

TESTING REPORT

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Location of Test: The University of Maine
The Process Development Center
5737 Jenness Hall
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Device Tested : AcquaFlow™ Valve (2-inch) – 316L Stainless Steel

Test Equipment: DLJ DN50 2-Inch Epoxy Coated Cast Iron Turbine Water Meter
2 pressure gauges
2-inch PVC pipe line

SUMMARY OF RESULTS

A test loop was set up to evaluate the ability of the provided AcquaFlow™ devices to reduce recorded consumption by the water meter without affecting water pressure or flow. A test loop was set up to measure water flow with both a water meter and by measuring the volume of water directly via volumetric calculation given the height of water in the receiving tank. For baseline runs, where no device was installed, the amount of water passed through the flow loop as read by the water meter and that determined from volumetric calculation agreed within an accuracy of 0.5%. When the test loop was pressurized by partially closing the outlet valve, the difference between gallons of water to flow through the test loop determined by the water meter and as calculated using volumetric calculations agreed within 0.8%. When the AcquaFlow™ devices were installed in the flow loop and the experiments repeated, the water meter read that up to 6% more water had flowed through the test loop than was actually determined from volumetric calculation.

TESTING PROCEDURES

Test Flow Loop

A test loop was constructed above a 3,000 gallon tank to measure water flows. House water was used as the water supply as it was available at the highest flowrates and pressures. These higher flows and pressures are more likely to be seen in large commercial installations.

The test loop was constructed using PVC piping and a DLJ 2-Inch epoxy coated cast iron water meter (Figure 1). House water entered the flow loop, flowed through about 20 feet of pipe, and then emptied into the 3,000 gallon tank. The inlet pressure was measured by pressure gauge P1, which was installed four inches before the water meter. The outlet pressure was measured using pressure gauge P2, which was installed 12 inches after the water meter. House water flow was controlled by the inlet valve as shown in Figure 2. Table 1 shows sample flow rates and pressures for the house cold-water line.

Two types of runs were conducted: 1) baseline runs where the AcquaFlow™ device was not installed, and 2) test runs where several different AcquaFlow™ devices were installed. For baseline runs, the inlet pressure (P1) was controlled by the outlet valve. For these runs, the inlet valve was fully open to maximize water flow. For test runs when an AcquaFlow™ device was installed, inlet pressure (P1) was controlled by the inlet valve. For these runs the outlet valve was also fully open.

The volume of water to flow through the test loop was measured by volumetric calculation, using the height of the water in the tank to determine volume and a stopwatch to determine time. This is a common practice to calibrate flow meters.

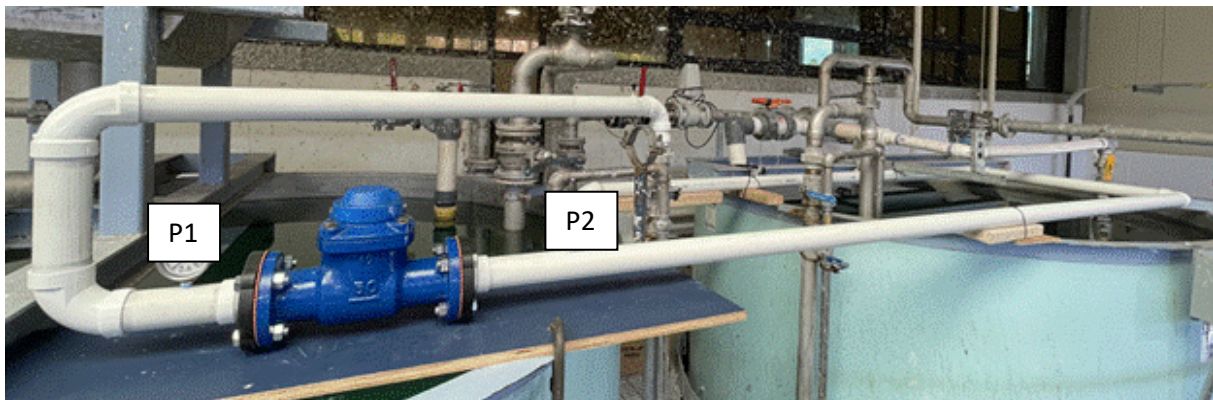


Figure 1. Water meter (blue) and test flow loop



Figure 2. House water inlet valve and test flow loop

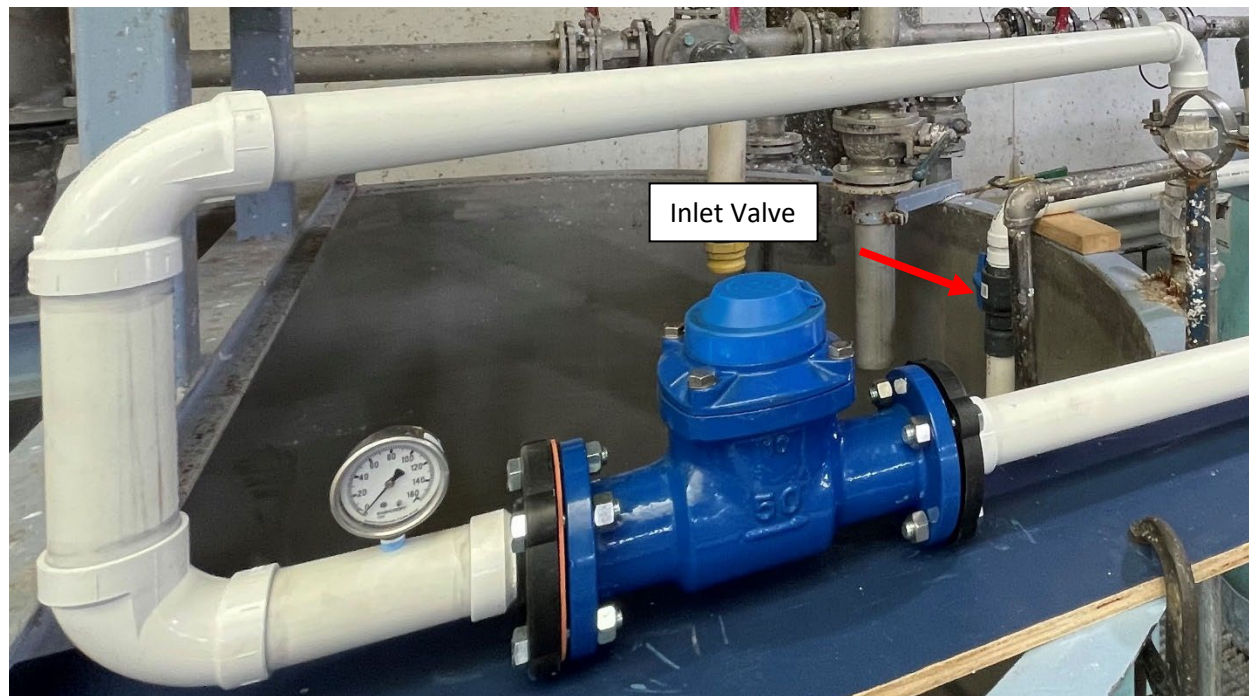


Figure 3. Location of flow loop outlet valve.

Table 1. Flow rate and pressure of cold water supply to Jenness Hall

TANK ID	Run Time (min)	Inlet Pressure (psig)	Volumetric Calculation (gallon)	Flow Rate (Gallon/min)
#3	3.5	~70	560	160
#4	3.0	~90	419	140

Baseline Runs

Baseline runs were conducted on the flow loop system to determine the correlation between the water meter and the volumetric calculation of gallons in the tank after a run. For these runs, the AcquaFlow™ device was not installed. These baseline runs were conducted at three different conditions, varying the inlet and outlet pressures for two different time ranges.

Table 2 shows results from these runs. Runs #1 and #2 are duplicate runs where the inlet and outlet valves are fully open. This represents a situation with water freely flowing into the open tank. The run time was 5 minutes. Run #3 was conducted at the same condition, but ran for 15 minutes. Table 2 shows the volume of water in gallons as measured by the water meter and by volumetric calculation (as noted above). For these runs, the difference between the amount of water measured by the water meter and that determined by volumetric calculation was less than 0.1%. This confirms that the measurement of water using the volumetric calculation is representative.

Runs #4 and #5 were conducted by adjusting the outlet valve to achieve a 20 psig (Run #4) or 30 psig (Run #5) target pressure at the outlet valve (P2). These runs represent a situation when water is flowing under a closed-loop situation as might be more common when installed for actual use. For Runs #4 and #5, there is less than a 1% difference between the volume measured by the water meter and that measured by volumetric calculation. Again, this confirms that the measurement of water using the volumetric calculation method is representative.

Table 2. Comparison of volume of water (gallons) as determined by volumetric calculation and the water meter reading for baseline runs.

Run #	Pressure P1 (psig)	Pressure P2 (psig)	Run Time (min)	Volumetric Calculation (gallon)	Water Meter (gallon)	Flow Rate (Gallon/min, based on Water Meter)	Difference (gallon)	Difference (%)
1	0	0	5	763.7	763.0	152.6	-0.7	-0.1%
2	0	0	5	763.7	761.0	152.2	-2.7	-0.4%
3	0	0	15	2272.3	2274.0	151.6	1.7	0.1%
4	20	20	5	308.5	311.0	62.2	2.5	0.8%
5	30	30	15	1331.8	1342.5	89.5	10.7	0.8%

Test Runs #1 – Standard House Water

For the first set of test runs, the AcquaFlow™ device was installed right after the water meter (Figure 5). Several different AcquaFlow™ devices were installed and tested. Each of these devices are a 2-inch diameter stainless steel AcquaFlow™ device. These devices are referred to as Device #1, Device #2 and Device #3 and supplied by AcquaFlow™ representatives.

Runs were conducted for 5 or 15 minutes, and several different inlet pressures were used. Longer continuous runs were not possible as the tanks would fill to capacity. For each device used during the varied run times, the inlet pressure and outlet pressure were recorded. The inlet valve was turned on and the house water allowed to flow for the indicated time. The outlet valve was fully open.

The volume of water in gallons to pass through the flow loop was determined by volumetric calculation and by reading the water meter. Pressure before and after the water meter were recorded. Data from these runs are shown in Table 3 (Device #1), Table 4 (Device #2), and Table 5 (Device #3).

For each of the AcquaFlow™ devices used, the gallons of water as recorded by volumetric calculation as compared to the water meter differed by less than 2%. In some cases the water meter read higher than the volumetric calculation, and in some cases less.

For all of these runs, the data show that when an AcquaFlow™ device was installed, there was an increase in pressure P1 as compared to without the device when the outlet valve is fully opened (Table 2).

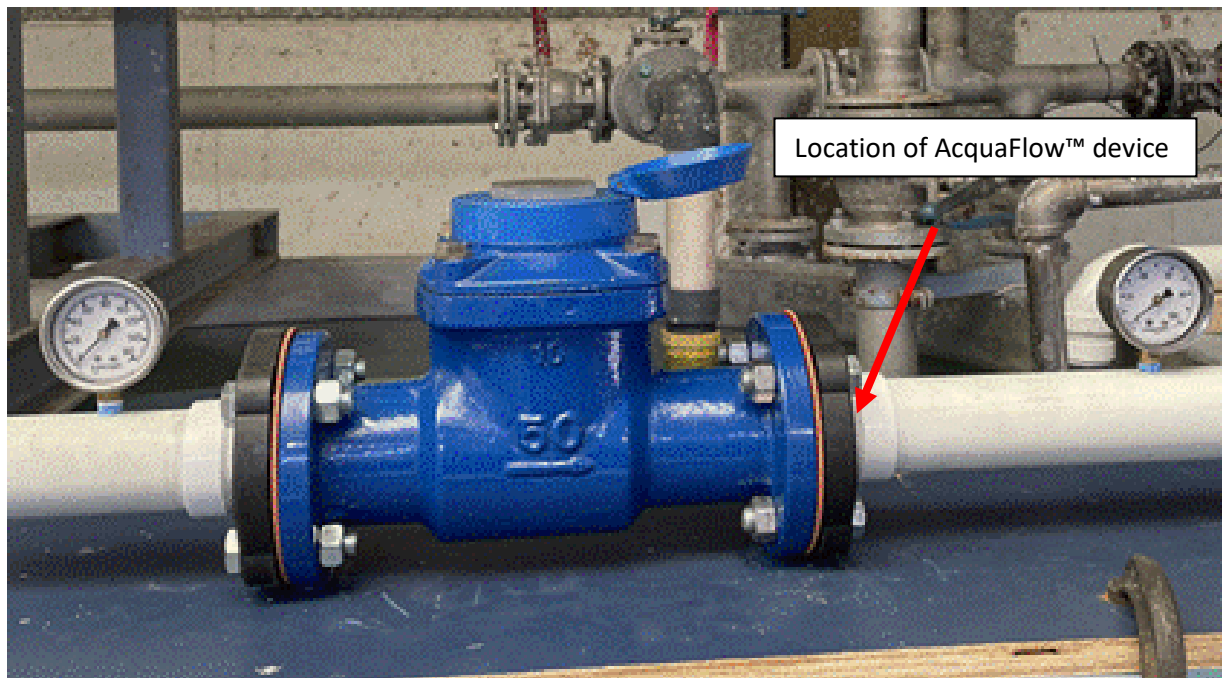


Figure 5. Location of AcquaFlow™ device during testing.

Table 3. Comparison of volume of water (gallons) as determined by volumetric calculation and water meter reading for AcquaFlow™ device #1

Pressure P1 (psig)	Pressure P2 (psig)*	Run Time (min)	Volumetric Calculation (gallon)	Water Meter (gallon)	Flow Rate (Gallon/min, based on Water Meter)	Difference (gallon)	Difference (%)
50	0	5	410.1	416.0	83.2	5.9	1.4%
50	0	15	1218.9	1228.0	81.9	9.1	0.7%
50	0	5	402.5	410.0	82.0	7.5	1.8%
20	0	5	301.0	307.0	61.4	6.0	2.0%
30	0	15	1000.7	1016.0	67.7	15.3	1.5%

* Outlet pressure P2 is zero as the valve is fully open

Table 4. Comparison of volume of water (gallons) as determined by volumetric calculation and water meter reading for AcquaFlow™ device #2

Pressure P1 (psig)	Pressure P2 (psig)*	Run Time (min)	Volumetric Calculation (gallon)	Water Meter (gallon)	Flow Rate (Gallon/min, based on Water Meter)	Difference (gallon)	Difference (%)
48	0	5	436.4	443.5	88.7	7.1	1.6%
48	0	15	1245.3	1248.5	83.2	3.2	0.3%
48	0	5	406.3	402.0	80.4	-4.3	-1.1%

* Outlet pressure P2 is zero as the valve is fully open

Table 5. Comparison of volume of water (gallons) as determined by volumetric calculation and water meter reading for AcquaFlow™ device #3

Pressure P1 (psig)	Pressure P2 (psig)*	Run Time (min)	Volumetric Calculation (gallon)	Water Meter (gallon)	Flow Rate (Gallon/min, based on Water Meter)	Difference (gallon)	Difference (%)
52	0	5	381.9	381.0	76.2	-0.9	-0.2%
52	0	15	1107.9	1112.0	74.1	4.1	0.4%
52	0	5	361.2	366.0	73.2	4.8	1.3%

* Outlet pressure P2 is zero as the valve is fully open

Test Runs #2 – Air in Standard House Water

The house water supply to the building is very stable with very few air “pockets” that could be present in other situations. To examine the impact of increased air in the house water line, house air was introduced into the water line. House air was available at 25 psi flowing at 18 ft³/hr and was introduced into the house water line about three feet prior to the inlet pressure gauge.

Table 6 shows the data from this experiment when the AcquaFlow™ device was not installed. With the entrained air introduced into the system, the water meter measures approximately 2% more flow than as determined by the volumetric calculation. This difference is slightly greater than difference seen in Table 2 for baseline runs that did not contain entrained air.

Table 6. Comparison of volume of water (gallons) with introduced entrained air (no device installed). Air flow rate was maintained at 25 psig at a flow of 18 cubic feet per hour.

Run #	Press. P1 (psig)	Press. P2 (psig)	Outlet Valve position	Run Time (min)	Vol. Calc. (gallon)	Water Meter (gallon)	Flow Rate (Gallon/min, based on Water Meter)	Difference (gallon)	Difference (%)
1	20	20	Partially open	15	1563.2	1595.0	106.3	31.8	2.0%

Table 7 shows the data for the test run when the AcquaFlow™ device was installed. For this run, it was observed that the pipe vibrated while the air and water moved through the pipe, and a high frequency tapping sound was heard where the AcquaFlow™ device was located. The data in Table 7 show that when the AcquaFlow™ device was installed, the water meter read nearly 6% higher than the actual volume of water measured by volumetric calculation. Again, as was shown in Table 1, the volumetric calculation used to determine the amount of water correlated highly with the water meter under baseline conditions. This experiment indicates that the water meter is not accurately measuring the volume of water when the AcquaFlow™ device was installed.

Table 7. Comparison of volume of water (gallons) with introduced entrained air (AcquaFlow™ device installed). Air flow rate was maintained at 25 psig at a flow of 18 cubic feet per hour.

Run #	Press. P1 (psig)	Press. P2 (psig)	Outlet Valve position	Run Time (min)	Vol. Calc. (gallon)	Water Meter (gallon)	Flow Rate (Gallon/min, based on Water Meter)	Difference (gallon)	Difference (%)
1	20	0	Fully open	15	810.7	860.0	57.3	49.3	5.7%

APPENDIX

Appendix A. Additional Pictures of Test Loop



Appendix B. Raw Data

No AQF Valve

Run Time	Inches Freeboard	Total Volume (gallons)	Delta V1 (gallon)	Flow Rate (Gallon /min)	Water Meter Reading	Delta V2 (gallon)	Flow Rate (Gallon /min)	P1 (psig)	P2 (psig)	Inlet Valve Open	Outlet Valve Open
0	104.375	233.10	0		425062						
5	79.00	996.8	764	152.7	425825	763	152.6	0	0	100%	100%
15	3.5	3269.1	2272	151.5	428099	2274	151.6	0	0	100%	100%
0	45.75	1997.5			428099						
5	20.375	2761.3	764	152.7	428860	761	152.2	0	0	100%	100%
0	35.75	2298.5			433304						
5	25.5	2607.0	308	61.7	433615	311	62.2	20	20	100%	Partial

0	103.5	259.4			433615						
15	59.25	1591.2	1332	88.8	434957.5	1343	89.5	30	30	100%	Partial
						11					
0	54	1749.2			437381						
15	2.0625	3312.4	1563	104.2	438976	1595	106.3	20	20	100%	Partial
						32					

with air inlet
25psi, 18 cf/hr

AQF Valve-1

Run Time	Inches Freeboard	Total Volume (gallons)	Delta V1 (gallon)	Flow Rate	Water Meter Reading	Delta V2 (gallon)	Flow Rate	P1 (psig)	P2 (psig)	Inlet Valve Open	Outlet Valve Open
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				(Gallon/ min)			(Gallon/ min)				
0	106.63	165			422995						
5	93.00	575	410	82.0	423411	416	83.2	50	0	100%	100%
15	52.50	1794	1219	81.3	424639	1228	81.9	50	0	100%	100%
5	39.13	2197	403	80.5	425049	410	82.0	50	0	100%	100%
	45.50	2005			432997						
5	35.50	2306	301	60.2	433304	307	61.4	20	0	Partial	100%
	59.25	1591			434947.5						
15	26.00	2592	1001	66.7	435963.5	1016	67.7	30	0	Partial	100%
					15						
	54.00	1749			436483						
15	27.0625	2560.0	811	54.0	437343	860	57.3	20	0	Partial	100%
					49						

with air inlet
25psi, 18 cf/hr

AQF Valve-2

Run Time	Inches Freeboard	Total Volume (gallons)	Delta V1 (gallon)	Flow Rate (Gallon/min)	Water Meter Reading	Delta V2 (gallon)	Flow Rate (Gallon/min)	P1 (psig)	P2 (psig)	Inlet Valve Open	Outlet Valve Open
0	103	274			428876						
5	88.50	711	436	87.3	429320	444	88.7	48	0	100%	100%
15	47.125	1956	1245	83.0	430568	1249	83.2	48	0	100%	100%
5	33.625	2362	406	81.3	430970	402	80.4	48	0	100%	100%

AQF Valve-3

Run Time	Inches Freeboard	Total Volume (gallons)	Delta V1 (gallon)	Flow Rate (Gallon/min)	Water Meter Reading	Delta V2 (gallon)	Flow Rate (Gallon/min)	P1 (psig)	P2 (psig)	Inlet Valve Open	Outlet Valve Open
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				/min)			/min)				
0	106.75	162			431138						
5	94.06	543	382	76.4	431519	381	76.2	52	0	100%	100%
15	57.25	1651	1108	73.9	432631	1112	74.1	52	0	100%	100%
5	45.25	2013	361	72.2	432997	366	73.2	52	0	100%	100%