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Doppler Flow Meters for Turnouts

Irrigation districts, farmers and other agricultural and environmental water users need reliable and low-cost flow meters with integrated data-loggers to measure water velocity and depth with a high level of precision. The scientific management of California's water and energy resources requires that the volume of irrigation water that is delivered, spilled, reused, etc. throughout the state is measured accurately.

The Irrigation Training and Research Center working under a technical services agreement with the United States Bureau of Reclamation (USBR) Mid-Pacific Region has undertaken a performance review of advanced electronic flow measurement technologies in irrigation applications. Examples include the Unidata STARFLOW Ultrasonic Doppler Instrument with MicroLogger and the MACE AgriFlo Ultrasonic Flow Monitoring System.

Principle of Operation

A Doppler flow meter provides remote velocity sampling and integrated flow measurement based on the physical principle called the Doppler shift. The sensors can either project a continuous beam of acoustic signals at angles above the horizontal position of the sensor or pulsed beams. Flow velocity is calculated by averaging the measured variations in sound frequency reflected back from particles in the water. Depth is measured with a ceramic-based pressure transducer integrally mounted in a surface mount velocity sensor and the device calculates the flow rate.

Continuous beam Dopplers send out a continuous signal with one transmitter and measures signals returning from debris anywhere and everywhere along the beam with a receiver (Figure 1). The measured velocities of the particles are resolved to a mean velocity that can be related to a channel velocity.

Pulsed or profiling Dopplers transmit encoded pulses with the carrier frequency along multiple beams and are able to target specific locations, and only measure these reflected signals. This allows the velocity distribution in a water column to be profiled. These instruments are generally more complex and expensive when compared to continuous Doppler systems.

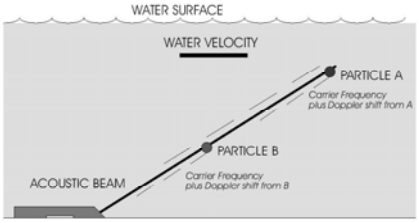

Figure 1. Principle of operation of a continuous beam Doppler flow meter

Unidata STARFLOW

Figure 2. Unidata STARFLOW Ultrasonic Doppler Flow Meter, secured to 1/4" steel plate to anchor it on the canal floor.

It is recommended that the STARFLOW sensors (Figure 2) be deployed at sites where velocities range from 0.07 - 14.8 ft/sec (20 mm/s - 4.5m/s). The device should be pointed downstream to avoid sand and other debris fouling the sensors.

All data collected by the sensor is stored and internally processed in the MicroLogger. The MicroLogger is a separate unit and is housed along with a battery for power supply (Figure 3). The STARFLOW sensor is connected to this box by a long power cable.

Figure 3. STARFLOW sensor connected to MicroLogger box, Kittitas ID. Note the battery and the communications cable connecting the MicroLogger to a laptop computer.

The MicroLogger can be programmed to have the sensor take readings at different intervals. Using the real-time water temperature measured by the sensor, the MicroLogger utilizes a factor based on the speed of sound in water at 20°C to calibrate the sensor's raw velocity readings. This factor can be changed by the user in order to field-calibrate the STARFLOW's measurements.

The MicroLogger can then internally average the velocity readings over a set time. The MicroLogger also has the ability to perform internal flow (discharge) computations as the product of mean velocity and cross-sectional area.

The MicroLogger box should be located on shore in a weatherproof enclosure (Figure 4).

Figure 4. MicroLogger in buried irrigation valve box, Sutter-Mutual WC. The unit sits on a masonry brick to keep it off the ground.

A Liquid Crystal Display (LCD) can also be installed on the MicroLogger to display current logging information and status on-site (Figure 5).

Figure 5. MicroLogger with LCD installed in toolbox for easier access, Sutter-Mutual WC.

MACE Agriflo

The MACE Agriflo provides 2 types of sensors for different applications: a strap mounted sensor for use in open channels or partially full pipelines, and an insertion sensor for use in full pipes. The strap-mounted sensor contains an additional depth sensor, which is not needed in full pipelines.

It is recommended that the sensors be deployed at sites where velocities range from 0.1-13 ft/sec. The accuracy of the velocity reading is ±1.0% for velocities up to 9.8 ft/sec, and ±1.5% at velocities greater than 9.8 ft/sec. The insertion sensor is designed to be pointed into the flow; while the front of the strap mounted sensor's transducer should be pointed into the flow.

Figure 6. The MACE Agriflo Doppler Flow meter installed at Patterson Irrigation District

All data collected by the sensor is stored and internally processed in the electronics module (Figure 7). The electronics module is a separate unit and is housed along with a battery and solar panel for power supply. Either the insertion or the strap-mounted sensor is connected to this module by a long power cable.

Figure 7. The electronics module of the MACE Agriflo

The electronics module is configured similarly to the STARFLOW MicroLogger, in that it can take readings at different intervals, adjust to different water temperatures, and average the velocities over time.

A Liquid Crystal Display (LCD) is located on the front of the electronics module to display current logging information and status.

Field Installation

It is important that the following operational guidelines and site considerations are observed for both units:

- Stable cross section
- Sufficient amount of reflectors in the water
- No excessive aeration in the water
- Calibration with a current meter is required in most applications
- Correct vertical and horizontal alignment
- Battery and memory duration are checked during installation

Benefits

Researchers and irrigation districts have used the Unidata STARFLOW and the MACE Agriflo Ultrasonic Doppler Flow Meters in a variety of applications. These devices provide:

- ✓ Programmable data collection and logging rates
- ✓ Ability to internally average readings
- ✓ Use in dirty water with heavy trash/moss loads
- ✓ Adaptable in applications where a small headloss is required
- ✓ With an added interface, meter can be integrated with a Supervisory Control And Data Acquisition System (SCADA)

Cost

Both units are comparable in price. It is recommended to add the visual display to the Unidata STARFLOW making them both around $2,500.

Use

Projects where these devices have been utilized:

- ✓ Biggs-West Gridley Water District
- ✓ Colorado River Indian Reservation- Main Canal
- ✓ Imperial Irrigation District
- ✓ Kittitas Reclamation District
- ✓ Oakdale Irrigation District
- ✓ Patterson Irrigation District
- ✓ Truckee Carson Irrigation District
- ✓ Turlock Irrigation District
- ✓ USBR- Fallon, Nevada
- ✓ Yuma Mesa Irrigation and Drainage District
- ✓ Yuma Irrigation District

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Figure 8. Collecting data from a MACE Agriflo Doppler Flow meter