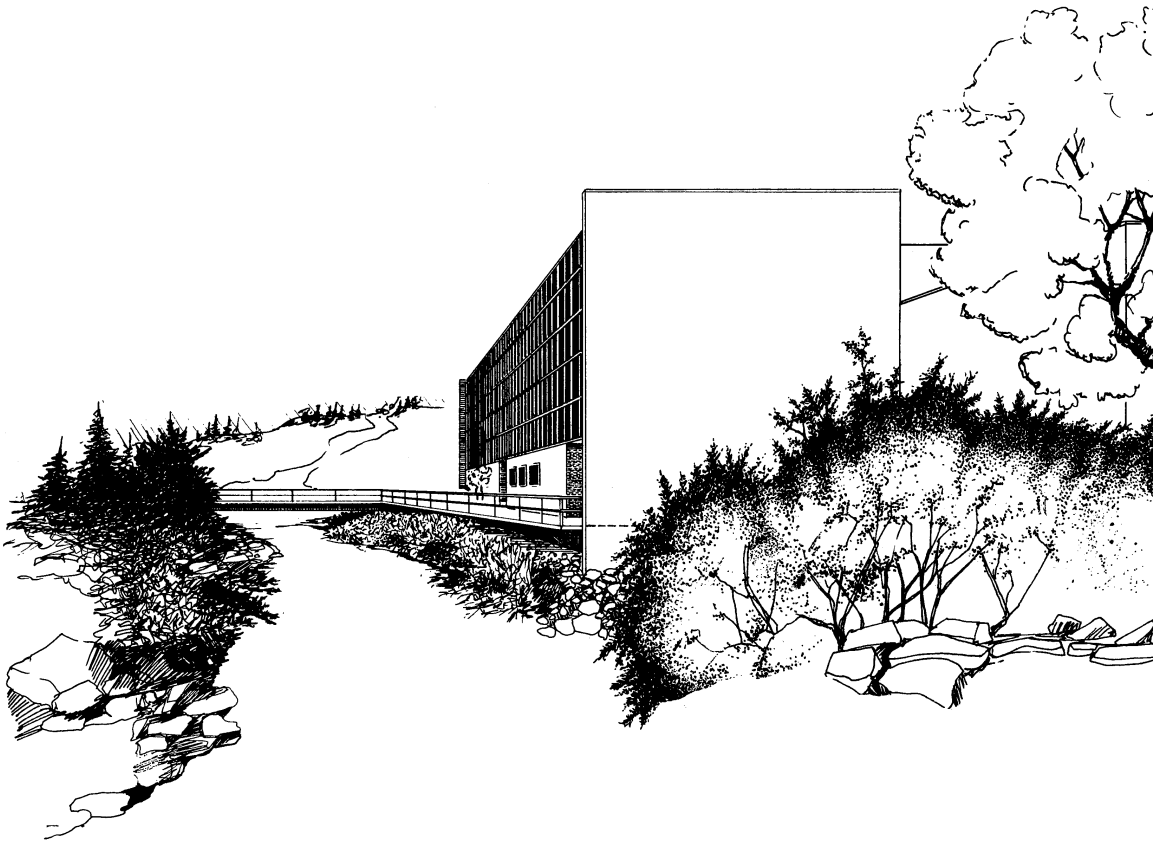
FLOW PERFORMANCE TESTING OF 3-INCH, 4-INCH, 6-INCH, 8-INCH AND 10-INCH STRAINERS

Prepared for

Metraflex

November 2015



UTAH WATER RESEARCH LABORATORY

Utah State University
Logan, Utah

Report No. 3370

FLOW PERFORMANCE TESTING OF 3-INCH, 4-INCH, 6-INCH, 8-INCH AND 10-INCH STRAINERS

Prepared for:

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INTRODUCTION

Flow performance tests were conducted at the Utah Water Research Laboratory (UWRL) on 3-inch, 4-inch, 6-inch, 8-inch and 10-inch Metraflex strainers. In addition, 4-inch, 6-inch, 8-inch and 10-inch Competitor strainers were also tested. The testing was developed to determine the flow versus pressure loss characteristics of each strainer and the flow coefficient of each strainer. Each strainer, with the exception of 3-inch Metraflex strainer and the 4-inch Competitor strainer, had strainer perforations measuring 0.125 inches in diameter. The 3-inch Metraflex strainer had 0.045 inch diameter perforations and the 4-inch Competitor strainer had 0.033 inch diameter perforations. The work was authorized under Metraflex Purchase Order No. 29582 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 each strainer's performance over a wide flow range.

EXPERIMENTAL PROGRAM

Each of the strainers was installed in a test line (standard steel diameters) with approximately 20 diameters of straight approach piping to provide uniform flow at the inlet of the strainer. There were approximately 10 diameters of straight pipe downstream from the strainer. Pressure taps were located two pipe diameters upstream from the strainer and six pipe diameters downstream from the strainer. Flow was supplied with a 100 horsepower pump. Figures 1 through 4 show the test setup for the 4-inch and 10-inch strainers respectively. Each of the other sizes had similar installations however they were installed in pipe sizes corresponding to each strainer size.

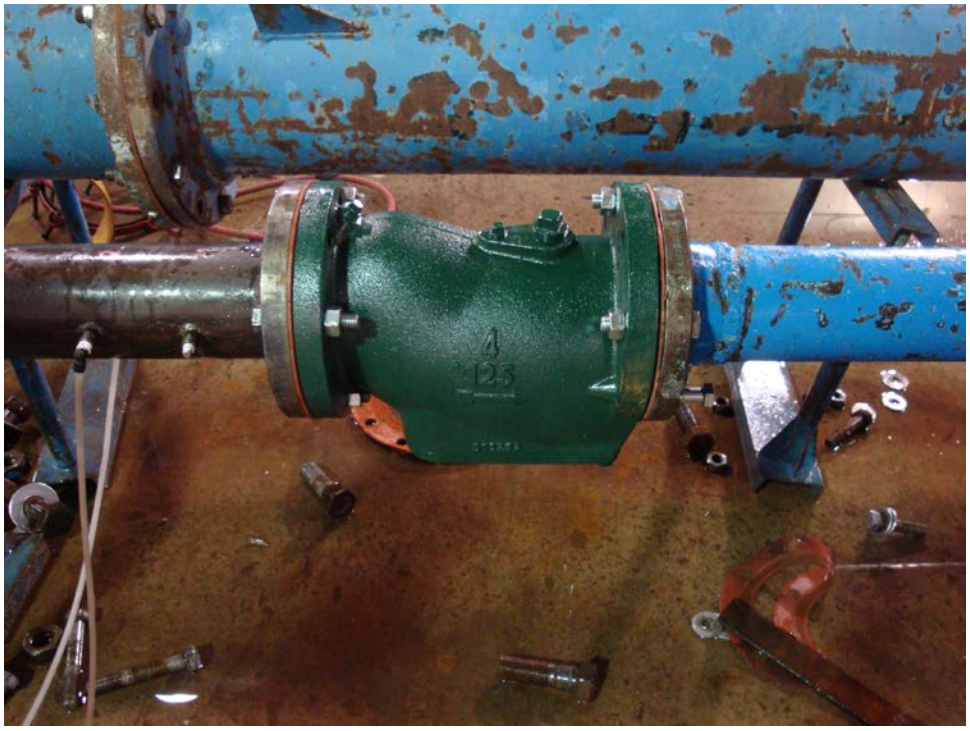

Figure 1. 4-inch strainer installation (Metraflex strainer shown).

Figure 2. 4-inch strainer installation (Competitor strainer shown).

Figure 3. 10-inch strainer installation (Metraflex strainer shown).

Figure 2. 10-inch strainer installation (Competitor strainer shown).

The flow rate was measured using calibrated flow meters which were verified against certified weight tanks. The differential pressure across the strainer was measured using Rosemount differential transmitters. The upstream pressure was measured using a Rosemount transmitter. The water temperature was measured using a calibrated RTD.

Each strainer was tested over a range of flows sufficient to generate 1.5 ft/s to 15 ft/s average velocities in the approach pipe. Ten points were taken over the velocity range of each size.

In the case of the 6-inch Metraflex strainer, certain tests were completed to simulate strainer blockage. This was accomplished by using duct tape to completely block the screen in areas suspected to plug first. The plugged portion of the screen was side opposite the strainers inlet.

To prevent screen plugging during testing, Metraflex provided a 10-inch 20 mesh strainer that was used upstream to capture any debris that entered the test system from water supplied from Logan River.

FLOW COEFFICIENT

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

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

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

The net flow coefficient was also computed by subtracting the friction expected from steel pipe between the gross differential pressure measured between the pressure taps. This calculation was completed using the Swamee-Jain equation to determine the friction factor associated with the specific data point taken in the laboratory. The Swamee-Jain equation is given by:

$$f = \frac{1.325}{\left(\ln\left(\frac{k}{3.7D} + \frac{5.74}{\mathrm{Re}^{0.9}}\right)\right)^2}$$

Where f is the friction factor, k is the pipe roughness, D is the inside diameter of the pipe and Re is the Reynolds number of the flow in the pipe. The headloss in feet was then converted to psi and subtracted from the gross pressure loss measurement.

TEST PROCEDURE

The test procedure essentially followed ISA 75.02.01-2008 with slight modifications to account for the fact that a strainer is not a valve and it was desired to determine the strainer's performance characteristics over a wide flow range.

C_v Determination

1. Install the strainer in straight piping of nominal size and standard wall thickness. Ensure that at least 20 diameters of straight pipe are upstream from the strainer and at least 8 diameters are installed downstream from the strainer.
2. Flow test the strainer 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 the strainer (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) Strainer description and identifying numbers.
4. Calculate the gross and net flow coefficient C_v.

TEST RESULTS

The pressure loss and flow coefficient C_v data are given in Tables 1 through 9 and the net pressure loss and net flow coefficient data are shown graphically on Figures 5 through 14.

Table 1. Strainer Flow Performance Testing

3" Metraflex LPD 0.045 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	3.068	Water temp. (F) =	**48.3**
Inlet Pipe Area (ft^2) =	0.051	Unit weight H2O (pcf) =	62.41
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	2.500	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.17
		Viscosity (cP) =	1.3430
		Kinematic visc. (ft^2/s) =	1.45E-05

Tested by: T. Christy 11/3/2015
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	25K	126.77	900	202.78	31.69	31.92	1.38	35	4.793	4	1.0227	33.19	33.17	0.0227	0.0195	**210.4**	**227.3**
2	6M	275.90			68.98		2.99	35	4.760	4	1.1022	32.90	32.80	0.1022	0.0888	**215.8**	**231.5**
3	6M	412.10			103.03		4.47	35	4.735	4	1.2201	32.68	32.46	0.2201	0.1920	**219.7**	**235.2**
4	6M	554.40			138.60		6.02	35	4.698	4	1.3961	32.36	31.96	0.3961	0.3470	**220.3**	**235.4**
5	6M	688.40			172.10		7.47	35	4.653	4	1.5983	31.96	31.37	0.5983	0.5244	**222.6**	**237.7**
6	6M	830.80			207.70		9.01	35	4.601	4	1.8718	31.51	30.64	0.8718	0.7662	**222.5**	**237.4**
7	25K	971.70	7200	213.37	242.93	242.66	10.54	35	4.540	4	2.1790	30.98	29.80	1.1790	1.0366	**223.8**	**238.7**
8	6M	1106.80			276.70		12.01	35	4.476	4	2.5270	30.42	28.89	1.5270	1.3442	**224.0**	**238.8**
9	6M	1244.70			311.18		13.50	35	4.396	4	2.9220	29.72	27.79	1.9220	1.6929	**224.5**	**239.3**
10	6M	1384.00			346.00		15.02	35	4.319	4	3.3580	29.04	26.68	2.3580	2.0769	**225.4**	**240.2**
															Average =	**220.9**	**236.1**

Table 2. Strainer Flow Performance Testing

4" Metraflex LPD 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	4.026	Water temp. (F) =	**47.4**
Inlet Pipe Area (ft^2) =	0.088	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	2.667	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.16
		Viscosity (cP) =	1.3632
		Kinematic visc. (ft^2/s) =	1.47E-05

Tested by: E. Fisher 11-2-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	6M	237.20			59.30		1.49	35	4.790	4	1.0197	33.16	33.14	0.0197	0.0168	**422.7**	**457.3**
2	6M	476.60			119.15		3.00	35	4.754	4	1.0778	32.85	32.77	0.0778	0.0675	**427.3**	**458.7**
3	6M	713.90			178.48		4.50	35	4.714	4	1.1748	32.50	32.32	0.1748	0.1531	**427.1**	**456.4**
4	6M	948.70			237.18		5.98	35	4.665	4	1.3054	32.07	31.76	0.3054	0.2683	**429.3**	**458.0**
5	6M	1195.30			298.83		7.53	35	4.602	4	1.4844	31.52	31.03	0.4844	0.4270	**429.5**	**457.5**
6	6M	1431.80			357.95		9.02	35	4.531	4	1.6868	30.90	30.21	0.6868	0.6059	**432.1**	**460.0**
7	25K	1675.70	14000	240.48	418.93	418.63	10.56	35	4.506	4	1.9346	30.68	29.74	0.9346	0.8254	**433.5**	**461.3**
8	6M	1903.80			475.95		12.00	35	4.485	4	2.1970	30.49	29.30	1.1970	1.0575	**435.2**	**463.0**
9	6M	2141.00			535.25		13.49	35	4.454	4	2.5110	30.22	28.71	1.5110	1.3361	**435.6**	**463.2**
10	6M	2384.00			596.00		15.02	35	4.398	4	2.8640	29.73	27.87	1.8640	1.6489	**436.7**	**464.3**
															Average =	**430.9**	**460.0**

Table 3. Strainer Flow Performance Testing

6" Metraflex LPD 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	6.065	Water temp. (F) =	**47.0**
Inlet Pipe Area (ft^2) =	0.201	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	4.000	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.16
		Viscosity (cP) =	1.3715
		Kinematic visc. (ft^2/s) =	1.48E-05

Tested by: M. Cannon 11-3-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Blockage 0 in^2																	
1	25K	13.94	4000	201.66	141.98		1.58	35	4.740	6	1.0160	32.73	32.70	0.0240	0.0211	**916.8**	**976.8**
2	250K	27.17			274.41		3.05	35	4.670	6	1.0600	32.11	32.02	0.0900	0.0804	**915.1**	**968.0**
3	250K	40.51			408.30		4.53	35	4.600	6	1.1360	31.50	31.30	0.2040	0.1840	**904.3**	**952.3**
4	250K	54.11	15060		544.88		6.05	35	4.620	6	1.2400	31.68	31.32	0.3600	0.3255	**908.5**	**955.4**
5	250K	66.61			669.35		7.43	35	4.570	6	1.3680	31.24	30.69	0.5520	0.5011	**901.3**	**946.0**
6	250K	81.02			812.33		9.02	35	4.500	6	1.5430	30.63	29.81	0.8145	0.7409	**900.5**	**944.1**
7	250K	95.62	26620	200.00	957.75	957.10	10.64	35	4.410	6	1.7560	29.84	28.70	1.1340	1.0332	**899.8**	**942.6**
8	250K	109.98			1101.73		12.23	35	4.300	6	1.9970	28.88	27.38	1.4955	1.3636	**901.3**	**943.9**
9	250K	121.08			1212.71		13.47	35	4.220	6	2.2010	28.18	26.37	1.8015	1.6428	**903.9**	**946.5**
10	250K	135.37	37640	200.00	1355.59		15.05	35	4.090	6	2.5050	27.04	24.78	2.2575	2.0608	**902.6**	**944.7**
																905.4	**952.0**
Blockage 231 in^2																	
1	250K	1473.30	10300	200.00	368.33	370.33	4.09	35	4.590	6	1.4104	31.41	30.80	0.6156	0.5991	**469.6**	**476.1**
2	250K	3255.00	22500	200.00	813.75	808.97	9.04	35	4.500	6	3.0380	30.63	27.57	3.0570	2.9832	**465.6**	**471.3**
3	250K	103.70	28820	200.00	1038.94	1036.20	11.54	35	4.350	6	4.3700	29.31	24.26	5.0550	4.9371	**462.3**	**467.8**
															Average =	**465.8**	**471.7**
Blockage 152 in^2																	
1	250K	40.64			409.60		4.55	35	4.590	6	1.4140	31.41	30.79	0.6210	0.6008	**520.0**	**528.6**
2	250K	91.84			920.10		10.22	35	4.430	6	3.0550	30.01	26.93	3.0825	2.9891	**524.3**	**532.4**
3	250K	118.50			1186.91		13.18	35	4.230	6	4.4330	28.26	23.11	5.1495	4.9973	**523.3**	**531.2**
															Average =	**522.5**	**530.7**
Blockage 92.7 in^2																	
1	250K	51.50			518.67		5.76	35	4.630	6	1.4200	31.76	31.13	0.6300	0.5986	**653.7**	**670.7**
2	250K	113.78			1139.72		12.66	35	4.280	6	3.0280	28.70	25.66	3.0420	2.9012	**653.7**	**669.4**
3	250K	148.23			1484.17		16.48	35	3.960	6	4.4530	25.90	20.72	5.1795	4.9451	**652.4**	**667.7**
															Average =	**653.3**	**669.3**

Table 4. Strainer Flow Performance Testing

8" Metraflex LPD 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	7.981	Water temp. (F) =	**47.4**
Inlet Pipe Area (ft^2) =	0.347	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	5.333	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.16
		Viscosity (cP) =	1.3632
		Kinematic visc. (ft^2/s) =	1.47E-05

Tested by: M. Cannon 11-3-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement								Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	250K	14.57	4000	194.22	148.29	148.10	0.95	35	4.740	6	1.0064	32.73	32.72	0.0096	0.0085	**1514.0**	**1607.8**
2	250K	24.82			250.90		1.61	35	4.690	6	1.0187	32.29	32.26	0.0280	0.0252	**1498.6**	**1580.1**
3	250K	40.21			405.28		2.60	35	4.610	6	1.0481	31.59	31.52	0.0722	0.0654	**1509.4**	**1585.9**
4	250K	54.02	15100	200.00	543.98	542.92	3.49	35	4.640	6	1.0868	31.85	31.72	0.1302	0.1185	**1508.2**	**1581.0**
5	250K	66.67			669.94		4.30	35	4.610	6	1.1321	31.59	31.39	0.1982	0.1809	**1505.6**	**1575.9**
6	250K	80.60			808.15		5.18	35	4.550	6	1.1925	31.06	30.77	0.2888	0.2642	**1504.5**	**1573.0**
7	250K	93.98	26140	200.00	941.42	939.86	6.04	35	4.490	6	1.2604	30.54	30.15	0.3906	0.3578	**1506.9**	**1574.4**
8	250K	108.64			1088.33		6.98	35	4.410	6	1.3487	29.84	29.31	0.5231	0.4799	**1505.4**	**1571.6**
9	250K	119.31			1195.01		7.66	35	4.340	6	1.4201	29.23	28.59	0.6302	0.5786	**1506.0**	**1571.6**
10	250K	133.71	37180	200.00	1338.99	1336.79	8.59	35	4.250	6	1.5257	28.44	27.65	0.7886	0.7246	**1508.5**	**1573.7**
11	250K	171.72			1720.00		11.03	35	3.930	6	1.8597	25.64	24.35	1.2896	1.1863	**1515.2**	**1579.8**
12	250K	201.10			2015.00		12.92	35	3.610	6	2.1760	22.84	21.07	1.7640	1.6240	**1517.7**	**1581.8**
13	250K	234.90			2352.77		15.09	35	3.190	6	2.6060	19.16	16.75	2.4090	2.2201	**1516.5**	**1579.7**
															Average =	**1506.7**	**1579.5**

Table 5. Strainer Flow Performance Testing

10" Metraflex LPD 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	10.020	Water temp. (F) =	**45.1**
Inlet Pipe Area (ft^2) =	0.548	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	6.667	Specific Gravity H2O =	1.0009
		Vapor pressure (psia) =	0.15
		Viscosity (cP) =	1.4160
		Kinematic visc. (ft^2/s) =	1.52E-05

Tested by: M. Cannon 11-4-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	250K	36.62	10220	200.00	369.23	367.43	1.50	35	4.628	6	1.0153	31.75	31.72	0.0230	0.0206	**2438.3**	**2574.7**
2	250K	75.41			756.65		3.08	35	4.612	6	1.0714	31.61	31.50	0.1071	0.0982	**2313.1**	**2415.0**
3	250K	110.62			1108.13		4.51	35	4.455	6	1.1529	30.23	30.00	0.2294	0.2113	**2314.9**	**2411.6**
4	250K	148.21			1483.97		6.04	35	4.228	6	1.2770	28.25	27.83	0.4155	0.3843	**2303.2**	**2395.0**
5	250K	184.58	51280	200.00	1849.16	1843.62	7.52	35	3.914	6	1.4258	25.50	24.86	0.6387	0.5913	**2314.8**	**2405.8**
6	250K	222.70			2230.85		9.08	35	3.507	6	1.6178	21.94	21.01	0.9267	0.8589	**2318.4**	**2408.1**
7	250K	254.50			2548.64		10.37	35	3.131	6	1.8112	18.65	17.43	1.2168	1.1294	**2311.5**	**2399.3**
8	250K	293.50			2938.37		11.96	35	2.639	6	2.0710	14.34	12.73	1.6065	1.4916	**2319.3**	**2407.0**
9	250K	329.90			3301.98		13.43	35	3.603	6	2.3510	22.78	20.75	2.0265	1.8827	**2320.5**	**2407.5**
10	250K	366.70	101840	200.00	3669.55	3661.35	14.93	35	3.229	6	2.6630	19.50	17.01	2.4945	2.3182	**2324.4**	**2411.2**
															Average =	**2327.8**	**2423.5**

Table 6. Strainer Flow Performance Testing

4" Competitor 0.033 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	4.026	Water temp. (F) =	**47.5**
Inlet Pipe Area (ft^2) =	0.088	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	2.667	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.16
		Viscosity (cP) =	1.3610
		Kinematic visc. (ft^2/s) =	1.47E-05

Tested by: E. Fisher 11-2-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	25K	247.50	1800	209.08	61.88	61.91	1.56	35	4.788	4	1.0740	33.15	33.07	0.0740	0.0709	**227.5**	**232.5**
2	25K	483.50			120.88		3.05	35	4.754	4	1.2870	32.85	32.56	0.2870	0.2765	**225.7**	**230.0**
3	25K	724.90			181.23		4.57	35	4.711	4	1.6490	32.47	31.82	0.6490	0.6266	**225.0**	**229.0**
4	25K	952.60	7400	223.30	238.15	238.30	6.00	35	4.661	4	2.1250	32.03	30.91	1.1250	1.0877	**224.6**	**228.4**
5	25K	1208.90			302.23		7.62	35	4.602	4	2.7950	31.52	29.72	1.7950	1.7364	**225.7**	**229.4**
6	25K	1434.10			358.53		9.04	35	4.529	4	3.5270	30.88	28.35	2.5270	2.4459	**225.6**	**229.3**
7	25K	1672.20	12000	206.86	418.05	417.15	10.54	35	4.477	4	4.4480	30.42	26.98	3.4480	3.3392	**225.2**	**228.9**
8	25K	1894.40			473.60		11.94	35	4.454	9	2.9670	30.22	25.80	4.4258	4.2876	**225.2**	**228.8**
9	25K	2135.00			533.75		13.45	35	4.430	9	3.5010	30.01	24.39	5.6273	5.4534	**225.1**	**228.7**
10	25K	2382.00	17000	206.02	595.50	593.37	15.01	35	4.377	9	4.1110	29.55	22.55	6.9998	6.7850	**225.2**	**228.7**
															Average =	**225.5**	**229.4**

Table 7. Strainer Flow Performance Testing

6" Competitor 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	6.065	Water temp. (F) =	**47.5**
Inlet Pipe Area (ft^2) =	0.201	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	4.000	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.16
		Viscosity (cP) =	1.3610
		Kinematic visc. (ft^2/s) =	1.47E-05

Tested by: M. Cannon 11-3-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
																	0.9996
1	25K	543.40	3900	206.97	135.85	135.50	1.51	35	4.743	4	1.0515	32.75	32.70	0.0515	0.0489	**598.9**	**614.8**
2	250K	27.08			273.51		3.04	35	4.659	4	1.2119	32.02	31.80	0.2119	0.2024	**594.4**	**608.2**
3	250K	40.32			406.39		4.51	35	4.592	4	1.4675	31.43	30.96	0.4675	0.4476	**594.6**	**607.6**
4	250K	54.23	15120	200.00	546.09	543.64	6.06	35	4.614	4	1.8465	31.62	30.78	0.8465	0.8119	**593.8**	**606.3**
5	250K	67.07			673.91		7.48	35	4.569	4	2.2910	31.23	29.94	1.2910	1.2395	**593.4**	**605.6**
6	250K	80.98			811.93		9.02	35	4.497	4	2.8780	30.60	28.72	1.8780	1.8045	**592.7**	**604.7**
7	250K	94.83	26400	200.00	949.88	949.21	10.55	35	4.410	4	3.5830	29.84	27.25	2.5830	2.4838	**591.3**	**603.0**
8	250K	107.84			1080.33		12.00	35	4.335	4	4.3130	29.18	25.87	3.3130	3.1860	**593.8**	**605.5**
9	250K	118.02			1182.12		13.13	35	4.225	6	3.7010	28.22	24.17	4.0515	3.9005	**587.5**	**598.8**
10	250K	135.24	37580	200.00	1354.29	1351.18	15.04	35	4.083	6	4.5450	26.98	21.66	5.3175	5.1212	**587.5**	**598.7**
															Average =	**592.8**	**605.3**

Table 8. Strainer Flow Performance Testing

8" Competitor 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	7.981	Water temp. (F) =	**47.1**
Inlet Pipe Area (ft^2) =	0.347	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	5.333	Specific Gravity H2O =	1.0008
		Vapor pressure (psia) =	0.16
		Viscosity (cP) =	1.3697
		Kinematic visc. (ft^2/s) =	1.47E-05

Tested by: M. Cannon 11-3-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	250K	14.02	4000	201.16	142.78	142.99	0.92	35	4.751	6	1.0179	32.82	32.79	0.0269	0.0258	**871.7**	**888.7**
2	250K	26.84			271.11		1.74	35	4.677	6	1.0646	32.17	32.08	0.0969	0.0937	**871.3**	**886.3**
3	250K	40.55			408.70		2.62	35	4.561	6	1.1462	31.16	30.94	0.2193	0.2124	**873.1**	**887.2**
4	250K	54.32	15140	200.00	546.99	544.35	3.51	35	4.651	6	1.2609	31.95	31.55	0.3914	0.3795	**874.7**	**888.3**
5	250K	67.64			679.57		4.36	35	4.609	6	1.4041	31.58	30.97	0.6062	0.5884	**873.2**	**886.3**
6	250K	80.32			805.37		5.16	35	4.565	6	1.5665	31.19	30.34	0.8498	0.8253	**874.0**	**886.9**
7	250K	94.67	26340	200.00	948.29	947.04	6.08	35	4.493	6	1.7848	30.56	29.39	1.1772	1.1440	**874.4**	**887.0**
8	250K	108.85			1090.43		6.99	35	4.413	6	2.0390	29.86	28.31	1.5585	1.5152	**873.8**	**886.2**
9	250K	119.89			1200.81		7.70	35	4.350	6	2.2540	29.31	27.43	1.8810	1.8290	**875.9**	**888.3**
10	250K	136.17	37860	200.00	1363.59	1361.23	8.74	35	4.243	6	2.6230	28.38	25.94	2.4345	2.3682	**874.3**	**886.4**
11	250K	171.24			1715.18		11.00	35	3.957	6	3.5450	25.87	22.16	3.8175	3.7147	**878.2**	**890.3**
12	250K	207.60			2079.96		13.34	35	3.553	6	4.7470	22.34	16.72	5.6205	5.4716	**877.7**	**889.6**
13	250K	233.30			2336.78		14.99	35	3.228	9	4.1580	19.50	12.39	7.1055	6.9190	**877.0**	**888.7**
															Average =	**873.6**	**887.1**

Table 9. Strainer Flow Performance Testing

10" Competitor 0.125 Perforations

Reference Data			
Pipe Dia. (I.D. in.) =	10.020	Water temp. (F) =	**45.1**
Inlet Pipe Area (ft^2) =	0.548	Unit weight H2O (pcf) =	62.42
Pipe roughness (ft) =	0.00015	Density (slug) =	1.940
Pipe Friction Length (ft) =	6.667	Specific Gravity H2O =	1.0009
		Vapor pressure (psia) =	0.15
		Viscosity (cP) =	1.4160
		Kinematic visc. (ft^2/s) =	1.52E-05

Tested by: M. Cannon 11-4-15
SS Prepared by: Michael C. Johnson 8/20/12
SS Checked by: Zac Sharp 8/27/12
Witnessed by: -

	Flow Measurement							Differential Measurement								Coef.	Coef.
Run No.	Key	Mag. Hz	Weight lbs	Time s	Mag gpm	W. Tank gpm	V (pipe) ft/s	Pu Span psi	Pu V	DP Span psi	DP V	Pu (psi)	Pd (psi)	ΔP gross (psi)	ΔP net (psi)	Cv gross	Cv net
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	250K	36.49	10180	200.00	367.92	365.99	1.50	35	4.622	7	1.0401	31.69	31.62	0.0702	0.0678	**1389.5**	**1413.4**
2	250K	74.69			749.51		3.05	35	4.602	7	1.1677	31.52	31.22	0.2935	0.2848	**1384.1**	**1405.1**
3	250K	112.96			1131.52		4.60	35	4.432	7	1.3822	30.03	29.36	0.6689	0.6501	**1384.2**	**1404.0**
4	250K	148.03	41140	200.00	1482.17	1479.06	6.03	35	4.218	7	1.6595	28.16	27.00	1.1541	1.1230	**1380.3**	**1399.3**
5	250K	185.50			1858.40		7.56	35	3.899	7	2.0350	25.37	23.56	1.8113	1.7634	**1381.5**	**1400.1**
6	250K	224.10			2244.84		9.13	35	3.495	7	2.5190	21.83	19.17	2.6583	2.5897	**1377.5**	**1395.6**
7	250K	259.30	71960	200.00	2596.60	2587.10	10.56	35	4.363	7	3.0300	29.43	25.87	3.5525	3.4619	**1378.3**	**1396.2**
8	250K	293.10			2934.37		11.94	35	3.878	7	3.5970	25.18	20.64	4.5448	4.4302	**1377.1**	**1394.7**
9	250K	330.60			3308.97		13.46	35	3.618	7	4.3010	22.91	17.13	5.7768	5.6324	**1377.3**	**1394.9**
10	250K	360.20	100020	200.00	3604.63	3595.91	14.67	35	3.316	7	4.9120	20.27	13.42	6.8460	6.6757	**1378.3**	**1395.7**
															Average =	**1380.8**	**1399.9**

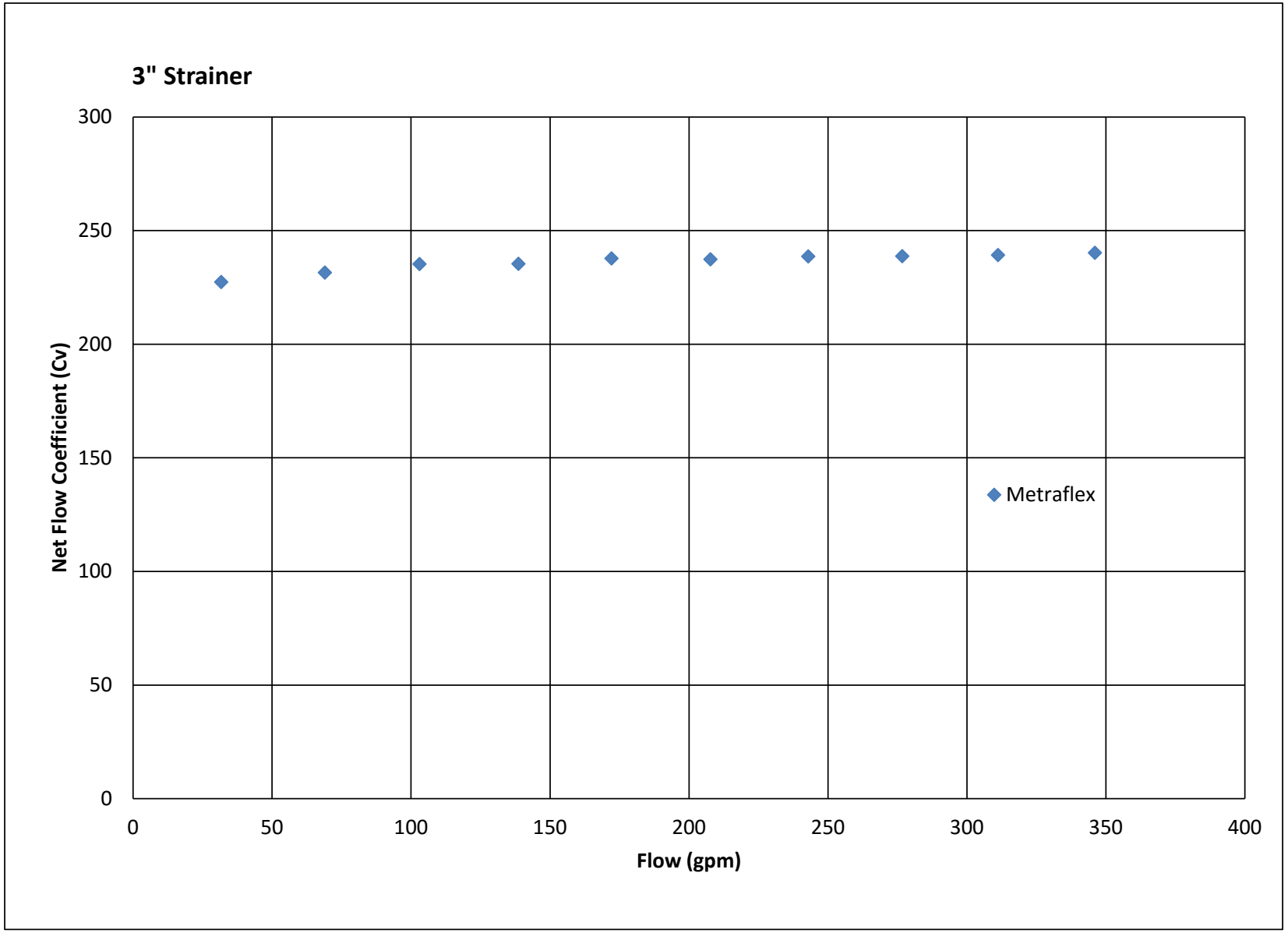

Figure 5. Flow rate versus flow coefficient.

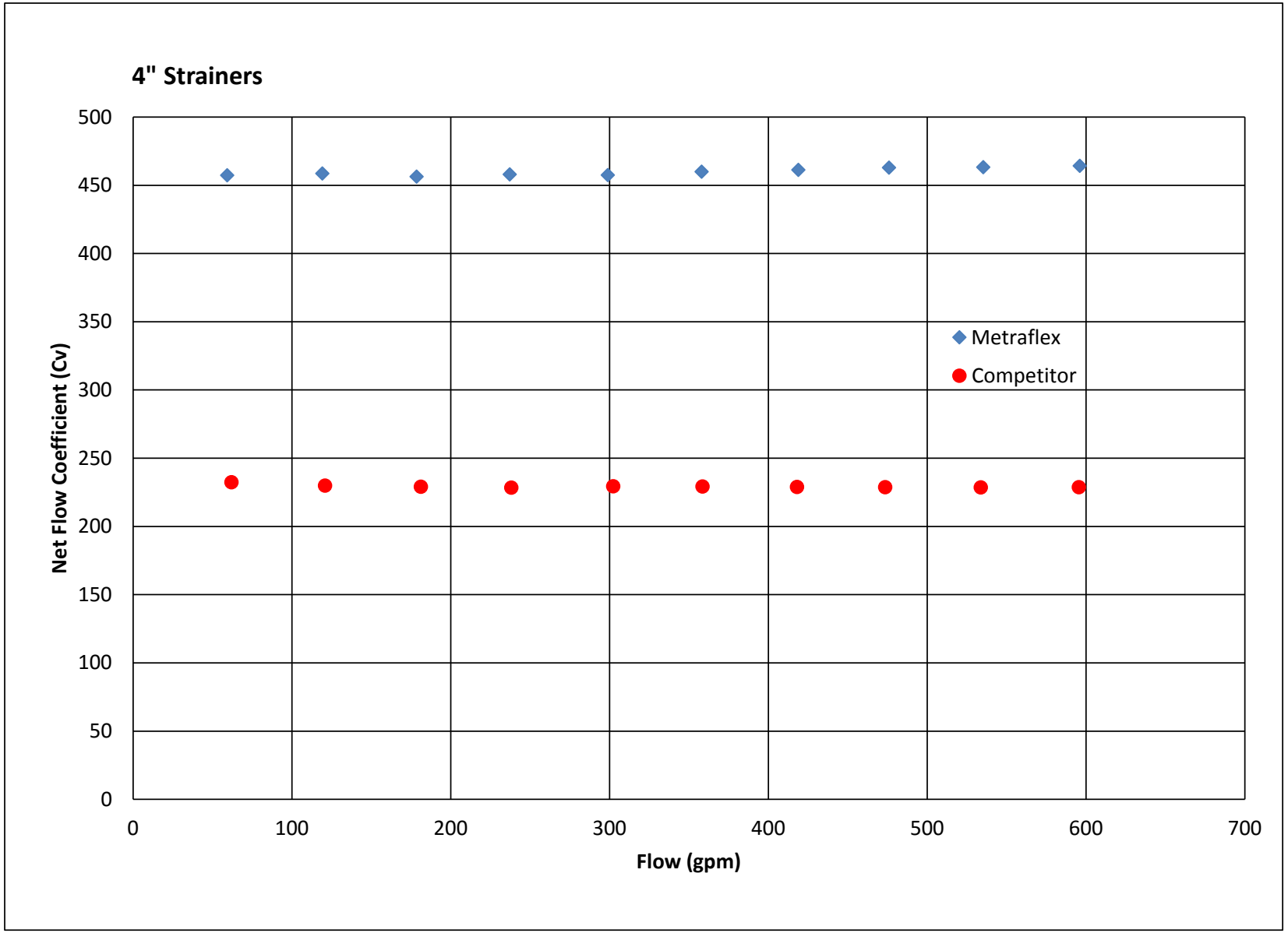

Figure 6. Flow rate versus flow coefficient.

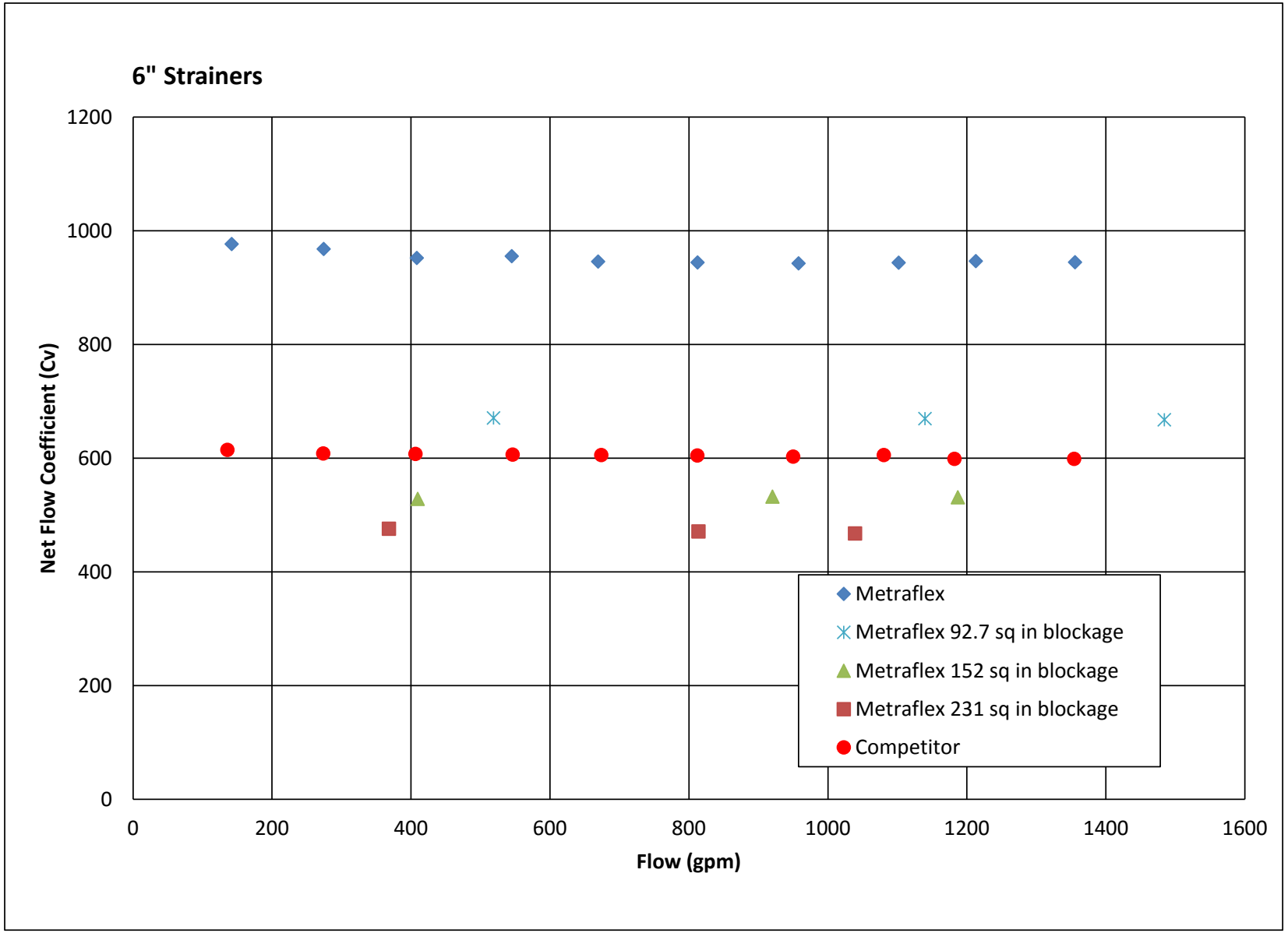

Figure 7. Flow rate versus flow coefficient.

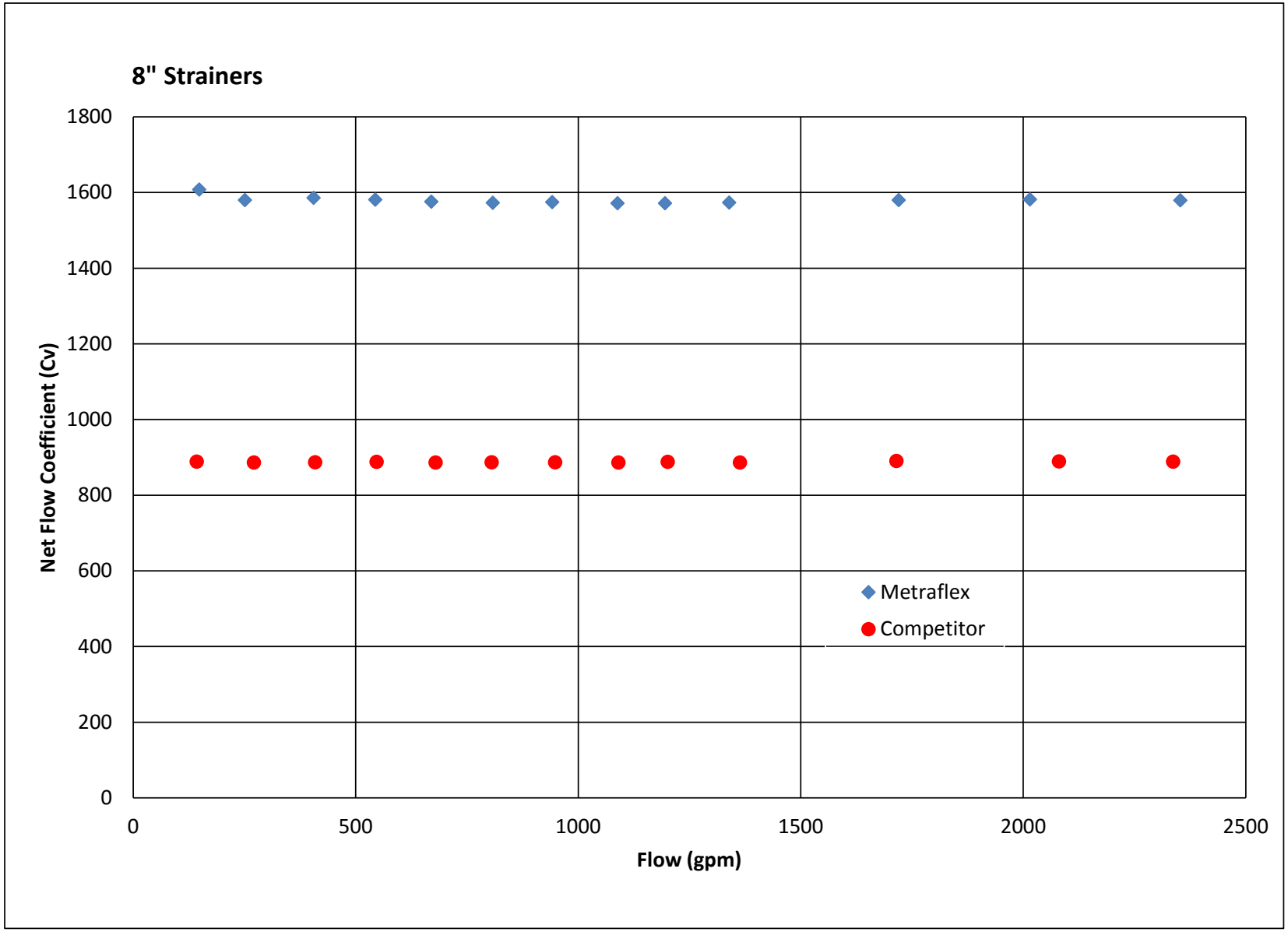

Figure 8. Flow rate versus flow coefficient.

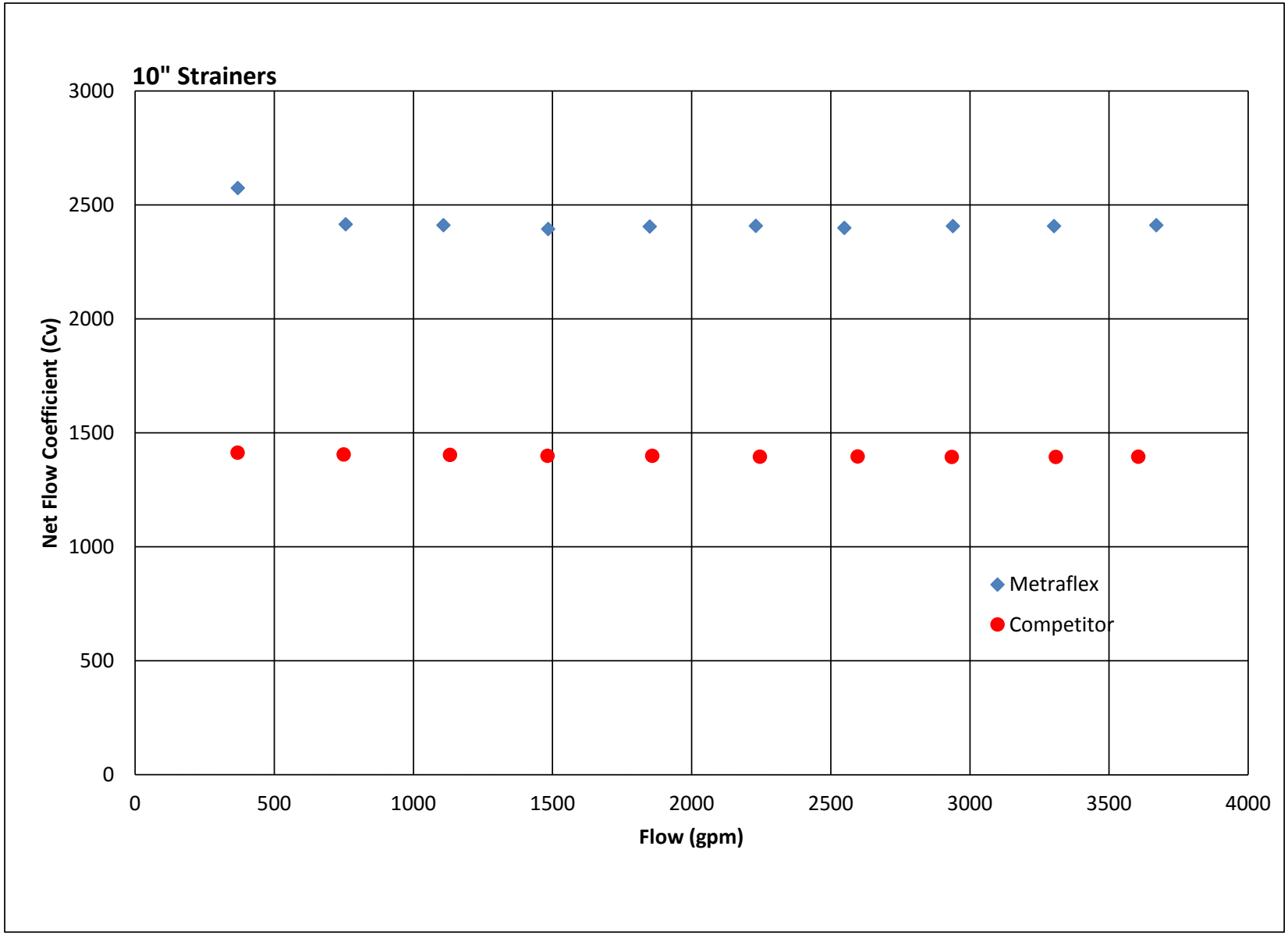

Figure 9. Flow rate versus flow coefficient.

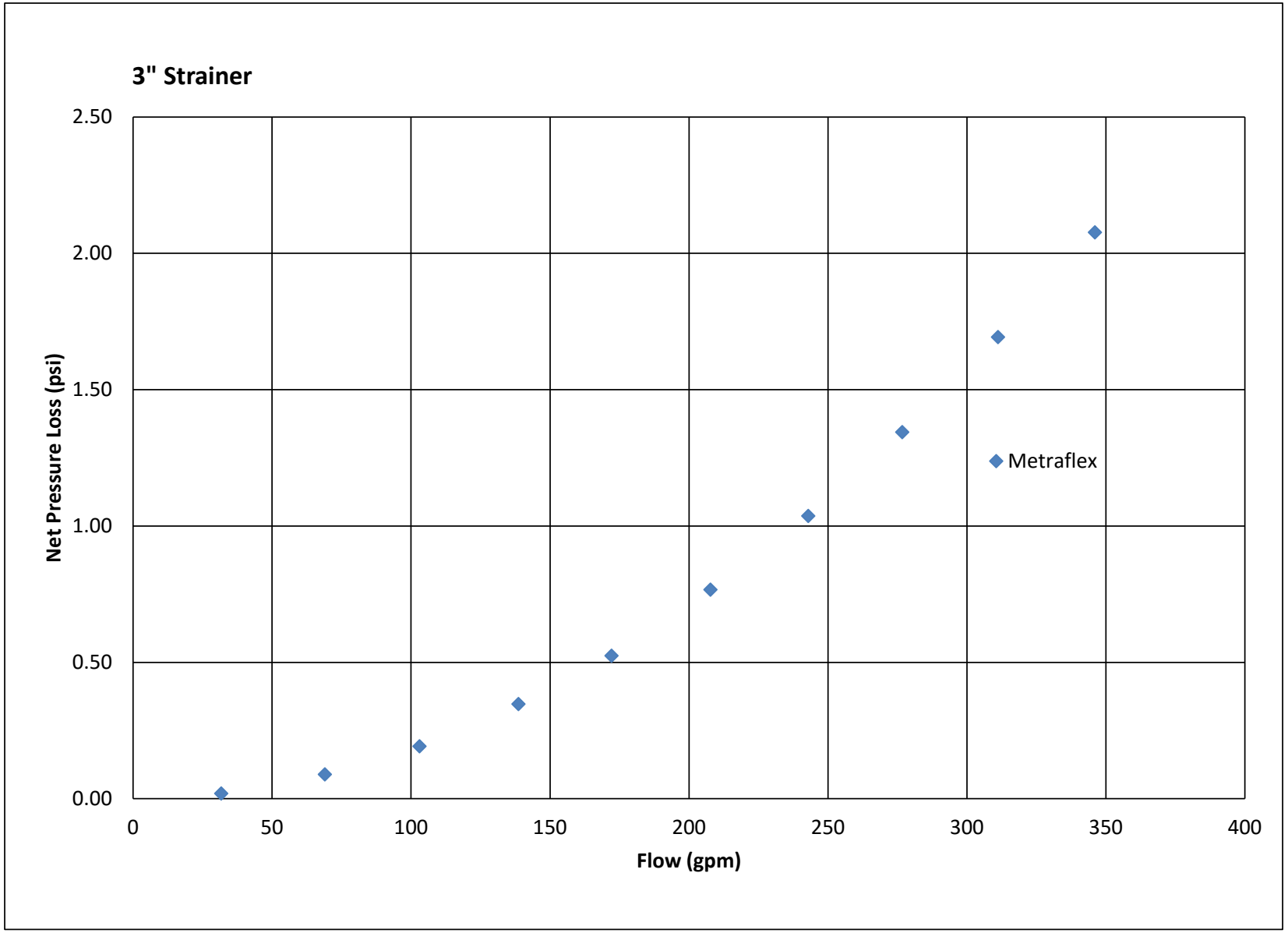

Figure 10. Flow rate versus differential pressure.

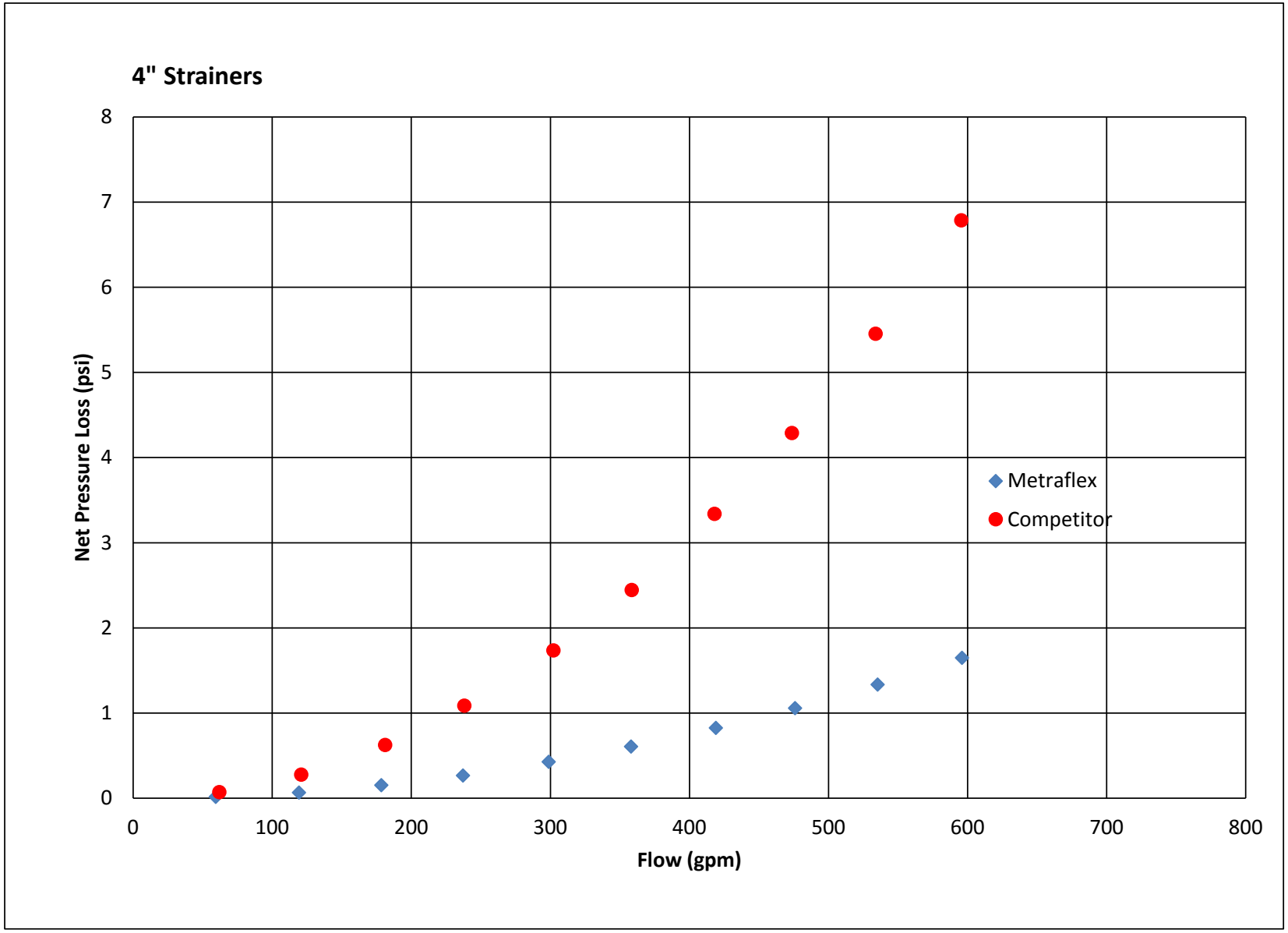

Figure 11. Flow rate versus differential pressure.

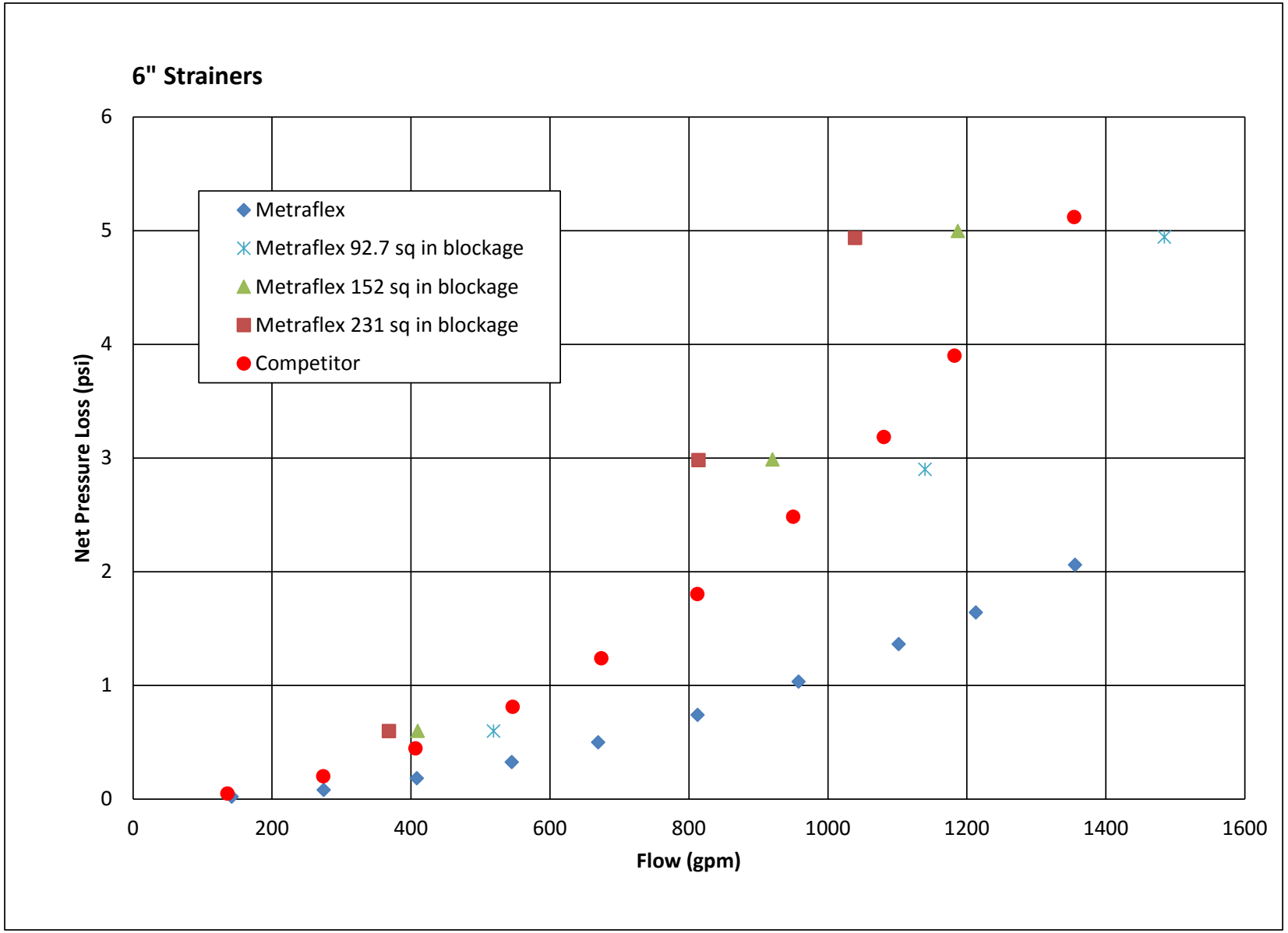

Figure 12. Flow rate versus differential pressure.

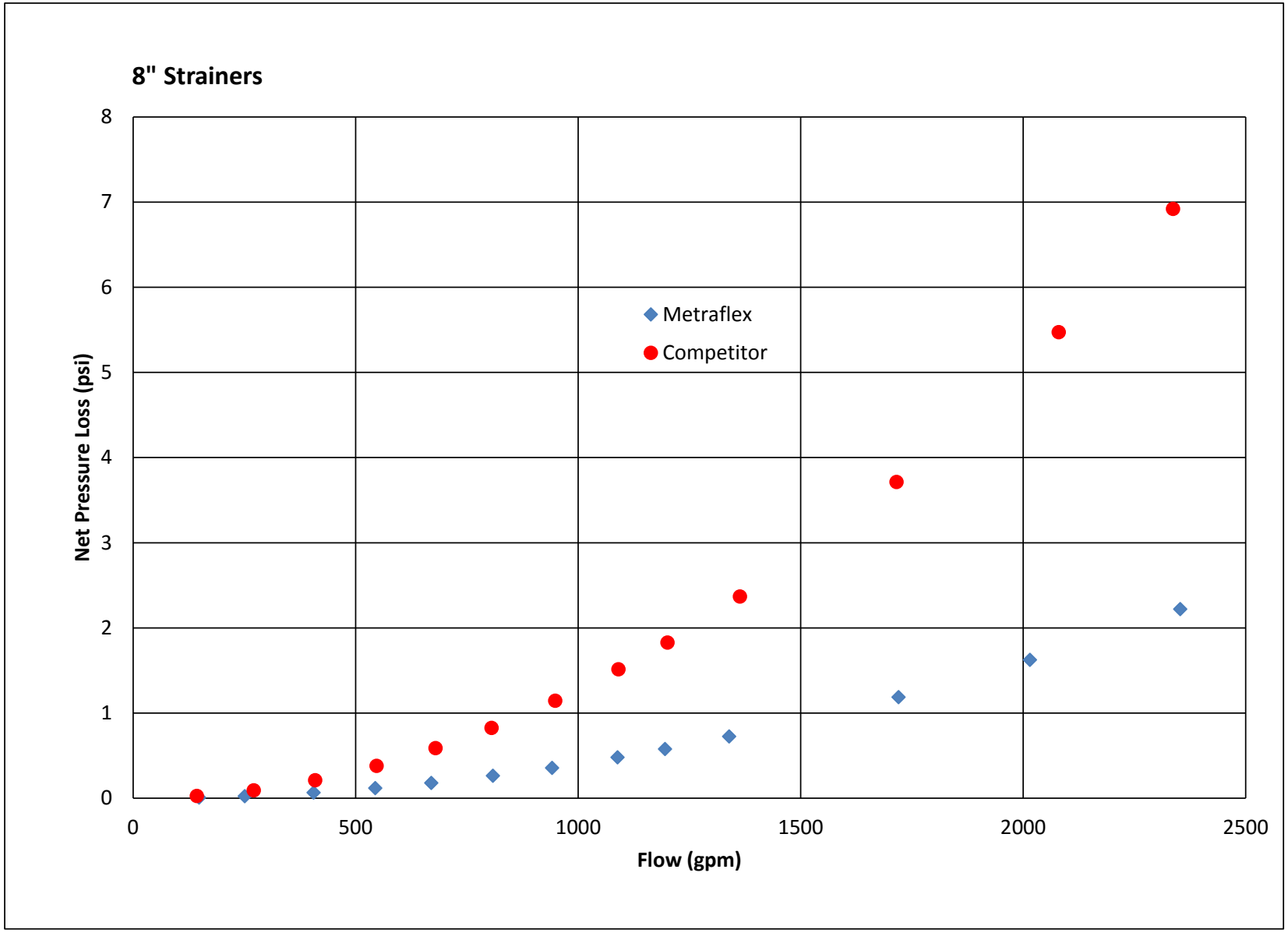

Figure 13. Flow rate versus differential pressure.

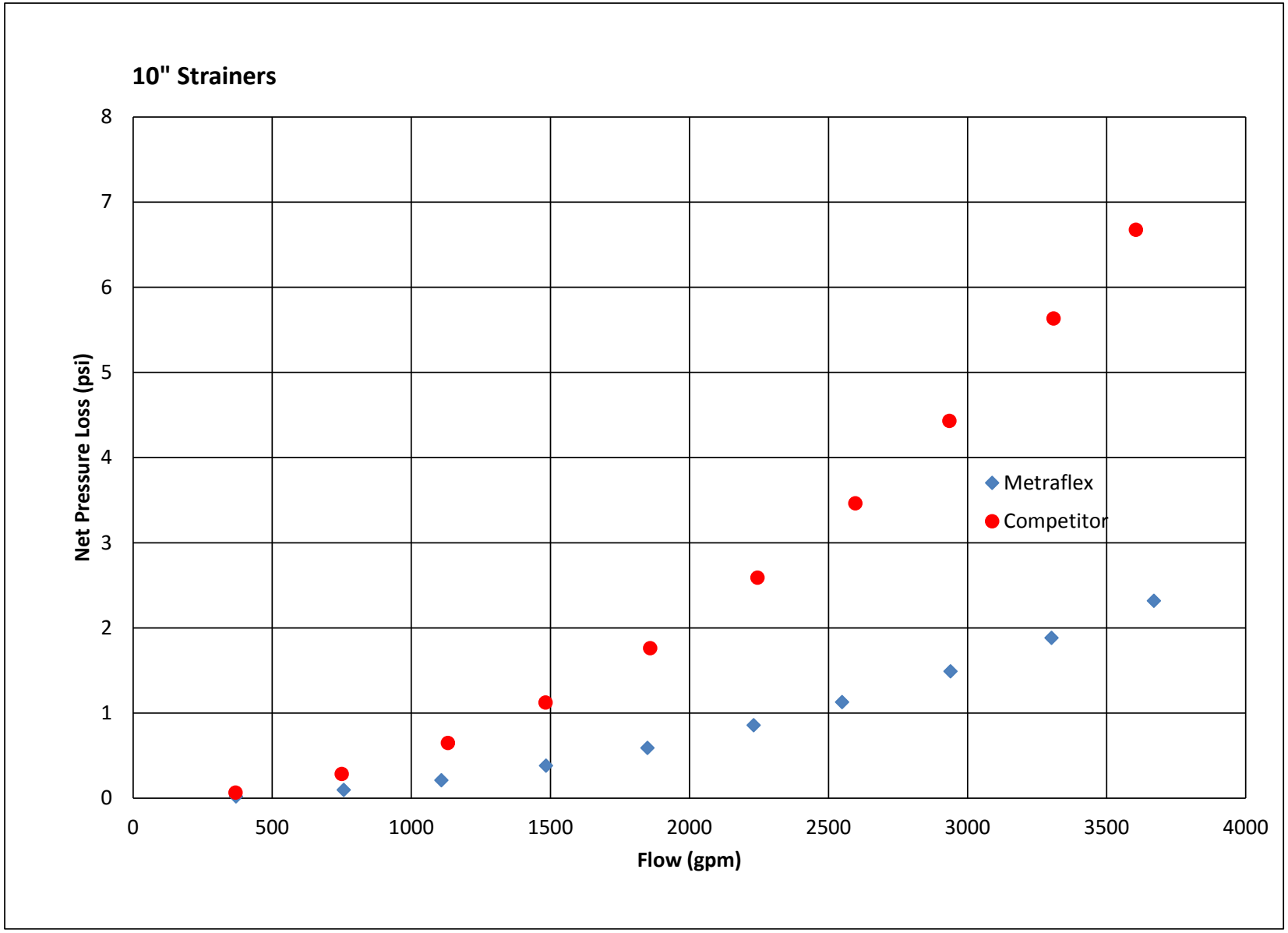

Figure 14. Flow rate versus differential pressure.