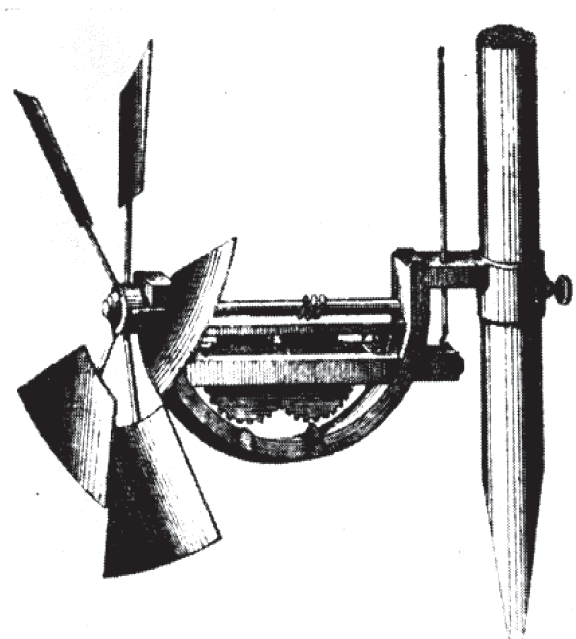
Navigating the Flood of Advanced Metering Technology

A WHITE PAPER BY NEPTUNE TECHNOLOGY GROUP INC.

While the benefit of technological advancement is clear, its rapid pace often puts pressure on utilities to make investments in technology that will not only address today's infrastructure and metering deployment challenges - but continue to be part of future solutions as well.

For example, even though a call can still be made on a flip phone, the difference between an old phone and current technology is in the improved quality and ease of use. Water can also still be metered using old technology; however, the benefits that advanced metering technology provide will better equip you to ensure that you are getting the most out of your investment.

In determining which meter is the best, it is important to remember that there is no "one-size-fits-all" solution. Informing yourself on the benefits and drawbacks of the available technology is imperative for your utility's success.



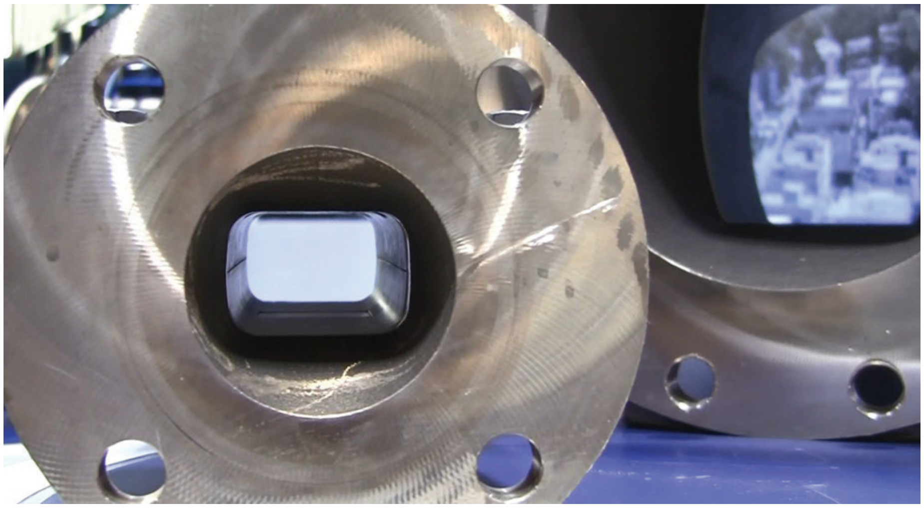
Concept for the first turbine meter[1]

ADVANCED METERING TECHNOLOGY

There are two distinct types of water meters: those with moving parts (mechanical meters) and those without (solid state meters).

Mechanical meters rely on water either displacing or rotating parts inside the meter to measure flow. Measurement relies on technology that was developed more than a century ago. However, newer meters no longer need moving parts in order to accurately measure water flow. These solid state technologies use ultrasonic waves, electromagnetic fields, or induced oscillations instead.

While the initial investment may be higher, solid state technologies boast impressive advantages over their mechanical counterparts, and will pay for themselves over the life of the meter. The absence of moving parts eliminates the meter's susceptibility to mechanical friction. Over time, mechanical friction wears down the mechanical meter's measurement components, causing a loss of accuracy and thus a loss of revenue for utilities. Solid state meters maintain their accuracy over the entire flow range for the life of the meter, providing peace of mind for



Open flow path of an Ultrasonic Meter

customer billing accuracy. Sustained accuracy also removes the need for field maintenance by eliminating costly truck rolls and down time from field testing.

Solid state meters offer low flow capabilities that can further maximize a utility's revenue by allowing them to bill for nearly every drop of water and detect even small leaks in their system. Unlike mechanical meters, solid state meters have no moving metrology elements and do not require strainers because of the meter's open flow path. Debris clogs and diminished intermediate flow accuracies experienced by compound meters are no longer an issue. Additionally, commercial and industrial sized solid state meters weigh less than an equal sized mechanical meter, making them safer and easier to handle.

SOLID STATE METERS AND SAMPLING RATES

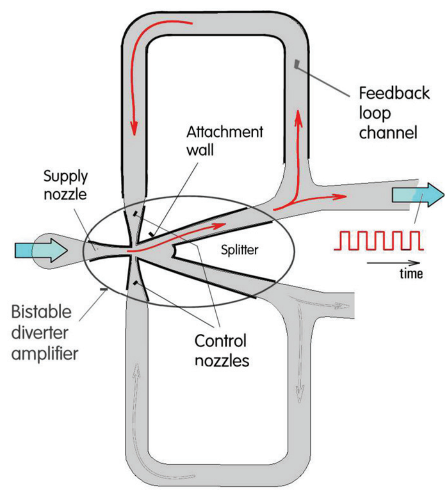
Before exploring the different types of solid state meters, it is important to understand a general operating principle known as sampling rate that will help you determine which solid state meter is right for you. Solid state meters act like digital computers, translating continuous fundamental quantities like flow rate, temperature, and pressure into discrete data in a process called sampling. Water meters with higher sampling rates measure water more frequently and report water flow and volume with greater fidelity than those with lower sampling rates.

The way in which a solid state meter collects a sampling rate can be compared to the frame rate of a movie camera. If the frame rate for a camera is too slow, important parts of the action are missed. Conversely, a camera with a higher frame rate captures more of the action to create a more complete picture.

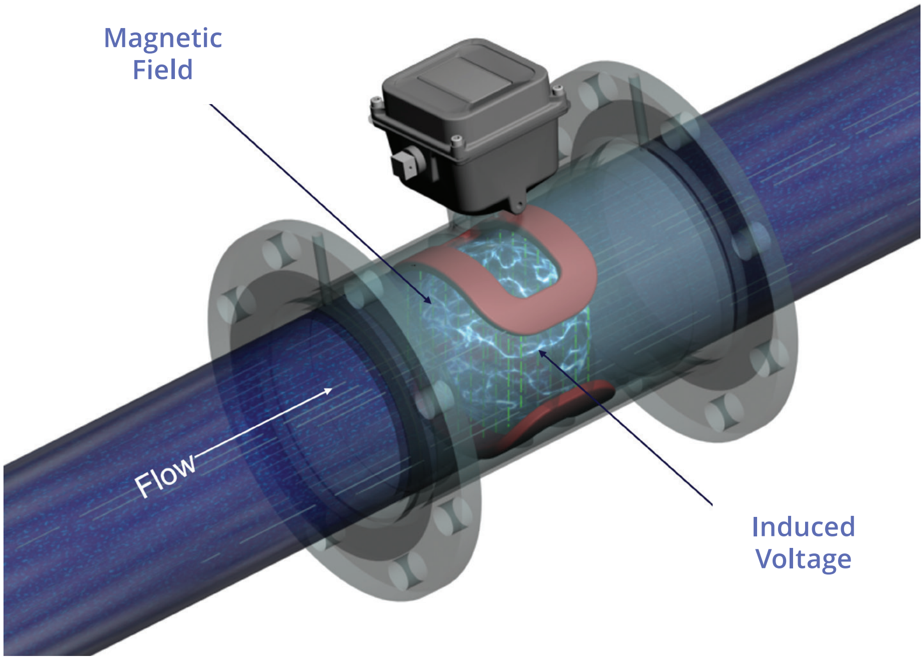
The same principles are true for water meters. Solid state meters with low sampling rates can miss important volume events, especially during rapidly changing flow conditions like those seen in residential applications or during meter testing. Higher sampling rates improve meter accuracy in real-world situations, which ensures accurate billing and can help utilities maximize their revenue. There are several kinds of solid state meters including: fluidic oscillators, electromagnetic meters, and ultrasonic meters.

FLUIDIC OSCILLATORS

Fluidic Oscillators use the Coanda effect (the phenomenon that explains the tendency of a jet flow to stay attached to a nearby surface, even as the surface curves) and feedback paths to create regular flow oscillations which are sensed electronically. The frequency of the oscillations is proportional to the fluid's velocity and temperature, allowing the meter to calculate the fluid's flow rate.



Two feedback channel fluidic oscillator[2]



Rendered view of water passing through a magnetic field in a mag meter

Although these devices have many promising applications[2], they also have numerous drawbacks to consider:

- Measurements are limited to a very small range of flows.
- Reverse flow events may go undetected because the internal meter passages operate in one direction.
- The internal passages produce large, unrecoverable pressure losses.
- The design does not scale up well in size, making it impractical for general metering applications.

Fluid oscillation is generally not used in the municipal water market. More widely-accepted solid state technologies have been developed to better suit the needs of today's utilities.

ELECTROMAGNETIC METERS

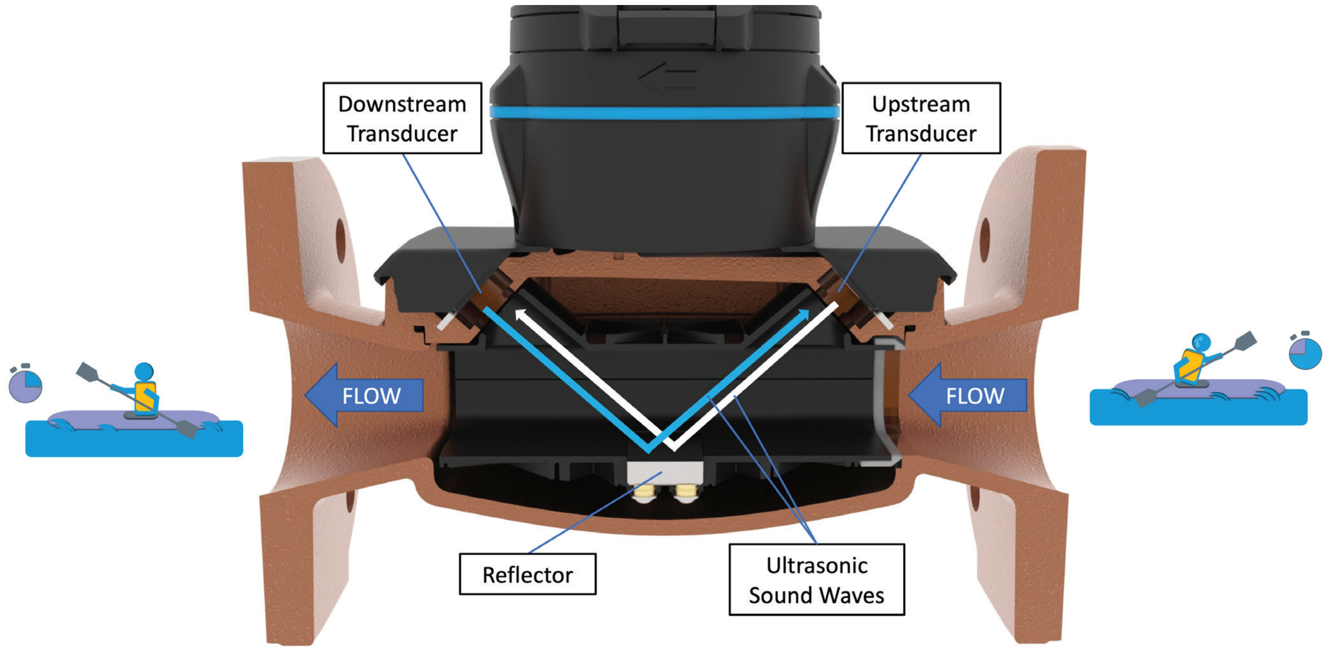
An electromagnetic flow meter, or mag meter, uses Faraday's Law of Induction to measure a fluid's velocity. When a conductor, such as water, moves through a magnetic field, a voltage is induced – one proportional to that conductor's velocity.

A measurement sample is taken by generating a magnetic field for a split second and recording the voltage across electrodes located inside the mag meter. Flow rate is calculated from that voltage and then converted to totalized volume. Turning the magnetic field on and off is necessary to cause a changing output voltage, which allows the meter to more easily distinguish between electronic noise and actual water flow. But because the conductive value of water is very low, achieving measurable voltage signals requires high water velocities. As flow rates drop, voltage levels diminish to the point where they become indistinguishable from background noise.

Although the magnetic field is generated across the entire cross-section of the pipe, the calculations are still affected by the water's profile because the measured voltage is only produced along the diameter (i.e. chord) that contains the electrodes. Generating fields strong enough to accurately measure water requires a lot of power, which in turn forces battery powered mag meters to resort to low sampling rates in order to conserve battery. Battery powered mag meters generate relatively weak magnetic fields, which forces them to have a low signal-to-noise ratio (SNR) which impacts low flow accuracy. This low SNR is why mag meters are most suitable for medium-to-high flow applications.

Battery powered mag meters resort to low sampling rates to conserve battery but can still be a smart choice for medium-to-high flow industrial applications where mains power is available. To help to conserve battery life, battery powered meters can use a hidden "new meter mode" that forces a high sampling rate out of the box for good test bench results. Once the meter is put in service, the sampling rate drops to conserve battery. A similar battery conservation method involves having a special "test mode" that can be activated. This test mode increases the sampling rate temporarily to force good test bench results, which may not be representative of actual field performance.

A mag meter's unobstructed flow channel provides minimal pressure loss, the capability to measure in both directions, and allows measurement



Ultrasonic transit time technology

of fluids that contain solids, such as sewage and other industrial sludges. Additionally, the calculations that mag meters use are largely unaffected by the measurement fluid's pressure, density, temperature, and viscosity. But, over time, even minor corrosion of the meter's metallic electrodes can significantly reduce already small signals, greatly diminishing the meter's low flow capabilities. Mag meters have been a useful industrial fluid measurement tool for decades, but utilities wanting to apply this technology to general water metering should keep in mind some of the challenges and limitations:

- Battery powered mag meters typically have lower accuracy than other comparable solid state meters because they measure the water less often.
- Low signal-to-noise ratio diminishes low flow capabilities.
- Generating magnetic fields takes a lot of power and can drain the meter's battery quickly.
- The meter is only capable of measuring electrically conductive fluids.
- Stray magnetic currents can affect accuracy.
- Mag meters can easily be tampered with using magnets.
- Extra equipment such as grounding straps or grounding rings are often required.
- Coated electrodes are susceptible to abrasion and corrosion which may affect accuracy.

Although "continuous" measurements are not possible, if the meter is connected to mains power it can generate a stronger magnetic field and sample the water more frequently. While industrial applications may have access to mains power, the majority of municipal applications require remote metering. In order for a solid state meter to operate remotely, it must use battery power. The amount of power needed to generate electromagnetic fields used to measure flow requires mag meters to make a tradeoff for either high accuracy or long battery life. Fortunately, a superior solid state technology has been developed that allows utilities to have the best of both worlds.

ULTRASONIC METERS

Ultrasonic meters can utilize either doppler effect or transit time measurement methods. Doppler effect meters require particles to be suspended in the fluid to determine the flow rate, making it difficult to measure potable water. Transit time meters send ultrasonic sound waves through the fluid and use the difference in transit time to determine the flow rate, making them significantly more accurate.

As illustrated in the image above, imagine that you are kayaking with the current on a river and then you turn around and start paddling upriver. Paddling against the flow requires significantly more time to go the same distance. Transit time ultrasonic meters use this principle to measure the speed of the river, or in the case of metering, the velocity of water being consumed - measuring the travel time of ultrasonic sound waves.

These high frequency sound waves are both generated and received in both directions by transducers made of specialized piezoelectric material. A transducer upstream generates a wave which is bounced off a reflector, or mirror, and sent to a transducer downstream. The same process happens in reverse, and because the difference in travel time upstream versus downstream is proportional to the velocity of the water, the meter can calculate flow rate and consumption volume.

Producing an ultrasonic wave takes very little power as compared to generating an electromagnetic field, which allows ultrasonic meters to have exceptional battery life, even when measuring flow multiple times a second. In contrast, some mag meters only sample as infrequently as once every thirty seconds. However, state-of-the-art ultrasonic meters can sample as often as four times per second.

Ultrasonic meters, like mag meters, can be installed in a variety of orientations and are largely unaffected by small particles or bubbles in the water. Ideally, they will be designed so that transducers and reflectors do not interfere with the flow path. This creates an open channel with minimal pressure drop, no clogging, and no strainer requirement.

When properly designed, ultrasonic meters will be constructed with transducer and reflector materials that are carefully selected to prevent buildup and guarantee accurate performance for the life of the meter. In combination with a rugged maincase, ultrasonic meters can withstand even the most demanding service conditions. In summary, ultrasonic meters can offer benefits such as:

- No moving parts for sustained accuracy over an impressive flow range.
- No maintenance or periodic testing required.
- Extended low flow and leak detection for maximum revenue.
- Exceptional signal-to-noise ratio.
- High sampling rates without sacrificing battery life.
- Highly accurate with no reduction in accuracy over time.
- No clogging or build up.
- Various mounting orientations and minimal straight pipe requirements.
- Suitable for fire service applications.
- No strainer requirement.
- Performance over a wide range of temperatures.
- Advanced detection capabilities including leak, backflow, excessive flow, empty pipe, and tamper.

SUMMARY

Advanced metering technology is designed to help utilities provide safe, clean drinking water to their customers while accurately measuring water use. Each has its own advantages and drawbacks; while fluidic oscillators and mag meters excel in specialized laboratory and industrial applications, ultrasonic meters pave the way for utilities to maximize their revenue, reduce their maintenance costs, and save time while working safely. Investing in the right industry-leading technology for your needs will help you to future-proof your utility and maximize your revenue year after year.

1. Crainic, Monica Sabina. "A SHORT HISTORY OF RESIDENTIAL WATER METERS PART I MECHANICAL WATER METERS WITH MOVING PARTS." Installations for Buildings and Ambiental Comfort Conference XXI- Edition, 20 Apr. 2012, pp. 27–35., www.researchgate.net/publication/283045689.
2. Ghanami, Soheil, and Mousa Farhadi. "Fluidic Oscillators' Applications, Structures and Mechanisms-A Review." Trans. Phenom. Nano Micro Scales, vol. 7, no. 1, 30 Jan. 2019, pp. 9–27. Winter and Spring 2019, doi:DOI: 10.22111/tpnms.2018.25051.115

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