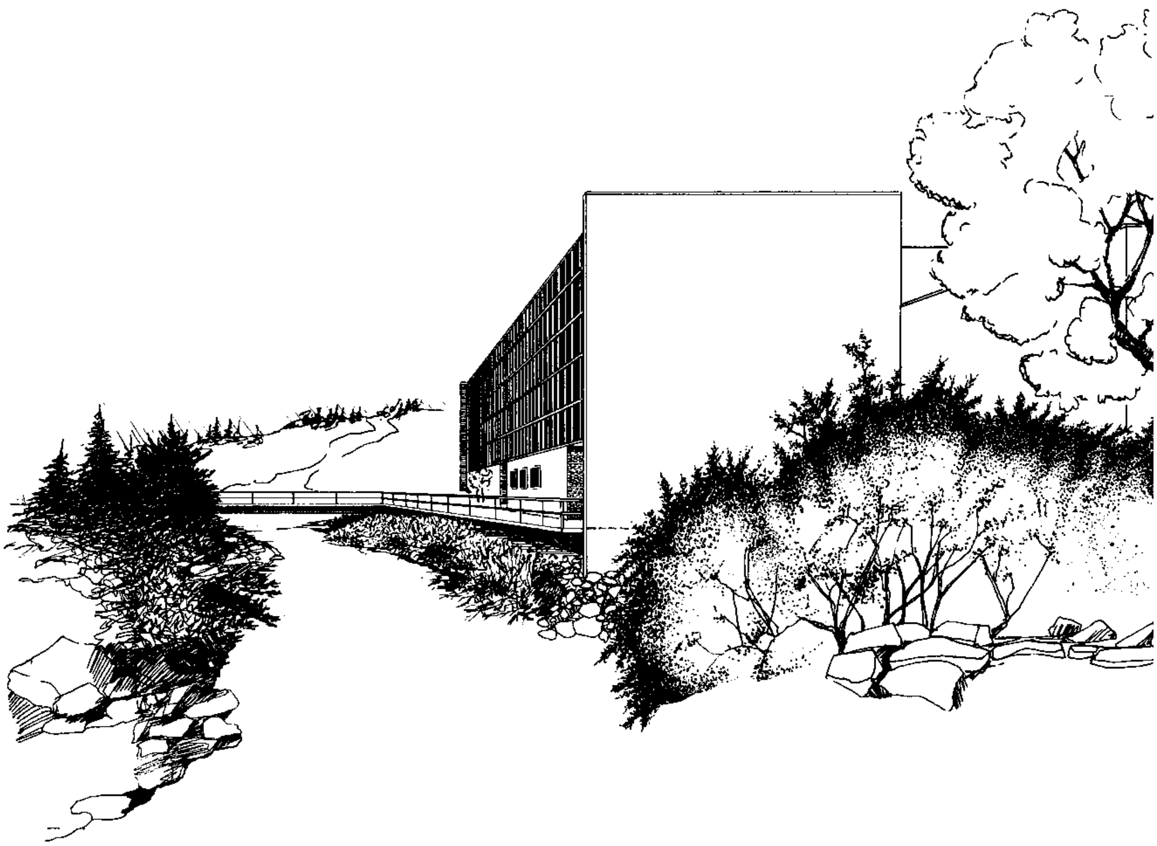
VALVE PERFORMANCE TEST ON A 4-INCH RUBBER CHECK VALVE

Prepared for

WAPRO

February 2016



UTAH WATER RESEARCH LABORATORY

Utah State University **Report No. 3468**

Logan, Utah

VALVE PERFORMANCE TEST ON A 4-INCH RUBBER CHECK VALVE

Submitted to:

WAPRO AB
Munkahusvagen 103
374 31 Karlshamn SWEDEN

By:

Steven L. Barfuss, P.E.
Research Associate Professor

and

Zac Sharp
Research Engineer

Utah Water Research Laboratory
8200 Old Main Hill
Logan, UT 84322-8200

February 2016

Hydraulics Report No. 3468

INTRODUCTION

Utah State University was contracted by WAPRO to perform a flow test at the Utah Water Research Laboratory (UWRL) in Logan, Utah on a 4-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 6-inch supply line, which included more than 40 pipe diameters of standard schedule 4-inch carbon steel laboratory pipe (4.026-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 4-Inch Rubber Check Valve Tests

Figure 2. Test Setup for the Submerged 4-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 either a calibrated 1-inch or 6-inch master laboratory magnetic flow meter installed upstream of the test valve. The calibration for each 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 0.30ft. The head necessary to close the valve was found to be 0.19ft. 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. Figure 4 illustrates additional points when the flow rate was slowly decreased. Video clips of specific runs are provided separately.

Table 1. Utah Water Research Laboratory Flow Meter Calibration Data

Manufacturer:	WAPRO		
Calibration Date:	2/22/16		
Calibration Location:	6-inch supply line	Valve Inside Diameter (in.) =	4.026
		Nominal Pipe Dia. =	4-inch
Serial Number:	NA	Pipe Diameter (in.) =	4.026
Valve Description:	NA	Pipe Area (ft^2) =	0.09
		Water Temp. (F) =	39.2
Pipe Setup		Unit Weight (lb/ft^3) =	62.43
Upstream:	4-inch std. wall steel pipe	Kin. Visc. (ft^2/s) =	1.69E-05
Downstream:	4-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	0.95	0.151	479	0.074	0.029	Free-Discharged	3.74
2	4.15	0.245	2,079	0.149	0.062	Free-Discharged	12.73
3	11.16	0.282	5,597	0.182	0.137	Free-Discharged	31.94
4	26.32	0.360	13,199	0.088	0.663	Free-Discharged	66.68
5	45.11	0.441	22,616	0.088	1.137	Free-Discharged	103.26
6	57.75	0.501	28,956	0.088	1.455	Free-Discharged	123.96
7	72.30	0.519	36,251	0.088	1.822	Free-Discharged	152.47
8	136.43	0.838	68,402	0.088	3.438	Free-Discharged	226.39
9	175.23	1.133	87,856	0.088	4.416	Free-Discharged	250.12
10	251.38	4.991	126,037	0.088	6.335	Free-Discharged	170.97
11	326.85	9.651	163,880	0.088	8.237	Free-Discharged	159.87
12	103.65	0.630	51,969	0.088	2.612	Free-Discharged	198.47
Valve hysteresis tests							
1	212.83	3.313	106,709	0.088	5.364	Free-Discharged	177.67
2	121.55	1.040	60,944	0.088	3.063	Free-Discharged	181.08
3	165.58	2.182	83,018	0.088	4.173	Free-Discharged	170.32
4	99.68	0.618	49,976	0.088	2.512	Free-Discharged	192.65
5	169.73	1.094	85,099	0.088	4.277	Free-Discharged	246.58
6	215.00	1.544	107,799	0.088	5.419	Free-Discharged	262.89
7	252.13	4.386	126,413	0.088	6.354	Free-Discharged	182.93
8	212.18	2.880	106,383	0.088	5.347	Free-Discharged	189.98
9	164.58	1.101	82,517	0.088	4.148	Free-Discharged	238.38
10	173.30	1.315	86,891	0.088	4.368	Free-Discharged	229.65

Certified by:

Steven L. Barfuss

Steven L. Barfuss P.E.
Research Associate Professor

Table 2. Utah Water Research Laboratory Flow Meter Calibration Data

Manufacturer: WAPRO
Calibration Date: 2/22/16
Calibration Location: 6-inch supply line

Serial Number: NA
Valve Description: NA

Pipe Setup
Upstream: 4-inch std. wall steel pipe
Downstream: 4-inch std. wall steel pipe

Valve Inside Diameter (in.) = 4.026
Nominal Pipe Dia. = 4-inch
Pipe Diameter (in.) = 4.026
Pipe Area (ft^2) = 0.09
Water Temp. (F) = 39.2
Unit Weight (lb/ft^3) = 62.43
Kin. Visc. (ft^2/s) = 1.69E-05

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	1.72	0.054	862	0.088	0.043	Submerged	11.26
2	4.47	0.088	2,240	0.088	0.113	Submerged	22.89
3	11.30	0.117	5,666	0.088	0.285	Submerged	50.26
4	26.31	0.156	13,192	0.088	0.663	Submerged	101.17
5	45.27	0.224	22,698	0.088	1.141	Submerged	145.33
6	58.54	0.276	29,352	0.088	1.475	Submerged	169.29
7	72.88	0.319	36,539	0.088	1.837	Submerged	196.18
8	139.38	0.692	69,882	0.088	3.513	Submerged	254.64
9	174.53	1.006	87,505	0.088	4.398	Submerged	264.36
10	212.65	2.299	106,621	0.088	5.359	Submerged	213.11
11	250.18	4.567	125,436	0.088	6.305	Submerged	177.88
12	325.53	10.526	163,216	0.088	8.204	Submerged	152.46
Valve hysteresis tests							
1	103.60	0.444	51,944	0.088	2.611	Submerged	236.24
2	166.75	1.823	83,607	0.088	4.203	Submerged	187.64
3	139.53	1.164	69,957	0.088	3.516	Submerged	196.53
4	105.60	0.691	52,947	0.088	2.661	Submerged	193.05
5	122.25	0.792	61,295	0.088	3.081	Submerged	208.69

Certified by:

Steven L. Barfuss

Steven L. Barfuss P.E.
Research Associate Professor

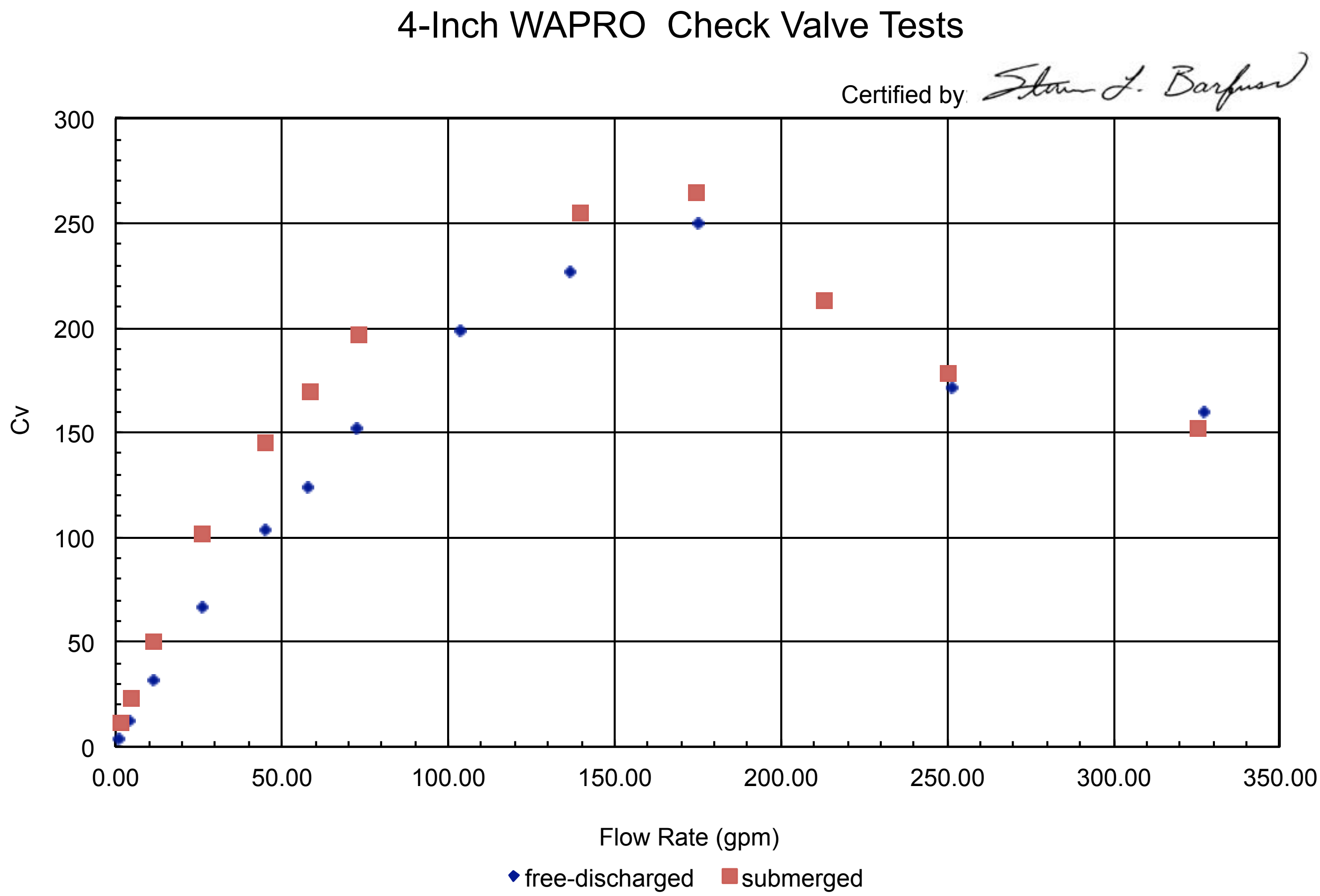


Figure 3. Flow Rate vs Cv for the 4-inch WAPRO rubber check valve

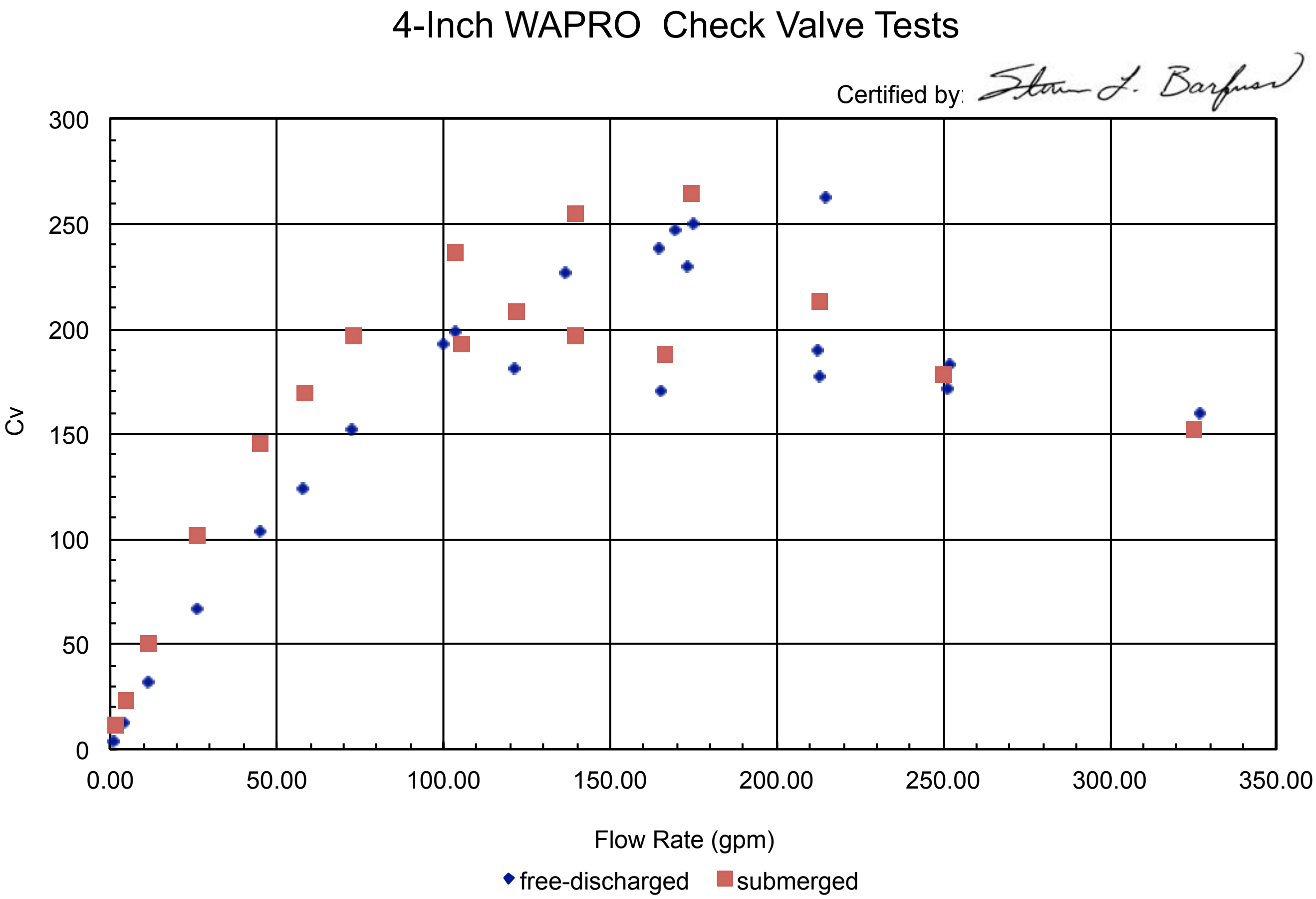


Figure 4. Flow Rate vs Cv for the 4-inch WAPRO rubber check valve (hysteresis shown)