

## **TAKING CLOSED PIPING FLOWMETERS TO THE NEXT LEVEL – NEW TECHNOLOGIES SUPPORT TRENDS IN DATA LOGGING AND SCADA SYSTEMS**

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### **ABSTRACT**

We are seeing some clear trends in water distribution and management systems which are especially true in the irrigation market where water is a precious, but sometimes scarce resource. Among these trends are usage regulations, advances in water monitoring equipment, data logging capabilities, and Supervisory Control And Data Acquisition (SCADA) systems or wireless telemetry systems. These trends require more sophisticated closed-pipe flowmeters with better accuracy, reduced maintenance, and less complicated retrofits into the existing piping system. New innovations in ultrasonic and electromagnetic flowmeter technologies bring battery-powered systems to remote locations where power is limited or too expensive to install. These new flowmeters allow full operation and offer extended battery life of up to 6 years. They also have beneficial features including alarm call up via cell phone modules, SMS text messages, drive by readings, and even web-based data transmission.

### **INTRODUCTION**

#### **Artificial rain**

According to [www.irrigation.org](http://www.irrigation.org), 97% of the water on earth lies in the oceans and seas, and 2% is locked up in glaciers. This leaves only 1% available for human consumption. The sources for the remaining 1% include rivers, lakes, streams, canals, and ground water wells.

Agricultural irrigation alone accounts for approximately 85 to 90% of surface water withdrawals. These withdrawals can reduce a river's flow 100%, essentially drying it up. In addition, underground aquifers are being depleted and some existing wells are no longer deep enough to reach water.

In some areas, overuse and heavy demands on these sources are depleting them at an alarming rate. Because of these challenges, agricultural irrigation is fast

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becoming the target for regulations and many state, county, and local agencies already have, or soon will have, requirements to register wells and to monitor the water usage. Some of these agencies are simply monitoring, while others are actually limiting the usage. As stricter water management practices are implemented, flowmeters will become mandatory to document water usage. As an example of stricter regulations, California Senate Bill 820, known as the Mega Water Bill, would require all users extracting more than 25 acre-feet annually to file a report with a state agency. Failure to do so would result in penalties, including fines, the potential forfeiture of water rights, and ineligibility for future state grants.

### **Real-time Resource Management**

The most powerful and utilized tool in water management is Supervisory Control and Data Acquisition (SCADA) systems. With the ability to remotely monitor real-time flow rates, water consumption, soil moisture, and reservoir inventory levels, irrigation districts can distribute water in the most efficient manner. Key components of SCADA management systems are the monitoring and integration of such points.

Even though many well heads or down-stream water distribution points already have equipment to monitor their output, the majority of them do not have monitoring equipment at all. Wherever new regulatory laws take effect, users will be required to comply by installing or retrofitting a flowmeter, often into short piping systems not originally designed to accommodate them.

Other benefits of monitoring usage with an accurate flowmeter include ensuring that the scheduled amount of water is actually applied, avoiding over-watering, minimizing fertilizer runoff, and eliminating surface and groundwater contamination. Accurate and repeatable record keeping is necessary for planning, managing, and annual water budgeting or cost estimation. Monitoring the flow of irrigation water is an essential aspect of efficient irrigation management.

At a minimum, flowmeters indicate instantaneous flow rate and keep a running total of the volume over time. Most flow rate indicators report in gallons per minute (gpm) or in cubic feet per second (cfs). Total flow indicators or totalizers typically report in gallons, acre-feet, or cubic feet. Monitoring and managing these resources not only requires an accurate flowmeter, but one that is reliable.

### **Mechanical Flowmeters**

The industry standard flowmeter for well monitoring is a propeller-type flowmeter. Because propeller flowmeters are mechanical devices, they pose many challenges: integration with SCADA systems, frequent maintenance, difficult to meet installation requirements, dirty water supply, and sabotage.

Propeller meters are mechanical devices that require costly non-standard add-ons to integrate with SCADA systems to provide minimal information, such as the totalized flow. Although this option exists, the typical method of bringing data from propeller flowmeters into a SCADA system is by manual readings followed by manual data entry.

With internal parts that move and subsequently wear, propeller flowmeters require periodic maintenance to keep them in working and reliable condition. They also require at least 15 straight pipe diameters in front of them to properly condition the flow profile.

Adding the required piping to accommodate a propeller flowmeter is not always an easy task. In typical installations, the piping system after a well pump head is limited and usually consists of a short length of horizontal pipe that takes a 90-degree turn downward and is buried underground to minimize the above ground obstruction, leaving it useful for farming. This short run of exposed pipe is not the ideal location for a propeller flowmeter. In order to accommodate the flow conditioning requirements of a propeller flowmeter, the user is required to dig up the existing underground piping and place a longer straight section of pipe above ground.

Another installation requirement is having a relatively clean water source. Propeller flowmeters are prone to clogging with trash and algae from open channels, while silt and sand from rivers will accelerate maintenance frequency. Occasionally, saboteurs may purposely clog the propeller flowmeter for financial gains.

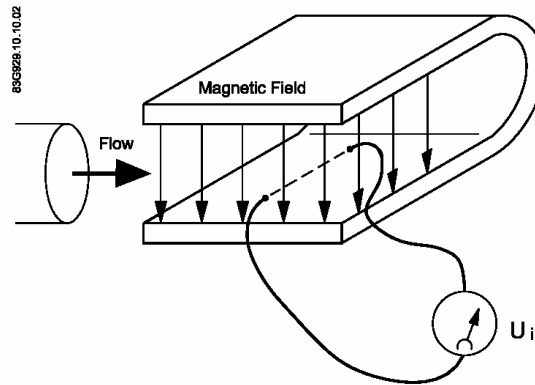
When installed correctly, mechanical flowmeters are reasonably accurate. Without the straight pipe installation, however, accuracy suffers considerably. Retrofitting the pipe to accommodate a propeller flowmeter can be a difficult and costly endeavor.

Because of growing demand and technical advancements, there are new breakthroughs in flowmeters specifically designed for the irrigation market. Based on advancements in electromagnetic and acoustic technologies, these new flowmeters offer increased accuracy, require virtually no maintenance, operate on a replaceable internal battery with up to 6 years of operation without the need for solar panels or additional power sources, provide more flexible installation condition requirements, and easily integrate with SCADA systems.

### **Electromagnetic flowmeters**

Electromagnetic flowmeters, often called magnetic flowmeters or simply magmeters, are based on Faraday's law of electromagnetic induction. The first

practical version was created in the late 1930's. When an electrical conductor of length  $L$  is moved at velocity  $v$ , perpendicular to the lines of flux through a magnetic field of strength  $B$ , a voltage  $U_i$  is induced at the ends of the conductor.



Simply stated, when a conductor is passed through a magnetic field, a voltage is generated. The amplitude of the voltage is directly proportional to the velocity of conductor. In a magnetic flowmeter, a coil within the housing creates the magnetic field. When a conductive liquid passes through the flowtube, a voltage is induced. The voltage is measured between two electrodes which come in contact with the fluid. The cross-sectional area within the flowtube is constant as is the distance between the electrodes. The only variable is the velocity of the fluid as it moves past the electrodes. The faster the fluid travels, the greater the amplitude of the voltage.

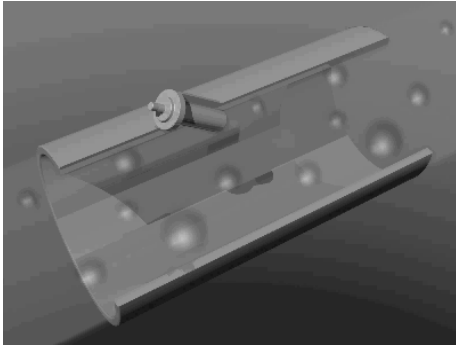
Because of the operating principals, magnetic flowmeters require a fluid with some electrical conductivity (i.e., the ability to conduct an electrical charge), typically above  $>5 \mu\text{S}/\text{cm}$  (microSiemens/cm). Most aqueous solutions have enough conductive dissolved solids to meet this requirement, however, ultra-pure water, some solvents, and most hydrocarbon-based solutions do not.

Since electromagnetic flowmeters have no obstructions, they create little or no pressure drop, an important factor in piping design with respect to pump size and their associated energy costs. This is especially true in gravity-fed applications that have very little pressure to begin with. Since they have no moving parts to wear out, maintenance is greatly reduced or nearly eliminated in many applications. The new battery-powered electromagnetic flowmeters offer greater accuracy than propeller-type flowmeters even in non-optimum installation conditions. Whether line-powered or battery-powered, both offer exceptional linearity over a wide measuring range, even in bidirectional flow applications

### Ultrasonic flowmeters

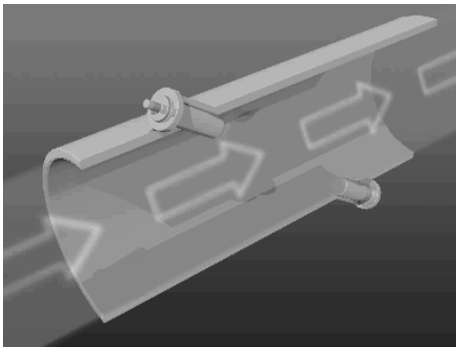
There are two different types of ultrasonic flowmeter designs; Doppler and Transit Time.

Doppler ultrasonic flowmeters have a transducer mounted at an oblique angle in



relation to the pipe. The transducer generates and focuses an ultrasonic sound wave into the fluid. Suspended particles or air bubbles within the media reflect the sound waves back to the transducer, which now acts as a receiver listening for the return echo. The delay in the echo is measured and directly correlates to the velocity of the particle, which is assumed to be equal to the fluid velocity.

Transit Time ultrasonic flowmeters have two transducers, again mounted at an oblique angle to the pipe and flow stream. One transmitter sends sound waves through the media to a second transmitter mounted on the other side of the pipe. The transducers alternately send the sound waves through the fluid, both upstream



and downstream. The time it takes for the sound to travel from one transmitter to the other is precisely measured. Velocity measurement is accomplished by comparing the time the sound wave takes to travel with the flow versus against the flow ( $\Delta$  Time). Some transit time flowmeters (generally permanent installations) make use of multiple acoustic paths to better sample the flow profile.

The signal in a Doppler type flowmeter is easily attenuated by the process so viscous fluids or suspended solids in the fluid may cause a loss of signal. Transit time flowmeters are still susceptible to this, but to a much lesser degree. Transit time principal has an advantage over Doppler in that it is independent of variations in the actual sound velocity of the liquid, such as temperature.

Like electromagnetic flowmeters, additional benefits include reduced maintenance, exceptional linearity over a wide measuring range, and even bidirectional flow measurements. With both types of flowmeters, overall performance increases, while the total cost of ownership is sharply reduced.

### **Additional benefits of non-mechanical flowmeters**

With both electromagnetic and ultrasonic flowmeters being microprocessor based, they come with additional benefits, such as data logging, diagnostics, and digital communications. Localized data logging eliminates the need for daily meter runs and allows irrigation districts to utilize their resources more efficiently. Visual diagnostics can better prepare technicians to remedy problems without having to pull flowmeters out of service. On-board digital communications, such as Modbus, allow for seamless integration into existing SCADA systems providing real-time data and diagnostics. In some cases, electromagnetic and ultrasonic flowmeters provide an open communication platform to incorporate emerging communication technologies as they gain traction such as GSM, Satellite, Zigbee, Wireless Ethernet, etc.

### **SUMMARY**

Traditional mechanical flowmeters require periodic maintenance to ensure their functionality. New, non-mechanical, microprocessor-based flowmeters provide long-term, trouble-free accuracy and are capable of seamlessly integrating data with SCADA and other telemetry systems. They also often have a wider velocity measurement range than mechanical meters and can usually measure reverse flow.

With better water management practices, recent advancements in flowmeter technology, and modern communication platforms, efficient and effective irrigation is now possible. Better technology in water management not only saves time and money, it helps secure the future of one of our most precious resources: water.

### **REFERENCES**

www.irrigation.org web-site  
The Irrigation Association Statesman – May 2005