VALVE PERFORMANCE TEST ON A 8-INCH RUBBER CHECK VALVE

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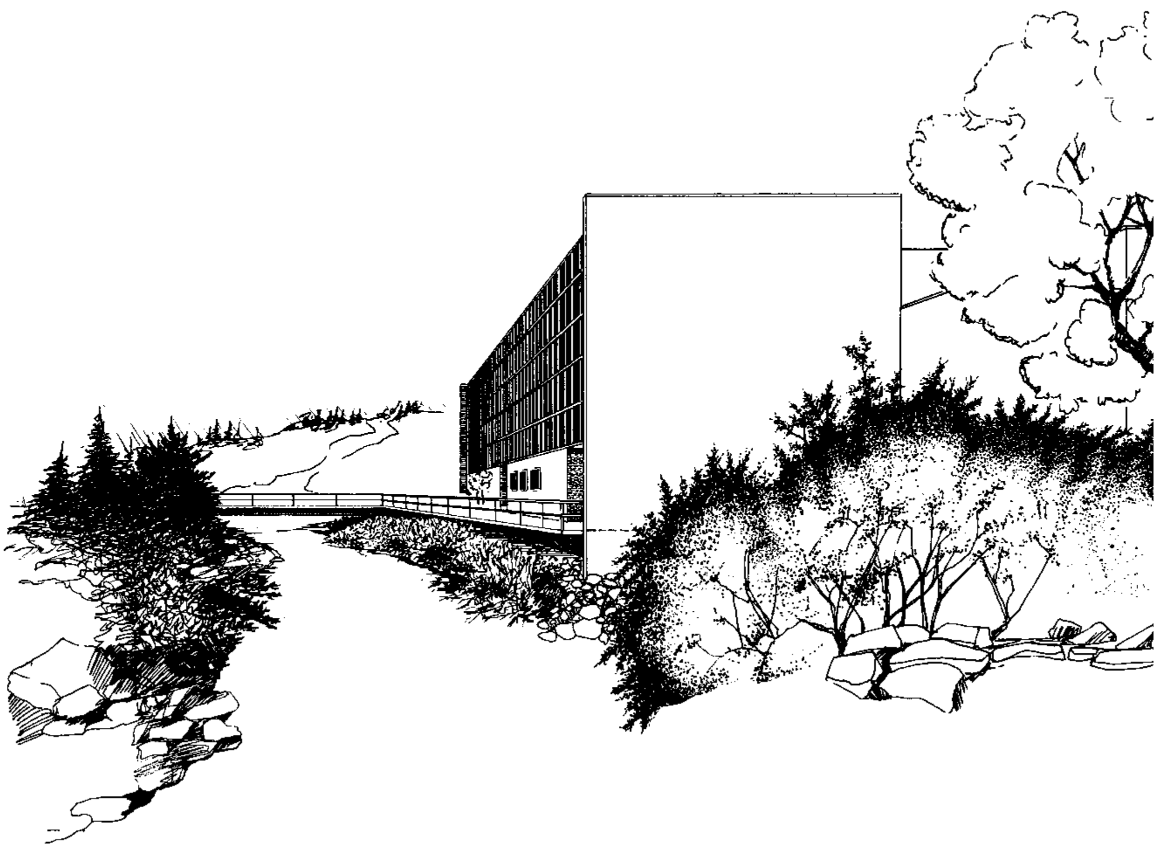

UTAH WATER RESEARCH LABORATORY

Utah State University

Logan, Utah

Report No. 3472

VALVE PERFORMANCE TEST ON A 8-INCH RUBBER CHECK VALVE

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INTRODUCTION

Utah State University was contracted by WAPRO to perform a flow test at the Utah Water Research Laboratory (UWRL) in Logan, Utah on an 8-inch rubber check valve manufactured by WAPRO. A cold-water test was performed to determine the discharge coefficient (Cv) for the valve over a wide range of flow rates under both free discharge and submerged conditions. Tests were also performed to determine the head necessary to open and close the valve.

EXPERIMENT SETUP

The valve was installed in a 12-inch supply line, which included more than 30 pipe diameters of standard schedule 8-inch carbon steel laboratory pipe (7.981-inch ID) installed immediately upstream of the valve. A pressure tap was installed on the invert of the pipe at approximately 2 diameters upstream of the valve. Laboratory instrumentation was connected to the pressure tap so that differential pressure measurements during the test could be documented. Discharge from the valve was released to a wooden box, in which water levels could be controlled. Figure 1 and Figure 2 illustrate the free-discharge and submerged tests respectively.

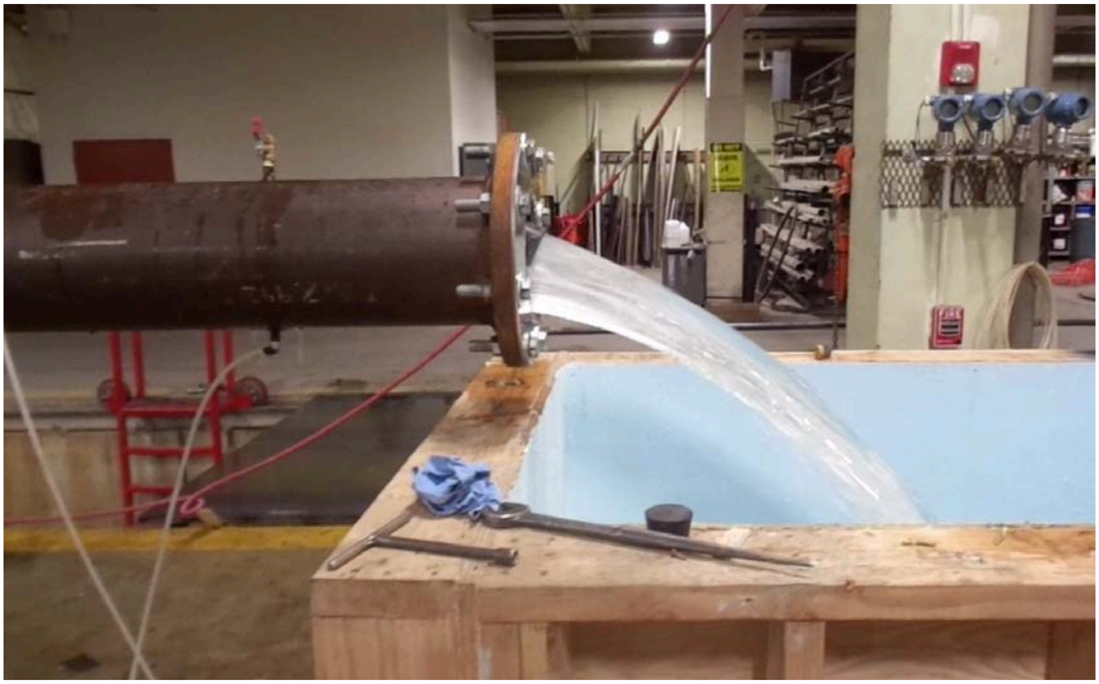

Figure 1. Test Setup for the Free-Discharge 8-Inch Rubber Check Valve Tests

Figure 2. Test Setup for the Submerged 8-Inch Rubber Check Valve Tests

FLOW COEFFICIENT

The coefficient Cv for the valve was calculated using the following equation:

$$Cv = \frac{Q}{\sqrt{\Delta P / sg}}$$

in which Q is the actual flow rate in gallons per minute, ΔP is the gross valve differential pressure reading in pounds per square inch (psi) and sg is the specific gravity of water during this test (sg = 1.0010).

PROCEDURE

Water was supplied to the test line from a reservoir near the hydraulics laboratory. The flow rate and differential pressure were measured for each run. The water temperature was also measured. During the free discharge tests, the differential pressure measurement across the valve was determined by measuring the difference between the upstream pressure at the pipe pressure tap located at two diameters upstream of the valve and the downstream pressure for the free-discharging valve (0 psi at atmospheric pressure). During the submerged discharge tests, the differential pressure measurement across the valve was determined by measuring the difference between the upstream pressure at the pipe pressure tap located at two diameters upstream of the valve and the measured tail water level in the receiving water downstream of the valve. The pressure tap for the tail water level was located in a corner of the box where no velocities existed.

All flow measurements were made using a calibrated 12-inch master laboratory magnetic flow meter installed upstream of the test valve. The calibration for the magnetic flow meter was previously performed using the laboratory weight tanks. The weight tank is regularly calibrated and is traceable to the National Institute of Standards and Technology. Discharge from the test line was controlled using a control valve upstream of the test section.

Valve differentials were measured using a Rosemount differential transmitter. The Rosemount transmitter was carefully zeroed to the invert of the pipe. The transmitter output was averaged during each individual run using an averaging Fluke volt/amp meter. Appropriate ranges were set on the transmitter to minimize uncertainties as the valve differentials changed.

The valve was tested over a wide range of flow rates. The differential pressure and the flow rate were accurately measured and the Cv was calculated for each run. The average Cv is provided in the data table. The head at which the valve just opens and just closes was also determined. Three data points were measured and averaged under both conditions. All instrumentation used is regularly calibrated and traceable to the National Institute of Standards and Technology.

RESULTS

The head necessary to open the valve was found to be 0.96ft. The head necessary to close the valve was found to be 0.61ft. Table 1 and Table 2 summarize the test results for the valve test. Table 1 includes the free-discharge test data and Table 2 includes the submerged test data. Within each table, hysteresis data is also presented. It was determined that slowly increasing the flow produced different results (upper curve) than when the flow was slowly decreasing (lower curve). Figure 3 illustrates the relationship between flow rate and the Cv for the valve with increasing flow (except the submerged curve which has both increasing and decreasing flows shown). Figure 4 illustrates additional points when slowly decreasing the flow rate on the free-discharge curve and slowly increasing the flow on the submerged curve. Video clips of specific runs are provided separately.

Table 1. Utah Water Research Laboratory Flow Meter Calibration Data

Manufacturer:	WAPRO		
Calibration Date:	2/23/16		
Calibration Location:	12-inch south supply line	Valve Inside Diameter (in.) =	7.981
		Nominal Pipe Dia. =	8-inch
Serial Number:	NA	Pipe Diameter (in.) =	7.981
Valve Description:	NA	Pipe Area (ft^2) =	0.35
		Water Temp. (F) =	39.7
Pipe Setup		Unit Weight (lb/ft^3) =	62.43
Upstream:	8-inch std. wall steel pipe	Kin. Visc. (ft^2/s) =	1.67E-05
Downstream:	8-inch std. wall steel pipe		

Calibration Performed by: Z. Sharp
Calibration Witnessed by: none

Run No.	Flow gpm	ΔH ft	Inlet Reynolds Number	Flow Area ft^2	Pipe Velocity fps	Pipe Flow Condition	Cv
1	2	3	4		5	6	5
1	50.05	0.660	12,770	0.347	0.321	Free-Discharged	93.61
2	104.68	0.746	26,710	0.347	0.671	Free-Discharged	184.21
3	206.72	0.897	52,747	0.347	1.326	Free-Discharged	331.71
4	421.68	1.251	107,596	0.347	2.704	Free-Discharged	572.78
5	593.92	1.720	151,545	0.347	3.809	Free-Discharged	688.20
6	808.80	2.650	206,374	0.347	5.187	Free-Discharged	754.90
7	1005.60	3.525	256,589	0.347	6.449	Free-Discharged	813.90
8	1213.36	4.635	309,601	0.347	7.782	Free-Discharged	856.41
9	1396.08	5.917	356,224	0.347	8.953	Free-Discharged	872.12
Valve hysteresis tests							
1	1503.12	18.285	383,537	0.347	9.640	Free-Discharged	534.14
2	1267.28	9.628	323,360	0.347	8.127	Free-Discharged	620.61
3	1062.32	4.768	271,062	0.347	6.813	Free-Discharged	739.28
4	960.48	3.863	245,077	0.347	6.160	Free-Discharged	742.56
5	833.12	2.883	212,579	0.347	5.343	Free-Discharged	745.63
6	626.32	1.837	159,812	0.347	4.017	Free-Discharged	702.12
7	24.00	0.399	6,124	0.218	0.245	Free-Discharged	57.71

Certified by:

Steven L. Barfuss

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Research Associate Professor

Table 2. Utah Water Research Laboratory Flow Meter Calibration Data

Manufacturer:	WAPRO		
Calibration Date:	2/23/16		
Calibration Location:	12-inch south supply line	Valve Inside Diameter (in.) =	7.981
		Nominal Pipe Dia. =	8-inch
Serial Number:	NA	Pipe Diameter (in.) =	7.981
Valve Description:	NA	Pipe Area (ft^2) =	0.35
		Water Temp. (F) =	39.2
Pipe Setup		Unit Weight (lb/ft^3) =	62.43
Upstream:	8-inch std. wall steel pipe	Kin. Visc. (ft^2/s) =	1.69E-05
Downstream:	8-inch std. wall steel pipe		

Calibration Performed by: Z. Sharp
Calibration Witnessed by: none

Run No.	Flow gpm	ΔH ft	Inlet Reynolds Number	Flow Area ft^2	Pipe Velocity fps	Pipe Flow Condition	Cv
1	2	3	4		5	6	5
1	55.58	0.301	14,059	0.347	0.356	Submerged	153.90
2	413.20	3.518	104,509	0.347	2.650	Submerged	334.76
3	592.80	5.899	149,935	0.347	3.802	Submerged	370.86
4	830.48	11.564	210,050	0.347	5.326	Submerged	371.10
5	1036.88	14.839	262,254	0.347	6.650	Submerged	409.01
6	1216.08	17.377	307,578	0.347	7.799	Submerged	443.29
7	1410.08	19.992	356,646	0.347	9.043	Submerged	479.20
8	1493.20	20.558	377,669	0.347	9.576	Submerged	500.42
9	1255.28	16.297	317,493	0.347	8.050	Submerged	472.49
10	1066.64	12.991	269,781	0.347	6.841	Submerged	449.68
11	962.48	11.289	243,436	0.347	6.173	Submerged	435.29
12	846.48	9.332	214,097	0.347	5.429	Submerged	421.06
13	631.44	6.166	159,708	0.347	4.050	Submerged	386.40
14	196.00	1.466	49,574	0.347	1.257	Submerged	246.00
15	384.88	3.323	97,346	0.347	2.468	Submerged	320.84
Valve hysteresis tests							
1	101.10	0.381	25,572	0.347	0.648	Submerged	248.93
2	201.20	0.537	50,889	0.347	1.290	Submerged	417.36

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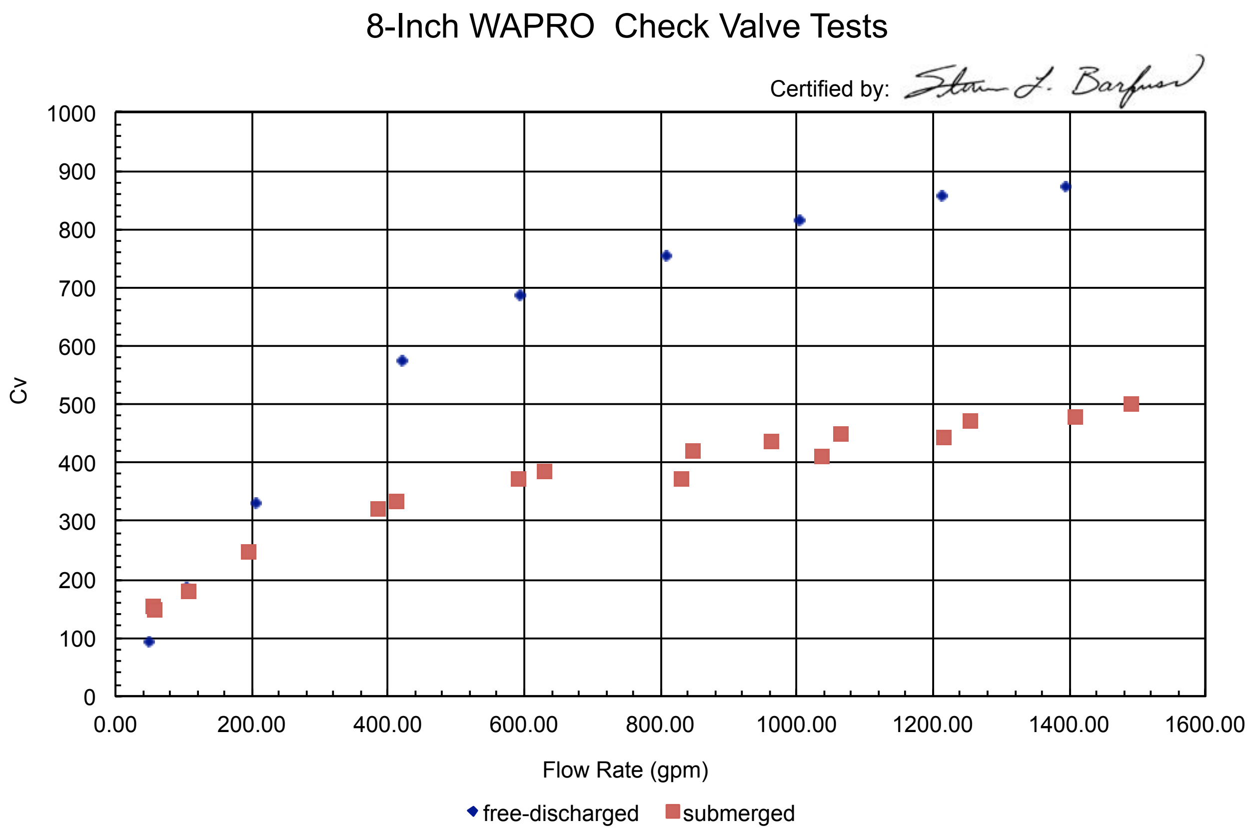

Figure 3. Flow Rate vs Cv for the 8-inch WAPRO rubber check valve

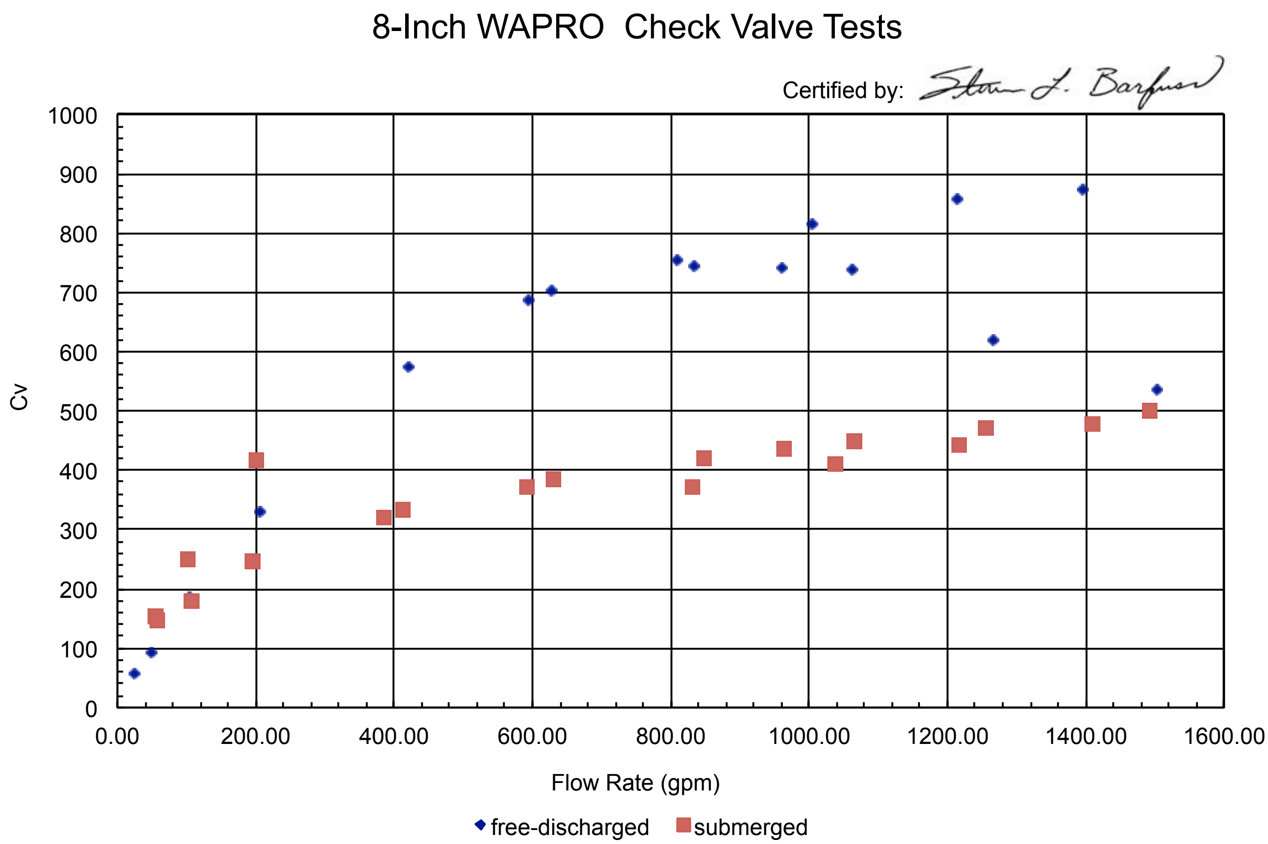

Figure 4. Flow Rate vs Cv for the 8-inch WAPRO rubber check valve (hysteresis shown)