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EVALUATION OF PRESSURE REGULATORS FROM CENTER PIVOT NOZZLE PACKAGES

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Abstract: *Performance evaluations of center pivot nozzle packages for uniformity have been conducted as part of the Mobile Irrigation Lab program for a number of years. These evaluations were performed using a catch can system. Later the evaluation expanded to spot checking pressure and flow for in-canopy nozzle packages that could not be tested with catch cans. However, the latter procedure did not measure the pressure drop across the pressure regulator and approximately 80 per cent of Kansas center pivot irrigation systems are pressure regulated. This study tested pressure regulator performance of regulators from existing center pivot nozzle packages.*

Keywords: Center pivot irrigation, pressure regulators

INTRODUCTION

Center pivot irrigation systems are the dominant irrigation system type in use within Kansas (Rogers et. al., 2007). Irrigation is also the dominant use of water supplies for the state, but in many areas of the state, water supplies are diminishing. However, irrigated agriculture makes significant contributions to the economy so improving irrigation water utility has long term benefits to the region. The Mobile Irrigation Lab (MIL) project previously developed a procedure to performance evaluate center pivot nozzle packages for uniformity (Rogers et. al., 2002). Later, the performance evaluation was expanded to include an evaluation procedure for in-canopy (low to the ground) nozzle packages (Rogers et. al., 2005), although, the performance evaluations did not focus on individual components. Approximately 80 percent of the nozzle packages were equipped with pressure regulators (Rogers et. al., 2007); however, the pressure drop across the regulator was not measured in the previous performance evaluation procedure. By observation, pressure regulator failure has appeared to be either excessive leaking at the regulator or clogging with no water passing, but otherwise the regulators were assumed to be functioning. In this study, pressure regulators from existing systems were collected and laboratory tested for performance.

PROCEDURES

Two sets of 10 pressure regulators each were initially intended to be removed from various systems in southwest Kansas. Older nozzle packages were selected. The samples were normally collected from the third and last span of the system. In one case, all the pressure regulators from the system were evaluated. The regulators were subsequently brought to the hydraulics laboratory at the Department of BAE, Kansas State University. Each regulator was tested at two input pressures (20 and 30 psi) and three nozzles sizes appropriate to the flow rating of the pressure regulator.

RESULTS AND DISCUSSION

Three hundred and nine pressure regulators were collected and tested. Only one regulator was recorded as failed. In this case, excessive leakage through the regulator body occurred, which was a part of the GFS3 test. The average results of this collection are based on the averages of the remaining 9 in the collection sample. In another case, a regulator had no flow passing through the regulator when it was initially installed on the test stand. It was removed, at which time debris was noted in the intake side which was then removed by tapping the regulator on a hard surface. This dislodged the debris, so the regulator was re-installed and tested.

An example of a pressure regulator performance chart is shown in figure 2. For the design output pressure or pressure rating, the downstream or output pressure will be slightly less than line (input) pressure due to friction losses through the regulator. Once the internal friction loss is overcome, the device will begin to output the approximate design rating. This value will generally be slightly elevated with increasing input pressure. The amount of flow through a pressure regulator will also affect the output pressure, with decreasing output pressure with increasing flow.

A summary of the results are in Table 1, where the average output pressure of the collected set are shown as well as the highest and lowest reading from the test set. The size of the nozzle is also noted in the table. Pressure regulators were collected from 8 different systems. On two systems only the outer span regulators were collected and on one system the S3 span had different pressure rated (6 psi) regulators than the LS span (10 psi); making 14 data sets. Based on figure 2 discussion, it would be expected that as nozzle size (higher flow) increased, the average output pressure would decrease. This was the case in 9 of the 14 sets for the 20 psi test. RKS3, RKLS, GFS3, MGLS, and RBLS did not follow the pattern of decreasing output pressure with increasing flow. At 30 psi, 8 of 14 followed the expected pattern with the same sets above and also GFLS breaking pattern. When comparing test results between 20 and 30 psi pressure tests, only RKS3, RKLS and TLLS did not have higher output pressure at 30 psi input pressure as compared to 20 psi, which would be different than the expected result. Overall, performance of the regulators seemed very good.

Figures 3 and 4 show the results of Test SFGF S3 and LS which are 6 psi rated regulators and, as noted previously, follow the expected pattern of performance. For example at 20 psi input pressure, the average S3 output pressure changes from 6.25 to 5.73 to 5.53 psi for the respective nozzle sizes. Figure 3 shows individual data points to indicate the range of values. Most test values are relatively close, although in the 20 psi LS test, one regulator had a test value of nearly 8 psi, which is an outlier as compared to the others. Figure 4 shows a different data presentation. In this figure, S3 and LS test results were averaged into a combined set. Note that flow through the nozzle has more impact on the output pressure than does the input pressure.

Figures 5 and 6 show the results of Test UB S3 and LS which are 10 psi rated pressure regulators. The S3 and LS models are the same but the former is a low flow model while the latter is a high flow model. As noted previously, they follow the expected pattern of performance. For example at 20 psi input pressure, the average S3 output pressure changes from 10.25 to 9.74 to 9.20 psi for the respective nozzle sizes. Figure 5 shows individual data points to indicate the range of values. Most test values are relatively close, although in the 30 psi LS test, the range of data points was larger than the other ranges. Figure 6 shows the data presented by nozzle size and the results show the decreasing output pressure with increasing nozzle size. The output pressures for the 20 and 30 psi input pressures were not as tight as in the SFGF example but still similar; with the average 20 psi LS test was slightly lower than the other average values

Figures 7 and 8 show the test results from 169 pressure regulators. These regulators were collected from one center pivot irrigation system in position order and tested at the two pressure and three flow rates as described previously. The most remarkable feature of either figure 7 or 8 is that the variability of results of the first thirty regulators as compared to the rest of the regulators from the position. At higher flows (figure 7), the regulators performed better, although still at higher output pressure as compared to higher numbers of position. The regulators also performed better at 30 psi (figure 8) than at 20 psi. No notable differences in appearance of the regulators during collection or during test installation were noted. S3 regulators as discussed previously would have been downstream of the variable area noted in this full system analysis.

CONCLUSION

Pressure regulators collected from a variety of center pivot systems located in SW Kansas were laboratory tested. Older nozzle packages were targeted. Although additional analysis of the data is planned, it appears the regulators performed well under the variety of conditions experienced in the region. One full system analysis was completed. Regulator performance in the inner part of this system was more variable than the outer part of the system, however no conclusions should be drawn from a single test.

ACKNOWLEDGEMENTS

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Table 1: Average, highest, and lowest Output Pressure of various pressure regulators for two input pressures and three flow rates.

Pressure Regulator ID	Nozzle Size	Ave Output Pressure PSI	High Pressure PSI	Low Pressure PSI	Ave Output Pressure PSI	High Pressure PSI	Low Pressure PSI
		Upstream Test Pressure = 20 psi			Upstream Test Pressure = 30 psi		
RKS3	15	10.21	11	9.5	9.86	10.9	8.4
10 psi	20	9.63	10.4	9.1	9.68	10.7	9.2
	24	10.26	11.6	9.4	10.47	12	9.1
RKLS	15	10.34	11.1	9.8	10.13	10.7	9.6
10 psi	20	9.93	10.5	9.6	9.78	10.7	8.4
	24	10.45	11.7	9.7	10.76	11.2	10.3
GFS3	15	5.28	6.3	4.2	5.73	6.70	4.60
6 psi	20	5.6	7.9	4.2	5.67	7.30	3.70
	24	5.47	8.50	4.20	5.51	7.50	3.60
GFLS	15	5.73	7.6	5.2	5.83	7.1	5.1
6 psi	20	5.73	7.2	4.9	5.97	7.2	4.7
	24	5.65	7.8	4.6	5.89	7.4	4.8
MGLS	7	8.91	11.1	7.1	10.09	12.5	6.2
10 psi	12	7.84	11.1	4.6	7.84	10	5
	15	8.33	10.4	4.8	7.98	11.3	6.5
RBLS	7	5.79	7.5	5	6.16	7.1	5
6 psi	12	4.77	6.7	3.6	4.77	6.9	4.1
	15	4.92	6.3	4.2	5.32	6.3	3.7
SFGFS3	7	6.25	6.6	6	6.54	7	6.1
6 psi	12	5.73	6.1	5.2	5.98	6.3	5.4
	15	5.53	5.9	4.8	5.6	6.1	5.1
SFGFLS	7	6.51	7.9	6	6.6	7	6.2
6 psi	12	6.13	6.7	5.6	6.05	6.5	5.8
	15	5.79	6.3	5.3	5.52	5.9	5.2

Pressure Regulator ID	Nozzle Size	Ave Output Pressure PSI	High Pressure PSI	Low Pressure PSI	Ave Output Pressure PSI	High Pressure PSI	Low Pressure PSI
UBS3	7	10.25	11.1	8.9	10.43	11.5	9.8
10 psi	12	9.74	10.5	9.2	9.86	10.7	9.2
	15	9.2	10.1	8.1	9.02	9.7	8.1
UBLS	15	9.7	11	7.7	10.32	12	8
10 psi	20	8.59	9.8	7.5	9.42	10.5	7.8
	24	8.55	9.7	7.3	8.64	9.2	7.7
TLS3	7	10.85	11.5	10.3	11.05	11.5	10.5
10 psi	12	10.24	10.6	9.6	10.39	10.7	10
	15	9.72	10.3	8.7	10.09	10.6	9.6
TLLS	15	6.51	7.6	5.2	6.34	7.1	5.8
6 psi	20	6.09	7.5	5.4	5.91	6.7	4.7
	24	5.88	8.2	4.7	5.54	6.6	4.7
ALS3	7	10.68	11.1	10.2	10.91	11.5	10.1
10 psi	12	10.21	10.5	9.9	10.12	10.6	8.6
	15	9.97	10.5	9.5	9.97	10.3	9.6
ALLS	7	10.48	11.1	9.9	10.6	11.3	9.9
10 psi	12	9.97	10.5	9.6	10.19	11	9.3
	15	9.7	10.1	8.8	9.66	10.1	8

Figure 1. Picture of Pressure Regulator Test Stand, including manifold, pressure regulator, pressure shunt, water meter, pressure shunt and flow nozzle.

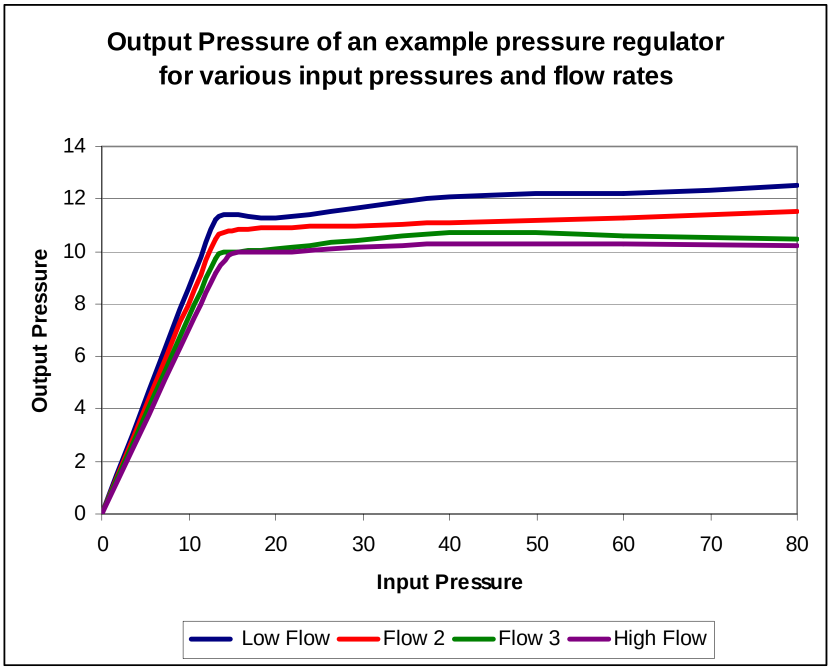

Figure 2. Example of Output Pressure verses Input Pressure for a Pressure Regulator.

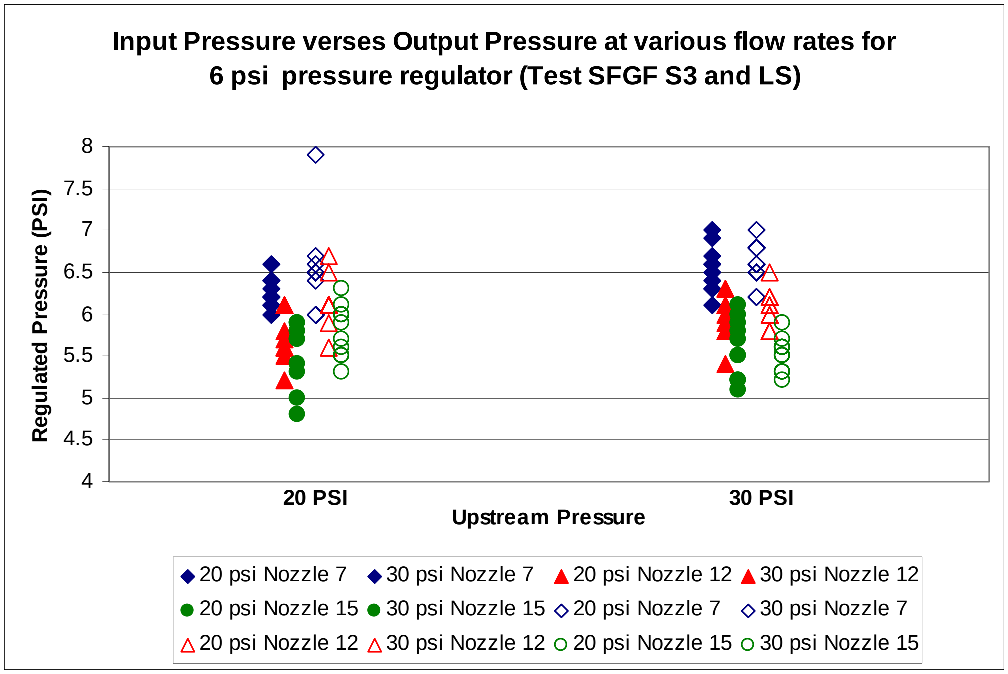

Figure 3. Input pressure verses output pressure at various flow rates for 10 6 psi pressure regulators for Tests SFGF S3 and LS.

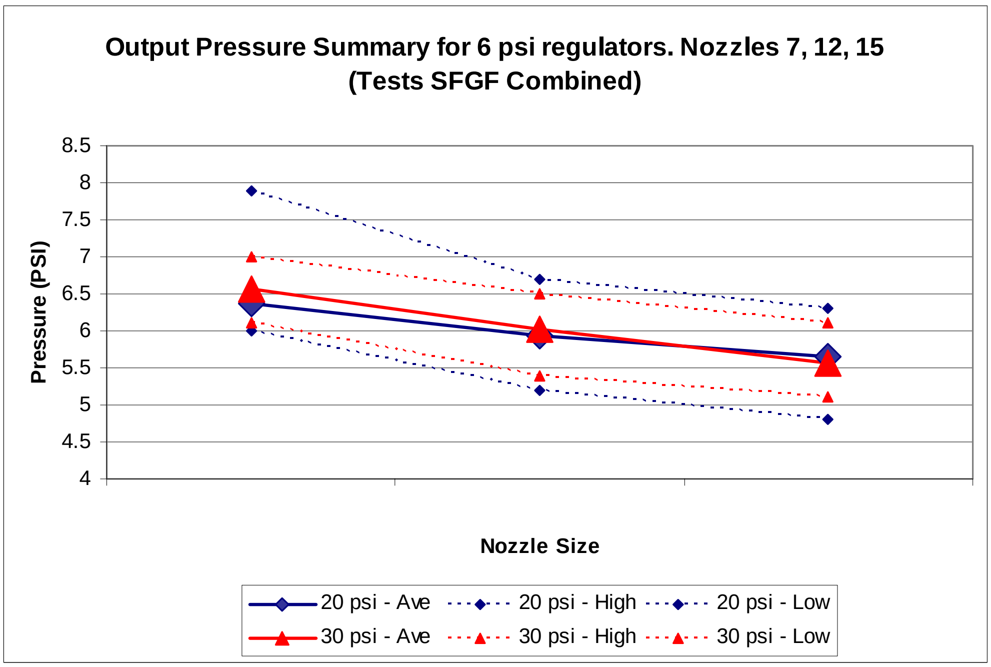

Figure 4. Average, high and low output pressures for 6 psi pressure regulators for Test SFGF S3 and LS.

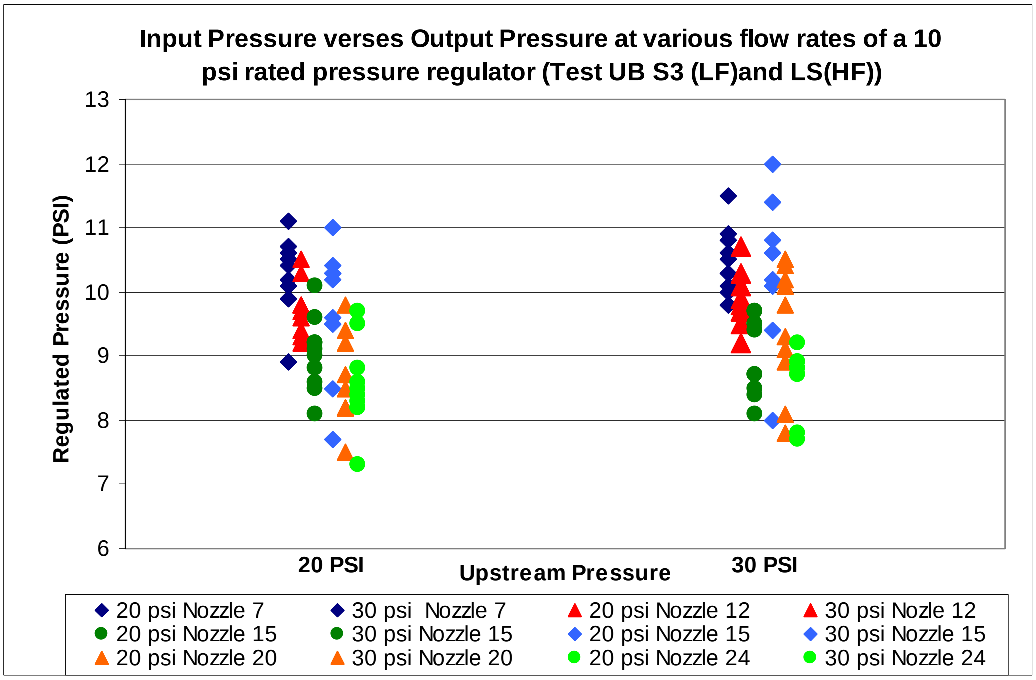

Figure 5. Input pressure verses output pressure at various flow rates for 10 psi pressure regulators for Tests UB S3 and LS.

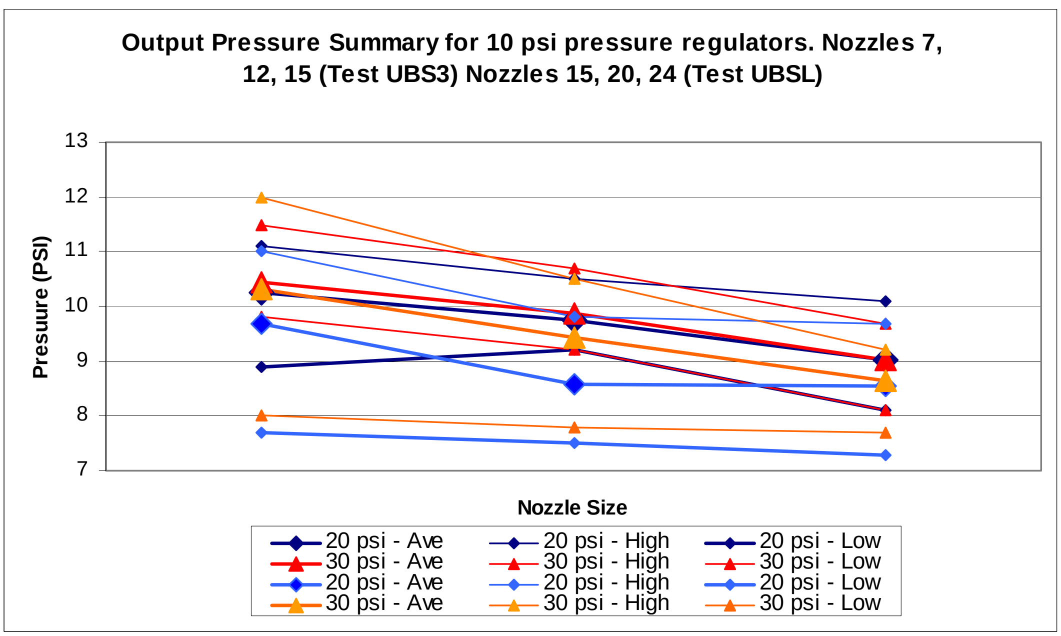

Figure 6. Average, high and low output pressures for 10 psi pressure regulators for Tests UB S3 and LS.

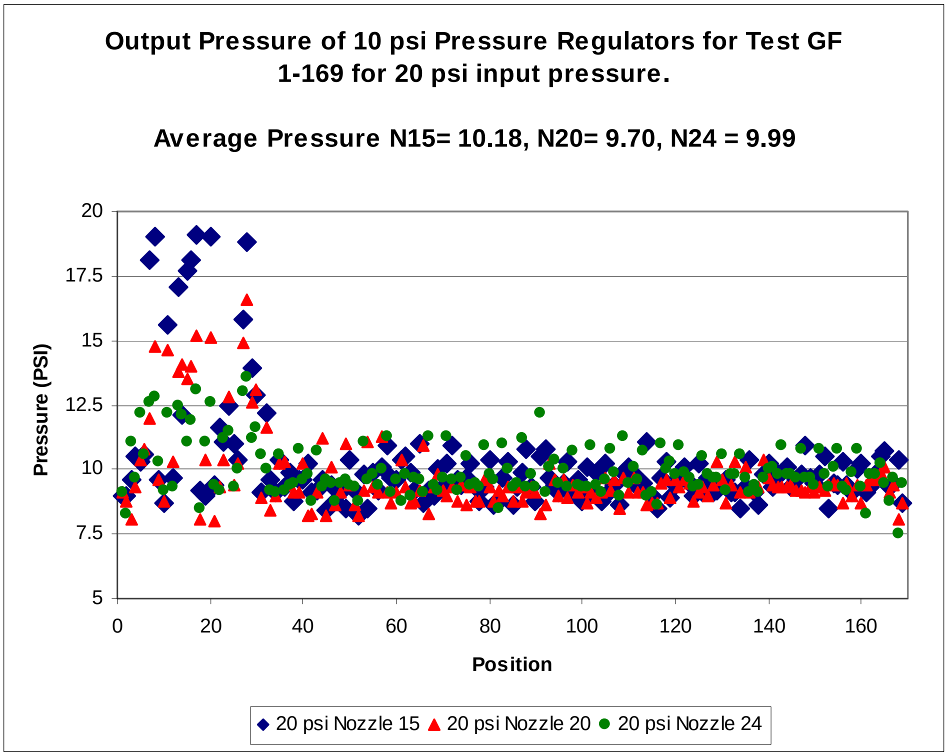

Figure 7. Output pressure of 169 pressure regulators tested at three nozzle sizes. Tests GF 1-169.

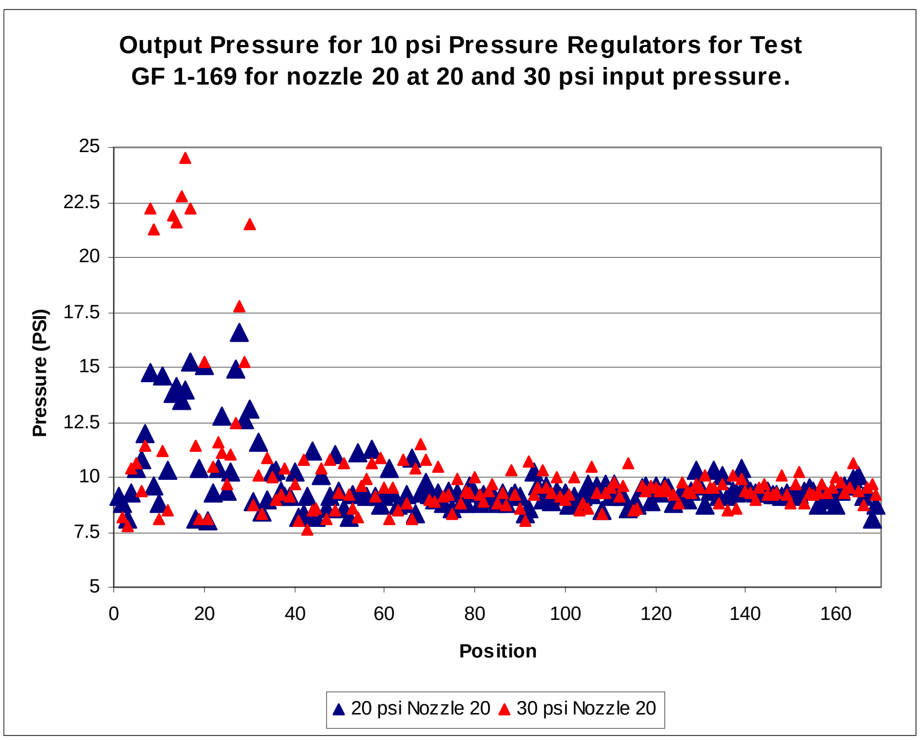

Figure 8. Output pressure of 169 pressure regulators tested at 20 and 30 psi input pressure. Tests GF 1-169.