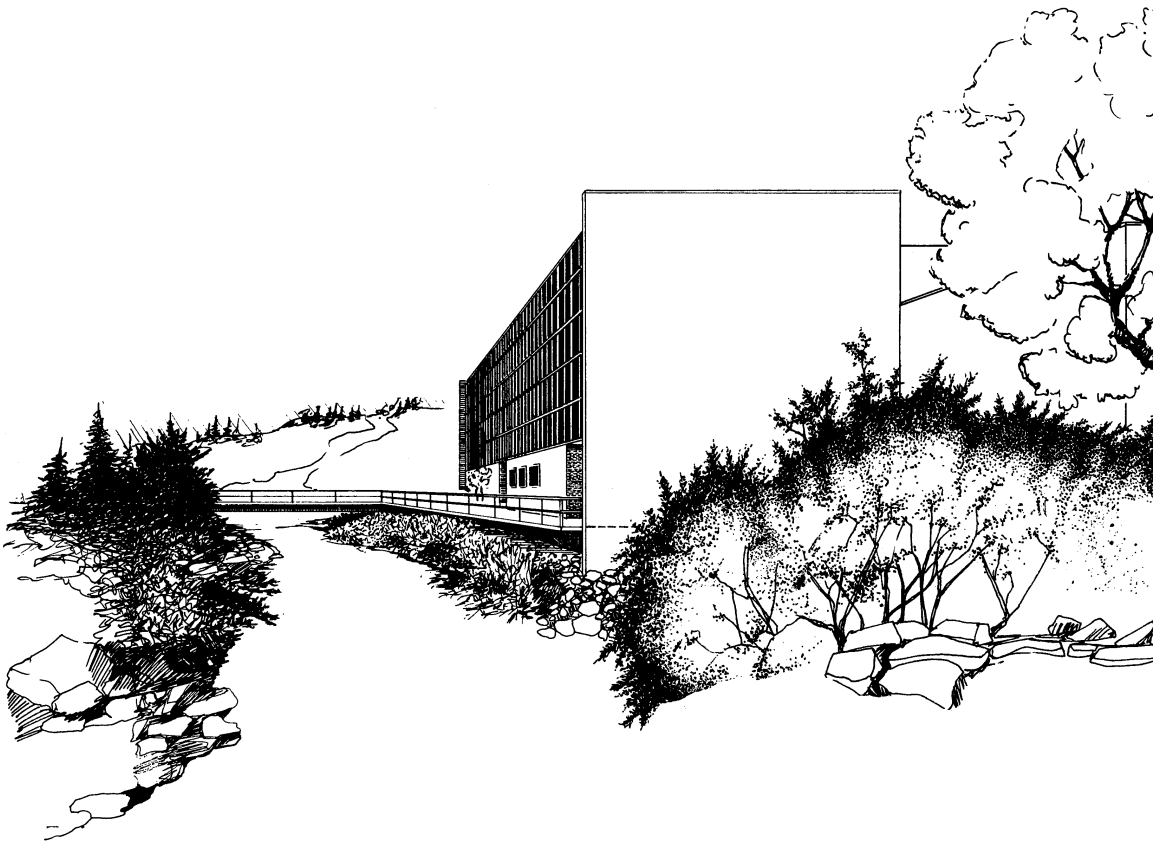
New VFD Check Valve VS Standard Check Valve
FLOW COEFFICIENT TESTING

Prepared for

Metraflex

December 2023



UTAH WATER RESEARCH LABORATORY

Utah State University
Logan, Utah

Report Nos. 4562, 4683, 4692

New VFD Check Valve VS Standard Check Valve
FLOW COEFFICIENT TESTING

Prepared for:

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December 2023

Hydraulics Report Nos. 4562, 4683, 4692

INTRODUCTION

Flow Coefficient performance tests were conducted at the Utah Water Research Laboratory (UWRL) on a 3, 4 & 6-inch standard globe check valves manufactured by Metraflex. The valve was provided with two disc configurations and two springs; the original disc, guide and spring and a new disc, guide and spring (VFD Check Valve). The intent of the testing was to quantify the valve's discharge capacity for the two different disc configurations over a wide range of flow conditions with the pressure loss and flow measured and flow coefficients determined. The work was authorized by Metraflex with the intent to pay using corporate credit card and was done in accordance with the ANSI/ISA 75.02.01-2008 Control Valve Capacity Test Procedures standard with slight modifications in order to characterize the valve's performance over a wide flow range.

EXPERIMENTAL PROGRAM

The valve under test was installed in a test line with approximately 20 diameters of straight approach piping to provide uniform flow at the inlet of the valve. There were approximately 10 diameters of straight pipe downstream from the valve. Pressure taps were located two pipe diameters upstream from the valve and six pipe diameters downstream from the valve. Flow was supplied using a 100-horsepower pump. Figure 1 shows the test setup.

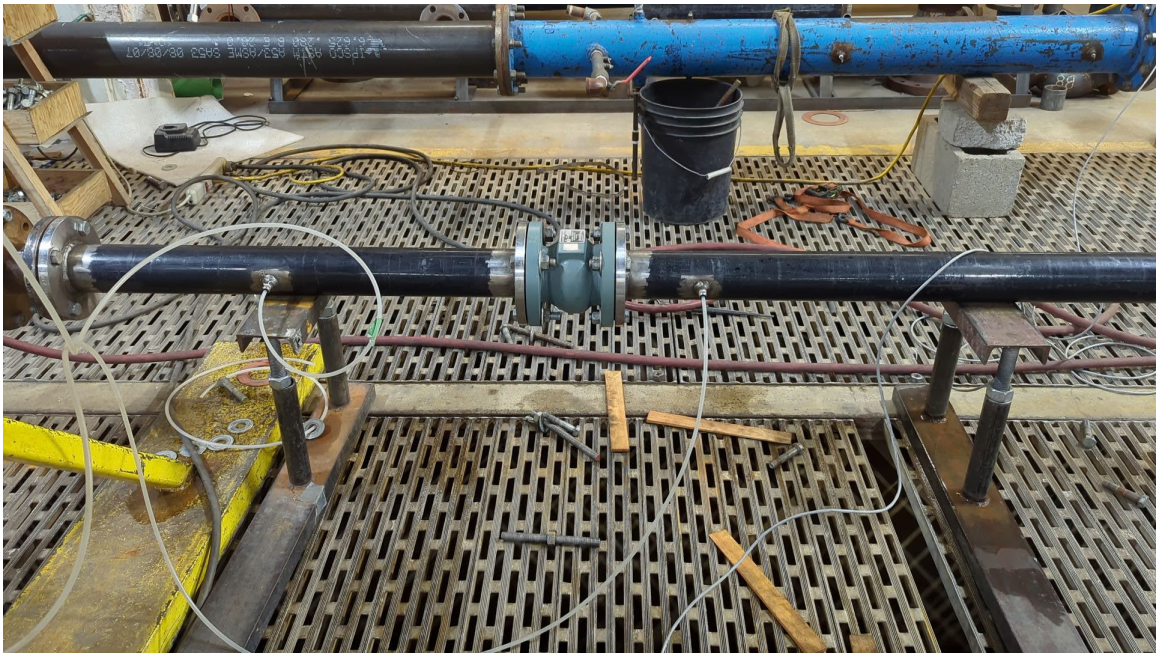

Figure 1. 3-inch check valve installed in test line.

The flow rate was measured using magnetic flow meters which were calibrated against certified weigh tanks. The weigh tank was used to verify the flow during testing for each meter. The differential pressure across the valve was measured using a Rosemount differential transmitter. The upstream pressure was measured using a Rosemount pressure transmitter. The water temperature was measured using a calibrated RTD.

FLOW COEFFICIENT

The definition of the flow coefficient used in this report is:

$$C_v = \frac{Q}{\sqrt{\frac{\Delta P}{SG}}} \tag{1}$$

where Q is the discharge of test fluid in U.S. gallons per minute flowing through the valve, ΔP is the pressure drop across the valve in psi, and SG is the specific gravity of the test fluid. C_v in Equation 1 is calculated using the gross pressure drop (ISA standard) between taps that are two diameters upstream and six diameters downstream.

TEST PROCEDURE

The test procedure essentially followed ISA 75.02.01-2008 with slight modifications to account for the fact that the valve is spring loaded and it was desired to determine the valve's performance characteristics over a wide flow range.

C_v Determinination

1. Install the check valve in straight piping of nominal size and standard wall thickness. Ensure that at least 20 diameters of straight pipe are upstream from the valve and at least 8 diameters are installed downstream from the valve.
2. Flow test the valve at several different flow rates and observe the relationship between flow and C_v.
3. The following data shall be recorded:
   a) Upstream pressure (measurement not to exceed 2 percent of actual value).
   b) Pressure differential across valve (measurement not to exceed 2 percent of actual value).
   c) Volumetric flow rate (measurement not to exceed 2 percent of actual value).
   d) Fluid temperature (measurement error not to exceed 2 degrees Fahrenheit).
   e) Valve description and identifying numbers.
4. Calculate the flow coefficient C_v as given in equation 1.

TEST RESULTS

The flow coefficient C_v for the valve is given in Tables 1 and 2 and plotted graphically on Figure 2. Figure 3 shows C_v plotted against pressure drop for the valve.

Table 1. Flow Coefficient

3" Standard Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	3.068	Water temp. (F) =	**39.9**
Pipe Area (ft^2) =	0.051	Unit weight H2O (pcf) =	62.43
		Density (slug) =	1.941
		Specific Gravity H2O =	1.0010
		Vapor pressure (psia) =	0.12
		Viscosity (cP) =	1.5477
Flow Key		Kinematic visc. (ft^2/s) =	1.67E-05
25K, 250K = Weigh Tank		Barometric Pressure (psi) =	12.47
12R = 12" Mag Meter			
6M = 6" Mag Meter			

Tested by: M. Cannon 12/13/23
Prepared by: Michael C. Johnson 11/23
Checked by: Zac Sharp
Witnessed by: -

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key	Wt. (lbs)	Mag/t (Hz/s)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M	1000	141.74	0.08	35.4	1.54	50	4.596	9	1.2833	44.95	0.64	44.31	44.4
2	6M		276.30	0.15	69.1	3.00	50	4.409	9	1.3499	42.61	0.79	41.83	77.9
3	6M		422.30	0.24	105.6	4.58	50	4.194	9	1.4245	39.93	0.96	38.97	108.1
4	6M		555.70	0.31	138.9	6.03	50	3.988	9	1.4932	37.35	1.11	36.24	131.9
5	6M	5000	694.60	0.39	173.7	7.54	50	3.775	9	1.5747	34.69	1.29	33.39	152.8
6	6M		819.80	0.46	205.0	8.89	50	3.581	9	1.6874	32.26	1.55	30.72	164.9
7	6M		972.10	0.54	243.0	10.55	50	3.343	9	1.9570	29.29	2.15	27.13	165.7
8	6M		1125.30	0.63	281.3	12.21	50	3.106	9	2.2730	26.33	2.86	23.46	166.3
9	6M		1245.00	0.69	311.3	13.51	50	2.916	9	2.5550	23.95	3.50	20.45	166.5
10	6M	9800	1376.00	0.77	344.0	14.93	50	2.705	9	2.8980	21.31	4.27	17.04	166.5

Table 2. Flow Coefficient

Metraflex 3" VFD Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	3.068	Water temp. (F) =	**40.7**
Pipe Area (ft^2) =	0.051	Unit weight H2O (pcf) =	62.43
		Density (slug) =	1.940
		Specific Gravity H2O =	1.0010
		Vapor pressure (psia) =	0.12
		Viscosity (cP) =	1.5262
Flow Key		Kinematic visc. (ft^2/s) =	1.64E-05
25K, 250K = Weigh Tank		Barometric Pressure (psi) =	12.47
12R = 12" Mag Meter			
6M = 6" Mag Meter			

Tested by: M. Cannon 12/13/23
Prepared by: Michael C. Johnson 11/23
Checked by: Zac Sharp
Witnessed by: -

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key		Mag/t (Hz/s)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M		140.43	0.08	35.1	1.52	35	4.581	9	1.2241	31.33	0.50	30.83	49.5
2	6M		278.20	0.15	69.6	3.02	35	4.384	9	1.2925	29.61	0.66	28.95	85.8
3	6M		402.10	0.22	100.5	4.36	35	4.214	9	1.3476	28.12	0.78	27.34	113.7
4	6M		556.10	0.31	139.0	6.03	35	3.992	9	1.4120	26.18	0.93	25.25	144.5
5	6M		686.40	0.38	171.6	7.45	35	3.786	9	1.4616	24.38	1.04	23.34	168.5
6	6M		833.30	0.46	208.3	9.04	35	3.565	9	1.5094	22.44	1.15	21.30	194.7
7	6M		970.50	0.54	242.6	10.53	35	3.350	9	1.6432	20.56	1.45	19.12	201.8
8	6M		1110.00	0.62	277.5	12.04	35	3.134	9	1.8363	18.67	1.88	16.79	202.4
9	6M		1252.30	0.70	313.1	13.59	35	2.913	9	2.0640	16.74	2.39	14.34	202.4
10	6M		1378.20	0.77	344.6	14.95	35	2.711	9	2.2820	14.97	2.88	12.09	203.0

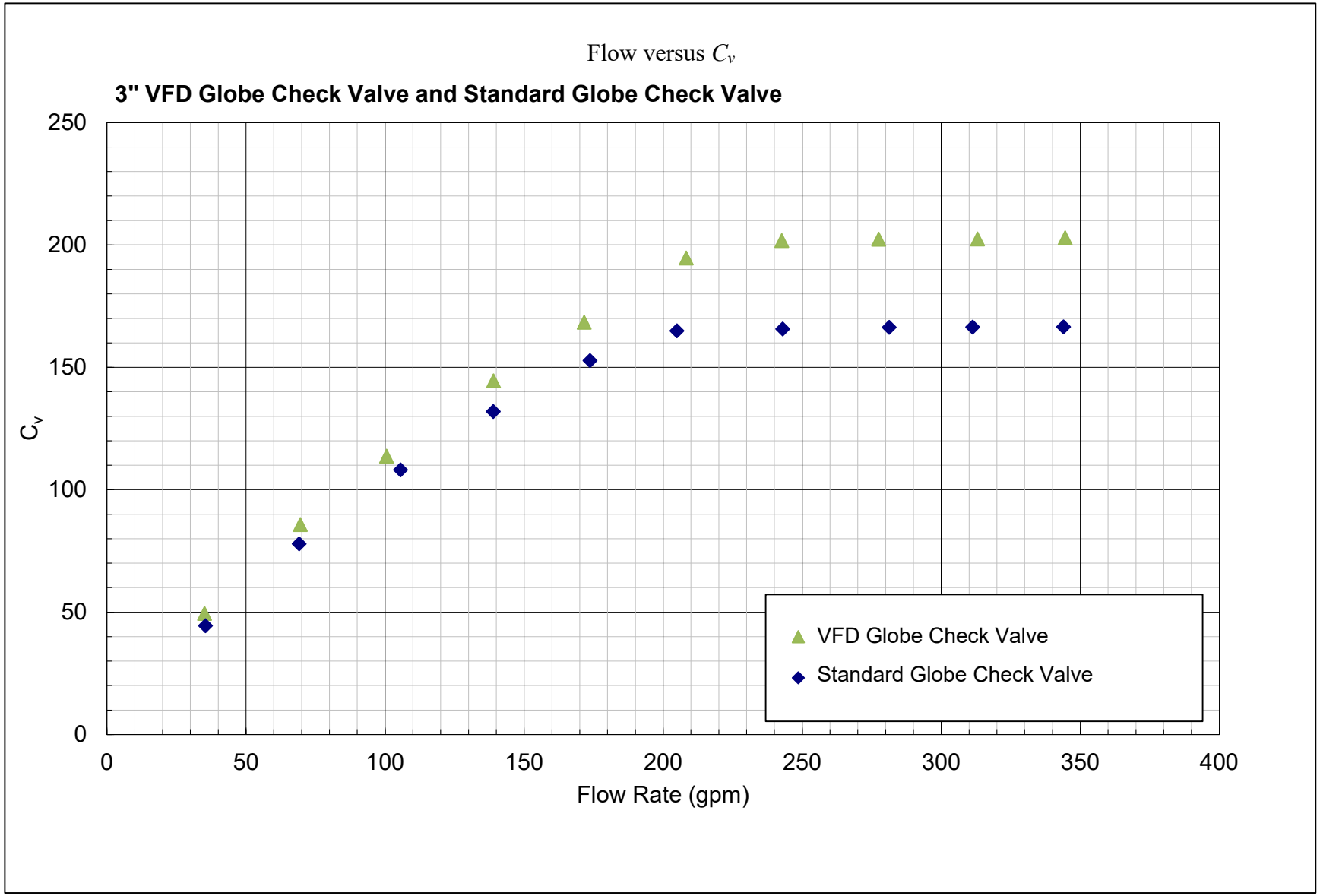

Figure 2. Flow versus C_v for the 3-inch check valve.

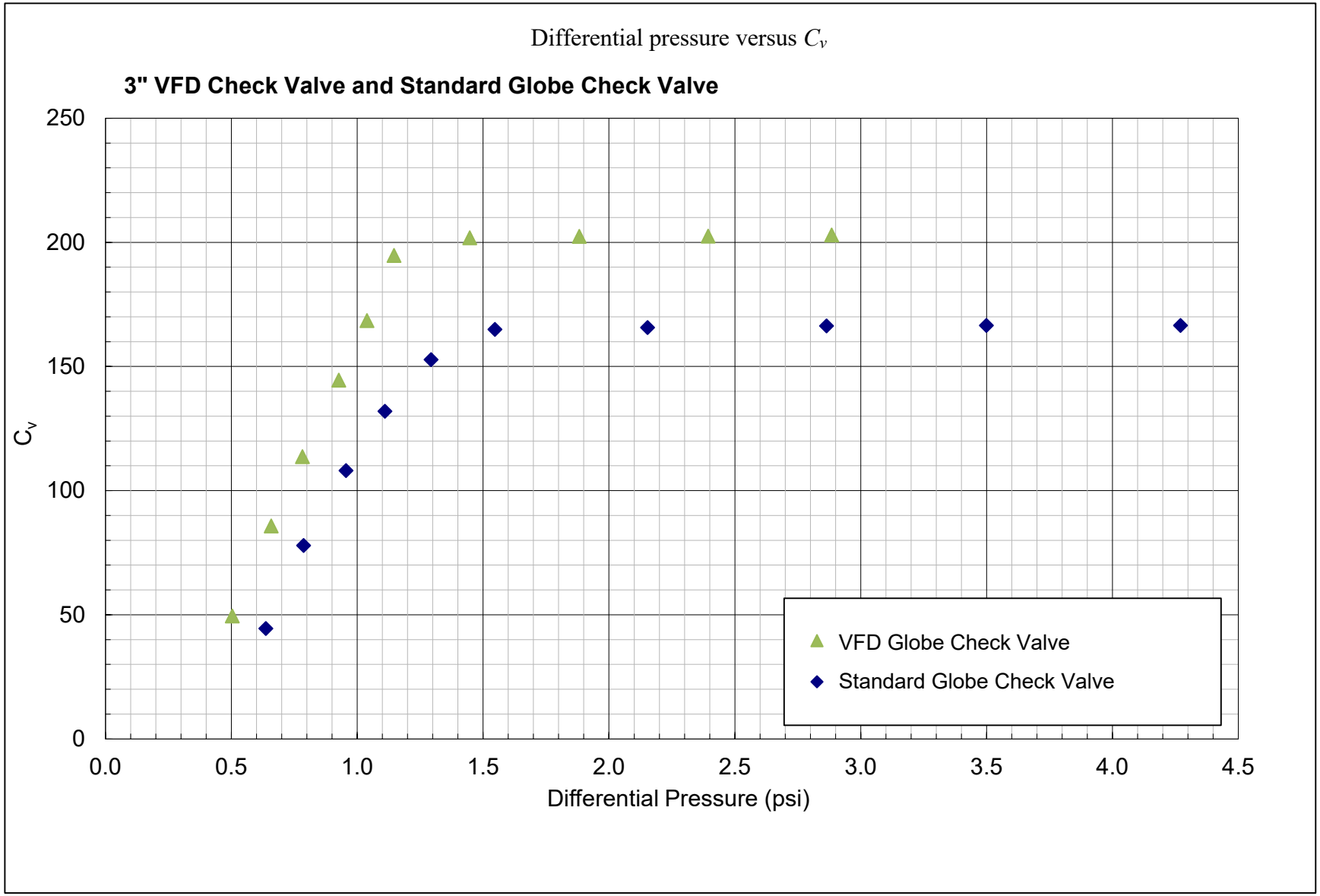

Figure 3. Differential pressure versus C_v for the 3-inch check valve.

Table 3. Flow Coefficient

4" Standard Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	4.026	Water temp. (F) =	**58.1**
Pipe Area (ft^2) =	0.088	Unit weight H2O (pcf) =	62.38
		Density (slug) =	1.939
		Specific Gravity H2O =	1.0002
		Vapor pressure (psia) =	0.24
		Viscosity (cP) =	1.1536
		Kinematic visc. (ft^2/s) =	1.24E-05
Flow Key		Barometric Pressure (psi) =	12.49
5K = Weigh Tank			
6M = 6" Mag Meter			

Tested by: S. Sanders 7/14/22
Prepared by: Michael C. Johnson 7/14/22
Checked by: Zac Sharp
Witnessed by: -

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key	Wt. (lbs)	Mag Out. (Hz)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M		244.20	0.14	61.1	1.54	50	4.411	9	1.3550	42.64	0.80	41.84	68.3
2	6M		479.20	0.27	119.8	3.02	50	4.098	9	1.4241	38.73	0.95	37.77	122.6
3	6M		713.30	0.40	178.3	4.49	50	3.780	9	1.5021	34.75	1.13	33.62	167.8
4	6M		957.30	0.53	239.3	6.03	50	3.473	9	1.6015	30.91	1.35	29.56	205.7
5	6M		1189.50	0.66	297.4	7.49	50	4.975	9	1.7088	49.69	1.59	48.09	235.5
6	6M		1427.80	0.80	357.0	9.00	50	4.466	9	1.9167	43.33	2.06	41.26	248.6
7	6M		1664.30	0.93	416.1	10.49	50	4.516	9	2.2420	43.95	2.79	41.16	248.9
8	6M		1902.70	1.06	475.7	11.99	50	4.804	9	2.6210	47.55	3.65	43.90	249.1
9	6M		2147.00	1.20	536.8	13.53	50	3.882	9	3.0630	36.03	4.64	31.38	249.2
10	6M		2381.00	1.33	595.3	15.00	50	4.677	9	3.5340	45.96	5.70	40.26	249.3

Table 4. Flow Coefficient

Metraflex 4" VFD Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	4.026	Water temp. (F) =	**58.1**
Pipe Area (ft^2) =	0.088	Unit weight H2O (pcf) =	62.38
		Density (slug) =	1.939
		Specific Gravity H2O =	1.0002
		Vapor pressure (psia) =	0.24
		Viscosity (cP) =	1.1538
		Kinematic visc. (ft^2/s) =	1.24E-05
Flow Key		Barometric Pressure (psi) =	12.49
5K = Weigh Tank			
6M = 6" Mag Meter			

Tested by: S. Sanders 7/14/22
Prepared by: Michael C. Johnson 7/14/22
Checked by: Zac Sharp
Witnessed by: -

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key		Mag Out. (Hz)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M		247.80	0.14	62.0	1.56	50	4.424	9	1.3350	42.80	0.75	42.05	71.4
2	6M		481.30	0.27	120.3	3.03	50	4.697	9	1.4553	46.21	1.02	45.19	118.9
3	6M		715.90	0.40	179.0	4.51	50	4.303	9	1.5558	41.29	1.25	40.04	160.1
4	6M		957.60	0.53	239.4	6.03	50	4.680	9	1.6396	46.00	1.44	44.56	199.6
5	6M		1198.20	0.67	299.6	7.55	50	4.238	9	1.7184	40.48	1.62	38.86	235.6
6	6M		1428.90	0.80	357.2	9.00	50	4.912	9	1.7913	48.90	1.78	47.12	267.7
7	6M		1672.60	0.93	418.2	10.54	50	4.372	9	1.8696	42.15	1.96	40.19	299.0
8	6M		1905.70	1.06	476.4	12.01	50	4.683	9	1.9466	46.04	2.13	43.91	326.5
9	6M		2141.00	1.19	535.3	13.49	50	4.126	9	2.0800	39.08	2.43	36.65	343.4
10	6M		2385.00	1.33	596.3	15.03	50	3.584	9	2.2720	32.30	2.86	29.44	352.5
11	6M		2852.00	1.59	713.0	17.97	50	4.633	9	2.8130	45.41	4.08	41.33	353.0
12	6M		2619.00	1.46	654.8	16.50	50	4.278	9	2.5340	40.98	3.45	37.52	352.5

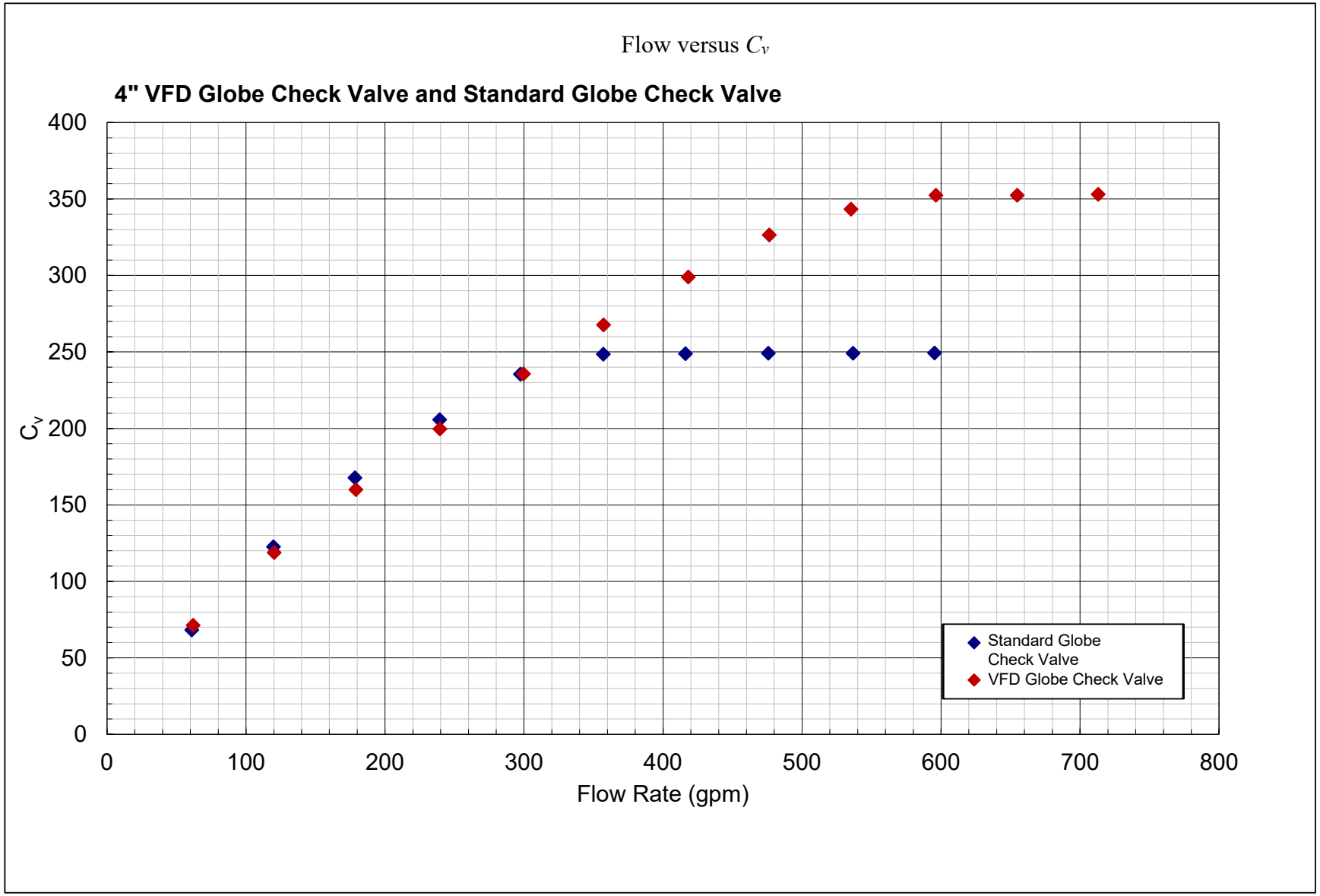

Figure 2. Flow versus C_v for the 4-inch check valve.

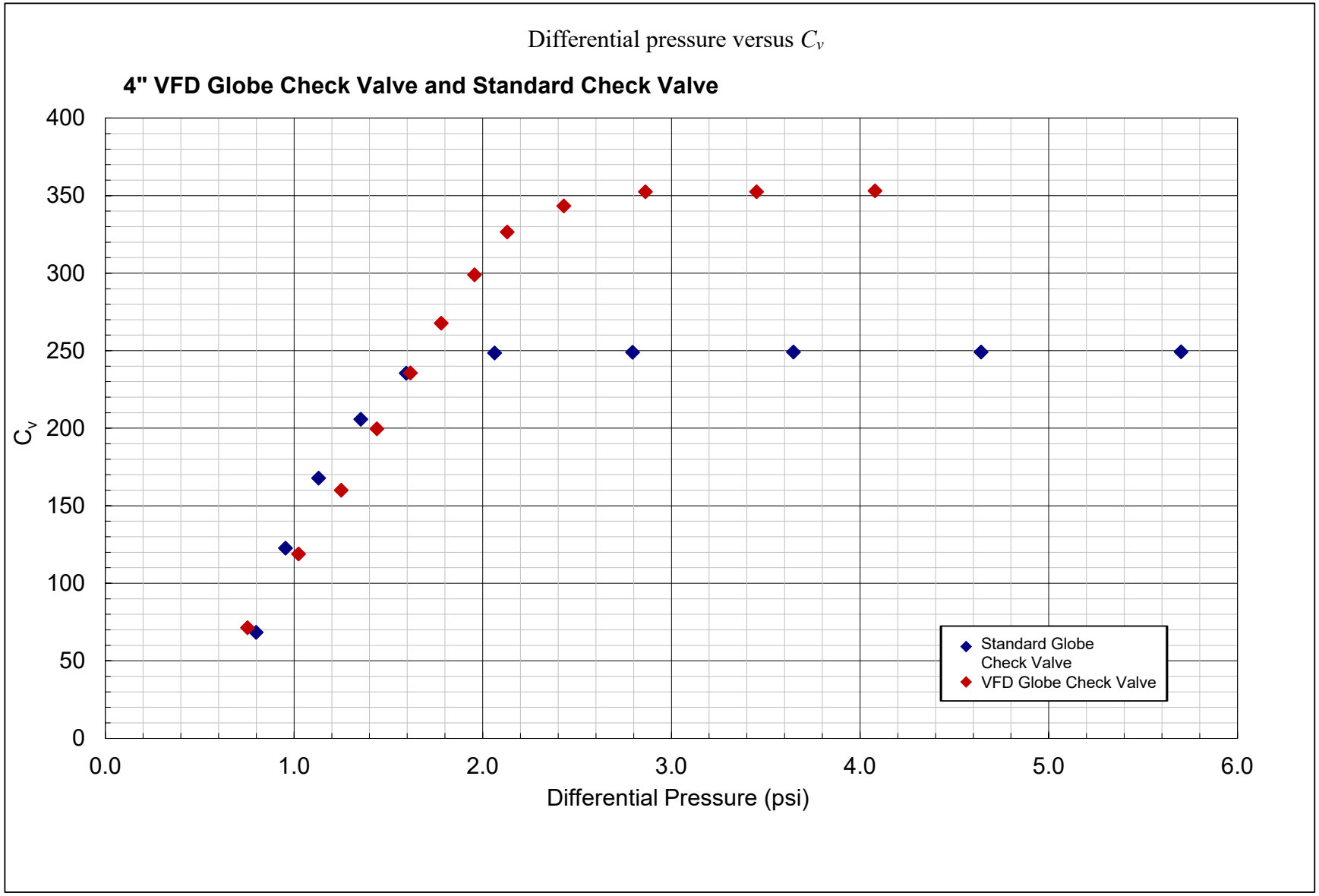

Figure 3. Differential pressure versus C_v for the 4-inch check valve.

Table 5. Flow Coefficient

6" Standard Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	6.125	Water temp. (F) =	**46.0**
Pipe Area (ft^2) =	0.205	Unit weight H2O (pcf) =	62.42
		Density (slug) =	1.940
		Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.15
		Viscosity (cP) =	1.3950
Flow Key		Kinematic visc. (ft^2/s) =	1.50E-05
25K, 250K = Weigh Tank		Barometric Pressure (psi) =	12.40
12R = 12" Mag Meter			
6M = 6" Mag Meter			

Tested by: M. Cannon 11/7/23
Prepared by: Michael C. Johnson 11/23
Checked by: Zac Sharp
Witnessed by: Jackson Kamedulski

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key	Wt. (lbs)	Mag/t (Hz/s)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M	3900	563.50	0.31	140.9	1.53	35	4.551	9	1.2319	31.07	0.52	30.55	195.1
2	6M		1113.40	0.62	278.4	3.03	35	4.438	9	1.2693	30.08	0.61	29.48	357.7
3	6M		1659.20	0.92	414.8	4.52	35	4.377	9	1.3256	29.55	0.73	28.82	484.8
4	6M	15500	2210.00	1.23	552.5	6.02	35	4.356	9	1.3880	29.37	0.87	28.49	591.6
5	12R	19400	69.59	1.55	696.4	7.58	35	4.306	9	1.6047	28.93	1.36	27.57	597.3
6	12R		83.62	1.86	836.6	9.11	35	4.230	9	1.8643	28.26	1.94	26.32	600.2
7	12R		96.20	2.14	962.3	10.48	35	4.155	9	2.1450	27.61	2.58	25.03	599.8
8	12R		109.67	2.44	1096.9	11.94	35	4.059	9	2.4870	26.77	3.35	23.42	599.9
9	12R		123.97	2.76	1239.7	13.50	35	3.961	9	2.8810	25.91	4.23	21.68	602.9
10	12R	38600	138.33	3.08	1383.2	15.06	35	3.847	9	3.3250	24.91	5.23	19.68	605.0

Table 6. Flow Coefficient

Metraflex 6" VFD Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	6.125	Water temp. (F) =	**46.0**
Pipe Area (ft^2) =	0.205	Unit weight H2O (pcf) =	62.42
		Density (slug) =	1.940
		Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.15
		Viscosity (cP) =	1.3950
Flow Key		Kinematic visc. (ft^2/s) =	1.50E-05
25K, 250K = Weigh Tank		Barometric Pressure (psi) =	12.40
12R = 12" Mag Meter			
6M = 6" Mag Meter			

Tested by: M. Cannon 11/7/23
Prepared by: Michael C. Johnson 11/23
Checked by: Zac Sharp
Witnessed by: Jackson Kamedulski

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key		Mag/t (Hz/s)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M		552.40	0.31	138.1	1.50	35	4.543	9	1.1498	31.00	0.34	30.66	238.0
2	6M		1112.60	0.62	278.2	3.03	35	4.429	9	1.1554	30.00	0.35	29.65	470.6
3	6M		1660.00	0.92	415.0	4.52	35	4.375	9	1.1816	29.53	0.41	29.12	649.5
4	6M		2223.00	1.24	555.8	6.05	35	4.349	9	1.2149	29.30	0.48	28.82	799.6
5	12R		68.76	1.53	688.1	7.49	35	4.303	9	1.3321	28.90	0.75	28.15	796.4
6	12R		83.38	1.86	834.2	9.08	35	4.227	9	1.4819	28.24	1.08	27.15	801.5
7	12R		96.39	2.15	964.2	10.50	35	4.140	9	1.6473	27.48	1.46	26.02	799.3
8	12R		111.76	2.49	1117.7	12.17	35	4.034	9	1.8607	26.55	1.94	24.61	803.5
9	12R		124.51	2.77	1245.1	13.56	35	3.940	9	2.0680	25.73	2.40	23.32	803.6
10	12R		139.03	3.10	1390.2	15.14	35	3.822	9	2.3230	24.69	2.98	21.72	806.1

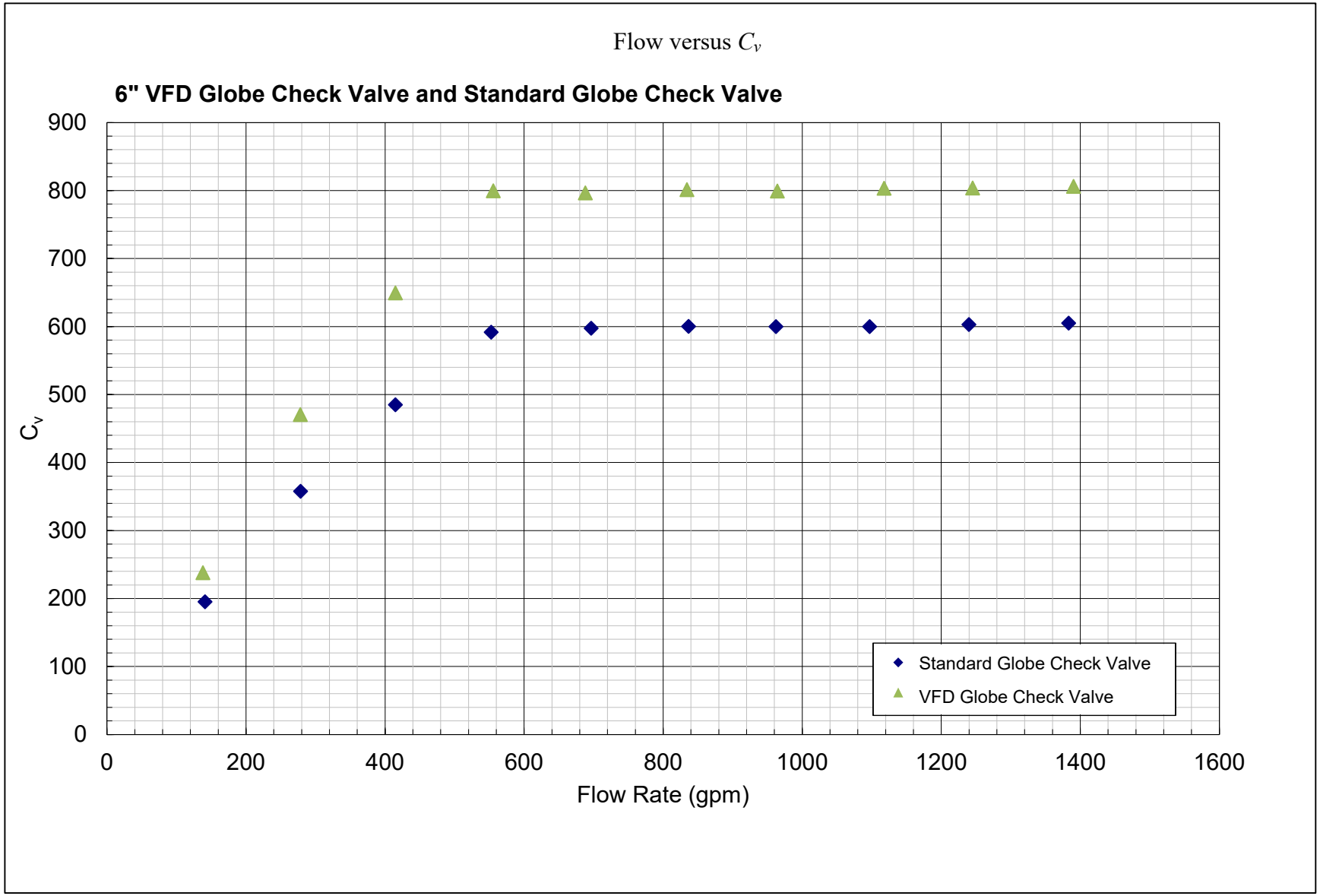

Figure 2. Flow versus C_v for the 6-inch check valve.

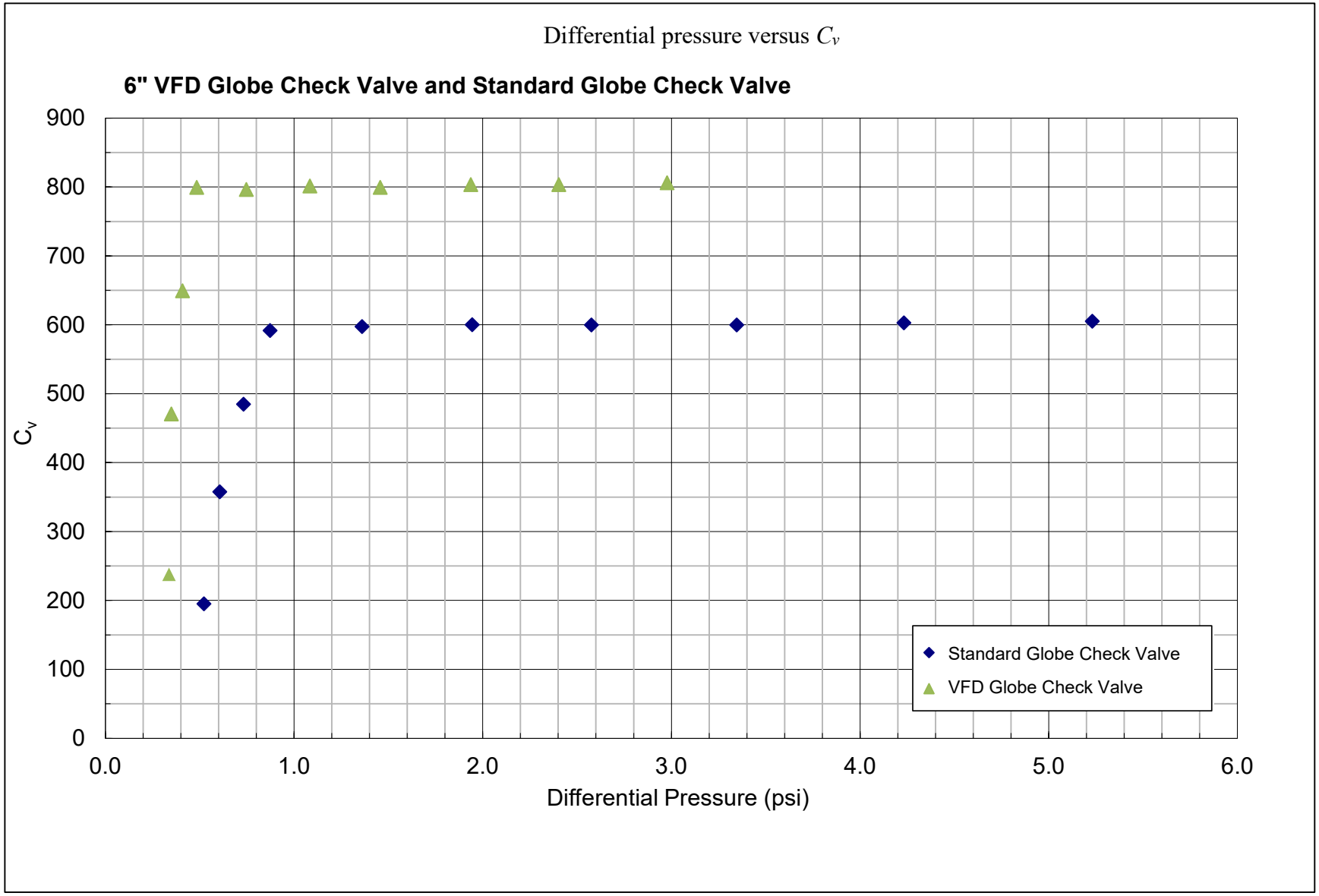

Figure 3. Differential pressure versus C_v for the 6-inch check valve.

Table 7. Flow Coefficient

8" Standard Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	7.981	Water temp. (F) =	**40.0**
Pipe Area (ft^2) =	0.347	Unit weight H2O (pcf) =	62.43
		Density (slug) =	1.941
		Specific Gravity H2O =	1.0010
		Vapor pressure (psia) =	0.12
		Viscosity (cP) =	1.5450
Flow Key		Kinematic visc. (ft^2/s) =	1.66E-05
25K, 250K = Weigh Tank		Barometric Pressure (psi) =	12.33
12R = 12" Mag Meter			
6M = 6" Mag Meter			

Tested by: M. Cannon 2/8/24
Prepared by: Michael C. Johnson 11/23
Checked by: Zac Sharp
Witnessed by: -

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key		Mag/t (Hz/s)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M		934.40	0.52	234.3	1.50	35	4.590	9	1.2792	31.41	0.63	30.78	295.8
2	6M		1877.90	1.05	470.9	3.02	35	4.513	9	1.2850	30.74	0.64	30.10	588.4
3	12R		71.28	1.60	716.9	4.60	35	4.471	9	1.3140	30.37	0.71	29.66	853.3
4	12R		93.60	2.10	941.0	6.03	35	4.398	9	1.4211	29.73	0.95	28.79	967.2
5	12R		116.98	2.62	1175.7	7.54	35	4.314	9	1.5497	29.00	1.24	27.76	1057.7
6	12R		141.00	3.16	1416.9	9.09	35	4.206	9	1.7188	28.05	1.62	26.44	1114.7
7	12R		163.16	3.65	1639.4	10.51	35	4.068	9	1.9570	26.85	2.15	24.69	1117.8
8	12R		187.00	4.19	1878.9	12.05	35	3.885	9	2.2540	25.24	2.82	22.42	1119.1
9	12R		211.00	4.72	2120.0	13.60	35	3.672	9	2.5910	23.38	3.58	19.80	1121.0
10	12R		233.10	5.22	2342.0	15.02	35	3.459	9	2.9470	21.52	4.38	17.14	1119.5

Table 8. Flow Coefficient

Metraflex 8" VFD Globe Check Valve

Reference Data			
Pipe Dia. (I.D. in.) =	7.981	Water temp. (F) =	**40.2**
Pipe Area (ft^2) =	0.347	Unit weight H2O (pcf) =	62.43
		Density (slug) =	1.941
		Specific Gravity H2O =	1.0010
		Vapor pressure (psia) =	0.12
		Viscosity (cP) =	1.5396
Flow Key		Kinematic visc. (ft^2/s) =	1.66E-05
25K, 250K = Weigh Tank		Barometric Pressure (psi) =	12.33
12R = 12" Mag Meter			
6M = 6" Mag Meter			

Tested by: M. Cannon 2/9/24
Prepared by: Michael C. Johnson 11/23
Checked by: Zac Sharp
Witnessed by: -

	Flow Measurement						Pressure Measurement							Coef.
Run No.	Flow Key	Wt. (lbs)	Mag/t (Hz/s)	Flow (cfs)	Flow (gpm)	V (pipe) (fps)	Pu Span (psi)	Pu (V)	ΔP Span (psi)	ΔP (V)	Pu (psi)	ΔP (psi)	Pd (psi)	C_v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	6M	6600	942.30	0.53	236.3	1.52	35	4.608	9	1.2141	31.57	0.48	31.09	340.6
2	6M		1862.40	1.04	467.0	3.00	35	4.525	9	1.2425	30.84	0.55	30.30	632.6
3	12R		71.17	1.59	715.8	4.59	35	4.478	9	1.2897	30.43	0.65	29.78	887.0
4	12R	26360	94.18	2.11	946.8	6.07	35	4.403	9	1.3150	29.78	0.71	29.07	1125.2
5	12R		115.33	2.58	1159.2	7.43	35	4.322	9	1.3324	29.07	0.75	28.32	1341.0
6	12R		140.84	3.15	1415.3	9.08	35	4.211	9	1.4386	28.10	0.99	27.11	1425.4
7	12R	45780	163.95	3.67	1647.4	10.56	35	4.069	9	1.5897	26.85	1.33	25.53	1430.8
8	12R		189.15	4.23	1900.5	12.19	35	3.875	9	1.7776	25.16	1.75	23.41	1437.5
9	12R		210.50	4.71	2115.0	13.56	35	3.676	9	1.9577	23.42	2.15	21.26	1441.5
10	12R	65140	233.20	5.22	2343.0	15.03	35	3.462	9	2.1620	21.54	2.61	18.93	1449.8

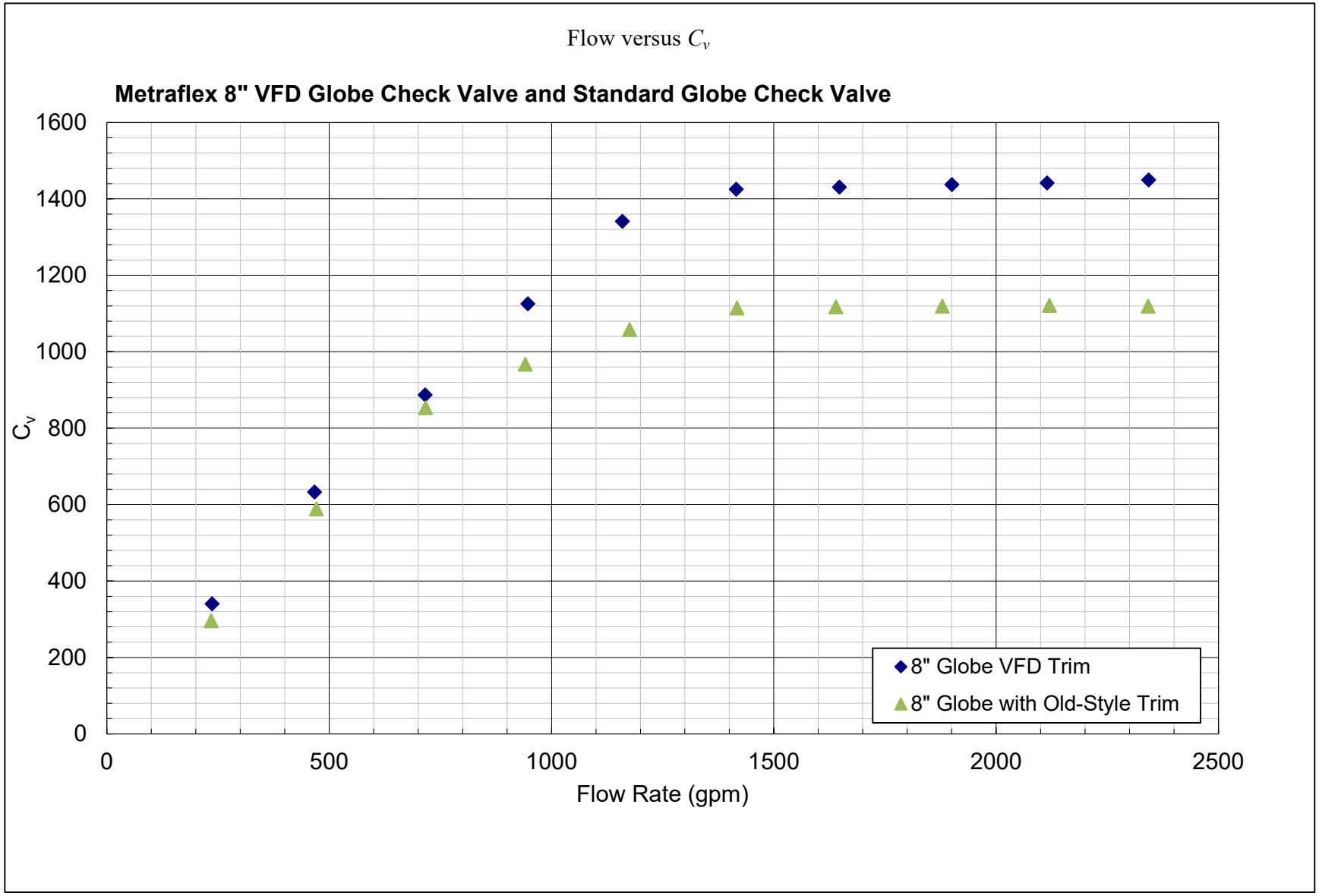

Figure 2. Flow versus C_v for the 8-inch check valve.

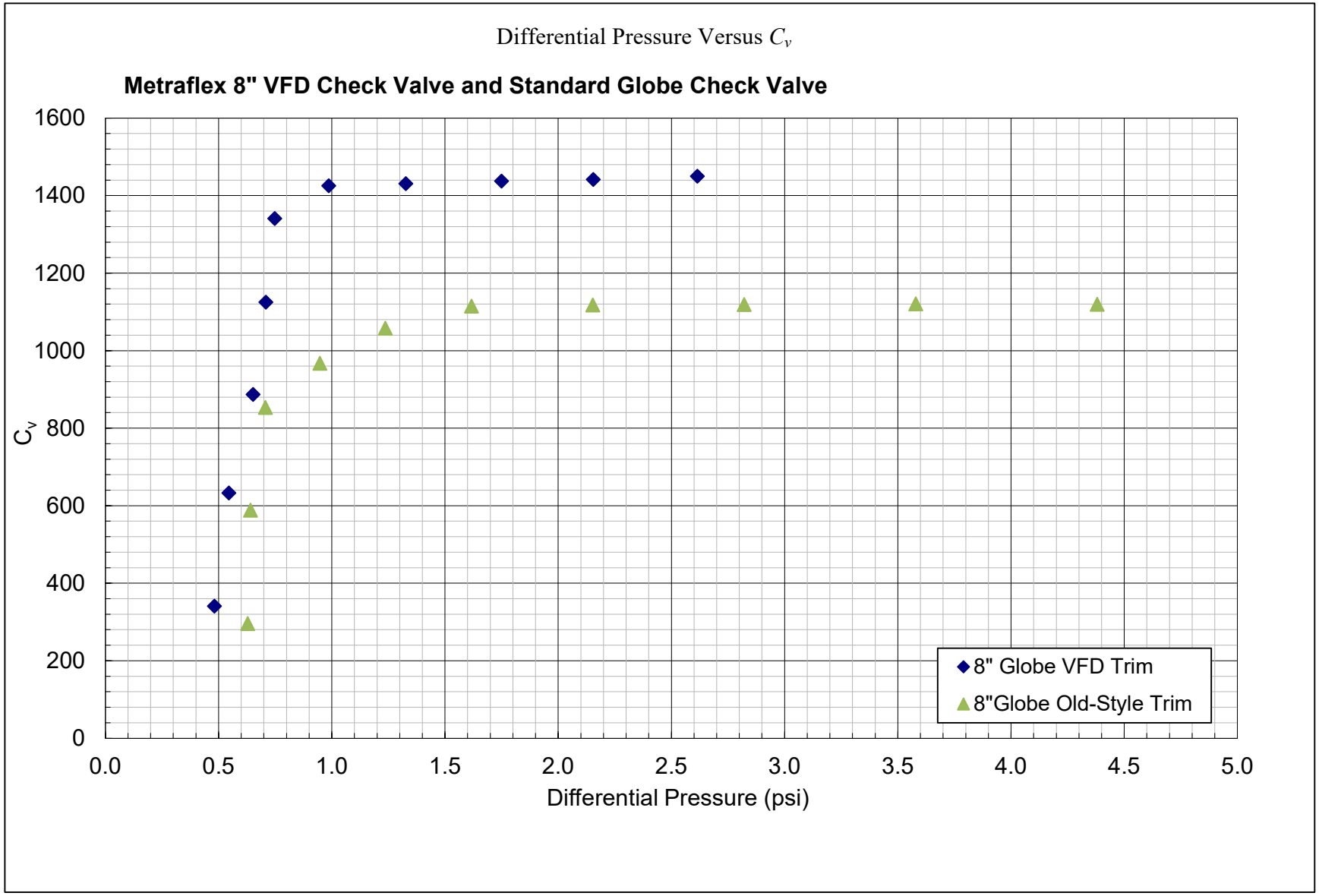

Figure 3. Differential pressure versus C_v for the 8-inch check valve.