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TECHNICAL MEMORANDUM

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To: Dr. Stuart Styles, P.E.
Director, ITRC

cc: David Hammerquist
Agricultural Market Manager, SeaMetrics

From: Marcus Cardenas
Support Engineer

Subject: ***SeaMetrics AG2000 Irrigation Magmeter***
Test Results and Summary

This technical memorandum summarizes test results for the SeaMetrics AG2000 Irrigation Magmeter conducted at the ITRC Water Delivery Facility on August 8-9, 2006. The purpose of the tests was to evaluate the performance of the AG2000 flow meter in conditions of severe turbulence. Electromagnetic flow meters are being investigated by ITRC for potential applications in irrigation pumping plants under non-standard conditions. The test results indicate that the AG2000 Irrigation Magmeter can be installed downstream of partially closed butterfly valves or other sources of turbulence without excessively degrading accuracy.

Background

Standard practice in pipeline flow measurement calls for installing flow meters in a straight section of pipe at least 8-10 pipe diameters from any turbulence source. In addition, standard practice recommends having at least 2 pipe diameters of straight unobstructed pipe downstream from the meter. However, in most agricultural pumping plants these rule-of-thumb requirements can rarely be met without extensive and expensive modifications to meet optimum hydraulic conditions.

Hanson and Schwankl published results from non-optimal flow meter testing in their paper *Error Analysis of Flowmeter Measurements* (1998). Pipeline measurements were taken with different types of flow meters to determine the effects on error resulting from different degrees of turbulence caused by elbows, check valves, and a partially opened check valve. Measurements were made at 2, 5, 10, and 15 pipe diameters downstream from the source of turbulence.

The results from Hanson and Schwankl (1998) indicated that for generally acceptable accuracy with propeller meters, pitot meters, and Doppler meters measurements should be take upstream of valves. Even though the tests found that in some circumstances with as little as 2 or 5 pipe diameters upstream of a flow meter, there were still large errors with all meters under conditions of severe turbulence.

Test Setup

Flow rates were measured with the SeaMetrics AG2000 Irrigation Magmeter in two different configurations at the Cal Poly Water Delivery Facility. Two tests were conducted over a flow range of approximately 12 to 1,800 gpm using a second magnetic meter in optimal flow conditions as the control unit. The AG2000 flow meter readings were compared with the control unit to calculate the percent discrepancy as follows:

$$\% \text{ Discrepancy} = \frac{\text{AG2000 flow meter - Control unit}}{\text{Control unit}} \times 100$$

The AG2000 flow meter is an electromagnetic flow meter for use in 4-12 inch pipelines. An optional 4-20 mA output module (AO55W) is available for remote monitoring applications with SCADA systems. The standard unit is battery powered and optional configurations are available for use with an external power source.

The control units used for the tests were a 4-in and 12-in McCrometer Ultra Mag flow meter. ITRC did not attempt to verify the true accuracy of the AG2000 flow meter readings, only the percent discrepancy from the control units.

The manufacturer's recommended minimal straight pipe requirement for the AG2000 flow meter is 2 pipe diameters upstream and 1 pipe diameter downstream. (Note: this recommendation applies to a straight section of pipe between two elbows.)

A 10-inch AG2000 flow meter was mounted on the WDF Pump #2, downstream of a 10x8 cast-iron concentric reducer, and immediately downstream of a butterfly valve (refer to **Figure 1**), designated as Test #1. This test configuration was designed to represent the worst possible conditions imaginable in an actual irrigation application.

A 4-inch AG2000 flow meter was mounted in a straight section of 4-inch pipeline only 8 inches downstream from a butterfly valve (equivalent to 2 pipe diameters), designated as Test #2. Refer to **Figure 2**.

The butterfly valves were adjusted during the tests from wide open to 75% and 90% closed in Tests #1 and #2, respectively.

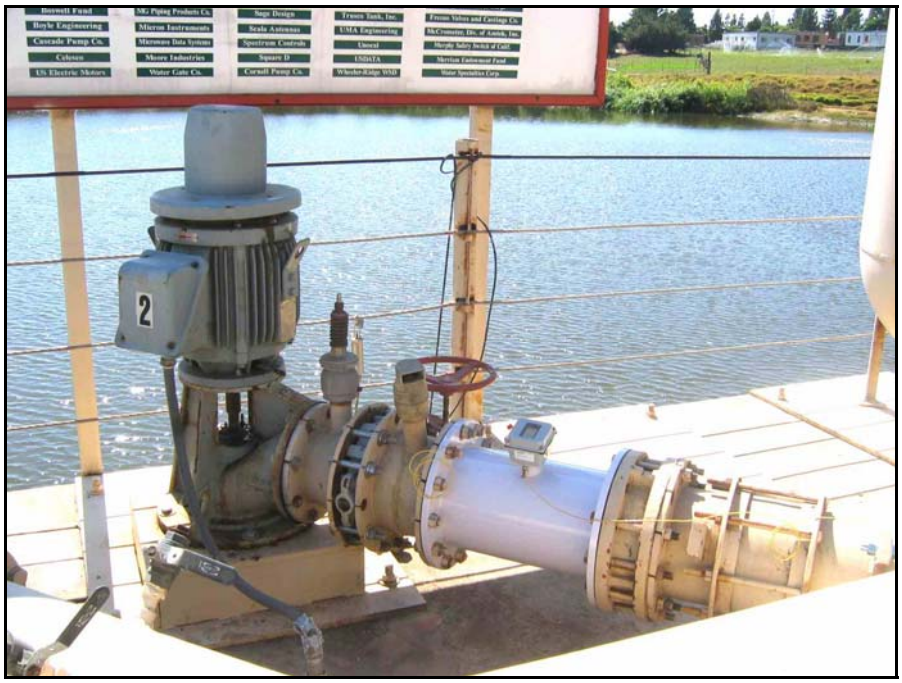

Figure 1. SeaMetrics AG2000 test condition for Test #1 (10-inch)

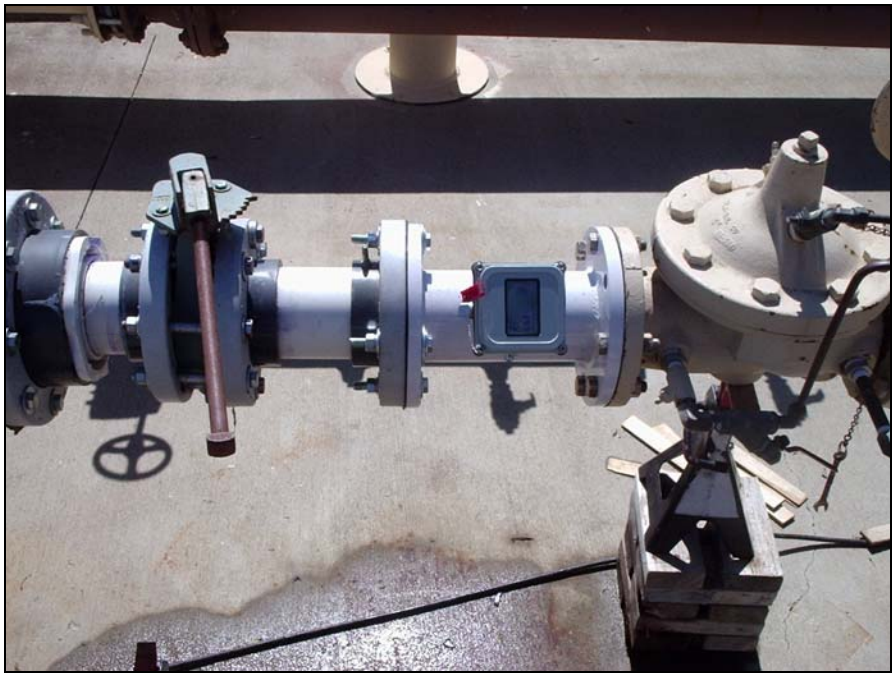

Figure 2. SeaMetrics AG 2000 test configuration for Test #3 (2 dia u/s & 0 dia d/s)

Test Results

The discrepancy analysis of the AG2000 flow meter test results is summarized in **Table 1**.

Table 1. SeaMetrics AG2000 Test Results
Cal Poly ITRC Water Delivery Facility
August 8-9, 2006

Test #	Test Condition	Control Unit	Control Flow Rate (gpm)	AG2000 Flow Rate (gpm)	Discrepancy (%)
Test #1 10" meter	Valve open	Ultra Mag	1,791	1,816	+1.4
	Valve 50% closed	Ultra Mag	1,597	1,603	+0.4
	Valve 60% closed	Ultra Mag	1,414	1,383	-2.2
	Valve 70% closed	Ultra Mag	1,271	1,140	-6.3
	Valve 75% closed	Ultra Mag	992	868	-12.5
Test #2 4" meter	Valve open	Ultra Mag	401	401	0.0
	Valve 50% closed	Ultra Mag	338	338	0.0
	Valve 70% closed	Ultra Mag	124	123	-0.8
	Valve 80% closed	Ultra Mag	31	31	0.0
	Valve ≈ 90 % closed	Ultra Mag	12	12	0.0

In Test #1 the percent difference was less than +2% when the butterfly valve was partially closed up to 50%. The percent difference was more than -10% when the butterfly valve was closed more than 75%. This increase in % difference may be contributed to the jetting effect of the 10x8 cast-iron concentric reducer coupled immediately upstream of the butterfly valve. Errors for this meter increased as the valve was closed and the flow rate was reduced. The AG2000 flow meter had a positive percent discrepancy (overestimating the flow rate) compared to the control unit when the butterfly valve was closed 50% or less. When the butterfly valve was closed more than 50% the AG2000 flow meter underestimated the flow rate by approximately 6-12%.

By comparison, the results reported by Hanson and Schwankl (Table 3; 1998) for partially closed butterfly valves with a propeller meter mounted 2 diameters downstream were ±14% at 668 gpm, ±15% at 1,153 gpm, and ±2% for flow rates of 2,190 gpm. The valve was closed 10 degrees (out of 90 degrees) to provide the throttling effect. Based on the results of their study, it was recommended to always use a six vane straightening arrangement if measuring the flow rate downstream of a throttled butterfly valve.

To verify that the AG2000 was provided good results downstream of a throttles butterfly valve, a second test was conducted. In Test #2, the 4-inch AG2000 flow meter had a percent discrepancy less than 1% even when the butterfly valve was 90% closed. Discrepancies were the same for

conditions where the butterfly valve was wide open and when it was closed 80-90%. These results suggest that turbulence from a partially closed butterfly valve located 2 pipe diameters upstream had negligible effect on the precision of the SeaMetrics meter as compared to the control unit.

In summary, the test results indicated that under conditions of severe turbulence due to a partially closed butterfly valve, the 4-inch AG2000 flow meter readings were not adversely affected. For the 10-inch AG2000 flow meter, a partially closed butterfly valve coupled with a pump discharge caused errors of 1-2% up to 50% valve closure. The recorded percent discrepancy was generally reduced at the higher flow rates. More investigation is necessary to determine how the true accuracy of the flow meter is affected in non-standard conditions.

Estimated Cost (list price without quantity discounting)

According to the manufacturer in August 2006, the approximate starting prices for a basic SeaMetrics flow meter were as follows:

SeaMetrics AG2000; 10-inch pipe	$1,485
SeaMetrics AG2000; 4-inch pipe	$990

A 12-inch AG2000 flow meter will be available in late 2006 for an estimated list price of $1,800.

REFERENCES

Hanson, B.R., and Schwankl, L.J. 1998. "Error Analysis of Flowmeter Measurements." *J. Irrig. and Drain. Engrg.*, ASCE 124(5), 248-256.