BY JESSE YODER

WATER WORKS

Flowmeter Selection for Utility Applications

Water is one of our most important natural resources. We drink it, use it for cooking and cleaning, and depend on it in many aspects of our lives. As such, it shouldn't be surprising that we have a need to measure the amount of water we use. Whether it's measuring household or office building water consumption, measuring water in open channels coming from natural reservoirs, or measuring water used inside chemical or power plants, water flow measurement is often a necessity. Enter the flowmeter.

There are a number of different flowmeter types that can be used to measure water flow, each of which is based on different measuring principles and presents certain advantages and disadvantages. Which flowmeter is selected for a given job depends on accuracy and reliability requirements, whether the water is dirty or clean, cost, available suppliers, and many other factors.

In the utility sector, turbine and positive displacement flowmeters are the predominant technology types. However, while these two categories have traditionally dominated utility water and wastewater measurements, new-technology meters such as magnetic and ultrasonic are beginning to make inroads (Figure 1).

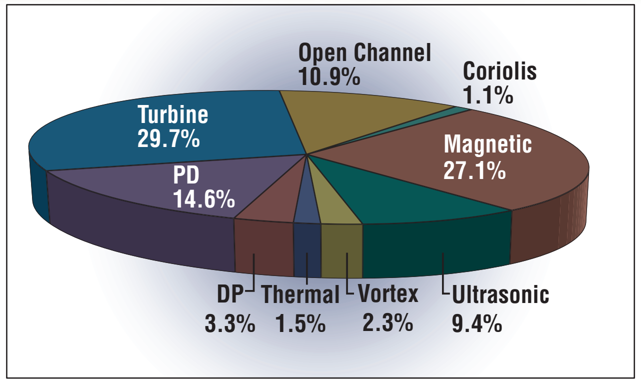

Figure 1. *Marketshare for Flowmeter Types Sold for Water and Wastewater Utility Applications in 2003*

Turbine

The word "turbine" means "spinning thing." Turbine flowmeters have a rotating blade that spins in proportion to flow rate. Unlike positive displacement meters, which excel at measuring fluids at low flow rates, turbine meters do especially well at measuring medium to high-speed flows. Turbine meters are also more adaptable to large pipe sizes than positive displacement devices, as they commonly support pipes over 12 inches in diameter. And they are widely used for custody transfer of commercial and industrial water and other liquids, as well as custody transfer of hydrocarbon-based liquids and natural gas.

Both the American Water Works Association (*www.awwa.org*) and the American Gas Association (*www.aga.org*) have formulated standards for the use of turbine meters for custody transfer purposes. With well over 100 suppliers worldwide, there are many types of turbine meters available for different applications.

Compound meters represent an interesting flowmeter type, as they use one form of technology when flow rates are low and another type when they are high. Low flow rates in compound meters are usually handled either by positive displacement or by single-jet or multi-jet turbines. High flow rates are handled by some type of turbine meter, usually either Woltman or axial. A typical use of compound meters is in apartment or office buildings, where flow rates peak during the day or evening, but are very low at night.

Positive Displacement

One of the most popular types of positive displacement meters used today for water applications is the nutating disc meter. Nutating disc meters were invented in 1830 by James and Edward Dakwyne. The Dakwyne's were granted a patent for a hydraulic pump using this same principle. In the early 1900s, these meters were improved when hard rubber became the material of choice for disc construction. The life of the meter was greatly extended by combining hard rubber on brass. This rubber and brass design was widely used until the late 1950s, when plastics and composites replaced the brass meter body and chamber.

Positive displacement meters capture the fluid to be measured in a small container of known size. They have counters that increment each time the fluid is captured. PD meters do very well in measuring the flow of viscous liquids, like oil, honey, and syrup. They also excel in measuring fluids with low flow rates. Besides being used for custody transfer of commercial and industrial water, PD meters are also used for custody transfer of hydrocarbon-based liquids to and from delivery trucks and airplanes. Regulatory bodies have approved their use for this purpose.

In addition, PD meters are widely used to measure water use in private homes and apartments. Their ability to measure low flow rates, along with their accuracy, makes them ideal for this purpose. While new-technology meters such as magnetic and ultrasonic are starting to make inroads in the PD water flow measurement market, positive displacement meters remain a prominent fixture in residential, commercial, and industrial water flow applications.

Magnetic

Magnetic flowmeters are widely used in the water and wastewater industry, where they have many advantages. They can measure flow in small and large pipes alike. Some magnetic flowmeters measure more than 100 inches in diameter. Magmeters are both accurate and reliable. Both inline and insertion models are available. Different liners make them applicable for sanitary applications and enable them to handle almost any type of liquid.

Unlike many other types of meters, magmeters can be used to meter dirty liquids and slurries. This makes them especially useful in the wastewater and pulp and paper industries. While magnetic flowmeters are highly versatile for measuring liquid flow, they have two main limitations. One limitation is that they cannot measure steam or gas flow, and the other is that they cannot measure the flow of nonconductive liquids. This limitation means that magmeters cannot be used for measuring hydrocarbon-based fluids.

Application Notes

Turbine: Turbine meters are particularly well suited for measuring medium to high-speed flows.

Positive Displacement: PD meters excel in measuring fluids with low flow rates.

Magnetic: Magnetic flowmeters are widely used and have many advantages in the water and wastewater industry.

Open Channel: Open channel flowmeters are often used to measure flow in water treatment plants.

Ultrasonic: Ultrasonic Doppler meters can measure the flow of dirty water and water containing particles, such as sand or gravel.

Magnetic flowmeters have coils that are mounted onto or outside of a pipe. As current is applied to the coils, a magnetic field is generated. As liquids pass through this magnetic field, a voltage is produced that is proportional to flow rate. This voltage is detected by electrodes that are mounted on either side of the pipe. The flowmeter computes flow rate based on the amount of voltage generated, along with other values.

While some early magnetic flowmeters used AC current to generate a magnetic field, more recent models use pulsed DC current. The use of pulsed DC current makes it easier to calibrate the meter in zero-flow condition. However, some pulsed DC meters have a difficult time generating a pulse sufficiently strong to measure the flow of dirty liquids. As a result, magmeters with AC current are still used for some difficult-to-measure dirty liquids.

Open Channel

Open channel flowmeters are designed to measure the flow of water and other liquids in rivers and streams, as well as in channels where flow occurs due to gravity. The flow of liquids in partially filled pipes that are not pressurized is also considered open channel flow. Open channel flowmeters are widely used in the water and wastewater industry. They are used to measure flow in water treatment plants, and also to measure water that is traveling from a natural resource, such as a dam or reservoir, to a water treatment facility.

Some open channel flowmeters use a weir or flume — a type of hydraulic structure that water passes through. Flow rate is calculated based on its level or depth as it passes through the weir or flume. Other open channel flowmeters use a velocity-area technique. Velocity-area flowmeters use one method to compute the velocity of the flow stream (e.g., electromagnetic), and another method to determine the level or depth of the flow stream (e.g., radar). Flow can then be calculated, provided the area of the flow stream is known.

Ultrasonic

Ultrasonic flowmeters come in two flavors: transit time and Doppler. Transit time meters are mainly used with clean fluids, although technology advances have widened their use to include fluids with some impurities. Transit time meters send one ultrasonic signal from a transducer across the pipe to another transducer that receives the signal. They also send a signal from the transducer on the other side of the pipe back to the original transducer. The signal moves faster when it travels with the flow than when it travels against the flow. Flow rate is computed based on the difference between the two transit times.

Doppler flowmeters work somewhat like transit time meters, in that they send an ultrasonic signal into the flow stream. However, instead of sending a signal all

Magmeter Application

City of Orlando Implements New Wastewater Measurement System

The Iron Bridge Regional Water Reclamation Facility, which is owned and operated by the City of Orlando, bills customers based on the amount of wastewater it processes. One of its customers, the North Authority, feeds wastewater through one large force main from a number of upstream points and calculates total monthly input based on the sum of several flowmeter readings. In total, the North Authority — a region comprised of unincorporated portions of Seminole and Orange counties — serves about 150,000 people and inputs about nine to 11 million gallons of wastewater to Iron Bridge per day.

Hence, flowmeter accuracy is an important issue, and, to that end, Iron Bridge recently implemented a rather robust metering system.

How Billing Is Determined

Once a month, the North Authority sends a Flow Report to the City of Orlando's Wastewater Billing Group. This report contains several input subtotals as determined from readings of 25 different flowmeters. The city compares the sum of the authority's subtotals with the totalized flow measured for the month by the master meter on the authority's input main. By mutual consent, the two totals must agree within five percent of each other.

There are two master magnetic flowmeters installed in parallel on the two branches of the wastewater input main. The master meters are located underground in a vault, accessible via a trap door. Each sensor connects by cable to its respective transmitter, mounted on the metering station panelboard. Above each transmitter is a circular chart recorder that plots wastewater flow rate on a seven-day cycle and totalizes the flow continuously.

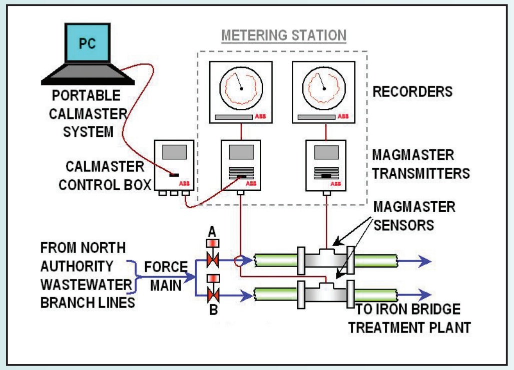

Figure 1. *In the North Authority metering station, two master magnetic flowmeters are installed in parallel on the two branches of the wastewater input main. A portable electronic system, named CalMaster, is used to verify and re-certify accuracy of the two master meters.*

Only one magmeter is used at a time, with the other serving as a standby. Valves "A" and "B," also underground in the vault, are installed on the two branch lines, upstream from the meter sensors. Operated manually at the station, one valve shuts off flow to the standby meter while the other opens the line to the active meter.

Until a radio telemetry system was installed in April 2003, staff drove to the metering station twice per week, more than two miles from the plant, to obtain totalized flow readings. On one such occasion, the active meter's seven-day chart was changed. Back at the plant, the totalized flow readings were e-mailed to the North Authority as interim "FYI" reports.

Installation of the telemetry system now provides automatic digital transmission of instantaneous flow and totalized flow readings every 30 seconds to the Iron Bridge facility. The system is connected to a computer that logs the information and automatically sends out e-mails to the North Authority. This not only cut travel time in half but also took over the task of e-mailing the information. What's more, the readings are truer because they are scheduled at exactly the same time (midnight) each day.

Both the North Authority and the city benefit from automatically receiving this daily data. It gives everyone a more current picture of flow conditions and provides valuable information regarding any unusual patterns of wastewater input flow.

MagMaster Magmeters Chosen

For sustainable high accuracy and performance, two 24-inch MagMaster magnetic flowmeters — manufactured by ABB (*www.abb.com*) — were installed to run as the master meters. Each of the meters can measure wastewater flows up to 64.45 million gallons per day. Daily flow rates from the North Authority vary over a wide range — typically from 900 to 15,000 gallons per minute.

A qualified ABB field service engineer is scheduled to visit the site on a yearly basis to check the calibrated accuracy of the master meters. With millions of gallons of wastewater being metered every day, only a few percentage points of error can very rapidly add up to literally thousands of dollars in questionable billings. As such, the ABB field service engineer uses a portable electronic system, named CalMaster, to verify and re-certify accuracy of the two master meters.

The system, which is designed to function specifically with the MagMaster meter, includes a portable computer that contains the necessary software to carry out a pre-programmed verification procedure. It also features a control box that enables the engineer to connect to the panel-mounted magmeter transmitter. Note that each transmitter remains connected to its sensor located in the vault during this process (Figure 1).

Once the system has been connected, the test procedure is initiated, and, in a few minutes, the system performs a verification procedure. The test checks out the entire magmeter system — the transmitter, the sensor, and the interconnecting cable.

To confirm that test results meet approved standards, the service engineer reviews them on the PC's display. If positive results are provided, a certificate of validation is printed for the tested meter.

The CalMaster can also serve as a diagnostic tool used for preventive maintenance on the master meters. It stores all previous validation data for each tested meter and, on its computer screen, can plot trend curves of data for selected components. If a curve shows gradual deterioration of the component, the affected meter can be repaired or replaced in-line while the standby meter takes over active measurement.

Information for this article was supplied by Roy A. Pelletier and Andrew J. Harbison. Mr. Pelletier is assistant division manager for the City of Orlando. Mr. Harbison is instrumentation chief for the city's Environmental Services Wastewater Division.

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Telemetry System Specifications

The radio telemetry system installed at the metering station connects directly to the RS232 communications port of each magmeter transmitter — the same port that is used to perform a CalMaster certification. Freewave 900 Mhz spread spectrum radios have been selected; these units do not require an FCC license.

Along with the radios, two types of computer software are used: Microsoft Visual Basic and Automate. Key Solutions Inc., a consultant to the City of Orlando, wrote the Visual Basic telemetry interface to the ABB magmeters. The Automate program provides automated dial-up networking and e-mailing of the flow readings to all appropriate parties.

the way across the pipe, Doppler flowmeters bounce their signals off of particles in the flow stream. As the signals bounce off the particles, a frequency shift occurs that is proportional to flow rate. A receiver detects this frequency shift, and the flowmeter computes flow based on this difference.

While transit time meters typically get more attention than Doppler meters, Doppler meters are of special importance in the water and wastewater industry. Like magnetic flowmeters, Doppler meters can measure the flow of dirty water and water containing particles, such as sand or gravel. Measuring flow under these conditions is difficult for many other types of flowmeters. Most flowmeters perform best with clean fluids. Even though Doppler flowmeters do not have the same accuracy as transit time meters, they still play an important role in measuring flow under difficult conditions. Doppler meters are particularly well suited for flow measurement in the wastewater industry, which often requires the measurement of dirty water high particle counts.

And the Rest...

Other flowmeters used in the water and wastewater industry include differential pressure, vortex, thermal, and Coriolis. While these types are not as widely used as the aforementioned meters, they still have a place in the water and wastewater market. In examining the appropriateness of a given flowmeter type, it is important to keep in mind that proper selection depends on the accuracy required, the condition of the fluid being measured, cost, the experience of the end-user, and other factors. As a result, a user must have a thorough understanding of the specific requirements of a water application before selecting a flowmeter for the job. This is particularly important when considering a flowmeter that isn't typically used for water and wastewater applications. FC

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