CPACL NOVA 50E RESEARCH PAPER SUMMARY

Effect of Flow Conditioners and Pulsation on the Performance of 8 inch Multi-path Ultrasonic Meters.

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This report presents the results of NPS – 8" flow conditioner installation effects research work with ultrasonic meters. The CPACL NOVA 50E flow conditioner improves the performance of both ultrasonic meters resulting in a near baseline performance. The performance of the 19 tube bundle is inconsistent and hence deemed to be unsatisfactory.

Installation:

Two elbows out of plane – zero spacing between elbows, high Re.

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EFFECT OF FLOW CONDITIONERS AND PULSATION ON THE PERFORMANCE OF 8INCH MULTI-PATH ULTRASONIC METERS

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ABSTRACT

The performance of two 8inch multi-path ultrasonic meters provided by Instromet and Daniel Industries is evaluated in the presence of a 19 tube bundle and the CPACL* flow conditioner. These flow conditioners are placed downstream of a single elbow and two elbows out of plane. The ultrasonic meters are tested at several locations downstream of the flow conditioners. NOVA's gravimetric facility is used to evaluate the performance of the meters. The present measurements indicate that the use of CPACL flow conditioner results in a near baseline performance of ultrasonic meters.

The two meters were also tested for pulsation effects using some of the solutions suggested by the manufacturers. Present tests indicate that the solutions were not effective enough and the meters are subject to errors when exposed to a pulsating flow.

INTRODUCTION

In the past (Karnik et al., 1997 and Rogi et al., 1997), rigorous testing of the Daniel and Instromet 8inch multipath ultrasonic meters was conducted and resulted in useful

*CPACL (Canadian Pipeline Accessories Company Ltd.) manufactures and markets the perforated plate flow conditioner developed at NOVA.

information on the performance of these meters in good flow conditions, when subjected to installation effects and pulsations and in field conditions with wet gas.

It was evident, from these tests, that installations such as a single elbow or two elbows out of plane could affect ultrasonic metering. Hence, tests were planned with flow conditioners for these installations. The meters were also affected by pulsations and it was believed by the manufacturers that the effect of pulsations could be eliminated. Thus, more testing was conducted to test the solutions suggested by the manufacturers. The results of these tests are presented in this paper.

EXPERIMENTAL FACILITY

The layout of the experimental facility is shown in Figure 1. The description of the facility and instrumentation and experimental procedures have been documented by Karnik et al. (1997). The flow rate of the ultrasonic meters is compared to that from the sonic nozzle bank. Traceability of the flow reference has been established by Karnik et al. (1996a). The test section for the pulsation tests is shown in Figure 2 and typical piping configurations for the tests on installation effects are shown in Figures 3 and 4.

FURTHER TESTS ON PULSATION EFFECTS

Both meters were tested for pulsation effects at flow rates of around 6.25kg/s and 10.5kg/s. The pulsation generator consists of a rotating 2 blade perforated paddle and has been described by McBrien (1997). It was placed approximately 13m downstream of the meters. Thus, the meters were only subjected to pure pulsations and not the velocity profile distortion that would result from the paddle.

Pulsation effects on metering are shown in Figures 5 to 8 along with the peak values of pulsation as a function of frequency. On examining these Figures, it is evident that the solutions to eliminate pulsation effects have not been successful.

Daniel Industries adjusted their acceptance level to 2σ and it can be seen, from Figures 5 and 6, that at around 8.5Hz, 22Hz and 45 Hz. the meter is affected by pulsations. The worst effect, occuring at 8.5Hz., was around 5.5% (Figure 6a.)

Instromet approached the problem by changing the electronics. Even so, the meter is affected at 8.5Hz and 22Hz resulting in metering errors as high as 9% and -4% respectively (Figure 8a). It was suggested that a larger sample be taken to evaluate the average flow rate. One log file (8.5Hz, 10.5kg/s) was taken from the data set logged by Dr. Dane of Instromet. This log file consisted of around 100 data points instead of the 20 that were collected by the NOVA process. The average velocity from the NOVA method was 8.775m/s whereas that from the Instromet log file was 8.729m/s indicating that the two methods provide similar results.

SINGLE ELBOW WITH FLOW CONDITIONER

The two flow conditioners that were tested were the CPACL perforated flow conditioner and the 19 tube bundle (T.B.). Measurements were conducted with both meters simultaneously during these tests. The two meters were physically separated by a spool piece at least 3D long. A typical installation is shown in Figure 3. The separation between the initial Tee and the inlet to the first elbow was 10D. The distance of the meter from the flow conditioner is defined as x/D. During all tests, data was taken simultaneously with the 4inch reference orifice meter. These measurements (not shown here) agreed with the historical measurements of this orifice meter (Karnik et al., 1996b) to within ±0.2%.

The results of testing the Daniel meter are shown in Figures 9, 10 &11 whereas results of tests with the Instromet meter are shown in Figures 12,13 & 14. Statistics are for flow rates greater than 5kg/s. Deviations are presented from the baseline average obtained for flows greater than 5kg/s. It is evident from the Figures and from Tables 1 and 2 that the presence of the CPACL flow conditioner improves the performance of the ultrasonic meter and results in a quasi-asymptotic performance, unlike the tube bundle (see Table 2.)

TWO ELBOWS OUT OF PLANE WITH FLOW CONDITIONER

As in the case of a single elbow, measurements were conducted with the two meters tested in series. The two elbows out of plane were separated by a 4D spacer. The separation between the initial Tee and the inlet to the first elbow was 10D. One typical Installation is shown in Figure 4.

The results of testing the Daniel meter are shown in Figure 15 whereas results of tests with the Instromet meter are shown in Figure 16. Deviations are presented from the baseline performance. Statistics are for flow rates greater than 5kg/s. For this installation also, the meters performance is quasi-asymptotic with the use of the CPACL flow conditioner, as seen in Tables 3 and 4. The tube bundle also performs well for this installation.

EFFECT OF UPSTREAM PROTRUSIONS

For some tests, the Daniel meter was located upstream of the Instromet meter. In the other cases, it was placed downstream of the Instromet meter. Interestingly, it was noted that when the Daniel meter was located upstream, its performance with the CPACL flow conditioner was comparable to the baseline performance. When the meter was located downstream of the Instromet meter, the deviations from baseline increased to around 0.9% at 11D and around 0.65% at 17D. These observations were found to be repeatable even a week later. This increase in deviation is attributed to the protruding (10mm) transducers of the Instromet meter which was upstream of the Daniel meter. As seen in Table 5, repeating the tests without the upstream Instromet meter resulted in a near baseline performance. A similar test, to study the effect of protrusions, was not conducted for the Instromet meter

CONCLUSIONS

The CPACL flow conditioner improves the performance of both ultrasonic meters resulting in a near baseline performance. The performance of the 19-tube bundle is inconsistent and hence deemed to be unsatisfactory. The improvement in the performance of 8inch ultrasonic meters with the use of flow conditioning has also been reported by Grimley (1997). Pulsations affect the performance of ultrasonic meters quite severely and needs to be better understood. Protrusions of upto 10mm appears to affect the Daniel meter and a similar test should be conducted on the Instromet meter.

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Rogi, M, Karnik, U.and Shen J., 1997, "Field Performance Tests of 8 inch Multi-Path Ultrasonic Meters at NOVA's Figure Lake Test Facility", ASME Fluids Engineering Division Summer Meeting, Vancouver, BC, Canada

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ACKNOWLEDGMENTS

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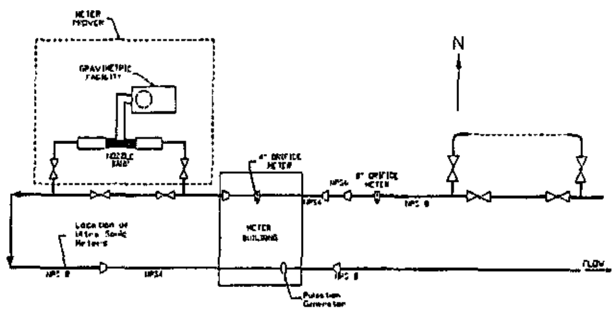

Figure 1. Sketch of NOVA's Test Facility.

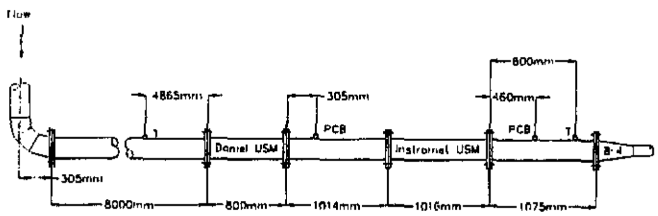

Figure 2. Test section for pulsation tests.

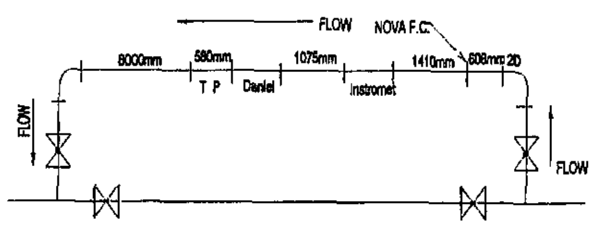

***Figure 3.* Typical experimental layout for testing with single elbow configuration with flow conditioner.**

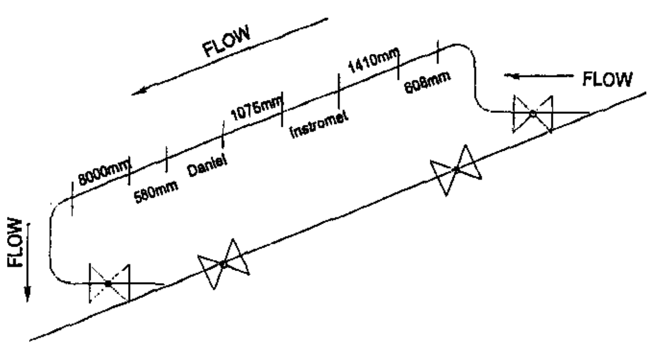

Figure 4. Typical experimental layout for testing with single elbow configuration with flow conditioner.

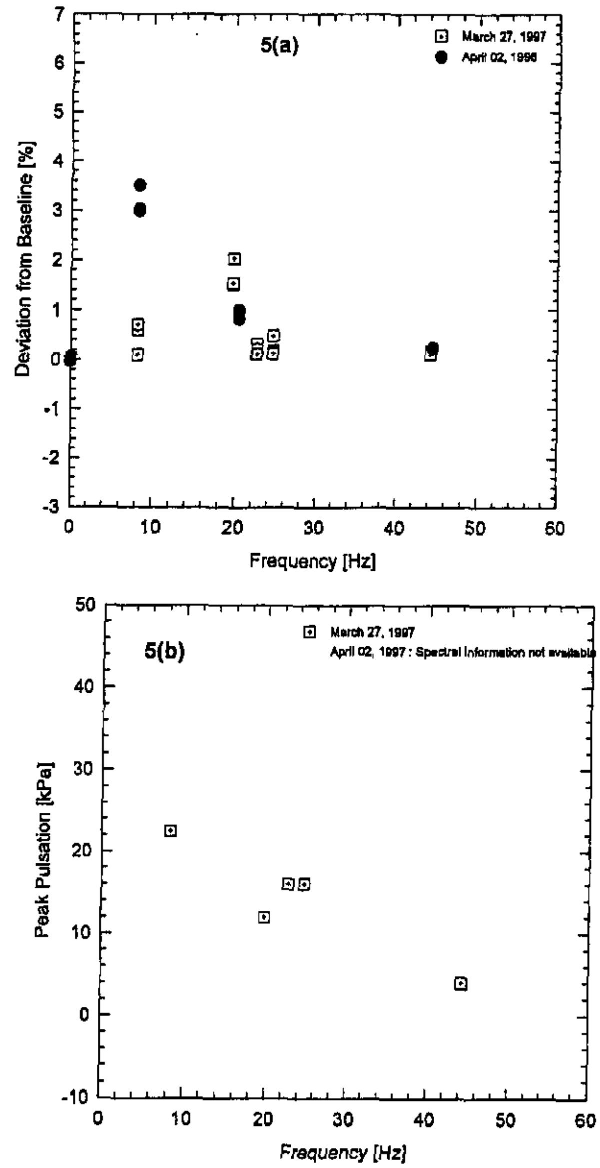

Figure 5. Performance of the Daniel Meter 530381 under pulsating flow conditions at a flow rate of ≈6.25kg/s.

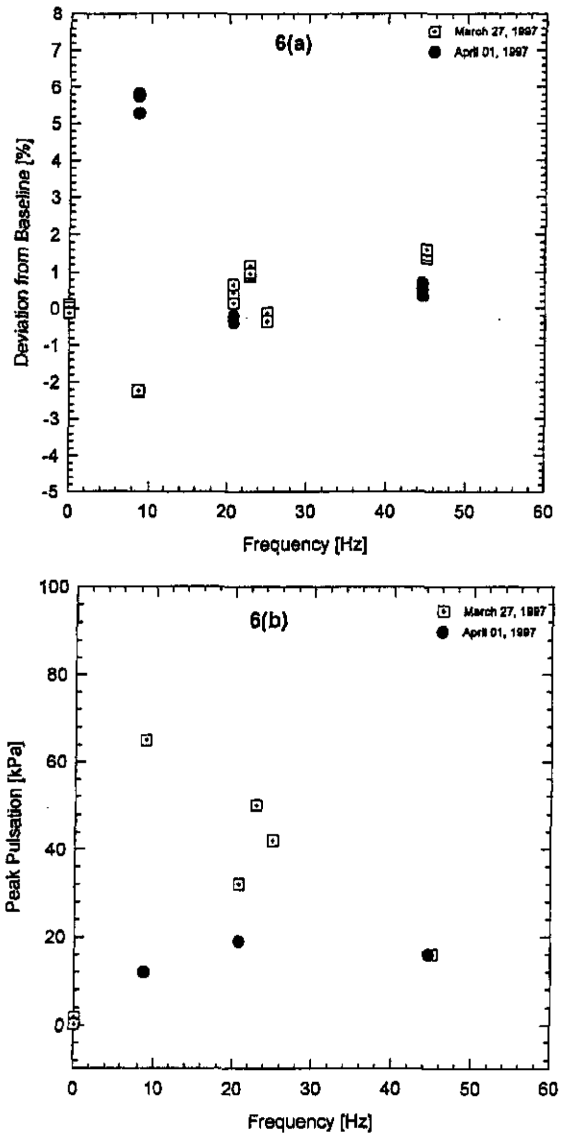

Figure 6. Performance of the Daniel Meter 530381 under pulsating flow conditions at a flow rate of ≈10.5kg/s.

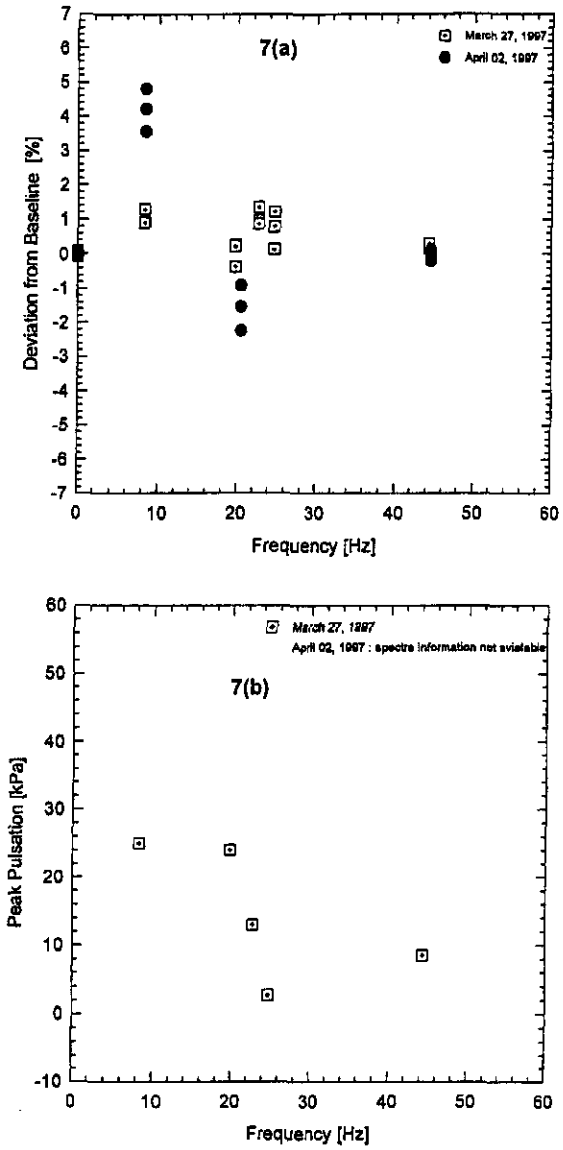

Figure 7. Performance of the Instromet Meter 2003 under pulsating flow conditions at a flow rate of ≈6.25.

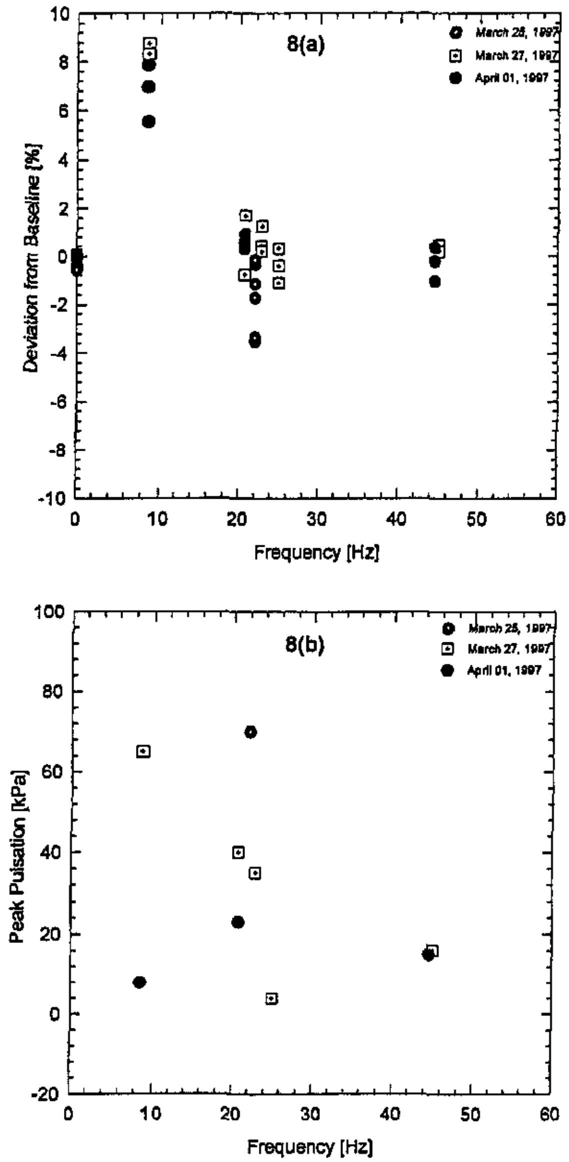

Figure 8. Performance of the Instromet Meter 2003 under pulsating flow conditions at a flow rate of ≈10.5kg/s.

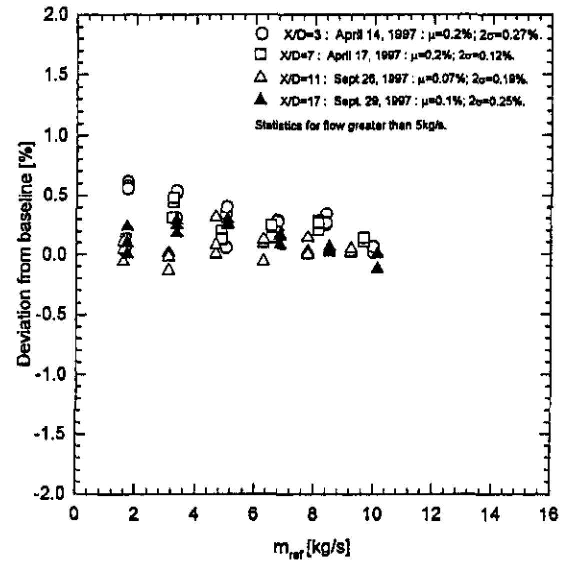

Figure 9. Performance of Daniel meter 530381 with **CPACL flow conditioner placed at 2D downstream of a single elbow.**

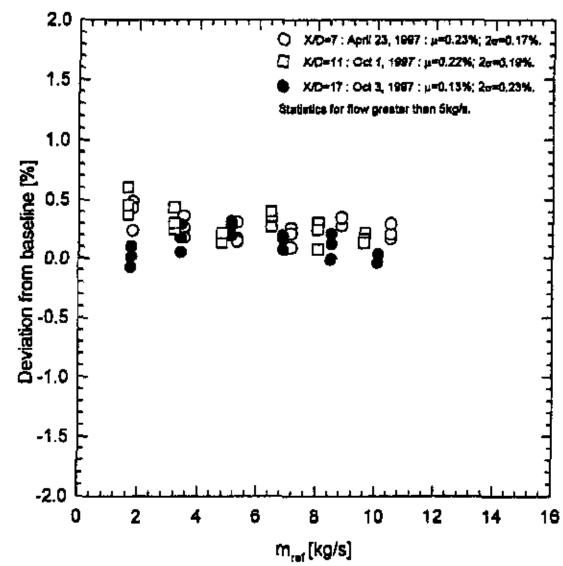

Figure 10. Performance of Daniel meter 530381 with CPACL flow conditioner placed at 5D downstream of a single elbow.

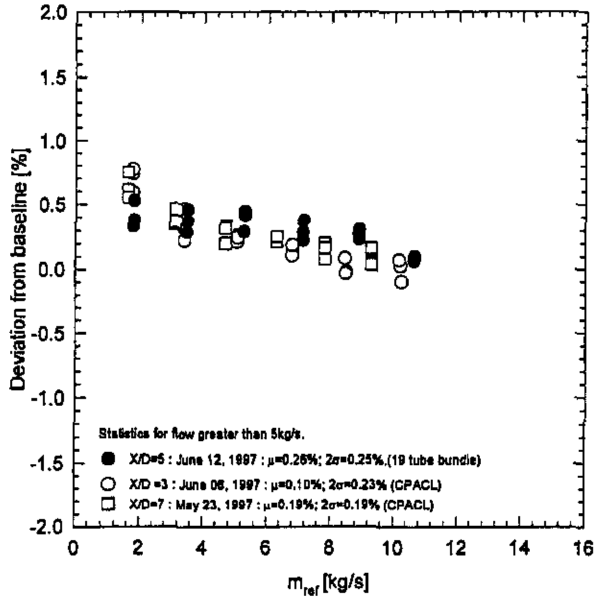

Figure 15. Performance of Daniel meter 530381 with flow conditioners placed at 5D downstream of two elbows out of plane.

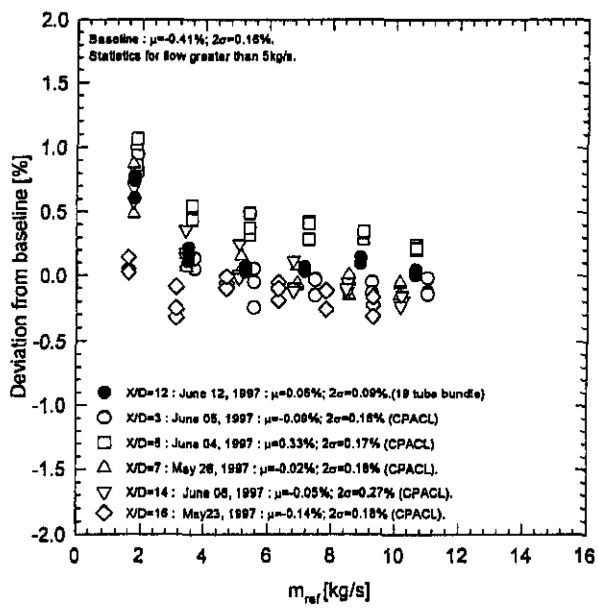

Figure 16. Performance of Instromet Meter 2003 with flow conditioners placed at 5D downstream of two elbows out of plane.

FC to eter	CPACL at 2D from installation	CPACL at 5D from installation	T.B. at 2D from Installation	NO F.C.
0.5D			0..86±0.34 %	
3D	0.2±0.27%			≈0.3%@2D
7D	0.2±0.12%	0.23±0.17 %		≈0.1%
8.5				≈-0.1%@9D
10D				
11D	0.07±0.19%	0.22±0.19 %		≈0.05%@12 D
17	0.10±0.25%	0.13±0.23 %		≈0.1%@19D

Table 1 Results for Single Elbow with Daniel Meter (statistics for flows greater than 5kg/s). Deviations are from baseline.

FC to Meter	CPACL at 2D from installation	CPACL at 5D from installation	T.B. at 2D rom Installation	NO F.C.
0.5D			0..08±0.13%	
3D	0.18±0.11			≈-1.0%@2D
7D	0.35±0.24	0.02±0.14%	0.58±0.16% @7.5D	
10D	0.07±0.23			≈-0..5%@9D
11D				≈0.35%@12
17	0.05±0.13	- .22±0.18%		≈0.35%@19

Table 2. Results for Single Elbow with Instromet Meter (statistics for flows greater than 5kg/s). Deviations are from baseline.

FC to Meter	CPACL at 5D from installation	T.B. at 2D from Installation	T.B. at 5D from Installation	NO F.C.
3D	0.1±0.23%			≈2.0%@2D
7D	0.19±0.19%			≈0.5% @5D
8D		0.30±0.35%	0.26±0.25%	≈-0.4%@9D

Table 3 Results for Two Elbows out of Plane with Daniel Meter (statistics for flows greater than 5kg/s). Deviations are from baseline.

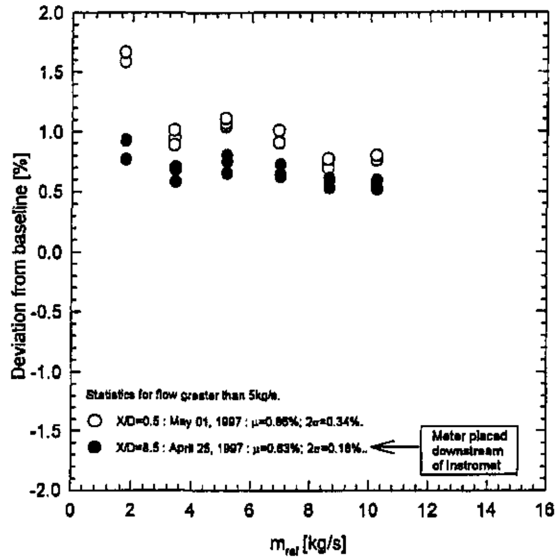

Figure 11. Performance of Daniel meter 530381 with 19 tube bundle flow conditioner placed at 2D downstream of a single elbow.

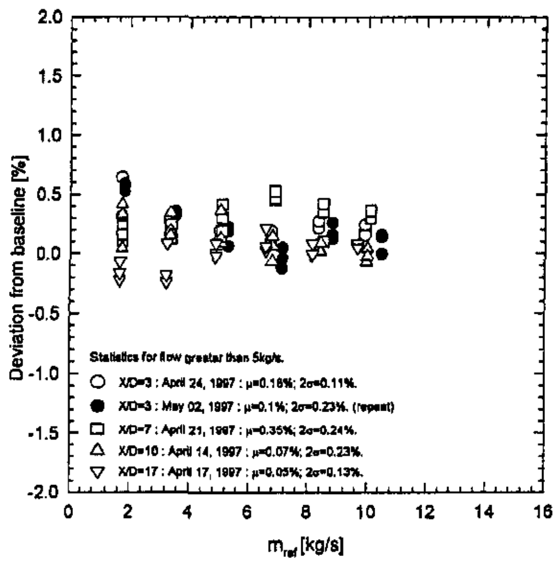

Figure 12. Performance of Instromet 2003 with CPACL flow conditioner placed at 2D downstream of a single elbow.

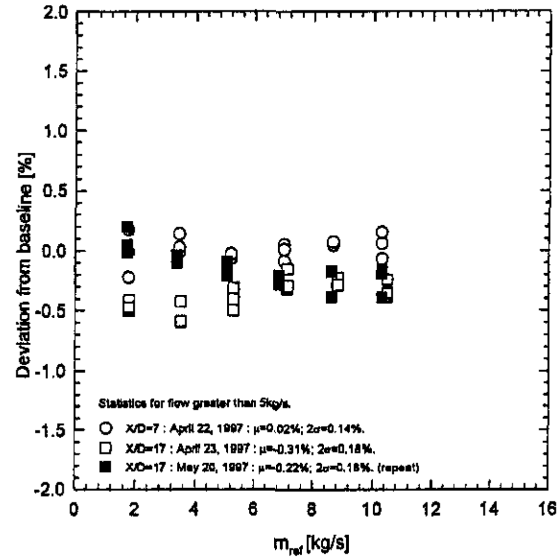

Figure 13. Performance of Instromet 2003 with CPACL flow conditioner placed at 5D downstream of a single elbow.

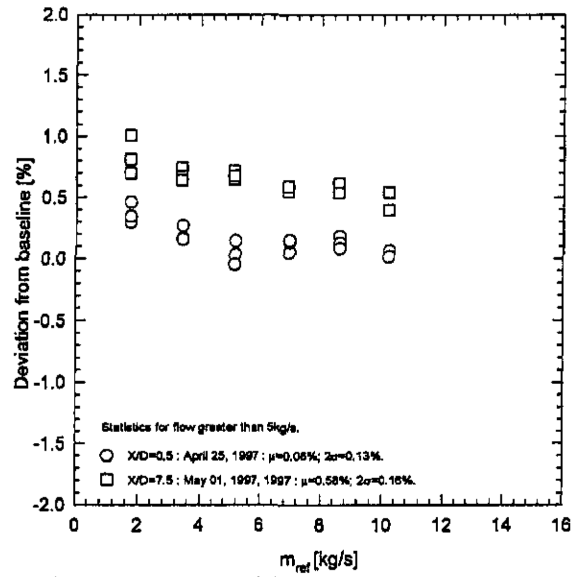

Figure 14. Performance of Instromet 2003 with 19 tube bundle flow conditioner placed at 2D downstream of a single elbow.

FC Meter	CPACL at 2D from installation	CPACL at 5D from installation	T.B. at 2D from Installation	T.B. at 5D from Installation	NO F.C.
3D		-0.1±0.16%			≈ -0.3%@2D
5D		0.33±0.17%			≈-0.4%
7D		-0.02±0.18%			
10D	0.10±0.15%				≈0.7.%@9D
12D			0.35 ±0.1%		≈-0.4%
14D		-0.05±0.27%			
15D				- 0.04±0.2%	
16D		-0.14±0.18%			≈0.4%@19D

Table 4. Results for Two Elbows out of Plane with Instromet Meter (statistics for flows greater than 5kg/s). Deviations are from baseline.

FC to Meter	Instromet Upstream	Without Protrusions
11D(FC at 2D)	0.96%	0.07%
17D (FC at 2D)	0.58%	0.1%
17D (FC at 5D)	*0.58%*	*0.13%*
15D (FC at 5D)-TEOP	0.63%	
17D (FC at 5D) - TEOP	0.71%	
17D (FC at 5D) - TEOP	0.64%	
20D (FC at 2D) - TEOP	0.64%	

Table 5. Results showing effect of protrusions on Daniel meter (statistics for flows greater than 5kg/s). Deviations are from baseline.