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North Sea FLOW Measurement Workshop

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Paper 2.1

Tests on the V-Cone Flow Meter at Southwest Research Institute® and the Utah State University in Accordance with the New API Chapter 5.7 Test Protocol

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TESTS OF THE V-CONE FLOW METER AT SOUTHWEST RESEARCH INSTITUTE® AND UTAH STATE UNIVERSITY IN ACCORDANCE WITH THE NEW API CHAPTER 5.7 TEST PROTOCOL

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ABSTRACT

The American Petroleum Institute Manual of Petroleum Measurement Standards, Chapter 5.7 (API 5.7) specifies a testing protocol for differential pressure flow measurement devices. The protocol was written to apply to all flow measurement devices that measure single-phase fluid flow based on the detection of a differential pressure created in the fluid flow stream. This standard was published in January 2003 “to supply industry with a comparable description of the capabilities of these devices for the measurement of single-phase fluid flow when they are used under similar operating conditions.”

This paper will show how API 5.7 was applied to the McCrometer V-Cone Flow Meter in gas and liquid testing. The results indicated that the V-Cone Flow Meter could be used with similar accuracy in both gas and liquid applications. Furthermore, in the non-standard gas tests, the V-Cone Flow Meter demonstrated a difference in the measured discharge coefficient of less than ± 0.50% compared to the baseline test.

Through the use of the test protocol, the authors have identified areas of the standard that may require more detail or possible revision. One of the issues of concern is the adequacy of the testing required for the non-standard installations. At present, API 5.7 requires testing of the differential pressure device in non-standard installations using one beta ratio, but tests at additional beta ratios and pipe diameters may be desirable to assess the performance of some meters. For the half moon orifice test, the orientation of the plate relative to any asymmetry within the meter is not defined. Additional issues that are addressed in the paper include the method required to decide the acceptability of the test laboratory and the specific requirements of the swirl generator test. These issues and possible solutions are addressed in the paper.

INTRODUCTION

The American Petroleum Institute Manual of Petroleum Measurement Standards, Chapter 5.7 (API 5.7) specifies a testing protocol for differential pressure flow measurement devices. The protocol was written to apply to all flow measurement devices that measure single-phase fluid flow based on the detection of a differential pressure created in the fluid flow stream. This standard was published in January 2003 "to supply industry with a comparable description of the capabilities of these devices for the measurement of single-phase fluid flow when they are used under similar operating conditions." In order to test a differential pressure device, the test laboratory must be traceable to the National Institute of Standards and Technology (NIST) or to another National standard.

McCrometer chose to undertake the gas flow tests of their Standard V-Cone flow meter, in accordance with API 5.7, at the Southwest Research Institute (SwRI®) Metering Research Facility (MRF). This facility is traceable to NIST standards for mass, time, temperature and pressure. Flow rates are determined through the MRF transfer standard, bank of critical flow Venturi nozzles (sonic nozzles) calibrated against an on-site weigh tank system.

The gas flow tests included standard and non-standard tests of the V-Cone Flow Meters. In the standard test, the test protocol specifies that three meters with varying area ratios be tested. In this case, three 4-inch diameter meters with beta ratios of 0.45, 0.60 and 0.75 were tested. The 4-inch meter with a beta ratio of 0.60 was also tested at a higher line pressure of 1000 psia, approximately five times greater than the baseline test pressure of 200 psia. In addition, a larger diameter (8-inch or larger) meter baseline test is required by the test protocol, to verify the accuracy of the meter in different line sizes.

The liquid testing of the V-Cone Flow Meter was performed by Utah State University in the Water Research Laboratory. The testing met the requirements of API 5.7 for liquid tests. A comparison of the V-Cone Flow Meter performance in the two test fluids and the agreement between the two test facilities is included in the summary of test results. The agreement in V-Cone Flow Meter performance over the large pressure range and in the two test facilities confirms the value of the expansion factor used in the V-Cone Flow Meter Equation.

In addition to the V-Cone Flow Meter tests, the paper includes data on facility verification tests at both test facilities. The facility verification tests were used to establish the veracity of the MRF High Pressure Loop and the Utah Water Research Laboratory. The tests confirmed the facilities' abilities to reproduce values of the orifice meter discharge coefficient within the 95% confidence interval of the R-G Equation, as stated in API MPMS Chapter 14.3, and as required by the API 5.7 test protocol.

Finally, an acoustic noise test was performed to estimate the meter noise emission during the gas flow testing. The results of the acoustic test are included in the discussion to follow.

Facility Verification of the MRF High Pressure Loop

The traceability of the Metering Research Facility is based in its primary weigh tank system, which is calibrated using NIST standards for mass and time. The weigh tank system is used to calibrate individual sonic nozzles, which are used in combination to provide the transfer flow standard for MRF testing and calibration. The High Pressure Loop sonic nozzle bank was used as the reference flow rate for the McCrometer V-Cone Flow Meter gas tests, as well as the facility verification tests. A schematic of the MRF High Pressure Loop is shown in Figure 1.

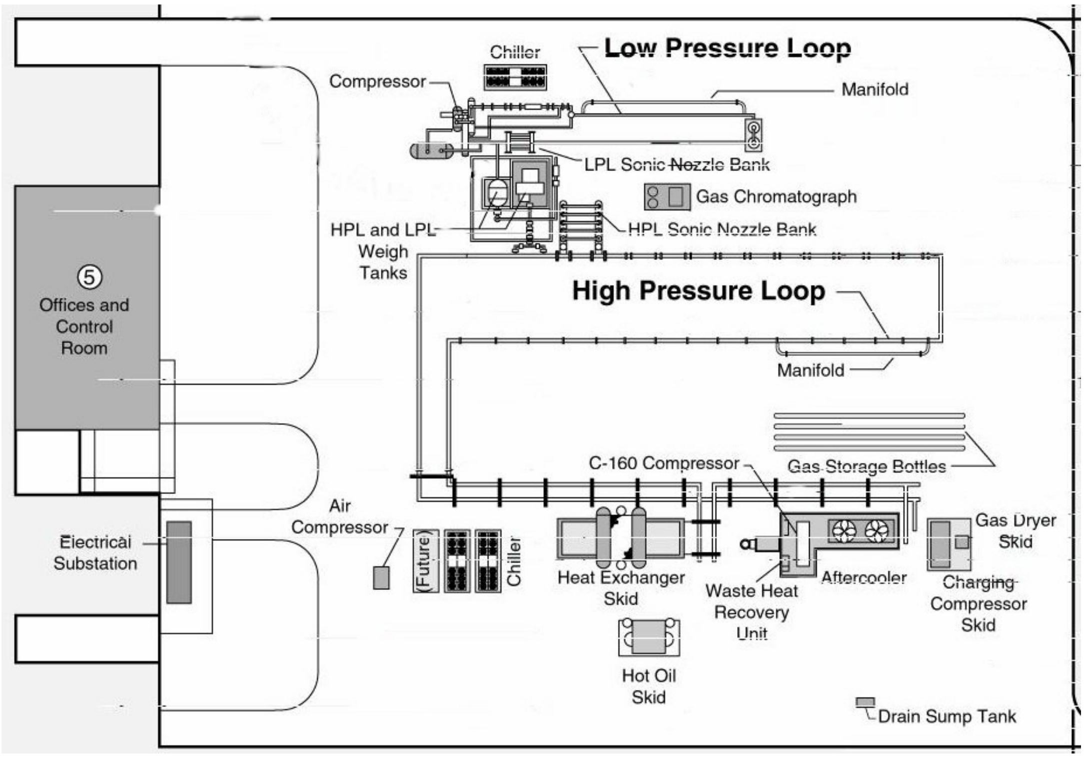

Figure 1. Schematic of MRF High Pressure Loop

Confirmation of the veracity of the test facility was performed using an orifice meter, as required by the standard. For orifice flow meters, the measured discharge coefficient, C_d, is determined according to the orifice flow meter equation (Equation 1.0) and the facility reference flow rate:

$$C_d = \frac{q_m}{\left(\frac{\pi}{4}\right) \times \left(\sqrt{2 g_c \times \rho_{t,P}}\right) \times \left(\frac{D^2 \times \beta^2}{\sqrt{1-\beta^4}}\right) \times \sqrt{\Delta P} \times Y} \qquad (1.0)$$

where q_m = facility reference flow rate in lb_m/sec,
g_c = dimensional conversion constant,
$\rho_{t,P}$ = density of the fluid at the test temperature and pressure, in units of lb_m/ft^3,
D = meter tube bore diameter;
β = diameter ratio of the meter,
ΔP = orifice differential pressure, in units of lb_f/ft^2,
Y = expansion factor.

The MRF performed two facility verification tests, before and after the McCrometer V-Cone Flow Meter testing. The first test used a 12-inch diameter orifice meter run. The meter run met the requirements of API MPMS Chapter 14.3, utilizing a 19-tube bundle at nine pipe diameters upstream of the orifice plate. The test included seven flow points, spanning a flow rate range of 332 to 1324 acfm. The maximum to minimum flow rate ratio was 3.985. The results of the test are shown in Figure 2, as a function of Reynolds number. Two differential pressure (DP) transmitters were used with two sets of pressure taps on opposite sides of the orifice run. The average difference between the measured C_d and the calculated C_d, using the R-G equation, was 0.196% using the top DP transmitter and 0.107% using the bottom DP transmitter.

The second facility verification test was performed using an 8-inch diameter orifice meter. The 8-inch diameter run contained a 19-tube bundle at 17 pipe diameters upstream. The test included eight flow points, spanning a flow rate range of 350 to 1039 acfm. The ratio of maximum to minimum flow rate was 2.97. The results of this test are shown in Figure 3. The average difference between the measured C_d and the calculated C_d was 0.3580%.

Test Setup for Standard Tests

The API Chapter 5.7 Test Protocol requires gas flow testing of the differential pressure device in standard and non-standard configurations. The standard tests are to be performed with straight pipe upstream and any flow conditioner recommended by the manufacturer. As described in the next section, the three non-standard test configurations utilize different upstream disturbances to generate asymmetric and high-swirl flows at the entrance to the meter being tested. The manufacturer specifies the distance between the test meter and the upstream disturbances, as well as the use (if any) of a flow-conditioning device.

As specified by McCrometer, no flow conditioner was used at any point in the testing of the V-Cone Flow Meter. The standard tests were performed with a minimum of thirty pipe diameters (30D) of straight pipe upstream of the meter. The exact upstream lengths for the 4-inch and 8-inch meters are shown in the installation drawings in the Appendix Figures A-1 and A-3. Photographs of the standard test configuration for both meter sizes are shown in Figures A-2 and A-4. The test conditions for each of the standard tests are shown in Table 1.

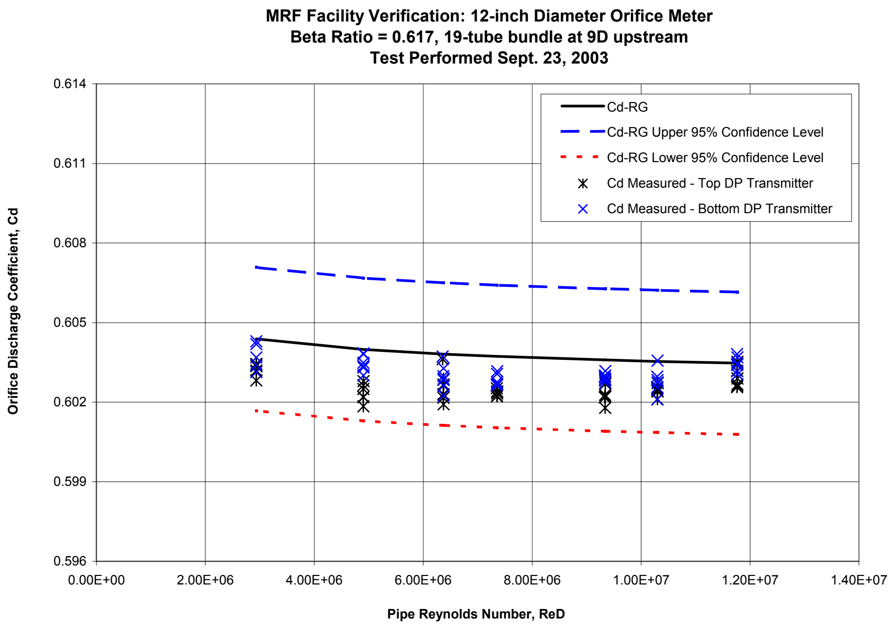

Figure 2. Facility verification test using a 12-inch diameter orifice meter.

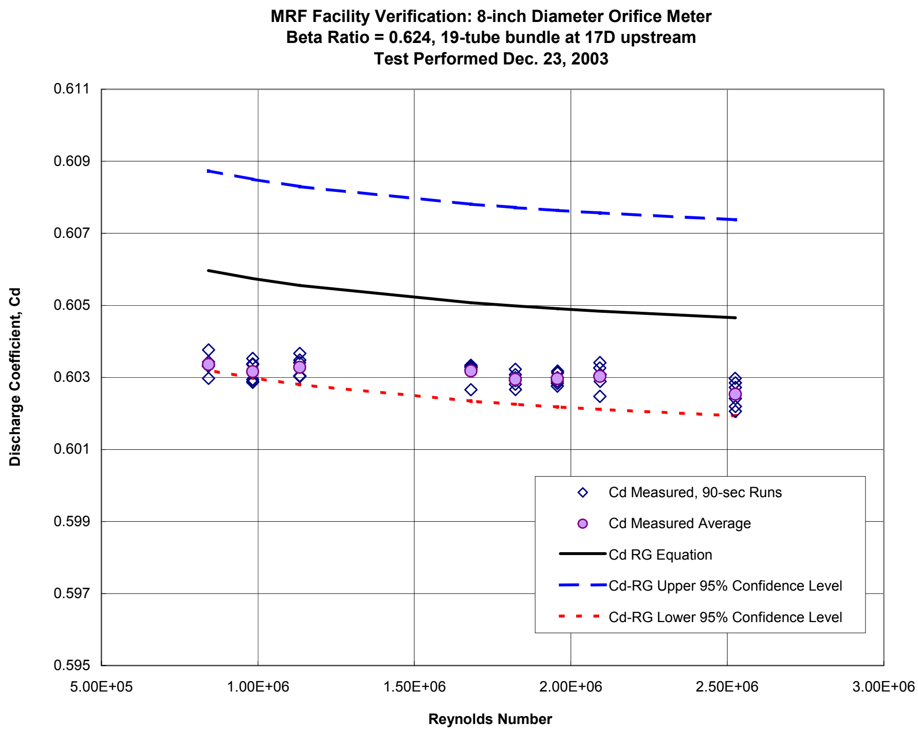

Figure 3. Facility verification test using an 8-inch diameter orifice meter.

Test Type	Test Pressure	Meter Size, Beta Ratio	Piping Configuration
Standard Test 1	165 psia	4-inch, Beta = 0.60	Straight Pipe Upstream, No Flow Conditioner
Standard Test 2	815 psia	4-inch, Beta = 0.60	
Standard Test 3	165 psia	4-inch, Beta = 0.75	
Standard Test 4	165 psia	4-inch, Beta = 0.45	
Standard Test 5	165 psia	8-inch, Beta = 0.60	
Non-Standard Test 1: Half-Moon Orifice Plate	165 psia	4-inch, Beta = 0.60	Half-Moon Orifice Plate in Up Position at 5D upstream, No Flow Conditioner
Non-Standard Test 2: Double Elbows Out-of-Plan	165 psia	4-inch, Beta = 0.60	Double Elbows Out-Of-Plane at 0D upstream, No Flow Conditioner
Non-Standard Test 3: Swirl Generator	165 psia	4-inch, Beta = 0.60	Swirl Generator at 18D Upstream, Swirl Angle = 27-30° No Flow Conditioner

Table 1. Test conditions for the Standard and Non-Standard Tests of the V-Cone Meters.

NON-STANDARD TESTS

In the non-standard tests, the meter location varied with each test. The non-standard tests were performed using the 4-inch diameter V-Cone Flow Meter with a Beta ratio of 0.60. The installation diagrams and photographs of the non-standard test configurations are shown in Appendix Figures A-5 through A-10.

Non-Standard Test 1 requires a half-moon orifice plate to be installed upstream of the 4-inch diameter test meter to generate an asymmetric flow profile. For the initial test, the V-Cone Flow Meter was placed at five diameters downstream of the plate, as specified by McCrometer (see Appendix Figure A-5). The half-moon orifice plate was turned so that the open area was positioned in the upper half of the flow stream.

Non-Standard Test 2 requires installation of two out-of-plane long radius 90º elbows upstream of the meter. The two out-of-plane elbows create both swirl and profile asymmetry in the flow entering the meter run. For this test, the V-Cone Flow Meter was positioned immediately downstream of the last elbow, as specified by McCrometer (see Figure A-7).

Non-Standard Test 3 calls for a swirl-generating device that produces high swirl conditions in the flow. The maximum swirl angle across the pipe is to be no less than 24º at 18 pipe diameters downstream of the swirl generator (see Figure A-9). The swirl angle must be measured at this location using a generally recognized method.

For this test, a Chevron swirl generator was used. This device (shown in Figure A-11) contains vanes with adjustable blade angles. The swirl generator was installed 18 pipe diameters upstream of a multi-hole Pitot tube, which was used to measure the swirl angle. The Pitot tube was positioned in the upper one-third of the pipe (*i.e.*, at 1/3 of the diameter from the top of the pipe). The swirl angle was measured to be approximately 27 to 30º. Confirmation measurements were performed at one-third of a diameter from the bottom of the pipe. The multi-hole Pitot tube is shown in Figure A-12 as it was installed at the MRF. Following the measurements of swirl angle, the multi-hole Pitot tube was removed and replaced with the V-Cone Flow Meter, at the same location, for the gas flow test.

In all of the protocol tests, the differential pressure was measured using three stacked Rosemount differential pressure transmitters of varying ranges: 0-25”, 0-250”, and 0-1000” of water column. The stacked transmitters allowed for a precise measurement of the differential pressure over the entire flow range available at the MRF. The temperature was measured downstream of the V-Cone Flow Meter, as specified in the installation configurations shown in the Appendix. The temperature measurement was made using a direct-insert resistance temperature device (RTD) connected to a Rosemount temperature transmitter. Data from six, consecutive 90-second runs were recorded at each flow rate.

DETERMINATION OF MEASURED DISCHARGE COEFFICIENT

In the Chapter 5.7 testing, the measured V-Cone Flow Meter discharge coefficient was determined using the MRF reference flow rate provided by the High Pressure Loop critical flow Venturi nozzles (sonic nozzles). The McCrometer equation for flow rate through a V-Cone can be solved for the discharge coefficient, C_d, as:

$$C_d = \frac{Q_{lb/s}}{\pi/4 \times \sqrt{2g_c \times \rho} \times \left(\frac{D^2 \beta^2}{\sqrt{1-\beta^4}} \right) \times \sqrt{\Delta P} \times Y} \qquad (2.0)$$

where $Q_{lb/s}$ = MRF reference mass flow rate, in lbm/sec
g_c = dimensional conversion constant = 32.174 lbm-ft/lbf-sec^2
ρ = gas density, in lbm/ft^3
D = pipe diameter of V-Cone spool piece, in ft
β = Beta ratio of the V-Cone Flow Meter
ΔP = differential pressure measured across the V-Cone Flow Meter, in lbf/ft^2
Y = expansion factor, as calculated by McCrometer, shown below

The measured discharge coefficient was determined according to Equation 2.0. In the graphs that follow, the measured discharge coefficient is shown as a function of the pipe Reynolds number, similar to an orifice flow meter. The measured values of C_d represent the calibrated values of the discharge coefficient for gas flow applications.

The equation for the V-Cone meter expansion factor is as follows:

$$Y = 1 - \left(0.649 + 0.696 \times \beta^4\right) \times \frac{\Delta P}{k \times P} \qquad (3.0)$$

where k = isentropic factor of the gas,
P = line pressure of the flowing gas, in lbf/ft^2

The expansion factor compensates for the variations in density in different test fluids and pressures. The accuracy of the expansion factor equation is tested by comparing the value of the discharge coefficient for different fluids, such as gas and water, and for different test pressures. The variation in the discharge coefficient during the gas and liquid Chapter 5.7 tests is discussed in the summary below.

ACOUSTIC NOISE TEST

The V-Cone meter did not emit a significant level of noise during any of the gas tests. The noise level in the area near the V-Cone meter installation was measured with a standard acoustic noise meter to be approximately 85 dB. This measurement was skewed by the noise from the High Pressure Loop SOLAR centrifugal compressor and related machinery. As such, it was difficult to measure the noise contribution from the V-Cone meter directly. By comparison, the noise level in the area closer to the HPL compressor was measured to be between 90-100 dB. The noise level emitted by the test environment was significantly greater than any noise contribution from the V-Cone test meter.

SUMMARY OF TEST RESULTS

Standard Test Results

The average C_d value for each flow rate (from the six individual test runs at a given Reynolds number) is provided in the data tables shown in the Appendix Figures A-21 through A-28. The linear curve-fits to the average C_d values, for the MRF gas testing and the Utah State University liquid testing, are shown in the Appendix Figures A-13 through A-20. These curves are discussed below.

It should be noted that the uncertainty in the measured discharge coefficient increases for the lower Reynolds numbers. This is due to the increased precision error associated with the low differential pressure measurement at these points. The data tables shown in the Appendix provide the uncertainty in the measured discharge coefficient (as shown in the graphs) and in the reference mass flow rate. This uncertainty estimate includes both bias and precision uncertainties. The uncertainty estimations provided by the MRF meet the requirements for uncertainty calculations as outlined in ASME PTC 19.1-1998, *Test Uncertainty*.

In addition, it should be noted that the V-Cone Flow Meter testing at Southwest Research Institute was limited to the flow range available in the MRF High Pressure Loop. The maximum flow rate available in this loop is 1380 acfm, while the minimum flow rate available is 60 acfm. As such, some of the standard tests did not test the V-Cone Flow Meter over a 10:1 turndown because of the laboratory flow rate constraints.

Since the discharge coefficient was measured using three stacked differential pressure transmitters, the test generated multiple sets of discharge coefficient data. Southwest Research Institute has chosen to present the information shown in the graphs, using the discharge coefficient measured by the most appropriate differential pressure transmitter. The most appropriate differential pressure transmitter is defined as the transmitter with the lowest measurement uncertainty for the differential pressure being measured.

A linear curve-fit has been used to fit the measured values of the discharge coefficient to a continuous curve, over the measured Reynolds number range. The linear curve-fit for the MRF gas testing can be compared to the curve-fit from the liquid testing conducted by Utah State University, in the case of two of the 4-inch diameter meters and the 8-inch diameter meter. This comparison shows the overlap in the two test facilities and the similar performance of the V-Cone meter in the two test fluids, at the same Reynolds numbers. Figures 4 and 5 (shown below) compare the average data from the two test facilities. For the 4-inch diameter meter with a Beta ratio of 0.75, the C_d values from the two facilities agree to within 1%, and for the other two meters, the C_d values agree to within better than 0.4%. In addition, Figures 6-8 compare the three Vcone Flow Meters performance during water calibrations at the Utah State University laboratory and the McCrometer water test facility.

V-Cone Expansion Factor (Y Factor) Results

Based on the good agreement between the curve-fits for the liquid and gas testing, the data shows that the V-Cone meter expansion factor equation takes into account the change in the density of the gas flow. The V-Cone meter can be expected to perform similarly in gas and liquid applications over a large Reynolds number range, based on these results.

Non Standard Test Results

The standard test of the 4-inch diameter, 0.60 Beta V-Cone can also be compared to the C_d values generated for the non-standard tests of the same meter. This comparison allows the user to estimate the probable meter deviation in non-standard installations, typically characterized by high-swirl or asymmetric velocity profiles. For this reason, the graph of the non-standard test results includes the data for the standard, baseline test of the Beta 0.60 meter, as well as the non-standard test of the same meter. The non-standard test results indicate that the probable deviation in the discharge coefficient, as compared to the baseline test, is within ±0.50% for the three non-standard installations. In the case of Non-Standard Tests 2 and 3, the average discharge coefficient under non-standard conditions was within ± 0.15% of the baseline C_d curve-fit.

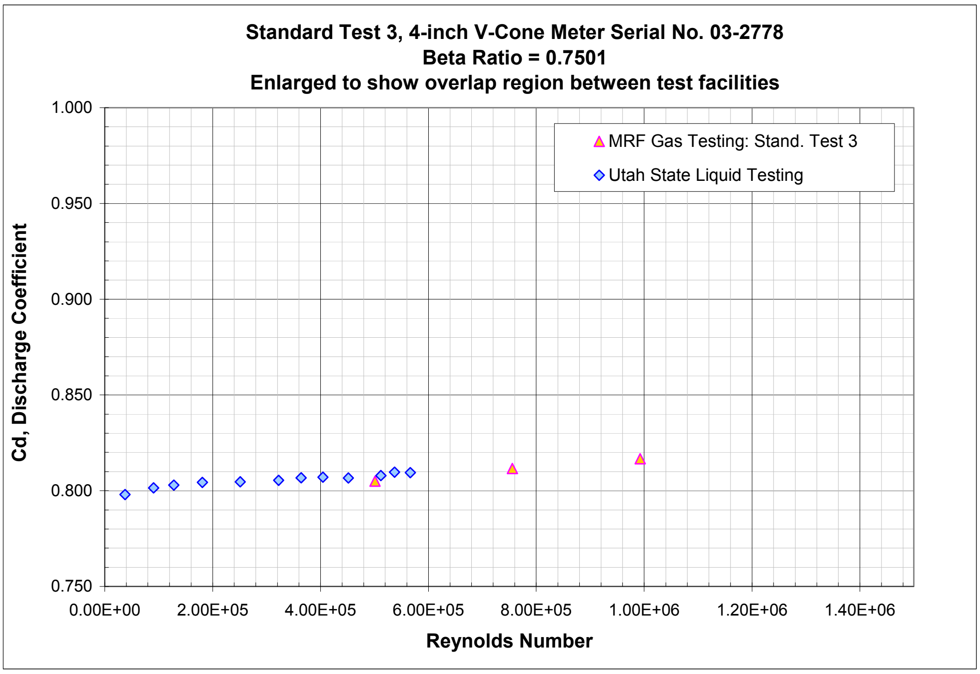

Figure 4. Comparison of 4-inch diameter 0.7501 Beta V-Cone meter performance in liquid and gas testing using standard test configuration.

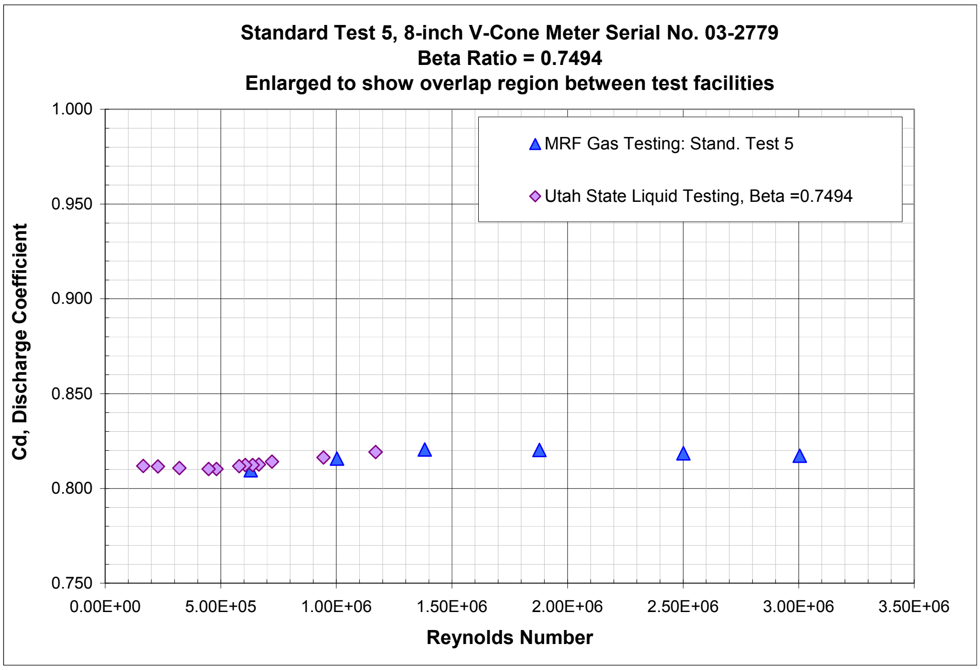

Figure 5. Comparison of 8-inch diameter 0.7494 Beta V-Cone meter performance in liquid and gas testing using standard test configuration.

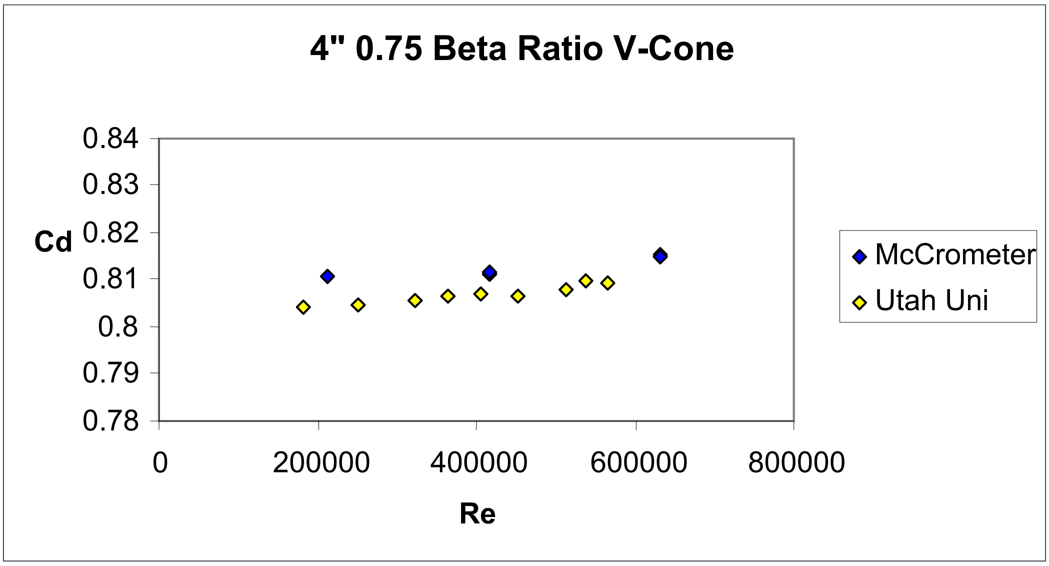

Figure 6. Comparison of 4-inch diameter 0.75 Beta V-Cone meter performance in water testing in Utah and at McCrometer's Lab.

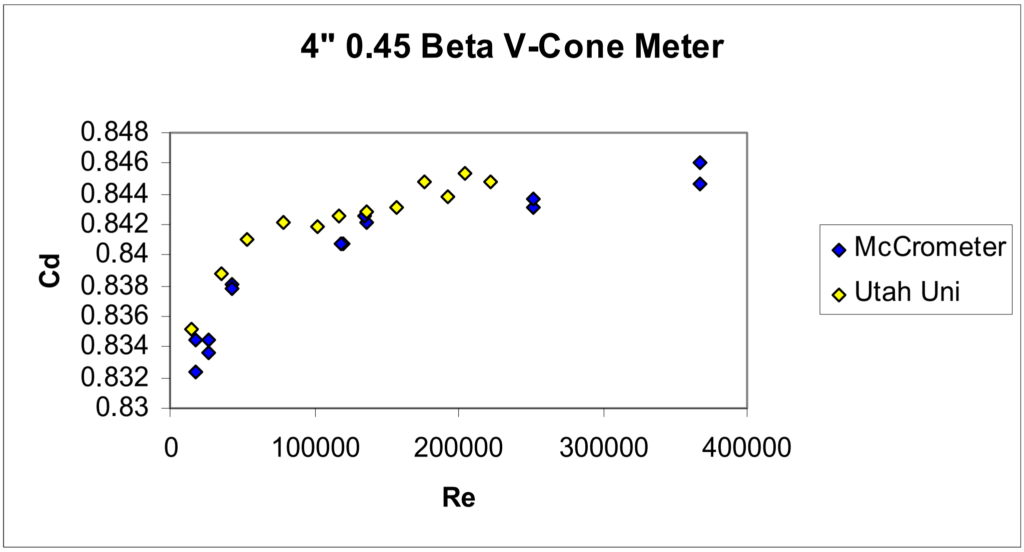

Figure 7. Comparison of 4-inch diameter 0.45 Beta V-Cone meter performance in water testing in Utah and at McCrometer's Lab.

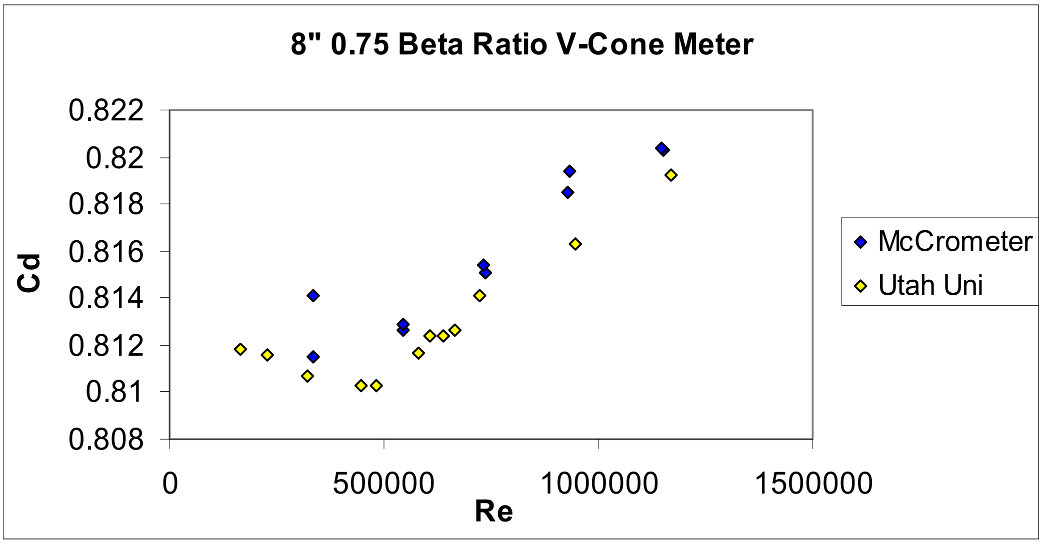

Figure 8. Comparison of 8-inch diameter 0.75 Beta V-Cone meter performance in water testing in Utah and at McCrometer's Lab.

CONCLUSIONS

- The tests of the V-Cone Flow Meter according to API Chapter 5.7 demonstrated the V-Cone Flow Meter performance high-pressure gas at the MRF and in water at Utah State University. The test results showed good meter repeatability, resulting in a small measurement uncertainty in the calibrated discharge coefficient. In addition, the tests showed the excellent agreement between the MRF, the Utah State University Water Research Laboratory and the McCrometer water laboratory.
- The V-cone Flow Meter met the claims of the manufacturer as a ±0.5% device over a large Reynolds number range. The expansibility equation supplied for the meter was effective over the full range of test pressures, differential pressures and meter line sizes.

- Non-standard Test 2 demonstrated that two, 90º out-of-plane elbows could be placed on the inlet of the meter with a maximum shift in the discharge coefficient of no more than ±0.15%. A flow with a swirl angle up to 30º at the inlet to the V-cone flow meter will produce similar results, with a minimal change (±0.15%) in the calibrated discharge coefficient. When a half moon orifice plate is placed at 5D upstream of the meter, the shift in the discharge coefficient can be expected to be no more than ±0.5%, within the tolerance claimed by the manufacturer.
- The Acoustic Noise Test indicated that there was no significant noise from the meter, but no conclusive noise level could be determined for the meter due to the background noise of the test facility.

DISCUSSION ON THE API 5.7 STANDARD, "TESTING PROTOCOL FOR DIFFERENTIAL PRESSURE FLOW MEASUREMENT DEVICES"

Based on the testing of the V-Cone Flow Meter in accordance with the API Chapter 5.7 Test Protocol, the authors have identified some of the areas of the standard that may be considered for revision, in order to provide a more effective test protocol:

- The authors found that Chapter 5.7 provides a comprehensive series of tests for a differential pressure flow measurement device and subjects the meter to onerous flow regimes.
- The standard specifies the use of an orifice plate to determine the laboratory's ability to test differential pressure meters in a manner that is traceable to NIST. However, the flow laboratory is required to provide the orifice meter runs and the test data (i.e. test time) to prove its own veracity. This presents a difficult requirement for a flow laboratory because the exact orifice meter sizes may not be available on-hand at the laboratory and the additional test time and materials add to the cost of performing the Chapter 5.7 tests. This requirement for traceability or laboratory veracity may be met through other means, and the next revision should consider other ways of proving traceability. If this requirement remains within the standard, a clearer and more practical definition of the orifice size needed for the test is required.
- The present standard requires certain uncertainty calculations and a specific presentation of laboratory uncertainty. Flow laboratories may present the uncertainty in a different manner than the standard specifies. The standard should be as specific as possible about the how the uncertainty is specified, without restricting the laboratory to a certain presentation format, which may add additional cost to the test.
- In the present testing of the V-Cone Flow Meter, the expansibility equation was proved over a range of fluid densities. However, if the expansibility equation had not proven to provide consistent and continuous values, the standard would not have provided sufficient guidance to this end. The next revision should offer a method of evaluating or changing the expansion factor equation, if this proves to be necessary, based on the test results.
- In a flow laboratory, it may be difficult to separate any noise from a meter from the noise generated by the facility's pumps, valves, etc. Consequently, there is no real value in testing the meter for noise under these conditions. The Chapter 5.7 Standard should be revised to require reporting of the noise level, only if the noise emitted from the meter proves to be unacceptable during testing.

ACKNOWLEDGEMENT

The authors wish to thank the engineering and management staff at McCrometer for their support of the Chapter 5.7 Testing. In addition, the authors would like to acknowledge Mr. Michael Robertson, Mr. John Sullenger and Mr. Roland Martinez at the Southwest Research Institute Metering Research Facility who installed the various test configurations and performed the high pressure gas testing. Finally, the authors would like to acknowledge the testing services provided by the researchers at the Utah State University Water Research Laboratory.

The attention to detail and high quality work by the contributors stated above resulted in a successful research project that can be used to guide and direct future research efforts in the area of flow measurement.

TESTS OF THE V-CONE FLOW METER AT SOUTHWEST RESEARCH INSTITUTE® AND UTAH STATE UNIVERSITY IN ACCORDANCE WITH THE NEW API CHAPTER 5.7 TEST PROTOCOL

APPENDIX

The data sheets shown in Figures A-21 through A-28 in the Appendix contain tabulated data. The columns are labeled according to the nomenclature below.

Pdn = flow static pressure, as measured at the V-Cone test meter.

T = gas temperature, as measured 2-4 diameters downstream of the test meter. The exact location of the temperature measurement is indicated in the installation diagram.

rho = gas density at flowing conditions, calculated based on sampled gas composition according to MRF online Daniel 2350 gas chromatograph.

DP = differential pressure across the meter using the most appropriate ranged output from three, stacked differential pressure transmitters of varying range.

ReD = pipe Reynolds number.

C_d = measured V-Cone discharge coefficient according to the MRF reference flow rate and the measured differential pressure.

Y1 = expansion factor used in calculating C_d.

Beta = V-Cone meter Beta ratio, based on measurements provided by McCrometer.

V = average velocity in V-Cone meter outer piping, according to the MRF reference flow rate provided by the sonic nozzles and measured gas density at the meter.

md = sonic nozzle mass flow rate, used as reference flow rate in calculating measured discharge coefficient.

UCd, Umd = total measurement uncertainty in indicated parameters according to laboratory measurement system. This uncertainty value is calculated at a 95% confidence level and accounts for both bias and precision uncertainty terms in the laboratory instruments.

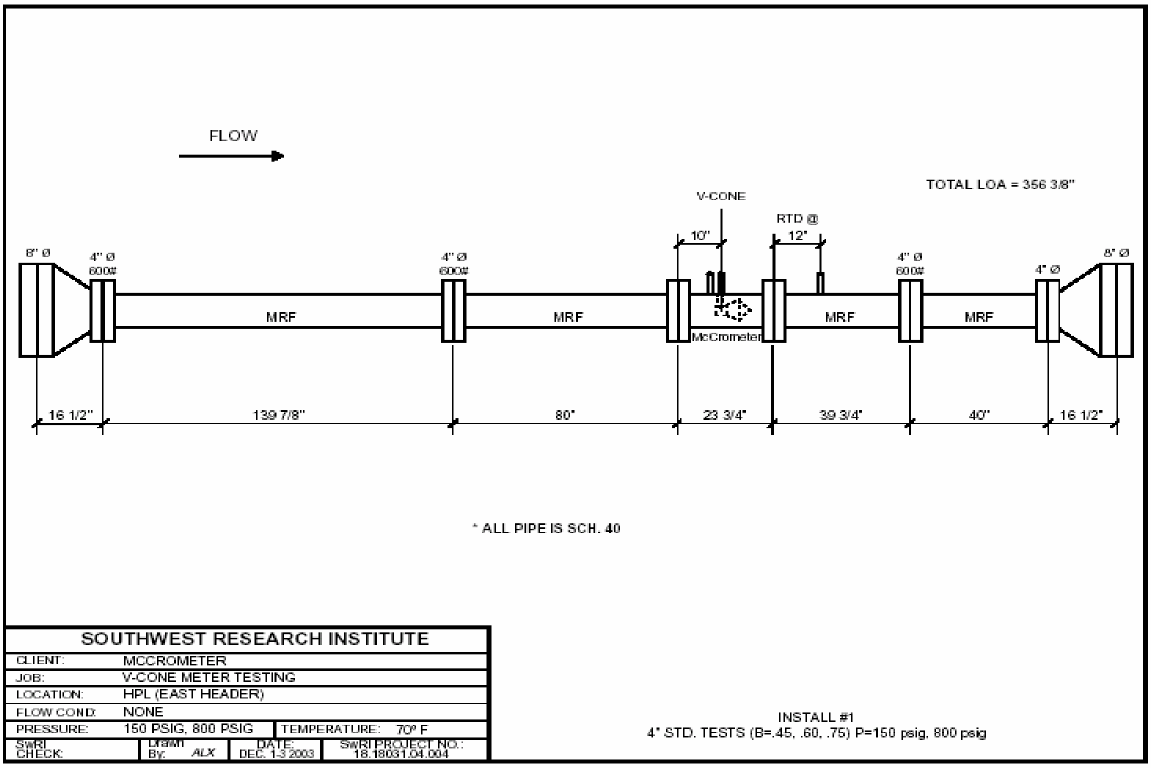

Figure A-1. Standard Test Configuration of 4-inch V-Cone Flow Meter in MRF High Pressure Loop East Header

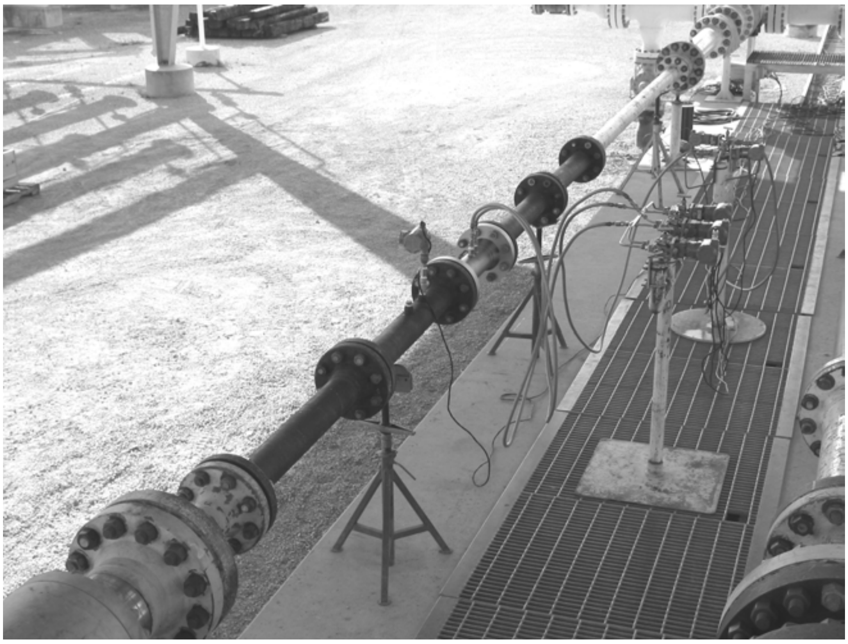

Figure A-2. Standard Tests 1-4: Installation of 4-inch Test Meter in MRF High Pressure Loop East Header

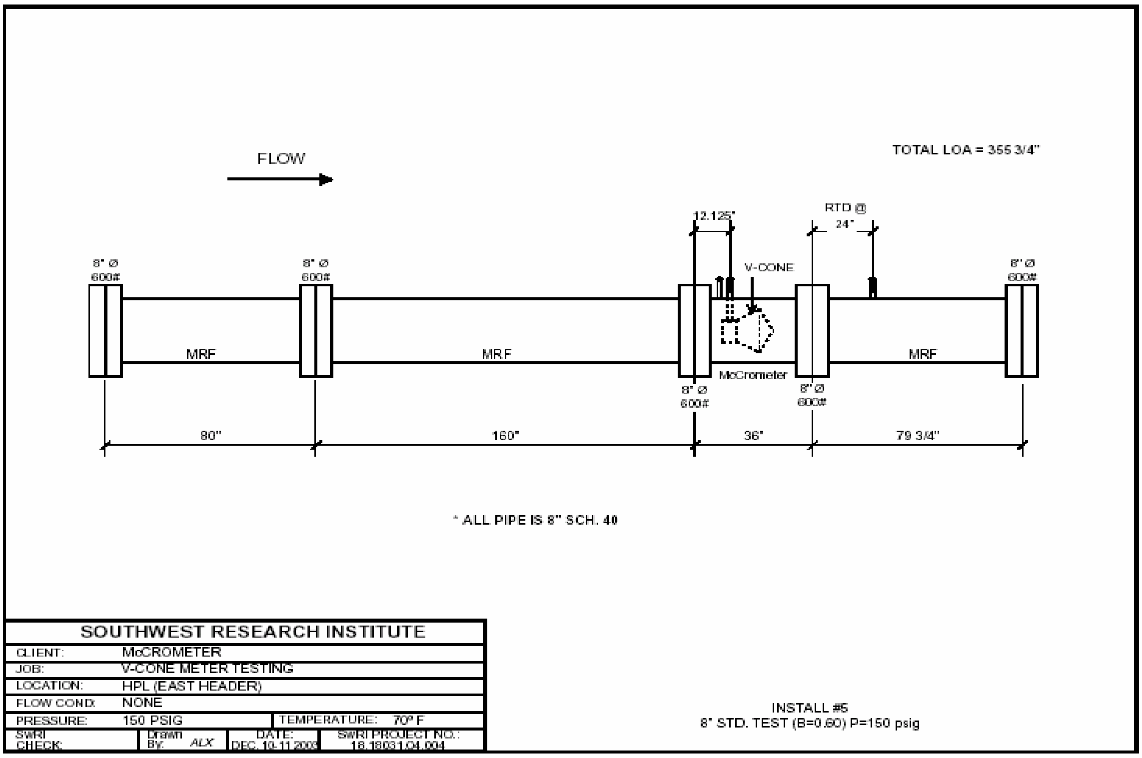

Figure A-3. Standard Test Configuration of 8-inch V-Cone Flow Meter in MRF High Pressure Loop East Header

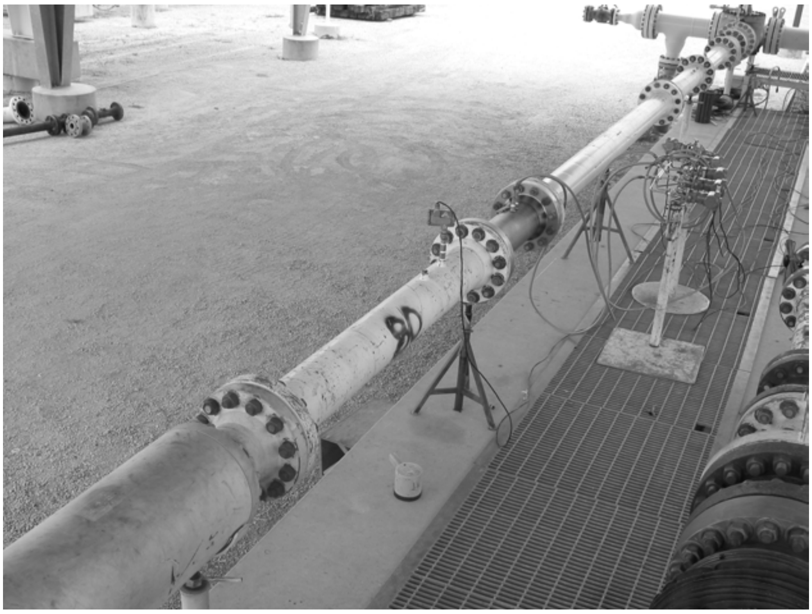

Figure A-4. Standard Test 5: Installation of 8-inch Test Meter in MRF High Pressure Loop East Header

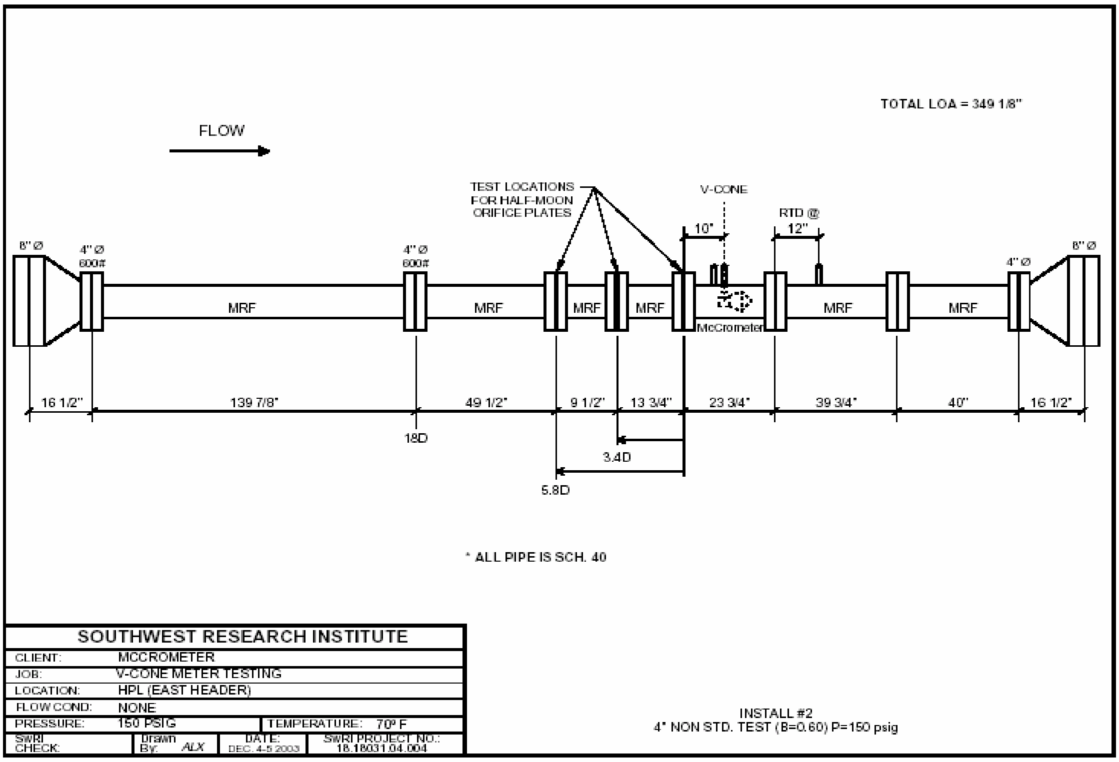

Figure A-5. Non-Standard Test 1: 4-inch V-Cone Flow Meter Downstream of Half-Moon Orifice Plate at 0D, 3D and 5D

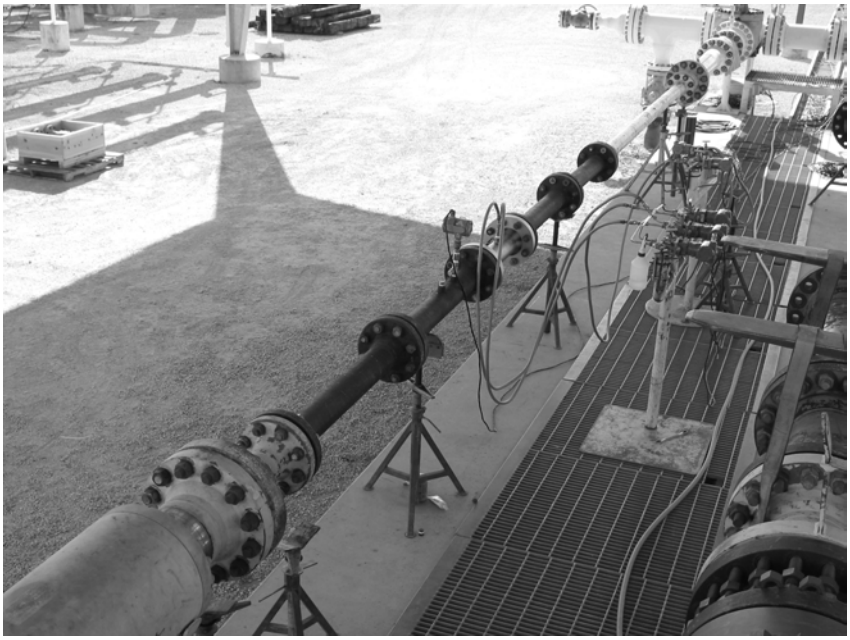

Figure A-6. Non-Standard Test 1: Installation of 4-inch Test Meter Downstream of Half-Moon Orifice Plate

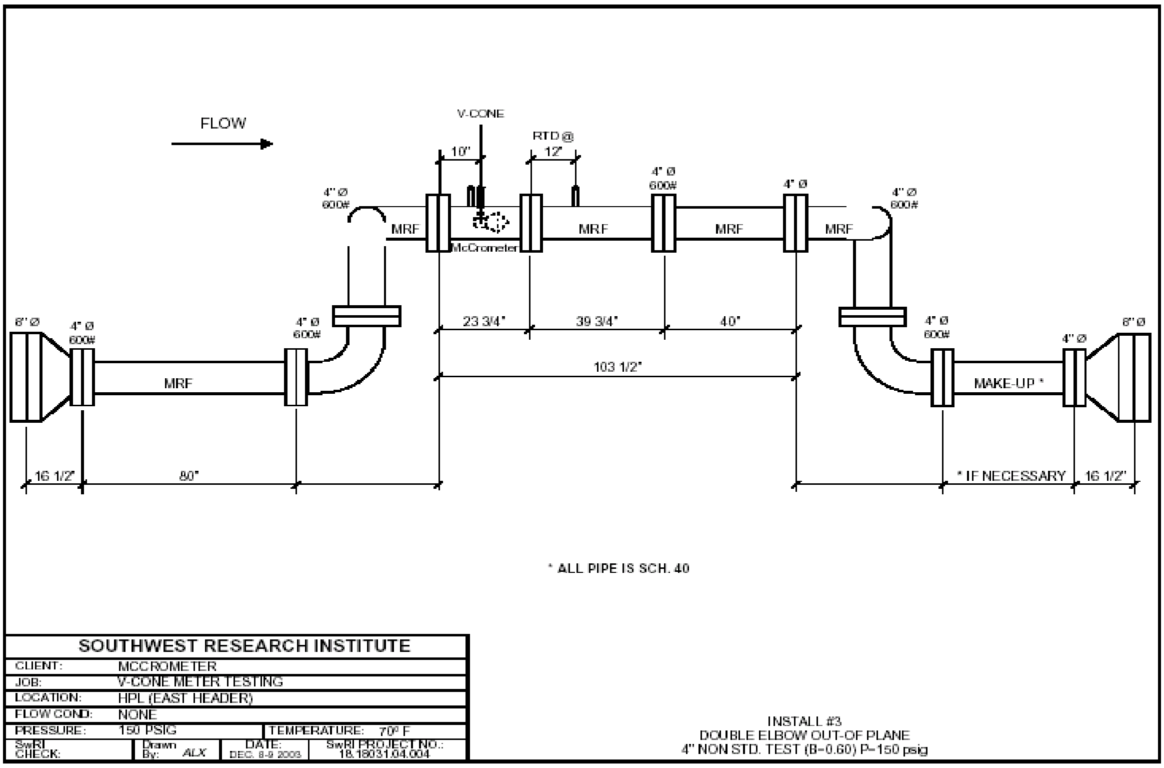

Figure A-7. Non-Standard Test 2: 4-inch V-Cone Flow Meter Immediately Downstream of Double 90º Out-of-Plane Long-Radius Elbows

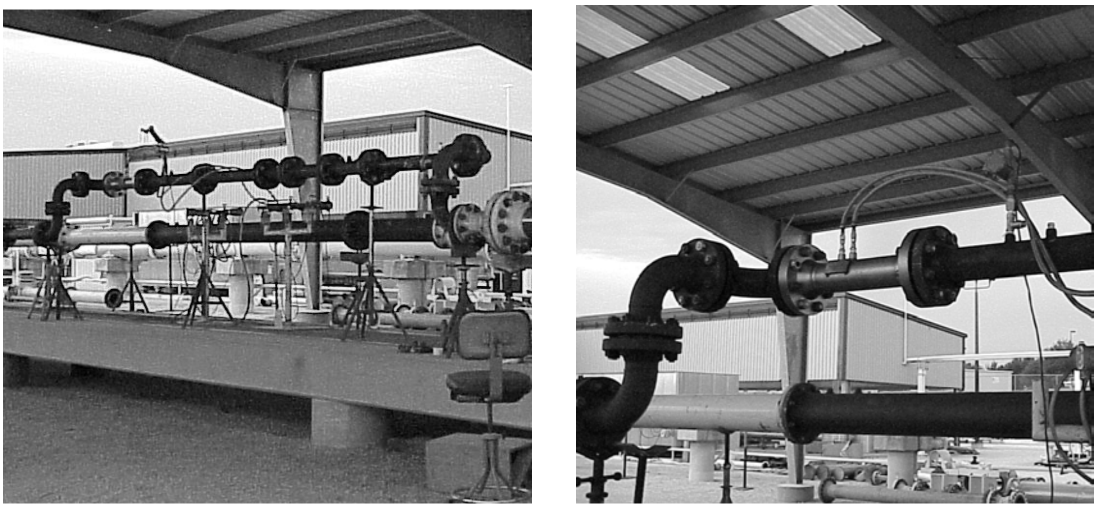

Figure A-8. Non-Standard Test 2: Installation of 4-inch Test Meter Immediately Downstream of Double 90º Out-of-Plane Long-Radius Elbows. The entire installation is shown at left and the V-Cone meter up-close is shown at right.

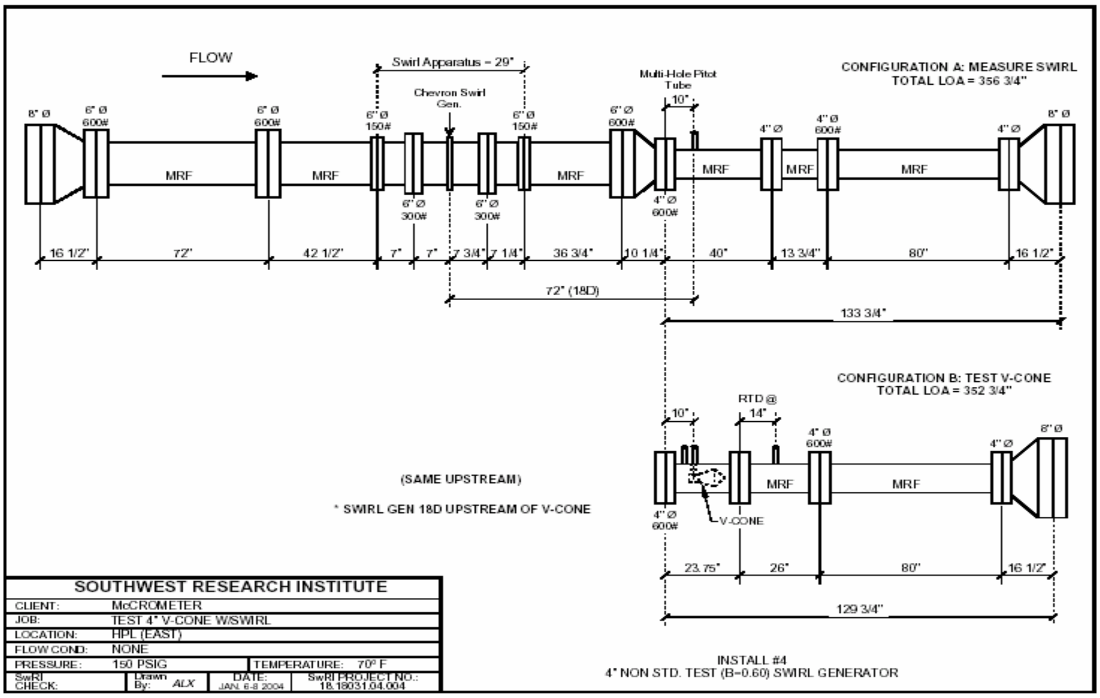

Figure A-9. Non-Standard Test 3: 4-inch V-Cone Flow Meter at 18 Pipe Diameters Downstream of Chevron Swirl Generator.

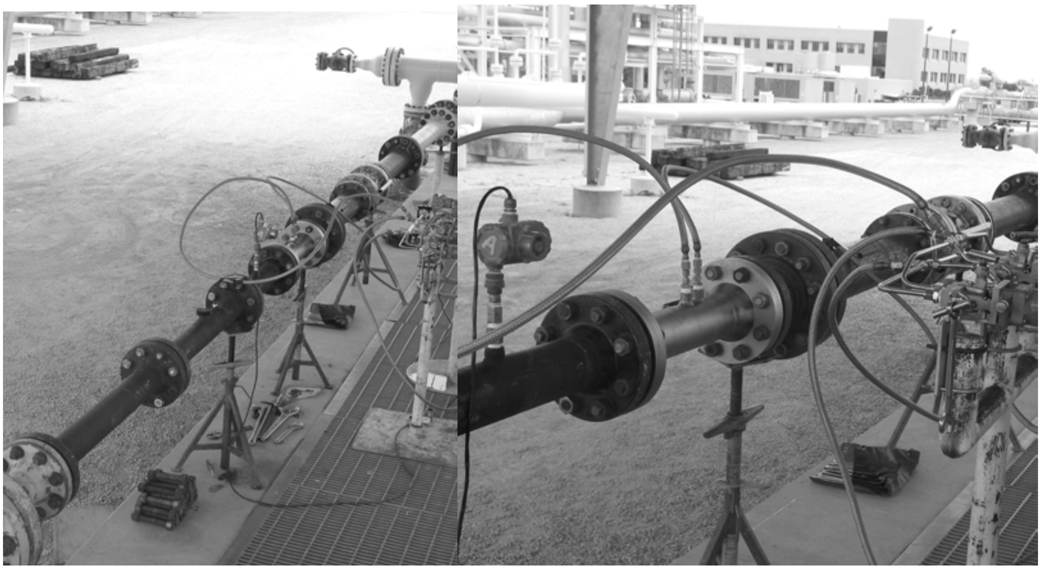

Figure A-10. Non-Standard Test 3: Installation of 4-inch Test Meter at 18 Pipe Diameters Downstream of Chevron Swirl Generator. Entire installation is shown at left and V-Cone test meter up-close is shown at right.

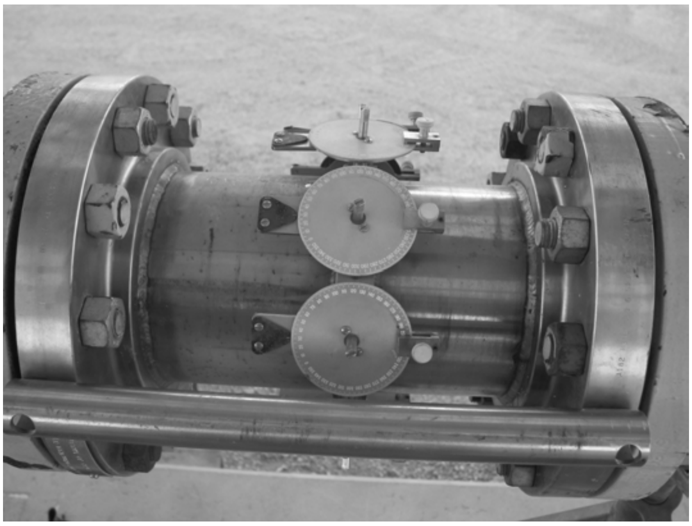

Figure A-11. Chevron Adjustable Vane-Angle Swirl Generator

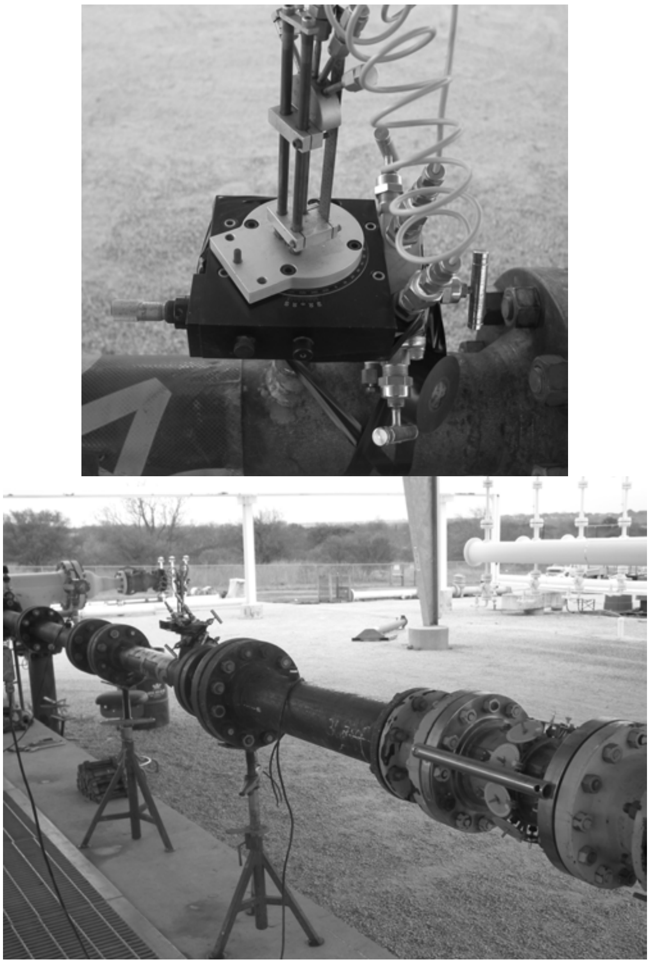

Figure A-12. Multi-hole Pitot tube used to confirm swirl angle in Non-Standard Test 3, shown up close, at left, and downstream of swirl generator device, at right.

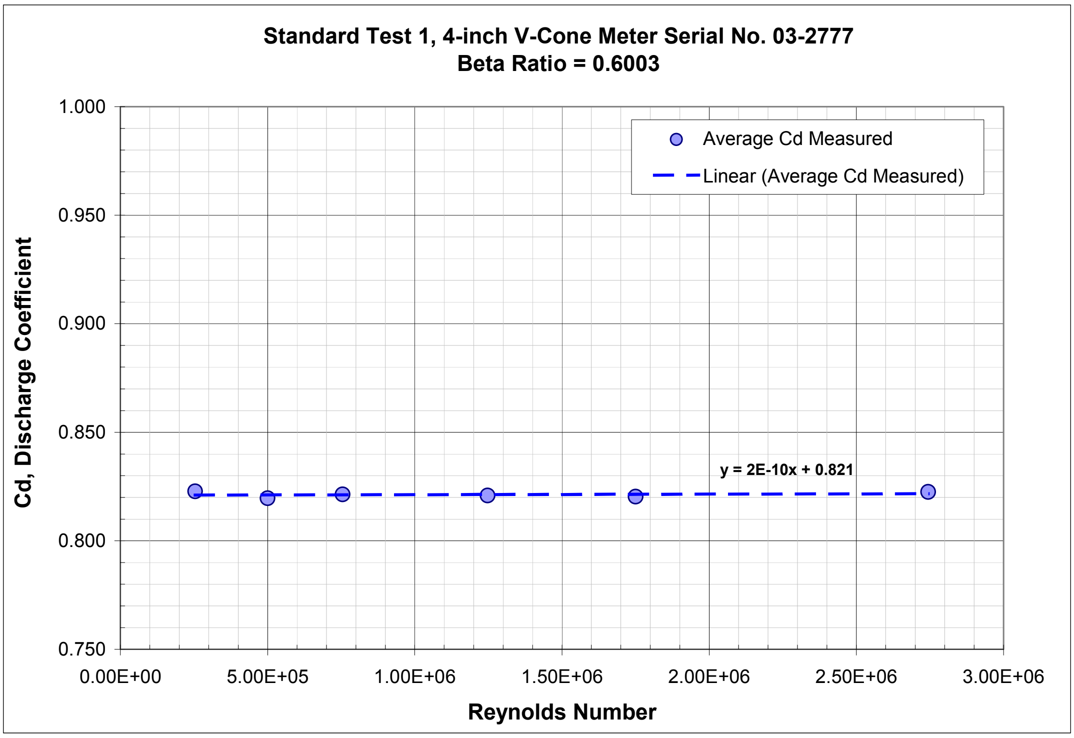

Figure A-13. Average measured discharge coefficient and linear curve-fit to Standard Test 1 data.

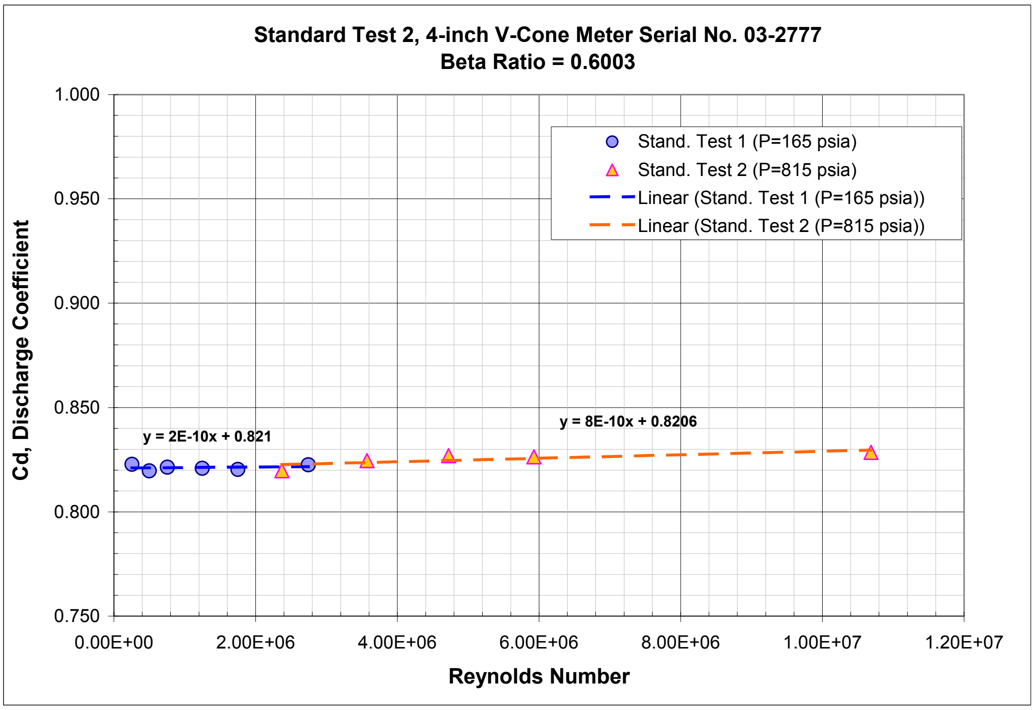

Figure A-14. Average measured discharge coefficient and linear curve-fit to Standard Test 1 and Test 2 data.

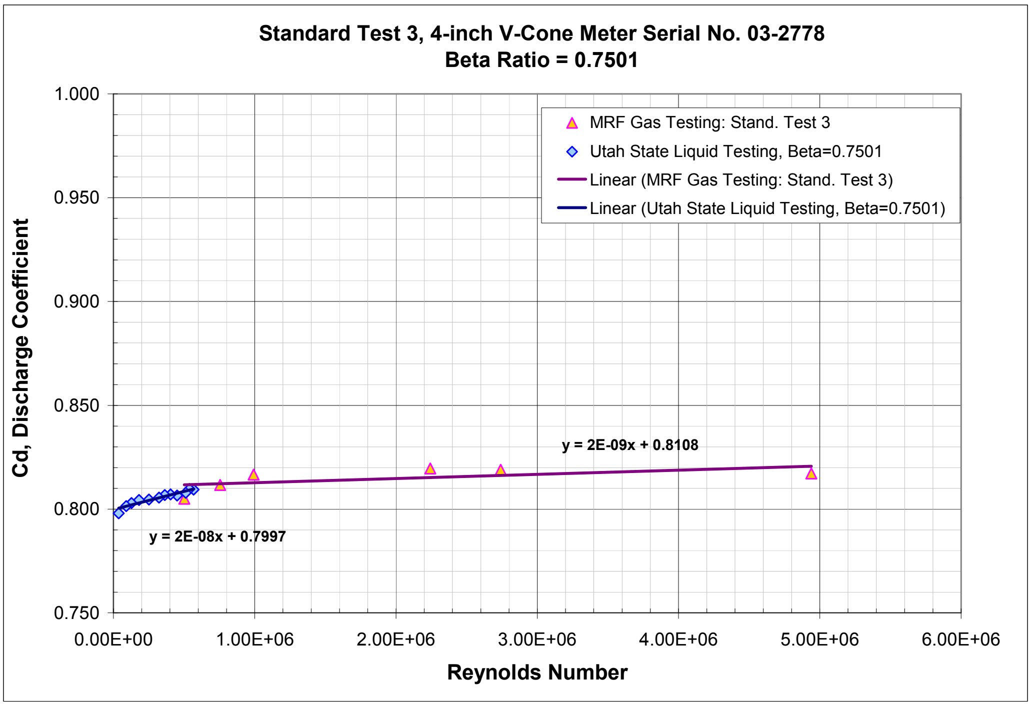

Figure A-15. Average measured discharge coefficient and linear curve-fit to Standard Test 3 performed at the MRF and liquid testing of the same meter at Utah State University.

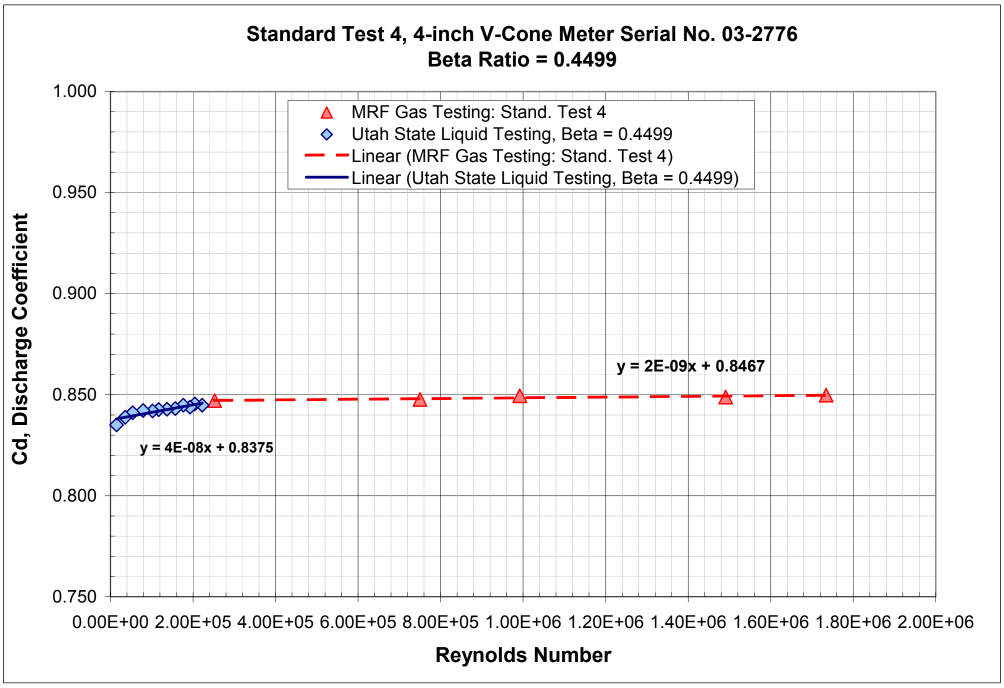

Figure A-16. Average measured discharge coefficient and linear curve-fit to Standard Test 4 performed at the MRF and liquid testing of the same meter at Utah State University.

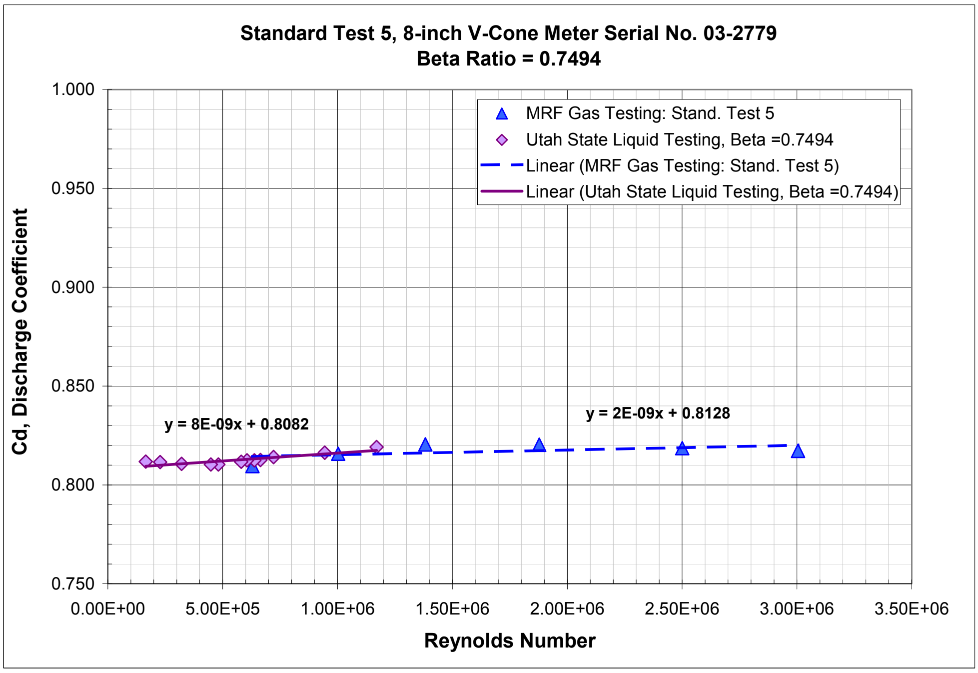

Figure A-17. Average measured discharge coefficient and linear curve-fit to Standard Test 5 performed at the MRF and liquid testing of the same meter at Utah State University.

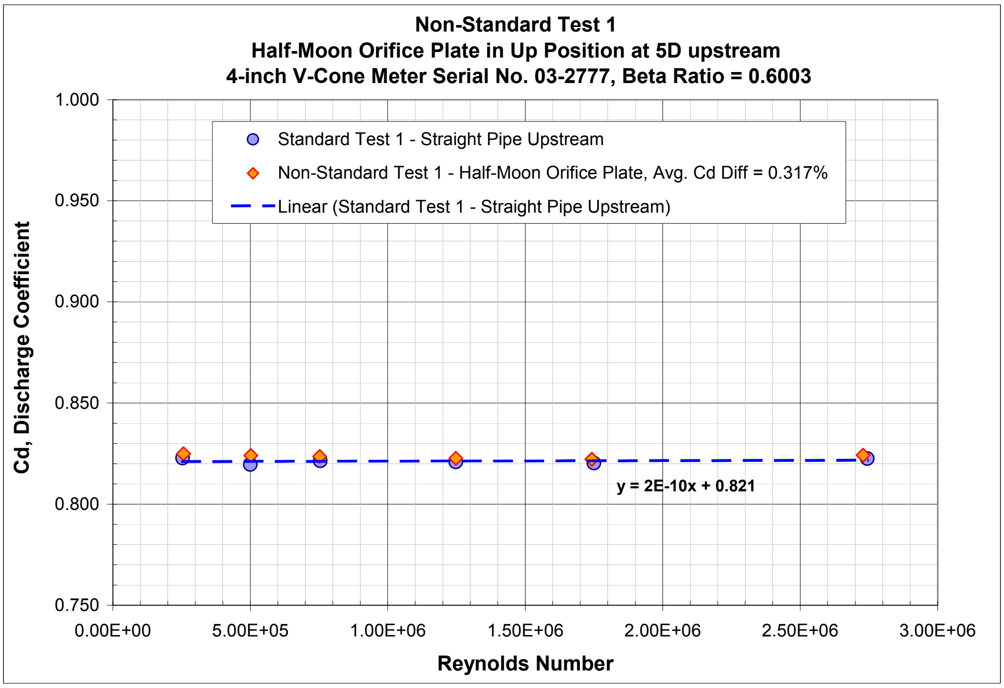

Figure A-18. Average measured discharge coefficient for Non-Standard Test 1 and Standard Test 1 with linear curve-fit to Standard Test 1 data.

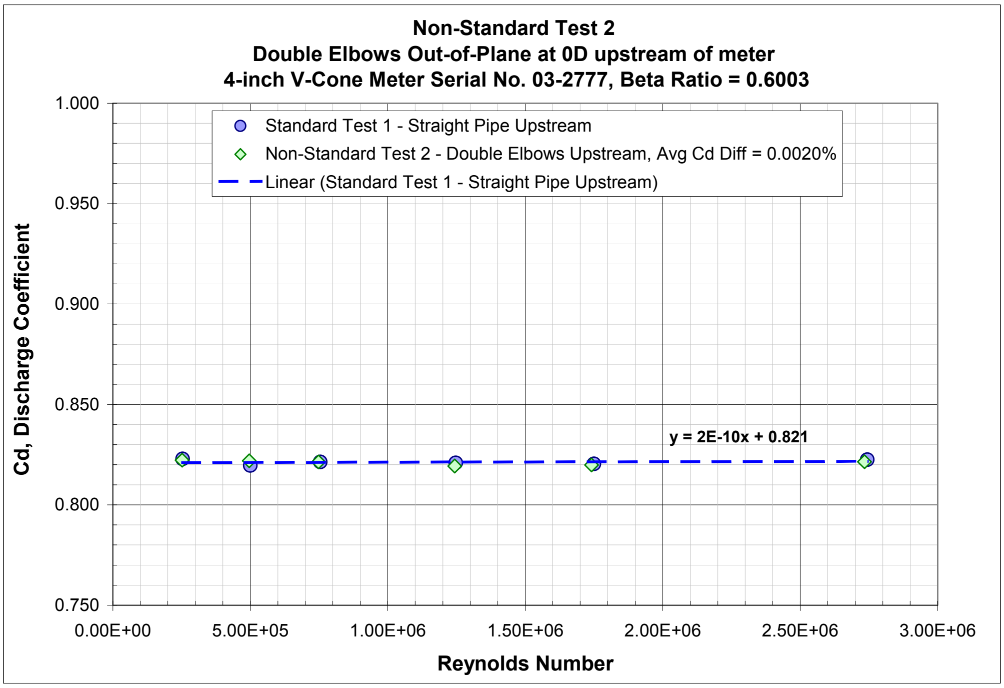

Figure A-19. Average measured discharge coefficient for Non-Standard Test 2 and Standard Test 1 with linear curve-fit to Standard Test 1 data.

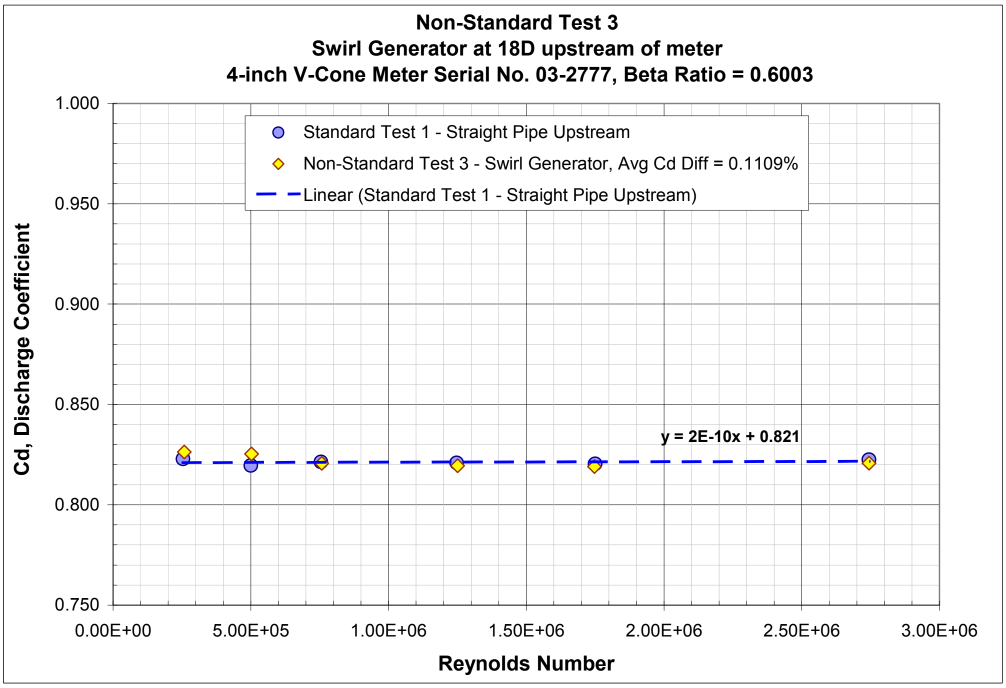

Figure A-20. Average measured discharge coefficient for Non-Standard Test 3 and Standard Test 1 with linear curve-fit to Standard Test 1 data.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F120403.000	31204	83055	160.795	72.938	0.5140	8.2217	2744214	0.82436	0.379	0.97234	0.60031	119.22	5.417	0.395
F120403.001	31204	83306	160.864	72.851	0.5144	8.2658	2743892	0.82169	0.314	0.97222	0.60031	119.09	5.416	0.395
F120403.002	31204	83504	160.782	72.698	0.5143	8.2604	2744129	0.82187	0.312	0.97223	0.60031	119.09	5.415	0.395
F120403.003	31204	83702	160.791	72.589	0.5144	8.2458	2744178	0.82239	0.300	0.97229	0.60031	119.05	5.414	0.395
F120403.004	31204	83900	160.667	72.445	0.5142	8.2506	2743866	0.82209	0.417	0.97223	0.60031	119.06	5.412	0.395
F120403.005	31204	84059	160.766	72.317	0.5146	8.2283	2743969	0.82264	0.315	0.97233	0.60031	118.95	5.411	0.395
					Average =	**8.2454**	**2744041**	**0.82251**			**Average =**	**119.08**	**5.414**	
F120403.006	31204	90331	162.694	71.333	0.5063	3.3041	1749694	0.81967	0.284	0.98869	0.60030	76.99	3.446	0.346
F120403.007	31204	90529	162.710	71.344	0.5064	3.3115	1749980	0.81890	0.275	0.98867	0.60030	76.99	3.446	0.346
F120403.008	31204	90727	162.750	71.330	0.5064	3.2954	1750142	0.82081	0.273	0.98872	0.60030	76.99	3.447	0.346
F120403.009	31204	90947	162.829	71.341	0.5066	3.2829	1750256	0.82227	0.396	0.98877	0.60030	76.96	3.447	0.346
F120403.010	31204	91146	162.743	71.350	0.5064	3.3040	1750430	0.82004	0.289	0.98869	0.60030	77.00	3.447	0.346
F120403.011	31204	91344	162.767	71.347	0.5065	3.3004	1750464	0.82042	0.309	0.98871	0.60030	76.99	3.447	0.346
					Average =	**3.2997**	**1750161**	**0.82035**			**Average =**	**76.99**	**3.447**	
F120403.012	31204	92141	162.840	71.249	0.5018	1.6788	1246228	0.81816	0.370	0.99420	0.60030	55.32	2.454	0.437
F120403.013	31204	92339	162.910	71.240	0.5019	1.6613	1246651	0.82259	0.440	0.99426	0.60030	55.32	2.455	0.437
F120403.014	31204	92537	162.935	71.226	0.5020	1.6615	1246972	0.82253	0.322	0.99426	0.60030	55.33	2.455	0.437
F120403.015	31204	92735	162.939	71.230	0.5020	1.6609	1247251	0.82291	0.371	0.99427	0.60030	55.34	2.456	0.437
F120403.016	31204	92934	162.979	71.240	0.5022	1.6796	1247582	0.81838	0.425	0.99420	0.60030	55.33	2.457	0.437
F120403.017	31204	93132	163.022	71.316	0.5022	1.6707	1247786	0.82080	0.360	0.99424	0.60030	55.35	2.457	0.437
					Average =	**1.6688**	**1247078**	**0.82090**			**Average =**	**55.33**	**2.456**	
F120403.018	31204	95322	163.662	70.907	0.5013	0.6076	754781	0.82047	0.509	0.99792	0.60030	33.52	1.486	0.391
F120403.019	31204	95520	163.700	70.873	0.5015	0.6058	755010	0.82179	0.437	0.99790	0.60030	33.52	1.486	0.391
F120403.020	31204	95719	163.733	70.893	0.5016	0.6067	755201	0.82134	0.509	0.99786	0.60030	33.52	1.486	0.390
F120403.021	31204	95917	163.763	70.911	0.5017	0.6064	755312	0.82159	0.508	0.99790	0.60030	33.52	1.487	0.390
F120403.022	31204	100115	163.742	70.890	0.5016	0.6073	755285	0.82100	0.474	0.99791	0.60030	33.52	1.487	0.390
F120403.023	31204	100314	163.744	70.958	0.5015	0.6059	755253	0.82202	0.440	0.99790	0.60030	33.53	1.487	0.390
					Average =	**0.6066**	**755140.3**	**0.82137**			**Average =**	**33.52**	**1.486**	
F120403.024	31204	100905	163.563	70.758	0.5001	0.2673	500061	0.81937	1.023	0.99907	0.60030	22.26	0.984	0.528
F120403.025	31204	101104	163.608	70.774	0.5002	0.2679	500177	0.81858	0.980	0.99907	0.60030	22.26	0.984	0.528
F120403.026	31204	101302	163.609	70.708	0.5003	0.2660	500250	0.82154	0.987	0.99907	0.60030	22.25	0.984	0.528
F120403.027	31204	101500	163.586	70.670	0.5003	0.2681	500217	0.81817	1.022	0.99906	0.60030	22.25	0.984	0.528
F120403.028	31204	101721	163.605	70.630	0.5004	0.2680	500319	0.81844	0.981	0.99907	0.60030	22.25	0.984	0.528
F120403.029	31204	101919	163.631	70.710	0.5004	0.2659	500321	0.82162	0.985	0.99908	0.60030	22.26	0.984	0.528
					Average =	**0.2672**	**500224.2**	**0.81962**			**Average =**	**22.25**	**0.984**	
F120403.030	31204	103901	163.329	69.914	0.4996	0.0681	253897	0.82285	3.674	0.99975	0.60030	11.30	0.499	0.514
F120403.031	31204	104059	163.350	69.968	0.4996	0.0676	253891	0.82628	3.714	0.99977	0.60030	11.30	0.499	0.513
F120403.032	31204	104257	163.404	70.047	0.4997	0.0678	253933	0.82524	3.683	0.99975	0.60030	11.30	0.499	0.513
F120403.033	31204	104455	163.406	70.111	0.4997	0.0684	253916	0.82164	3.657	0.99975	0.60030	11.30	0.499	0.513
F120403.034	31204	104654	163.398	70.153	0.4996	0.0686	253887	0.82044	3.671	0.99976	0.60030	11.30	0.499	0.513
F120403.035	31204	104912	163.388	70.173	0.4996	0.0686	253855	0.82043	3.651	0.99975	0.60030	11.30	0.499	0.514
					Average =	**0.0682**	**253896.5**	**0.82281**			**Average =**	**11.30**	**0.499**	

Figure A-21. Standard Test 1 Data: 4-inch V-Cone Flow Meter, Beta = 0.60, Low Pressure Test.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(lb/s)
F120303.000	31203	100228	803.630	70.279	2.7862	27.0767	10688509	0.82602	0.2960	0.98223	0.60030	94.05	23.167	0.223
F120303.001	31203	100426	803.436	70.235	2.7853	26.9140	10688135	0.82847	0.3110	0.98234	0.60030	94.08	23.164	0.223
F120303.002	31203	100624	803.291	70.191	2.7850	26.9027	10686864	0.82850	0.2920	0.98233	0.60030	94.06	23.160	0.223
F120303.003	31203	100851	802.971	70.161	2.7839	26.8480	10685154	0.82925	0.2910	0.98236	0.60030	94.08	23.154	0.223
F120303.004	31203	101050	802.847	70.133	2.7837	26.8659	10683614	0.82891	0.3020	0.98235	0.60030	94.07	23.149	0.223
F120303.005	31203	101248	802.887	70.133	2.7836	26.7936	10682985	0.82998	0.3130	0.98240	0.60030	94.07	23.148	0.223
					Average =	**26.9001**	**10685877**	**0.82852**			**Average =**	**94.07**	**23.157**	
F120303.006	31203	103823	810.923	70.483	2.7418	8.2933	5930382	0.82589	0.2670	0.99447	0.60030	53.12	12.875	0.208
F120303.007	31203	104022	810.604	70.504	2.7403	8.2500	5929201	0.82807	0.2910	0.99450	0.60030	53.13	12.872	0.208
F120303.008	31203	104221	810.491	70.494	2.7401	8.2815	5928228	0.82631	0.2780	0.99448	0.60030	53.13	12.870	0.208
F120303.009	31203	104420	810.449	70.451	2.7403	8.2919	5927183	0.82561	0.2540	0.99447	0.60030	53.11	12.867	0.208
F120303.010	31203	104618	810.357	70.400	2.7403	8.2847	5927043	0.82588	0.2580	0.99448	0.60030	53.11	12.865	0.208
F120303.011	31203	104816	810.267	70.373	2.7402	8.2726	5927110	0.82648	0.2790	0.99448	0.60030	53.11	12.865	0.208
					Average =	**8.2790**	**5928191**	**0.82637**			**Average =**	**53.12**	**12.869**	
F120303.012	31203	105639	812.017	70.510	2.7343	5.2409	4725466	0.82761	0.3450	0.99650	0.60030	42.45	10.262	0.254
F120303.013	31203	105838	812.262	70.556	2.7349	5.2471	4726715	0.82721	0.3290	0.99650	0.60030	42.46	10.265	0.254
F120303.014	31203	110036	812.294	70.535	2.7353	5.2721	4726214	0.82516	0.3230	0.99648	0.60030	42.45	10.264	0.254
F120303.015	31203	110235	811.928	70.521	2.7338	5.2166	4725530	0.82959	0.3920	0.99652	0.60030	42.46	10.262	0.254
F120303.016	31203	110511	811.869	70.487	2.7341	5.2802	4724391	0.82426	0.3340	0.99647	0.60030	42.44	10.259	0.254
F120303.017	31203	110710	811.862	70.451	2.7342	5.2383	4724130	0.82746	0.3510	0.99650	0.60030	42.44	10.258	0.254
					Average =	**5.2492**	**4725408**	**0.82688**			**Average =**	**42.45**	**10.262**	
F120303.018	31203	112904	813.864	70.524	2.7266	1.3473	2372024	0.81879	0.5330	0.99910	0.60030	21.38	5.153	0.252
F120303.019	31203	113102	813.796	70.577	2.7260	1.3490	2371593	0.81853	0.6190	0.99910	0.60030	21.38	5.152	0.252
F120303.020	31203	113300	813.693	70.615	2.7253	1.3371	2371194	0.82182	0.5840	0.99910	0.60030	21.38	5.152	0.252
F120303.021	31203	113459	813.595	70.633	2.7248	1.3533	2370782	0.81687	0.5160	0.99909	0.60030	21.38	5.151	0.252
F120303.022	31203	113657	813.494	70.634	2.7244	1.3501	2370339	0.81781	0.5650	0.99910	0.60030	21.38	5.150	0.252
F120303.023	31203	113856	813.300	70.640	2.7236	1.3288	2369709	0.82426	0.5940	0.99911	0.60030	21.38	5.148	0.252
					Average =	**1.3443**	**2370940**	**0.81968**			**Average =**	**21.38**	**5.151**	
F120303.024	31203	124432	812.885	70.310	2.7308	2.9928	3573869	0.82745	0.3090	0.99800	0.60030	32.15	7.761	0.184
F120303.025	31203	124630	812.886	70.340	2.7306	3.0214	3573458	0.82376	0.4320	0.99798	0.60030	32.15	7.760	0.184
F120303.026	31203	124829	812.772	70.369	2.7299	3.0038	3573361	0.82600	0.3460	0.99799	0.60030	32.15	7.760	0.184
F120303.027	31203	125027	812.791	70.384	2.7299	2.9982	3573099	0.82683	0.3280	0.99799	0.60030	32.15	7.759	0.184
F120303.028	31203	125249	812.672	70.412	2.7294	3.0398	3572245	0.82126	0.4400	0.99797	0.60030	32.15	7.758	0.184
F120303.029	31203	125447	812.513	70.452	2.7284	3.0325	3571365	0.82196	0.3820	0.99797	0.60030	32.15	7.756	0.184
					Average =	**3.0148**	**3572900**	**0.82454**			**Average =**	**32.15**	**7.759**	

Figure A-22. Standard Test 2 Data: 4-inch V-Cone Flow Meter, Beta = 0.60, High Pressure Test.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F120503.000	31205	113812	158.862	71.189	0.5091	8.8874	4937467	0.81844	0.357	0.96466	0.75011	216.12	9.727	0.249
F120503.001	31205	114026	158.921	71.087	0.5094	8.8896	4938577	0.81816	0.395	0.96463	0.75011	216.01	9.728	0.249
F120503.002	31205	114225	158.980	70.875	0.5099	8.9185	4940799	0.81665	0.395	0.96454	0.75011	215.83	9.729	0.249
F120503.003	31205	114423	158.839	70.695	0.5097	8.9223	4940856	0.81645	0.356	0.96452	0.75011	215.87	9.726	0.249
F120503.004	31205	114621	158.824	70.581	0.5097	8.9027	4940942	0.81719	0.459	0.96456	0.75011	215.83	9.725	0.249
F120503.005	31205	114819	158.801	70.479	0.5098	8.9167	4941014	0.81639	0.415	0.96451	0.75011	215.76	9.723	0.249
					Average =	**8.9062**	**4939943**	**0.81721**			**Average =**	**215.90**	**9.726**	
F120503.006	31205	132528	162.854	71.062	0.5022	2.6277	2741486	0.82053	0.270	0.98940	0.75011	121.67	5.402	0.207
F120503.007	31205	132726	162.848	71.076	0.5022	2.6283	2740887	0.82037	0.378	0.98939	0.75011	121.66	5.401	0.207
F120503.008	31205	132925	162.835	71.054	0.5022	2.6405	2740591	0.81838	0.286	0.98935	0.75011	121.63	5.400	0.207
F120503.009	31205	133123	162.815	70.960	0.5022	2.6360	2740761	0.81897	0.347	0.98936	0.75011	121.62	5.400	0.207
F120503.010	31205	133321	162.807	70.937	0.5022	2.6304	2740353	0.81965	0.294	0.98939	0.75011	121.60	5.399	0.207
F120503.011	31205	133543	162.811	70.980	0.5022	2.6564	2740414	0.81576	0.301	0.98929	0.75011	121.60	5.399	0.207
					Average =	**2.6365**	**2740749**	**0.81894**			**Average =**	**121.63**	**5.400**	
F120503.012	31205	134445	163.247	70.924	0.5008	1.7494	2242361	0.82060	0.327	0.99293	0.75011	99.77	4.418	0.246
F120503.013	31205	134644	163.245	70.868	0.5009	1.7503	2242373	0.82034	0.428	0.99292	0.75011	99.75	4.417	0.246
F120503.014	31205	134841	163.258	70.928	0.5009	1.7604	2242552	0.81820	0.404	0.99288	0.75011	99.77	4.418	0.246
F120503.015	31205	135040	163.243	70.895	0.5009	1.7586	2242363	0.81846	0.333	0.99289	0.75011	99.76	4.417	0.246
F120503.016	31205	135238	163.192	70.899	0.5007	1.7519	2241678	0.81992	0.349	0.99291	0.75011	99.77	4.416	0.246
F120503.017	31205	135515	163.177	70.950	0.5006	1.7539	2241706	0.81957	0.342	0.99290	0.75011	99.79	4.417	0.246
					Average =	**1.7541**	**2242172**	**0.81952**			**Average =**	**99.77**	**4.417**	
F120503.018	31205	141809	163.764	70.404	0.4986	0.3422	992427	0.81767	0.812	0.99860	0.75011	44.32	1.954	0.279
F120503.019	31205	142008	163.808	70.417	0.4987	0.3431	992687	0.81672	0.787	0.99860	0.75011	44.32	1.954	0.279
F120503.020	31205	142206	163.855	70.481	0.4988	0.3435	992848	0.81643	0.785	0.99859	0.75011	44.33	1.955	0.279
F120503.021	31205	142415	163.866	70.510	0.4988	0.3441	992866	0.81575	0.786	0.99860	0.75011	44.33	1.955	0.279
F120503.022	31205	142625	163.820	70.359	0.4988	0.3430	992892	0.81690	0.790	0.99859	0.75011	44.32	1.954	0.279
F120503.023	31205	142823	163.793	70.342	0.4988	0.3433	992844	0.81649	0.787	0.99858	0.75011	44.32	1.954	0.279
					Average =	**0.3432**	**992761**	**0.81666**			**Average =**	**44.32**	**1.954**	
F120503.024	31205	144611	164.285	70.003	0.5002	0.2003	755051	0.81090	1.218	0.99919	0.75010	33.59	1.485	0.204
F120503.025	31205	144810	164.371	70.069	0.5004	0.1999	755424	0.81206	1.274	0.99917	0.75010	33.60	1.486	0.203
F120503.026	31205	145008	164.420	70.104	0.5005	0.2006	755633	0.81092	1.268	0.99917	0.75010	33.60	1.487	0.204
F120503.027	31205	145206	164.454	70.063	0.5007	0.2004	755875	0.81125	1.270	0.99917	0.75010	33.60	1.487	0.203
F120503.028	31205	145405	164.478	70.064	0.5007	0.1997	756070	0.81292	1.270	0.99918	0.75010	33.61	1.488	0.204
F120503.029	31205	145614	164.492	70.010	0.5009	0.2004	756258	0.81161	1.315	0.99918	0.75010	33.60	1.488	0.203
					Average =	**0.2002**	**755719**	**0.81161**			**Average =**	**33.60**	**1.487**	
F120503.030	31205	150043	164.109	69.650	0.4997	0.0892	500519	0.80521	2.838	0.99963	0.75010	22.28	0.984	0.277
F120503.031	31205	150241	164.125	69.546	0.4998	0.0894	500679	0.80415	2.828	0.99963	0.75010	22.28	0.984	0.277
F120503.032	31205	150450	164.135	69.425	0.5000	0.0893	500859	0.80488	2.813	0.99963	0.75010	22.27	0.984	0.277
F120503.033	31205	150648	164.102	69.313	0.5000	0.0892	500899	0.80529	2.799	0.99963	0.75010	22.27	0.984	0.277
F120503.034	31205	150846	164.106	69.295	0.5000	0.0893	500966	0.80475	2.820	0.99963	0.75010	22.27	0.984	0.277
F120503.035	31205	151056	164.134	69.308	0.5001	0.0891	501079	0.80555	2.815	0.99963	0.75010	22.27	0.985	0.277
					Average =	**0.0892**	**500834**	**0.80497**			**Average =**	**22.27**	**0.984**	

Figure A-23. Standard Test 3 Data: 4-inch V-Cone Flow Meter, Beta = 0.75.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F120803.000	31208	93040	160.836	71.611	0.5198	10.7249	1733562	0.85090	0.381	0.96749	0.44991	74.40	3.419	0.181
F120803.001	31208	93544	160.745	71.203	0.5200	10.7451	1734161	0.84972	0.337	0.96742	0.44991	74.35	3.418	0.180
F120803.002	31208	93743	160.745	71.059	0.5201	10.7212	1734478	0.85047	0.322	0.96750	0.44991	74.34	3.418	0.181
F120803.003	31208	94004	160.777	70.910	0.5203	10.7094	1734929	0.85078	0.401	0.96755	0.44991	74.31	3.418	0.180
F120803.004	31208	94203	160.730	70.804	0.5206	10.8103	1735272	0.84683	0.331	0.96726	0.44990	74.27	3.418	0.181
F120803.005	31208	94402	160.731	70.720	0.5204	10.7254	1735395	0.85002	0.398	0.96751	0.44990	74.29	3.418	0.181
					Average =	**10.7394**	**1734633**	**0.84979**			**Average =**	**74.33**	**3.418**	
F120803.006	31208	95038	162.218	70.572	0.5163	7.8652	1490520	0.84844	0.332	0.97595	0.44990	64.31	2.935	0.206
F120803.007	31208	95237	162.180	70.535	0.5162	7.8566	1490713	0.84905	0.343	0.97600	0.44990	64.32	2.935	0.206
F120803.008	31208	95435	162.236	70.530	0.5163	7.8524	1490949	0.84927	0.331	0.97599	0.44990	64.31	2.936	0.206
F120803.009	31208	95633	162.252	70.495	0.5164	7.8538	1491171	0.84922	0.347	0.97599	0.44990	64.31	2.936	0.206
F120803.010	31208	95843	162.232	70.502	0.5164	7.8578	1491431	0.84920	0.361	0.97598	0.44990	64.33	2.937	0.206
F120803.011	31208	100041	162.286	70.519	0.5166	7.8804	1491473	0.84789	0.362	0.97591	0.44990	64.30	2.937	0.206
					Average =	**7.8610**	**1491043**	**0.84884**			**Average =**	**64.31**	**2.936**	
F120803.012	31208	100914	163.272	70.680	0.5058	3.4590	991897	0.84895	0.338	0.98922	0.44990	43.70	1.954	0.280
F120803.013	31208	101124	163.268	70.709	0.5057	3.4594	991777	0.84884	0.340	0.98921	0.44990	43.70	1.954	0.280
F120803.014	31208	101323	163.253	70.770	0.5056	3.4582	991759	0.84922	0.348	0.98922	0.44990	43.71	1.954	0.280
F120803.015	31208	101521	163.292	70.794	0.5057	3.4498	991677	0.85007	0.348	0.98924	0.44991	43.70	1.954	0.280
F120803.016	31208	101730	163.270	70.784	0.5056	3.4581	991584	0.84897	0.336	0.98922	0.44990	43.70	1.953	0.280
F120803.017	31208	101929	163.240	70.817	0.5055	3.4478	991532	0.85043	0.385	0.98924	0.44991	43.71	1.953	0.280
					Average =	**3.4554**	**991704**	**0.84941**			**Average =**	**43.70**	**1.954**	
F120803.018	31208	103759	163.561	70.923	0.5018	1.9886	750512	0.84693	0.304	0.99375	0.44991	33.33	1.479	0.204
F120803.019	31208	103958	163.552	70.902	0.5018	1.9776	750375	0.84908	0.284	0.99379	0.44991	33.33	1.479	0.204
F120803.020	31208	104207	163.537	70.935	0.5018	1.9876	750248	0.84696	0.324	0.99376	0.44991	33.33	1.478	0.204
F120803.021	31208	104406	163.512	70.979	0.5016	1.9778	750033	0.84895	0.295	0.99379	0.44991	33.33	1.478	0.204
F120803.022	31208	104604	163.502	71.041	0.5015	1.9868	749934	0.84706	0.336	0.99376	0.44991	33.34	1.478	0.204
F120803.023	31208	104803	163.489	71.077	0.5015	1.9907	749886	0.84638	0.351	0.99374	0.44991	33.34	1.478	0.204
					Average =	**1.9848**	**750165**	**0.84756**			**Average =**	**33.33**	**1.478**	
F120803.024	31208	105516	164.032	70.889	0.4979	0.2251	252748	0.84638	1.149	0.99928	0.44991	11.32	0.498	0.270
F120803.025	31208	105714	163.965	70.921	0.4976	0.2242	252619	0.84779	1.161	0.99929	0.44991	11.32	0.498	0.270
F120803.026	31208	105923	163.956	70.973	0.4976	0.2246	252572	0.84713	1.157	0.99929	0.44991	11.32	0.498	0.270
F120803.027	31208	110121	163.954	71.017	0.4975	0.2248	252536	0.84676	1.148	0.99928	0.44991	11.32	0.498	0.270
F120803.028	31208	110320	163.927	71.028	0.4974	0.2244	252487	0.84743	1.155	0.99928	0.44991	11.32	0.498	0.270
F120803.029	31208	110518	163.908	71.100	0.4973	0.2246	252417	0.84707	1.135	0.99928	0.44991	11.32	0.498	0.270
F120803.030	31208	110518	163.908	71.100	0.4973	0.2246	252417	0.84707	1.135	0.99928	0.44991	11.32	0.498	0.270
					Average =	**0.2246**	**252542**	**0.84709**			**Average =**	**11.32**	**0.498**	

Figure A-24. Standard Test 4 Data: 4-inch V-Cone Flow Meter, Beta = 0.45.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F010504.000	40105	90336	165.001	71.874	0.5025	0.8082	3004187	0.81726	0.396	0.99673	0.74941	67.50	11.790	0.221
F010504.001	40105	90728	165.026	71.764	0.5027	0.8061	3004934	0.81818	0.397	0.99673	0.74941	67.48	11.790	0.221
F010504.002	40105	90929	164.928	71.611	0.5025	0.8075	3004995	0.81743	0.434	0.99674	0.74941	67.49	11.788	0.221
F010504.003	40105	91710	164.951	71.544	0.5027	0.8083	3005216	0.81691	0.397	0.99672	0.74941	67.47	11.787	0.221
F010504.004	40105	91911	164.916	71.548	0.5025	0.8078	3004912	0.81718	0.396	0.99672	0.74941	67.48	11.786	0.221
F010504.005	40105	92112	164.906	71.561	0.5025	0.8088	3004945	0.81671	0.394	0.99670	0.74941	67.48	11.787	0.221
					Average =	**0.8078**	**3004865**	**0.81728**			**Average =**	**67.48**	**11.788**	
F010504.006	40105	94628	164.743	71.739	0.5011	0.5597	2502387	0.81815	0.525	0.99773	0.74941	56.37	9.818	0.249
F010504.007	40105	94839	164.685	71.834	0.5008	0.5575	2501168	0.81973	0.485	0.99771	0.74941	56.38	9.815	0.249
F010504.008	40105	95049	164.710	71.971	0.5007	0.5592	2500876	0.81862	0.565	0.99772	0.74941	56.40	9.816	0.249
F010504.009	40105	95259	164.724	72.015	0.5007	0.5585	2500667	0.81908	0.524	0.99774	0.74941	56.40	9.815	0.249
F010504.010	40105	95457	164.750	72.024	0.5007	0.5605	2500611	0.81757	0.522	0.99779	0.74941	56.39	9.815	0.249
F010504.011	40105	95656	164.744	72.009	0.5008	0.5597	2500649	0.81817	0.524	0.99776	0.74941	56.39	9.815	0.249
					Average =	**0.5592**	**2501060**	**0.81855**			**Average =**	**56.39**	**9.816**	
F010504.012	40105	101846	164.393	71.796	0.4991	0.3140	1879269	0.82107	0.800	0.99872	0.74941	42.50	7.374	0.168
F010504.013	40105	102047	164.369	71.873	0.4990	0.3150	1878849	0.81988	0.839	0.99873	0.74941	42.51	7.373	0.168
F010504.014	40105	102248	164.347	72.004	0.4988	0.3148	1878168	0.82010	0.820	0.99874	0.74941	42.52	7.372	0.168
F010504.015	40105	102449	164.320	72.065	0.4986	0.3148	1877724	0.82015	0.821	0.99872	0.74941	42.53	7.371	0.168
F010504.016	40105	102651	164.312	72.068	0.4986	0.3147	1877326	0.82013	0.820	0.99872	0.74941	42.52	7.369	0.168
F010504.017	40105	102920	164.319	72.189	0.4985	0.3146	1877094	0.82041	0.843	0.99872	0.74942	42.53	7.370	0.168
					Average =	**0.3147**	**1878072**	**0.82029**			**Average =**	**42.52**	**7.371**	
F010504.018	40105	103524	164.585	71.960	0.4991	0.1701	1381890	0.82025	1.481	0.99931	0.74941	31.26	5.424	0.208
F010504.019	40105	103753	164.630	71.994	0.4992	0.1703	1382338	0.81996	1.509	0.99931	0.74941	31.27	5.426	0.208
F010504.020	40105	103954	164.672	72.068	0.4993	0.1704	1382534	0.81990	1.483	0.99931	0.74941	31.27	5.427	0.208
F010504.021	40105	104234	164.664	72.034	0.4993	0.1702	1382714	0.82033	1.488	0.99931	0.74941	31.27	5.427	0.208
F010504.022	40105	104447	164.674	71.997	0.4994	0.1695	1382871	0.82191	1.496	0.99932	0.74941	31.27	5.428	0.208
F010504.023	40105	104648	164.678	71.988	0.4994	0.1700	1383002	0.82078	1.486	0.99930	0.74941	31.27	5.428	0.208
					Average =	**0.1701**	**1382558**	**0.82052**			**Average =**	**31.27**	**5.427**	
F010504.024	40105	105327	164.530	71.562	0.4991	0.0904	1004147	0.81677	2.786	0.99963	0.74941	22.70	3.939	0.276
F010504.025	40105	105547	164.616	71.582	0.4994	0.0907	1004617	0.81562	2.789	0.99961	0.74941	22.70	3.941	0.276
F010504.032	40105	114907	164.771	73.320	0.4981	0.0910	1003080	0.81621	2.761	0.99963	0.74942	22.79	3.945	0.276
F010504.033	40105	115130	164.747	73.355	0.4980	0.0910	1002784	0.81630	2.762	0.99963	0.74942	22.79	3.944	0.276
F010504.034	40105	115405	164.724	73.318	0.4979	0.0913	1002544	0.81482	2.759	0.99963	0.74942	22.78	3.943	0.276
F010504.035	40105	115646	164.649	73.171	0.4979	0.0913	1002329	0.81446	2.752	0.99962	0.74942	22.78	3.941	0.276
F010504.036	40105	120009	164.624	73.177	0.4978	0.0909	1002091	0.81585	2.773	0.99963	0.74942	22.78	3.941	0.276
F010504.037	40105	120211	164.626	73.172	0.4978	0.0909	1002085	0.81596	2.758	0.99962	0.74942	22.77	3.940	0.276
					Average =	**0.0909**	**1002960**	**0.81575**			**Average =**	**22.76**	**3.942**	
F010504.038	40105	132015	164.500	71.514	0.4989	0.0362	629278	0.80864	6.886	0.99985	0.74941	14.23	2.468	0.230
F010504.039	40105	132212	164.504	71.512	0.4989	0.0360	629322	0.81050	6.902	0.99985	0.74941	14.23	2.468	0.230
F010504.040	40105	132426	164.542	71.583	0.4990	0.0362	629419	0.80956	6.911	0.99985	0.74941	14.24	2.469	0.230
F010504.041	40105	132630	164.545	71.607	0.4989	0.0362	629432	0.80946	6.909	0.99985	0.74941	14.24	2.469	0.229
F010504.042	40105	132828	164.544	71.674	0.4989	0.0359	629357	0.81205	6.971	0.99986	0.74941	14.24	2.469	0.229
F010504.043	40105	133026	164.545	71.690	0.4989	0.0364	629326	0.80711	6.868	0.99985	0.74941	14.24	2.469	0.230
					Average =	**0.0361**	**629356**	**0.80955**			**Average =**	**14.24**	**2.469**	

Figure A-25. Standard Test 5 Data: 8-inch V-Cone Flow Meter, Beta = 0.75.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F120903.066	31209	173627	160.721	72.470	0.5096	8.1999	2729835	0.82501	0.309	0.97247	0.60031	119.68	5.392	0.208
F120903.067	31209	173916	160.777	72.365	0.5100	8.2103	2729209	0.82393	0.304	0.97245	0.60031	119.56	5.390	0.208
F120903.068	31209	174130	160.710	72.314	0.5098	8.2172	2728864	0.82360	0.420	0.97239	0.60031	119.57	5.389	0.208
F120903.069	31209	174334	160.627	72.246	0.5096	8.1989	2728583	0.82443	0.355	0.97248	0.60031	119.60	5.388	0.207
F120903.070	31209	174532	160.624	72.190	0.5096	8.2008	2728411	0.82421	0.312	0.97244	0.60031	119.57	5.387	0.208
F120903.071	31209	174731	160.636	72.067	0.5098	8.1952	2728447	0.82417	0.302	0.97247	0.60031	119.51	5.386	0.208
					Average =	**8.2037**	**2728892**	**0.82422**			**Average =**	**119.58**	**5.389**	
F120903.072	31209	182324	162.767	70.889	0.5023	3.2856	1742564	0.82240	0.231	0.98878	0.60030	77.34	3.434	0.181
F120903.073	31209	182522	162.749	70.919	0.5022	3.2895	1742507	0.82202	0.235	0.98877	0.60030	77.35	3.434	0.181
F120903.074	31209	182720	162.812	70.992	0.5023	3.2874	1742598	0.82232	0.249	0.98878	0.60030	77.35	3.435	0.181
F120903.075	31209	182918	162.814	71.099	0.5023	3.3031	1742649	0.82065	0.264	0.98872	0.60030	77.37	3.436	0.181
F120903.076	31209	183117	162.819	71.079	0.5023	3.2914	1742609	0.82197	0.273	0.98876	0.60030	77.37	3.435	0.181
F120903.077	31209	183338	162.783	71.057	0.5021	3.2746	1742221	0.82389	0.266	0.98882	0.60030	77.37	3.435	0.181
					Average =	**3.2886**	**1742525**	**0.82221**			**Average =**	**77.36**	**3.435**	
F120903.078	31209	183833	163.260	70.642	0.4991	1.6703	1244402	0.82147	0.328	0.99426	0.60030	55.57	2.452	0.229
F120903.079	31209	184031	163.984	70.678	0.5013	1.6912	1249965	0.81841	0.327	0.99421	0.60030	55.57	2.463	0.230
F120903.080	31209	184230	163.696	70.571	0.5004	1.6553	1248369	0.82677	0.385	0.99432	0.60030	55.59	2.459	0.229
F120903.081	31209	184428	163.364	70.477	0.4995	1.6632	1246085	0.82382	0.348	0.99429	0.60030	55.58	2.454	0.229
F120903.082	31209	184642	163.348	70.413	0.4995	1.6646	1246295	0.82352	0.335	0.99428	0.60030	55.58	2.455	0.230
F120903.083	31209	185005	163.399	70.455	0.4997	1.6722	1246861	0.82199	0.352	0.99425	0.60030	55.59	2.456	0.229
					Average =	**1.6695**	**1246996**	**0.82266**			**Average =**	**55.58**	**2.456**	
F120903.084	31209	190919	162.914	68.605	0.4967	0.6019	751637	0.82285	0.473	0.99790	0.60030	33.61	1.476	0.204
F120903.085	31209	191128	162.904	68.552	0.4967	0.6003	751788	0.82401	0.457	0.99793	0.60030	33.62	1.476	0.205
F120903.086	31209	191326	162.901	68.475	0.4968	0.5999	751966	0.82428	0.476	0.99792	0.60030	33.61	1.476	0.205
F120903.087	31209	191524	162.899	68.380	0.4969	0.6021	752151	0.82284	0.492	0.99790	0.60030	33.61	1.477	0.204
F120903.088	31209	191801	162.882	68.235	0.4970	0.5997	752385	0.82445	0.476	0.99792	0.60030	33.61	1.477	0.204
F120903.089	31209	192021	162.889	68.174	0.4971	0.6017	752622	0.82321	0.476	0.99789	0.60030	33.61	1.477	0.204
					Average =	**0.6009**	**752092**	**0.82361**			**Average =**	**33.61**	**1.476**	
F120903.090	31209	192445	163.575	67.483	0.4989	0.2646	501425	0.82380	1.011	0.99907	0.60030	22.29	0.983	0.278
F120903.091	31209	192644	163.618	67.325	0.4992	0.2637	501780	0.82533	0.972	0.99908	0.60030	22.28	0.983	0.278
F120903.092	31209	192853	163.632	67.203	0.4994	0.2657	502008	0.82218	1.007	0.99907	0.60030	22.28	0.984	0.278
F120903.093	31209	193051	163.646	67.083	0.4995	0.2648	502219	0.82370	0.993	0.99908	0.60030	22.28	0.984	0.278
F120903.094	31209	193249	163.581	66.893	0.4995	0.2639	502246	0.82495	0.998	0.99907	0.60030	22.27	0.984	0.279
F120903.095	31209	193447	163.582	66.756	0.4997	0.2643	502431	0.82427	1.014	0.99908	0.60030	22.27	0.984	0.279
					Average =	**0.2645**	**502018**	**0.82404**			**Average =**	**22.28**	**0.984**	
F120903.096	31209	195503	163.888	64.103	0.5028	0.0679	257071	0.82576	3.705	0.99976	0.60029	11.28	0.501	0.271
F120903.097	31209	195722	163.876	63.963	0.5029	0.0682	257151	0.82358	3.663	0.99976	0.60029	11.28	0.501	0.271
F120903.098	31209	195926	163.881	63.844	0.5030	0.0677	257231	0.82648	3.708	0.99975	0.60029	11.27	0.501	0.271
F120903.099	31209	200124	163.857	63.707	0.5031	0.0677	257280	0.82645	3.697	0.99976	0.60029	11.27	0.501	0.271
F120903.100	31209	200322	163.776	63.517	0.5030	0.0683	257276	0.82300	3.675	0.99976	0.60029	11.27	0.501	0.272
F120903.101	31209	200520	163.747	63.383	0.5031	0.0681	257323	0.82402	3.679	0.99976	0.60029	11.27	0.501	0.271
					Average =	**0.0680**	**257222**	**0.82488**			**Average =**	**11.27**	**0.501**	

Figure A-26. Non-Standard Test 1 Data: 4-inch V-Cone Flow Meter, Beta = 0.60, Half Moon Orifice Plate at 5D.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F121003.000	31210	130006	161.651	70.947	0.5138	8.2010	2735319	0.82139	0.391	0.97260	0.60030	118.69	5.391	0.208
F121003.001	31210	130305	161.603	70.985	0.5135	8.1740	2734533	0.82266	0.359	0.97272	0.60030	118.73	5.390	0.208
F121003.002	31210	130503	161.619	70.979	0.5137	8.2240	2733826	0.81990	0.300	0.97255	0.60030	118.66	5.388	0.208
F121003.003	31210	130702	161.526	70.982	0.5134	8.2101	2733412	0.82078	0.350	0.97256	0.60030	118.71	5.388	0.208
F121003.004	31210	130915	161.632	71.028	0.5136	8.1935	2733492	0.82140	0.367	0.97265	0.60030	118.68	5.388	0.208
F121003.005	31210	131135	161.571	71.024	0.5133	8.1770	2733455	0.82241	0.379	0.97267	0.60030	118.73	5.388	0.208
					Average =	**8.1966**	**2734006**	**0.82142**			**Average =**	**118.70**	**5.389**	
F121003.006	31210	133455	163.186	70.698	0.5036	3.2969	1740770	0.81897	0.273	0.98877	0.60030	77.05	3.430	0.181
F121003.007	31210	133658	163.235	70.689	0.5037	3.2979	1740800	0.81873	0.223	0.98878	0.60030	77.03	3.430	0.181
F121003.008	31210	133857	163.196	70.645	0.5036	3.2860	1740780	0.82018	0.220	0.98882	0.60030	77.04	3.430	0.181
F121003.009	31210	134055	163.190	70.667	0.5036	3.2905	1740985	0.81978	0.282	0.98880	0.60030	77.05	3.430	0.181
F121003.010	31210	134253	163.192	70.646	0.5036	3.2897	1740842	0.81977	0.223	0.98880	0.60030	77.04	3.430	0.181
F121003.011	31210	134452	163.193	70.601	0.5036	3.2731	1740852	0.82170	0.339	0.98885	0.60030	77.04	3.430	0.181
					Average =	**3.2890**	**1740838**	**0.81986**			**Average =**	**77.04**	**3.430**	
F121003.012	31210	135901	163.655	70.619	0.5000	1.6620	1243168	0.82204	0.323	0.99430	0.60030	55.41	2.449	0.229
F121003.013	31210	140105	163.742	70.634	0.5003	1.6729	1243261	0.81927	0.349	0.99427	0.60030	55.39	2.450	0.229
F121003.014	31210	140303	163.716	70.619	0.5002	1.6600	1243370	0.82253	0.353	0.99431	0.60030	55.40	2.450	0.229
F121003.015	31210	140513	163.688	70.638	0.5002	1.6950	1243253	0.81404	0.374	0.99418	0.60030	55.40	2.450	0.229
F121003.016	31210	140712	163.728	70.658	0.5002	1.6701	1243286	0.81996	0.335	0.99427	0.60030	55.40	2.450	0.230
F121003.017	31210	140910	163.714	70.724	0.5001	1.6776	1243178	0.81834	0.332	0.99425	0.60030	55.41	2.450	0.230
					Average =	**1.6729**	**1243253**	**0.81936**			**Average =**	**55.40**	**2.450**	
F121003.018	31210	144835	163.840	71.059	0.4968	0.6036	748626	0.82159	0.476	0.99792	0.60030	33.61	1.476	0.204
F121003.019	31210	145038	163.833	71.072	0.4968	0.6030	748511	0.82191	0.457	0.99790	0.60030	33.60	1.476	0.204
F121003.020	31210	145237	163.798	71.062	0.4967	0.6043	748401	0.82096	0.474	0.99795	0.60030	33.61	1.476	0.204
F121003.021	31210	145435	163.792	71.087	0.4967	0.6046	748349	0.82079	0.477	0.99790	0.60030	33.61	1.476	0.204
F121003.022	31210	145650	163.782	71.037	0.4967	0.6047	748302	0.82062	0.455	0.99790	0.60030	33.60	1.475	0.204
F121003.023	31210	150013	163.771	71.045	0.4967	0.6020	748256	0.82241	0.478	0.99790	0.60030	33.60	1.475	0.204
					Average =	**0.6037**	**748408**	**0.82138**			**Average =**	**33.60**	**1.476**	
F121003.024	31210	150413	164.076	71.019	0.4966	0.2645	496810	0.82284	0.993	0.99909	0.60030	22.31	0.980	0.278
F121003.025	31210	150650	164.035	70.978	0.4965	0.2647	496708	0.82241	0.992	0.99906	0.60030	22.31	0.979	0.278
F121003.026	31210	150854	164.010	70.998	0.4964	0.2658	496614	0.82063	1.009	0.99908	0.60030	22.31	0.979	0.278
F121003.027	31210	151052	164.029	71.039	0.4964	0.2650	496625	0.82202	1.012	0.99908	0.60030	22.31	0.979	0.279
F121003.028	31210	151250	164.028	71.013	0.4964	0.2648	496619	0.82220	1.012	0.99908	0.60030	22.31	0.979	0.279
F121003.029	31210	151448	164.012	71.000	0.4964	0.2655	496576	0.82103	1.011	0.99908	0.60030	22.31	0.979	0.278
					Average =	**0.2651**	**496659**	**0.82186**			**Average =**	**22.31**	**0.979**	
F121003.030	31210	153415	164.136	70.933	0.4962	0.0685	252405	0.82099	3.661	0.99976	0.60030	11.34	0.498	0.271
F121003.031	31210	153630	164.135	70.959	0.4962	0.0679	252392	0.82516	3.679	0.99976	0.60030	11.34	0.498	0.271
F121003.032	31210	153852	164.102	70.927	0.4961	0.0685	252351	0.82099	3.650	0.99977	0.60030	11.34	0.497	0.271
F121003.033	31210	154050	164.093	70.949	0.4961	0.0684	252320	0.82189	3.644	0.99976	0.60030	11.34	0.497	0.271
F121003.034	31210	154248	164.084	71.023	0.4960	0.0681	252262	0.82318	3.672	0.99977	0.60030	11.34	0.497	0.271
F121003.035	31210	154446	164.091	71.090	0.4959	0.0685	252241	0.82112	3.661	0.99975	0.60030	11.34	0.497	0.271
					Average =	**0.0683**	**252329**	**0.82222**			**Average =**	**11.34**	**0.497**	

Figure A-27. Non-Standard Test 2 Data: 4-inch V-Cone Flow Meter, Beta = 0.60, Double Elbows Out-of-Plane.

File	Date	Time	Pdn(psia)	T(F)	rho(lb/ft3)	DP(psid)	ReD	Cd	UCd(%)	Y1	Beta	V(ft/s)	md(lb/s)	Umd(%)
F010704.000	40107	123032	161.526	71.592	0.5160	8.3135	2744523	0.81996	0.365	0.97224	0.60031	119.00	5.428	0.208
F010704.001	40107	123247	161.463	71.541	0.5157	8.2777	2744129	0.82170	0.345	0.97232	0.60031	119.03	5.427	0.207
F010704.002	40107	123444	161.506	71.534	0.5159	8.2773	2744031	0.82155	0.314	0.97233	0.60030	118.99	5.427	0.208
F010704.003	40107	123643	161.508	71.553	0.5159	8.2883	2743674	0.82094	0.341	0.97230	0.60031	118.98	5.426	0.208
F010704.004	40107	123841	161.435	71.542	0.5157	8.3034	2743612	0.82032	0.363	0.97227	0.60031	119.01	5.426	0.208
F010704.005	40107	124038	161.364	71.500	0.5156	8.3127	2743504	0.81991	0.310	0.97220	0.60030	119.03	5.426	0.208
					Average =	**8.2955**	**2743912**	**0.82073**			**Average =**	**119.01**	**5.427**	
F010704.006	40107	125923	163.216	71.354	0.5060	3.3256	1747573	0.81962	0.292	0.98868	0.60030	77.25	3.456	0.181
F010704.007	40107	130121	163.254	71.327	0.5061	3.3172	1747505	0.82050	0.338	0.98870	0.60030	77.23	3.456	0.181
F010704.008	40107	130331	163.302	71.334	0.5063	3.3347	1747682	0.81826	0.268	0.98866	0.60030	77.21	3.456	0.181
F010704.009	40107	130529	163.373	71.408	0.5064	3.3314	1747728	0.81872	0.285	0.98867	0.60030	77.20	3.456	0.181
F010704.010	40107	130728	163.323	71.486	0.5062	3.3404	1747585	0.81782	0.226	0.98863	0.60030	77.24	3.457	0.181
F010704.011	40107	130927	163.324	71.475	0.5062	3.3273	1747919	0.81957	0.280	0.98867	0.60030	77.25	3.457	0.181
					Average =	**3.3294**	**1747665**	**0.81908**			**Average =**	**77.23**	**3.456**	
F010704.012	40107	131438	164.049	71.328	0.5035	1.6949	1249558	0.81837	0.342	0.99419	0.60030	55.51	2.471	0.229
F010704.013	40107	131636	164.054	71.232	0.5036	1.6931	1250282	0.81908	0.316	0.99421	0.60030	55.52	2.472	0.229
F010704.014	40107	131835	164.107	71.214	0.5038	1.6898	1250621	0.81993	0.380	0.99422	0.60030	55.52	2.473	0.229
F010704.015	40107	132044	164.109	71.222	0.5038	1.6961	1250708	0.81847	0.330	0.99419	0.60030	55.52	2.473	0.229
F010704.016	40107	132242	164.082	71.223	0.5037	1.6741	1250433	0.82379	0.360	0.99427	0.60030	55.52	2.472	0.229
F010704.017	40107	132440	164.126	71.272	0.5039	1.7039	1250806	0.81666	0.300	0.99417	0.60030	55.53	2.473	0.229
					Average =	**1.6920**	**1250401**	**0.81938**			**Average =**	**55.52**	**2.472**	
F010704.018	40107	134320	164.398	70.121	0.5025	0.6112	756492	0.82130	0.436	0.99790	0.60030	33.61	1.493	0.204
F010704.019	40107	134519	164.434	70.040	0.5027	0.6132	756801	0.82002	0.473	0.99786	0.60030	33.61	1.494	0.204
F010704.020	40107	134733	164.442	69.950	0.5028	0.6125	757081	0.82062	0.472	0.99789	0.60030	33.61	1.494	0.204
F010704.021	40107	134957	164.435	69.952	0.5028	0.6124	757149	0.82076	0.468	0.99790	0.60030	33.61	1.494	0.204
F010704.022	40107	135201	164.480	69.882	0.5030	0.6118	757496	0.82124	0.470	0.99789	0.60030	33.61	1.495	0.204
F010704.023	40107	135359	164.536	69.894	0.5032	0.6140	757739	0.81996	0.501	0.99788	0.60030	33.61	1.495	0.204
					Average =	**0.6125**	**757126**	**0.82065**			**Average =**	**33.61**	**1.494**	
F010704.024	40107	135935	164.409	69.251	0.5024	0.2660	502394	0.82477	0.950	0.99908	0.60030	22.30	0.990	0.278
F010704.025	40107	140258	164.392	69.044	0.5025	0.2650	502613	0.82627	0.992	0.99908	0.60030	22.29	0.990	0.278
F010704.026	40107	140513	164.395	68.955	0.5027	0.2645	502731	0.82701	0.988	0.99907	0.60030	22.29	0.990	0.278
F010704.027	40107	140716	164.378	68.838	0.5027	0.2657	502819	0.82512	1.026	0.99909	0.60030	22.29	0.990	0.278
F010704.028	40107	140915	164.344	68.723	0.5027	0.2664	502851	0.82396	0.988	0.99908	0.60030	22.28	0.990	0.278
F010704.029	40107	141113	164.344	68.536	0.5029	0.2658	503056	0.82478	1.028	0.99907	0.60030	22.28	0.990	0.278
					Average =	**0.2656**	**502744**	**0.82532**			**Average =**	**22.29**	**0.990**	
F010704.036	40107	151114	164.119	63.454	0.5069	0.0680	258175	0.82630	3.684	0.99976	0.60029	11.25	0.504	0.271
F010704.037	40107	151311	164.144	63.401	0.5070	0.0680	258259	0.82646	3.683	0.99976	0.60029	11.25	0.504	0.271
F010704.038	40107	151510	164.155	63.305	0.5071	0.0681	258344	0.82601	3.682	0.99976	0.60029	11.25	0.504	0.271
F010704.039	40107	151724	164.138	63.239	0.5072	0.0681	258386	0.82594	3.692	0.99975	0.60029	11.25	0.504	0.271
F010704.040	40107	151928	164.147	63.211	0.5072	0.0680	258447	0.82646	3.693	0.99976	0.60029	11.25	0.505	0.271
F010704.041	40107	152126	164.126	63.162	0.5072	0.0680	258461	0.82664	3.684	0.99976	0.60029	11.25	0.505	0.271
					Average =	**0.0680**	**258345**	**0.82630**			**Average =**	**11.25**	**0.504**	

Figure A-28. Non-Standard Test 3 Data: 4-inch V-Cone Flow Meter, Beta = 0.60, High-Swirl Flow.