IRRIGATION

Propeller Meters for Irrigation no. 4.710

by R.G. Evans[1]

Quick Facts...

Accurate measurement of water helps producers to increase irriga

tion efficiencies and reduce both energy and costs.

Flow measurement facilitates water management. This can be done with the use of a flow measuring device.

Propeller meters can provide accurate measurement of flow rate and volume if properly selected, installed and maintained.

Accurate measurement of water is of primary importance to increase irrigation efficiencies, reduce pumping energy and reduce fertilizer costs. Growers must know how much water they're using, as well as the location of the water, if they are to manage it properly. Flow measurement also provides for equitable division of water between users.

High irrigation efficiencies reduce costs by minimizing the leaching and surface runoff of nutrients (which require substantial amounts of energy to produce) and reduce the amount of water applied to meet crop needs. Flow measurement greatly facilitates water management and can be used easily with the proper selection and installation of a flow measuring device.

Closed-conduit flow can be measured by numerous types of devices, such as orifice, venturi meters, electromagnetic and sonic devices, Collins and Cox meters (pitot tubes), shunt meters, and impeller and propeller meters. Each type has specific advantages and disadvantages. This fact sheet discusses only the propeller meter since it is the most common closed-conduit method used in Colorado (Figure 1).

Propeller meters can provide accurate measurement of flow rate and volume if properly selected, installed and maintained. Most manufacturers state that plus or minus 2 percent accuracy can be attained with propeller meters. These meters measure only the average velocity (i.e., revolutions per second) of the water in a pipe and mechanically translate this information into a flow rate and/or volume reading. This is analogous to the speedometer and odometer in an automobile.

Each meter is calibrated for strict conditions such as the specific inside diameter of a pipe section. The flow must be relatively uniform, within a specified flow range, and the pipe must be completely full of water while measuring. There are several manufacturers of propeller meters, and it often pays to compare brands. The cheapest is not always the most economical or reliable.

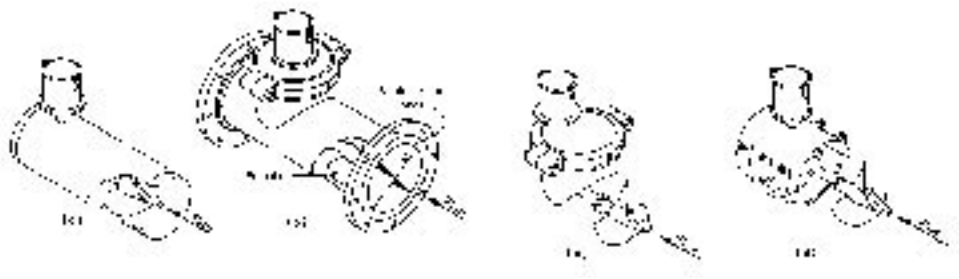

Figure 1: Typical propeller meters for use in irrigation. a) Weld-on in-line type. This type also can use compression-type connectors. b) Flange bolt-on in-line meter. c) Weld-on saddle-type meter. d) Clamp-on saddle meter.

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Putting Knowledge to Work

Table 1: Common flow rate ranges for propeller meters.

Meter size	Minimum flow (gpm)	Maximum flow (gpm)
4 inches	50	400
6 inches		90
900		
8 inches	100	1200
10 inches	125	1500
12 inches	150	2000

Selection of a Propeller Meter

The size of a propeller meter for irrigation depends primarily on the flow — the rate the water is pumped. Table 1 indicates typical flow rate ranges for common sizes of propeller meters. It is not advisable to operate near either of the extreme values indicated in this table. For example, a 900 gpm system should use an 8-inch or 10-inch propeller meter rather than a 6-inch meter.

Three additional things to consider when ordering a propeller meter are the inside diameter of the pipe, the units of flow measurement, and the quality of the water.

The inside diameter is important since the individual meters are preset by the manufacturer for a specific type and size of pipe. For example, the inside diameter of 8-inch Schedule 40 steel pipe is different from 100 psi 8-inch plastic irrigation pipe, and 8-inch aluminum tubing has yet another value. The meter gear mechanisms mechanically multiply the velocity of the water times the full cross-sectional interior area of the pipe. Consequently, large errors can be introduced by using a meter calibrated for another pipe classification.

For saddle-type meters, the wall thickness of a pipe can influence the location of the propeller, which should be located exactly in the center of the pipe. If a tube-type propeller meter is installed, the wall thicknesses and the inside diameters of the pipe and meter should match as closely as possible. If the outside diameter and wall thickness are known, subtract twice the wall thickness from the outside diameter to obtain the inside diameter.

Almost all propeller meters record the total volume of flow and, optionally, rate of flow. Generally, the totalizing-only meter is considerably less expensive. Rate of flow can be determined using a stop-watch and the “sweep” hand on the meter dial.

Meters can be ordered with almost any flow measurement units. Some of the more common volume units are acre-feet, acre-inches, gallons, cubic feet, cubic meters and liters. Many farmers prefer to use acre-inches (one acre-inch will cover one acre to a depth of one inch) because of the ease in calculating the depth of application in inches.

Common units of flow rate are gallons per minute, cubic feet per second, cubic meters per second and liters per second. Gallons per minute is probably the most widely used in the United States. It is possible to order meters with the totalizing units completely different from the rate-of-flow units, such as acre-

inches and gallons per minute, respectively. Table 2 gives a list of equivalent units for water measurement. By knowing the rate of flow, the volume applied can be calculated using Table 2. For example, a 900 gpm well will apply approximately 2 inches to 1 acre in one hour (900 / 452 is approximately 2). The total application per irrigation set can be calculated using the following formula:

Application (inches) = (flow rate, gpm) * (hours per set) * (acres per set)

The readout dial (indicator head) usually is mounteddirectly on top of the meter, but can be ordered with the dial extending above the ground or electronically transmitting the information to the pump house or other central location. There are numerous other possibilities. Order the meter to meet specific requirements and personal preferences.

When ordering a meter it is wise to order straightening vanes to place in front of the meter, particularly with turbine pumps. This reduces turbulence and maximizes the uniformity of flow for best measurement. If sediment (sand, clay or silt) is pumped, it is advisable to use a magnetic drive with sealed bearings, although the sediment will still considerably shorten the expected life of the meter.

The diameter of the propeller usually is 50 to 80 percent of the inside diameter of the pipe. Generally, the larger the propeller, the better the measurement, because the average velocity is used. If a pipeline is carrying

Table 2: List of equivalent units for water measurement.

Volume units	
1 gallon	= 8.33 pounds
1 cubic foot	= 7.48 gallons
1 acre-inch	= 3.630 cubic feet
1 acre-foot	= 43,560 cubic feet
1 acre-inch	= 27,154 gallons
1 acre-foot	= 325,851 gallons
Rate-of-flow units	
1 cubic foot per second	= 449 gallons per minute (use 450 gpm for most cases)
1 cubic foot per second for 1 hour	= 1 acre-inch
452 gallons per minute for 1 hour	= 1 acre-inch
1 gallon per minute	= 0.00223 cubic feet per second
1 gallon per minute	= 0.00221 acre-inches per hour
38.4 Colorado miners inches	= 1 cubic foot per second

debris, such as sticks or gravel, it is best to use the smaller diameter propeller because the objects could jam the meter. However, for accurate results, exercise more caution with the placement and installation of the smaller propeller. If the pipeline is carrying moss, aquatic weeds or other vegetation, use screening or other means to remove this material before it reaches the meter.

Saddle-type propeller meters are bolted or welded over a precut hole in the pipe. They are the easiest to install and generally the least expensive. Tube-type meters that are premounted in a pipe section are installed in-line with compression-type fittings, flanges, or are welded between two adjacent sections of pipe. Bolt-on saddle meters or bolted flange connectors are recommended for agricultural users because of the easy removal for inspection and/or repair. Tube-type meters also can be ordered with special adapters to fit directly into aluminum or other special types of tubing.

Installation of Propeller Meters

The first consideration in installing the meter is to ensure that the pipe is completely full of water at all times when in use. It may be advisable to construct special pipe sections, constrictions or other controls to achieve this. The meters may be installed vertically, horizontally or inclined, as long as the pipe remains full of water while measuring.

As a general rule, there should be a distance at least equivalent to eight pipe diameters of uniform straight pipe with no fittings preceding the meter, as well as a minimum distance of three pipe diameters below the meter. An even greater length on both sides of the meter is desirable.

Turbulence caused by a fitting or valve, the turbine pump or an expansion or contraction in pipe size, can cause serious measurement errors if not corrected by straightening vanes. In addition, pumping plants with large amounts of entrained air (surging) can cause a substantial over-reading error since the propeller and pipe section will not be totally full of water at all times. The readings may be either too high or too low depending on the specific circumstances and causes, but mismeasurement in any case completely negates the reason for installing the meter — that is, as a tool for better water management. It is a waste of time and money to have an improperly functioning meter.

Position the meters properly within the pipe (especially a problem with saddle meters). Make sure that the point of the propeller is pointed directly into the direction of flow and exactly parallel to the sides of the pipe. If the propeller is not located exactly in the center, the velocity readings will wrong. It also is possible that the tips of the propeller may actually touch the walls of the pipe and even stop.

The friction or head losses caused by a propeller meter usually are between 6 to 12 inches of water (0.2 psi to 0.4 psi) depending on the flow rate and propeller size. This loss often makes little difference in the operation of the system, but should be considered nonetheless when the system is designed. This information is provided by the manufacturer on request.

A major consideration, especially for buried pipelines, is easy access to the meter for maintenance. It often is necessary to entirely remove the meter for servicing and checking. Provide a minimum of a 36-inch diameter access pit.

For greatest accuracy and reliability, calibrate the meter at least twice a season. This may mean temporarily installing another meter, pitot tube flume or other flow measurement device downstream and comparing the two readings. For open discharge situations, the horizontal pipe or trajectory method often is an easy and satisfactory check on the discharge.

Maintenance Procedures

Some propeller meters have sealed bearings and lubrication is not a problem. Other meter bearings have grease fittings and should be lubricated monthly. However, sand and sediment can cause excessive wear; check the bearing at least once a season under these conditions. Many manufacturers sell sealed replacement bearings units, but use extreme care in their removal and replacement. Inspect the propeller for wear and damage and check the bearings for free turning at least twice a season. Under high sediment conditions, it may be necessary to frequently flush the bearing assembly with clean water.

Remove the meters at the end of each irrigation season. Check them thoroughly, remove all water, clean, and store in a protected, dry location until spring. If the meter requires repair, do so at this time. Return the meters to the manufacturer for any repair and recalibration. It is advisable to return the meters for a complete overhaul and recalibration at least every five years.

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