Summary of Testing
FOCUS^{TM} PROBE OPTICAL GAS FLOW METER

CEESI Test Results Taken September 19-30, 2005 At
Colorado Engineering Experiment Station, Inc.,
Nunn, Colorado

Prepared for Photon Control
March 6, 2006

Prepared by:
Richard (Rick) Rans P.Eng.
RANSolutions Ltd.

606 Varsity Est. Pl. N.W.
Calgary, Alberta T3B 3C2
(403) 288-7865

RANSolutions

1 Introduction

The FOCUS™ Probe Optical Gas Flow Meter was tested in NPS6 and NPS12 steel pipe at the Colorado Engineering Experiment Station, Inc. (CEESI) test facilities in Nunn Colorado September 19-30, 2005. The CEESI facility uses compressed air vented to atmosphere for meter testing and produces test results that closely match actual flare metering conditions. For the purposes of brevity, this report may refer to the FOCUS™ Probe Optical Gas Flow Meter as probe or probe meter.

2 Test Objective

To obtain independent data on the FOCUS™ Probe Optical Gas Flow Meter measurement performance over the 0.1 to 100 m/sec experienced in flare measurement.

To obtain basic installation effect data on the FOCUS™ Probe Optical Gas Flow Meter.

3 Observations

3.1 Meter Performance

The FOCUS™ Probe Optical Gas Flow Meter performed within +/- 2.5% over the 1 to 100 m/sec operating range and +/- 7% over the 0.1 to 1 m/sec operating range. Increased flow instability was measured by the FOCUS™ Probe meter in the 0.1 to 1 m/sec area. This instability causes increased metering error at these low flows for all flare meters.

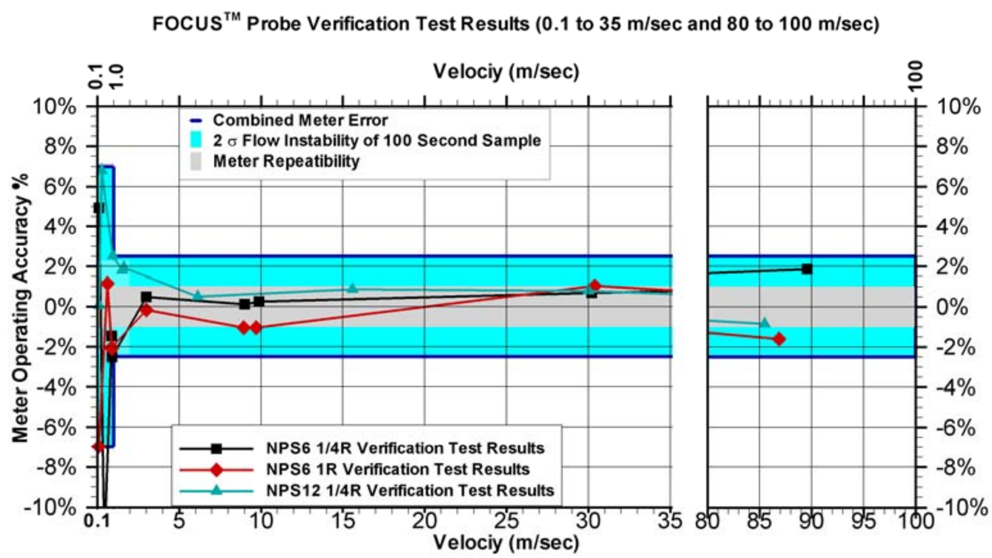

Figure 1 – FOCUS™ Probe Meter Verification Results

Line Size	Velocity Range (m/s)	Maximum Difference (+/-)	Velocity Range (m/s)	Maximum Difference (+/-)
6" Center	0.602 - 88.3	2.1%	0.090 – 0.899	7.0%
6" 1/4 Radius	0.901 - 88.0	2.5%	0.090 – 0.901	12%
12" 1/4 Radius	0.931 - 86.2	2.5%	0.097 – 0.931	6.8%

Figure 2 – Table of Verification Test Results

3.2 NPS6 1R Installation Effects

Installation effect testing of the FOCUS™ Probe installed at the centerline of NPS6 pipe identified systematic metering bias. The graphs below summarize the "Order of Magnitude" estimate of the installation effect bias caused by the disturbances.

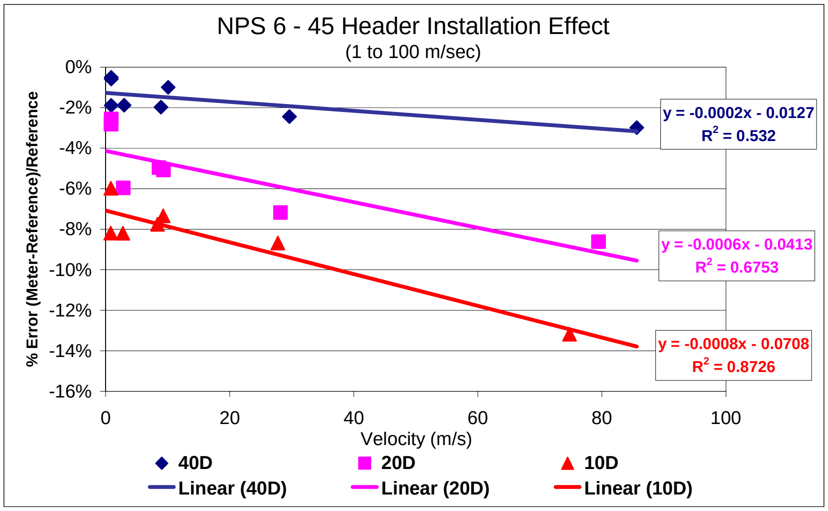

Figure 3 – NPS6 45 Degree Header Installation Effect Test Results

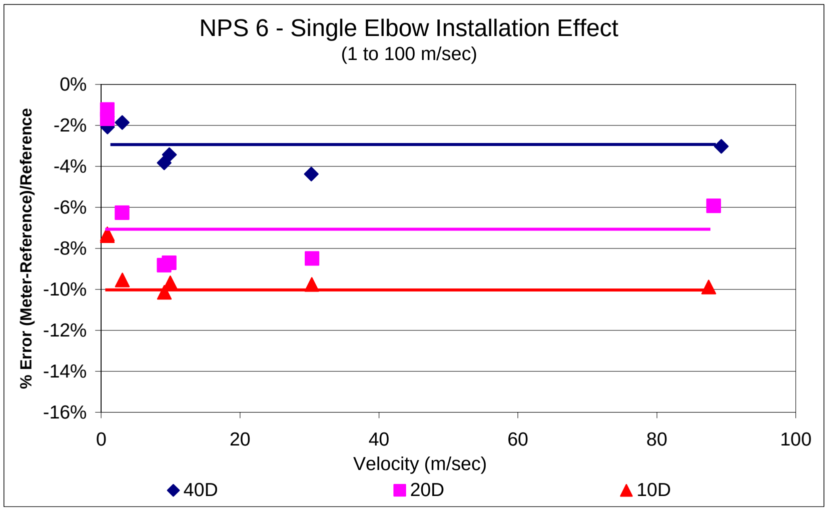

Figure 4 – NPS6 Single 90° Elbow Installation Effect Test Results

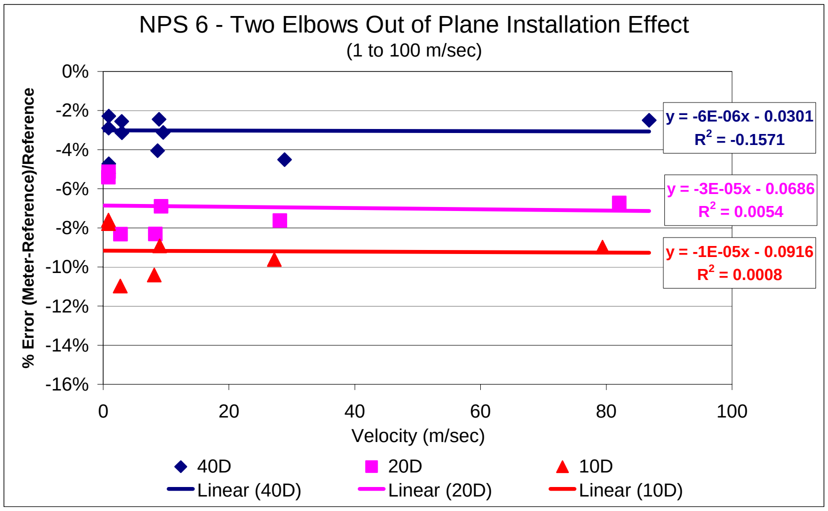

Figure 5 – NPS6 Double 90° Elbows Out of Plain Installation Effect Test Results

The velocity at the center of the pipe reduces relative to the pipe average velocity due to the installation effect of the three flow disturbances. Multiplying the centerline velocity by the fully developed profile average velocity instead of the disturbed profile average velocity results in under measurement of the flow. This error reduces as the distance from the disturbance is increased and the flow starts to return to a fully developed profile.

3.3 NPS12 1/4R Installation Effects

Installation effect testing of the NPS12 1/4R FOCUS™ Probe identified systematic metering bias. The graphs below summarize the "Order of Magnitude" estimate of the installation effect bias caused by the disturbances.

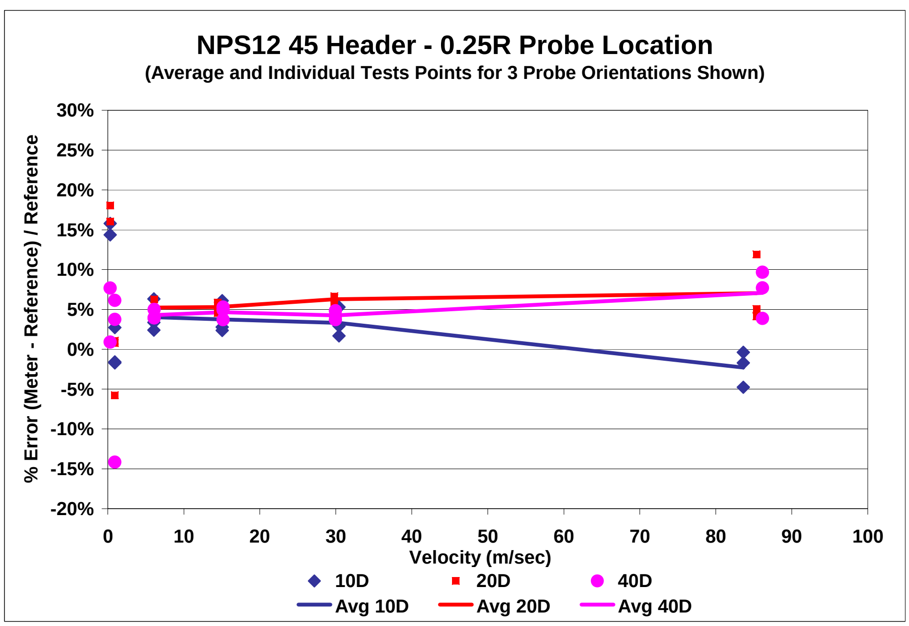

Figure 6 – NPS12 45 Degree Header Installation Effect Test Results

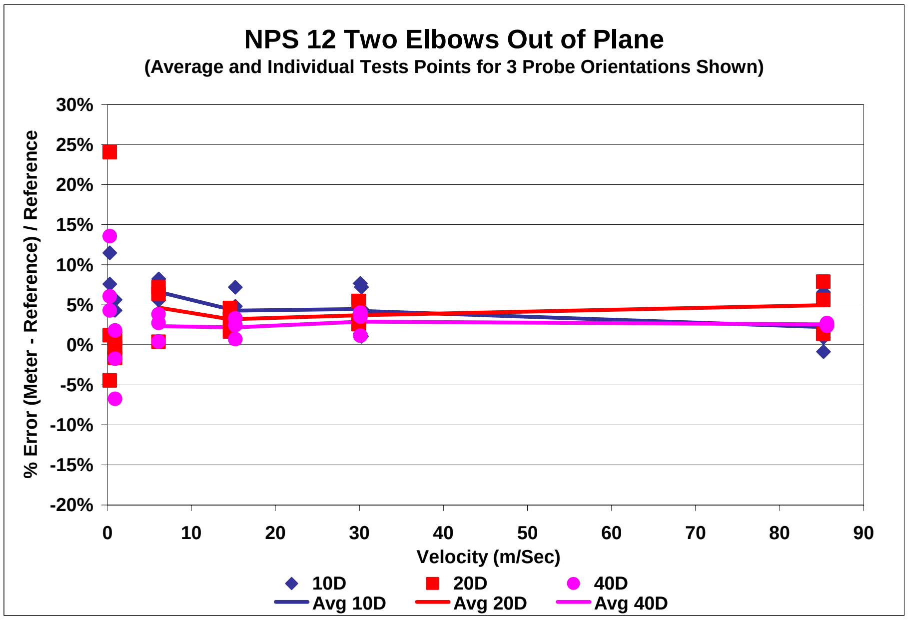

Figure 7 – NPS12 Two 90^o Elbows Out Of Plane Installation Effect Test Results

The velocity at the center of the pipe reduces relative to the pipe average velocity due to the installation effect of the flow disturbances. This flow is redistributed toward the outside of the pipe increasing the velocity relative to average velocity at 0.25R. Multiplying the 0.25R velocity by the fully developed profile average velocity instead of the disturbed profile average velocity results in over measurement of the flow.

4 Conclusions

The FocusTM Probe Optical Gas Flow Meter is capable of measuring over a 1000/1 operating range. It is able to measure fully developed flow in this range to an accuracy of better than +/-2.5% in the upper 99% of this range. It experiences an increase in metering uncertainty to +/- 7% in the bottom 1% of the measurement range due to the flow transitioning from turbulent to laminar flow.

During testing the FocusTM Probe Optical Gas Flow Meter demonstrated its ability to measure flare flow fluctuations. This information was used to develop the meter uncertainty limits in Figure 1 for 100 second flow verifications in fully developed flow.

The order of magnitude effect of installation disturbances has been determined. Review of the FocusTM Probe Optical Gas Flow Meter instantaneous output during the installation effect testing shows large instantaneous flow fluctuations and the presence of low frequency flow instability. This information indicates that comparison intervals required to accurately quantify installation effects must increased by a factor of 10 of more.