CPACL NOVA 50E RESEARCH PAPER SUMMARY

Scale up Tests on the NOVA Flow Conditioner for Orifice Meter Applications.			
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This report presents the results of NPS – 8” flow conditioner installation effects research work. The intent of this work is to show scalability of the plate in compliance with the NEW AGA –3 metering standard requirements.

Installation:

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

SCALE UP TESTS ON THE NOVA FLOW CONDITIONER FOR ORIFICE METER APPLICATIONS

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ABSTRACT

The NOVA-50E flow conditioner has been extensively and successfully tested for its performance as an isolating type of flow conditioner in orifice meter applications. However, it has only been tested in 4inch meter tubes. Although the flow conditioner is designed to be scalable, the claim was verified in the present tests in an 8 inch line size. The disturbance was generated by using two elbows out of plane, with zero spacer between the elbows. The 8-inch flow conditioner has been placed at several distances from the installation and from an 8 inch orifice meter. The tests were carried out at the Didsbury Gas Dynamic Test Facility in natural gas, at static pressures in the range 5000 to 6000 kPa. The orifice meter performance in the presence of the flow conditioner was compared to its baseline performance when placed downstream of a 19 tube bundle + 80D long meter run. The reference flow, in both cases, was a bank of sonic nozzles traceable to the primary gravimetric system. Results indicate that the flow conditioner is scalable and performs as expected in larger meter runs. In addition to the flow conditioner performance tests, some results of the 8-inch orifice meter without the flow conditioner are also presented. These results agree very well with the data available in literature.

1.0 INTRODUCTION

During the early/mid 90's, flow conditioners for orifice metering were the center of attention for the natural gas industry. This stemmed from the fact that the tube bundle, within the framework of the orifice standard, was unable to perform to the expectations of an industry driven to reduce costs associated with unaccounted gas. The identification of a relationship between mean velocity profiles and orifice metering was possible by means of velocity profile measurements, for example, by Mattingly & Yeh (1991), Morrow & Park (1992) & Park et al. (1992). The importance of the mean and turbulent velocity profiles and their combined effect on orifice metering was demonstrated by Karnik et al. (1994) and Karnik (1994). It was clear why the tube bundle was unable to meet performance expectations. Subsequently, several new flow conditioners emerged such as Laws (1990), Stuart et al. (1993), Gallagher et al. (1994), Spearman et al. (1994), Laws & Quazzane (1995) and Karnik (1995).

The NOVA 50E flow conditioner, in the past, has been tested mainly in 4 inch line sizes, for example, Karnik (1995) and Morrow (1995, 1997). Although, the NOVA-50E flow conditioner was designed such that it could be easily scaled to any line size, there was no experimental data available for this flow conditioner in large pipe sizes. Thus, the present tests provide the necessary data to demonstrate that this flow conditioner can be scaled to perform in any pipe size.

2.0 BASELINE MEASUREMENTS

All experiments were conducted at the Didsbury Gas Dynamic Test Facility on natural gas at nominal pressures of around 5500kPa. Details of the facility and the measurement accuracies, uncertainties and traceabilty have been presented previously by Karnik et al. (1996).

Baseline measurements with the 8 inch orifice meter were taken with a 19 tube bundle followed by nearly 80D (D is the pipe internal diameter) of straight pipe. A sketch of the piping layout is shown in Figure 1. The orifice meter run was turned backward so that the flow conditioner could be tested at locations which were closer to the meter than would otherwise be possible. According to Daniel Industries, Canada, the performance of the meter would not be compromised by such an installation. The tests included β-ratios of 0.3133,0.4073 and 0.5012. Measurements of baseline with β-ratios of 0.2193, 0.5952, 0.6704 and 0.7512 exhibited considerable scatter and are not presented. Results of the baseline tests are shown in Table 1.

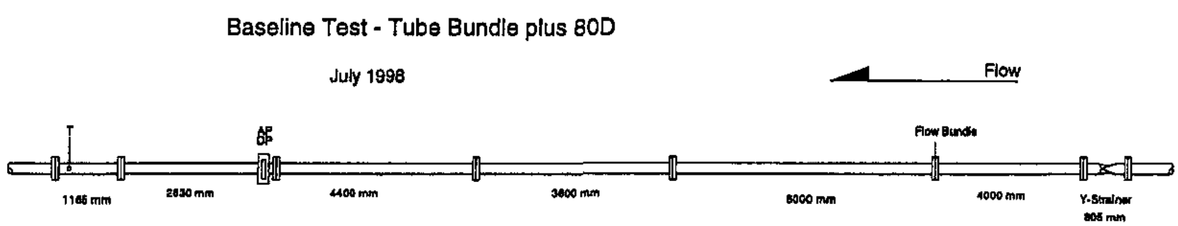

Figure 1. Schematic for the Baseline Tests.

β-Ratio	19 T.B. + 80D
0.3133	0.12%
0.4073	0.09%
0.5013	0.16%

Table 1. Average baseline deviation in mass flow from sonic nozzle bank using 19 tube bundle + 80D.

3.0 INSTALLATION EFFECTS WITHOUT THE FLOW CONDITIONER

The experimental set up for the tests without flow conditioner are shown in Figure 2. The installation consisted of a tee followed by a 10D spacer subsequently followed by two elbows out of plane with no spacer between the two elbows. Mass flow deviations due to the installation are compared to the baseline deviations of Table 1. The differences between two are shown in Figures 3 and 4. The data foβ-ratios of 0.4 and 0.5 agree very well with the data for two elbows out of plane (spacer$\leq$ 2D) presented by the White Paper Writing Group (Studzinski et al., 1997).

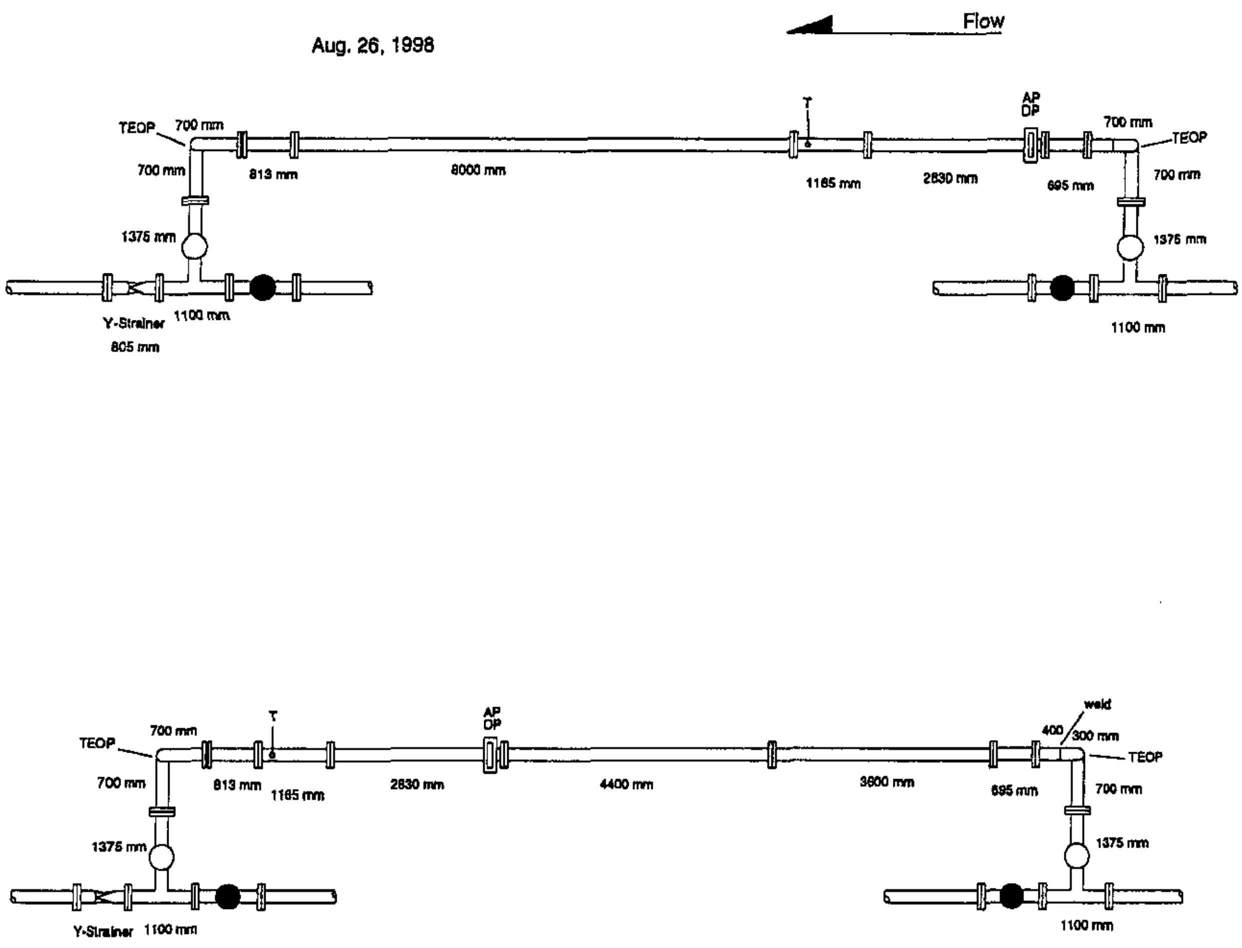

Figure 2. Meter configuration for installation test without flow conditioner; top : 5D; bottom: 45D.

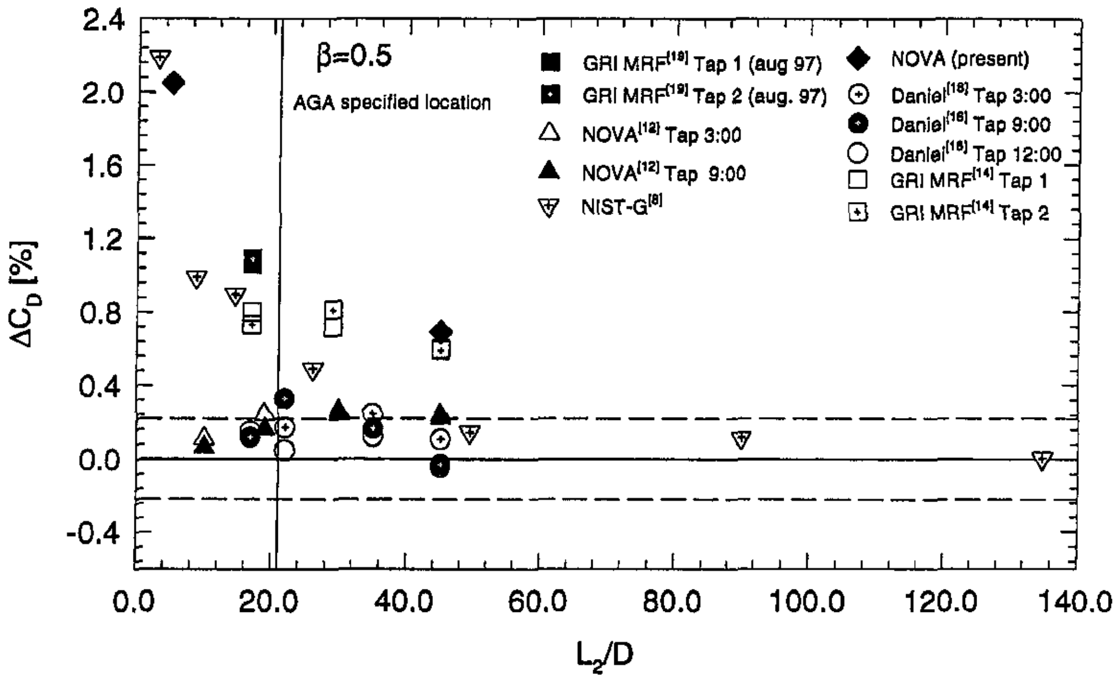

Figure 3. Effect of Two Elbows Out of Plane (Spacer ≤ 2D) (Without Flow Conditioner) on Orifice Meter; β=0.5; Reproduced from Studzinski et al. (1997); L_2 is the distance from the disturbing element to the orifice meter.

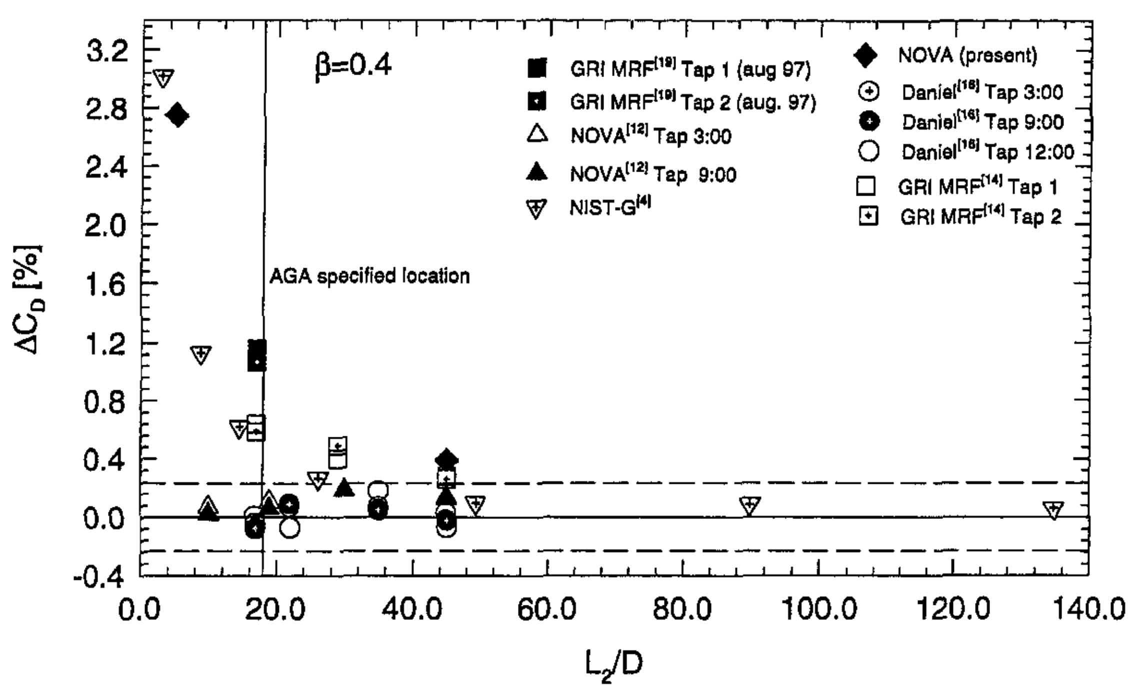

Figure 4. Effect of Two Elbows Out of Plane (Spacer ≤ 2D) (Without Flow Conditioner) on Orifice Meter; β=0.4. Reproduced from Studzinski et al. (1997).

4.0 PERFORMANCE OF THE NOVA 50E FLOW CONDITIONER

It was decided that the flow conditioner should be subjected to a severe test. The swirling flow test was thought to be the most severe. However, since a swirler was not available for high pressure applications, it was decided to use two elbows out of plane with no spacer between the elbows. Due to the piping logistics this installation was preceded by a Tee, located at 10D from the first elbow. The design of the NOVA-50E flow conditioner is shown in Figure 5. Various piping configurations were tested and one typical configuration is shown in Figure 6.

The results from these tests are shown in Tables 2,3 and 4.

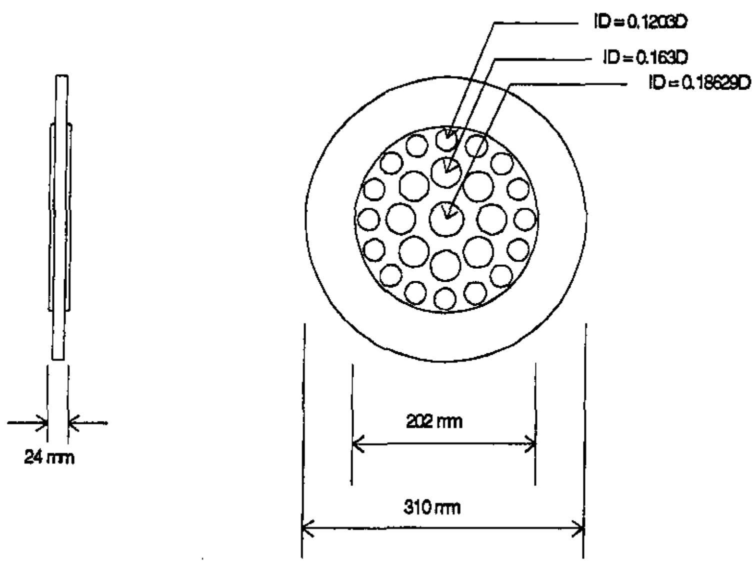

Figure 5. The NOVA 50E flow conditioner.

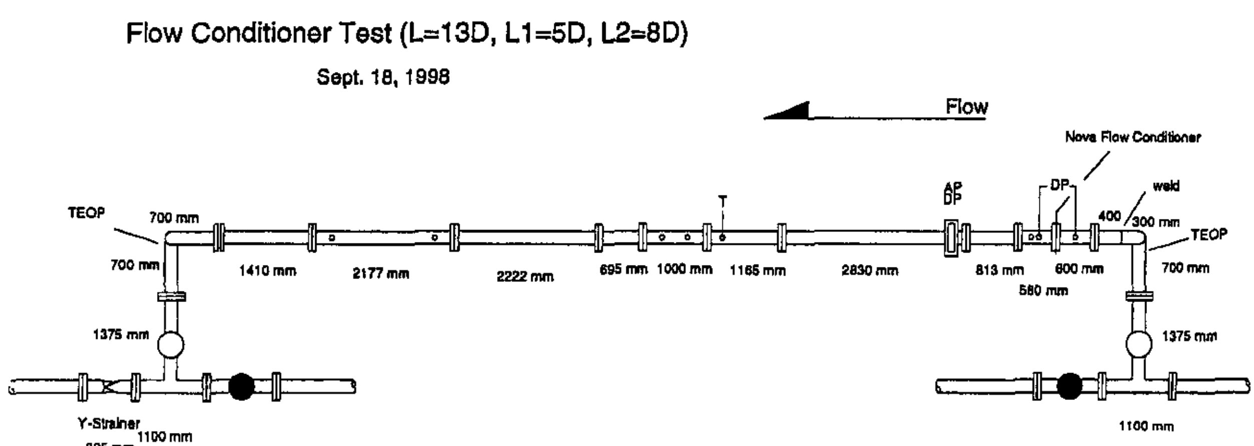

Figure 6. Piping layout for flow conditioner tests.

β-Ratio	12D- 5D	10D- 7D	5D-12D	23D-22D	5D- 8D	13D-12D
	L1 – L2	L1 – L2	L1 – L2	L1 – L2	L1 – L2	L1 – L2
0.3133	0.16%	0.24%	0.17%	0.19%	0.12%	0.11%
0.4073	0.14%	-0.01%	0.05%	0.08%	0.03%	0.04%
0.5013	0.17%	-0.06%	-0.03%	0.03%	0.01%	-0.03%
0.5952	0.26%	0.02%	-0.04%	0.03%	-0.06%	-0.06%
0.6704	0.43%	0.15%	-0.01%	0.07%	-0.06%	-0.09%
0.7519	0.21%	-0.06%	-0.39%	-0.28%	-0.40%	-0.38%

Table 2. Results of flow conditioner tests. Deviations are shown in mass flow with respect to reference sonic nozzles. L: total meter run length; L1: distance from installation to flow conditioner; L2: distance from flow conditioner to orifice meter.

On examining the results in Table 2, it appears that for a β-ratios with L2>5D, the use of the flow conditioner results in asymptotic performance of the orifice meter. This is not surprising since the flow conditioner is designed to produce a repeatable profile at distance ≥ 8D.

Comparison of the flow conditioner tests with respect to the baseline of 80D is shown in Table 3. For $\beta \leq 0.5013$, the flow conditioner is well within the $\pm\sigma$ limits of the R-G equation i.e. less than ±0.22 to ±0.28%.

β-Ratio	12D- 5D	10D- 7D	5D-12D	23D-22D	5D- 8D	13D-12D
	L1 – L2	L1 – L2	L1 – L2	L1 – L2	L1 – L2	L1 – L2
0.3133	0.04%	0.12%	0.05%	0.07%	0.00%	-0.01%
0.4073	0.05	-0.10	-0.04	-0.01	-0.06	-0.05%
0.5013	0.01	-0.22	-0.19	-0.13	-0.15	-0.19

Table 3. Results of flow conditioner tests. Deviations of mass flow are from average Baseline values from Table 1

Since baselines for the larger β-ratios were not available, if one were to assume that the L1=23D and L2=22D were a baseline, then as seen in Table 4, this asymptotic behaviour is in most cases within ±0.1%. Only for β=0.7519, does this deviation get to be as high as 0.22% but is well within the performance limits imposed by the AGA White Paper Writing Group in their Performance Test.

β-Ratio	12D- 5D	10D- 7D	5D-12D	23D-22D	5D- 8D	13D-12D
	L1 – L2	L1 – L2	L1 – L2	L1 – L2	L1 – L2	L1 – L2
0.5952	0.23%	-0.01%	-0.07%	0	-0.09%	-0.09%
0.6704	0.36%	0.08%	-0.08%	0	-0.13%	-0.16%
0.7519	-0.49%	-0.22%	-0.11%	0	-0.12%	-0.10%

Table 4. Results of flow conditioner tests. Deviations are shown in mass flow with respect to data of L1=23D and L2=22D; for β-Ratios ≥0.6.

5.0 CONCLUSIONS

The NOVA 50E has demonstrated that it is an isolating flow conditioner with the capability of producing an asymptotic performance from an 8inch orifice meter, for aβ-ratios ≤0.75.

6.0 ACKNOWLEDGEMENTS

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