

Tech Brief

PUBLISHED BY THE NATIONAL ENVIRONMENTAL SERVICES CENTER

Water Meters

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Summary

Any viable business must be able to determine how much product it is making and selling and if that product is profitable. Water is a business. And, the best way for a water utility to measure or account for the water produced and then sold is by using water meters. This Tech Brief, discusses the different types of meters, their applications, and their importance for a water utility business.

Why are meters important?

Water meters are important to a utility for several reasons:

1. They make it possible to charge customers in proportion to the amount of water they use.
2. They allow the system to demonstrate accountability.
3. They are fair for all customers because they record specific usage.
4. They encourage customers to conserve water (especially as compared to flat rates).
5. They allow a utility system to monitor the volume of finished water it puts out.
6. They aid in the detection of leaks and waterline breaks in the distribution system.

A system without meters is like a taxi without a fare counter. Without a meter, it costs the same to drive around the block as it does from New York to Los Angeles.

Types of Meters

Meters are classified into two basic types: positive displacement and velocity. Each of these meter types has variations, leading to the perception that there are several different kinds. Meters that feature both positive displacement and velocity are known as compound meters. The unit of measurement is usually in gallons but sometimes in cubic feet.

Positive Displacement Meters

In this type of meter, a known volume of liquid in a tiny compartment moves with the flow of water. Positive displacement flow meters operate by repeatedly filling and emptying these compartments. The flow rate is calculated based on the number of times these compartments are filled and emptied. The movement of a disc or piston drives an arrangement of gears that registers and records the volume of liquid exiting the meter. There are two types of positive displacement meters: nutating disc and piston.

Nutating disc meters have a round disc that is located inside a cylindrical chamber. The disc is mounted on a spindle. The disk nutates, or wobbles, as it passes a known volume of liquid through the cylindrical chamber. The rotating motion of the disk is then transmitted to the register that records the volume of water that went through the meter. (See **Figure 1** below.)

Piston meters have a piston that oscillates back and forth as water flows through the meter. A known volume of water is measured for each rotation, and the motion is transmitted to a register through an arrangement of magnetic drive and gear assembly.

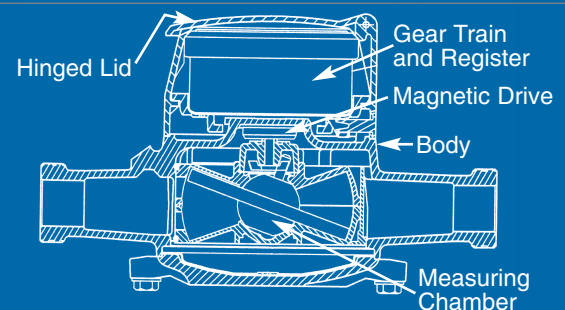
Positive displacement meters are sensitive to low flow rates and have high accuracy over a wide range of flow rates. Positive displacement meters are used in homes, small businesses, hotels, and apartment complexes. They are available in sizes from 5/8" to two inches.

Velocity Meters

Velocity meters operate on the principle that water passing through a known cross-sectional area with a measured velocity can be equated into a volume of flow. Velocity meters are good for high flow applications.

Velocity meters come in different types, including turbine, multi-jet, propeller, ultrasonic, venture, and orifice meters. These meters are available in sizes of two

Figure 1 - Nutating-Disk Meter with Plastic Housing



Source: American Water Works Association, *Water Transmission and Distribution, Principles and Practices of Water Supply Operations*, 2nd Edition

inches and larger with the exception of multi-jet meters, which are between 5/8" and two inches.

Turbine meters have a rotating element that turns with the flow of water. Volume of water is measured by the number of revolutions by the rotor.

Venturi meters have a section that has a smaller diameter than the pipe on the upstream side. Based on a principle of hydraulics, as water flows through the pipe, its velocity is increased as it flows through a reduced cross-sectional area. Difference in pressure before water enters the smaller diameter section and at the smaller diameter "throat" is measured. The change in pressure is proportional to the square of velocity. Flow rate can be determined by measuring the difference in pressure. Venturi meters are suitable for large pipelines and do not require much maintenance.

Orifice meters work on the same principle as venturi meters, except that, instead of the decreasing cross-sectional area, there is a circular disk with a concentric hole. Flow rate is calculated similarly to the venturimeter by measuring the difference in pressures.

Ultrasonic meters send sound waves diagonally across the flow of water in the pipe. Changes in the velocity of water are converted electronically to change in flow rate.

Magnetic meters have an insulated section through which water flows. The flow of water induces an electrical current that is proportional to the velocity and hence the flow rate.

Propeller meters have a fan-shaped rotor that spins with the flow of water. A recorder is attached to the rotor to register the readings.

Multi-jet meters have tangential openings in a chamber to direct the water flow across a rotor with many vanes. Flow is measured proportional to the speed of the rotor.

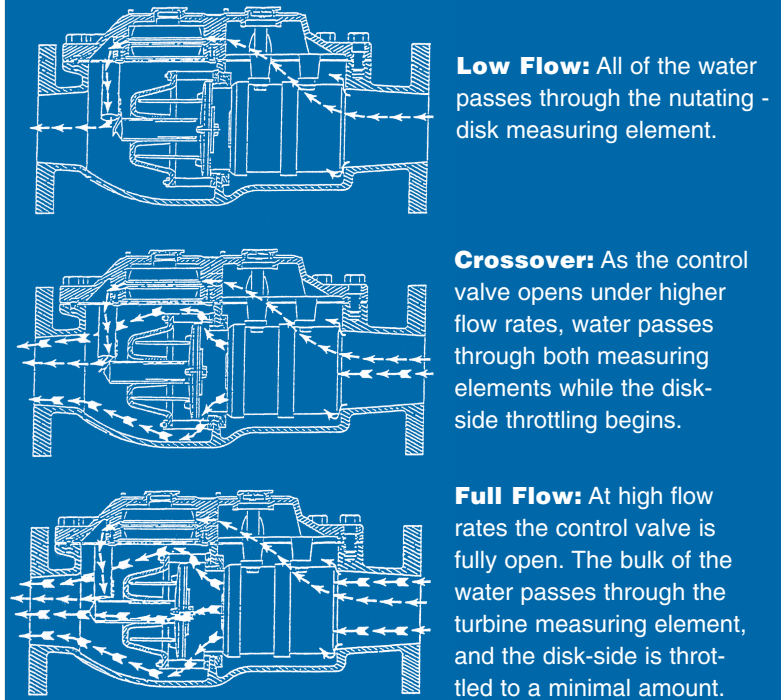
Compound Meters

In some cases, it is necessary to have a combination meter—both a positive displacement meter and velocity meter installed together—to be able to measure high and low flows. Low flows are measured through positive displacement while high flows are measured by velocity. A valve arrangement directs flows into each part of the meter. (See **Figure 2**.)

Meter Installation

Meters are installed either in outdoor meter pits (also known as meter wells) or inside the building served. Although it is common to have a meter installed in the basement, it is better to have the meter located at the curb or property line because of easy access for reading or maintenance. It is sometimes difficult to gain access to the residence or building when no one is there. Nevertheless, it may be necessary due to

Figure 2 - Compound Meter



Source: American Water Works Association, *Water Transmission and Distribution, Principles and Practices of Water Supply Operations*, 2nd Edition

extreme cold weather to have the meter located indoors to prevent frost damage. Large meters are usually installed in concrete or block vaults preferably out of traffic areas, but they also can be installed inside.

General guidelines for installing meters are:

- In outdoor meter pits, the face of the meter should be between 18 and 24 inches from the ground surface or top of the meter pit lid.
- Meter pits or wells should have six to 12 inches of gravel at the bottom to help with drainage.
- Large meter pits should have a drain or a sump pump if a drain is not possible. There should never be standing water in a meter pit or well.
- If at all possible, the meter pit or well should not be located in an area prone to flooding.
- The meter setting should have a shut-off valve on both sides of the meter (i.e., the customer's side and the water main side).
- If possible, the meter should be installed in a horizontal position.
- The meter should be easily accessible for service, inspection, and reading even if meter reading is via remote sensing equipment.
- Protect the meter from freezing.
- Always be mindful of public safety. Don't have the meter lid sticking up or have it too low so that it creates a hole.
- Install seals on the meter to reduce tampering and indicate when tampering does occur.

The following suggestions apply to larger meter vaults or pits:

- Large meter pits should also have a drain or a sump pump if a drain is not possible. There should never be standing water in a meter pit or well.
- To prevent disruption of service when replacing or repairing large meters, there should be a bypass that can also be metered. Having the bypass metered would be similar to a manifold set-up where you have two or more meters in parallel making service of one meter easy without service disruption or lost revenue.
- Large meter installations should have good structural support to prevent stress on the water line. Also there should be at least 10 times the pipe diameter of straight pipe before the meter and five times the pipe diameter of straight pipe after the meter.
- Some large meters recommend or require a strainer to be installed ahead of the meter.
- With large meters that are located in concrete vaults or pits, ideally, the meter face should be located over the hatchway to help with reading the meter, possibly reading the meter without even entering the pit. This will also help in lifting the meter from the pit. Remember, if the meter reader has to enter the meter vault or pit, this is considered a confined space entry and the proper safety procedures must be followed.

Small meter installation is easier with a meter yoke (also known as a meter setter). Meter yokes have different configurations and can have any combination of built-in check valves, regulators, and lockable shutoff valves. Utilities should have their own set specifications with illustrations depicting proper meter installations.

Meter Reading

There are two common types of water meter registers: circular and straight. Either of the meters can be manufactured to read in gallons or cubic feet. The circular register is somewhat more difficult to read.

The straight register is what is seen on newer meters and is read like a car's odometer. On some larger meters there will be a multiplier on the register face or the meter itself. The multiplier will be noted as 10X, 100X, or 1000X depending on the size of the meter. The multiplier indicates that the meter reader must multiply what is read by the number noted 10, 100, or 1,000. For example, if the register displays the number 975 and the multiplier is 10X, then the meter reading is 9750 gallons.

There are several different ways meter reading can be accomplished.

- Direct read is, as the name suggests, an individual directly reading the register.
- Remote reading is done through an electronic signal, usually with a wire to a separate station where the individual could either direct read or touch read.

- Touch read or plug-in readers use a handheld device that takes the electronic signal from plugging-in or touching the remote station and translates it into the number of gallons used. The remote station can even be on top of the meter pit lid. The readings are stored on the hand-held device until the meter reader gets back to the office to be downloaded to a computer.
- A newer development is automatic meter reading, which enables the meter reader to drive down the street and obtain the readings from the meters usually through radio transmission.

Selecting a Meter

Meters are selected using several factors: flow rate, size of pipe, pressure loss and safety considerations, such as fire service regulations. For sizes of one inch and smaller and low flow rates, positive displacement types of meters are common. For residential uses, 5/8" or 3/4" meters are used.

For medium flows, such as in apartment buildings, businesses, and public buildings, positive displacement meters in sizes of 1", 1 1/2", or two inches are used. In sizes of two and three inches, either, displacement, multi-jet, or turbine types of meters can be used. In the three- to four-inch size range, the meter type depends on the average flow rate. If the flow rate is between five and 35 percent of maximum flow rate, the positive displacement type is better. If the flow rates are going to be 10 to 15 percent of the maximum capacity, a turbine type should be used. If close accuracy at low flows is important, but large flows also have to be measured, a compound meter is best.

For large flows, velocity meters are more appropriate. Turbine meters are suitable for large flows where minimum flow rate is above 10 to 20 percent of maximum rating. Turbine meters have low pressure loss at high flow rates. Propeller meters are suitable for large mainlines or for pump station discharge.

Meter Testing and Maintenance

For meters to be effective, they must accurately read the amount of water flowing through them. Proper testing and maintenance procedures should be in place to assure accuracy.

Master meters—meters at the treatment plant that measure the largest water volumes—are the highest priority in the meter testing and maintenance program. These meters determine how much water is produced or sold and should be tested once a year. (More often if large amounts of water are measured through the meter.)

Industrial and commercial meters are the second testing and maintenance priority in the system. "The most expensive water loss in the distribution system is associated with under registration of industrial and commercial water meters, rather than leaks,"

says Jeff Bennett utility inspector with the West Virginia Public Service Commission. “Lost water sales are lost revenue at the retail rate. Lost water due to leaks is only the loss of the cost to produce the water.”

Bennett also points out, “a two-inch meter will, at a minimum, provide as much revenue as eight residential meters, while a six-inch meter will provide at least as much revenue as 50 residential meters. Since large meters provide considerably more revenue per meter, it only makes ‘cents’ to test them more frequently.”

Meters larger than two inches are usually tested in-place using a calibrated field test meter. To be able to field test a meter, there must be a tap and an isolation valve immediately downstream from the meter. This temporary connection can be made with a fire hose. Even new meters should be tested.

Master meters in water plants are, in some cases, difficult or impossible to test using a field test meter. In these situations, a draw-down test can be conducted, which involves comparing a known volume of water pumped out of a tank (clearwell) to the volume recorded on the meter being tested.

Although residential meters may be the final priority in the testing and maintenance program, in small systems, they may be the most important. The residential meters can be broken down to the ones that have high usage and the ones that don’t. It only makes sense to concentrate on residential meters that have high usage because of a big family or multiple occupants compared to residential meters that never reach the minimum bill because of single occupancy of an elderly person.

The majority of residential meters are the positive displacement type, which almost always slow down when they are worn or encrusted by minerals or debris. With residential meters, the testing program should either consist of periodic testing on a test bench or a complete change-out program.

Residential meters should be checked, cleaned, and calibrated every seven to 10 years or as indicated by your state primacy agency. If your system does not have a meter test bench, check with a neighboring system or shop around for a company that can do testing on a certified test bench.

Testing and maintenance of the meters depends on the quality and quantity of the water. If adverse conditions, such as high minerals or large flows are encountered, meters will require more frequent attention. Water that has high levels of minerals will affect the operation of a meter over time. This should be taken into account with a system’s preventive maintenance program by cleaning the meter to extend its life and to improve the accuracy of the meter.

Maintenance requirements will vary depending upon the material used in the meter components. Although plastic meters are less expensive, more maintenance and more frequent replacement may be necessary.

If your water system does not have any meters for residential connections, and you want to start metering it, a typical cost would be \$280 for connection (house). The price breaks down as follows:

• Direct read 5/8” meter	\$40
• Tandem meter setter (yoke) able to accept regulator	\$90
• Pressure regulator (3/4” typical size)	\$40
• Meter well (pit)	\$25
• Meter frame and lid	\$35
• Corporation-stop	\$15
• 6” service saddle	\$35
• Total for each connection	\$280

If the system has 200 residential connections, the total material cost would be \$56,000. With a meter life expectancy of 15 years, it would take less than \$1.50 per connection per month to recoup the cost.

If your system already has meters, but doesn’t have a good maintenance program, here is an example of revenue lost due to a slow residential meter (assuming a 4,500 gallons per month rate at a cost of \$25.00):

Loss with a meter 3 percent slow = \$0.75 per month or \$9.00 per year **for one meter.**

Loss with a meter 5 percent slow = \$1.25 per month or \$15.00 per year **for one meter.**

In some small systems, city buildings, golf courses, municipal swimming pools, and even the water plant are not charged. These connections should be metered to account for all treated water.

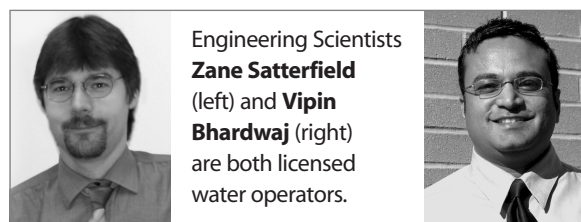
Keep in mind that if your system has a sewer utility, the loss is compounded, because most sewer utilities rely on water meters to bill for the sewer service. In these cases having an inaccurate water meter will have a direct impact on sewer revenue.

References:

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