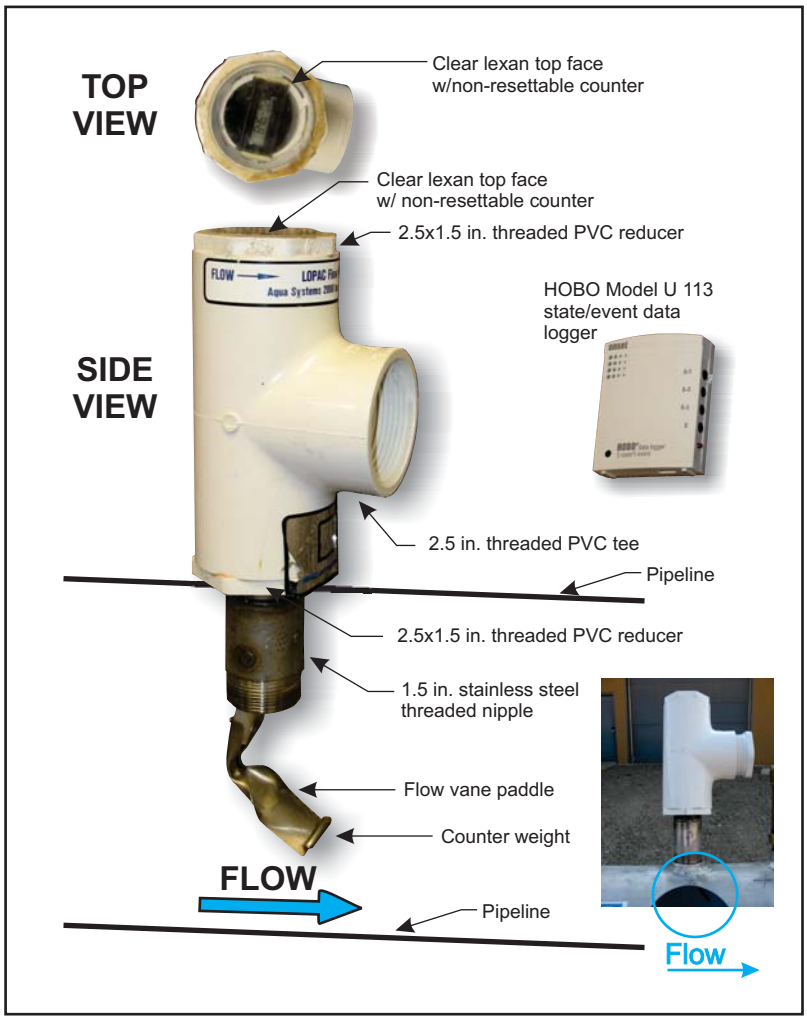
Technical Overview
Low Power Automatic Controls (LOPAC) LHE2 Flow Monitor

Introduction – The Low Power Automatic Controls (LOPAC) flow monitor was designed by *Aqua Systems 2000 Inc.* (Lethbridge, Alberta) to sense and totalize the occurrence of flow time in one direction and is not capable of determining flow velocity or volumetric measurements. In 2007, a second generation of the LOPAC flow monitor, the model LHE2 was developed with an additional housing containing a Hobo Model U11 3-State/1 Event Data Logger. The data logger was instrumented to the monitor to time/date stamp on and off cycles which were required to meet the needs of an irrigation management practices research project titled – Current Irrigation Management Practices 2 (CIMP2) – conducted by Alberta Agriculture and Rural Development (ARD) and cooperating irrigation districts. The data logging procedure provided a detailed log of irrigation applications, timings and duration of each application throughout an entire growing season. A detailed list of component specifications for the LOPAC can be obtained from *Aqua Systems 2000 Inc*.

LOPAC Model LHE2 Description and Diagram

- The sensor housing is a one and one half inch diameter stainless steel fitting. A standard two and one half inch PVC threaded tee provides the housing for the data logger and time counter.
- A non-resettable time counter is sealed within the unit.
- Water velocity in the pipe moves the flow vane into the "on" position, when flow stops, the vane, assisted by a counter weight, returns to the "off" position.
- The sensor consists of a single pole double throw magnetic reed switch. A start or stop in water flow initiates travel of the flow vane which activates the switch, simultaneously closing or opening circuits to both the time counter and data logger.



Current Irrigation Management Practices 2

From 2007 to 2009, ARD implemented the CIMP2 study, which was designed to monitor irrigation management practices as a means to better understand the on-farm component as it relates to overall water resource management. Irrigation amounts and detection of the timing of applications was accomplished by installing a LOPAC Model LHE2 flow monitor at the turn-out of each centre pivot field involved in the study. A comprehensive report titled "Current Irrigation Management Practices 2" is available from ARD.

Site Selection

- Flow monitors were installed a minimum of forty centimeters downstream of the turnout valve.
- The monitors encountered problems if installed in a vertical section of pipe – due to the existence of turbulent flow. The turbulence would continuously toggle the monitor on and off, or chatter, and the data loggers would prematurely fill up with data.
- Turbulent flows may have existed at sites where monitors were installed in horizontal sections of pipe; however, problems interfering with data collection were experienced almost exclusively at sites where monitors were installed in the vertical section of turn-outs or sharp horizontal elbows.

Installation

- To install the LOPAC flow monitor, a two inch hole is cut into the top of the turnout pipe and a threaded coupler is inserted and welded in place on a level plane. It is important to position the coupler so that it protrudes into the inside diameter of the pipe by approximately five millimeters. This helps to insure that the base of the monitor is adequately recessed into the pipe to allow for unobstructed travel of the flow vane.
- If possible position the welded coupler in a section of pipe that can be isolated from the water delivery system in the event that the monitor needs to be removed or replaced.
- The threaded base of the monitor must then be wrapped with thread sealant tape to ensure a proper seal. It is recommended not to use grease or pipe sealant compound, as it may interfere with the movement of the flow vane.
- The base of the monitor can then be inserted and tightened into the coupler. Be careful to apply torque only to the metal fitting and not the upper PVC housing, as it can easily be turned on the opposing end.
- The LOPAC flow monitor has front and back sides and must be oriented so that the paddle of the flow vane angles in the direction of water flow.

LOPAC Performance testing results and redesign measures – During the first year of testing and evaluation of the LOPAC flow monitor, 46% of the 52 units deployed in 2007 operated trouble free for the season (Table 1). The majority of the problems encountered in the first year were due to flow vanes sticking in the "on" position when flow had ceased, or counters malfunctioning. Based on the performance issues and field testing observations recorded by ARD staff, *Aqua Systems 2000* redesigned and made alterations to some of the monitor's components prior to the 2008 season. Redesigning the flow vane and changing the reed switch configuration greatly improved the ability of the monitor to sense changes in flow status and provide reliable flow monitoring data in the subsequent two years of testing. Trouble free operation increased to 64% in 2008 and 92% in 2009.

Table 1. Assessment of LOPAC flow monitor performance from 2007 to 2009. Some LOPAC flow monitors exhibited more than one performance issue.

Number of LOPAC flow monitors	2007	2008	2009
Originally installed units	*52*	*69*	*61*
Trouble free field performance	*24*	*44*	*56*
Pivot off, counter or data logger "on"	16	n/a	n/a
Pivot off, counter "on"	n/a	9	4
Counter stopped working	10	18	5
Site unsuitable (elbow installation)	2	2	2

Installation – The first units to be installed in 2007 were installed with the coupler positioned on top of the outer surface of the pipe rather than sinking it slightly into the pipe. As a result, approximately twenty of the monitors incurred problems with the flow vanes rusting to the welded couplers or adhered to excess thread sealant and did not respond to changes in water flow. To address this problem the couplers, when welded to the pipe were inserted or sunken slightly into the pipe to provide more clearance for travel of the flow vane.

Flow vane – The flow vane was originally designed to conform as closely as possible to the inside circumference of the pipe to reduce the likelihood of debris buildup. As a result the flow vane would come in contact with the installation coupler or the inside wall of the pipe when triggered on. When the flow vane contacted any of the pre-mentioned components the amount of travel or movement of the flow vane was reduced, and sometimes, resulted in incomplete activation of the reed switches. Modifications for the 2008 season consisted of the flow vane being made longer, enabling it to travel on and off without making contact to other components.

Installing LOPAC into threaded coupler welded to pipe

Orient with paddle angled with direction of flow

Hobo shuttle off- loading data logger

Approximate minimum pipe length of 40 cm required for installation

Counter – A number of counters malfunctioned or slid down in the housing during the irrigation seasons of 2007 and 2008. The counters were more securely fastened in the housing and a new style tested in ten monitors in 2009. The ten monitors equipped with the new version of counters for a single year – a Redington model 53 – did not exhibit any problems in 2009. The type of time counter used in the LHE2 flow monitor operates on a non replaceable battery with a usable time span of approximately five years, therefore requiring the counter unit itself to be replaced for continued usage.

Data logger – The LHE2 flow monitor can be configured to operate with either the time counter or the Hobo logger, or both. This provides the option of using the monitor for longer term applications with only the loggers installed, as the loggers have replaceable batteries.

Reed Switch – In 2007 the counter and data logger operated on two independent switches, thereby requiring a certain amount of travel from the flow vane to activate both switches. Incomplete travel of the flow vane could switch one component on but leave the other off, making identification of the problem component difficult and causing errors in the recorded data. The reed switches were changed to a single pole, double throw switch, to have the counter and data logger operating on the same switch which aided in identifying the occurrence of problems to either of the two components.

Recommended uses for the LOPAC

- The testing results for the LOPAC model LHE2 monitor – with the redesigned flow vane, reed switch and new counter– indicate that the relatively low-cost LOPAC monitor is a reliable device capable of sensing water flow in closed pipelines and recording and storing the corresponding on/off times and durations of flow.
- The LOPAC flow monitor requires installation in a coupler welded in a horizontal section of pipe with non-turbulent water flow.
- The LOPAC flow monitor equipped with the Hobo data logger presents various possibilities for collecting useful information regarding water delivery and usage. Potential applications of the LOPAC flow monitor are likely best suited to smaller scale, specific data acquisition programs or research related projects requiring regular site visits.
- As with any flow meter or monitor, the LOPAC flow monitor requires proper installation and maintenance to ensure accurate and reliable performance.

A comprehensive report evaluating the performance of the LOPAC LHE2 flow monitor titled "Technical Evaluation for the Low Power Automatic Controls Flow Monitor" is available from Alberta Agriculture and Rural Development.

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