METERING

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Contents

Summary

Metering in water transport systems provides a measure of the quantity of water that passes a point in the system. Metering is required to ensure conformance to water rights, to establish a basis for revenue, to control system equipment, and to provide information for planning future needs. Only the more common flow-metering methods are described herein.

1. General Considerations

The first consideration for selecting a meter is the presence of suspended solids in the flow. Gross solids in sewage or raw water flows can foul many meter types. Abrasive solids such as sand may cause excessive wear in certain types of meters. Some meters are suitable only for clear water. On the other hand, some meters require the presence of either suspended solids or entrained gas bubbles to function.

Another basic selection consideration is the required measurement accuracy. No meter is free of measurement error. Accuracy requirements should be established considering the value of the water and the purpose of the measurement. A corollary of meter accuracy is the useful measurement range of the meter. Generally, meters with greater accuracy over a wide flow range are more expensive than less accurate meters or meters that produce the required accuracy over narrow flow ranges.

Meters require energy to operate. Many meters extract this energy from the flowing water. The usual result is a finite head loss through the meter. Some meters obtain energy from an outside source, usually electricity. Most practical metering installations obtain some of their operating energy from the water flow and the remainder from an electricity source such as commercial electric power, batteries, or solar converters. In those situations where electricity is not available except by utilizing batteries or solar panels, meters that obtain most of their operating energy from the flowing water are advantageous.

Secondary instrumentation associated with metering installations such as recorders, totalizers, data loggers, and telemetry equipment also require energy in addition to the energy required by the metering element itself. In modern practice, secondary instrumentation is generally electrically powered except for small positive-displacement revenue meters where a mechanical register is typically driven directly by the measuring element.

In many situations, particularly revenue meters, data security is an important consideration. If totalizers are operated by electric power, batteries are usually required to ensure that the flow measurement is not lost if there is an electric power failure. Batteries for solar converters are required to supply electricity during non-productive periods of the solar converter.

Metering data are frequently transmitted to a central location for indication and/or totalization. Any meter that utilizes electric secondary instrumentation can readily be fitted with telemetry equipment. Meters with mechanical registers can also be fitted with telemetry equipment, but telemetry equipment on mechanical registers is somewhat cumbersome and is not widely used at this time. Telemetering a measurement to a central location saves time, reduces errors, and eliminates the need to visit the meter physically to renew recorder charts and/or to transcribe totalizer readings manually.

2. Flow Measurement Methods

Various methods for the measurement of flow quantity are given in Table 1 for both open channels (OC) and for pipes under pressure (PP). The expected errors are given as a percentage of the upper range value (URV) or as a percentage of the flow rate at the time of measurement (rate). The lower error (where given) can be only be obtained under carefully controlled laboratory conditions, and the larger value is likely under the best field conditions with care in design, installation, and operation. Many open channel meters rely on head measurement, which introduces additional error. An investigation of many flow meters in sewage service in the United States in 1975, showed errors of 10 per cent were normal and errors of 50 to 200 per cent were not uncommon. Meters must be installed carefully and *exactly* as recommended by the manufacturer.

Type	Use		Expected error	Relative cost	Remarks
	OC[a]	PP[b]			
Acoustic flow profiler	✓	✓	2% of rate	Moderate	Proprietary. Manufactured by MGD Technologies. Not for clean water.
Current meter	✓		10% of rate	Low	Frequently used where permanent meter not justified.
Flumes:					
Long-Throated	✓		3% of rate	High	Good for all waters.
Palmer-Bowlus	✓		3% of rate	Moderate	Good for sewage.
Parshall	✓		5% of rate	High	Good for water and sewage.
Magnetic		✓	½-1% of rate	High	Accurate. Cost effective for small (<500 mm) pipes.
Orifice		✓	½% of URV	Low	Not for dirty water.
Submerged orifice	✓		3% of rate	Moderate	Not for dirty water.
Pitot tube		✓	2% of URV	Low	Not for dirty water. Velocity >1 m s^{-1} for usable signal.
Positive displacement		✓	2% of rate	Low	Custody transfer for small (household) flows of clean water.
Propeller		✓	3% of rate	Low	Not for dirty water.
Tracers	✓	✓	1-2% of rate	High	Used to calibrate permanent flow meters.
Transit-time ultrasonic	✓	✓	2% of rate	Moderate	Limited use with dirty water.
Venturi tube		✓	½% of URV	High	Widely accepted for custody transfer.
Weirs	✓		2% of rate	Moderate	Not for dirty water. High head loss.

[a]for open channel flow [b]for pipes under pressure

Table 1: Devices for measuring flow rates

3. Acoustic Flow Profiler

Doppler meters use an electro-acoustic transducer to project an ultrasonic pulse of known frequency into a flowing fluid. If suspended solids or gas bubbles are present in the fluid, the acoustic pulse is reflected back to the transducer with a frequency shift proportional to the speed at which the particle is moving toward or away from the transducer in accordance with the principal developed by Christian Doppler (1803-1854).

Many commercial Doppler meters are available, but suffer from errors introduced by variations in the speed of sound through a fluid and the unknown trajectory of the

particle(s) that reflect the ultrasonic pulse. As such, these meters do not provide reasonably accurate flow measurement.
The acoustic flow profiler is a proprietary meter (based on the Doppler principle) manufactured by MGD Technologies, San Diego, California, USA, (web site: www.mgdinc.com).

It incorporates sophisticated technology to correct most of the errors inherent in other Doppler flow meters. Excellent accuracy has been demonstrated in both open channels and pressure pipes and also in highly distorted flow profiles. As with any Doppler meter, suspended solids and/or gas bubbles must be present in the flow to provide reliable reflection of the ultrasonic pulses.

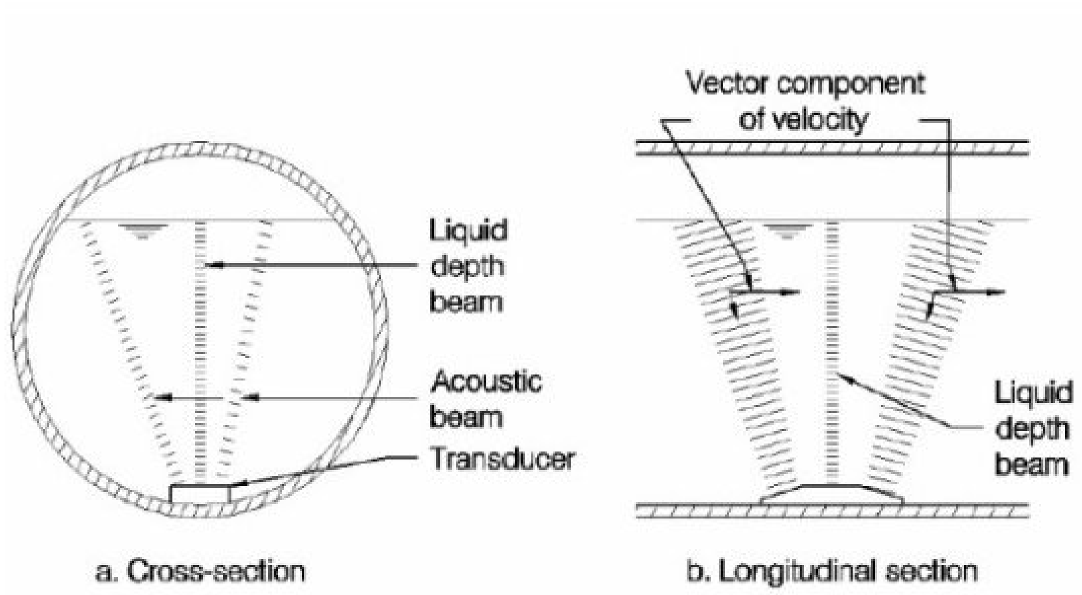

Figure 1: Acoustic flow profiler.

4. Current Meter

A current meter is a zero head loss device. The measuring element in a current meter is either a propeller or cup rotor attached to an upright staff. Current meters are mostly used to survey the water velocity at several to many points in an existing channel. No modification to the channel is required, but a reasonably straight section with uniform approach conditions should be selected to limit the number of required velocity measurements.

Boats, cableways, bridges, or wading are used to position the current meter at various locations in the flow cross-section. The geometry of the channel cross-section must also be measured for determining the area. The accuracy of flow measurements depends partly on the number of velocity determinations made. Experienced surveyors can obtain errors as low as 10%. Current meters are particularly useful for calibrating the stage or water level in rivers versus flow rate to permit determining flow. Such calibrations permit the determination of flow by simple stage measurement either telemetered or recorded on a strip chart.

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Biographical Sketches

Robert S. Benfell, P. E. (deceased), had received his Bachelor of Science in electrical engineering from the University of Washington in 1957. He then worked for Westinghouse Electric Co. in the Large Electrical Machines group. He returned to Seattle in 1966 to work for the joint venture firm, Metropolitan Engineers, engaged in designing facilities for an area-wide wastewater interception, treatment, and disposal project serving the Lake Washington drainage basin in Seattle, Washington, USA. Mr. Benfell's responsibilities included the design of electrical and instrumentation systems for several large wastewater pumping stations and the design of CATAD (Computer Augmented Treatment And Disposal), a computerized system for control of flow in an the area-wide interceptor system serving the metropolitan Seattle area. The system was designed to prevent overflow to local waters when storms influenced conditions in a combined sewer system serving almost 500 square miles along the shores of Lake Washington and Puget Sound. The CATAD system, the first of its kind, regulated flows in the interceptor system to store dry weather flows in large diameter combined sewers and allow storm-influenced wastewater to flow to downstream treatment plants. The back-to-back computer system (two computers for redundancy) controlled over 75 pumping stations and automated regulator stations to effectively reduce the incidence of overflows to local waters. The system was controlled through leased telephone lines and had provisions for local as well as computerized control of local stations to retain functionality when system communications were not available.

Mr. Benfell, registered in the states of Washington and Oregon, joined Brown and Caldwell, San Franciso, in the early 1970s after completion of the Seattle project. After eight years in San Francisco, he transferred to the firm's Seattle office where he remained until his untimely death in 1999. During his career, Mr. Benfell was responsible for the electrical and instrumentation design some of the firm's most noteworthy projects and was involved in all aspects of planning, design, construction assistance and startup services on all projects involving instrumentation; wire, fiber-optic, and UHF and microwave radio communications; and digital and analog process control systems in water and wastewater pumping and treatment systems**.**

Robert L. Sanks, Ph.D., P.E, is Professor Emeritus, Montana State University at Bozeman and a consulting engineer. He has B.S. and Ph.D. degrees from the University of California at Berkeley and the M.S. degree from Iowa State University. He established the graduate environmental engineering program at Montana State University, directed it, and taught the subject for many years. He conceived and directed the Conference on Pumping Station Design for the Practicing Engineer and was Editor-in-Chief for the first (Award of Excellence, Association of American Publishers) and second editions of Pumping Station Design published by Butterworth-Heinemann. He has studied hydraulic models of pump intake basins for many years and has consulted on the design of several medium to large pumping stations. He has written five books and many papers and monographs. He is a Life member in American Society of Civil Engineers and a member of American Water Works Association and Water Environment Federation.