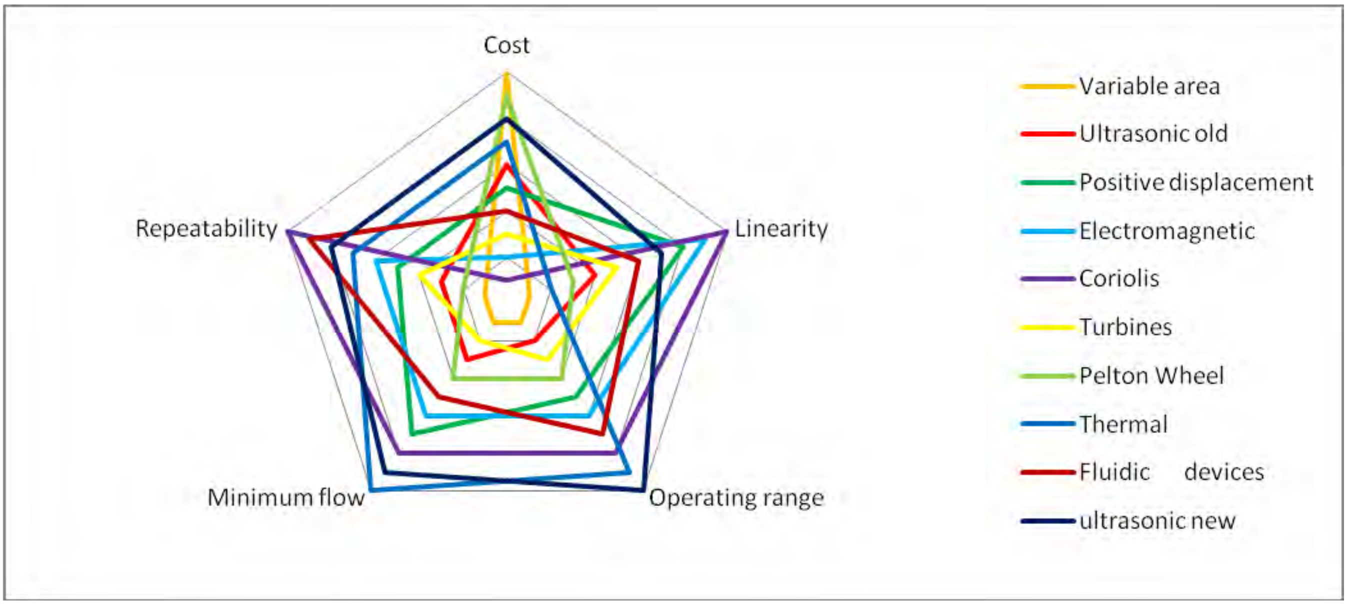
Coriolis

The Coriolis flowmeter gives a direct reading of mass flow and can meter down to low rates. It uses the fact that 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.

With the Coriolis, there is no obstruction in the bore (although the flow path can be very contorted) but these meters can be very accurate, with linearity's quoted down to ±0.1%. Coriolis type meters are also usually very expensive.

Conclusion

In conclusion, in finding the ideal flowmeter for small bore applications there are several options for any given low flow rate. The final choice is likely to be a compromise between performance, price and operating parameters.



The new generation ultrasonic meters are able to satisfy a wide range of requirements, and, as can be seen from the summary chart, perform very well across all parameters. However, if *exceptionally low flow* detection is required, the thermal meters are perhaps the only option. For cost, the old fashioned variable area devices are good for local indication but for inexpensive electronic outputs, Pelton wheel meters are hard to beat. Finally, if ultimate accuracy is required, the Coriolis meter could provide the highest performance at a cost.

Summary

An opportunity to work in partnership

With over 40 years experience in flowmeter innovation and manufacture, Titan's company philosophy of " pushing the envelope by trying to do things a little different and better" has resulted in sales of over 250,000 products into 40 countries worldwide and a repeat purchase percentage of over 95% - something which founder Trevor Forster is justly proud of.

Titan's chemically resistant, high accuracy digital flow meters with pulse outputs can handle almost anything. Its process control and measuring instruments can monitor and/or display :-total, batch size, flow rate, switch, consumption and 4-20mA or 10 volt analogue loops. Its batching instruments can be used for dispensing, totaliser, accumulated totaliser, flow rate, dispense amount as well as full process monitoring.

The Oval gear, positive displacement and Turbine flow meters produced by Titan are designed and manufactured to ISO9001 and calibrated to an uncertainty of ±0.25%. Its team can offer either an off the shelf meter or fully bespoke flow products designed for a particular application whether it is a low cost OEM flow solution or a specialist flowmeter in exotic materials.

If the information and topics covered in this briefing highlight issues which are important to you then we would be delighted to discuss how we can work in partnership.

Please don't hesitate to contact one of the Titan team to discuss things further.

Further resources

The New Revised Guide to Specifying Flowmeters

This Technical Briefing outlines the various techniques used for liquid measurement and assesses the relative strengths and weaknesses according to application. The briefing illustrates the main aspects of each technique and provides information and advice on the most suitable and effective methods according to the tasks required.
Please see the contact information below to request a free copy.

Help, Advice and Support

If the issues discussed in this document relate to your business and you consider them sufficiently important to take action then we hope we've helped to inform your decision as to how to take the next step.

We would be delighted to discuss your individual issues and explore how *our* individual approach could help you. Simply contact us today to arrange to speak with one of our team.

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Important Information: