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Flow Conditioner Tests for Three Orifice Flowmeter Sizes

J.L. Scott
M.A. Lewis

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J.L. Scott
M.A. Lewis

Process Measurements Division
Chemical Science and Technology Laboratory
National Institute of Standards and Technology
325 Broadway
Boulder, Colorado 80303-3328

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FLOW CONDITIONER TESTS FOR THREE ORIFICE FLOWMETER SIZES

Jennifer L. Scott, Michael A. Lewis
Process Measurement Division
Chemical Science and Technology Laboratory
National Institute of Standards and Technology
325 Broadway
Boulder, Colorado 80303-3228

Tests sponsored by the Gas Research Institute were performed with orifice flowmeters of three nominal sizes: 52, 104, and 154 mm (2, 4, and 6 in). Tests with the 52 mm orifice meter included establishing a baseline curve for 6 beta ratios and then conducting flow conditioner performance tests with an elbow located 17 pipe diameters (17D) upstream of the orifice plate. Results from this laboratory indicate that beta ratios of 0.54 or less do not require flow conditioning in this configuration and the 19 tube bundle flow conditioner at 12D produces the best results for larger beta ratios. For the 104 mm orifice meter in the same piping configuration, flow conditioning is necessary for beta ratios of 0.55 and greater. Meter performance is less sensitive to the location of the 7 tube bundle than the 19 tube bundle flow conditioner, but the influence of the flange tap location is greater. Testing of two beta ratios in the 154 mm orifice meter in a baseline configuration and with a tee located 18D from the orifice plate indicates that placing a 19 tube bundle flow conditioner at 12D produces discharge coefficients equivalent to those measured in baseline conditions. Flow rates for all tests were in the turbulent regime.

Key words: baseline; beta ratio; discharge coefficient; flange tap location; flow conditioner; flow measurement; orifice flowmeter; Sprenkle; tube bundle; turbine flowmeter; turbulent

1. INTRODUCTION

This report details the results of metering research with orifice meters of the following nominal sizes: 52, 104, and 154 mm (2, 4, and 6 in). We report the performance characteristics of these meters in fully developed or 'good' flow conditions as baseline data and evaluate the success of several flow conditioning schemes in achieving discharge coefficients equivalent to baseline values when the piping configuration upstream of the orifice meter creates disturbed flow patterns.

The general objective of the orifice meter research at this laboratory is to provide information needed to update installation guidelines in the orifice metering standards, ANSI/API 2530 and A.G.A. 3 [1]. We investigate how the flow can be conditioned to mitigate the effects of disturbances located upstream of the orifice meter. We attempt to determine what type and location of flow conditioners will succeed in producing discharge coefficients equivalent to baseline values. Baseline values for each beta ratio (the ratio of the diameter of the hole in the orifice plate to the inner diameter of the meter tube) are determined by calculating discharge coefficients in a piping configuration designed to produce fully developed turbulent flow.

Baseline data for the 52 and 154 mm orifice meters are included in this report. The piping configuration used for these tests is shown in Figure 1. Baseline data for the 104 mm orifice meter were taken with the orifice meter in a configuration similar to Figure 1 and in other configurations with longer lengths of straight upstream pipes, with and without flow conditioning. These data have been reported in previous National Institute of Standards and Technology (NIST) Technical Notes [2,3,4].

A linear regression of discharge coefficients measured in baseline conditions versus pipe Reynolds number is performed. The resulting first-order curve is considered the baseline curve for each beta ratio. For every configuration and/or flow conditioner we test, we use a comparative method to evaluate the performance of the orifice meter. Values of discharge coefficients used in the comparison are also determined by linear regression. For each configuration, the discharge coefficients measured at each flange pressure tap location are regressed versus pipe Reynolds number, and this regression is solved at a median Reynolds number to determine the discharge coefficient resulting from these installation tests. This discharge coefficient is compared to the baseline discharge coefficient calculated from the baseline linear regression at the same pipe Reynolds number. The Reynolds number used in the comparison is near the middle of the Reynolds number range for each beta ratio.

The percent shift in orifice meter discharge coefficients resulting from specific upstream piping configurations and flow conditioner locations at selected Reynolds numbers is computed as follows:

$$\Delta C(\%) = \frac{(C_t - C_b) x 100}{C_b}, \qquad (1)$$

where C_b is the discharge coefficient that was experimentally determined with the baseline configurations and C_t is the discharge coefficient calculated for the various test configurations. Figures that display these shifts between experimental data and baseline values provide indicator lines at ± 0.1 percent. Baseline data for the 52 mm orifice meter are also compared to the discharge coefficient values predicted by the equation found in the orifice metering standard [5].

For each beta ratio tested, we typically calculate discharge coefficients at four flow rates. A complete data set includes at least four measurements at each flow rate taken over two days to include any effects of daily variability. For some tests we limit the size of beta ratios tested to those that would best characterize the effects of the configuration of interest. Figures 2 and 3 show the flow conditioners used during the course of our research. The dimensions and salient features are described in Table 1.

Table 1. Flow conditioner codes, descriptions, and measurements.

Identi-fication	Name	Number Tubes	Pattern/ In-line (I) Flanged (F)	Dimension mm (in) Length OD Tube ID
IT8	tube bundle	19	round-I	121 76 9.7 (4.8) (2.0) (0.4)
IT3	tube bundle	7	round-I	152 48 13 (6) (1.9) (0.5)
IT9	tube bundle	7	round-I	340 100 32 (13) (4) (1.3)
IT5	tube bundle	19	round-I	305 147 27 (12) (5.8) (1.1)
OS4	Sprenkle		three perf. plates (F)	203 104 --- (8) (4) ---
OS10	Sprenkle		three perf. plates (F)	508 254 --- (20) (10) ---

We measure differential pressures at either two or four flange tap positions. Figure 4 illustrates how each tap position is referenced in this report. Location A is in the plane of the nearest upstream elbow, along the inside of the bend. Location C is in the same plane but along the outside of the bend. Location B is in a plane perpendicular to the elbow and on top of the pipe, and location D is opposite to B.

Table 2 shows the various piping configurations, orifice meters, beta ratios, and flange pressure tap locations tested, and identifies the appropriate tables and figures where results for each configuration are summarized.

Table 2. Cross reference chart.

Fig. No.	ID (mm)	Beta Ratio						Flow Cond.	Table No.	Config. Fig. No.	Tap Location			
		0.24	0.40	0.48	0.54	0.67	0.73				A	B	C	D
5	52	X						OS4	4-7	1	X	X	X	X
6	"		X					OS4	8-15	1	X	X	X	X
7	"			X				OS4	16-19	1	X	X	X	X
8	"				X			OS4	20-23	1	X	X	X	X
9	"					X		OS4	24-27	1	X	X	X	X
10	"						X	OS4	28-31	1	X	X	X	X
12	"		X					---	32	11	X	X	X	X
13	"				X			---	33	11	X	X	X	X
14	"					X		---	34	11	X	X	X	X
15	"						X	---	35	11	X	X	X	X
16	"		X		X	X	X	---	SUM.	11	X	X	X	X
17	"				X			IT3	36-37	11	X	X	X	X
18	"					X		IT3	38-39	11	X	X	X	X
19	"						X	IT3	40-41	11	X	X	X	X
20	"				X	X	X	IT3	SUM.	11	X	X	X	X
21	"				X			IT5	42-43	11	X	X	X	X
22	"					X		IT9	44-45	11	X	X	X	X
23	"						X	IT8	46-47	11	X	X	X	X
24	"				X	X	X	IT8	SUM.	11	X	X	X	X
25	104		0.43					---	48	11	X		X	
26	"				0.55			---	11	11	X		X	
27	"					X		---	50	11	X		X	
28	"						X	---	51	11	X		X	
29	"		0.43		0.55	X	X	---	SUM.	11	X		X	
30	"					X		IT9	52-53	11	X		X	
31	"					X		IT9	SUM.-	11	X		X	
32	"						X	IT9	54-55	11	X		X	
33	"						X	IT8	SUM.	11	X		X	
34	154		0.37					OS10	56	1	X		X	
35	"				0.57			0S10	57	1	X		X	
37	"		0.37					IT5	58-59	36	X		X	
38	"		0.37					IT5	SUM.	36	X		X	
39	"				0.57			IT5	60-61	36	X		X	
40	"				0.57			IT5	SUM.	36	X		X	

2. SYSTEM DESCRIPTION

The gas research facility at the NIST in Boulder, Colorado, is a closed-loop thermodynamic cycle in which nitrogen is circulated between temperature limits of 85 K and 290 K at pressures of 0.5 MPa to 4.1 MPa. The portion of the loop in which the orifice meter is located operates near the upper end of the pressure and temperature ranges, 4 MPa and 289 K (580 psia, 60 °F). After the nitrogen gas passes through the orifice meter test section it is expanded and cooled to liquid phase. Mass flow rate is determined by weighing the liquid nitrogen collected in the weigh tank during a measured time interval.

The lower flow rate limit for our mass-based weighing system is 0.5 kg/s (1.1 lb/s). In order to test the 52 mm orifice meter at flow rates below 0.5 kg/s, we installed two calibrated turbine meters, in series, upstream of the orifice meter and any flow conditioners or piping configurations we are testing. When the weigh tank is used for mass measurement, all nitrogen flows through the turbines and orifice meter and then to the weigh tank. To measure flows below 0.5 kg/s, we bypass part of the gas through the turbine-orifice meter arrangement while maintaining the overall flow above 0.5 kg/s and use the turbines to measure flow rate. One of the turbine meters is used as the primary measurement device, and the other is used as a constant reference to the primary turbine meter by monitoring the output ratio between the two meters.

The turbine meters were calibrated over the range of our mass system. The turbine meters and associated piping were then sent to an independent calibration facility to be calibrated at lower flow rates. This calibration was done using air at pressure and temperatures similar to those at which our facility operates. These calibration data were combined to arrive at a calibration curve for the turbine meters which covers the entire flow range.

An uncertainty evaluation of our gas test facility is available as NIST Technical Note 1364 [6]. The uncertainty (2σ) in our ability to measure nitrogen mass flow rate with the weigh tank is ±0.18 percent, and uncertainty in mass flow rate when measured by the turbine meter is ±0.47 percent. These uncertainties do not include the uncertainty associated with nitrogen thermodynamic properties. The uncertainty in discharge coefficient calculation, a component of which is mass flow rate, varies with pressure differential. Table 3 provides the pressure differential ranges we measure for each orifice meter and beta ratio. Based on this information, measurement uncertainty for each beta ratio can be determined by referring to graphical information in [6]. Discharge coefficient uncertainties in [6] are calculated for the product of discharge coefficient and the expansion factor Y_2. We have included this product both the product CY_2 and the discharge coefficient C in the data tables.

Table 3. Pressure differential ranges.

Orifice Meter ID, mm (in)	Beta Ratio	Pressure Differential Range, kPa (inches H_2O)
52 (2)	0.24	75-180 (301-723)
	0.40	25-130 (100-522)
	0.48	12-130 (48-522)
	0.54	12-150 (48-603)
	0.67	12-75 (48-301)
	0.73	12-50 (48-200)
104 (4)	0.43	9-48 (36-193)
	0.55	3-20 (12-80)
	0.67	2.5-7.5 (10-30)
	0.73	2.5-5 (10-20)
154 (6)	0.37	4-27 (16-109)
	0.57[a]	2.5-4.3 (10-17)

a. Uncertainties of the pressure transducers used for this beta ratio were not analyzed.

3. TESTS AND RESULTS

3.1 52 mm (2 in) Orifice Meter

The nominal 52 mm (2 in) orifice meter is a commercially available stainless steel flowmeter with an actual internal diameter of 52.50 mm (2.067 in). The orifice meter consists of three sections: approach, upstream, and downstream (Figure 1). Meter tube sections are pinned to ensure alignment. One of two approach sections was used in the research conducted with this orifice meter, depending upon the piping configuration. One of the sections is 34D in length with an internal surface roughness of 4.3 μm (170 μin) Ra and was used for baseline work. Ra is the mean absolute deviation value of the surface finish measurement. The other approach section is 8D and is constructed of standard schedule 40 carbon steel pipe and weld-neck flanges. The upstream section is 9D with a roughness of 4.1 μm (160 μin), and the downstream section is 20D with a roughness of 4.4 μm (175 μin) Ra.

3.1.1 Baseline (52 mm)

Six beta ratios were tested in baseline conditions (Figure 1): 0.24, 0.40, 0.48, 0.54, 0.67, and 0.73. The baseline piping configuration consists of a 104 mm (4 in) Sprenkle flow conditioner and 44D of straight pipe upstream of the orifice plate. We measured differential pressures at four flange tap locations, simultaneously. Baseline tests with a more limited flow range using the 0.54 and 0.67 beta ratio plates were conducted in 1991. These data can be found in NIST Technical Note 1356 [4] and are included in this evaluation in graphical form only. However, these data are included in the regression fit to determine the baseline curve for the 0.54 and 0.67 beta ratios.

For this line size only, we compare baseline data to the orifice meter equation curve (RG) defined in the ANSI/API 2530-A.G.A. 3 orifice metering standard [5]. The database used to develop the equation is the result of more than 10 years of orifice meter work from laboratories in the United States and Europe. The database contains over 10 000 data points measured in nominal orifice meters sizes from 52 mm to 250 mm but does not contain any data for the 52 mm orifice meter with gas as the working fluid. For this reason, we compare our baseline data to the equation curves in Figures 5 through 10. The experimental data are listed in Tables 4 through 31. In general, the deviation between baseline discharge coefficients for the 52 mm orifice meter measured in our laboratory and the equation values shifts from negative to positive as the beta ratio increases.

Figure 5 shows that for a beta ratio of 0.24 the discharge coefficients measured in the baseline configuration are about -0.1 to -0.2 percent from those predicted by the RG equation. There is no difference in discharge coefficients between tap locations. Because all flow rates were below 0.5 kg/s, the turbine meter was used to determine mass flow for all data points with the 0.24 beta ratio.

Results from the baseline measurements with the 0.4 beta are shown in Figure 6. As with the 0.24 beta ratio, all mass flow measurements were turbine-meter based. This plot contains data using two orifice plates, 2C and 2D, with beta ratios of 0.4. We began our tests with plate 2C. On the fourth day of testing in the baseline configuration, all discharge coefficients were significantly lower (-0.3 percent) than those measured on previous days. All discharge coefficients measured in subsequent installation tests with plate 2C remained low. No reason for these shifts could be found.

To investigate the problem, we purchased another 0.4 beta ratio plate, 2D, and tested it in baseline conditions. The discharge coefficients with the new plate were the same as those from the first three days' tests with 2C. These combined data sets (first three days with 2C and one day with 2D) are shown in Figure 6. A curve fit to these data serves as a baseline for this beta ratio. Figure 6 indicates that the baseline curve is from -0.2 to -0.6 percent below the RG equation curve found in the standard. We still cannot explain the anomalous behavior with this beta ratio.

Figure 7 shows the agreement between data taken using the 0.48 beta ratio plate and the RG equation. Although there is some flow rate dependency, the mean deviation between our data and the RG equation values is less the 0.1 percent. The turbine meter was used to measure mass flow for all data except those above a pipe Reynolds number of 1.4×10^6, which is a combination of weigh tank-based mass measurements and turbine-based mass measurements.

For the 0.54 beta ratio approximately half of the mass flow rates were measured by the weigh tank, and the other half were turbine-based measurements. The filled symbols in Figure 8 represent the discharge coefficients measured in 1991. By improving our differential pressure measurement capability in 1992, we were able to expand the Reynolds number range, so baseline tests were repeated in 1992. The mean difference between our data and the RG equation values is about 0.23 percent.

Figure 9 displays baseline data from 1991 and 1992 for the 0.67 beta ratio. The mean deviation between our data and equation values is 0.3 percent, but the curve fit represented by all data varies from 0 to 0.27 percent from the equation. All values fall within the uncertainty parameters found in the standard [5] for this beta ratio and pipe Reynolds number. The fact that all discharge coefficients fall above the equation line may be due to the internal surface roughness of our orifice meter tube. Discharge coefficients measured when using larger beta ratios are more sensitive to pipe roughness and concentricity of the orifice.

The same trend is seen in Figure 10, which shows the baseline results for the 0.73 beta ratio. The mean deviation between our data and the equation values is 0.59 percent and the deviation between our baseline curve and the equation is 0.62 percent at a pipe Reynolds number of $2.34 \times 10^{6.}$ These values are within the practical uncertainty limits for this beta ratio as discussed in ANSI/API 2530 [5]. The practical uncertainty given in the standard for a beta ratio of 0.70 is 1 percent and increases with increasing beta ratio. Our results indicate that beta ratios of 0.67 or larger are much more sensitive to any disturbance and/or pressure tap location than smaller beta ratios.

3.1.2 No Flow Conditioner (52 mm)

Figure 11 illustrates the piping configuration used to test the effect of a long radius elbow located 17D upstream of the orifice meter. Seventeen pipe diameters of straight pipe is the minimum allowable overall distance between two elbows (separated by more than 10D) in the same plane and the orifice plate using a beta ratio of 0.75 and no flow conditioning [1]. The largest beta ratio requires the most upstream length, but if plates with different beta ratios will be used to meet different flow requirements, the length of straight pipe must be that required for the maximum beta ratio used. A 17D upstream length of straight pipe is also required for the 0.75 beta ratio plate downstream of a partially opened valve, but flow conditioning is required. Therefore, we performed many flow conditioner location tests in the 17D piping configuration. This section reviews the results of tests with no flow conditioning. The difference between discharge coefficients measured in this configuration and baseline values are computed at pipe Reynolds numbers of 0.4×10^6 for the 0.4 beta ratio and 1.6×10^6 for all other beta ratios. The results are displayed in Figures 12 through 16 and are listed in Tables 32 through 35.

Figure 12 shows that for the 0.4 beta ratio, discharge coefficients measured with an elbow at 17D and no flow conditioning are not different than baseline values. Plate 2D was used for these tests (Section 3.1.1). All data for this beta ratio were computed using the turbine meter as the reference.

Figure 13 indicates that in this configuration flow conditioning is not necessary for the 0.54 beta ratio. Reference flow rates for this and larger beta ratios are measured using a combination of measurements by the turbine and the weigh tank.

Figure 14 shows that with the 0.67 beta ratio, discharge coefficients are below baseline values, and the location of the flange pressure tap becomes a factor. If the differential pressure measured at flange tap location B (pipe top, $\perp$ to elbow) is used to calculate discharge coefficient, the value is only 0.13 percent from baseline values.

However, if tap location C (outside of bend, in elbow plane) is used, the deviation from baseline values is nearly 0.5 percent.

This same pattern is magnified in the 0.73 beta ratio tests: discharge coefficients are low and the difference between tap location B and C is nearly 0.5 percent. Data for this beta ratio are shown in Figure 15. Discharge coefficients measured at location C are -0.74 percent from baseline values.

The results for all beta ratios tested are shown in Figure 16. Our methods for determining the percent shift in discharge coefficients from baseline values is described in the introduction of this report. With an elbow at 17D and no flow conditioner, all discharge coefficients for the 0.4 and 0.54 beta ratios are near baseline values. This would not be an appropriate installation configuration in which to use the 0.67 or 0.73 beta ratio. Even though the discharge coefficients measured at tap location B are within 0.25 percent of the baseline, this result could be very installation dependent. We performed similar tests with a 104 mm (4 in) orifice meter with two tap locations (A and C) and did not get similar results with respect to which tap location yields discharge coefficients closest to baseline values (Section 3.2.2, Fig. 29).

3.1.3 Flow Conditioner Tests (52 mm)

In the same piping configuration (Figure 11), we tested the effect of placing either a 7 tube bundle flow conditioner (IT3) or a 19 tube bundle flow conditioner (IT8) at two positions upstream of the orifice plate. We conducted these tests with the three largest beta ratios: 0.54, 0.67, and 0.73. Because previous work at NIST-B and other laboratories [2,7,8] has shown that placing a flow conditioner 7D upstream of the orifice plate can result in discharge coefficients below baseline values, we limited our work to one day's test with the flow conditioner at this location. Results for these tests are shown in Figures 17 through 24 and are listed in Tables 36 through 47.

3.1.3.1 7 Tube Bundle Flow Conditioner (IT3)

Figure 17 shows that 11D is a better location for the 7 tube bundle (IT3) than 7D; however, tests in this piping configuration with no flow conditioning show that flow conditioning is not necessary with the 0.54 beta ratio (Figure 16). In fact, when IT3 is placed at 7D, discharge coefficients are farther from baseline values than if no flow conditioner is used. Figure 20 illustrates this result.

The 7 tube bundle does not improve the 0.67 beta ratio results regardless of position. Figure 18 shows that all discharge coefficients were below baseline values. There is less sensitivity to pressure tap location when IT3 is at 7D rather than 11D, but the relative effect of the tap location changes also. When IT3 is at 7D, measurement at flange tap location D are farthest from baseline, but if IT3 is located at 11D, using flange tap location C results in the largest error. This indicates that discharge coefficients may be affected by the orientation of the 7 tube bundle. We do not see this result with the 19 tube bundle flow conditioner.

Results are similar for the 0.73 beta ratio. Figure 19 shows that in general, all discharge coefficients are below baseline values when using the 7 tube bundle, but the 12D position is better than the 7D position. When IT3 is at 12D, discharge coefficients are within -0.5 percent of baseline values regardless of pressure tap location. Figure 20 shows that for the 0.73 beta ratio, as with the 0.67 beta ratio, the relative effect of tap location changes as the IT3 is moved closer to the orifice plate. This may be caused by the orientation of the 7 tube bundle in the pipe. For each beta ratio in figure 20, the graph indicates a slight offset between results from the two flow conditioner location tests. This is done for clarity and is not an indication of slightly varying beta ratios.

3.1.3.2 19 Tube Bundle Flow Conditioner (IT8)

For all beta ratios tested, the 19 tube bundle performs better than the 7 tube bundle when an elbow disturbance is 17D from the orifice plate. Figure 21 shows that with the 0.54 beta ratio placing IT8 at either 7D or 12D gives good results.

Figure 22 indicates that for the 0.67 beta ratio, 12D is a good location for the IT8 flow conditioner, but results for the 7D location are somewhat flow rate dependent.

Figure 23 shows that for the 0.73 beta ratio, the 12D location is preferable to the 7D location for IT8. Comparison of the results from Figure 23 to those in Figure 19, in which the 7 tube bundle was used, shows that there is less data scatter with 19 tube bundle, the result of a quieter pressure differential measurement. In all of our research we observe that for larger beta ratios, 0.67 and 0.73, the signal-to-noise ratio decreases. We think this phenomenon is greater with the 7 tube bundle than the 19 tube bundle in the 52 mm orifice meter and the 104 mm orifice meter (Section 3.2.2).

In general, we find that the 12D location for the 19 tube bundle provides the best results for all beta ratios when there is an elbow 17D from the orifice plate. A composite of these results is shown in Figure 24. For beta ratios of 0.67 and larger, flow conditioning improves meter performance. These results differ from the suggested installation guideline found in the standard, which indicates no flow conditioning in necessary for any beta ratio in this piping configuration.

3.2 104 mm (4 in) Orifice Meter

The nominal 104 mm (4 in) orifice meter is made from schedule 40 stainless steel that has been bored to an internal diameter of 103.657 mm (4.081 in). As with the 52 mm orifice meter, we used two approach sections with this meter. One approach section is 8D in length with an Ra of 0.76 μm (30 μin); the other is 6D with an Ra of 2.5 μm (100 μin). The upstream section is 11D with an internal roughness of 3.8 μm (150 μin) Ra and the downstream section is 16D. Pressure drop across the orifice plate is measured at flange tap locations A and C (Figure 4). Deviations between discharge coefficients measured in test configurations and baseline values are evaluated at a pipe Reynolds number of 1.25×10^6.

3.2.1 No Flow Conditioner (104 mm)

Figure 11 shows the piping configuration used for these tests. The rationale for conducting tests in this piping configuration is explained in Section 3.1.2. We tested four beta ratios in this configuration: 0.43, 0.55, 0.67, and 0.73. The results are shown in Figures

25 through 29 and are listed in Tables 48 through 51.

Figure 25 shows that for the 0.43 beta ratio orifice meter in the 104 mm line size, discharge coefficients are within 0.15 percent of baseline values for all but the lowest Reynolds number where increased scatter is observed. We estimate the repeatability of our system at approximately 0.15 percent.

Contrary to the results with the 52 mm orifice meter (Figure 13), it appears that flow conditioning is necessary for the 0.55 beta ratio in the 104 mm orifice meter. Figure 26 indicates that discharge coefficients are approximately -0.35 percent from baseline values. We previously tested this configuration and beta ratio with a 19 tube bundle at 13D [4]. In those tests the discharge coefficients were -0.25 percent from baseline values. For this beta ratio, we found the best location for the 19 tube bundle was directly downstream of the elbow; however, the difference in discharge coefficients at the two tap locations was 0.1 percent.

Discharge coefficients measured with the 0.67 beta ratio plate installed were about -0.24 percent from baseline values as seen in Figure 27. Figure 28 shows that with the 0.73 beta ratio the shift from baseline values is -0.35 to -0.5 percent, depending on tap location. It appears that flow conditioning is advisable for both of these beta ratios. Figure 29 displays the results for all beta ratios tested in this configuration.

3.2.2 Flow Conditioner Tests (104 mm)

Flow conditioner tests were conducted in the piping configuration shown in Figure 11. Only the 0.67 and 0.73 beta ratio plates were tested. Previous tests have shown that discharge coefficients measured with these beta ratios were the most susceptible to changes in upstream conditions. Results of these tests are shown in Figures 30 through 33, and data are listed in Tables 51 through 54.

Figure 30 shows the results for the 0.67 beta ratio and a 7 tube bundle (IT9) located in two positions, 7D and 12D. There is more scatter in the data than we have seen with the 19 tube bundle or with no flow conditioning, but the data show much less sensitivity to flow conditioner location. Figure 31 illustrates this point. We have included on this graph data that were reported in NIST Technical Note 1356 [4]. The 7 tube bundle can be placed at 7D or 12D and discharge coefficients are within 0.16 percent of baseline values. If the 19 tube bundle is used, placing the flow conditioner at 13D results in discharge coefficients from 0.1 to 0.3 percent below baseline values, depending on tap location. With the flow conditioner at 11D, shifts are even greater.

Figure 32 shows the results for the 0.73 beta ratio tests with the 7 tube bundle flow conditioner. The data scatter with this beta ratio is no greater then we have seen in previous tests. As with the 0.67 beta ratio results, discharge coefficients show little sensitivity to flow conditioner location. Again we have included results from NIST Technical Note 1356 [4] in Figure 33 to demonstrate the difference in performance between the 7 and 19 tube bundle (IT1). The 19 tube bundle performs marginally better at 13D than the 7 tube bundle performs at 12D only because the tap location effect is slightly smaller.

3.3 154 mm (6 in) Orifice Meter

The nominal 154 mm (6 in) orifice meter is a commercially available stainless steel flowmeter with an actual internal diameter of 154.330 mm (6.076 in). Two approach sections were used in the research conducted with this orifice meter, one for baseline and another for disturbed flow. The section used in baseline tests is approximately 34D in length. The other approach section is 9D with an internal surface roughness of 2.8 μm (110 μin) Ra. The upstream section is 9D with a roughness of 5.1 μm (200 μin), and the downstream section is approximately 15D.

Our reason for conducting tests with the 154 mm orifice meter is to determine whether the results of previous installation effects research conducted with orifice meters of other sizes are applicable to the 154 mm orifice meter. Because of our flow system limitations, we were only able to calculate discharge coefficients over a narrow Reynolds number range, particularly for the 0.57 beta ratio plate. These brief and limited tests were sufficient to predict that results from previous tests apply to the 154 mm orifice meter. All discharge coefficients were calculated with mass flow rate measured by the weigh tank. Deviations between discharge coefficients measured in the tee configuration and baseline values are evaluated at a pipe Reynolds number of 1×10^6.

3.3.1 Baseline (154 mm)

Figures 34 and 35 display the baseline data for beta ratios of 0.37 and 0.57 in the 154 mm orifice meter. These data are listed in Tables 56 and 57. The piping configuration used for these tests is shown in Figure 1. Data from all tap locations were fitted to a linear curve which appears on these figures as well as all subsequent figures exhibiting results from flow conditioner tests.

3.3.2 Flow Conditioner Tests (154 mm)

The piping configuration used to evaluate flow conditioner location in the 154 mm orifice meter is shown in Figure 36. This configuration was chosen because we have previously performed tests with the 104 mm orifice meter and a tee located 17D upstream of the orifice plate. Without flow conditioning, this configuration produced the largest shifts in discharge coefficients, especially with small beta ratios [3]. The results for the 154 mm tests are shown in Figures 37 through 40 and data are listed in Tables 58 through 61.

The data for the 0.37 beta ratio shown in Figures 37 and 38 indicate that placing a 19 tube bundle at either 7D or 12D results in discharge coefficients equivalent to baseline values. Figures 39 and 40 indicate the results for the 0.57 beta ratio in the 154 mm orifice meter are more consistent with results from previous tests in other line sizes. Placing the 19 tube bundle at 7D causes a negative shift in discharge coefficients. If the flow conditioner is located 12D from the orifice plate, discharge coefficients are equivalent to those measured in baseline conditions.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Research results from this laboratory are usually reported as comparative results; we compare orifice meter discharge coefficients measured in various piping configurations to those measured in baseline conditions. However, in this report we compare the 52 mm baseline data to values predicted by the standards equation [5] because the regression database used to develop the equation contained no gas data for the 52 mm orifice meter (Section 3.1.1). For all beta ratios we tested, the difference between our data and the values predicted by the equation were within the uncertainty of the equation as presented in the standard. A more detailed comparison that includes data points from the regression database can be found in the proceedings from the American Society of Mechanical Engineers Fluid Measurement and Instrumentation Forum [9].

Although the standard [1] states that no flow conditioning is necessary when a single elbow is at least 17D from the orifice plate, we find that for the larger beta ratios this is not the case. Flow conditioning is necessary with the 0.55, 0.67, and 0.73 beta ratios in the 104 mm orifice meter and with the 0.67 and 0.73 beta ratios for the 52 mm orifice meter.

For the 52 mm orifice meter, results from tests with the 7 and 19 tube bundle flow conditioners at two locations with beta ratios of 0.54, 0.67 and 0.73 were beta ratio dependent, but the best results were achieved by placing a 19-tube bundle flow conditioner 12D upstream of the orifice plate. However, with this arrangement, discharge coefficients for the 0.67 and 0.73 beta ratios were below baseline values. We interpret this to mean that 12D is not a sufficient distance between the flow conditioner and the orifice plate in our facility. Though the 0.54 beta ratio does not need flow conditioning, placing the 19 tube bundle at 12D does not deteriorate performance.

Results of the 104 mm orifice meter tests with the 0.67 and 0.73 beta ratio are different from those for the 52 mm orifice meter. When the 7 tube bundle flow conditioner is used, discharge coefficients are less sensitive to the location of the flow conditioner than when a 19 tube bundle is used. Discharge coefficients are closer to baseline values when the 7 tube bundle flow conditioner is located at 12D than when the 19 tube bundle is located at 11D or 13D, but signal to noise ratio is smaller when the 7 tube bundle is used, and there is more variability between tap locations with the 0.73 beta ratio. Our work in the past has indicated that for beta ratios of 0.55 and larger, the best location for the 19 tube bundle in our 104 mm orifice meter is at the outlet of the elbow [4], and these results are better than the 12D location of the 7 tube bundle. The most unpredictable results are found with the 0.73 beta ratio, and we recommend avoiding its use.

We taxed the limitations of this facility to test the 154 mm orifice meter, but we think that general results for other orifice meter line sizes can be translated to this orifice meter. With a tee 18D upstream of the orifice plate and a 19 tube bundle flow conditioner is located 12D from the orifice plate, discharge coefficients are within 0.1 percent of baseline values for the 0.37 and 0.57 beta ratios.

4.2 Synopsis of Results from the NIST Flow Facility

(1) When a single elbow is 17D from the orifice plate, flow conditioning is necessary with the 0.67 and 0.73 beta ratios in the 52 mm orifice meter and with the 0.55, 0.67, and 0.73 beta ratios in the 104 mm orifice meter.

(2) Flow conditioner tests with the 52 mm orifice meter are beta ratio dependent, but the best results were achieved with a 19 tube bundle flow conditioner 12D upstream of the orifice plate. Discharge coefficients were below baseline values indicating that 12D is not a sufficient distance between flow conditioner and orifice plate in this facility.

(3) In the 104 mm orifice meter, discharge coefficients are less sensitive to the position of the 7 tube bundle than the 19 tube bundle, but there is more data scatter.

(4) Tests with 0.37 and 0.57 beta ratios in a 154 mm orifice meter indicate that placing a 19 tube bundle flow conditioner at 12D resulted in discharge coefficients at baseline values.

4.3 Recommendations

We have performed years of research to try to determine when flow conditioning is necessary, and if so, where the flow conditioner should be placed to produce discharge coefficients equivalent to those measured in well-developed flow. Ideally, we would like the flow conditioner to isolate the orifice plate from upstream flow disturbances no matter what creates them and to perform comparably in a particular location for all beta ratios. Tests from this laboratory and others have determined that these criteria cannot be met by commonly used tube bundle flow conditioners. The 'best' location for flow conditioning varies with the type of flow conditioner, the disturbance, the flange pressure tap location, and beta ratio. Results between laboratories sometimes differ even though piping configurations between the last disturbance and the orifice plate are similar. This may be due to differing configurations upstream of the last disturbance, and if so, the task of establishing general guidelines for all field installations is even further complicated.

A positive outcome of this exhaustive research is the expanded effort to design and test new flow conditioners that will meet the criteria outlined above. In general, we have found that in this laboratory placing a 19 tube bundle flow conditioner from 12D to 14D upstream of the orifice plate produces discharge coefficients within ±0.25 percent of baseline values for beta ratios of 0.67 and smaller.

5. ACKNOWLEDGEMENTS

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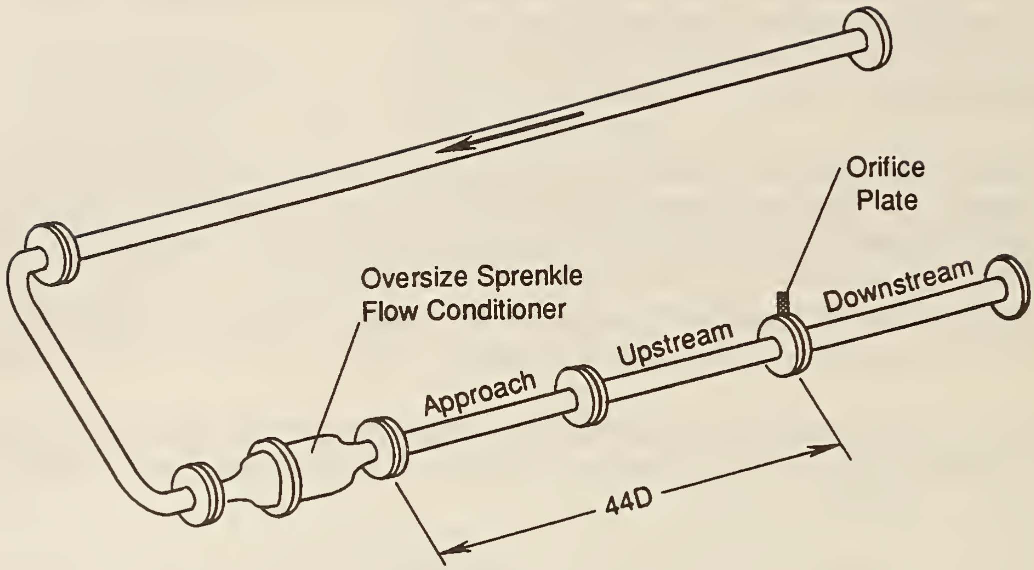

Figure 1. Baseline configuration.

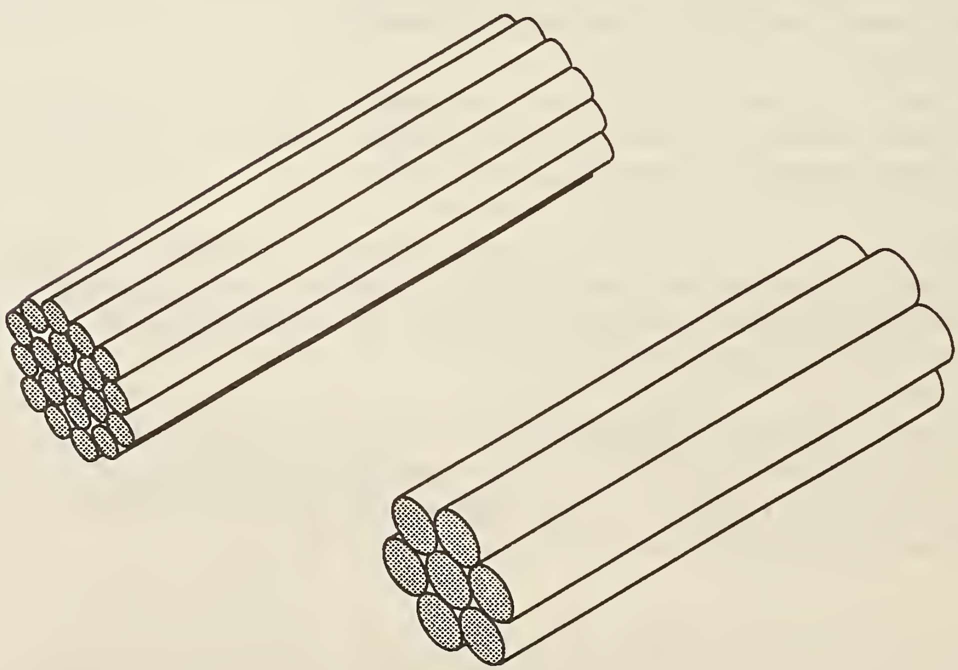

Figure 2. In-line, 19 and 7 tube bundle flow conditioners.

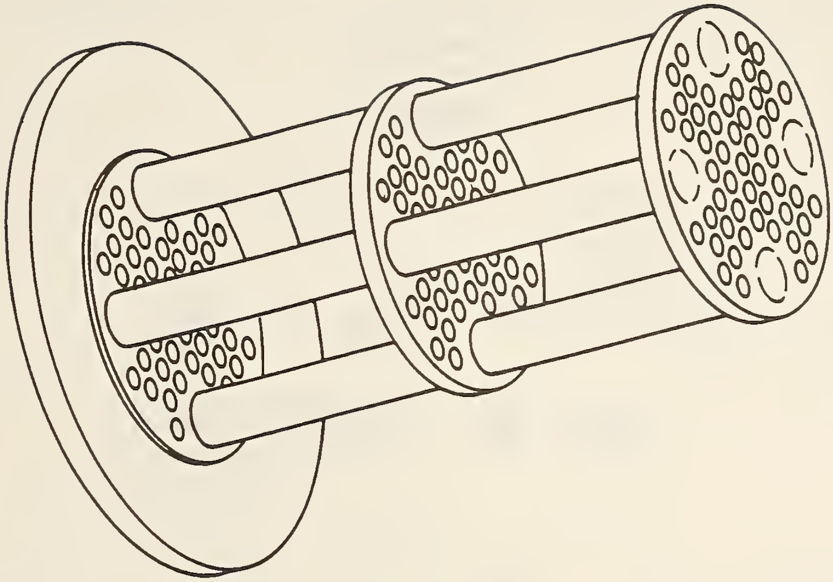

Figure 3. Flanged, Sprenkle flow conditioner.

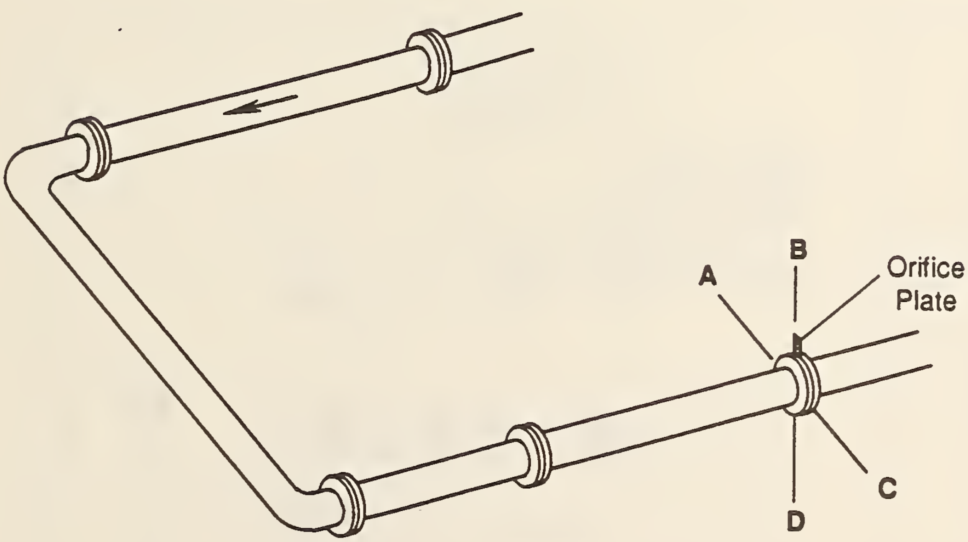

Figure 4. Flange pressure tap location code.

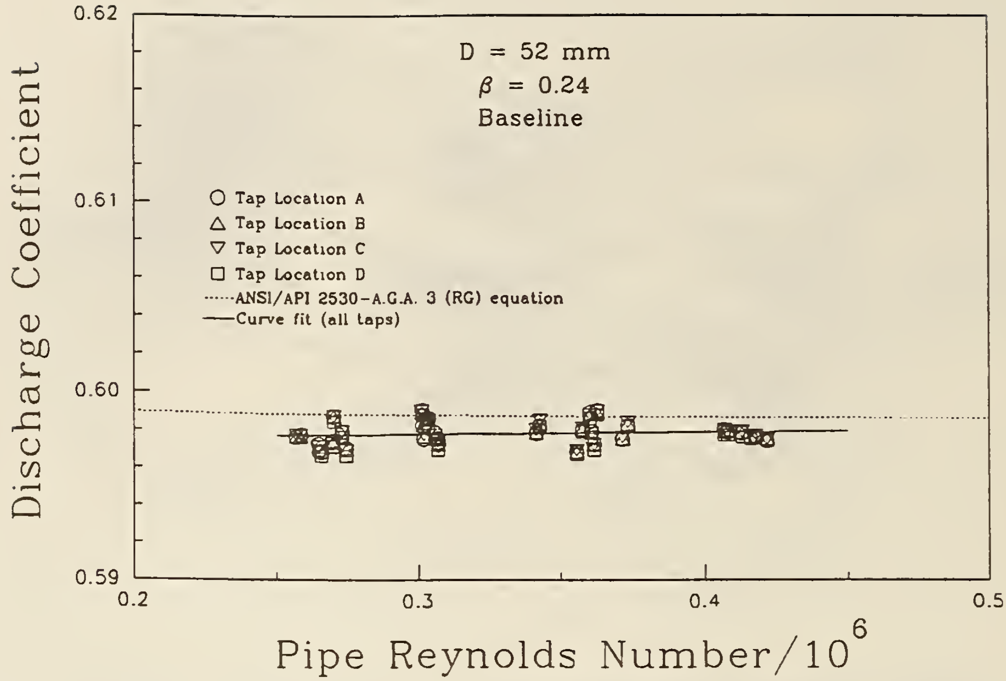

Figure 5. Discharge coefficient vs. Reynolds number for the 0.24 beta ratio plate, oversize Sprenkle at 44D, and 4 flange tap locations.

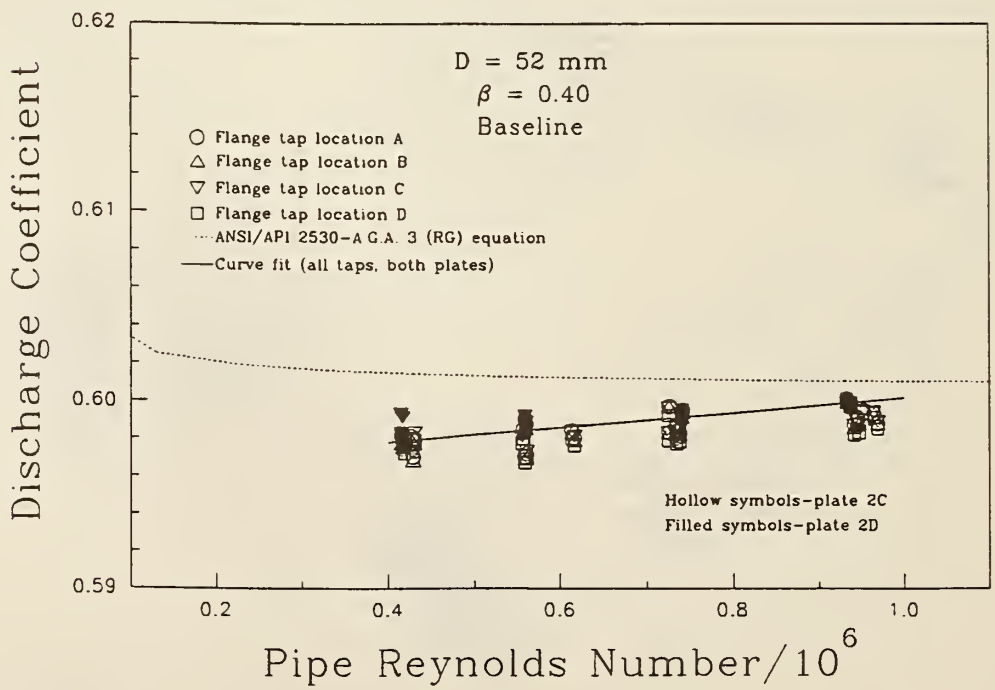

Figure 6. Discharge coefficient vs. Reynolds number for the 0.40 beta ratio plate, oversize Sprenkle at 44D, and 4 flange tap locations.

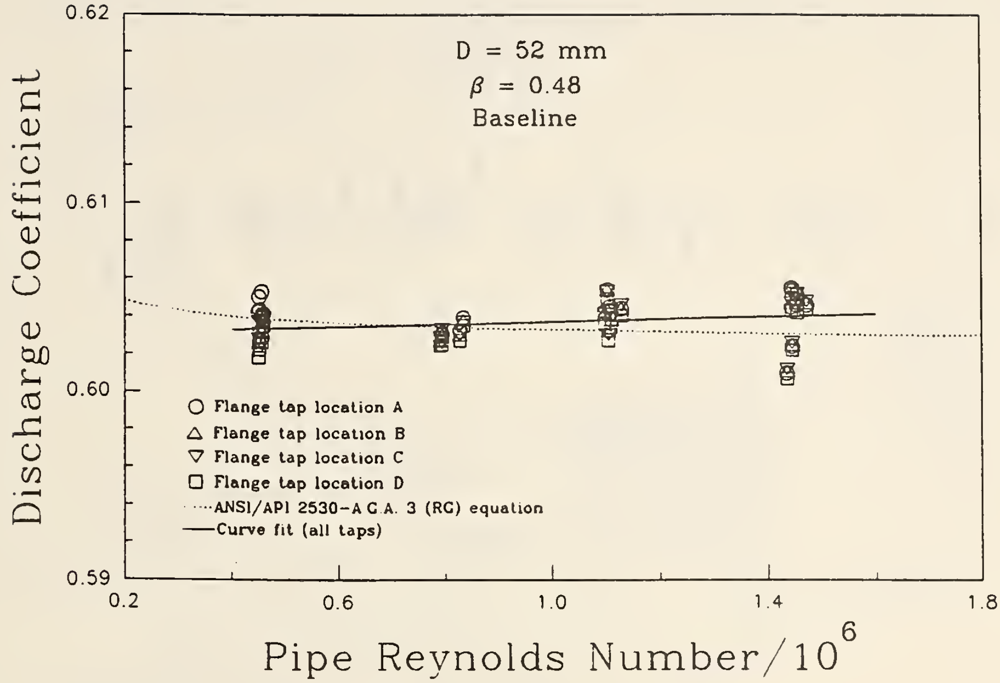

Figure 7. Discharge coefficient vs. Reynolds number for the 0.48 beta ratio plate, oversize Sprenkle at 44D, and 4 flange tap locations.

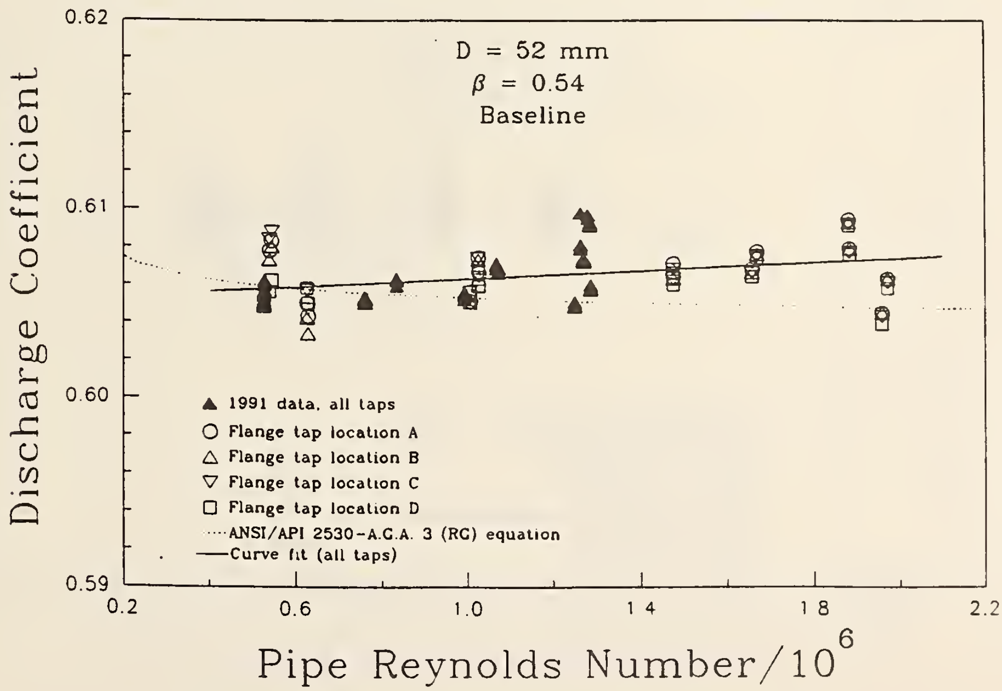

Figure 8. Discharge coefficient vs. Reynolds number for the 0.54 beta ratio plate, oversize Sprenkle at 44D, and 4 flange tap locations.

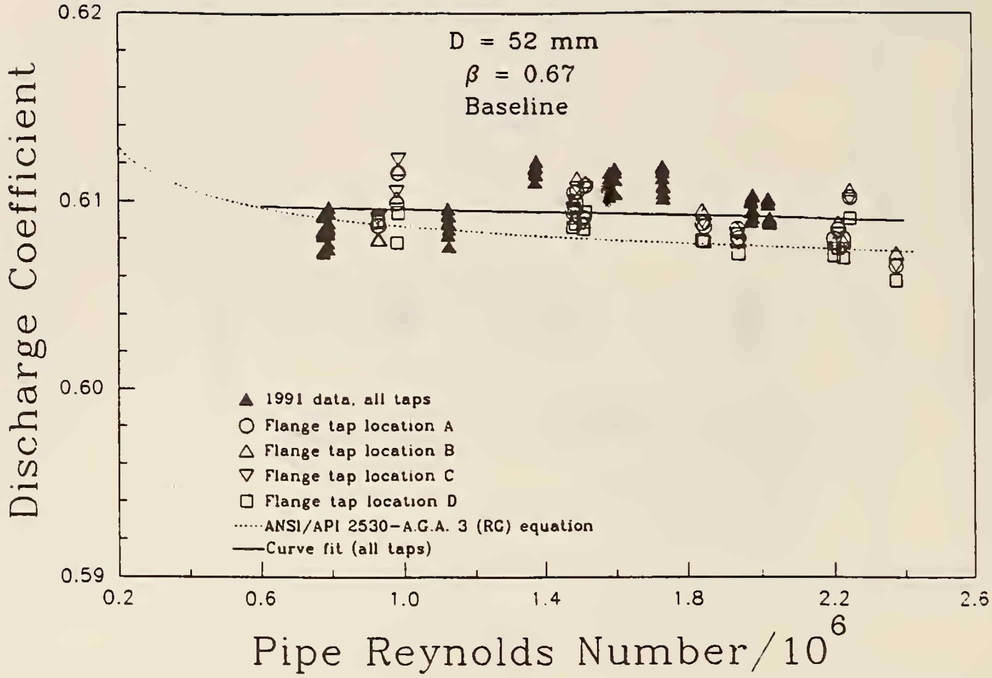

Figure 9. Discharge coefficient vs. Reynolds number for the 0.67 beta ratio plate, oversize Sprenkle at 44D, and 4 flange tap locations.

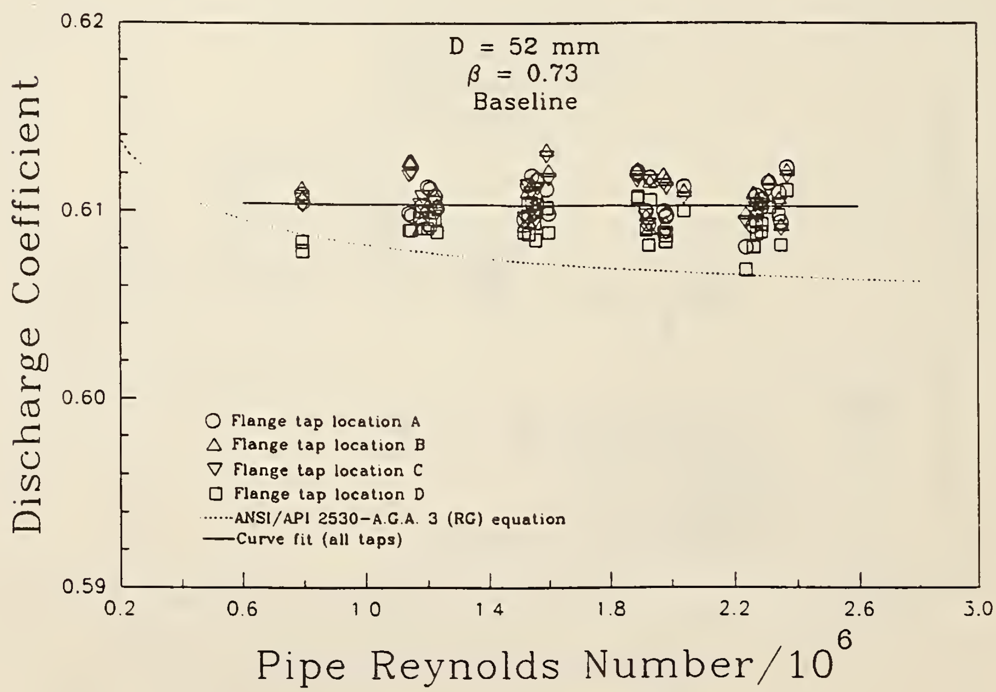

Figure 10. Discharge coefficient vs. Reynolds number for the 0.73 beta ratio plate, oversize Sprenkle at 44D, and 4 flange tap locations.

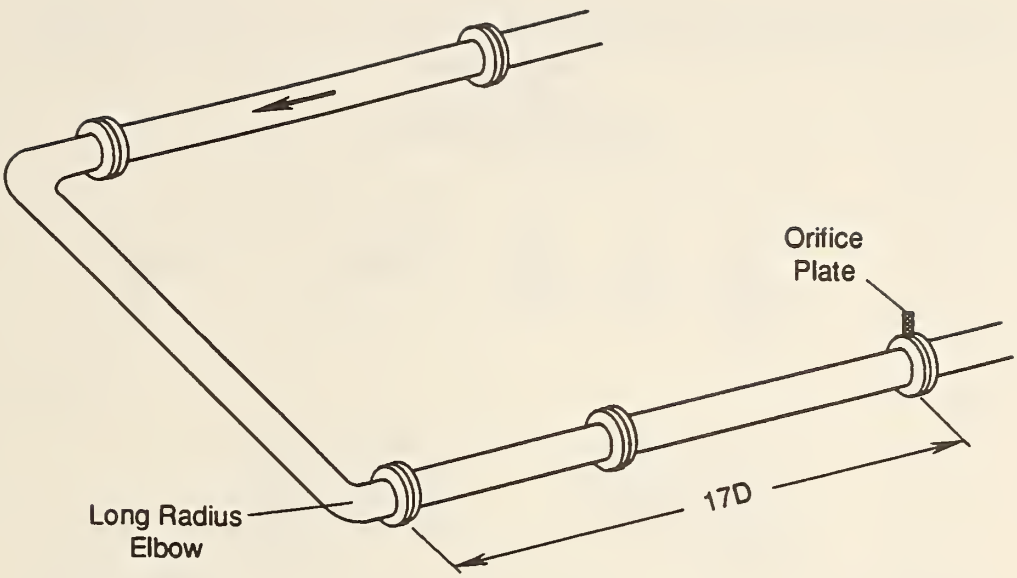

Figure 11. Test configuration, long radius elbow at 17D.

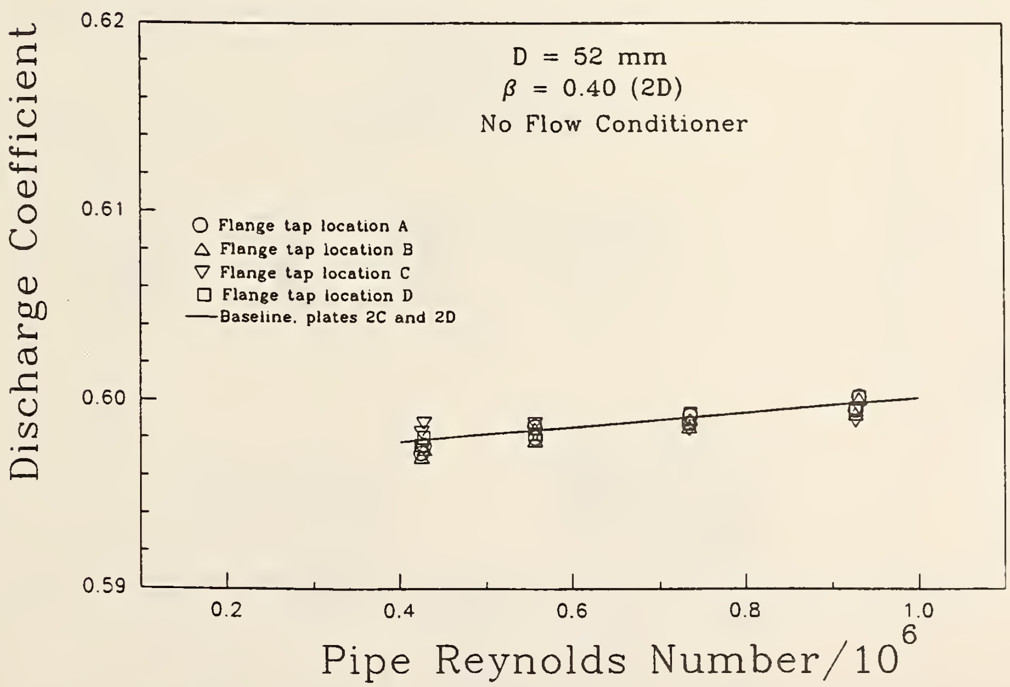

Figure 12. Discharge coefficient vs. Reynolds number for the 0.40 beta ratio plate, elbow at 17D, no flow conditioner, and 4 flange tap locations.

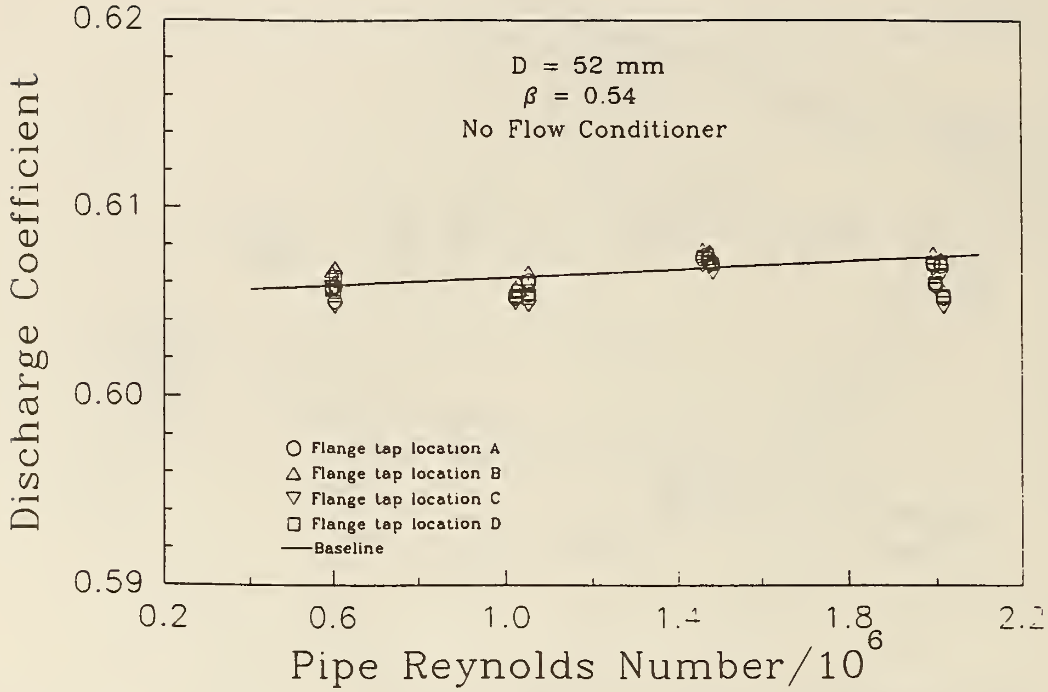

Figure 13. Discharge coefficient vs. Reynolds number for the 0.54 beta ratio plate, elbow at 17D, no flow conditioner, and 4 flange tap locations.

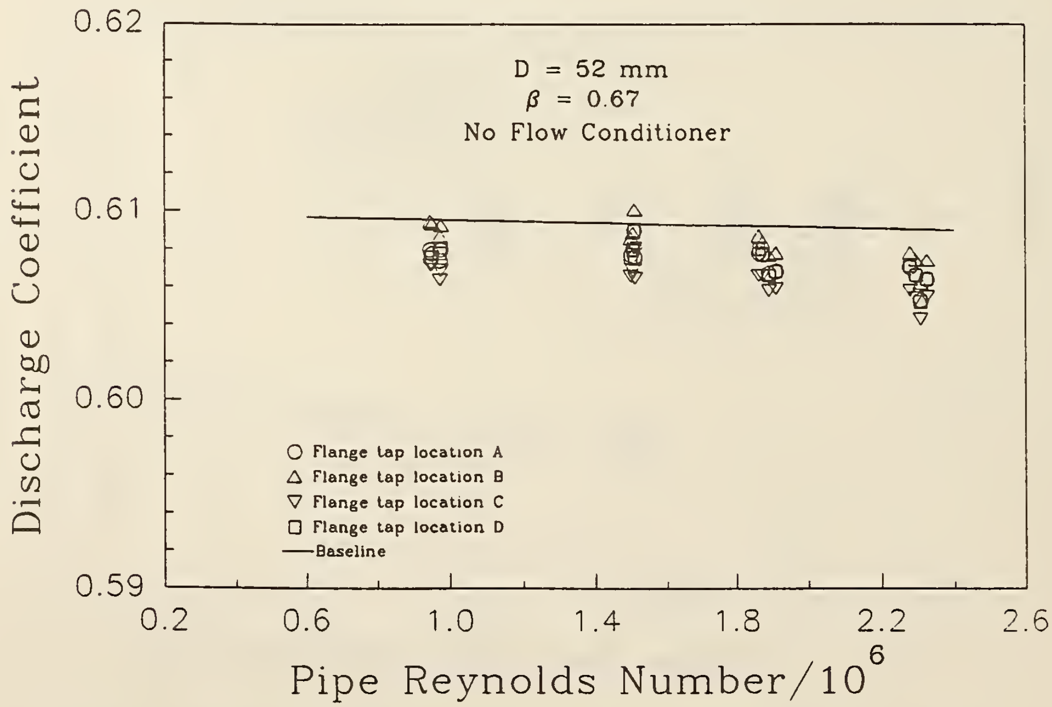

Figure 14. Discharge coefficient vs. Reynolds number for the 0.67 beta ratio plate, elbow at 17D, no flow conditioner, and 4 flange tap locations.

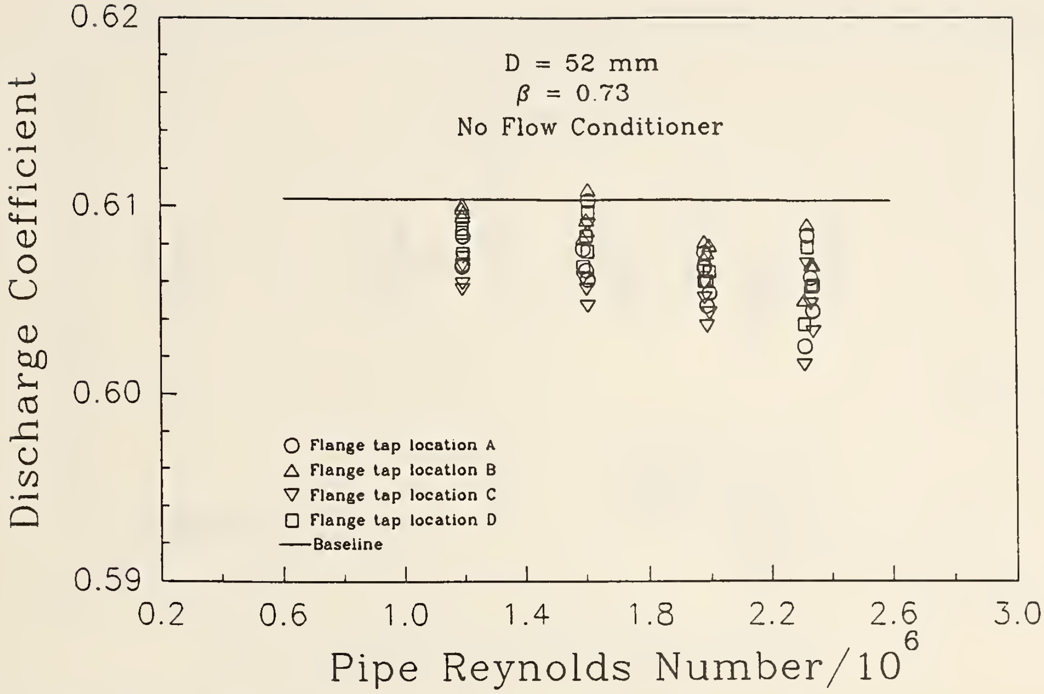

Figure 15. Discharge coefficient vs. Reynolds number for the 0.73 beta ratio plate, elbow at 17D, no flow conditioner, and 4 flange tap locations.

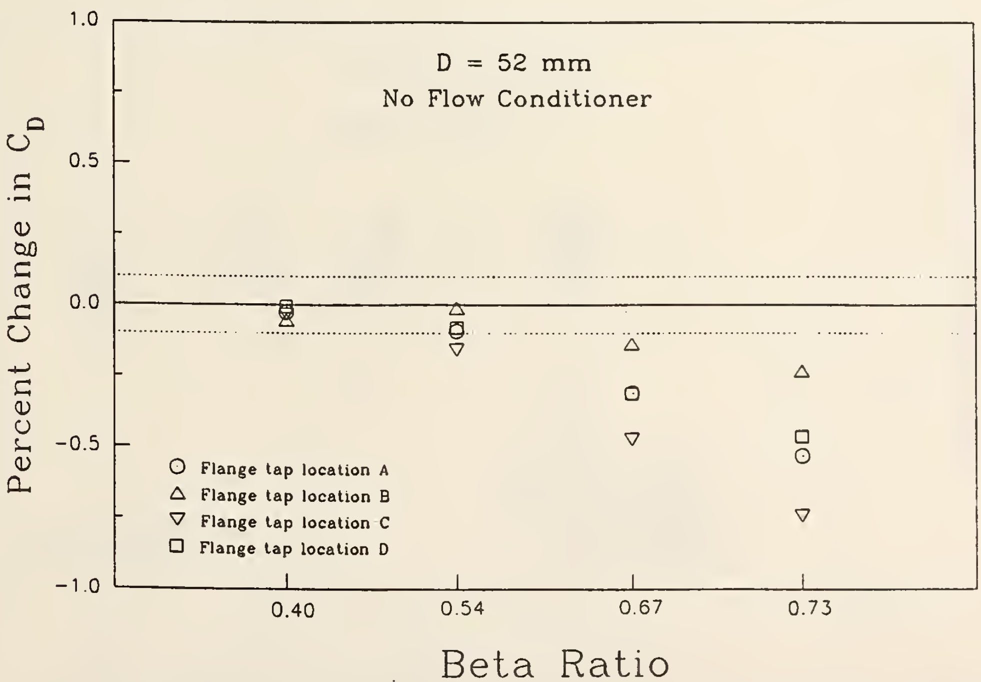

Figure 16. Percent change in discharge coefficient vs. beta ratio with an elbow at 17D, no flow conditioner, and 4 flange tap locations.

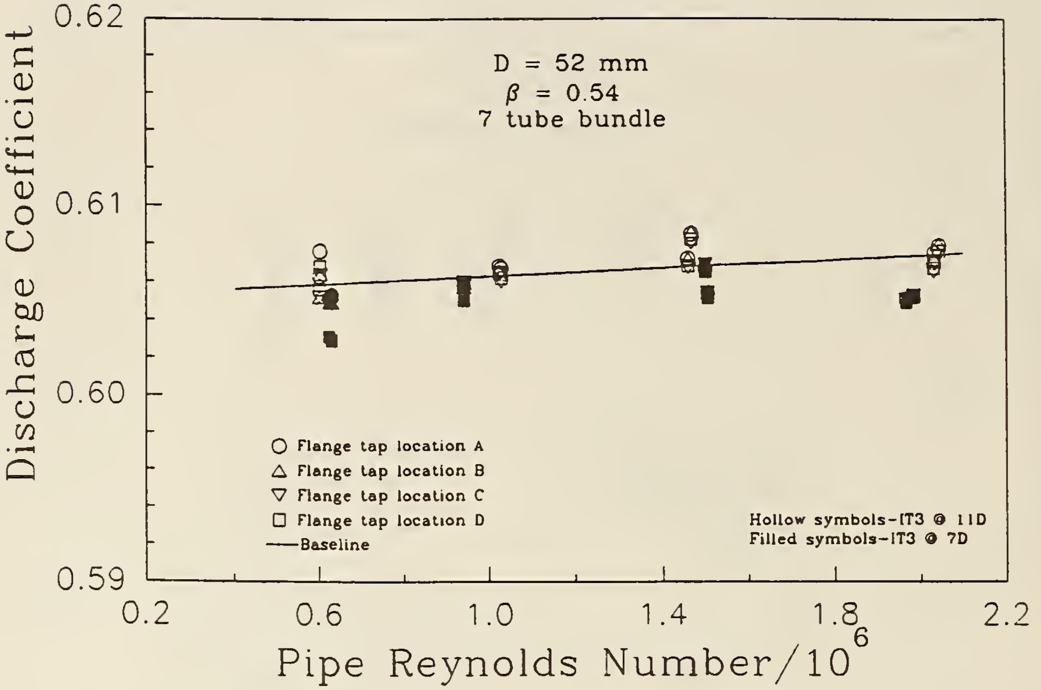

Figure 17. Discharge coefficient vs. Reynolds number for the 0.54 beta ratio plate, elbow at 17D, 7 tube bundle flow conditioner at 7D or 11D, and 4 flange tap locations.

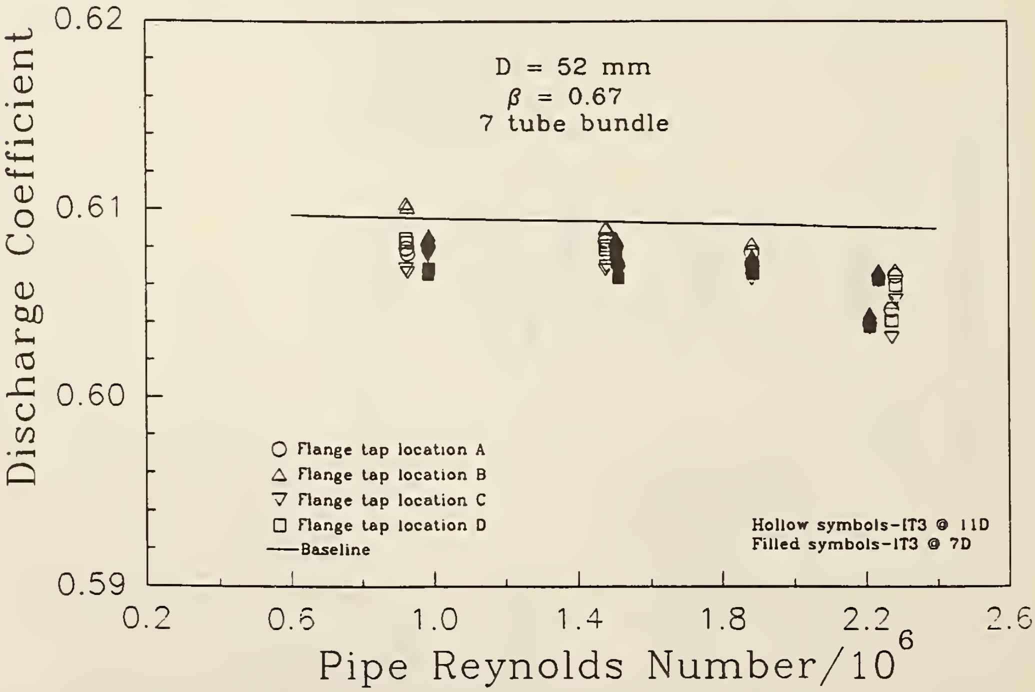

Figure 18. Discharge coefficient vs. Reynolds number for the 0.67 beta ratio plate, elbow at 17D, 7 tube bundle flow conditioner at 7D or 11D, and 4 flange tap locations.

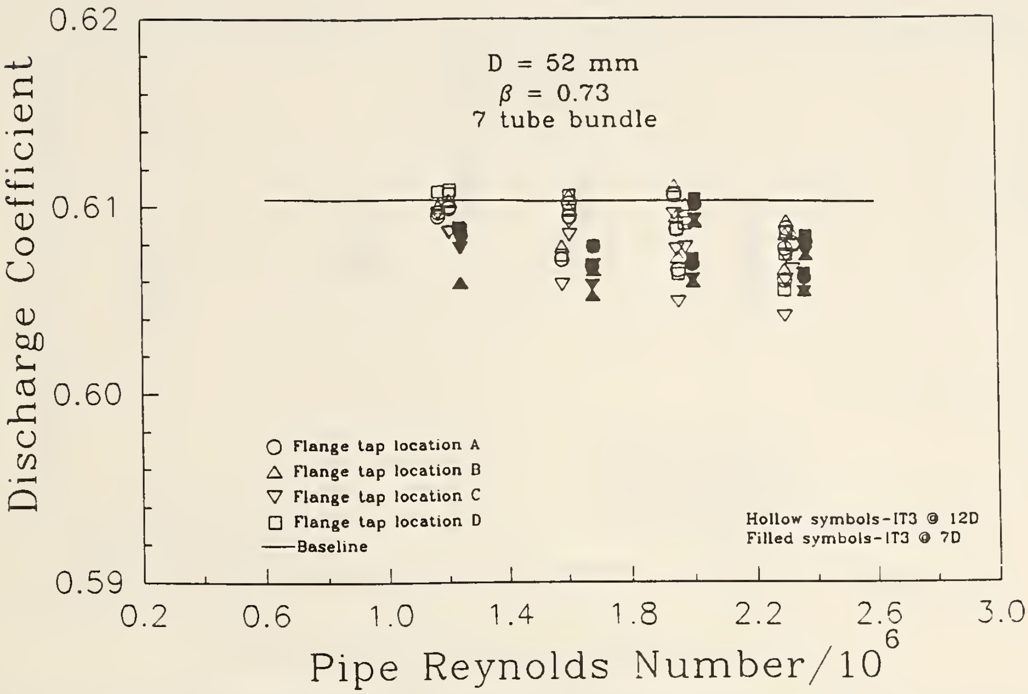

Figure 19. Discharge coefficient vs. Reynolds number for the 0.73 beta ratio plate, elbow at 17D, 7 tube bundle flow conditioner at 7D or 12D, and 4 flange tap locations.

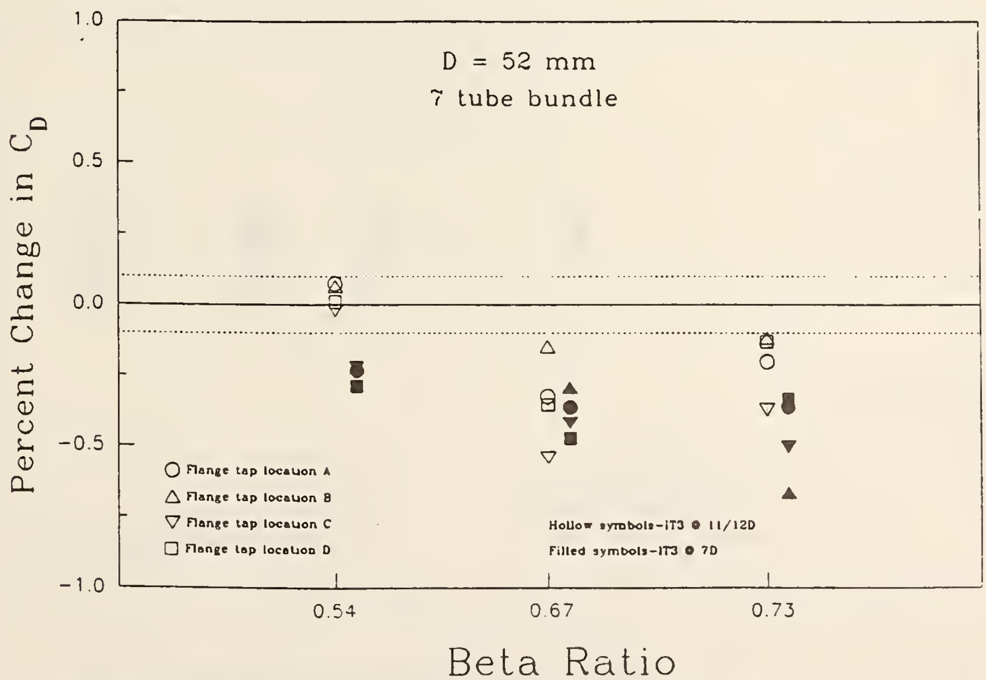

Figure 20. Percent change in discharge coefficient vs. beta ratio with an elbow at 17D, 7 tube bundle flow conditioner at 7D, 11D, or 12D, and 4 flange tap locations.

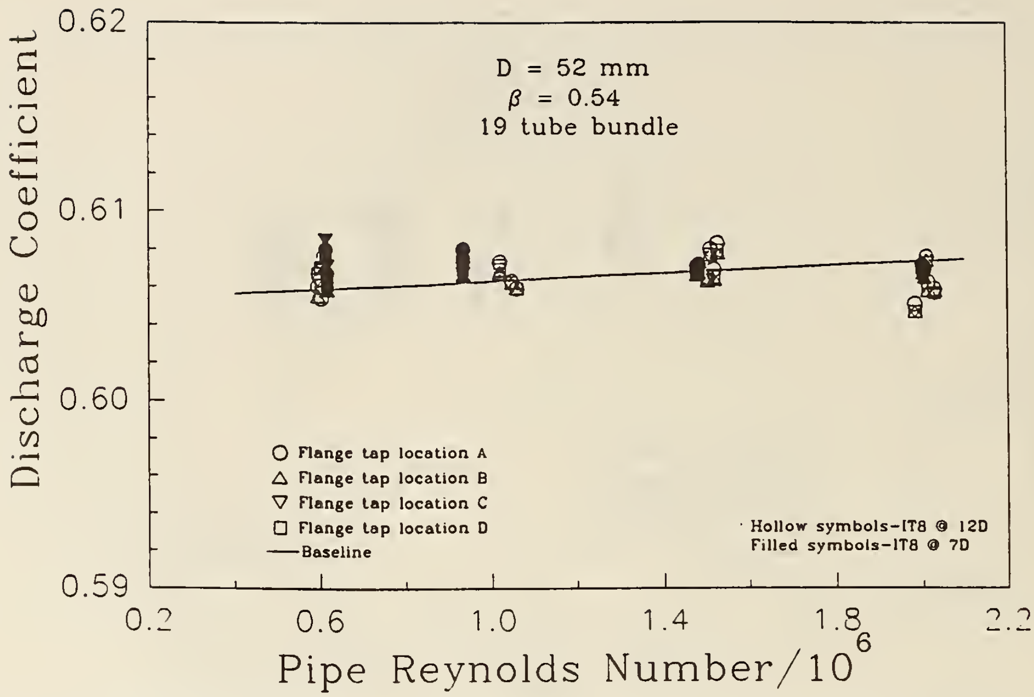

Figure 21. Discharge coefficient vs. Reynolds number for the 0.54 beta ratio plate, elbow at 17D, 19 tube bundle flow conditioner at 7D or 12D, and 4 flange tap locations.

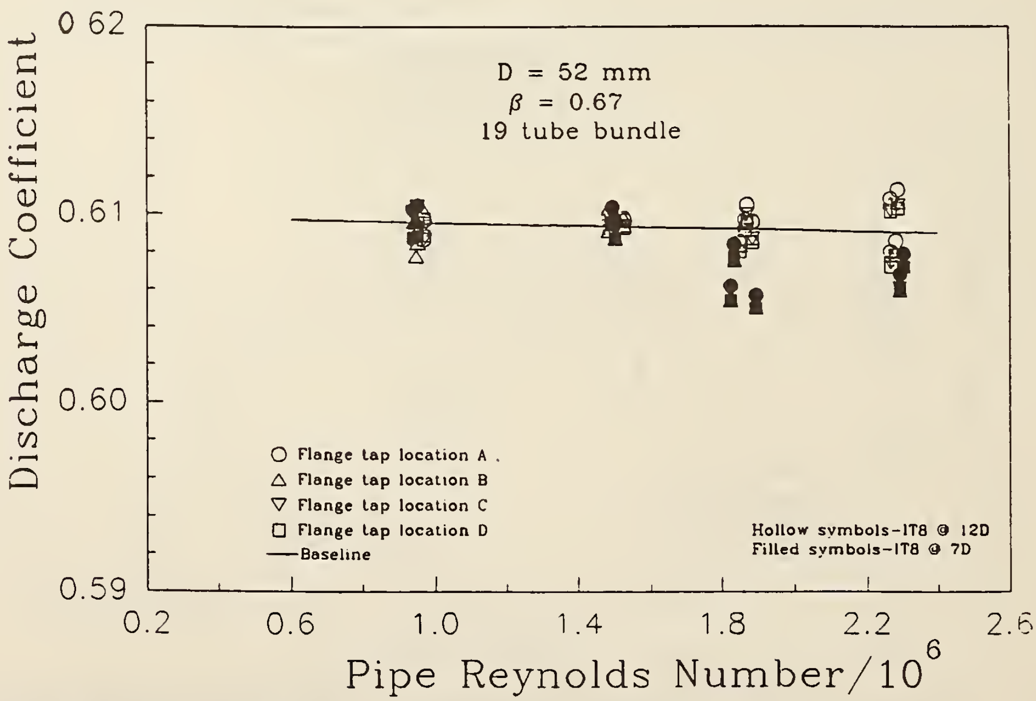

Figure 22. Discharge coefficient vs. Reynolds number for the 0.67 beta ratio plate, elbow at 17D, 19 tube bundle flow conditioner at 7D or 12D, and 4 flange tap locations.

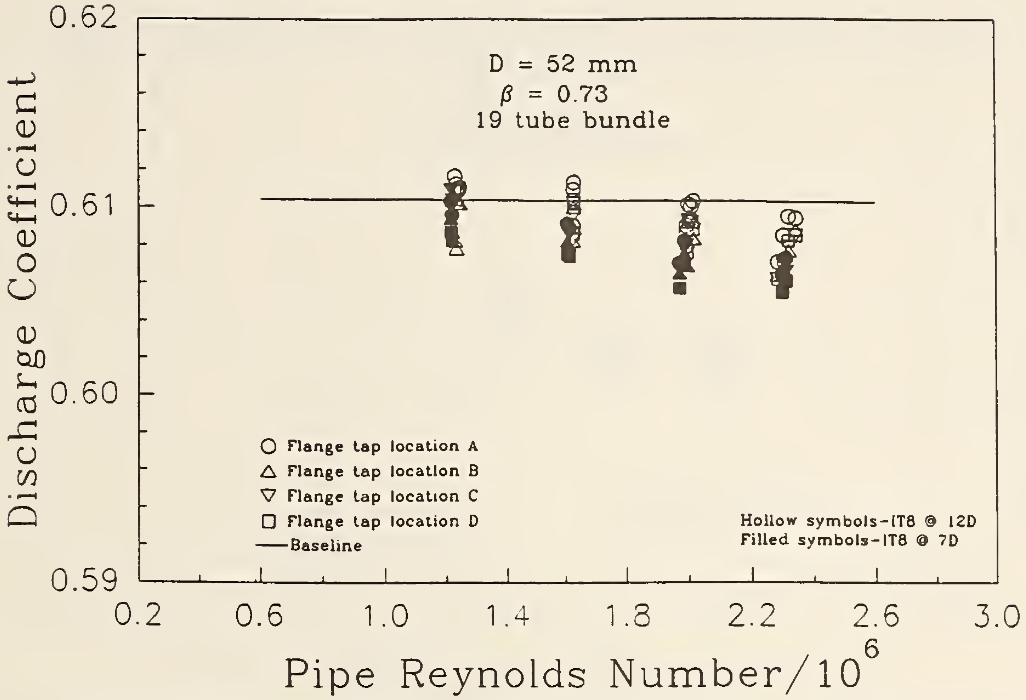

Figure 23. Discharge coefficient vs. Reynolds number for the 0.73 beta ratio plate, elbow at 17D, 19 tube bundle flow conditioner at 7D or 12D, and 4 flange tap locations.

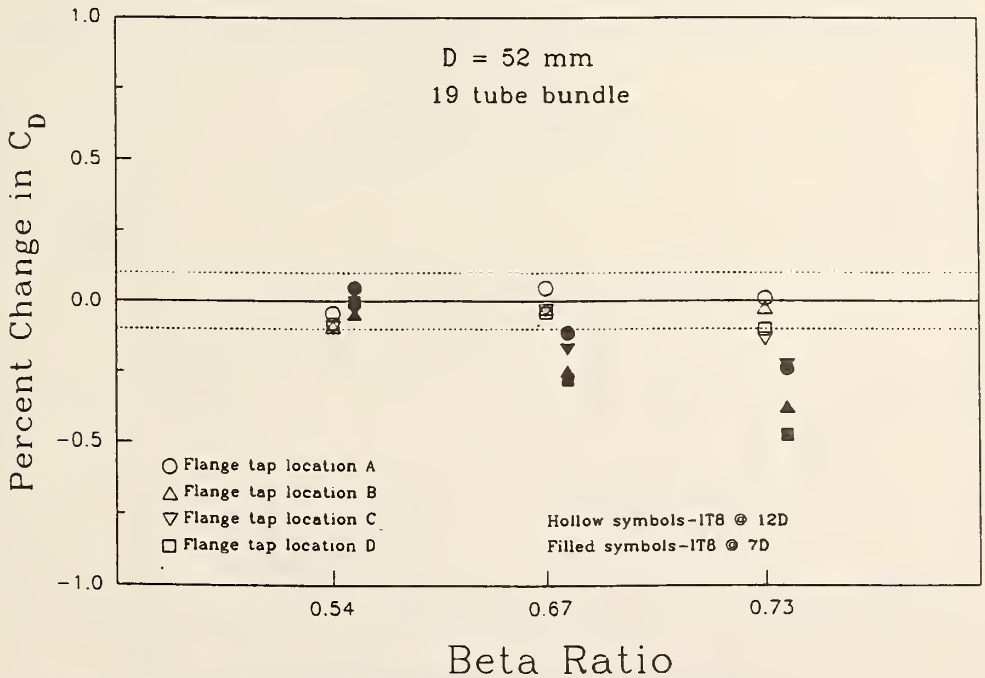

Figure 24. Percent change in discharge coefficient vs. beta ratio with an elbow at 17D, 19 tube bundle flow conditioner at 7D or 12D, and 4 flange tap locations.

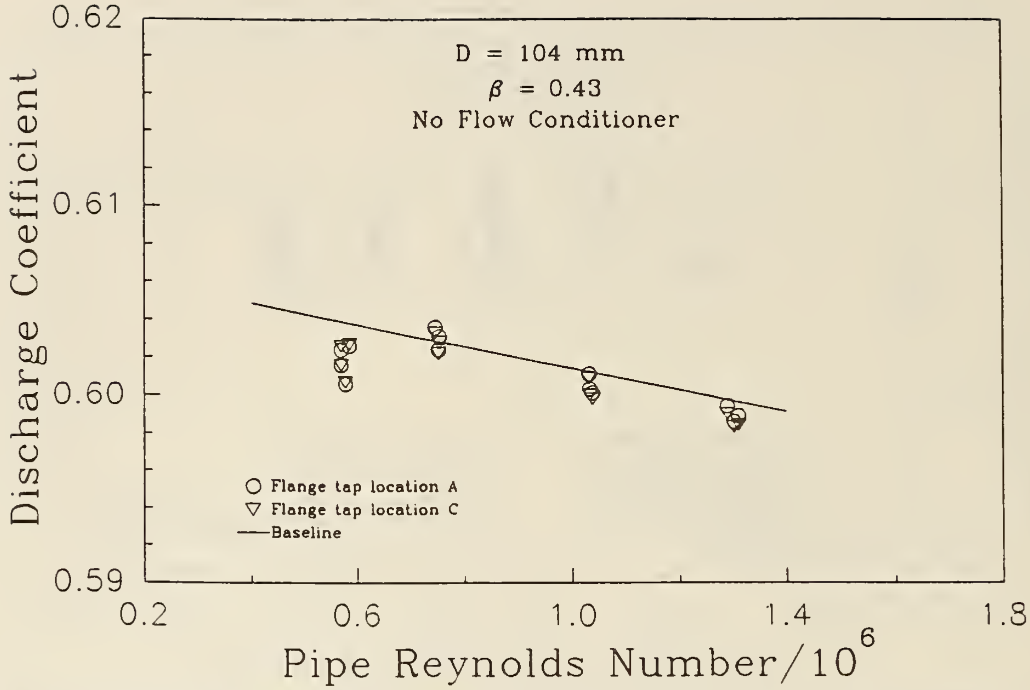

Figure 25. Discharge coefficient vs. Reynolds number for the 0.43 beta ratio plate, elbow at 17D, no flow conditioner, and 2 flange tap locations.

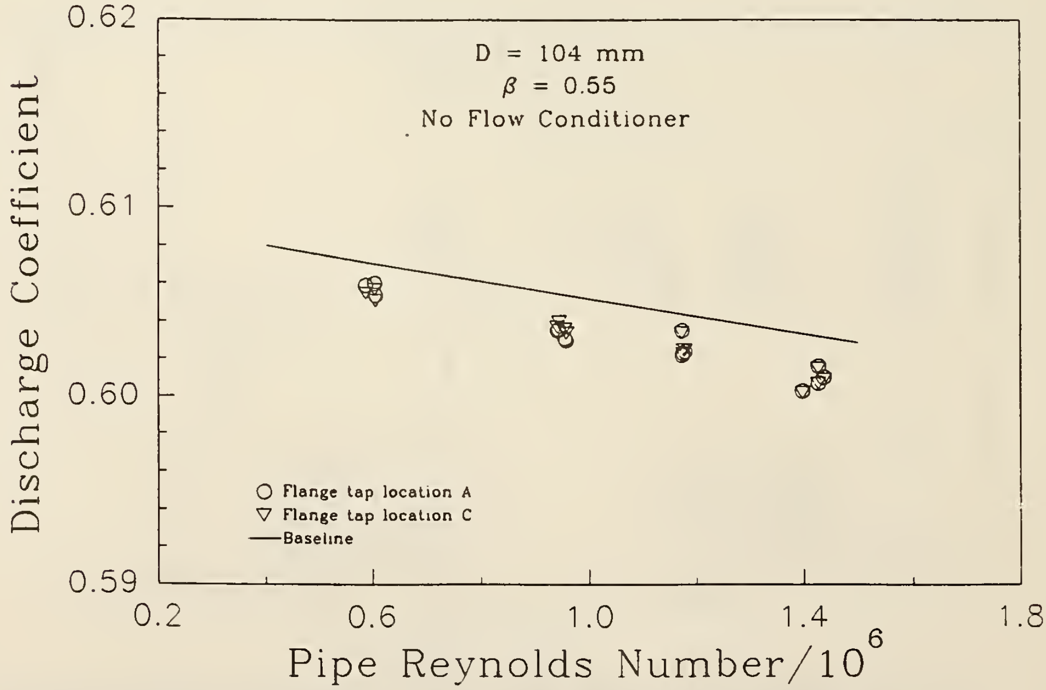

Figure 26. Discharge coefficient vs. Reynolds number for the 0.55 beta ratio plate, elbow at 17D, no flow conditioner, and 2 flange tap locations.

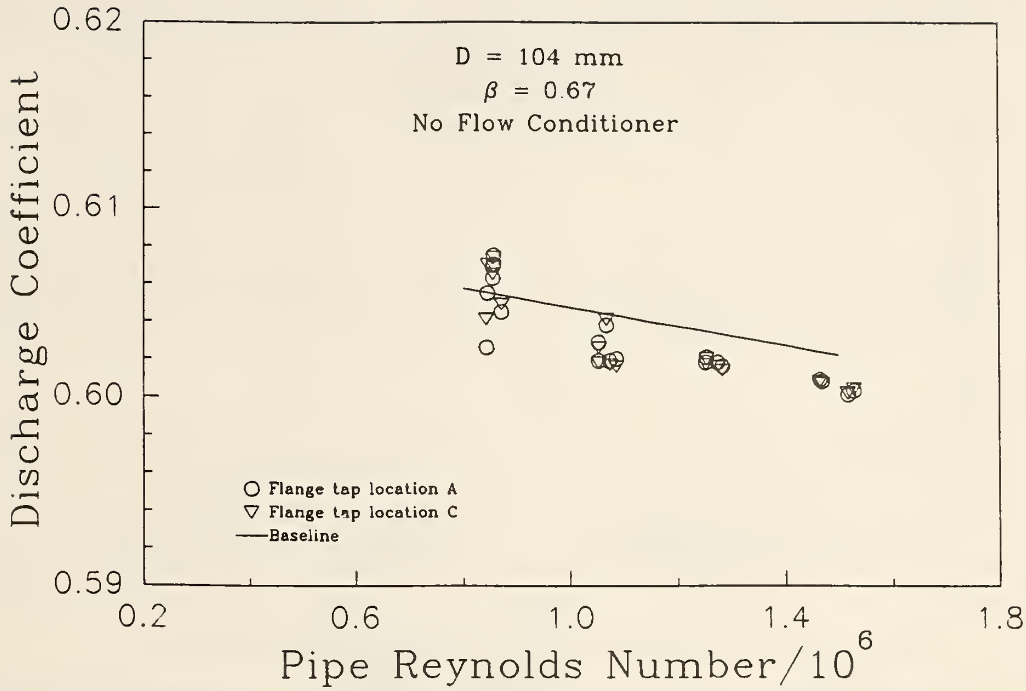

Figure 27. Discharge coefficient vs. Reynolds number for the 0.67 beta ratio plate, elbow at 17D, no flow conditioner, and 2 flange tap locations.

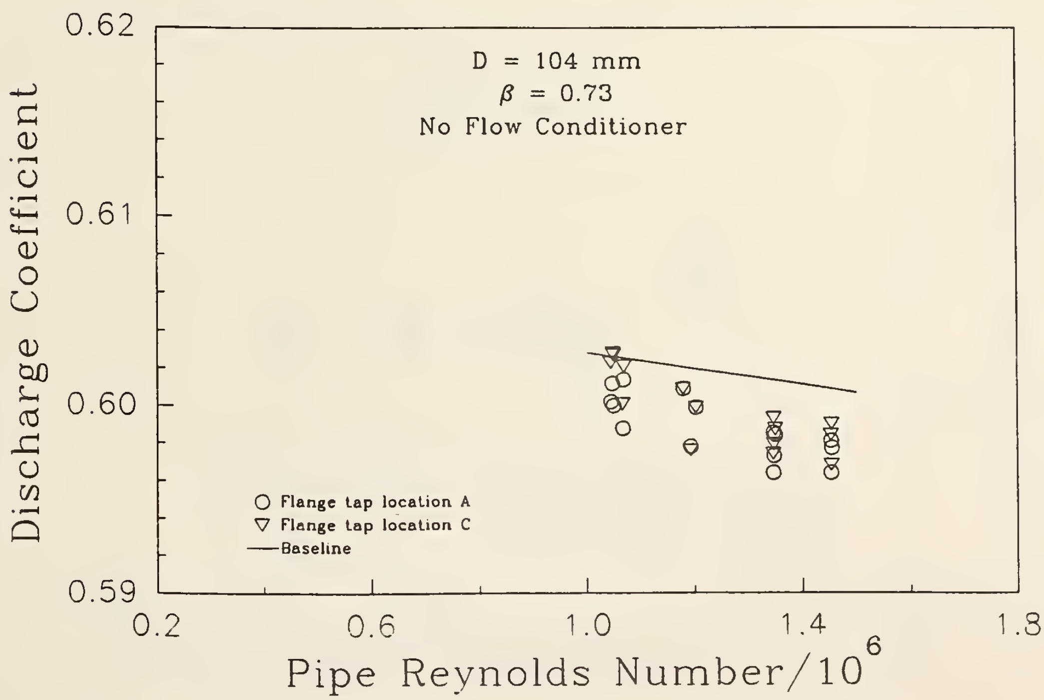

Figure 28. Discharge coefficient vs. Reynolds number for the 0.73 beta ratio plate, elbow at 17D, no flow conditioner, and 2 flange tap locations.

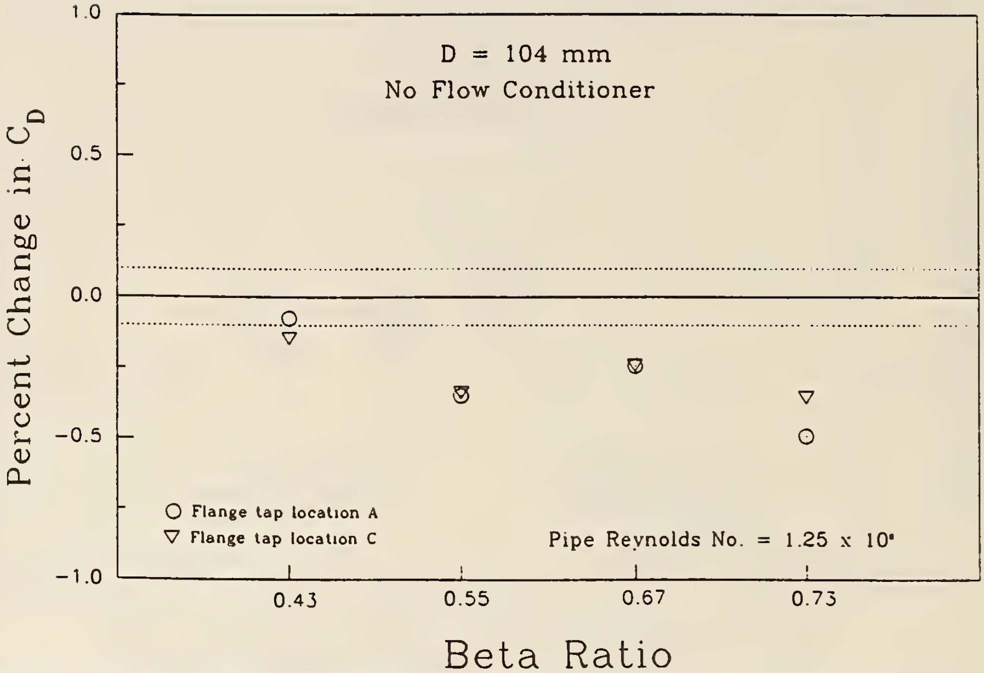

Figure 29. Percent change in discharge coefficient vs. beta ratio with an elbow at 17D, no flow conditioner, and 2 flange tap locations.

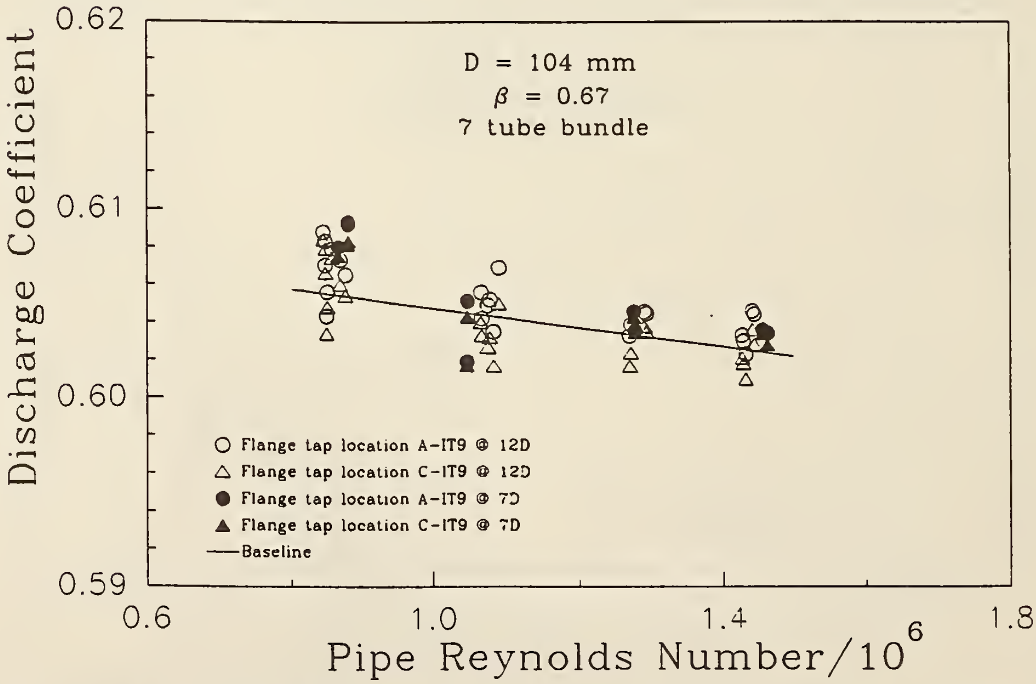

Figure 30. Discharge coefficient vs. Reynolds number for the 0.67 beta ratio plate, elbow at 17D, 7 tube bundle flow conditioner at 7D or 12D, and 2 flange tap locations.

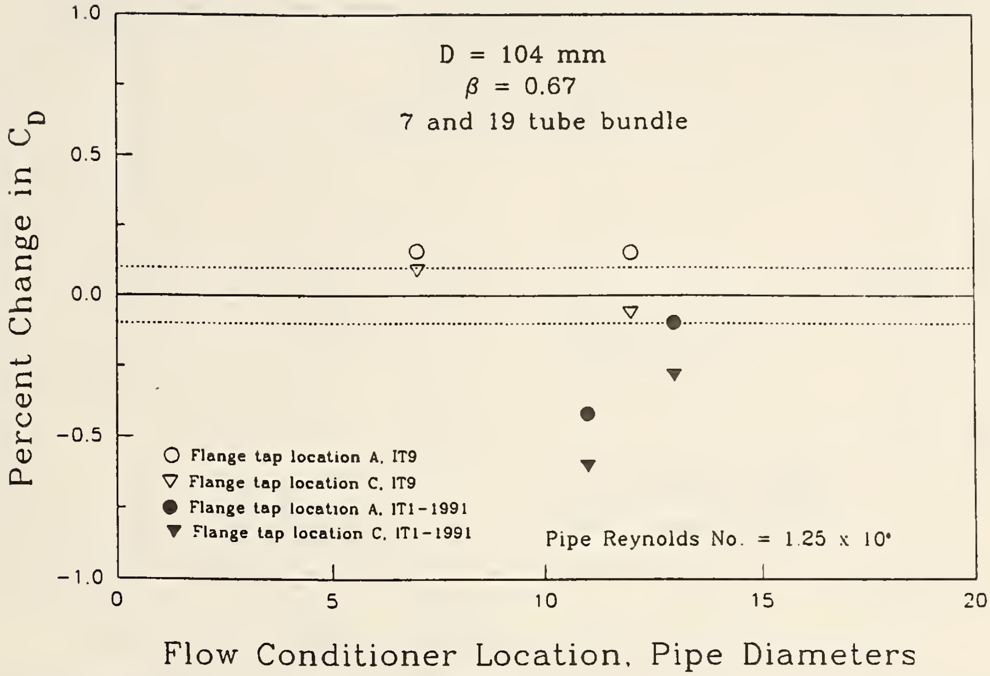

Figure 31. Percent change in discharge coefficient vs. flow conditioner location with an elbow at 17D, 7 or 19 tube bundle flow conditioner, and 2 flange tap locations.

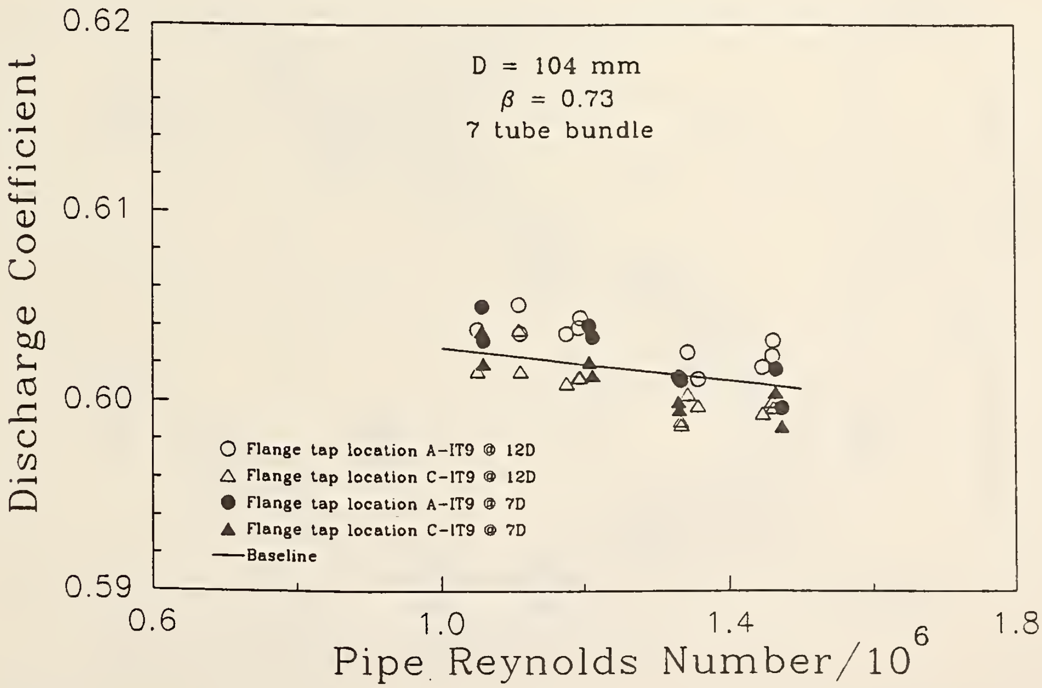

Figure 32. Discharge coefficient vs. Reynolds number for the 0.73 beta ratio plate, elbow at 17D, 7 tube bundle flow conditioner at 7D or 12D, and 2 flange tap locations.

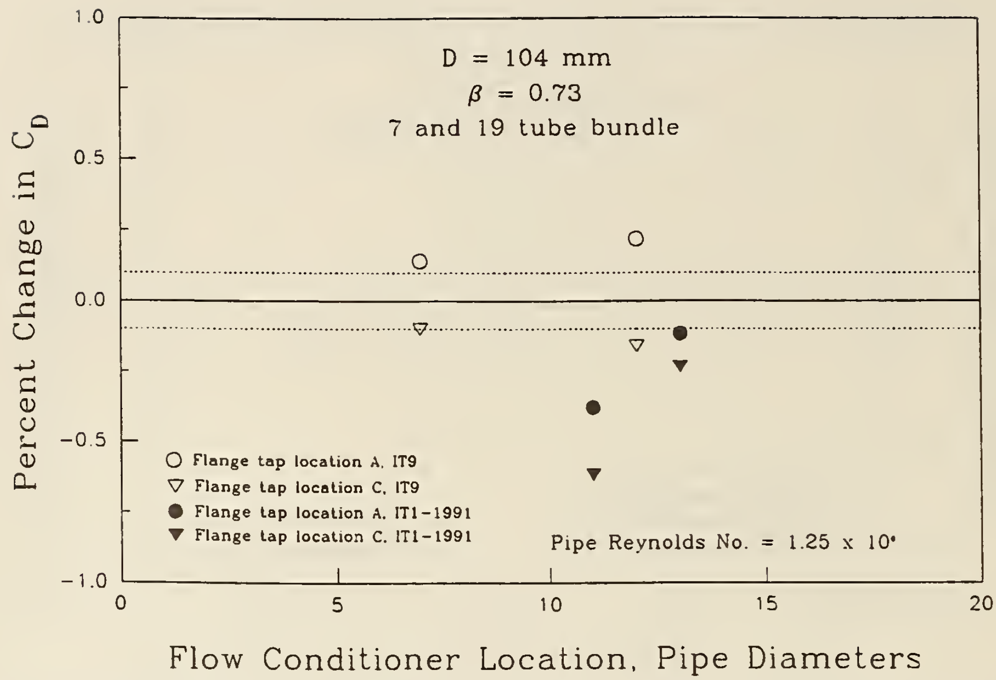

Figure 33. Percent change in discharge coefficient vs. flow conditioner location with an elbow at 17D, 7 or 19 tube bundle flow conditioner, and 2 flange tap locations.

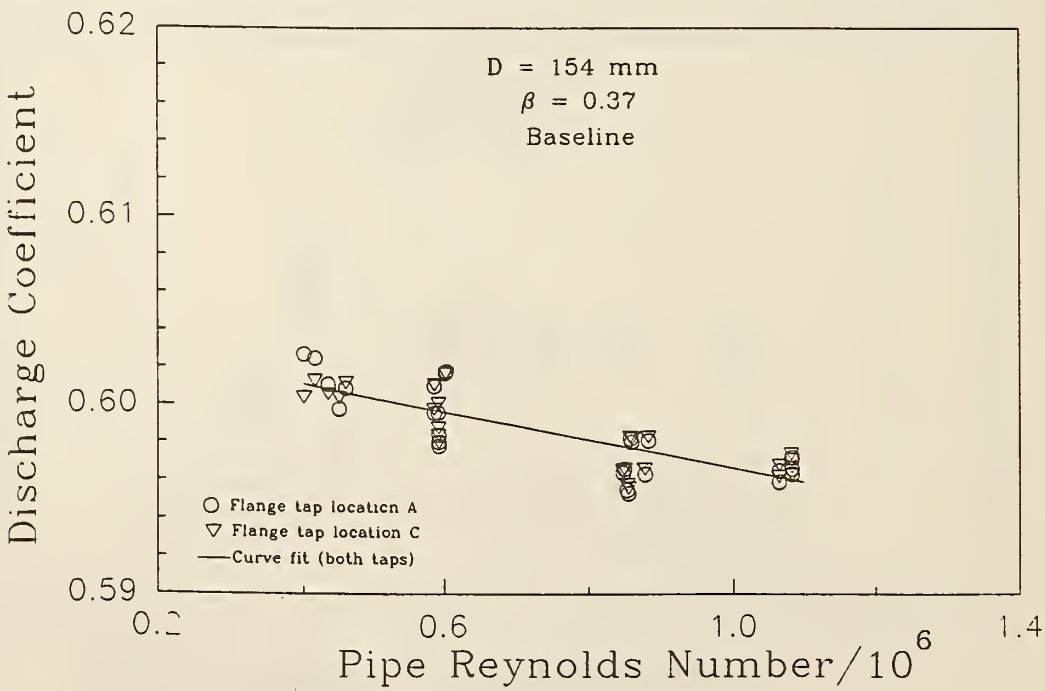

Figure 34. Discharge coefficient vs. Reynolds number for the 0.37 beta ratio plate, oversize Sprenkle at 44D, and 2 flange tap locations.

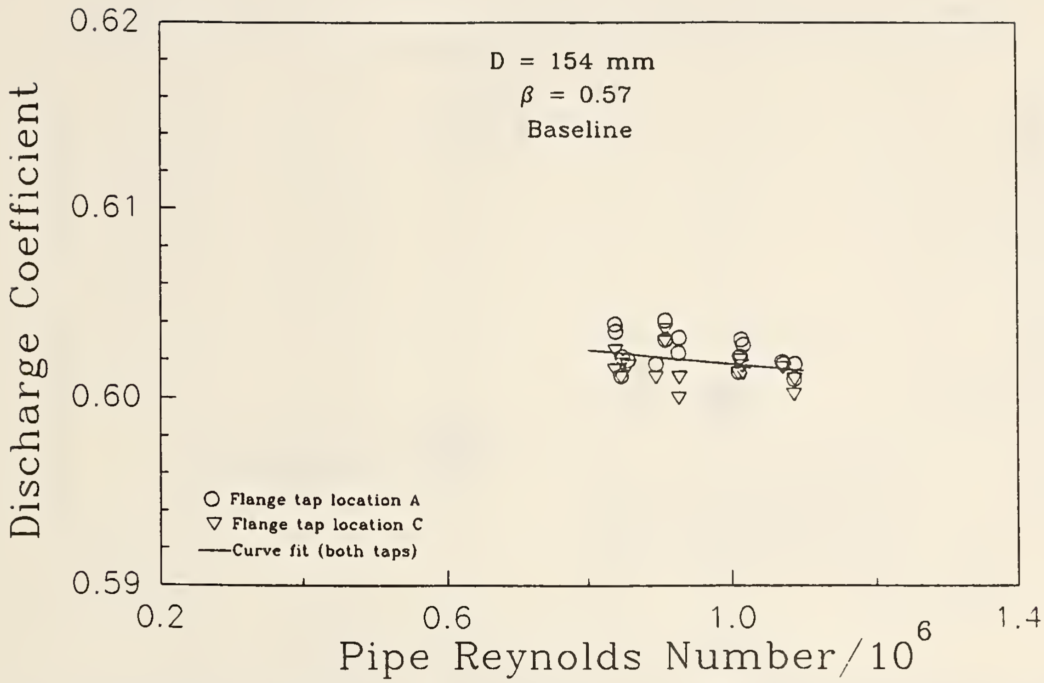

Figure 35. Discharge coefficient vs. Reynolds number for the 0.57 beta ratio plate, oversize Sprenkle at 44D, and 2 flange tap locations.

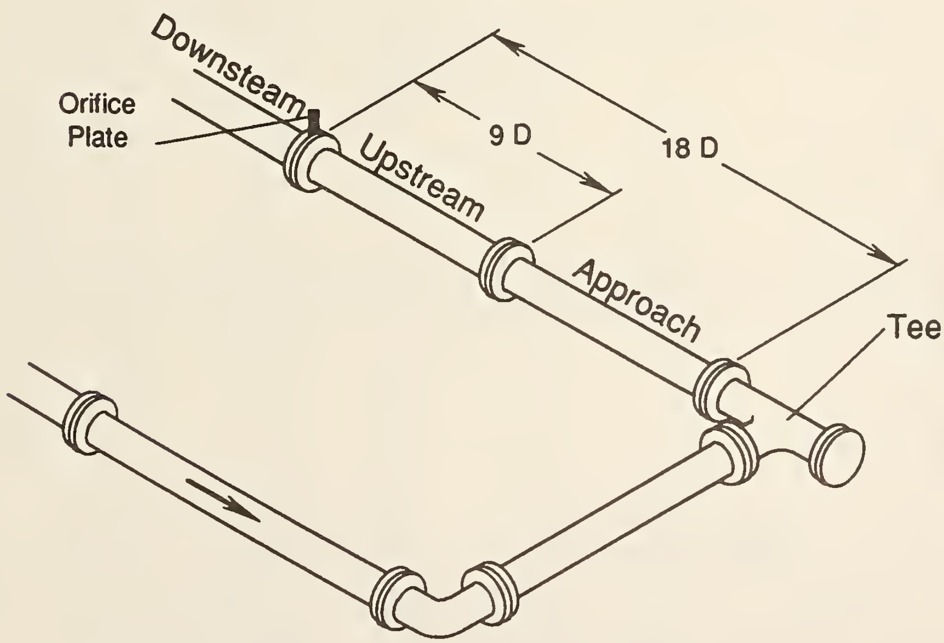

Figure 36. Test configuration, tee at 18D.

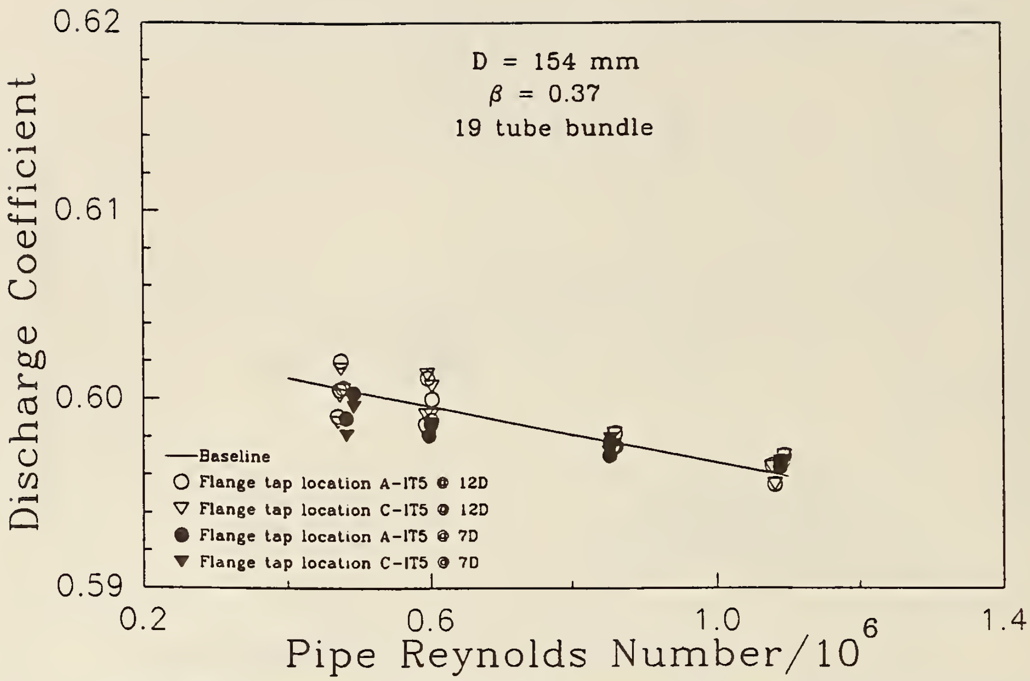

Figure 37. Discharge coefficient vs. Reynolds number for the 0.37 beta ratio plate, tee at 18D, 19 tube bundle flow conditioner at 7D or 12D, and 2 flange tap locations.

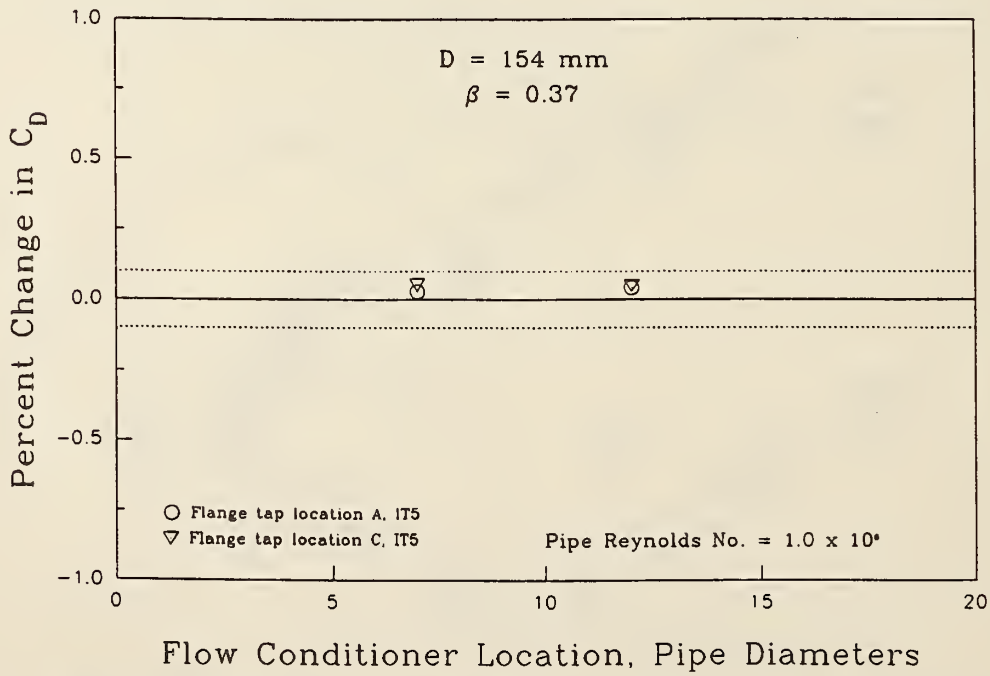

Figure 38. Percent change in discharge coefficient vs. flow conditioner location with a tee at 18D, 19 tube bundle flow conditioner at 7D or 12D, and 2 flange tap locations.

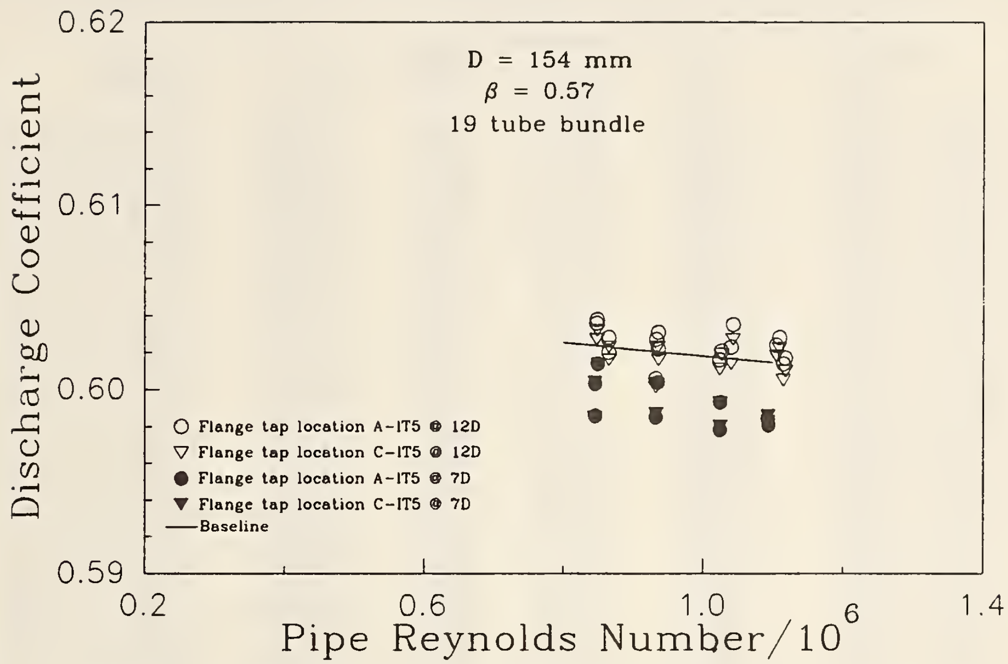

Figure 39. Discharge coefficient vs. Reynolds number for the 0.57 beta ratio plate, tee at 18D, 19 tube bundle flow conditioner at 7D or 12D, and 2 flange tap locations.

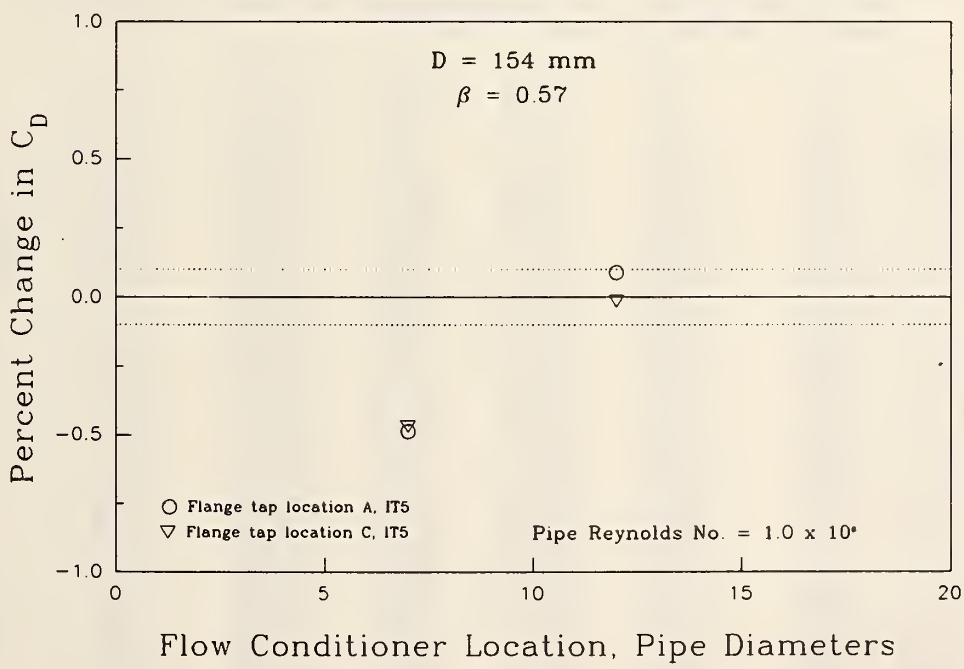

Figure 40. Percent change in discharge coefficient vs. flow conditioner location with a tee at 18D, 19 tube bundle flow conditioner at 7D or 12D, and 2 flange tap locations.

Table 4. Measured and calculated quantities for 0.24 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042992- 1	3.7824	289.43	44.34	73.088	0.1935	0.2585	0.5977	0.6002
042992- 2	3.7814	289.18	44.37	72.140	0.1923	0.2570	0.5976	0.6001
042992- 3	3.6957	288.33	43.50	100.611	0.2252	0.3020	0.5975	0.6011
042992- 4	3.6868	288.32	43.40	100.266	0.2248	0.3015	0.5982	0.6018
042992- 5	3.7827	288.03	44.58	125.118	0.2547	0.3414	0.5978	0.6022
042992- 6	3.7847	288.02	44.61	125.697	0.2555	0.3426	0.5982	0.6026
042992- 7	3.7662	287.68	44.44	149.252	0.2783	0.3735	0.5982	0.6035
042992- 8	3.7654	287.79	44.41	148.289	0.2770	0.3716	0.5975	0.6027
051392- 1	3.8391	287.99	45.26	96.975	0.2258	0.3026	0.5986	0.6020
051392- 2	3.8402	287.65	45.32	95.680	0.2246	0.3012	0.5990	0.6023
051392- 3	3.8633	287.80	45.57	76.906	0.2016	0.2702	0.5987	0.6014
051392- 4	3.8618	287.72	45.57	77.108	0.2014	0.2699	0.5974	0.6000
051392- 5	3.7642	287.06	44.53	176.767	0.3035	0.4079	0.5979	0.6041
051392- 6	3.7703	286.96	44.61	175.296	0.3025	0.4067	0.5980	0.6041
051392- 7	3.8012	287.04	44.97	137.754	0.2686	0.3609	0.5979	0.6027
051392- 8	3.8003	287.06	44.96	138.857	0.2701	0.3629	0.5990	0.6038
051392- 1	3.8380	287.93	45.25	99.315	0.2282	0.3058	0.5978	0.6012
051392- 2	3.8388	287.72	45.30	97.334	0.2263	0.3035	0.5986	0.6020
051392- 3	3.8010	287.34	44.91	139.129	0.2695	0.3618	0.5972	0.6020
051392- 4	3.8029	287.32	44.94	137.239	0.2684	0.3604	0.5989	0.6037
051392- 5	3.8543	287.57	45.51	78.778	0.2036	0.2731	0.5979	0.6006
051392- 6	3.8512	287.62	45.46	80.003	0.2048	0.2746	0.5970	0.5997
051392- 7	3.7563	286.97	44.45	183.933	0.3093	0.4159	0.5976	0.6041
051392- 8	3.7600	286.70	44.54	180.796	0.3070	0.4130	0.5978	0.6042
051892- 1	3.9458	289.10	46.32	133.241	0.2680	0.3577	0.5980	0.6025
051892- 2	3.9401	288.46	46.37	131.779	0.2661	0.3558	0.5968	0.6013
051892- 3	3.9902	288.66	46.92	72.774	0.1984	0.2649	0.5972	0.5996
051892- 4	3.9877	288.61	46.90	73.393	0.1991	0.2659	0.5968	0.5993
051892- 5	3.9655	288.34	46.69	97.635	0.2296	0.3069	0.5972	0.6005
051892- 6	3.9641	288.21	46.69	97.406	0.2294	0.3068	0.5975	0.6008
051892- 7	3.8825	287.49	45.85	184.582	0.3145	0.4217	0.5974	0.6037
051892- 8	3.8836	287.36	45.89	181.029	0.3116	0.4179	0.5976	0.6038

Table 5. Measured and calculated quantities for 0.24 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042992- 1	3.7824	289.43	44.34	73.099	0.1935	0.2585	0.5976	0.6002
042992- 2	3.7814	289.18	44.37	72.146	0.1923	0.2570	0.5976	0.6001
042992- 3	3.6957	288.33	43.50	100.595	0.2252	0.3020	0.5976	0.6012
042992- 4	3.6868	288.32	43.40	100.267	0.2248	0.3015	0.5982	0.6017
042992- 5	3.7827	288.03	44.58	125.123	0.2547	0.3414	0.5978	0.6022
042992- 6	3.7847	288.02	44.61	125.682	0.2555	0.3426	0.5983	0.6027
042992- 7	3.7662	287.68	44.44	149.224	0.2783	0.3735	0.5983	0.6035
042992- 8	3.7654	287.79	44.41	148.275	0.2770	0.3716	0.5975	0.6027
051392- 1	3.8391	287.99	45.26	97.007	0.2258	0.3026	0.5985	0.6019
051392- 2	3.8402	287.65	45.32	95.692	0.2246	0.3012	0.5989	0.6022
051392- 3	3.8633	287.80	45.57	76.917	0.2016	0.2702	0.5987	0.6013
051392- 4	3.8618	287.72	45.57	77.117	0.2014	0.2699	0.5973	0.6000
051392- 5	3.7642	287.06	44.53	176.781	0.3035	0.4079	0.5979	0.6041
051392- 6	3.7703	286.96	44.61	175.309	0.3025	0.4067	0.5979	0.6041
051392- 7	3.8012	287.04	44.97	137.779	0.2686	0.3609	0.5978	0.6026
051392- 8	3.8003	287.06	44.96	138.882	0.2701	0.3629	0.5989	0.6038
051392- 1	3.8380	287.93	45.25	99.337	0.2282	0.3058	0.5977	0.6012
051392- 2	3.8388	287.72	45.30	97.366	0.2263	0.3035	0.5985	0.6019
051392- 3	3.8010	287.34	44.91	139.122	0.2695	0.3618	0.5972	0.6020
051392- 4	3.8029	287.32	44.94	137.270	0.2684	0.3604	0.5988	0.6036
051392- 5	3.8543	287.57	45.51	78.794	0.2036	0.2731	0.5978	0.6005
051392- 6	3.8512	287.62	45.46	80.027	0.2048	0.2746	0.5969	0.5996
051392- 7	3.7563	286.97	44.45	183.945	0.3093	0.4159	0.5976	0.6041
051392- 8	3.7600	286.70	44.54	180.822	0.3070	0.4130	0.5978	0.6042
051892- 1	3.9458	289.10	46.32	133.232	0.2680	0.3577	0.5980	0.6025
051892- 2	3.9401	288.46	46.37	131.786	0.2661	0.3558	0.5968	0.6013
051892- 3	3.9902	288.66	46.92	72.783	0.1984	0.2649	0.5971	0.5995
051892- 4	3.9877	288.61	46.90	73.407	0.1991	0.2659	0.5968	0.5992
051892- 5	3.9655	288.34	46.69	97.634	0.2296	0.3069	0.5972	0.6005
051892- 6	3.9641	288.21	46.69	97.393	0.2294	0.3068	0.5976	0.6008
051892- 7	3.8825	287.49	45.85	184.541	0.3145	0.4217	0.5975	0.6038
051892- 8	3.8836	287.36	45.89	180.982	0.3116	0.4179	0.5977	0.6039

Table 6. Measured and calculated quantities for 0.24 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
042992- 1	3.7824	289.43	44.34	73.082	0.1935	0.2585	0.5977	0.6003
042992- 2	3.7814	289.18	44.37	72.120	0.1923	0.2570	0.5977	0.6002
042992- 3	3.6957	288.33	43.50	100.563	0.2252	0.3020	0.5977	0.6013
042992- 4	3.6868	288.32	43.40	100.230	0.2248	0.3015	0.5983	0.6019
042992- 5	3.7827	288.03	44.58	125.064	0.2547	0.3414	0.5980	0.6023
042992- 6	3.7847	288.02	44.61	125.593	0.2555	0.3426	0.5985	0.6029
042992- 7	3.7662	287.68	44.44	149.158	0.2783	0.3735	0.5984	0.6036
042992- 8	3.7654	287.79	44.41	148.208	0.2770	0.3716	0.5976	0.6028
051392- 1	3.8391	287.99	45.26	96.991	0.2258	0.3026	0.5986	0.6019
051392- 2	3.8402	287.65	45.32	95.669	0.2246	0.3012	0.5990	0.6023
051392- 3	3.8633	287.80	45.57	76.925	0.2016	0.2702	0.5987	0.6013
051392- 4	3.8618	287.72	45.57	77.111	0.2014	0.2699	0.5973	0.6000
051392- 5	3.7642	287.06	44.53	176.741	0.3035	0.4079	0.5979	0.6042
051392- 6	3.7703	286.96	44.61	175.281	0.3025	0.4067	0.5980	0.6042
051392- 7	3.8012	287.04	44.97	137.783	0.2686	0.3609	0.5978	0.6026
051392- 8	3.8003	287.06	44.96	138.847	0.2701	0.3629	0.5990	0.6039
051392- 1	3.8380	287.93	45.25	99.334	0.2282	0.3058	0.5977	0.6012
051392- 2	3.8388	287.72	45.30	97.380	0.2263	0.3035	0.5985	0.6018
051392- 3	3.8010	287.34	44.91	139.124	0.2695	0.3618	0.5972	0.6020
051392- 4	3.8029	287.32	44.94	137.263	0.2684	0.3604	0.5988	0.6036
051392- 5	3.8543	287.57	45.51	78.785	0.2036	0.2731	0.5979	0.6006
051392- 6	3.8512	287.62	45.46	80.016	0.2048	0.2746	0.5969	0.5996
051392- 7	3.7563	286.97	44.45	183.920	0.3093	0.4159	0.5977	0.6041
051392- 8	3.7600	286.70	44.54	180.785	0.3070	0.4130	0.5979	0.6042
051892- 1	3.9458	289.10	46.32	133.208	0.2680	0.3577	0.5981	0.6025
051892- 2	3.9401	288.46	46.37	131.778	0.2661	0.3558	0.5969	0.6013
051892- 3	3.9902	288.66	46.92	72.799	0.1984	0.2649	0.5971	0.5995
051892- 4	3.9877	288.61	46.90	73.412	0.1991	0.2659	0.5968	0.5992
051892- 5	3.9655	288.34	46.69	97.683	0.2296	0.3069	0.5971	0.6003
051892- 6	3.9641	288.21	46.69	97.430	0.2294	0.3068	0.5974	0.6007
051892- 7	3.8825	287.49	45.85	184.528	0.3145	0.4217	0.5975	0.6038
051892- 8	3.8836	287.36	45.89	180.960	0.3116	0.4179	0.5977	0.6039

Table 7. Measured and calculated quantities for 0.24 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
042992- 5	3.7827	288.03	44.58	125.119	0.2547	0.3414	0.5978	0.6022
042992- 6	3.7847	288.02	44.61	125.694	0.2555	0.3426	0.5982	0.6026
042992- 7	3.7662	287.68	44.44	149.244	0.2783	0.3735	0.5982	0.6035
042992- 8	3.7654	287.79	44.41	148.286	0.2770	0.3716	0.5975	0.6027
051392- 1	3.8391	287.99	45.26	97.079	0.2258	0.3026	0.5983	0.6017
051392- 2	3.8402	287.65	45.32	95.734	0.2246	0.3012	0.5988	0.6021
051392- 3	3.8633	287.80	45.57	76.992	0.2016	0.2702	0.5984	0.6010
051392- 4	3.8618	287.72	45.57	77.175	0.2014	0.2699	0.5971	0.5997
051392- 5	3.7642	287.06	44.53	176.890	0.3035	0.4079	0.5977	0.6039
051392- 6	3.7703	286.96	44.61	175.438	0.3025	0.4067	0.5977	0.6039
051392- 7	3.8012	287.04	44.97	137.874	0.2686	0.3609	0.5976	0.6024
051392- 8	3.8003	287.06	44.96	138.960	0.2701	0.3629	0.5988	0.6036
051392- 1	3.8380	287.93	45.25	99.417	0.2282	0.3058	0.5975	0.6009
051392- 2	3.8388	287.72	45.30	97.460	0.2263	0.3035	0.5982	0.6016
051392- 3	3.8010	287.34	44.91	139.240	0.2695	0.3618	0.5969	0.6018
051392- 4	3.8029	287.32	44.94	137.382	0.2684	0.3604	0.5986	0.6034
051392- 5	3.8543	287.57	45.51	78.848	0.2036	0.2731	0.5976	0.6003
051392- 6	3.8512	287.62	45.46	80.085	0.2048	0.2746	0.5966	0.5994
051392- 7	3.7563	286.97	44.45	184.044	0.3093	0.4159	0.5975	0.6039
051392- 8	3.7600	286.70	44.54	180.922	0.3070	0.4130	0.5976	0.6040
051892- 1	3.9458	289.10	46.32	133.284	0.2680	0.3577	0.5979	0.6024
051892- 2	3.9401	288.46	46.37	131.826	0.2661	0.3558	0.5967	0.6012
051892- 3	3.9902	288.66	46.92	72.833	0.1984	0.2649	0.5969	0.5993
051892- 4	3.9877	288.61	46.90	73.449	0.1991	0.2659	0.5966	0.5990
051892- 5	3.9655	288.34	46.69	97.738	0.2296	0.3069	0.5969	0.6002
051892- 6	3.9641	288.21	46.69	97.480	0.2294	0.3068	0.5973	0.6005
051892- 7	3.8825	287.49	45.85	184.628	0.3145	0.4217	0.5974	0.6037
051892- 8	3.8836	287.36	45.89	181.057	0.3116	0.4179	0.5976	0.6037

Table 8. Measured and calculated quantities for 0.40 (2C) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
042992- 1	3.8925	288.49	45.80	24.440	0.3126	0.4181	0.5982	0.5990
042992- 2	3.8919	288.19	45.84	24.505	0.3131	0.4190	0.5979	0.5987
042992- 3	3.8384	287.54	45.32	75.994	0.5501	0.7379	0.5983	0.6009
042992- 4	3.8429	287.02	45.47	75.142	0.5482	0.7362	0.5987	0.6012
042992- 5	3.7782	286.46	44.80	130.589	0.7198	0.9687	0.5988	0.6032
042992- 6	3.7804	286.67	44.78	129.276	0.7166	0.9639	0.5993	0.6037
042992- 7	3.8511	287.18	45.54	52.347	0.4571	0.6136	0.5984	0.6002
042992- 8	3.8481	286.94	45.54	52.869	0.4591	0.6167	0.5980	0.5998
043092- 1	3.8693	287.51	45.69	72.933	0.5410	0.7255	0.5983	0.6007
043092- 2	3.8680	287.97	45.60	72.913	0.5416	0.7255	0.5997	0.6021
043092- 3	3.9028	287.94	46.01	42.729	0.4149	0.5555	0.5983	0.5997
043092- 4	3.9013	287.89	46.01	42.911	0.4158	0.5569	0.5985	0.5999
043092- 5	3.8167	287.06	45.15	123.630	0.7031	0.9445	0.5991	0.6033
043092- 6	3.8114	286.73	45.14	125.129	0.7079	0.9518	0.5995	0.6038
043092- 7	3.9143	288.09	46.13	25.215	0.3187	0.4265	0.5981	0.5990
043092- 8	3.9173	288.09	46.16	25.445	0.3201	0.4284	0.5979	0.5988
051992- 1	3.8561	287.02	45.63	74.679	0.5469	0.7343	0.5980	0.6005
051992- 2	3.8574	287.38	45.58	74.598	0.5468	0.7336	0.5986	0.6011
051992- 3	3.8108	286.84	45.12	124.291	0.7044	0.9468	0.5988	0.6030
051992- 4	3.8079	287.11	45.04	123.140	0.7004	0.9408	0.5987	0.6029
051992- 5	3.8811	287.25	45.88	43.340	0.4163	0.5585	0.5970	0.5984
051992- 6	3.8799	287.19	45.88	43.673	0.4180	0.5609	0.5972	0.5986
051992- 7	3.9008	287.42	46.09	25.539	0.3200	0.4290	0.5970	0.5978
051992- 8	3.9015	287.69	46.05	25.761	0.3217	0.4310	0.5979	0.5987

Table 9. Measured and calculated quantities for 0.40 (2C) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
042992- 1	3.8925	288.49	45.80	24.466	0.3126	0.4181	0.5978	0.5986
042992- 2	3.8919	288.19	45.84	24.519	0.3131	0.4190	0.5977	0.5985
042992- 3	3.8384	287.54	45.32	76.007	0.5501	0.7379	0.5982	0.6008
042992- 4	3.8429	287.02	45.47	75.160	0.5482	0.7362	0.5986	0.6011
042992- 5	3.7782	286.46	44.80	130.579	0.7198	0.9687	0.5988	0.6033
042992- 6	3.7804	286.67	44.78	129.272	0.7166	0.9639	0.5993	0.6037
042992- 7	3.8511	287.18	45.54	52.370	0.4571	0.6136	0.5983	0.6001
042992- 8	3.8481	286.94	45.54	52.887	0.4591	0.6167	0.5979	0.5997
043092- 1	3.8693	287.51	45.69	72.933	0.5410	0.7255	0.5983	0.6007
043092- 2	3.8680	287.97	45.60	72.903	0.5416	0.7255	0.5997	0.6022
043092- 3	3.9028	287.94	46.01	42.728	0.4149	0.5555	0.5983	0.5997
043092- 4	3.9013	287.89	46.01	42.920	0.4158	0.5569	0.5984	0.5998
043092- 5	3.8167	287.06	45.15	123.644	0.7031	0.9445	0.5990	0.6032
043092- 6	3.8114	286.73	45.14	125.105	0.7079	0.9518	0.5996	0.6039
043092- 7	3.9143	288.09	46.13	25.224	0.3187	0.4265	0.5980	0.5989
043092- 8	3.9173	288.09	46.16	25.458	0.3201	0.4284	0.5978	0.5986
051992- 1	3.8561	287.02	45.63	74.675	0.5469	0.7343	0.5981	0.6006
051992- 2	3.8574	287.38	45.58	74.617	0.5468	0.7336	0.5986	0.6011
051992- 3	3.8108	286.84	45.12	124.279	0.7044	0.9468	0.5988	0.6030
051992- 4	3.8079	287.11	45.04	123.185	0.7004	0.9408	0.5986	0.6028
051992- 5	3.8811	287.25	45.88	43.356	0.4163	0.5585	0.5969	0.5983
051992- 6	3.8799	287.19	45.88	43.701	0.4180	0.5609	0.5970	0.5984
051992- 7	3.9008	287.42	46.09	25.558	0.3200	0.4290	0.5968	0.5976
051992- 8	3.9015	287.69	46.05	25.776	0.3217	0.4310	0.5977	0.5986

Table 10. Measured and calculated quantities for 0.40 (2C) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
042992- 1	3.8925	288.49	45.80	24.456	0.3126	0.4181	0.5980	0.5988
042992- 2	3.8919	288.19	45.84	24.517	0.3131	0.4190	0.5977	0.5986
042992- 3	3.8384	287.54	45.32	75.974	0.5501	0.7379	0.5984	0.6009
042992- 4	3.8429	287.02	45.47	75.129	0.5482	0.7362	0.5987	0.6013
042992- 5	3.7782	286.46	44.80	130.526	0.7198	0.9687	0.5989	0.6034
042992- 6	3.7804	286.67	44.78	129.210	0.7166	0.9639	0.5994	0.6039
042992- 7	3.8511	287.18	45.54	52.358	0.4571	0.6136	0.5984	0.6001
042992- 8	3.8481	286.94	45.54	52.850	0.4591	0.6167	0.5981	0.5999
043092- 1	3.8693	287.51	45.69	72.930	0.5410	0.7255	0.5983	0.6008
043092- 2	3.8680	287.97	45.60	72.944	0.5416	0.7255	0.5996	0.6020
043092- 3	3.9028	287.94	46.01	42.762	0.4149	0.5555	0.5981	0.5995
043092- 4	3.9013	287.89	46.01	42.927	0.4158	0.5569	0.5984	0.5998
043092- 5	3.8167	287.06	45.15	123.666	0.7031	0.9445	0.5990	0.6032
043092- 6	3.8114	286.73	45.14	125.177	0.7079	0.9518	0.5994	0.6037
043092- 7	3.9143	288.09	46.13	25.229	0.3187	0.4265	0.5980	0.5988
043092- 8	3.9173	288.09	46.16	25.469	0.3201	0.4284	0.5976	0.5985
051992- 1	3.8561	287.02	45.63	74.673	0.5469	0.7343	0.5981	0.6006
051992- 2	3.8574	287.38	45.58	74.610	0.5468	0.7336	0.5986	0.6011
051992- 3	3.8108	286.84	45.12	124.332	0.7044	0.9468	0.5987	0.6029
051992- 4	3.8079	287.11	45.04	123.147	0.7004	0.9408	0.5987	0.6028
051992- 5	3.8811	287.25	45.88	43.328	0.4163	0.5585	0.5971	0.5985
051992- 6	3.8799	287.19	45.88	43.658	0.4180	0.5609	0.5973	0.5987
051992- 7	3.9008	287.42	46.09	25.520	0.3200	0.4290	0.5972	0.5981
051992- 8	3.9015	287.69	46.05	25.724	0.3217	0.4310	0.5983	0.5992

Table 11. Measured and calculated quantities for 0.40 (2C) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
042992- 1	3.8925	288.49	45.80	24.501	0.3126	0.4181	0.5974	0.5982
042992- 2	3.8919	288.19	45.84	24.563	0.3131	0.4190	0.5972	0.5980
042992- 3	3.8384	287.54	45.32	76.118	0.5501	0.7379	0.5978	0.6004
042992- 4	3.8429	287.02	45.47	75.217	0.5482	0.7362	0.5984	0.6009
042992- 5	3.7782	286.46	44.80	130.693	0.7198	0.9687	0.5985	0.6030
042992- 6	3.7804	286.67	44.78	129.342	0.7166	0.9639	0.5991	0.6035
042992- 7	3.8511	287.18	45.54	52.431	0.4571	0.6136	0.5980	0.5997
042992- 8	3.8481	286.94	45.54	52.946	0.4591	0.6167	0.5976	0.5994
043092- 1	3.8693	287.51	45.69	73.033	0.5410	0.7255	0.5979	0.6003
043092- 2	3.8680	287.97	45.60	73.024	0.5416	0.7255	0.5992	0.6017
043092- 3	3.9028	287.94	46.01	42.810	0.4149	0.5555	0.5977	0.5992
043092- 4	3.9013	287.89	46.01	42.982	0.4158	0.5569	0.5980	0.5994
043092- 5	3.8167	287.06	45.15	123.801	0.7031	0.9445	0.5987	0.6029
043092- 6	3.8114	286.73	45.14	125.344	0.7079	0.9518	0.5990	0.6033
043092- 7	3.9143	288.09	46.13	25.263	0.3187	0.4265	0.5975	0.5984
043092- 8	3.9173	288.09	46.16	25.497	0.3201	0.4284	0.5973	0.5981
051992- 1	3.8561	287.02	45.63	74.761	0.5469	0.7343	0.5977	0.6002
051992- 2	3.8574	287.38	45.58	74.694	0.5468	0.7336	0.5982	0.6007
051992- 3	3.8108	286.84	45.12	124.467	0.7044	0.9468	0.5983	0.6026
051992- 4	3.8079	287.11	45.04	123.347	0.7004	0.9408	0.5982	0.6024
051992- 5	3.8811	287.25	45.88	43.378	0.4163	0.5585	0.5967	0.5982
051992- 6	3.8799	287.19	45.88	43.714	0.4180	0.5609	0.5969	0.5983
051992- 7	3.9008	287.42	46.09	25.541	0.3200	0.4290	0.5970	0.5978
051992- 8	3.9015	287.69	46.05	25.764	0.3217	0.4310	0.5979	0.5987

Table 12. Measured and calculated quantities for 0.40 (2D) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
091792- 1	3.9308	291.47	45.73	24.418	0.3126	0.4149	0.5981	0.5989
091792- 2	3.9304	290.45	45.90	24.439	0.3132	0.4167	0.5978	0.5986
091792- 3	3.8034	288.84	44.68	123.282	0.7004	0.9369	0.5999	0.6041
091792- 4	3.8061	288.33	44.80	121.272	0.6958	0.9318	0.6001	0.6043
091792- 5	3.8451	288.46	45.24	76.552	0.5533	0.7404	0.5993	0.6019
091792- 6	3.8427	288.68	45.18	76.845	0.5541	0.7412	0.5995	0.6021
091792- 7	3.8704	288.96	45.46	43.700	0.4180	0.5586	0.5990	0.6004
091792- 8	3.8695	288.72	45.49	43.907	0.4190	0.5602	0.5988	0.6002

Table 13. Measured and calculated quantities for 0.40 (2D) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
091792- 1	3.9308	291.47	45.73	24.444	0.3126	0.4149	0.5977	0.5985
091792- 2	3.9304	290.45	45.90	24.467	0.3132	0.4167	0.5975	0.5983
091792- 3	3.8034	288.84	44.68	123.371	0.7004	0.9369	0.5997	0.6039
091792- 4	3.8061	288.33	44.80	121.350	0.6958	0.9318	0.5999	0.6041
091792- 5	3.8451	288.46	45.24	76.603	0.5533	0.7404	0.5991	0.6017
091792- 6	3.8427	288.68	45.18	76.874	0.5541	0.7412	0.5994	0.6020
091792- 7	3.8704	288.96	45.46	43.742	0.4180	0.5586	0.5987	0.6002
091792- 8	3.8695	288.72	45.49	43.951	0.4190	0.5602	0.5985	0.5999

Table 14. Measured and calculated quantities for 0.40 (2D) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
091792- 1	3.9308	291.47	45.73	24.318	0.3126	0.4149	0.5993	0.6001
091792- 2	3.9304	290.45	45.90	24.335	0.3132	0.4167	0.5991	0.5999
091792- 3	3.8034	288.84	44.68	123.472	0.7004	0.9369	0.5994	0.6036
091792- 4	3.8061	288.33	44.80	121.466	0.6958	0.9318	0.5996	0.6038
091792- 5	3.8451	288.46	45.24	76.624	0.5533	0.7404	0.5990	0.6016
091792- 6	3.8427	288.68	45.18	76.898	0.5541	0.7412	0.5993	0.6019
091792- 7	3.8704	288.96	45.46	43.672	0.4180	0.5586	0.5992	0.6006
091792- 8	3.8695	288.72	45.49	43.893	0.4190	0.5602	0.5989	0.6003

Table 15. Measured and calculated quantities for 0.40 (2D) beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
091792- 1	3.9308	291.47	45.73	24.396	0.3126	0.4149	0.5983	0.5991
091792- 2	3.9304	290.45	45.90	24.418	0.3132	0.4167	0.5981	0.5989
091792- 3	3.8034	288.84	44.68	123.297	0.7004	0.9369	0.5999	0.6041
091792- 4	3.8061	288.33	44.80	121.295	0.6958	0.9318	0.6001	0.6042
091792- 5	3.8451	288.46	45.24	76.575	0.5533	0.7404	0.5992	0.6018
091792- 6	3.8427	288.68	45.18	76.847	0.5541	0.7412	0.5995	0.6021
091792- 7	3.8704	288.96	45.46	43.702	0.4180	0.5586	0.5990	0.6004
091792- 8	3.8695	288.72	45.49	43.930	0.4190	0.5602	0.5986	0.6001

Table 16. Measured and calculated quantities for 0.48 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042992- 1	3.9036	288.11	46.00	12.491	0.3374	0.4516	0.6043	0.6047
042992- 2	3.9084	288.21	46.03	12.391	0.3361	0.4498	0.6042	0.6046
042992- 3	3.9074	288.28	46.01	12.409	0.3367	0.4505	0.6050	0.6054
042992- 4	3.7594	286.53	44.56	133.525	1.0937	1.4721	0.6046	0.6091
042992- 5	3.7568	286.41	44.55	128.684	1.0669	1.4364	0.6010	0.6053
042992- 6	3.7563	286.13	44.59	129.452	1.0731	1.4457	0.6024	0.6068
042992- 7	3.8169	286.53	45.25	78.116	0.8400	1.1298	0.6044	0.6070
042992- 8	3.8182	287.00	45.18	76.006	0.8270	1.1111	0.6038	0.6063
042992- 9	3.8708	287.06	45.79	38.147	0.5877	0.7889	0.6028	0.6040
042992- 10	3.8662	287.09	45.73	38.609	0.5912	0.7936	0.6031	0.6044
043092- 1	3.7495	286.46	44.45	130.661	1.0804	1.4546	0.6046	0.6090
043092- 2	3.7794	287.31	44.66	130.432	1.0830	1.4545	0.6052	0.6095
043092- 3	3.8530	287.08	45.58	41.997	0.6157	0.8266	0.6032	0.6045
043092- 4	3.8444	286.52	45.57	42.464	0.6198	0.8334	0.6039	0.6052
043092- 5	3.8918	287.57	45.95	12.773	0.3408	0.4568	0.6039	0.6043
043092- 6	3.8924	287.67	45.94	12.936	0.3430	0.4597	0.6041	0.6045
043092- 7	3.8018	287.08	44.97	74.949	0.8215	1.1037	0.6054	0.6079
043092- 8	3.8103	287.10	45.07	74.455	0.8181	1.0989	0.6042	0.6067
051892- 1	3.9495	286.93	46.75	37.775	0.5910	0.7929	0.6030	0.6042
051892- 2	3.9503	286.56	46.83	37.705	0.5910	0.7936	0.6030	0.6043
051892- 3	4.0082	287.52	47.34	12.319	0.3405	0.4558	0.6053	0.6056
051892- 4	4.0089	287.57	47.34	12.388	0.3407	0.4560	0.6040	0.6043
051892- 5	3.9172	286.95	46.36	73.743	0.8260	1.1085	0.6045	0.6069
051892- 6	3.9164	286.33	46.46	73.296	0.8227	1.1057	0.6032	0.6056
051892- 8	3.8637	285.74	45.94	124.390	1.0727	1.4447	0.6055	0.6096
051892- 9	3.8644	285.99	45.90	125.034	1.0733	1.4447	0.6045	0.6086

Table 17. Measured and calculated quantities for 0.48 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042992- 1	3.9036	288.11	46.00	12.550	0.3374	0.4516	0.6029	0.6033
042992- 2	3.9084	288.21	46.03	12.457	0.3361	0.4498	0.6026	0.6030
042992- 3	3.9074	288.28	46.01	12.475	0.3367	0.4505	0.6034	0.6038
042992- 4	3.7594	286.53	44.56	133.493	1.0937	1.4721	0.6047	0.6092
042992- 5	3.7568	286.41	44.55	128.657	1.0669	1.4364	0.6011	0.6054
042992- 6	3.7563	286.13	44.59	129.426	1.0731	1.4457	0.6025	0.6068
042992- 7	3.8169	286.53	45.25	78.114	0.8400	1.1298	0.6044	0.6070
042992- 8	3.8182	287.00	45.18	75.991	0.8270	1.1111	0.6038	0.6063
042992- 9	3.8708	287.06	45.79	38.158	0.5877	0.7889	0.6027	0.6040
042992- 10	3.8662	287.09	45.73	38.614	0.5912	0.7936	0.6031	0.6044
043092- 1	3.7495	286.46	44.45	130.633	1.0804	1.4546	0.6047	0.6091
043092- 2	3.7794	287.31	44.66	130.335	1.0830	1.4545	0.6054	0.6098
043092- 3	3.8530	287.08	45.58	42.014	0.6157	0.8266	0.6030	0.6044
043092- 4	3.8444	286.52	45.57	42.471	0.6198	0.8334	0.6038	0.6052
043092- 5	3.8918	287.57	45.95	12.777	0.3408	0.4568	0.6038	0.6042
043092- 6	3.8924	287.67	45.94	12.940	0.3430	0.4597	0.6040	0.6044
043092- 7	3.8018	287.08	44.97	74.947	0.8215	1.1037	0.6054	0.6079
043092- 8	3.8103	287.10	45.07	74.455	0.8181	1.0989	0.6042	0.6067
051892- 1	3.9495	286.93	46.75	37.783	0.5910	0.7929	0.6029	0.6041
051892- 2	3.9503	286.56	46.83	37.716	0.5910	0.7936	0.6030	0.6042
051892- 3	4.0082	287.52	47.34	12.352	0.3405	0.4558	0.6044	0.6048
051892- 4	4.0089	287.57	47.34	12.418	0.3407	0.4560	0.6032	0.6036
051892- 5	3.9172	286.95	46.36	73.750	0.8260	1.1085	0.6045	0.6068
051892- 6	3.9164	286.33	46.46	73.303	0.8227	1.1057	0.6032	0.6056
051892- 8	3.8637	285.74	45.94	124.375	1.0727	1.4447	0.6056	0.6096
051892- 9	3.8644	285.99	45.90	124.986	1.0733	1.4447	0.6047	0.6088

Table 18. Measured and calculated quantities for 0.48 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042992- 1	3.9036	288.11	46.00	12.541	0.3374	0.4516	0.6031	0.6035
042992- 2	3.9084	288.21	46.03	12.447	0.3361	0.4498	0.6028	0.6032
042992- 3	3.9074	288.28	46.01	12.461	0.3367	0.4505	0.6037	0.6041
042992- 4	3.7594	286.53	44.56	133.447	1.0937	1.4721	0.6048	0.6093
042992- 5	3.7568	286.41	44.55	128.617	1.0669	1.4364	0.6012	0.6055
042992- 6	3.7563	286.13	44.59	129.367	1.0731	1.4457	0.6026	0.6070
042992- 7	3.8169	286.53	45.25	78.073	0.8400	1.1298	0.6046	0.6072
042992- 8	3.8182	287.00	45.18	75.983	0.8270	1.1111	0.6039	0.6064
042992- 9	3.8708	287.06	45.79	38.136	0.5877	0.7889	0.6029	0.6041
042992- 10	3.8662	287.09	45.73	38.592	0.5912	0.7936	0.6033	0.6045
043092- 1	3.7495	286.46	44.45	130.679	1.0804	1.4546	0.6045	0.6090
043092- 2	3.7794	287.31	44.66	130.405	1.0830	1.4545	0.6052	0.6096
043092- 3	3.8530	287.08	45.58	42.022	0.6157	0.8266	0.6030	0.6044
043092- 4	3.8444	286.52	45.57	42.487	0.6198	0.8334	0.6037	0.6051
043092- 5	3.8918	287.57	45.95	12.782	0.3408	0.4568	0.6037	0.6041
043092- 6	3.8924	287.67	45.94	12.944	0.3430	0.4597	0.6039	0.6043
043092- 7	3.8018	287.08	44.97	74.982	0.8215	1.1037	0.6053	0.6077
043092- 8	3.8103	287.10	45.07	74.480	0.8181	1.0989	0.6041	0.6066
051892- 1	3.9495	286.93	46.75	37.819	0.5910	0.7929	0.6026	0.6038
051892- 2	3.9503	286.56	46.83	37.760	0.5910	0.7936	0.6026	0.6038
051892- 3	4.0082	287.52	47.34	12.379	0.3405	0.4558	0.6038	0.6042
051892- 4	4.0089	287.57	47.34	12.447	0.3407	0.4560	0.6025	0.6029
051892- 5	3.9172	286.95	46.36	73.788	0.8260	1.1085	0.6043	0.6067
051892- 6	3.9164	286.33	46.46	73.355	0.8227	1.1057	0.6030	0.6053
051892- 8	3.8637	285.74	45.94	124.422	1.0727	1.4447	0.6054	0.6095
051892- 9	3.8644	285.99	45.90	124.981	1.0733	1.4447	0.6047	0.6088

Table 19. Measured and calculated quantities for 0.48 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042992- 1	3.9036	288.11	46.00	12.580	0.3374	0.4516	0.6022	0.6026
042992- 2	3.9084	288.21	46.03	12.489	0.3361	0.4498	0.6018	0.6022
042992- 3	3.9074	288.28	46.01	12.504	0.3367	0.4505	0.6027	0.6031
042992- 4	3.7594	286.53	44.56	133.647	1.0937	1.4721	0.6044	0.6089
042992- 5	3.7568	286.41	44.55	128.811	1.0669	1.4364	0.6007	0.6050
042992- 6	3.7563	286.13	44.59	129.560	1.0731	1.4457	0.6022	0.6065
042992- 7	3.8169	286.53	45.25	78.213	0.8400	1.1298	0.6040	0.6066
042992- 8	3.8182	287.00	45.18	76.097	0.8270	1.1111	0.6034	0.6059
042992- 9	3.8708	287.06	45.79	38.196	0.5877	0.7889	0.6024	0.6037
042992- 10	3.8662	287.09	45.73	38.667	0.5912	0.7936	0.6027	0.6039
043092- 1	3.7495	286.46	44.45	130.819	1.0804	1.4546	0.6042	0.6086
043092- 2	3.7794	287.31	44.66	130.553	1.0830	1.4545	0.6049	0.6093
043092- 3	3.8530	287.08	45.58	42.066	0.6157	0.8266	0.6027	0.6040
043092- 4	3.8444	286.52	45.57	42.520	0.6198	0.8334	0.6035	0.6048
043092- 5	3.8918	287.57	45.95	12.793	0.3408	0.4568	0.6034	0.6039
043092- 6	3.8924	287.67	45.94	12.960	0.3430	0.4597	0.6035	0.6040
043092- 7	3.8018	287.08	44.97	75.066	0.8215	1.1037	0.6049	0.6074
043092- 8	3.8103	287.10	45.07	74.600	0.8181	1.0989	0.6036	0.6061
051892- 1	3.9495	286.93	46.75	37.840	0.5910	0.7929	0.6025	0.6037
051892- 2	3.9503	286.56	46.83	37.774	0.5910	0.7936	0.6025	0.6037
051892- 3	4.0082	287.52	47.34	12.372	0.3405	0.4558	0.6040	0.6043
051892- 4	4.0089	287.57	47.34	12.443	0.3407	0.4560	0.6026	0.6030
051892- 5	3.9172	286.95	46.36	73.841	0.8260	1.1085	0.6041	0.6065
051892- 6	3.9164	286.33	46.46	73.422	0.8227	1.1057	0.6027	0.6051
051892- 8	3.8637	285.74	45.94	124.521	1.0727	1.4447	0.6052	0.6093
051892- 9	3.8644	285.99	45.90	125.140	1.0733	1.4447	0.6043	0.6084

Table 20. Measured and calculated quantities for 0.54 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042792- 1	3.7766	285.92	44.87	128.586	1.3969	1.8826	0.6079	0.6120
042792- 2	3.7957	285.64	45.15	38.284	0.7604	1.0252	0.6074	0.6087
042792- 3	3.7940	286.24	45.02	38.693	0.7623	1.0263	0.6066	0.6078
042792- 4	3.8154	285.82	45.35	100.512	1.2394	1.6699	0.6077	0.6109
042792- 5	3.8129	286.46	45.21	100.075	1.2329	1.6586	0.6068	0.6100
042792- 6	3.9381	286.72	46.65	10.346	0.4014	0.5389	0.6078	0.6081
042792- 7	3.9348	287.12	46.54	10.610	0.4064	0.5450	0.6083	0.6086
042792- 8	3.7809	285.59	44.98	127.117	1.3940	1.8801	0.6094	0.6135
051992- 1	3.9129	287.32	46.25	36.715	0.7507	1.0067	0.6051	0.6063
051992- 2	3.9102	287.37	46.21	36.618	0.7500	1.0055	0.6056	0.6067
051992- 3	3.8582	286.51	45.74	78.483	1.0974	1.4754	0.6071	0.6096
051992- 5	3.8493	286.54	45.63	78.921	1.0980	1.4762	0.6064	0.6089
051992- 6	3.9453	287.18	46.66	14.126	0.4671	0.6263	0.6050	0.6055
051992- 7	3.9461	287.04	46.69	14.245	0.4686	0.6285	0.6043	0.6047
051992- 8	3.7237	285.57	44.30	142.944	1.4609	1.9718	0.6063	0.6110
051992- 9	3.7235	285.92	44.23	142.294	1.4522	1.9583	0.6045	0.6091

Table 21. Measured and calculated quantities for 0.54 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042792- 1	3.7766	285.92	44.87	128.584	1.3969	1.8826	0.6079	0.6120
042792- 2	3.7957	285.64	45.15	38.300	0.7604	1.0252	0.6073	0.6085
042792- 3	3.7940	286.24	45.02	38.730	0.7623	1.0263	0.6063	0.6075
042792- 4	3.8154	285.82	45.35	100.526	1.2394	1.6699	0.6076	0.6109
042792- 5	3.8129	286.46	45.21	100.114	1.2329	1.6586	0.6066	0.6099
042792- 6	3.9381	286.72	46.65	10.361	0.4014	0.5389	0.6073	0.6076
042792- 7	3.9348	287.12	46.54	10.618	0.4064	0.5450	0.6080	0.6083
042792- 8	3.7809	285.59	44.98	127.133	1.3940	1.8801	0.6093	0.6135
051992- 1	3.9129	287.32	46.25	36.736	0.7507	1.0067	0.6050	0.6061
051992- 2	3.9102	287.37	46.21	36.666	0.7500	1.0055	0.6052	0.6063
051992- 3	3.8582	286.51	45.74	78.551	1.0974	1.4754	0.6068	0.6093
051992- 5	3.8493	286.54	45.63	78.963	1.0980	1.4762	0.6063	0.6088
051992- 6	3.9453	287.18	46.66	14.164	0.4671	0.6263	0.6042	0.6047
051992- 7	3.9461	287.04	46.69	14.283	0.4686	0.6285	0.6034	0.6039
051992- 8	3.7237	285.57	44.30	142.942	1.4609	1.9718	0.6063	0.6110
051992- 9	3.7235	285.92	44.23	142.282	1.4522	1.9583	0.6045	0.6092

Table 22. Measured and calculated quantities for 0.54 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042792- 1	3.7766	285.92	44.87	128.645	1.3969	1.8826	0.6077	0.6119
042792- 2	3.7957	285.64	45.15	38.288	0.7604	1.0252	0.6074	0.6086
042792- 3	3.7940	286.24	45.02	38.712	0.7623	1.0263	0.6064	0.6077
042792- 4	3.8154	285.82	45.35	100.567	1.2394	1.6699	0.6075	0.6107
042792- 5	3.8129	286.46	45.21	100.132	1.2329	1.6586	0.6066	0.6098
042792- 6	3.9381	286.72	46.65	10.323	0.4014	0.5389	0.6084	0.6088
042792- 7	3.9348	287.12	46.54	10.589	0.4064	0.5450	0.6088	0.6092
042792- 8	3.7809	285.59	44.98	127.194	1.3940	1.8801	0.6092	0.6133
051992- 1	3.9129	287.32	46.25	36.701	0.7507	1.0067	0.6053	0.6064
051992- 2	3.9102	287.37	46.21	36.616	0.7500	1.0055	0.6056	0.6067
051992- 3	3.8582	286.51	45.74	78.548	1.0974	1.4754	0.6068	0.6093
051992- 5	3.8493	286.54	45.63	78.956	1.0980	1.4762	0.6063	0.6088
051992- 6	3.9453	287.18	46.66	14.096	0.4671	0.6263	0.6057	0.6061
051992- 7	3.9461	287.04	46.69	14.224	0.4686	0.6285	0.6047	0.6051
051992- 8	3.7237	285.57	44.30	143.011	1.4609	1.9718	0.6061	0.6108
051992- 9	3.7235	285.92	44.23	142.386	1.4522	1.9583	0.6043	0.6089

Table 23. Measured and calculated quantities for 0.54 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042792- 1	3.7766	285.92	44.87	128.672	1.3969	1.8826	0.6076	0.6118
042792- 2	3.7957	285.64	45.15	38.357	0.7604	1.0252	0.6069	0.6081
042792- 3	3.7940	286.24	45.02	38.783	0.7623	1.0263	0.6059	0.6071
042792- 4	3.8154	285.82	45.35	100.606	1.2394	1.6699	0.6074	0.6106
042792- 5	3.8129	286.46	45.21	100.195	1.2329	1.6586	0.6064	0.6096
042792- 6	3.9381	286.72	46.65	10.419	0.4014	0.5389	0.6056	0.6059
042792- 7	3.9348	287.12	46.54	10.682	0.4064	0.5450	0.6062	0.6065
042792- 8	3.7809	285.59	44.98	127.241	1.3940	1.8801	0.6091	0.6132
051992- 1	3.9129	287.32	46.25	36.725	0.7507	1.0067	0.6051	0.6062
051992- 2	3.9102	287.37	46.21	36.639	0.7500	1.0055	0.6054	0.6066
051992- 3	3.8582	286.51	45.74	78.595	1.0974	1.4754	0.6066	0.6091
051992- 5	3.8493	286.54	45.63	79.035	1.0980	1.4762	0.6060	0.6085
051992- 6	3.9453	287.18	46.66	14.091	0.4671	0.6263	0.6058	0.6062
051992- 7	3.9461	287.04	46.69	14.212	0.4686	0.6285	0.6050	0.6054
051992- 8	3.7237	285.57	44.30	143.185	1.4609	1.9718	0.6058	0.6105
051992- 9	3.7235	285.92	44.23	142.578	1.4522	1.9583	0.6039	0.6085

Table 24. Measured and calculated quantities for 0.67 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042792- 1	3.7692	285.61	44.83	72.221	1.6649	2.2456	0.6102	0.6123
042792- 2	3.7678	285.82	44.78	70.675	1.6415	2.2129	0.6085	0.6106
042792- 3	3.8392	285.75	45.65	13.679	0.7288	0.9818	0.6099	0.6103
042792- 4	3.8396	286.88	45.45	13.864	0.7340	0.9862	0.6115	0.6119
042792- 5	3.8955	285.28	46.40	31.973	1.1260	1.5176	0.6108	0.6117
042892- 1	3.9783	288.08	46.88	31.161	1.1167	1.4934	0.6105	0.6113
042892- 2	3.9707	287.04	46.98	30.542	1.1047	1.4813	0.6094	0.6102
042892- 3	3.7886	285.62	45.06	81.363	1.7620	2.3759	0.6066	0.6089
042892- 4	3.8953	286.33	46.21	47.859	1.3712	1.8434	0.6088	0.6101
042892- 5	3.8968	285.99	46.29	48.033	1.3744	1.8491	0.6086	0.6099
051992- 1	3.8482	286.08	45.70	31.439	1.1056	1.4881	0.6095	0.6104
051992- 2	3.8518	287.13	45.55	31.473	1.1061	1.4849	0.6104	0.6112
051992- 3	3.8901	287.27	45.98	12.333	0.6932	0.9298	0.6087	0.6091
051992- 4	3.8884	286.70	46.06	12.366	0.6946	0.9331	0.6087	0.6090
051992- 5	3.8497	286.23	45.69	32.490	1.1232	1.5112	0.6091	0.6100
051992- 6	3.7576	285.32	44.75	71.629	1.6505	2.2281	0.6080	0.6100
051992- 7	3.7408	285.77	44.47	70.553	1.6328	2.2022	0.6080	0.6100
051992- 8	3.7906	286.23	44.98	54.164	1.4391	1.9376	0.6085	0.6101
051992- 9	3.7918	285.99	45.04	54.343	1.4410	1.9413	0.6080	0.6095

Table 25. Measured and calculated quantities for 0.67 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
042792- 1	3.7692	285.61	44.83	72.121	1.6649	2.2456	0.6106	0.6127
042792- 2	3.7678	285.82	44.78	70.594	1.6415	2.2129	0.6089	0.6109
042792- 3	3.8392	285.75	45.65	13.668	0.7288	0.9818	0.6102	0.6105
042792- 4	3.8396	286.88	45.45	13.852	0.7340	0.9862	0.6117	0.6121
042792- 5	3.8955	285.28	46.40	31.951	1.1260	1.5176	0.6110	0.6119
042892- 1	3.9783	288.08	46.88	31.090	1.1167	1.4934	0.6112	0.6120
042892- 2	3.9707	287.04	46.98	30.469	1.1047	1.4813	0.6101	0.6110
042892- 3	3.7886	285.62	45.06	81.179	1.7620	2.3759	0.6073	0.6096
042892- 4	3.8953	286.33	46.21	47.752	1.3712	1.8434	0.6095	0.6108
042892- 5	3.8968	285.99	46.29	47.927	1.3744	1.8491	0.6093	0.6106
051992- 1	3.8482	286.08	45.70	31.478	1.1056	1.4881	0.6091	0.6100
051992- 2	3.8518	287.13	45.55	31.513	1.1061	1.4849	0.6100	0.6108
051992- 3	3.8901	287.27	45.98	12.361	0.6932	0.9298	0.6080	0.6084
051992- 4	3.8884	286.70	46.06	12.394	0.6946	0.9331	0.6080	0.6083
051992- 5	3.8497	286.23	45.69	32.521	1.1232	1.5112	0.6089	0.6098
051992- 6	3.7576	285.32	44.75	71.657	1.6505	2.2281	0.6079	0.6099
051992- 7	3.7408	285.77	44.47	70.583	1.6328	2.2022	0.6078	0.6099
051992- 8	3.7906	286.23	44.98	54.177	1.4391	1.9376	0.6085	0.6100
051992- 9	3.7918	285.99	45.04	54.364	1.4410	1.9413	0.6079	0.6094

Table 26. Measured and calculated quantities for 0.67 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042792- 1	3.7692	285.61	44.83	72.241	1.6649	2.2456	0.6101	0.6122
042792- 2	3.7678	285.82	44.78	70.729	1.6415	2.2129	0.6083	0.6103
042792- 3	3.8392	285.75	45.65	13.652	0.7288	0.9818	0.6105	0.6109
042792- 4	3.8396	286.88	45.45	13.833	0.7340	0.9862	0.6122	0.6126
042792- 5	3.8955	285.28	46.40	31.981	1.1260	1.5176	0.6107	0.6116
042892- 1	3.9783	288.08	46.88	31.135	1.1167	1.4934	0.6107	0.6116
042892- 2	3.9707	287.04	46.98	30.517	1.1047	1.4813	0.6096	0.6105
042892- 3	3.7886	285.62	45.06	81.355	1.7620	2.3759	0.6066	0.6089
042892- 4	3.8953	286.33	46.21	47.837	1.3712	1.8434	0.6089	0.6103
042892- 5	3.8968	285.99	46.29	48.020	1.3744	1.8491	0.6087	0.6100
051992- 1	3.8482	286.08	45.70	31.475	1.1056	1.4881	0.6091	0.6100
051992- 2	3.8518	287.13	45.55	31.505	1.1061	1.4849	0.6100	0.6109
051992- 3	3.8901	287.27	45.98	12.316	0.6932	0.9298	0.6091	0.6095
051992- 4	3.8884	286.70	46.06	12.346	0.6946	0.9331	0.6092	0.6095
051992- 5	3.8497	286.23	45.69	32.522	1.1232	1.5112	0.6088	0.6098
051992- 6	3.7576	285.32	44.75	71.738	1.6505	2.2281	0.6075	0.6096
051992- 7	3.7408	285.77	44.47	70.669	1.6328	2.2022	0.6075	0.6095
051992- 8	3.7906	286.23	44.98	54.225	1.4391	1.9376	0.6082	0.6097
051992- 9	3.7918	285.99	45.04	54.389	1.4410	1.9413	0.6077	0.6092

Table 27. Measured and calculated quantities for 0.67 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042792- 1	3.7692	285.61	44.83	72.476	1.6649	2.2456	0.6091	0.6112
042792- 2	3.7678	285.82	44.78	70.929	1.6415	2.2129	0.6075	0.6095
042792- 3	3.8392	285.75	45.65	13.773	0.7288	0.9818	0.6078	0.6082
042792- 4	3.8396	286.88	45.45	13.958	0.7340	0.9862	0.6094	0.6098
042792- 5	3.8955	285.28	46.40	32.125	1.1260	1.5176	0.6094	0.6103
042892- 1	3.9783	288.08	46.88	31.233	1.1167	1.4934	0.6098	0.6106
042892- 2	3.9707	287.04	46.98	30.620	1.1047	1.4813	0.6086	0.6095
042892- 3	3.7886	285.62	45.06	81.586	1.7620	2.3759	0.6058	0.6081
042892- 4	3.8953	286.33	46.21	48.001	1.3712	1.8434	0.6079	0.6092
042892- 5	3.8968	285.99	46.29	48.164	1.3744	1.8491	0.6078	0.6091
051992- 1	3.8482	286.08	45.70	31.512	1.1056	1.4881	0.6088	0.6097
051992- 2	3.8518	287.13	45.55	31.548	1.1061	1.4849	0.6096	0.6105
051992- 3	3.8901	287.27	45.98	12.323	0.6932	0.9298	0.6090	0.6093
051992- 4	3.8884	286.70	46.06	12.357	0.6946	0.9331	0.6089	0.6092
051992- 5	3.8497	286.23	45.69	32.556	1.1232	1.5112	0.6085	0.6094
051992- 6	3.7576	285.32	44.75	71.866	1.6505	2.2281	0.6070	0.6090
051992- 7	3.7408	285.77	44.47	70.766	1.6328	2.2022	0.6071	0.6091
051992- 8	3.7906	286.23	44.98	54.294	1.4391	1.9376	0.6078	0.6093
051992- 9	3.7918	285.99	45.04	54.487	1.4410	1.9413	0.6072	0.6087

Table 28. Measured and calculated quantities for 0.73 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location A, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042892- 1	3.8426	285.37	45.75	46.062	1.6785	2.2633	0.6092	0.6103
042892- 2	3.8380	285.22	45.72	45.195	1.6592	2.2382	0.6081	0.6093
042892- 3	3.8793	285.94	46.09	34.981	1.4695	1.9778	0.6100	0.6109
042892- 4	3.8793	286.53	45.99	35.467	1.4774	1.9857	0.6098	0.6107
042892- 5	3.9328	286.55	46.62	22.557	1.1885	1.5962	0.6112	0.6118
042892- 6	3.9271	286.66	46.53	22.867	1.1930	1.6020	0.6099	0.6105
042892- 7	3.8108	286.36	45.20	12.108	0.8550	1.1506	0.6098	0.6101
042892- 8	3.8127	286.98	45.11	12.016	0.8511	1.1435	0.6099	0.6102
051392- 1	3.9278	287.33	46.42	5.671	0.5939	0.7962	0.6109	0.6110
051392- 2	3.9244	286.62	46.51	5.673	0.5941	0.7979	0.6105	0.6106
051392- 3	3.8613	286.38	45.80	32.049	1.4065	1.8914	0.6120	0.6128
051392- 4	3.8645	285.26	46.04	31.793	1.4047	1.8940	0.6121	0.6129
051392- 5	3.8983	286.19	46.27	21.687	1.1586	1.5581	0.6100	0.6105
051392- 6	3.8979	286.13	46.28	21.740	1.1633	1.5647	0.6117	0.6122
051392- 7	3.9038	286.85	46.22	13.464	0.9134	1.2263	0.6108	0.6112
051392- 8	3.9023	286.22	46.31	13.571	0.9169	1.2329	0.6102	0.6105
051392- 9	3.7665	284.30	45.03	48.147	1.7090	2.3125	0.6115	0.6127
051392- 10	3.7618	286.22	44.64	48.187	1.6987	2.2880	0.6102	0.6114
051392- 11	3.7652	285.36	44.83	47.829	1.6970	2.2905	0.6106	0.6118
051892- 1	3.9390	287.09	46.60	35.095	1.4791	1.9838	0.6097	0.6105
051892- 4	3.9799	286.64	47.16	20.879	1.1514	1.5451	0.6119	0.6125
051892- 5	3.9772	286.73	47.12	21.269	1.1594	1.5556	0.6108	0.6113
051892- 6	3.8544	286.37	45.72	50.289	1.7624	2.3702	0.6123	0.6135
051892- 7	3.8486	285.96	45.72	49.837	1.7462	2.3510	0.6094	0.6106
051892- 8	3.8549	285.93	45.80	49.208	1.7411	2.3441	0.6110	0.6122
051892- 9	3.9086	285.23	46.57	36.679	1.5158	2.0430	0.6113	0.6122
051892- 10	3.9690	286.66	47.03	12.718	0.8961	1.2027	0.6113	0.6116
051892- 11	3.9630	286.82	46.93	12.936	0.9027	1.2111	0.6112	0.6115
051992- 1	3.8745	286.81	45.88	21.322	1.1435	1.5360	0.6098	0.6103
051992- 2	3.8782	286.48	45.98	21.034	1.1400	1.5323	0.6114	0.6119
051992- 3	3.8798	286.69	45.96	20.856	1.1318	1.5205	0.6096	0.6102
051992- 4	3.8258	286.79	45.30	34.030	1.4353	1.9290	0.6093	0.6102
051992- 5	3.8238	285.64	45.48	33.604	1.4348	1.9337	0.6118	0.6126
051992- 6	3.8231	285.82	45.44	33.383	1.4253	1.9202	0.6100	0.6109
051992- 7	3.8775	286.73	45.93	12.543	0.8776	1.1789	0.6100	0.6103
051992- 8	3.8784	286.47	45.99	12.620	0.8812	1.1845	0.6103	0.6106
051992- 9	3.7556	286.05	44.60	47.563	1.6865	2.2727	0.6101	0.6113
051992- 10	3.7555	284.67	44.83	46.864	1.6805	2.2722	0.6108	0.6120

Table 29. Measured and calculated quantities for 0.73 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location B, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042892- 1	3.8426	285.37	45.75	45.799	1.6785	2.2633	0.6110	0.6121
042892- 2	3.8380	285.22	45.72	44.935	1.6592	2.2382	0.6099	0.6110
042892- 3	3.8793	285.94	46.09	34.755	1.4695	1.9778	0.6120	0.6129
042892- 4	3.8793	286.53	45.99	35.244	1.4774	1.9857	0.6117	0.6126
042892- 5	3.9328	286.55	46.62	22.405	1.1885	1.5962	0.6133	0.6138
042892- 6	3.9271	286.66	46.53	22.698	1.1930	1.6020	0.6122	0.6127
042892- 7	3.8108	286.36	45.20	11.995	0.8550	1.1506	0.6127	0.6130
042892- 8	3.8127	286.98	45.11	11.904	0.8511	1.1435	0.6127	0.6130
051392- 1	3.9278	287.33	46.42	5.664	0.5939	0.7962	0.6113	0.6114
051392- 2	3.9244	286.62	46.51	5.666	0.5941	0.7979	0.6108	0.6109
051392- 3	3.8613	286.38	45.80	32.027	1.4065	1.8914	0.6122	0.6130
051392- 4	3.8645	285.26	46.04	31.772	1.4047	1.8940	0.6123	0.6131
051392- 5	3.8983	286.19	46.27	21.669	1.1586	1.5581	0.6103	0.6108
051392- 6	3.8979	286.13	46.28	21.722	1.1633	1.5647	0.6119	0.6125
051392- 7	3.9038	286.85	46.22	13.460	0.9134	1.2263	0.6109	0.6113
051392- 8	3.9023	286.22	46.31	13.563	0.9169	1.2329	0.6104	0.6107
051392- 9	3.7665	284.30	45.03	48.114	1.7090	2.3125	0.6117	0.6129
051392- 10	3.7618	286.22	44.64	48.142	1.6987	2.2880	0.6104	0.6117
051392- 11	3.7652	285.36	44.83	47.792	1.6970	2.2905	0.6108	0.6120
051892- 1	3.9390	287.09	46.60	35.128	1.4791	1.9838	0.6094	0.6102
051892- 4	3.9799	286.64	47.16	20.906	1.1514	1.5451	0.6115	0.6121
051892- 5	3.9772	286.73	47.12	21.294	1.1594	1.5556	0.6105	0.6110
051892- 6	3.8544	286.37	45.72	50.304	1.7624	2.3702	0.6122	0.6134
051892- 7	3.8486	285.96	45.72	49.854	1.7462	2.3510	0.6093	0.6105
051892- 8	3.8549	285.93	45.80	49.248	1.7411	2.3441	0.6107	0.6119
051892- 9	3.9086	285.23	46.57	36.704	1.5158	2.0430	0.6111	0.6120
051892- 10	3.9690	286.66	47.03	12.759	0.8961	1.2027	0.6103	0.6107
051892- 11	3.9630	286.82	46.93	12.982	0.9027	1.2111	0.6101	0.6104
051992- 1	3.8745	286.81	45.88	21.338	1.1435	1.5360	0.6095	0.6101
051992- 2	3.8782	286.48	45.98	21.055	1.1400	1.5323	0.6111	0.6116
051992- 3	3.8798	286.69	45.96	20.881	1.1318	1.5205	0.6093	0.6098
051992- 4	3.8258	286.79	45.30	34.056	1.4353	1.9290	0.6091	0.6099
051992- 5	3.8238	285.64	45.48	33.629	1.4348	1.9337	0.6116	0.6124
051992- 6	3.8231	285.82	45.44	33.410	1.4253	1.9202	0.6098	0.6106
051992- 7	3.8775	286.73	45.93	12.578	0.8776	1.1789	0.6091	0.6094
051992- 8	3.8784	286.47	45.99	12.651	0.8812	1.1845	0.6096	0.6099
051992- 9	3.7556	286.05	44.60	47.578	1.6865	2.2727	0.6100	0.6112
051992- 10	3.7555	284.67	44.83	46.884	1.6805	2.2722	0.6107	0.6119

Table 30. Measured and calculated quantities for 0.73 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location C, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042892- 1	3.8426	285.37	45.75	45.880	1.6785	2.2633	0.6104	0.6116
042892- 2	3.8380	285.22	45.72	45.004	1.6592	2.2382	0.6094	0.6106
042892- 3	3.8793	285.94	46.09	34.826	1.4695	1.9778	0.6114	0.6123
042892- 4	3.8793	286.53	45.99	35.305	1.4774	1.9857	0.6112	0.6121
042892- 5	3.9328	286.55	46.62	22.430	1.1885	1.5962	0.6129	0.6135
042892- 6	3.9271	286.66	46.53	22.734	1.1930	1.6020	0.6117	0.6123
042892- 7	3.8108	286.36	45.20	12.021	0.8550	1.1506	0.6120	0.6123
042892- 8	3.8127	286.98	45.11	11.935	0.8511	1.1435	0.6119	0.6122
051392- 1	3.9278	287.33	46.42	5.673	0.5939	0.7962	0.6108	0.6109
051392- 2	3.9244	286.62	46.51	5.677	0.5941	0.7979	0.6103	0.6104
051392- 3	3.8613	286.38	45.80	32.093	1.4065	1.8914	0.6116	0.6124
051392- 4	3.8645	285.26	46.04	31.829	1.4047	1.8940	0.6118	0.6126
051392- 5	3.8983	286.19	46.27	21.725	1.1586	1.5581	0.6095	0.6100
051392- 6	3.8979	286.13	46.28	21.777	1.1633	1.5647	0.6112	0.6117
051392- 7	3.9038	286.85	46.22	13.480	0.9134	1.2263	0.6105	0.6108
051392- 8	3.9023	286.22	46.31	13.583	0.9169	1.2329	0.6099	0.6102
051392- 9	3.7665	284.30	45.03	48.200	1.7090	2.3125	0.6111	0.6124
051392- 10	3.7618	286.22	44.64	48.237	1.6987	2.2880	0.6098	0.6111
051392- 11	3.7652	285.36	44.83	47.871	1.6970	2.2905	0.6103	0.6115
051892- 1	3.9390	287.09	46.60	35.199	1.4791	1.9838	0.6088	0.6096
051892- 4	3.9799	286.64	47.16	20.943	1.1514	1.5451	0.6110	0.6115
051892- 5	3.9772	286.73	47.12	21.344	1.1594	1.5556	0.6098	0.6103
051892- 6	3.8544	286.37	45.72	50.368	1.7624	2.3702	0.6118	0.6130
051892- 7	3.8486	285.96	45.72	49.905	1.7462	2.3510	0.6090	0.6102
051892- 8	3.8549	285.93	45.80	49.296	1.7411	2.3441	0.6104	0.6116
051892- 9	3.9086	285.23	46.57	36.758	1.5158	2.0430	0.6107	0.6116
051892- 10	3.9690	286.66	47.03	12.784	0.8961	1.2027	0.6097	0.6100
051892- 11	3.9630	286.82	46.93	12.991	0.9027	1.2111	0.6099	0.6102
051992- 1	3.8745	286.81	45.88	21.320	1.1435	1.5360	0.6098	0.6103
051992- 2	3.8782	286.48	45.98	21.028	1.1400	1.5323	0.6114	0.6120
051992- 3	3.8798	286.69	45.96	20.849	1.1318	1.5205	0.6097	0.6103
051992- 4	3.8258	286.79	45.30	34.039	1.4353	1.9290	0.6093	0.6101
051992- 5	3.8238	285.64	45.48	33.623	1.4348	1.9337	0.6116	0.6125
051992- 6	3.8231	285.82	45.44	33.407	1.4253	1.9202	0.6098	0.6106
051992- 7	3.8775	286.73	45.93	12.528	0.8776	1.1789	0.6104	0.6107
051992- 8	3.8784	286.47	45.99	12.599	0.8812	1.1845	0.6108	0.6111
051992- 9	3.7556	286.05	44.60	47.613	1.6865	2.2727	0.6097	0.6109
051992- 10	3.7555	284.67	44.83	46.921	1.6805	2.2722	0.6104	0.6116

Table 31. Measured and calculated quantities for 0.73 beta ratio, oversize Sprenkle at 44 pipe diameters, flange tap location D, 52 mm orifice meter.

Run ID	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
042892- 1	3.8426	285.37	45.75	46.233	1.6785	2.2633	0.6081	0.6092
042892- 2	3.8380	285.22	45.72	45.381	1.6592	2.2382	0.6069	0.6080
042892- 3	3.8793	285.94	46.09	35.115	1.4695	1.9778	0.6089	0.6097
042892- 4	3.8793	286.53	45.99	35.594	1.4774	1.9857	0.6087	0.6096
042892- 5	3.9328	286.55	46.62	22.633	1.1885	1.5962	0.6102	0.6107
042892- 6	3.9271	286.66	46.53	22.943	1.1930	1.6020	0.6089	0.6095
042892- 7	3.8108	286.36	45.20	12.140	0.8550	1.1506	0.6090	0.6093
042892- 8	3.8127	286.98	45.11	12.052	0.8511	1.1435	0.6090	0.6093
051392- 1	3.9278	287.33	46.42	5.718	0.5939	0.7962	0.6084	0.6085
051392- 2	3.9244	286.62	46.51	5.720	0.5941	0.7979	0.6079	0.6081
051392- 3	3.8613	286.38	45.80	32.186	1.4065	1.8914	0.6107	0.6115
051392- 4	3.8645	285.26	46.04	31.924	1.4047	1.8940	0.6108	0.6116
051392- 5	3.8983	286.19	46.27	21.797	1.1586	1.5581	0.6085	0.6090
051392- 6	3.8979	286.13	46.28	21.833	1.1633	1.5647	0.6104	0.6109
051392- 7	3.9038	286.85	46.22	13.518	0.9134	1.2263	0.6096	0.6099
051392- 8	3.9023	286.22	46.31	13.630	0.9169	1.2329	0.6089	0.6092
051392- 9	3.7665	284.30	45.03	48.347	1.7090	2.3125	0.6102	0.6114
051392- 10	3.7618	286.22	44.64	48.381	1.6987	2.2880	0.6089	0.6101
051392- 11	3.7652	285.36	44.83	48.022	1.6970	2.2905	0.6093	0.6105
051892- 1	3.9390	287.09	46.60	35.241	1.4791	1.9838	0.6084	0.6093
051892- 4	3.9799	286.64	47.16	20.980	1.1514	1.5451	0.6105	0.6110
051892- 5	3.9772	286.73	47.12	21.370	1.1594	1.5556	0.6094	0.6099
051892- 6	3.8544	286.37	45.72	50.489	1.7624	2.3702	0.6111	0.6123
051892- 7	3.8486	285.96	45.72	50.033	1.7462	2.3510	0.6082	0.6094
051892- 8	3.8549	285.93	45.80	49.391	1.7411	2.3441	0.6098	0.6111
051892- 9	3.9086	285.23	46.57	36.836	1.5158	2.0430	0.6100	0.6109
051892- 10	3.9690	286.66	47.03	12.811	0.8961	1.2027	0.6091	0.6094
051892- 11	3.9630	286.82	46.93	13.016	0.9027	1.2111	0.6093	0.6096
051992- 1	3.8745	286.81	45.88	21.388	1.1435	1.5360	0.6088	0.6093
051992- 2	3.8782	286.48	45.98	21.101	1.1400	1.5323	0.6104	0.6109
051992- 3	3.8798	286.69	45.96	20.906	1.1318	1.5205	0.6089	0.6094
051992- 4	3.8258	286.79	45.30	34.151	1.4353	1.9290	0.6082	0.6091
051992- 5	3.8238	285.64	45.48	33.730	1.4348	1.9337	0.6106	0.6115
051992- 6	3.8231	285.82	45.44	33.498	1.4253	1.9202	0.6090	0.6098
051992- 7	3.8775	286.73	45.93	12.557	0.8776	1.1789	0.6097	0.6100
051992- 8	3.8784	286.47	45.99	12.632	0.8812	1.1845	0.6100	0.6103
051992- 9	3.7556	286.05	44.60	47.754	1.6865	2.2727	0.6088	0.6100
051992- 10	3.7555	284.67	44.83	47.060	1.6805	2.2722	0.6095	0.6107

Table 32. Measured and calculated quantities for 0.40 (2D) beta ratio, elbow at 17 pipe diameters, no flow conditioner, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
091792- 1A	3.9495	290.95	46.04	25.519	0.3202	0.4255	0.5972	0.5981
091792- 2A	3.9486	289.86	46.22	25.612	0.3217	0.4285	0.5976	0.5985
091792- 3A	3.9303	289.28	46.11	43.161	0.4177	0.5573	0.5980	0.5994
091792- 4A	3.9296	289.26	46.10	42.988	0.4173	0.5568	0.5986	0.6001
091792- 5A	3.8309	288.32	45.10	120.397	0.6955	0.9312	0.6002	0.6043
091792- 6A	3.8325	287.37	45.28	118.620	0.6909	0.9272	0.5995	0.6035
091792- 7A	3.8653	288.72	45.44	75.278	0.5494	0.7346	0.5988	0.6014
091792- 8A	3.8649	288.33	45.50	75.261	0.5500	0.7361	0.5992	0.6017
091792- 1B	3.9495	290.95	46.04	25.541	0.3202	0.4255	0.5970	0.5978
091792- 2B	3.9486	289.86	46.22	25.633	0.3217	0.4285	0.5974	0.5982
091792- 3B	3.9303	289.28	46.11	43.180	0.4177	0.5573	0.5979	0.5993
091792- 4B	3.9296	289.26	46.10	43.006	0.4173	0.5568	0.5985	0.5999
091792- 5B	3.8309	288.32	45.10	120.428	0.6955	0.9312	0.6001	0.6042
091792- 6B	3.8325	287.37	45.28	118.685	0.6909	0.9272	0.5993	0.6033
091792- 7B	3.8653	288.72	45.44	75.339	0.5494	0.7346	0.5986	0.6011
091792- 8B	3.8649	288.33	45.50	75.305	0.5500	0.7361	0.5990	0.6015
091792- 1C	3.9495	290.95	46.04	25.433	0.3202	0.4255	0.5983	0.5991
091792- 2C	3.9486	289.86	46.22	25.515	0.3217	0.4285	0.5988	0.5996
091792- 3C	3.9303	289.28	46.11	43.131	0.4177	0.5573	0.5982	0.5996
091792- 4C	3.9296	289.26	46.10	42.962	0.4173	0.5568	0.5988	0.6002
091792- 5C	3.8309	288.32	45.10	120.617	0.6955	0.9312	0.5996	0.6037
091792- 6C	3.8325	287.37	45.28	118.849	0.6909	0.9272	0.5989	0.6029
091792- 7C	3.8653	288.72	45.44	75.394	0.5494	0.7346	0.5984	0.6009
091792- 8C	3.8649	288.33	45.50	75.354	0.5500	0.7361	0.5988	0.6013
091792- 1D	3.9495	290.95	46.04	25.489	0.3202	0.4255	0.5976	0.5984
091792- 2D	3.9486	289.86	46.22	25.584	0.3217	0.4285	0.5980	0.5988
091792- 3D	3.9303	289.28	46.11	43.140	0.4177	0.5573	0.5982	0.5996
091792- 4D	3.9296	289.26	46.10	42.971	0.4173	0.5568	0.5988	0.6002
091792- 5D	3.8309	288.32	45.10	120.386	0.6955	0.9312	0.6002	0.6043
091792- 6D	3.8325	287.37	45.28	118.584	0.6909	0.9272	0.5996	0.6036
091792- 7D	3.8653	288.72	45.44	75.278	0.5494	0.7346	0.5988	0.6014
091792- 8D	3.8649	288.33	45.50	75.241	0.5500	0.7361	0.5993	0.6018

Table 33. Measured and calculated quantities for 0.54 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
062592- 1A	3.9696	284.86	47.37	38.603	0.7800	1.0515	0.6061	0.6073
062592- 2A	3.9692	283.81	47.56	38.400	0.7785	1.0521	0.6054	0.6066
062592- 3A	4.0102	284.94	47.84	12.713	0.4484	0.6040	0.6050	0.6054
062592- 4A	4.0076	285.18	47.76	12.757	0.4495	0.6051	0.6058	0.6062
062592- 5A	3.9277	284.38	46.95	76.165	1.0947	1.4782	0.6071	0.6095
062592- 6A	3.9273	283.91	47.03	74.060	1.0807	1.4609	0.6073	0.6096
062592- 7A	3.8197	283.09	45.88	140.764	1.4734	1.9984	0.6059	0.6104
062592- 8A	3.8186	283.29	45.84	139.817	1.4705	1.9935	0.6071	0.6116
062992- 1A	4.0076	284.47	47.90	12.301	0.4418	0.5959	0.6057	0.6060
062992- 2A	4.0059	285.11	47.76	12.406	0.4432	0.5968	0.6058	0.6062
062992- 3A	3.8211	283.81	45.77	144.539	1.4898	2.0171	0.6052	0.6098
062992- 4A	3.7970	282.98	45.63	142.700	1.4820	2.0111	0.6069	0.6115
062992- 5A	3.9397	284.69	47.04	36.851	0.7582	1.0229	0.6052	0.6063
062992- 6A	3.9432	284.45	47.13	37.199	0.7627	1.0295	0.6053	0.6065
062992- 7A	3.9017	284.88	46.55	77.748	1.1012	1.4855	0.6070	0.6094
062992- 8A	3.9044	284.28	46.69	75.910	1.0903	1.4729	0.6073	0.6097
062592- 1B	3.9696	284.86	47.37	38.538	0.7800	1.0515	0.6066	0.6078
062592- 2B	3.9692	283.81	47.56	38.332	0.7785	1.0521	0.6059	0.6071
062592- 3B	4.0102	284.94	47.84	12.667	0.4484	0.6040	0.6061	0.6065
062592- 4B	4.0076	285.18	47.76	12.716	0.4495	0.6051	0.6068	0.6072
062592- 5B	3.9277	284.38	46.95	76.014	1.0947	1.4782	0.6077	0.6101
062592- 6B	3.9273	283.91	47.03	73.936	1.0807	1.4609	0.6078	0.6102
062592- 7B	3.8197	283.09	45.88	140.490	1.4734	1.9984	0.6065	0.6110
062592- 8B	3.8186	283.29	45.84	139.583	1.4705	1.9935	0.6076	0.6121
062992- 1B	4.0076	284.47	47.90	12.263	0.4418	0.5959	0.6066	0.6070
062992- 2B	4.0059	285.11	47.76	12.374	0.4432	0.5968	0.6066	0.6070
062992- 3B	3.8211	283.81	45.77	144.362	1.4898	2.0171	0.6056	0.6102
062992- 4B	3.7970	282.98	45.63	142.514	1.4820	2.0111	0.6073	0.6119
062992- 5B	3.9397	284.69	47.04	36.780	0.7582	1.0229	0.6058	0.6069
062992- 6B	3.9432	284.45	47.13	37.119	0.7627	1.0295	0.6060	0.6071
062992- 7B	3.9017	284.88	46.55	77.674	1.1012	1.4855	0.6073	0.6097
062992- 8B	3.9044	284.28	46.69	75.832	1.0903	1.4729	0.6076	0.6100
062592- 1C	3.9696	284.86	47.37	38.668	0.7800	1.0515	0.6056	0.6068
062592- 2C	3.9692	283.81	47.56	38.468	0.7785	1.0521	0.6048	0.6060
062592- 3C	4.0102	284.94	47.84	12.725	0.4484	0.6040	0.6047	0.6051
062592- 4C	4.0076	285.18	47.76	12.767	0.4495	0.6051	0.6056	0.6060
062592- 5C	3.9277	284.38	46.95	76.232	1.0947	1.4782	0.6068	0.6092
062592- 6C	3.9273	283.91	47.03	74.162	1.0807	1.4609	0.6069	0.6092
062592- 7C	3.8197	283.09	45.88	140.844	1.4734	1.9984	0.6057	0.6102
062592- 8C	3.8186	283.29	45.84	139.982	1.4705	1.9935	0.6067	0.6112
062992- 1C	4.0076	284.47	47.90	12.295	0.4418	0.5959	0.6058	0.6062
062992- 2C	4.0059	285.11	47.76	12.405	0.4432	0.5968	0.6058	0.6062
062992- 3C	3.8211	283.81	45.77	144.777	1.4898	2.0171	0.6047	0.6093
062992- 4C	3.7970	282.98	45.63	142.893	1.4820	2.0111	0.6064	0.6111
062992- 5C	3.9397	284.69	47.04	36.881	0.7582	1.0229	0.6049	0.6061
062992- 6C	3.9432	284.45	47.13	37.218	0.7627	1.0295	0.6052	0.6063
062992- 7C	3.9017	284.88	46.55	77.878	1.1012	1.4855	0.6065	0.6089
062992- 8C	3.9044	284.28	46.69	76.035	1.0903	1.4729	0.6068	0.6092
062592- 1D	3.9696	284.86	47.37	38.616	0.7800	1.0515	0.6060	0.6072
062592- 2D	3.9692	283.81	47.56	38.419	0.7785	1.0521	0.6052	0.6064
062592- 3D	4.0102	284.94	47.84	12.692	0.4484	0.6040	0.6055	0.6059
062592- 4D	4.0076	285.18	47.76	12.739	0.4495	0.6051	0.6063	0.6067
062592- 5D	3.9277	284.38	46.95	76.166	1.0947	1.4782	0.6071	0.6095
062592- 6D	3.9273	283.91	47.03	74.054	1.0807	1.4609	0.6074	0.6097
062592- 7D	3.8197	283.09	45.88	140.737	1.4734	1.9984	0.6060	0.6105
062592- 8D	3.8186	283.29	45.84	139.855	1.4705	1.9935	0.6070	0.6115
062992- 1D	4.0076	284.47	47.90	12.305	0.4418	0.5959	0.6056	0.6060
062992- 2D	4.0059	285.11	47.76	12.413	0.4432	0.5968	0.6056	0.6060
062992- 3D	3.8211	283.81	45.77	144.460	1.4898	2.0171	0.6053	0.6100
062992- 4D	3.7970	282.98	45.63	142.584	1.4820	2.0111	0.6071	0.6117
062992- 5D	3.9397	284.69	47.04	36.831	0.7582	1.0229	0.6053	0.6065
062992- 6D	3.9432	284.45	47.13	37.168	0.7627	1.0295	0.6056	0.6067
062992- 7D	3.9017	284.88	46.55	77.737	1.1012	1.4855	0.6070	0.6095
062992- 8D	3.9044	284.28	46.69	75.879	1.0903	1.4729	0.6075	0.6098

Table 34. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
062592- 1A	3.9687	284.32	47.46	30.908	1.1143	1.5040	0.6080	0.6088
062592- 2A	3.9656	284.21	47.44	30.699	1.1097	1.4983	0.6077	0.6085
062592- 3A	4.0012	285.06	47.71	12.996	0.7232	0.9739	0.6074	0.6077
062592- 1A	4.0019	284.92	47.74	13.052	0.7257	0.9777	0.6080	0.6084
062592- 2A	3.9172	283.21	47.04	50.150	1.4116	1.9116	0.6068	0.6082
062592- 3A	3.9166	283.94	46.90	49.497	1.4000	1.8927	0.6067	0.6081
062592- 4A	3.8480	281.88	46.45	74.409	1.7093	2.3245	0.6064	0.6085
062592- 5A	3.8429	282.61	46.25	74.088	1.6989	2.3064	0.6053	0.6074
062992- 1A	3.8729	283.88	46.38	48.889	1.3858	1.8747	0.6077	0.6090
062992- 2A	3.8742	284.57	46.28	48.590	1.3803	1.8642	0.6078	0.6092
062992- 3A	3.9086	284.22	46.75	31.397	1.1165	1.5085	0.6090	0.6099
062992- 4A	3.9054	283.92	46.77	31.575	1.1173	1.5107	0.6076	0.6084
062992- 5A	3.9624	285.18	47.22	12.417	0.7039	0.9481	0.6080	0.6083
062992- 6A	3.9636	284.02	47.45	12.396	0.7048	0.9521	0.6078	0.6082
062992- 7A	3.8067	282.52	45.83	73.575	1.6889	2.2943	0.6066	0.6087
062992- 8A	3.8089	283.33	45.71	72.913	1.6802	2.2778	0.6070	0.6090
062592- 1B	3.9687	284.32	47.46	30.816	1.1143	1.5040	0.6089	0.6098
062592- 2B	3.9656	284.21	47.44	30.610	1.1097	1.4983	0.6086	0.6094
062592- 3B	4.0012	285.06	47.71	12.939	0.7232	0.9739	0.6087	0.6091
062592- 1B	4.0019	284.92	47.74	12.996	0.7257	0.9777	0.6093	0.6097
062592- 2B	3.9172	283.21	47.04	49.991	1.4116	1.9116	0.6078	0.6092
062592- 3B	3.9166	283.94	46.90	49.336	1.4000	1.8927	0.6077	0.6091
062592- 4B	3.8480	281.88	46.45	74.163	1.7093	2.3245	0.6074	0.6095
062592- 5B	3.8429	282.61	46.25	73.862	1.6989	2.3064	0.6062	0.6083
062992- 1B	3.8729	283.88	46.38	48.773	1.3858	1.8747	0.6084	0.6097
062992- 2B	3.8742	284.57	46.28	48.449	1.3803	1.8642	0.6087	0.6100
062992- 3B	3.9086	284.22	46.75	31.284	1.1165	1.5085	0.6101	0.6109
062992- 4B	3.9054	283.92	46.77	31.490	1.1173	1.5107	0.6084	0.6092
062992- 5B	3.9624	285.18	47.22	12.354	0.7039	0.9481	0.6095	0.6098
062992- 6B	3.9636	284.02	47.45	12.333	0.7048	0.9521	0.6094	0.6097
062992- 7B	3.8067	282.52	45.83	73.379	1.6889	2.2943	0.6074	0.6095
062992- 8B	3.8089	283.33	45.71	72.714	1.6802	2.2778	0.6078	0.6099
062592- 1C	3.9687	284.32	47.46	31.022	1.1143	1.5040	0.6069	0.6077
062592- 2C	3.9656	284.21	47.44	30.810	1.1097	1.4983	0.6066	0.6074
062592- 3C	4.0012	285.06	47.71	13.038	0.7232	0.9739	0.6064	0.6068
062592- 1C	4.0019	284.92	47.74	13.100	0.7257	0.9777	0.6069	0.6072
062592- 2C	3.9172	283.21	47.04	50.295	1.4116	1.9116	0.6059	0.6073
062592- 3C	3.9166	283.94	46.90	49.651	1.4000	1.8927	0.6058	0.6072
062592- 4C	3.8480	281.88	46.45	74.622	1.7093	2.3245	0.6055	0.6076
062592- 5C	3.8429	282.61	46.25	74.332	1.6989	2.3064	0.6043	0.6064
062992- 1C	3.8729	283.88	46.38	49.062	1.3858	1.8747	0.6066	0.6079
062992- 2C	3.8742	284.57	46.28	48.776	1.3803	1.8642	0.6066	0.6080
062992- 3C	3.9086	284.22	46.75	31.489	1.1165	1.5085	0.6081	0.6090
062992- 4C	3.9054	283.92	46.77	31.688	1.1173	1.5107	0.6065	0.6073
062992- 5C	3.9624	285.18	47.22	12.447	0.7039	0.9481	0.6072	0.6076
062992- 6C	3.9636	284.02	47.45	12.420	0.7048	0.9521	0.6072	0.6076
062992- 7C	3.8067	282.52	45.83	73.864	1.6889	2.2943	0.6054	0.6075
062992- 8C	3.8089	283.33	45.71	73.195	1.6802	2.2778	0.6058	0.6079
062592- 1D	3.9687	284.32	47.46	30.910	1.1143	1.5040	0.6080	0.6088
062592- 2D	3.9656	284.21	47.44	30.706	1.1097	1.4983	0.6076	0.6085
062592- 3D	4.0012	285.06	47.71	12.980	0.7232	0.9739	0.6078	0.6081
062592- 1D	4.0019	284.92	47.74	13.047	0.7257	0.9777	0.6081	0.6085
062592- 2D	3.9172	283.21	47.04	50.160	1.4116	1.9116	0.6068	0.6081
062592- 3D	3.9166	283.94	46.90	49.523	1.4000	1.8927	0.6066	0.6079
062592- 4D	3.8480	281.88	46.45	74.425	1.7093	2.3245	0.6064	0.6084
062592- 5D	3.8429	282.61	46.25	74.124	1.6989	2.3064	0.6052	0.6072
062992- 1D	3.8729	283.88	46.38	48.876	1.3858	1.8747	0.6077	0.6091
062992- 2D	3.8742	284.57	46.28	48.565	1.3803	1.8642	0.6080	0.6093
062992- 3D	3.9086	284.22	46.75	31.394	1.1165	1.5085	0.6090	0.6099
062992- 4D	3.9054	283.92	46.77	31.579	1.1173	1.5107	0.6075	0.6084
062992- 5D	3.9624	285.18	47.22	12.431	0.7039	0.9481	0.6076	0.6080
062992- 6D	3.9636	284.02	47.45	12.403	0.7048	0.9521	0.6076	0.6080
062992- 7D	3.8067	282.52	45.83	73.569	1.6889	2.2943	0.6066	0.6087
062992- 8D	3.8089	283.33	45.71	72.893	1.6802	2.2778	0.6071	0.6091

Table 35. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
062592- 1A	3.9891	284.54	47.66	22.517	1.1919	1.6075	0.6061	0.6067
062592- 2A	3.9884	284.36	47.69	22.352	1.1887	1.6039	0.6066	0.6071
062592- 3A	4.0096	284.24	47.96	12.354	0.8864	1.1960	0.6069	0.6072
062592- 4A	4.0085	284.24	47.95	12.339	0.8855	1.1948	0.6068	0.6071
062592- 5A	3.8671	282.31	46.60	48.420	1.7250	2.3428	0.6044	0.6056
062592- 6A	3.8641	283.76	46.30	48.166	1.7095	2.3135	0.6025	0.6036
062592- 7A	3.9274	282.37	47.32	34.710	1.4733	1.9991	0.6054	0.6062
062592- 8A	3.9279	283.92	47.04	34.936	1.4722	1.9901	0.6047	0.6056
062992- 1A	3.9641	284.98	47.28	12.513	0.8879	1.1966	0.6084	0.6087
062992- 2A	3.9621	284.71	47.30	12.513	0.8881	1.1977	0.6084	0.6087
062992- 3A	3.8229	282.31	46.06	48.374	1.7195	2.3365	0.6062	0.6074
062992- 4A	3.8202	283.30	45.85	47.968	1.7146	2.3243	0.6084	0.6096
062992- 5A	3.9310	284.46	46.98	22.292	1.1804	1.5934	0.6077	0.6082
062992- 6A	3.9603	283.39	47.53	22.192	1.1896	1.6096	0.6103	0.6108
062992- 7A	3.8762	284.11	46.38	34.913	1.4663	1.9825	0.6067	0.6076
062992- 8A	3.8739	283.66	46.44	34.723	1.4650	1.9829	0.6075	0.6084
062592- 1B	3.9891	284.54	47.66	22.331	1.1919	1.6075	0.6087	0.6092
062592- 2B	3.9884	284.36	47.69	22.157	1.1887	1.6039	0.6093	0.6098
062592- 3B	4.0096	284.24	47.96	12.228	0.8864	1.1960	0.6101	0.6103
062592- 4B	4.0085	284.24	47.95	12.212	0.8855	1.1948	0.6099	0.6102
062592- 5B	3.8671	282.31	46.60	48.017	1.7250	2.3428	0.6069	0.6081
062592- 6B	3.8641	283.76	46.30	47.768	1.7095	2.3135	0.6050	0.6061
062592- 7B	3.9274	282.37	47.32	34.421	1.4733	1.9991	0.6079	0.6088
062592- 8B	3.9279	283.92	47.04	34.618	1.4722	1.9901	0.6075	0.6084
062992- 1B	3.9641	284.98	47.28	12.471	0.8879	1.1966	0.6095	0.6098
062992- 2B	3.9621	284.71	47.30	12.460	0.8881	1.1977	0.6097	0.6100
062992- 3B	3.8229	282.31	46.06	48.266	1.7195	2.3365	0.6069	0.6081
062992- 4B	3.8202	283.30	45.85	47.873	1.7146	2.3243	0.6090	0.6102
062992- 5B	3.9310	284.46	46.98	22.249	1.1804	1.5934	0.6083	0.6088
062992- 6B	3.9603	283.39	47.53	22.148	1.1896	1.6096	0.6109	0.6115
062992- 7B	3.8762	284.11	46.38	34.860	1.4663	1.9825	0.6072	0.6081
062992- 8B	3.8739	283.66	46.44	34.653	1.4650	1.9829	0.6081	0.6090
062592- 1C	3.9891	284.54	47.66	22.622	1.1919	1.6075	0.6047	0.6053
062592- 2C	3.9884	284.36	47.69	22.426	1.1887	1.6039	0.6056	0.6061
062592- 3C	4.0096	284.24	47.96	12.395	0.8864	1.1960	0.6059	0.6062
062592- 4C	4.0085	284.24	47.95	12.384	0.8855	1.1948	0.6056	0.6059
062592- 5C	3.8671	282.31	46.60	48.589	1.7250	2.3428	0.6033	0.6045
062592- 6C	3.8641	283.76	46.30	48.319	1.7095	2.3135	0.6015	0.6027
062592- 7C	3.9274	282.37	47.32	34.836	1.4733	1.9991	0.6043	0.6051
062592- 8C	3.9279	283.92	47.04	35.065	1.4722	1.9901	0.6036	0.6045
062992- 1C	3.9641	284.98	47.28	12.575	0.8879	1.1966	0.6069	0.6072
062992- 2C	3.9621	284.71	47.30	12.556	0.8881	1.1977	0.6073	0.6076
062992- 3C	3.8229	282.31	46.06	48.595	1.7195	2.3365	0.6048	0.6061
062992- 4C	3.8202	283.30	45.85	48.217	1.7146	2.3243	0.6069	0.6081
062992- 5C	3.9310	284.46	46.98	22.401	1.1804	1.5934	0.6062	0.6067
062992- 6C	3.9603	283.39	47.53	22.289	1.1896	1.6096	0.6090	0.6095
062992- 7C	3.8762	284.11	46.38	35.098	1.4663	1.9825	0.6051	0.6060
062992- 8C	3.8739	283.66	46.44	34.903	1.4650	1.9829	0.6059	0.6068
062592- 1D	3.9891	284.54	47.66	22.406	1.1919	1.6075	0.6076	0.6082
062592- 2D	3.9884	284.36	47.69	22.219	1.1887	1.6039	0.6084	0.6090
062592- 3D	4.0096	284.24	47.96	12.279	0.8864	1.1960	0.6088	0.6091
062592- 4D	4.0085	284.24	47.95	12.265	0.8855	1.1948	0.6086	0.6089
062592- 5D	3.8671	282.31	46.60	48.196	1.7250	2.3428	0.6058	0.6070
062592- 6D	3.8641	283.76	46.30	47.968	1.7095	2.3135	0.6037	0.6049
062592- 7D	3.9274	282.37	47.32	34.580	1.4733	1.9991	0.6065	0.6074
062592- 8D	3.9279	283.92	47.04	34.789	1.4722	1.9901	0.6060	0.6069
062992- 1D	3.9641	284.98	47.28	12.554	0.8879	1.1966	0.6075	0.6078
062992- 2D	3.9621	284.71	47.30	12.549	0.8881	1.1977	0.6075	0.6078
062992- 3D	3.8229	282.31	46.06	48.453	1.7195	2.3365	0.6057	0.6069
062992- 4D	3.8202	283.30	45.85	48.068	1.7146	2.3243	0.6078	0.6090
062992- 5D	3.9310	284.46	46.98	22.354	1.1804	1.5934	0.6068	0.6074
062992- 6D	3.9603	283.39	47.53	22.239	1.1896	1.6096	0.6097	0.6102
062992- 7D	3.8762	284.11	46.38	35.003	1.4663	1.9825	0.6060	0.6068
062992- 8D	3.8739	283.66	46.44	34.811	1.4650	1.9829	0.6068	0.6076

Table 36. Measured and calculated quantities for 0.54 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 11D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
062392- 1A	3.9650	285.17	47.26	12.704	0.4465	0.6014	0.6063	0.6067
062392- 2A	3.9650	285.36	47.22	12.739	0.4479	0.6030	0.6076	0.6080
062392- 5A	3.9346	283.81	47.14	36.531	0.7578	1.0245	0.6068	0.6080
062392- 6A	3.9326	284.44	47.00	37.066	0.7620	1.0286	0.6067	0.6078
062392- 7A	3.7782	283.62	45.29	148.160	1.5075	2.0430	0.6079	0.6127
062392- 8A	3.7815	281.99	45.62	144.822	1.4934	2.0319	0.6070	0.6117
062392- 9A	3.7801	282.17	45.57	145.048	1.4948	2.0331	0.6075	0.6122
062392- 10A	3.8802	284.12	46.43	75.027	1.0807	1.4610	0.6072	0.6096
062392- 11A	3.8784	284.01	46.43	75.466	1.0861	1.4687	0.6085	0.6109
062392- 1B	3.9650	285.17	47.26	12.752	0.4465	0.6014	0.6052	0.6056
062392- 2B	3.9650	285.36	47.22	12.788	0.4479	0.6030	0.6064	0.6068
062392- 5B	3.9346	283.81	47.14	36.556	0.7578	1.0245	0.6066	0.6077
062392- 6B	3.9326	284.44	47.00	37.101	0.7620	1.0286	0.6064	0.6075
062392- 7B	3.7782	283.62	45.29	148.095	1.5075	2.0430	0.6080	0.6128
062392- 8B	3.7815	281.99	45.62	144.735	1.4934	2.0319	0.6072	0.6119
062392- 9B	3.7801	282.17	45.57	144.930	1.4948	2.0331	0.6077	0.6124
062392- 10B	3.8802	284.12	46.43	75.027	1.0807	1.4610	0.6072	0.6096
062392- 11B	3.8784	284.01	46.43	75.444	1.0861	1.4687	0.6086	0.6110
062392- 1C	3.9650	285.17	47.26	12.751	0.4465	0.6014	0.6052	0.6056
062392- 2C	3.9650	285.36	47.22	12.790	0.4479	0.6030	0.6064	0.6068
062392- 5C	3.9346	283.81	47.14	36.580	0.7578	1.0245	0.6064	0.6075
062392- 6C	3.9326	284.44	47.00	37.143	0.7620	1.0286	0.6060	0.6072
062392- 7C	3.7782	283.62	45.29	148.368	1.5075	2.0430	0.6074	0.6123
062392- 8C	3.7815	281.99	45.62	145.076	1.4934	2.0319	0.6065	0.6112
062392- 9C	3.7801	282.17	45.57	145.256	1.4948	2.0331	0.6070	0.6117
062392- 10C	3.8802	284.12	46.43	75.167	1.0807	1.4610	0.6067	0.6091
062392- 11C	3.8784	284.01	46.43	75.593	1.0861	1.4687	0.6080	0.6104
062392- 1D	3.9650	285.17	47.26	12.733	0.4465	0.6014	0.6056	0.6060
062392- 2D	3.9650	285.36	47.22	12.772	0.4479	0.6030	0.6068	0.6072
062392- 5D	3.9346	283.81	47.14	36.564	0.7578	1.0245	0.6065	0.6077
062392- 6D	3.9326	284.44	47.00	37.123	0.7620	1.0286	0.6062	0.6074
062392- 7D	3.7782	283.62	45.29	148.280	1.5075	2.0430	0.6076	0.6124
062392- 8D	3.7815	281.99	45.62	144.975	1.4934	2.0319	0.6067	0.6114
062392- 9D	3.7801	282.17	45.57	145.237	1.4948	2.0331	0.6071	0.6118
062392- 10D	3.8802	284.12	46.43	75.132	1.0807	1.4610	0.6068	0.6092
062392- 11D	3.8784	284.01	46.43	75.535	1.0861	1.4687	0.6082	0.6106

Table 37. Measured and calculated quantities for 0.54 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 7D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
072092- 1A	3.7872	285.03	45.15	142.521	1.4693	1.9841	0.6052	0.6098
072092- 2A	3.7928	285.03	45.22	139.875	1.4561	1.9662	0.6051	0.6096
072092- 3A	3.8820	285.16	46.26	79.998	1.1133	1.5012	0.6067	0.6092
072092- 4A	3.8811	286.12	46.08	81.619	1.1199	1.5067	0.6054	0.6080
072092- 5A	3.9621	286.27	47.02	13.904	0.4651	0.6248	0.6051	0.6056
072092- 6A	3.9654	286.39	47.04	14.175	0.4698	0.6310	0.6053	0.6057
072092- 7A	3.9396	285.87	46.82	31.458	0.6996	0.9410	0.6058	0.6068
072092- 8A	3.9430	285.72	46.89	31.397	0.6994	0.9411	0.6058	0.6068
072092- 1B	3.7872	285.03	45.15	142.453	1.4693	1.9841	0.6053	0.6099
072092- 2B	3.7928	285.03	45.22	139.835	1.4561	1.9662	0.6052	0.6097
072092- 3B	3.8820	285.16	46.26	79.973	1.1133	1.5012	0.6068	0.6093
072092- 4B	3.8811	286.12	46.08	81.622	1.1199	1.5067	0.6054	0.6080
072092- 5B	3.9621	286.27	47.02	13.917	0.4651	0.6248	0.6049	0.6053
072092- 6B	3.9654	286.39	47.04	14.195	0.4698	0.6310	0.6049	0.6053
072092- 7B	3.9396	285.87	46.82	31.453	0.6996	0.9410	0.6059	0.6069
072092- 8B	3.9430	285.72	46.89	31.416	0.6994	0.9411	0.6057	0.6066
072092- 1C	3.7872	285.03	45.15	142.477	1.4693	1.9841	0.6053	0.6099
072092- 2C	3.7928	285.03	45.22	139.842	1.4561	1.9662	0.6051	0.6096
072092- 3C	3.8820	285.16	46.26	79.952	1.1133	1.5012	0.6069	0.6094
072092- 4C	3.8811	286.12	46.08	81.621	1.1199	1.5067	0.6054	0.6080
072092- 5C	3.9621	286.27	47.02	13.911	0.4651	0.6248	0.6050	0.6054
072092- 6C	3.9654	286.39	47.04	14.199	0.4698	0.6310	0.6048	0.6052
072092- 7C	3.9396	285.87	46.82	31.445	0.6996	0.9410	0.6060	0.6069
072092- 8C	3.9430	285.72	46.89	31.405	0.6994	0.9411	0.6058	0.6067
072092- 1D	3.7872	285.03	45.15	142.537	1.4693	1.9841	0.6052	0.6098
072092- 2D	3.7928	285.03	45.22	139.949	1.4561	1.9662	0.6049	0.6094
072092- 3D	3.8820	285.16	46.26	80.066	1.1133	1.5012	0.6065	0.6090
072092- 4D	3.8811	286.12	46.08	81.708	1.1199	1.5067	0.6051	0.6076
072092- 5D	3.9621	286.27	47.02	14.001	0.4651	0.6248	0.6031	0.6035
072092- 6D	3.9654	286.39	47.04	14.288	0.4698	0.6310	0.6029	0.6033
072092- 7D	3.9396	285.87	46.82	31.544	0.6996	0.9410	0.6050	0.6060
072092- 8D	3.9430	285.72	46.89	31.483	0.6994	0.9411	0.6050	0.6060

Table 38. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 11D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
062292- 1A	3.9140	284.21	46.82	30.199	1.0946	1.4789	0.6084	0.6092
062292- 2A	3.9108	284.12	46.80	30.151	1.0933	1.4775	0.6083	0.6091
062292- 3A	3.7997	283.62	45.55	73.747	1.6855	2.2837	0.6065	0.6086
062292- 4A	3.8083	282.07	45.93	72.341	1.6711	2.2726	0.6047	0.6067
062292- 5A	3.9608	284.63	47.30	11.756	0.6855	0.9246	0.6080	0.6083
062292- 6A	3.9660	284.46	47.40	11.815	0.6876	0.9278	0.6077	0.6080
062292- 7A	3.9499	283.06	47.46	48.220	1.3922	1.8854	0.6077	0.6090
062292- 1B	3.9140	284.21	46.82	30.128	1.0946	1.4789	0.6091	0.6099
062292- 2B	3.9108	284.12	46.80	30.083	1.0933	1.4775	0.6090	0.6098
062292- 3B	3.7997	283.62	45.55	73.668	1.6855	2.2837	0.6068	0.6089
062292- 4B	3.8083	282.07	45.93	72.250	1.6711	2.2726	0.6051	0.6071
062292- 5B	3.9608	284.63	47.30	11.662	0.6855	0.9246	0.6104	0.6107
062292- 6B	3.9660	284.46	47.40	11.720	0.6876	0.9278	0.6102	0.6105
062292- 7B	3.9499	283.06	47.46	48.141	1.3922	1.8854	0.6082	0.6095
062292- 1C	3.9140	284.21	46.82	30.330	1.0946	1.4789	0.6070	0.6079
062292- 2C	3.9108	284.12	46.80	30.299	1.0933	1.4775	0.6068	0.6076
062292- 3C	3.7997	283.62	45.55	74.069	1.6855	2.2837	0.6052	0.6073
062292- 4C	3.8083	282.07	45.93	72.685	1.6711	2.2726	0.6032	0.6053
062292- 5C	3.9608	284.63	47.30	11.797	0.6855	0.9246	0.6069	0.6072
062292- 6C	3.9660	284.46	47.40	11.857	0.6876	0.9278	0.6067	0.6070
062292- 7C	3.9499	283.06	47.46	48.447	1.3922	1.8854	0.6063	0.6076
062292- 1D	3.9140	284.21	46.82	30.226	1.0946	1.4789	0.6081	0.6089
062292- 2D	3.9108	284.12	46.80	30.188	1.0933	1.4775	0.6079	0.6087
062292- 3D	3.7997	283.62	45.55	73.866	1.6855	2.2837	0.6060	0.6081
062292- 4D	3.8083	282.07	45.93	72.478	1.6711	2.2726	0.6041	0.6061
062292- 5D	3.9608	284.63	47.30	11.733	0.6855	0.9246	0.6085	0.6089
062292- 6D	3.9660	284.46	47.40	11.792	0.6876	0.9278	0.6083	0.6087
062292- 7D	3.9499	283.06	47.46	48.312	1.3922	1.8854	0.6071	0.6084

Table 39. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 7D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
072092- 1A	3.8449	285.84	45.70	71.357	1.6602	2.2360	0.6064	0.6084
072092- 2A	3.8335	284.71	45.76	69.884	1.6372	2.2114	0.6039	0.6058
072092- 3A	3.9252	287.15	46.42	32.045	1.1226	1.5056	0.6081	0.6090
072092- 4A	3.9264	286.22	46.60	32.142	1.1245	1.5116	0.6071	0.6080
072092- 5A	3.9683	285.28	47.28	13.481	0.7341	0.9886	0.6081	0.6085
072092- 6A	3.9681	286.44	47.06	13.538	0.7341	0.9858	0.6082	0.6086
072092- 7A	3.8901	285.33	46.33	50.066	1.4003	1.8872	0.6070	0.6084
072092- 8A	3.8884	284.90	46.39	49.794	1.3975	1.8854	0.6071	0.6085
072092- 1B	3.8449	285.84	45.70	71.252	1.6602	2.2360	0.6068	0.6088
072092- 2B	3.8335	284.71	45.76	69.748	1.6372	2.2114	0.6045	0.6064
072092- 3B	3.9252	287.15	46.42	32.003	1.1226	1.5056	0.6085	0.6094
072092- 4B	3.9264	286.22	46.60	32.113	1.1245	1.5116	0.6074	0.6083
072092- 5B	3.9683	285.28	47.28	13.455	0.7341	0.9886	0.6087	0.6091
072092- 6B	3.9681	286.44	47.06	13.527	0.7341	0.9858	0.6085	0.6089
072092- 7B	3.8901	285.33	46.33	49.991	1.4003	1.8872	0.6075	0.6089
072092- 8B	3.8884	284.90	46.39	49.723	1.3975	1.8854	0.6075	0.6089
072092- 1C	3.8449	285.84	45.70	71.412	1.6602	2.2360	0.6062	0.6081
072092- 2C	3.8335	284.71	45.76	69.930	1.6372	2.2114	0.6037	0.6056
072092- 3C	3.9252	287.15	46.42	32.080	1.1226	1.5056	0.6078	0.6087
072092- 4C	3.9264	286.22	46.60	32.188	1.1245	1.5116	0.6067	0.6076
072092- 5C	3.9683	285.28	47.28	13.496	0.7341	0.9886	0.6078	0.6082
072092- 6C	3.9681	286.44	47.06	13.567	0.7341	0.9858	0.6076	0.6080
072092- 7C	3.8901	285.33	46.33	50.125	1.4003	1.8872	0.6067	0.6080
072092- 8C	3.8884	284.90	46.39	49.841	1.3975	1.8854	0.6068	0.6082
072092- 1D	3.8449	285.84	45.70	71.382	1.6602	2.2360	0.6063	0.6083
072092- 2D	3.8335	284.71	45.76	69.909	1.6372	2.2114	0.6038	0.6057
072092- 3D	3.9252	287.15	46.42	32.098	1.1226	1.5056	0.6076	0.6085
072092- 4D	3.9264	286.22	46.60	32.218	1.1245	1.5116	0.6064	0.6073
072092- 5D	3.9683	285.28	47.28	13.537	0.7341	0.9886	0.6069	0.6072
072092- 6D	3.9681	286.44	47.06	13.611	0.7341	0.9858	0.6066	0.6070
072092- 7D	3.8901	285.33	46.33	50.136	1.4003	1.8872	0.6066	0.6080
072092- 8D	3.8884	284.90	46.39	49.848	1.3975	1.8854	0.6068	0.6081

Table 40. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 12D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
063092- 2A	3.8658	283.67	46.34	22.260	1.1706	1.5846	0.6072	0.6078
063092- 3A	3.7548	283.43	45.04	47.976	1.6975	2.3022	0.6077	0.6089
063092- 4A	3.7573	281.68	45.38	47.313	1.6872	2.2981	0.6060	0.6072
063092- 5A	3.8809	284.15	46.43	12.780	0.8914	1.2050	0.6099	0.6102
063092- 6A	3.8842	284.27	46.45	12.850	0.8942	1.2083	0.6100	0.6103
063092- 7A	3.8200	282.68	45.96	34.528	1.4580	1.9795	0.6094	0.6103
063092- 8A	3.8168	282.84	45.90	34.129	1.4416	1.9565	0.6066	0.6074
063092- 1A	3.8265	283.09	45.97	33.713	1.4392	1.9519	0.6088	0.6097
063092- 2A	3.8222	283.20	45.90	33.360	1.4348	1.9455	0.6106	0.6115
063092- 3A	3.8666	283.03	46.46	22.702	1.1882	1.6109	0.6095	0.6101
063092- 4A	3.8595	283.51	46.29	22.762	1.1888	1.6100	0.6102	0.6107
063092- 5A	3.8920	283.86	46.62	12.007	0.8655	1.1706	0.6097	0.6100
063092- 6A	3.8933	284.41	46.54	12.052	0.8660	1.1697	0.6095	0.6098
063092- 7A	3.7552	281.48	45.39	48.063	1.7062	2.3252	0.6080	0.6092
063092- 8A	3.7587	282.18	45.31	47.367	1.6946	2.3053	0.6088	0.6100
063092- 2B	3.8658	283.67	46.34	22.214	1.1706	1.5846	0.6079	0.6084
063092- 3B	3.7548	283.43	45.04	47.853	1.6975	2.3022	0.6085	0.6097
063092- 4B	3.7573	281.68	45.38	47.223	1.6872	2.2981	0.6066	0.6078
063092- 5B	3.8809	284.15	46.43	12.760	0.8914	1.2050	0.6104	0.6107
063092- 6B	3.8842	284.27	46.45	12.835	0.8942	1.2083	0.6103	0.6107
063092- 7B	3.8200	282.68	45.96	34.453	1.4580	1.9795	0.6101	0.6110
063092- 8B	3.8168	282.84	45.90	34.045	1.4416	1.9565	0.6073	0.6082
063092- 1B	3.8265	283.09	45.97	33.641	1.4392	1.9519	0.6095	0.6103
063092- 2B	3.8222	283.20	45.90	33.306	1.4348	1.9455	0.6111	0.6120
063092- 3B	3.8666	283.03	46.46	22.674	1.1882	1.6109	0.6099	0.6105
063092- 4B	3.8595	283.51	46.29	22.726	1.1888	1.6100	0.6106	0.6112
063092- 5B	3.8920	283.86	46.62	11.994	0.8655	1.1706	0.6101	0.6104
063092- 6B	3.8933	284.41	46.54	12.032	0.8660	1.1697	0.6100	0.6103
063092- 7B	3.7552	281.48	45.39	47.984	1.7062	2.3252	0.6085	0.6097
063092- 8B	3.7587	282.18	45.31	47.297	1.6946	2.3053	0.6092	0.6104
063092- 2C	3.8658	283.67	46.34	22.369	1.1706	1.5846	0.6058	0.6063
063092- 3C	3.7548	283.43	45.04	48.243	1.6975	2.3022	0.6060	0.6072
063092- 4C	3.7573	281.68	45.38	47.609	1.6872	2.2981	0.6041	0.6053
063092- 5C	3.8809	284.15	46.43	12.833	0.8914	1.2050	0.6086	0.6089
063092- 6C	3.8842	284.27	46.45	12.903	0.8942	1.2083	0.6087	0.6091
063092- 7C	3.8200	282.68	45.96	34.716	1.4580	1.9795	0.6078	0.6087
063092- 8C	3.8168	282.84	45.90	34.311	1.4416	1.9565	0.6049	0.6058
063092- 1C	3.8265	283.09	45.97	33.839	1.4392	1.9519	0.6077	0.6085
063092- 2C	3.8222	283.20	45.90	33.480	1.4348	1.9455	0.6096	0.6104
063092- 3C	3.8666	283.03	46.46	22.779	1.1882	1.6109	0.6085	0.6091
063092- 4C	3.8595	283.51	46.29	22.834	1.1888	1.6100	0.6092	0.6098
063092- 5C	3.8920	283.86	46.62	12.009	0.8655	1.1706	0.6097	0.6100
063092- 6C	3.8933	284.41	46.54	12.047	0.8660	1.1697	0.6096	0.6099
063092- 7C	3.7552	281.48	45.39	48.276	1.7062	2.3252	0.6066	0.6078
063092- 8C	3.7587	282.18	45.31	47.601	1.6946	2.3053	0.6073	0.6085
063092- 2D	3.8658	283.67	46.34	22.250	1.1706	1.5846	0.6074	0.6079
063092- 3D	3.7548	283.43	45.04	48.016	1.6975	2.3022	0.6074	0.6087
063092- 4D	3.7573	281.68	45.38	47.390	1.6872	2.2981	0.6055	0.6067
063092- 5D	3.8809	284.15	46.43	12.748	0.8914	1.2050	0.6107	0.6110
063092- 6D	3.8842	284.27	46.45	12.813	0.8942	1.2083	0.6109	0.6112
063092- 7D	3.8200	282.68	45.96	34.566	1.4580	1.9795	0.6091	0.6100
063092- 8D	3.8168	282.84	45.90	34.147	1.4416	1.9565	0.6064	0.6072
063092- 1D	3.8265	283.09	45.97	33.719	1.4392	1.9519	0.6088	0.6096
063092- 2D	3.8222	283.20	45.90	33.356	1.4348	1.9455	0.6107	0.6115
063092- 3D	3.8666	283.03	46.46	22.682	1.1882	1.6109	0.6098	0.6104
063092- 4D	3.8595	283.51	46.29	22.727	1.1888	1.6100	0.6106	0.6112
063092- 5D	3.8920	283.86	46.62	11.965	0.8655	1.1706	0.6108	0.6111
063092- 6D	3.8933	284.41	46.54	11.998	0.8660	1.1697	0.6108	0.6111
063092- 7D	3.7552	281.48	45.39	48.073	1.7062	2.3252	0.6079	0.6091
063092- 8D	3.7587	282.18	45.31	47.389	1.6946	2.3053	0.6086	0.6098

Table 41. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 7D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
071792- 1A	3.9361	284.02	47.12	24.847	1.2487	1.6873	0.6079	0.6085
071792- 2A	3.9401	284.02	47.17	24.810	1.2460	1.6837	0.6068	0.6074
071792- 3A	3.8324	284.26	45.83	50.221	1.7476	2.3631	0.6062	0.6074
071792- 4A	3.8321	283.70	45.92	49.902	1.7495	2.3689	0.6081	0.6094
071792- 5A	3.9459	283.32	47.37	13.255	0.9153	1.2387	0.6088	0.6091
071792- 6A	3.9415	284.43	47.11	13.559	0.9228	1.2457	0.6085	0.6089
071792- 7A	3.8905	282.47	46.85	34.951	1.4748	2.0016	0.6069	0.6078
071792- 8A	3.8864	282.92	46.72	35.035	1.4823	2.0097	0.6101	0.6110
071792- 1B	3.9361	284.02	47.12	24.953	1.2487	1.6873	0.6066	0.6073
071792- 2B	3.9401	284.02	47.17	24.927	1.2460	1.6837	0.6053	0.6059
071792- 3B	3.8324	284.26	45.83	50.336	1.7476	2.3631	0.6055	0.6067
071792- 4B	3.8321	283.70	45.92	50.018	1.7495	2.3689	0.6074	0.6087
071792- 5B	3.9459	283.32	47.37	13.383	0.9153	1.2387	0.6059	0.6062
071792- 6B	3.9415	284.43	47.11	13.675	0.9228	1.2457	0.6059	0.6063
071792- 7B	3.8905	282.47	46.85	35.049	1.4748	2.0016	0.6060	0.6069
071792- 8B	3.8864	282.92	46.72	35.137	1.4823	2.0097	0.6092	0.6101
071792- 1C	3.9361	284.02	47.12	24.935	1.2487	1.6873	0.6069	0.6075
071792- 2C	3.9401	284.02	47.17	24.893	1.2460	1.6837	0.6058	0.6064
071792- 3C	3.8324	284.26	45.83	50.342	1.7476	2.3631	0.6054	0.6067
071792- 4C	3.8321	283.70	45.92	50.014	1.7495	2.3689	0.6075	0.6087
071792- 5C	3.9459	283.32	47.37	13.298	0.9153	1.2387	0.6078	0.6081
071792- 6C	3.9415	284.43	47.11	13.591	0.9228	1.2457	0.6078	0.6082
071792- 7C	3.8905	282.47	46.85	35.044	1.4748	2.0016	0.6061	0.6070
071792- 8C	3.8864	282.92	46.72	35.124	1.4823	2.0097	0.6093	0.6102
071792- 1D	3.9361	284.02	47.12	24.851	1.2487	1.6873	0.6079	0.6085
071792- 2D	3.9401	284.02	47.17	24.810	1.2460	1.6837	0.6068	0.6074
071792- 3D	3.8324	284.26	45.83	50.190	1.7476	2.3631	0.6064	0.6076
071792- 4D	3.8321	283.70	45.92	49.866	1.7495	2.3689	0.6084	0.6096
071792- 5D	3.9459	283.32	47.37	13.252	0.9153	1.2387	0.6089	0.6092
071792- 6D	3.9415	284.43	47.11	13.547	0.9228	1.2457	0.6088	0.6091
071792- 7D	3.8905	282.47	46.85	34.920	1.4748	2.0016	0.6072	0.6080
071792- 8D	3.8864	282.92	46.72	35.001	1.4823	2.0097	0.6104	0.6113

Table 42. Measured and calculated quantities for 0.54 beta ratio, elbow at 17 pipe diameters, 19 tube bundle at 12D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
070192- 1A	3.8145	282.31	45.96	144.366	1.4938	2.0301	0.6059	0.6106
070192- 2A	3.8132	282.66	45.88	141.518	1.4816	2.0118	0.6076	0.6122
070192- 3A	3.9481	284.69	47.14	38.409	0.7764	1.0473	0.6063	0.6075
070192- 4A	3.9377	284.67	47.02	39.418	0.7851	1.0592	0.6059	0.6071
070192- 5A	3.9072	285.36	46.53	80.097	1.1167	1.5046	0.6065	0.6090
070192- 6A	3.9097	284.09	46.79	79.515	1.1185	1.5116	0.6080	0.6105
070192- 7A	3.9872	284.98	47.56	12.712	0.4474	0.6027	0.6054	0.6058
070192- 8A	3.9839	285.19	47.48	12.878	0.4509	0.6071	0.6066	0.6070
071692- 1A	3.8607	283.04	46.39	81.421	1.1276	1.5288	0.6083	0.6109
071692- 2A	3.8592	283.38	46.31	81.223	1.1228	1.5210	0.6069	0.6095
071692- 3A	3.9104	283.77	46.86	36.310	0.7538	1.0195	0.6073	0.6085
071692- 4A	3.9111	284.07	46.81	36.377	0.7541	1.0192	0.6073	0.6084
071692- 5A	3.7564	282.84	45.17	144.741	1.4837	2.0152	0.6063	0.6110
071692- 6A	3.7616	283.64	45.09	141.706	1.4639	1.9842	0.6051	0.6097
071692- 7A	3.9336	284.02	47.09	12.415	0.4403	0.5950	0.6060	0.6063
071692- 8A	3.9337	284.12	47.07	12.662	0.4449	0.6011	0.6064	0.6068
070192- 1B	3.8145	282.31	45.96	144.450	1.4938	2.0301	0.6058	0.6104
070192- 2B	3.8132	282.66	45.88	141.638	1.4816	2.0118	0.6074	0.6119
070192- 3B	3.9481	284.69	47.14	38.420	0.7764	1.0473	0.6062	0.6074
070192- 4B	3.9377	284.67	47.02	39.421	0.7851	1.0592	0.6059	0.6071
070192- 5B	3.9072	285.36	46.53	80.136	1.1167	1.5046	0.6063	0.6088
070192- 6B	3.9097	284.09	46.79	79.586	1.1185	1.5116	0.6077	0.6102
070192- 7B	3.9872	284.98	47.56	12.687	0.4474	0.6027	0.6060	0.6064
070192- 8B	3.9839	285.19	47.48	12.847	0.4509	0.6071	0.6074	0.6078
071692- 1B	3.8607	283.04	46.39	81.559	1.1276	1.5288	0.6078	0.6104
071692- 2B	3.8592	283.38	46.31	81.363	1.1228	1.5210	0.6064	0.6090
071692- 3B	3.9104	283.77	46.86	36.371	0.7538	1.0195	0.6068	0.6079
071692- 4B	3.9111	284.07	46.81	36.443	0.7541	1.0192	0.6067	0.6079
071692- 5B	3.7564	282.84	45.17	144.964	1.4837	2.0152	0.6058	0.6105
071692- 6B	3.7616	283.64	45.09	141.906	1.4639	1.9842	0.6047	0.6093
071692- 7B	3.9336	284.02	47.09	12.432	0.4403	0.5950	0.6055	0.6059
071692- 8B	3.9337	284.12	47.07	12.687	0.4449	0.6011	0.6058	0.6062
070192- 1C	3.8145	282.31	45.96	144.537	1.4938	2.0301	0.6056	0.6102
070192- 2C	3.8132	282.66	45.88	141.681	1.4816	2.0118	0.6073	0.6118
070192- 3C	3.9481	284.69	47.14	38.442	0.7764	1.0473	0.6060	0.6072
070192- 4C	3.9377	284.67	47.02	39.431	0.7851	1.0592	0.6058	0.6070
070192- 5C	3.9072	285.36	46.53	80.150	1.1167	1.5046	0.6063	0.6088
070192- 6C	3.9097	284.09	46.79	79.642	1.1185	1.5116	0.6075	0.6100
070192- 7C	3.9872	284.98	47.56	12.701	0.4474	0.6027	0.6057	0.6060
070192- 8C	3.9839	285.19	47.48	12.865	0.4509	0.6071	0.6069	0.6073
071692- 1C	3.8607	283.04	46.39	81.511	1.1276	1.5288	0.6079	0.6105
071692- 2C	3.8592	283.38	46.31	81.325	1.1228	1.5210	0.6066	0.6091
071692- 3C	3.9104	283.77	46.86	36.338	0.7538	1.0195	0.6071	0.6082
071692- 4C	3.9111	284.07	46.81	36.420	0.7541	1.0192	0.6069	0.6081
071692- 5C	3.7564	282.84	45.17	144.949	1.4837	2.0152	0.6058	0.6106
071692- 6C	3.7616	283.64	45.09	141.904	1.4639	1.9842	0.6047	0.6093
071692- 7C	3.9336	284.02	47.09	12.395	0.4403	0.5950	0.6064	0.6068
071692- 8C	3.9337	284.12	47.07	12.649	0.4449	0.6011	0.6067	0.6071
070192- 1D	3.8145	282.31	45.96	144.456	1.4938	2.0301	0.6057	0.6104
070192- 2D	3.8132	282.66	45.88	141.612	1.4816	2.0118	0.6074	0.6120
070192- 3D	3.9481	284.69	47.14	38.423	0.7764	1.0473	0.6062	0.6074
070192- 4D	3.9377	284.67	47.02	39.418	0.7851	1.0592	0.6059	0.6071
070192- 5D	3.9072	285.36	46.53	80.129	1.1167	1.5046	0.6064	0.6089
070192- 6D	3.9097	284.09	46.79	79.596	1.1185	1.5116	0.6077	0.6102
070192- 7D	3.9872	284.98	47.56	12.684	0.4474	0.6027	0.6061	0.6064
070192- 8D	3.9839	285.19	47.48	12.842	0.4509	0.6071	0.6075	0.6079
071692- 1D	3.8607	283.04	46.39	81.520	1.1276	1.5288	0.6079	0.6105
071692- 2D	3.8592	283.38	46.31	81.342	1.1228	1.5210	0.6065	0.6091
071692- 3D	3.9104	283.77	46.86	36.338	0.7538	1.0195	0.6071	0.6082
071692- 4D	3.9111	284.07	46.81	36.423	0.7541	1.0192	0.6069	0.6080
071692- 5D	3.7564	282.84	45.17	144.970	1.4837	2.0152	0.6058	0.6105
071692- 6D	3.7616	283.64	45.09	141.913	1.4639	1.9842	0.6047	0.6093
071692- 7D	3.9336	284.02	47.09	12.384	0.4403	0.5950	0.6067	0.6071
071692- 8D	3.9337	284.12	47.07	12.634	0.4449	0.6011	0.6070	0.6074

Table 43. Measured and calculated quantities for 0.54 beta ratio, elbow at 17 pipe diameters, 19 tube bundle at 7D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
072192- 1A	3.8083	286.42	45.16	145.823	1.4912	2.0064	0.6070	0.6117
072192- 2A	3.8100	285.03	45.43	143.247	1.4824	2.0013	0.6072	0.6118
072192- 3A	3.9096	286.49	46.35	77.913	1.1004	1.4785	0.6071	0.6096
072192- 4A	3.9097	286.42	46.37	78.390	1.1042	1.4838	0.6072	0.6097
072192- 5A	3.9757	286.87	47.07	13.302	0.4573	0.6134	0.6080	0.6085
072192- 6A	3.9761	287.06	47.04	13.551	0.4604	0.6173	0.6067	0.6071
072192- 7A	3.9553	286.32	46.93	30.792	0.6948	0.9333	0.6075	0.6084
072192- 8A	3.9558	287.16	46.78	30.958	0.6962	0.9334	0.6080	0.6090
072192- 1B	3.8083	286.42	45.16	146.097	1.4912	2.0064	0.6065	0.6112
072192- 2B	3.8100	285.03	45.43	143.505	1.4824	2.0013	0.6067	0.6113
072192- 3B	3.9096	286.49	46.35	78.042	1.1004	1.4785	0.6066	0.6091
072192- 4B	3.9097	286.42	46.37	78.537	1.1042	1.4838	0.6067	0.6091
072192- 5B	3.9757	286.87	47.07	13.341	0.4573	0.6134	0.6071	0.6076
072192- 6B	3.9761	287.06	47.04	13.590	0.4604	0.6173	0.6058	0.6062
072192- 7B	3.9553	286.32	46.93	30.883	0.6948	0.9333	0.6066	0.6076
072192- 8B	3.9558	287.16	46.78	31.027	0.6962	0.9334	0.6073	0.6083
072192- 1C	3.8083	286.42	45.16	146.082	1.4912	2.0064	0.6065	0.6112
072192- 2C	3.8100	285.03	45.43	143.557	1.4824	2.0013	0.6065	0.6112
072192- 3C	3.9096	286.49	46.35	78.052	1.1004	1.4785	0.6066	0.6090
072192- 4C	3.9097	286.42	46.37	78.543	1.1042	1.4838	0.6067	0.6091
072192- 5C	3.9757	286.87	47.07	13.282	0.4573	0.6134	0.6085	0.6089
072192- 6C	3.9761	287.06	47.04	13.531	0.4604	0.6173	0.6071	0.6075
072192- 7C	3.9553	286.32	46.93	30.838	0.6948	0.9333	0.6070	0.6080
072192- 8C	3.9558	287.16	46.78	31.002	0.6962	0.9334	0.6076	0.6085
072192- 1D	3.8083	286.42	45.16	145.902	1.4912	2.0064	0.6069	0.6116
072192- 2D	3.8100	285.03	45.43	143.355	1.4824	2.0013	0.6070	0.6116
072192- 3D	3.9096	286.49	46.35	77.997	1.1004	1.4785	0.6068	0.6092
072192- 4D	3.9097	286.42	46.37	78.502	1.1042	1.4838	0.6068	0.6093
072192- 5D	3.9757	286.87	47.07	13.328	0.4573	0.6134	0.6075	0.6079
072192- 6D	3.9761	287.06	47.04	13.578	0.4604	0.6173	0.6061	0.6065
072192- 7D	3.9553	286.32	46.93	30.856	0.6948	0.9333	0.6069	0.6078
072192- 8D	3.9558	287.16	46.78	31.016	0.6962	0.9334	0.6074	0.6084

Table 44. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, 19 tube bundle at 12D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
070192- 1A	3.9450	284.14	47.20	47.410	1.3813	1.8657	0.6097	0.6110
070192- 2A	3.9421	283.72	47.25	46.754	1.3696	1.8519	0.6085	0.6098
070192- 3A	3.9703	284.98	47.36	31.863	1.1336	1.5276	0.6098	0.6107
070192- 4A	3.9716	284.18	47.52	31.674	1.1319	1.5283	0.6097	0.6106
070192- 5A	4.0032	284.61	47.82	12.764	0.7202	0.9709	0.6097	0.6100
070192- 6A	4.0014	285.20	47.69	12.854	0.7205	0.9701	0.6087	0.6090
070192- 7A	3.8681	285.32	46.07	72.232	1.6817	2.2671	0.6080	0.6100
070192- 8A	3.8686	284.56	46.21	71.053	1.6780	2.2663	0.6108	0.6128
071692- 1A	3.8650	284.89	46.11	49.684	1.3974	1.8859	0.6096	0.6110
071692- 3A	3.9538	283.73	47.39	12.248	0.7015	0.9484	0.6091	0.6094
071692- 4A	3.9465	283.48	47.34	12.330	0.7042	0.9528	0.6096	0.6100
071692- 5A	3.9195	284.03	46.92	30.440	1.1034	1.4913	0.6102	0.6110
071692- 6A	3.9159	284.30	46.83	30.329	1.1000	1.4857	0.6100	0.6108
071692- 7A	3.8667	284.31	46.23	48.503	1.3846	1.8713	0.6105	0.6119
071692- 8A	3.7938	284.23	45.37	73.537	1.6857	2.2806	0.6086	0.6107
071692- 9A	3.7936	283.09	45.57	72.614	1.6861	2.2876	0.6113	0.6134
070192- 1B	3.9450	284.14	47.20	47.437	1.3813	1.8657	0.6095	0.6108
070192- 2B	3.9421	283.72	47.25	46.797	1.3696	1.8519	0.6083	0.6095
070192- 3B	3.9703	284.98	47.36	31.866	1.1336	1.5276	0.6098	0.6106
070192- 4B	3.9716	284.18	47.52	31.709	1.1319	1.5283	0.6094	0.6103
070192- 5B	4.0032	284.61	47.82	12.744	0.7202	0.9709	0.6102	0.6105
070192- 6B	4.0014	285.20	47.69	12.830	0.7205	0.9701	0.6092	0.6096
070192- 7B	3.8681	285.32	46.07	72.296	1.6817	2.2671	0.6078	0.6098
070192- 8B	3.8686	284.56	46.21	71.099	1.6780	2.2663	0.6106	0.6126
071692- 1B	3.8650	284.89	46.11	49.823	1.3974	1.8859	0.6087	0.6101
071692- 3B	3.9538	283.73	47.39	12.297	0.7015	0.9484	0.6078	0.6082
071692- 4B	3.9465	283.48	47.34	12.378	0.7042	0.9528	0.6085	0.6088
071692- 5B	3.9195	284.03	46.92	30.523	1.1034	1.4913	0.6093	0.6102
071692- 6B	3.9159	284.30	46.83	30.412	1.1000	1.4857	0.6091	0.6100
071692- 7B	3.8667	284.31	46.23	48.616	1.3846	1.8713	0.6098	0.6112
071692- 8B	3.7938	284.23	45.37	73.699	1.6857	2.2806	0.6080	0.6100
071692- 9B	3.7936	283.09	45.57	72.780	1.6861	2.2876	0.6106	0.6127
070192- 1C	3.9450	284.14	47.20	47.516	1.3813	1.8657	0.6090	0.6103
070192- 2C	3.9421	283.72	47.25	46.842	1.3696	1.8519	0.6080	0.6092
070192- 3C	3.9703	284.98	47.36	31.908	1.1336	1.5276	0.6094	0.6102
070192- 4C	3.9716	284.18	47.52	31.727	1.1319	1.5283	0.6092	0.6101
070192- 5C	4.0032	284.61	47.82	12.774	0.7202	0.9709	0.6094	0.6098
070192- 6C	4.0014	285.20	47.69	12.852	0.7205	0.9701	0.6087	0.6091
070192- 7C	3.8681	285.32	46.07	72.392	1.6817	2.2671	0.6074	0.6094
070192- 8C	3.8686	284.56	46.21	71.203	1.6780	2.2663	0.6102	0.6122
071692- 1C	3.8650	284.89	46.11	49.827	1.3974	1.8859	0.6087	0.6101
071692- 3C	3.9538	283.73	47.39	12.258	0.7015	0.9484	0.6088	0.6091
071692- 4C	3.9465	283.48	47.34	12.332	0.7042	0.9528	0.6096	0.6099
071692- 5C	3.9195	284.03	46.92	30.492	1.1034	1.4913	0.6097	0.6105
071692- 6C	3.9159	284.30	46.83	30.385	1.1000	1.4857	0.6094	0.6102
071692- 7C	3.8667	284.31	46.23	48.588	1.3846	1.8713	0.6100	0.6114
071692- 8C	3.7938	284.23	45.37	73.728	1.6857	2.2806	0.6078	0.6099
071692- 9C	3.7936	283.09	45.57	72.809	1.6861	2.2876	0.6105	0.6126
070192- 1D	3.9450	284.14	47.20	47.511	1.3813	1.8657	0.6091	0.6104
070192- 2D	3.9421	283.72	47.25	46.840	1.3696	1.8519	0.6080	0.6092
070192- 3D	3.9703	284.98	47.36	31.907	1.1336	1.5276	0.6094	0.6103
070192- 4D	3.9716	284.18	47.52	31.723	1.1319	1.5283	0.6093	0.6101
070192- 5D	4.0032	284.61	47.82	12.757	0.7202	0.9709	0.6098	0.6102
070192- 6D	4.0014	285.20	47.69	12.846	0.7205	0.9701	0.6089	0.6092
070192- 7D	3.8681	285.32	46.07	72.428	1.6817	2.2671	0.6072	0.6092
070192- 8D	3.8686	284.56	46.21	71.216	1.6780	2.2663	0.6101	0.6121
071692- 1D	3.8650	284.89	46.11	49.854	1.3974	1.8859	0.6085	0.6099
071692- 3D	3.9538	283.73	47.39	12.261	0.7015	0.9484	0.6087	0.6091
071692- 4D	3.9465	283.48	47.34	12.339	0.7042	0.9528	0.6094	0.6098
071692- 5D	3.9195	284.03	46.92	30.503	1.1034	1.4913	0.6096	0.6104
071692- 6D	3.9159	284.30	46.83	30.398	1.1000	1.4857	0.6093	0.6101
071692- 7D	3.8667	284.31	46.23	48.656	1.3846	1.8713	0.6096	0.6109
071692- 8D	3.7938	284.23	45.37	73.789	1.6857	2.2806	0.6076	0.6097
071692- 9D	3.7936	283.09	45.57	72.858	1.6861	2.2876	0.6103	0.6124

Table 45. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, 19 tube bundle at 7D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
072192- 1A	3.9248	287.56	46.34	47.670	1.3696	1.8351	0.6084	0.6097
072192- 2A	3.9266	286.77	46.51	47.176	1.3598	1.8255	0.6062	0.6075
072192- 3A	3.9154	285.47	46.61	50.466	1.4070	1.8950	0.6057	0.6071
072192- 4A	3.8389	284.51	45.86	74.505	1.7040	2.3026	0.6079	0.6100
072192- 5A	3.8394	284.81	45.81	74.263	1.6971	2.2916	0.6068	0.6088
072192- 6A	3.9639	286.02	47.09	12.505	0.7084	0.9523	0.6105	0.6109
072192- 7A	3.9810	287.34	47.05	12.287	0.7016	0.9400	0.6103	0.6106
072192- 8A	3.9663	285.68	47.18	31.059	1.1169	1.5026	0.6097	0.6106
072192- 9A	3.9655	286.26	47.06	30.815	1.1125	1.4946	0.6104	0.6113
072192- 1B	3.9248	287.56	46.34	47.815	1.3696	1.8351	0.6075	0.6088
072192- 2B	3.9266	286.77	46.51	47.296	1.3598	1.8255	0.6054	0.6067
072192- 3B	3.9154	285.47	46.61	50.583	1.4070	1.8950	0.6050	0.6064
072192- 4B	3.8389	284.51	45.86	74.689	1.7040	2.3026	0.6072	0.6093
072192- 5B	3.8394	284.81	45.81	74.465	1.6971	2.2916	0.6059	0.6080
072192- 6B	3.9639	286.02	47.09	12.538	0.7084	0.9523	0.6097	0.6101
072192- 7B	3.9810	287.34	47.05	12.314	0.7016	0.9400	0.6096	0.6099
072192- 8B	3.9663	285.68	47.18	31.165	1.1169	1.5026	0.6087	0.6095
072192- 9B	3.9655	286.26	47.06	30.910	1.1125	1.4946	0.6095	0.6103
072192- 1C	3.9248	287.56	46.34	47.741	1.3696	1.8351	0.6080	0.6093
072192- 2C	3.9266	286.77	46.51	47.219	1.3598	1.8255	0.6059	0.6072
072192- 3C	3.9154	285.47	46.61	50.530	1.4070	1.8950	0.6053	0.6067
072192- 4C	3.8389	284.51	45.86	74.674	1.7040	2.3026	0.6072	0.6093
072192- 5C	3.8394	284.81	45.81	74.419	1.6971	2.2916	0.6061	0.6082
072192- 6C	3.9639	286.02	47.09	12.505	0.7084	0.9523	0.6105	0.6109
072192- 7C	3.9810	287.34	47.05	12.291	0.7016	0.9400	0.6102	0.6105
072192- 8C	3.9663	285.68	47.18	31.108	1.1169	1.5026	0.6092	0.6101
072192- 9C	3.9655	286.26	47.06	30.859	1.1125	1.4946	0.6100	0.6108
072192- 1D	3.9248	287.56	46.34	47.786	1.3696	1.8351	0.6077	0.6090
072192- 2D	3.9266	286.77	46.51	47.301	1.3598	1.8255	0.6054	0.6067
072192- 3D	3.9154	285.47	46.61	50.585	1.4070	1.8950	0.6050	0.6064
072192- 4D	3.8389	284.51	45.86	74.676	1.7040	2.3026	0.6072	0.6093
072192- 5D	3.8394	284.81	45.81	74.473	1.6971	2.2916	0.6059	0.6080
072192- 6D	3.9639	286.02	47.09	12.572	0.7084	0.9523	0.6089	0.6093
072192- 7D	3.9810	287.34	47.05	12.347	0.7016	0.9400	0.6088	0.6091
072192- 8D	3.9663	285.68	47.18	31.159	1.1169	1.5026	0.6087	0.6096
072192- 9D	3.9655	286.26	47.06	30.912	1.1125	1.4946	0.6095	0.6103

Table 46. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, 19 tube bundle at 12D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
071692- 1A	3.8880	282.81	46.76	35.032	1.4828	2.0108	0.6100	0.6109
071692- 2A	3.8882	283.98	46.55	35.099	1.4809	2.0025	0.6101	0.6109
071692- 4A	3.8878	282.90	46.74	34.686	1.4718	1.9955	0.6087	0.6096
071692- 5A	3.9471	284.64	47.14	13.254	0.9160	1.2357	0.6108	0.6111
071692- 6A	3.9477	284.47	47.18	13.357	0.9202	1.2419	0.6110	0.6113
071692- 7A	3.8147	282.16	45.99	48.161	1.7233	2.3429	0.6094	0.6106
071692- 9A	3.8156	284.46	45.59	47.117	1.6907	2.2855	0.6071	0.6082
071692- 10A	3.9044	282.86	46.95	22.854	1.2011	1.6284	0.6109	0.6115
071692- 11A	3.9035	283.64	46.80	23.112	1.2022	1.6266	0.6090	0.6096
071792- 1A	3.9569	284.48	47.28	22.921	1.2079	1.6300	0.6113	0.6118
071792- 3A	3.8493	284.28	46.03	47.728	1.7165	2.3205	0.6095	0.6107
071792- 4A	3.8502	284.03	46.08	47.101	1.7034	2.3041	0.6085	0.6097
071792- 5A	3.9703	283.84	47.57	12.872	0.9080	1.2270	0.6116	0.6119
071792- 6A	3.9701	284.29	47.48	13.040	0.9125	1.2318	0.6112	0.6116
071792- 7A	3.9056	282.94	46.95	35.101	1.4878	2.0165	0.6103	0.6111
071792- 8A	3.9052	284.76	46.61	35.099	1.4794	1.9962	0.6090	0.6099
071692- 1B	3.8880	282.81	46.76	35.095	1.4828	2.0108	0.6095	0.6104
071692- 2B	3.8882	283.98	46.55	35.168	1.4809	2.0025	0.6095	0.6103
071692- 4B	3.8878	282.90	46.74	34.755	1.4718	1.9955	0.6081	0.6089
071692- 5B	3.9471	284.64	47.14	13.280	0.9160	1.2357	0.6102	0.6105
071692- 6B	3.9477	284.47	47.18	13.390	0.9202	1.2419	0.6102	0.6105
071692- 7B	3.8147	282.16	45.99	48.264	1.7233	2.3429	0.6088	0.6100
071692- 9B	3.8156	284.46	45.59	47.218	1.6907	2.2855	0.6064	0.6076
071692- 10B	3.9044	282.86	46.95	22.919	1.2011	1.6284	0.6100	0.6106
071692- 11B	3.9035	283.64	46.80	23.169	1.2022	1.6266	0.6082	0.6088
071792- 1B	3.9569	284.48	47.28	23.101	1.2079	1.6300	0.6089	0.6095
071792- 3B	3.8493	284.28	46.03	48.012	1.7165	2.3205	0.6077	0.6089
071792- 4B	3.8502	284.03	46.08	47.377	1.7034	2.3041	0.6067	0.6079
071792- 5B	3.9703	283.84	47.57	13.020	0.9080	1.2270	0.6082	0.6085
071792- 6B	3.9701	284.29	47.48	13.188	0.9125	1.2318	0.6078	0.6081
071792- 7B	3.9056	282.94	46.95	35.329	1.4878	2.0165	0.6083	0.6092
071792- 8B	3.9052	284.76	46.61	35.342	1.4794	1.9962	0.6069	0.6078
071692- 1C	3.8880	282.81	46.76	35.126	1.4828	2.0108	0.6092	0.6101
071692- 2C	3.8882	283.98	46.55	35.189	1.4809	2.0025	0.6093	0.6102
071692- 4C	3.8878	282.90	46.74	34.763	1.4718	1.9955	0.6080	0.6089
071692- 5C	3.9471	284.64	47.14	13.249	0.9160	1.2357	0.6109	0.6112
071692- 6C	3.9477	284.47	47.18	13.364	0.9202	1.2419	0.6108	0.6111
071692- 7C	3.8147	282.16	45.99	48.303	1.7233	2.3429	0.6085	0.6097
071692- 9C	3.8156	284.46	45.59	47.257	1.6907	2.2855	0.6062	0.6073
071692- 10C	3.9044	282.86	46.95	22.904	1.2011	1.6284	0.6102	0.6108
071692- 11C	3.9035	283.64	46.80	23.164	1.2022	1.6266	0.6083	0.6089
071792- 1C	3.9569	284.48	47.28	23.048	1.2079	1.6300	0.6096	0.6101
071792- 3C	3.8493	284.28	46.03	47.972	1.7165	2.3205	0.6079	0.6091
071792- 4C	3.8502	284.03	46.08	47.332	1.7034	2.3041	0.6070	0.6082
071792- 5C	3.9703	283.84	47.57	12.927	0.9080	1.2270	0.6103	0.6106
071792- 6C	3.9701	284.29	47.48	13.091	0.9125	1.2318	0.6100	0.6104
071792- 7C	3.9056	282.94	46.95	35.268	1.4878	2.0165	0.6088	0.6097
071792- 8C	3.9052	284.76	46.61	35.262	1.4794	1.9962	0.6076	0.6085
071692- 1D	3.8880	282.81	46.76	35.128	1.4828	2.0108	0.6092	0.6101
071692- 2D	3.8882	283.98	46.55	35.194	1.4809	2.0025	0.6092	0.6101
071692- 4D	3.8878	282.90	46.74	34.774	1.4718	1.9955	0.6079	0.6088
071692- 5D	3.9471	284.64	47.14	13.246	0.9160	1.2357	0.6109	0.6113
071692- 6D	3.9477	284.47	47.18	13.356	0.9202	1.2419	0.6110	0.6113
071692- 7D	3.8147	282.16	45.99	48.299	1.7233	2.3429	0.6085	0.6097
071692- 9D	3.8156	284.46	45.59	47.249	1.6907	2.2855	0.6062	0.6074
071692- 10D	3.9044	282.86	46.95	22.894	1.2011	1.6284	0.6104	0.6110
071692- 11D	3.9035	283.64	46.80	23.143	1.2022	1.6266	0.6086	0.6092
071792- 1D	3.9569	284.48	47.28	23.005	1.2079	1.6300	0.6102	0.6107
071792- 3D	3.8493	284.28	46.03	47.934	1.7165	2.3205	0.6082	0.6094
071792- 4D	3.8502	284.03	46.08	47.309	1.7034	2.3041	0.6072	0.6083
071792- 5D	3.9703	283.84	47.57	12.909	0.9080	1.2270	0.6108	0.6111
071792- 6D	3.9701	284.29	47.48	13.077	0.9125	1.2318	0.6104	0.6107
071792- 7D	3.9056	282.94	46.95	35.269	1.4878	2.0165	0.6088	0.6097
071792- 8D	3.9052	284.76	46.61	35.259	1.4794	1.9962	0.6076	0.6085

Table 47. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, 19 tube bundle at 7D, 4 flange tap locations, 52 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
072192- 1A	3.9322	287.46	46.45	35.489	1.4832	1.9877	0.6082	0.6091
072192- 2A	3.9279	286.35	46.60	34.787	1.4678	1.9724	0.6070	0.6079
072192- 3A	3.9761	285.98	47.24	12.891	0.9036	1.2147	0.6103	0.6106
072192- 4A	3.9729	286.33	47.14	13.043	0.9070	1.2183	0.6096	0.6100
072192- 5A	3.8689	286.36	45.89	48.402	1.7200	2.3129	0.6073	0.6085
072192- 6A	3.8695	285.65	46.03	47.684	1.7074	2.2999	0.6065	0.6077
072192- 7A	3.9603	286.46	46.96	22.796	1.1963	1.6065	0.6091	0.6096
072192- 8A	3.9634	286.90	46.92	23.091	1.2031	1.6138	0.6089	0.6094
072192- 1B	3.9322	287.46	46.45	35.579	1.4832	1.9877	0.6075	0.6083
072192- 2B	3.9279	286.35	46.60	34.851	1.4678	1.9724	0.6065	0.6073
072192- 3B	3.9761	285.98	47.24	12.927	0.9036	1.2147	0.6094	0.6097
072192- 4B	3.9729	286.33	47.14	13.084	0.9070	1.2183	0.6087	0.6090
072192- 5B	3.8689	286.36	45.89	48.521	1.7200	2.3129	0.6065	0.6077
072192- 6B	3.8695	285.65	46.03	47.799	1.7074	2.2999	0.6058	0.6070
072192- 7B	3.9603	286.46	46.96	22.864	1.1963	1.6065	0.6082	0.6087
072192- 8B	3.9634	286.90	46.92	23.154	1.2031	1.6138	0.6080	0.6086
072192- 1C	3.9322	287.46	46.45	35.535	1.4832	1.9877	0.6078	0.6087
072192- 2C	3.9279	286.35	46.60	34.826	1.4678	1.9724	0.6067	0.6075
072192- 3C	3.9761	285.98	47.24	12.865	0.9036	1.2147	0.6109	0.6112
072192- 4C	3.9729	286.33	47.14	13.010	0.9070	1.2183	0.6104	0.6107
072192- 5C	3.8689	286.36	45.89	48.516	1.7200	2.3129	0.6066	0.6078
072192- 6C	3.8695	285.65	46.03	47.771	1.7074	2.2999	0.6060	0.6072
072192- 7C	3.9603	286.46	46.96	22.820	1.1963	1.6065	0.6088	0.6093
072192- 8C	3.9634	286.90	46.92	23.113	1.2031	1.6138	0.6086	0.6091
072192- 1D	3.9322	287.46	46.45	35.651	1.4832	1.9877	0.6069	0.6077
072192- 2D	3.9279	286.35	46.60	34.934	1.4678	1.9724	0.6057	0.6066
072192- 3D	3.9761	285.98	47.24	12.958	0.9036	1.2147	0.6087	0.6090
072192- 4D	3.9729	286.33	47.14	13.104	0.9070	1.2183	0.6082	0.6085
072192- 5D	3.8689	286.36	45.89	48.587	1.7200	2.3129	0.6061	0.6073
072192- 6D	3.8695	285.65	46.03	47.850	1.7074	2.2999	0.6055	0.6067
072192- 7D	3.9603	286.46	46.96	22.917	1.1963	1.6065	0.6075	0.6080
072192- 8D	3.9634	286.90	46.92	23.203	1.2031	1.6138	0.6074	0.6080

Table 48. Measured and calculated quantities for 0.43 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
100792- 1A	3.6631	288.59	43.07	48.293	1.9326	1.3123	0.5989	0.6006
100792- 3A	3.8691	289.11	45.41	9.097	0.8645	0.5849	0.6026	0.6029
100792- 4A	3.8651	289.61	45.28	8.976	0.8547	0.5776	0.6006	0.6009
100792- 1A	3.8551	288.16	45.41	28.671	1.5300	1.0377	0.6001	0.6010
100792- 3A	3.9337	289.63	46.08	14.908	1.1149	0.7528	0.6024	0.6029
100892- 1A	3.8779	289.68	45.42	28.597	1.5289	1.0329	0.6003	0.6013
100892- 2A	3.8758	289.36	45.45	28.361	1.5249	1.0310	0.6011	0.6020
100892- 3A	3.9295	289.58	46.04	14.982	1.1185	0.7553	0.6031	0.6036
100892- 4A	3.9272	289.37	46.05	14.646	1.1067	0.7478	0.6036	0.6040
100892- 5A	3.7679	288.06	44.40	46.230	1.9184	1.3028	0.5986	0.6002
100892- 6A	3.7705	289.38	44.21	45.746	1.9067	1.2907	0.5994	0.6010
100892- 7A	3.9250	289.95	45.93	8.570	0.8435	0.5692	0.6024	0.6027
100892- 8A	3.9288	289.87	45.98	8.589	0.8438	0.5694	0.6016	0.6019
100792- 1C	3.6631	288.59	43.07	48.378	1.9326	1.3123	0.5984	0.6001
100792- 3C	3.8691	289.11	45.41	9.093	0.8645	0.5849	0.6027	0.6030
100792- 4C	3.8651	289.61	45.28	8.974	0.8547	0.5776	0.6007	0.6010
100792- 1C	3.8551	288.16	45.41	28.695	1.5300	1.0377	0.5998	0.6008
100792- 3C	3.9337	289.63	46.08	14.919	1.1149	0.7528	0.6022	0.6027
100892- 1C	3.8779	289.68	45.42	28.626	1.5289	1.0329	0.6000	0.6010
100892- 2C	3.8758	289.36	45.45	28.380	1.5249	1.0310	0.6009	0.6018
100892- 3C	3.9295	289.58	46.04	14.999	1.1185	0.7553	0.6028	0.6033
100892- 4C	3.9272	289.37	46.05	14.661	1.1067	0.7478	0.6033	0.6037
100892- 5C	3.7679	288.06	44.40	46.282	1.9184	1.3028	0.5983	0.5999
100892- 6C	3.7705	289.38	44.21	45.810	1.9067	1.2907	0.5990	0.6006
100892- 7C	3.9250	289.95	45.93	8.564	0.8435	0.5692	0.6026	0.6029
100892- 8C	3.9288	289.87	45.98	8.588	0.8438	0.5694	0.6016	0.6019

Table 49. Measured and calculated quantities for 0.55 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
100692- 1A	3.7637	288.65	44.25	12.859	1.7302	1.1734	0.6022	0.6026
100692- 2A	3.7629	288.54	44.26	12.780	1.7287	1.1727	0.6035	0.6039
100692- 3A	3.9034	289.56	45.74	3.103	0.8689	0.5870	0.6059	0.6060
100692- 5A	3.8478	288.31	45.30	8.110	1.3930	0.9446	0.6036	0.6038
100692- 6A	3.8431	288.95	45.14	8.108	1.3903	0.9413	0.6035	0.6038
100692- 7A	3.6309	286.82	42.98	19.705	2.1074	1.4378	0.6010	0.6016
100692- 8A	3.6322	287.27	42.92	19.452	2.0945	1.4274	0.6016	0.6023
100792- 1A	3.7128	288.02	43.75	19.240	2.0998	1.4271	0.6007	0.6013
100792- 2A	3.7262	288.04	43.91	18.441	2.0579	1.3983	0.6003	0.6009
100792- 3A	3.8892	288.30	45.79	8.218	1.4089	0.9549	0.6031	0.6034
100792- 4A	3.8897	288.89	45.69	8.319	1.4157	0.9581	0.6030	0.6032
100792- 5A	3.9557	289.14	46.43	3.257	0.8962	0.6057	0.6054	0.6055
100792- 6A	3.9575	289.59	46.37	3.246	0.8950	0.6042	0.6060	0.6061
100792- 7A	3.8100	288.27	44.86	12.777	1.7372	1.1786	0.6024	0.6029
100792- 8A	3.8098	289.28	44.69	12.817	1.7362	1.1750	0.6023	0.6027
100692- 1C	3.7637	288.65	44.25	12.854	1.7302	1.1734	0.6023	0.6027
100692- 2C	3.7629	288.54	44.26	12.785	1.7287	1.1727	0.6034	0.6038
100692- 3C	3.9034	289.56	45.74	3.108	0.8689	0.5870	0.6055	0.6056
100692- 5C	3.8478	288.31	45.30	8.098	1.3930	0.9446	0.6040	0.6043
100692- 6C	3.8431	288.95	45.14	8.102	1.3903	0.9413	0.6037	0.6040
100692- 7C	3.6309	286.82	42.98	19.714	2.1074	1.4378	0.6009	0.6015
100692- 8C	3.6322	287.27	42.92	19.462	2.0945	1.4274	0.6015	0.6021
100792- 1C	3.7128	288.02	43.75	19.239	2.0998	1.4271	0.6007	0.6013
100792- 2C	3.7262	288.04	43.91	18.447	2.0579	1.3983	0.6002	0.6008
100792- 3C	3.8892	288.30	45.79	8.206	1.4089	0.9549	0.6036	0.6039
100792- 4C	3.8897	288.89	45.69	8.307	1.4157	0.9581	0.6034	0.6037
100792- 5C	3.9557	289.14	46.43	3.261	0.8962	0.6057	0.6051	0.6052
100792- 6C	3.9575	289.59	46.37	3.249	0.8950	0.6042	0.6057	0.6058
100792- 7C	3.8100	288.27	44.86	12.775	1.7372	1.1786	0.6025	0.6029
100792- 8C	3.8098	289.28	44.69	12.808	1.7362	1.1750	0.6025	0.6029

Table 50. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
100692- 2A	3.8147	287.91	44.98	4.085	1.5737	1.0685	0.6038	0.6039
100692- 3A	3.8808	288.84	45.60	2.526	1.2495	0.8458	0.6055	0.6056
100692- 4A	3.8856	289.27	45.58	2.539	1.2463	0.8427	0.6026	0.6027
100692- 5A	3.7469	287.32	44.28	5.727	1.8435	1.2545	0.6021	0.6022
100692- 6A	3.7656	287.32	44.50	5.695	1.8420	1.2532	0.6018	0.6019
100692- 7A	3.6193	285.96	42.99	8.715	2.2343	1.5278	0.6003	0.6005
100692- 8A	3.6175	284.87	43.15	8.515	2.2120	1.5167	0.6001	0.6004
100692- 9A	3.8107	290.27	44.53	4.249	1.5920	1.0748	0.6019	0.6020
100692- 10A	3.8045	289.16	44.65	4.305	1.6047	1.0864	0.6020	0.6021
100692- 11A	3.8727	287.89	45.67	2.676	1.2848	0.8718	0.6045	0.6046
100892- 1A	3.8751	290.00	45.33	4.013	1.5609	1.0537	0.6019	0.6020
100892- 2A	3.8740	289.64	45.38	3.990	1.5599	1.0540	0.6029	0.6030
100892- 3A	3.9143	289.19	45.93	2.563	1.2648	0.8551	0.6063	0.6064
100892- 4A	3.9115	289.31	45.88	2.569	1.2680	0.8571	0.6075	0.6076
100892- 5A	3.9092	289.49	45.82	2.580	1.2689	0.8573	0.6070	0.6071
100892- 6A	3.7961	289.59	44.47	6.055	1.8984	1.2840	0.6016	0.6018
100892- 7A	3.7974	289.38	44.52	5.954	1.8841	1.2750	0.6018	0.6019
100892- 8A	3.7062	287.81	43.71	8.002	2.1609	1.4694	0.6008	0.6010
100892- 9A	3.7113	286.80	43.94	7.875	2.1495	1.4652	0.6009	0.6011
100692- 2C	3.8147	287.91	44.98	4.081	1.5737	1.0685	0.6041	0.6042
100692- 3C	3.8808	288.84	45.60	2.514	1.2495	0.8458	0.6070	0.6071
100692- 4C	3.8856	289.27	45.58	2.526	1.2463	0.8427	0.6041	0.6042
100692- 5C	3.7469	287.32	44.28	5.729	1.8435	1.2545	0.6020	0.6021
100692- 6C	3.7656	287.32	44.50	5.697	1.8420	1.2532	0.6017	0.6018
100692- 7C	3.6193	285.96	42.99	8.711	2.2343	1.5278	0.6004	0.6007
100692- 8C	3.6175	284.87	43.15	8.514	2.2120	1.5167	0.6002	0.6004
100692- 9C	3.8107	290.27	44.53	4.252	1.5920	1.0748	0.6017	0.6018
100692- 10C	3.8045	289.16	44.65	4.310	1.6047	1.0864	0.6016	0.6017
100692- 11C	3.8727	287.89	45.67	2.672	1.2848	0.8718	0.6049	0.6050
100892- 1C	3.8751	290.00	45.33	4.014	1.5609	1.0537	0.6018	0.6019
100892- 2C	3.8740	289.64	45.38	3.994	1.5599	1.0540	0.6026	0.6027
100892- 3C	3.9143	289.19	45.93	2.562	1.2648	0.8551	0.6065	0.6065
100892- 4C	3.9115	289.31	45.88	2.570	1.2680	0.8571	0.6074	0.6074
100892- 5C	3.9092	289.49	45.82	2.581	1.2689	0.8573	0.6069	0.6070
100892- 6C	3.7961	289.59	44.47	6.058	1.8984	1.2840	0.6014	0.6016
100892- 7C	3.7974	289.38	44.52	5.958	1.8841	1.2750	0.6016	0.6017
100892- 8C	3.7062	287.81	43.71	8.006	2.1609	1.4694	0.6007	0.6009
100892- 9C	3.7113	286.80	43.94	7.877	2.1495	1.4652	0.6008	0.6010

Table 51. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, no flow conditioner, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
100792- 1A	3.7049	288.14	43.64	4.279	1.9822	1.3468	0.5985	0.5986
100792- 3A	3.6479	287.74	43.03	5.056	2.1370	1.4544	0.5977	0.5979
100792- 5A	3.7900	289.09	44.49	2.533	1.5469	1.0476	0.6012	0.6013
100792- 6A	3.7940	288.32	44.66	2.509	1.5399	1.0448	0.6002	0.6003
100792- 7A	3.8016	288.34	44.75	2.531	1.5474	1.0497	0.6000	0.6001
100792- 8A	3.7496	289.12	44.01	3.242	1.7395	1.1786	0.6009	0.6010
100792- 10A	3.6895	287.39	43.58	4.291	1.9769	1.3459	0.5964	0.5965
100892- 1A	3.8967	289.69	45.64	3.282	1.7795	1.2019	0.5999	0.6000
100892- 2A	3.8891	289.91	45.51	3.266	1.7664	1.1925	0.5978	0.5979
100892- 3A	3.9252	289.21	46.06	2.555	1.5811	1.0688	0.6014	0.6014
100892- 4A	3.9199	288.82	46.06	2.562	1.5764	1.0666	0.5988	0.5989
100892- 5A	3.7540	289.09	44.06	4.967	2.1445	1.4530	0.5981	0.5982
100892- 6A	3.7547	287.82	44.28	4.945	2.1389	1.4536	0.5964	0.5965
100892- 7A	3.7978	289.34	44.54	4.247	1.9945	1.3498	0.5984	0.5985
100892- 8A	3.7965	288.99	44.58	4.237	1.9893	1.3474	0.5973	0.5974
100792- 1C	3.7049	288.14	43.64	4.267	1.9822	1.3468	0.5993	0.5994
100792- 3C	3.6479	287.74	43.03	5.035	2.1370	1.4544	0.5990	0.5991
100792- 5C	3.7900	289.09	44.49	2.520	1.5469	1.0476	0.6028	0.6029
100792- 6C	3.7940	288.32	44.66	2.492	1.5399	1.0448	0.6023	0.6024
100792- 7C	3.8016	288.34	44.75	2.508	1.5474	1.0497	0.6027	0.6027
100792- 8C	3.7496	289.12	44.01	3.242	1.7395	1.1786	0.6009	0.6010
100792- 10C	3.6895	287.39	43.58	4.277	1.9769	1.3459	0.5974	0.5975
100892- 1C	3.8967	289.69	45.64	3.282	1.7795	1.2019	0.5999	0.6000
100892- 2C	3.8891	289.91	45.51	3.268	1.7664	1.1925	0.5976	0.5976
100892- 3C	3.9252	289.21	46.06	2.549	1.5811	1.0688	0.6021	0.6021
100892- 4C	3.9199	288.82	46.06	2.551	1.5764	1.0666	0.6001	0.6001
100892- 5C	3.7540	289.09	44.06	4.962	2.1445	1.4530	0.5984	0.5985
100892- 6C	3.7547	287.82	44.28	4.938	2.1389	1.4536	0.5968	0.5969
100892- 7C	3.7978	289.34	44.54	4.242	1.9945	1.3498	0.5987	0.5988
100892- 8C	3.7965	288.99	44.58	4.228	1.9893	1.3474	0.5979	0.5980

Table 52. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 12D, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
120292- 1A	3.8859	286.96	45.99	2.531	1.2610	0.8574	0.6079	0.6080
120292- 2A	3.8845	287.68	45.85	2.534	1.2523	0.8500	0.6043	0.6044
120292- 3A	3.8862	287.89	45.83	2.536	1.2552	0.8515	0.6056	0.6056
120292- 4A	3.8374	286.81	45.44	4.149	1.6021	1.0904	0.6069	0.6070
120292- 5A	3.8376	287.34	45.35	4.162	1.5940	1.0835	0.6035	0.6036
120292- 6A	3.7749	287.29	44.61	5.806	1.8688	1.2714	0.6039	0.6041
120292- 7A	3.7741	286.27	44.78	5.754	1.8621	1.2700	0.6033	0.6035
120292- 8A	3.6935	286.68	43.75	7.598	2.1191	1.4452	0.6044	0.6046
120292- 9A	3.6950	286.33	43.83	7.496	2.0994	1.4330	0.6023	0.6025
120292- 10A	3.6915	286.74	43.72	7.475	2.0962	1.4294	0.6030	0.6033
120292- 11A	3.8723	287.94	45.65	2.636	1.2809	0.8691	0.6073	0.6074
120292- 12A	3.8726	287.09	45.81	2.670	1.2895	0.8767	0.6065	0.6066
120292- 13A	3.8282	286.58	45.37	4.081	1.5834	1.0784	0.6052	0.6054
120292- 14A	3.8277	286.88	45.31	4.078	1.5811	1.0760	0.6049	0.6051
120392- 1A	3.9202	286.97	46.40	2.436	1.2443	0.8457	0.6088	0.6088
120392- 2A	3.9194	287.53	46.29	2.468	1.2500	0.8484	0.6083	0.6084
120392- 3A	3.9200	287.15	46.36	2.470	1.2488	0.8484	0.6070	0.6070
120392- 4A	3.7157	285.60	44.20	7.454	2.1101	1.4425	0.6046	0.6048
120392- 5A	3.7195	286.18	44.14	7.365	2.0917	1.4278	0.6033	0.6035
120392- 6A	3.8564	286.61	45.70	3.962	1.5668	1.0667	0.6056	0.6057
120392- 7A	3.8574	287.66	45.53	4.022	1.5721	1.0675	0.6042	0.6043
120392- 8A	3.7690	286.64	44.65	5.971	1.8978	1.2932	0.6045	0.6046
120392- 9A	3.7687	287.21	44.56	5.967	1.8957	1.2901	0.6046	0.6048
120292- 1C	3.8859	286.96	45.99	2.535	1.2610	0.8574	0.6074	0.6075
120292- 2C	3.8845	287.68	45.85	2.541	1.2523	0.8500	0.6034	0.6035
120292- 3C	3.8862	287.89	45.83	2.543	1.2552	0.8515	0.6048	0.6048
120292- 4C	3.8374	286.81	45.44	4.174	1.6021	1.0904	0.6050	0.6051
120292- 5C	3.8376	287.34	45.35	4.186	1.5940	1.0835	0.6017	0.6018
120292- 6C	3.7749	287.29	44.61	5.834	1.8688	1.2714	0.6024	0.6026
120292- 7C	3.7741	286.27	44.78	5.785	1.8621	1.2700	0.6017	0.6019
120292- 8C	3.6935	286.68	43.75	7.638	2.1191	1.4452	0.6028	0.6031
120292- 9C	3.6950	286.33	43.83	7.529	2.0994	1.4330	0.6010	0.6012
120292- 10C	3.6915	286.74	43.72	7.506	2.0962	1.4294	0.6018	0.6020
120292- 11C	3.8723	287.94	45.65	2.648	1.2809	0.8691	0.6060	0.6060
120292- 12C	3.8726	287.09	45.81	2.679	1.2895	0.8767	0.6054	0.6055
120292- 13C	3.8282	286.58	45.37	4.109	1.5834	1.0784	0.6032	0.6033
120292- 14C	3.8277	286.88	45.31	4.108	1.5811	1.0760	0.6027	0.6028
120392- 1C	3.9202	286.97	46.40	2.439	1.2443	0.8457	0.6084	0.6085
120392- 2C	3.9194	287.53	46.29	2.472	1.2500	0.8484	0.6079	0.6079
120392- 3C	3.9200	287.15	46.36	2.473	1.2488	0.8484	0.6066	0.6066
120392- 4C	3.7157	285.60	44.20	7.477	2.1101	1.4425	0.6036	0.6038
120392- 5C	3.7195	286.18	44.14	7.394	2.0917	1.4278	0.6021	0.6023
120392- 6C	3.8564	286.61	45.70	3.984	1.5668	1.0667	0.6040	0.6041
120392- 7C	3.8574	287.66	45.53	4.035	1.5721	1.0675	0.6033	0.6034
120392- 8C	3.7690	286.64	44.65	5.989	1.8978	1.2932	0.6035	0.6037
120392- 9C	3.7687	287.21	44.56	5.983	1.8957	1.2901	0.6038	0.6040

Table 53. Measured and calculated quantities for 0.67 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 7D, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
120192- 1A	3.7516	289.25	44.01	4.019	1.5475	1.0481	0.6051	0.6053
120192- 2A	3.7610	288.81	44.19	4.032	1.5449	1.0473	0.6019	0.6021
120192- 3A	3.9528	289.38	46.35	2.598	1.2827	0.8664	0.6080	0.6081
120192- 4A	3.9369	289.81	46.09	2.692	1.3048	0.8806	0.6092	0.6093
120192- 5A	3.9303	289.09	46.14	2.678	1.3020	0.8803	0.6093	0.6093
120192- 6A	3.8206	289.23	44.82	5.900	1.8876	1.2775	0.6036	0.6038
120192- 7A	3.8212	288.90	44.89	5.845	1.8831	1.2754	0.6046	0.6047
120192- 8A	3.7308	287.72	44.02	7.821	2.1532	1.4641	0.6034	0.6037
120192- 9A	3.7315	288.62	43.87	7.803	2.1479	1.4573	0.6036	0.6039
120192- 1C	3.7516	289.25	44.01	4.030	1.5475	1.0481	0.6043	0.6045
120192- 2C	3.7610	288.81	44.19	4.034	1.5449	1.0473	0.6017	0.6018
120192- 3C	3.9528	289.38	46.35	2.602	1.2827	0.8664	0.6075	0.6076
120192- 4C	3.9369	289.81	46.09	2.700	1.3048	0.8806	0.6083	0.6084
120192- 5C	3.9303	289.09	46.14	2.688	1.3020	0.8803	0.6081	0.6081
120192- 6C	3.8206	289.23	44.82	5.902	1.8876	1.2775	0.6035	0.6037
120192- 7C	3.8212	288.90	44.89	5.849	1.8831	1.2754	0.6043	0.6045
120192- 8C	3.7308	287.72	44.02	7.837	2.1532	1.4641	0.6028	0.6031
120192- 9C	3.7315	288.62	43.87	7.810	2.1479	1.4573	0.6034	0.6036

Table 54. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 12D, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
120292- 1A	3.8384	289.42	45.00	3.141	1.7392	1.1762	0.6036	0.6037
120292- 3A	3.7505	289.12	44.02	4.294	2.0032	1.3572	0.6012	0.6013
120292- 5A	3.8564	288.92	45.30	2.488	1.5534	1.0516	0.6038	0.6038
120292- 7A	3.6956	286.56	43.79	4.900	2.1414	1.4608	0.6032	0.6033
120392- 1A	3.8055	287.29	44.98	3.199	1.7568	1.1947	0.6044	0.6045
120392- 2A	3.8051	286.72	45.07	3.180	1.7521	1.1932	0.6039	0.6040
120392- 3A	3.6843	286.06	43.74	4.896	2.1364	1.4594	0.6024	0.6025
120392- 4A	3.6847	286.22	43.72	4.826	2.1184	1.4465	0.6018	0.6019
120392- 5A	3.8121	287.12	45.09	2.743	1.6306	1.1093	0.6051	0.6052
120392- 6A	3.8131	286.61	45.18	2.754	1.6315	1.1113	0.6036	0.6036
120392- 7A	3.7308	285.58	44.38	4.078	1.9648	1.3430	0.6026	0.6027
120392- 8A	3.7303	286.83	44.16	4.082	1.9563	1.3331	0.6012	0.6013
120392- 9A	3.7327	285.53	44.41	4.039	1.9509	1.3336	0.6011	0.6012
120292- 1C	3.8384	289.42	45.00	3.169	1.7392	1.1762	0.6010	0.6010
120292- 3C	3.7505	289.12	44.02	4.314	2.0032	1.3572	0.5998	0.5999
120292- 5C	3.8564	288.92	45.30	2.506	1.5534	1.0516	0.6016	0.6017
120292- 7C	3.6956	286.56	43.79	4.956	2.1414	1.4608	0.5997	0.5998
120392- 1C	3.8055	287.29	44.98	3.232	1.7568	1.1947	0.6013	0.6014
120392- 2C	3.8051	286.72	45.07	3.208	1.7521	1.1932	0.6013	0.6013
120392- 3C	3.6843	286.06	43.74	4.934	2.1364	1.4594	0.6000	0.6001
120392- 4C	3.6847	286.22	43.72	4.864	2.1184	1.4465	0.5994	0.5995
120392- 5C	3.8121	287.12	45.09	2.755	1.6306	1.1093	0.6038	0.6039
120392- 6C	3.8131	286.61	45.18	2.771	1.6315	1.1113	0.6016	0.6017
120392- 7C	3.7308	285.58	44.38	4.109	1.9648	1.3430	0.6004	0.6005
120392- 8C	3.7303	286.83	44.16	4.113	1.9563	1.3331	0.5990	0.5991
120392- 9C	3.7327	285.53	44.41	4.070	1.9509	1.3336	0.5988	0.5989

Table 55. Measured and calculated quantities for 0.73 beta ratio, elbow at 17 pipe diameters, 7 tube bundle at 7D, 2 flange tap locations, 104 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
120192- 1A	3.7793	289.20	44.34	4.097	1.9642	1.3300	0.6013	0.6014
120192- 2A	3.7783	289.00	44.36	4.101	1.9654	1.3315	0.6012	0.6013
120192- 3A	3.8669	289.83	45.26	2.520	1.5657	1.0575	0.6050	0.6050
120192- 4A	3.8682	288.28	45.55	2.509	1.5629	1.0595	0.6032	0.6033
120192- 5A	3.8236	287.90	45.09	3.305	1.7850	1.2118	0.6034	0.6035
120192- 6A	3.8241	288.07	45.06	3.278	1.7792	1.2074	0.6040	0.6041
120192- 7A	3.7130	287.68	43.82	5.062	2.1646	1.4723	0.5997	0.5998
120192- 8A	3.7189	288.22	43.79	4.990	2.1558	1.4643	0.6017	0.6018
120192- 1C	3.7793	289.20	44.34	4.115	1.9642	1.3300	0.6000	0.6001
120192- 2C	3.7783	289.00	44.36	4.122	1.9654	1.3315	0.5996	0.5997
120192- 3C	3.8669	289.83	45.26	2.530	1.5657	1.0575	0.6037	0.6038
120192- 4C	3.8682	288.28	45.55	2.520	1.5629	1.0595	0.6020	0.6021
120192- 5C	3.8236	287.90	45.09	3.327	1.7850	1.2118	0.6014	0.6015
120192- 6C	3.8241	288.07	45.06	3.299	1.7792	1.2074	0.6021	0.6022
120192- 7C	3.7130	287.68	43.82	5.080	2.1646	1.4723	0.5987	0.5988
120192- 8C	3.7189	288.22	43.79	5.011	2.1558	1.4643	0.6005	0.6006

Table 56. Measured and calculated quantities for 0.37 beta ratio, oversize Sprenkle at 44 pipe diameters, 2 flange tap locations, 154 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
122192- 1A	3.9626	287.71	46.77	7.798	1.3250	0.6035	0.6018	0.6020
122192- 2A	3.9657	287.64	46.81	7.757	1.3219	0.6022	0.6017	0.6020
122192- 4A	3.9768	288.22	46.84	3.442	0.8820	0.4011	0.6027	0.6029
122192- 5A	3.8893	286.86	46.05	16.142	1.8804	0.8590	0.5980	0.5985
122192- 6A	3.8841	287.24	45.92	16.113	1.8769	0.8566	0.5982	0.5988
122192- 7A	3.7542	286.73	44.46	26.524	2.3673	1.0835	0.5972	0.5982
122192- 8A	3.7535	286.28	44.53	26.395	2.3630	1.0827	0.5972	0.5981
122292- 1A	3.7598	286.95	44.49	16.545	1.8637	0.8525	0.5955	0.5960
122292- 2A	3.7632	286.82	44.56	16.584	1.8667	0.8541	0.5953	0.5959
122292- 3A	3.8490	287.59	45.44	7.818	1.2996	0.5929	0.5980	0.5983
122292- 4A	3.8498	288.06	45.37	7.869	1.3023	0.5935	0.5978	0.5981
122292- 6A	3.9417	288.37	46.40	4.117	0.9574	0.4355	0.6011	0.6012
122292- 1A	4.0348	288.82	47.42	7.364	1.2917	0.5863	0.5996	0.5998
122292- 2A	4.0372	288.73	47.46	7.329	1.2924	0.5867	0.6010	0.6013
122292- 3A	3.9317	288.02	46.34	16.996	1.9363	0.8816	0.5981	0.5987
122292- 4A	3.9303	288.66	46.21	17.017	1.9291	0.8770	0.5963	0.5969
122292- 5A	3.7984	288.33	44.71	25.845	2.3379	1.0653	0.5959	0.5967
122292- 6A	3.7931	287.32	44.82	25.606	2.3325	1.0655	0.5965	0.5974
122292- 7A	4.0306	289.19	47.30	3.694	0.9180	0.4163	0.6025	0.6026
122392- 1A	3.9519	289.09	46.39	7.721	1.3058	0.5928	0.5984	0.5987
122392- 2A	3.9483	288.92	46.38	7.676	1.3046	0.5925	0.5996	0.5999
122392- 3A	3.8619	288.67	45.41	16.194	1.8662	0.8490	0.5966	0.5971
122392- 4A	3.8620	288.72	45.40	16.121	1.8612	0.8466	0.5964	0.5970
122392- 5A	3.7329	287.62	44.06	26.925	2.3718	1.0835	0.5966	0.5975
122392- 6A	3.7285	287.95	43.95	27.080	2.3747	1.0840	0.5963	0.5973
122392- 7A	3.9612	289.25	46.47	4.620	1.0150	0.4606	0.6009	0.6010
122392- 8A	3.9625	289.18	46.50	4.439	0.9934	0.4509	0.5998	0.5999
122192- 1C	3.9626	287.71	46.77	7.801	1.3250	0.6035	0.6017	0.6019
122192- 2C	3.9657	287.64	46.81	7.758	1.3219	0.6022	0.6017	0.6019
122192- 4C	3.9768	288.22	46.84	3.469	0.8820	0.4011	0.6004	0.6005
122192- 5C	3.8893	286.86	46.05	16.131	1.8804	0.8590	0.5982	0.5987
122192- 6C	3.8841	287.24	45.92	16.106	1.8769	0.8566	0.5983	0.5989
122192- 7C	3.7542	286.73	44.46	26.535	2.3673	1.0835	0.5971	0.5980
122192- 8C	3.7535	286.28	44.53	26.374	2.3630	1.0827	0.5974	0.5983
122292- 1C	3.7598	286.95	44.49	16.529	1.8637	0.8525	0.5958	0.5963
122292- 2C	3.7632	286.82	44.56	16.570	1.8667	0.8541	0.5956	0.5961
122292- 3C	3.8490	287.59	45.44	7.808	1.2996	0.5929	0.5984	0.5986
122292- 4C	3.8498	288.06	45.37	7.865	1.3023	0.5935	0.5980	0.5982
122292- 6C	3.9417	288.37	46.40	4.123	0.9574	0.4355	0.6006	0.6007
122292- 1C	4.0348	288.82	47.42	7.357	1.2917	0.5863	0.5998	0.6001
122292- 2C	4.0372	288.73	47.46	7.327	1.2924	0.5867	0.6011	0.6014
122292- 3C	3.9317	288.02	46.34	16.983	1.9363	0.8816	0.5983	0.5989
122292- 4C	3.9303	288.66	46.21	17.003	1.9291	0.8770	0.5966	0.5971
122292- 5C	3.7984	288.33	44.71	25.816	2.3379	1.0653	0.5962	0.5971
122292- 6C	3.7931	287.32	44.82	25.586	2.3325	1.0655	0.5968	0.5976
122292- 7C	4.0306	289.19	47.30	3.709	0.9180	0.4163	0.6013	0.6014
122392- 1C	3.9519	289.09	46.39	7.711	1.3058	0.5928	0.5988	0.5991
122392- 2C	3.9483	288.92	46.38	7.664	1.3046	0.5925	0.6001	0.6004
122392- 3C	3.8619	288.67	45.41	16.196	1.8662	0.8490	0.5966	0.5971
122392- 4C	3.8620	288.72	45.40	16.114	1.8612	0.8466	0.5965	0.5971
122392- 5C	3.7329	287.62	44.06	26.917	2.3718	1.0835	0.5967	0.5976
122392- 6C	3.7285	287.95	43.95	27.081	2.3747	1.0840	0.5963	0.5973
122392- 7C	3.9612	289.25	46.47	4.615	1.0150	0.4606	0.6012	0.6014
122392- 8C	3.9625	289.18	46.50	4.430	0.9934	0.4509	0.6004	0.6006

Table 57. Measured and calculated quantities for 0.57 beta ratio, oversize Sprenkle at 44 pipe diameters, 2 flange tap locations, 154 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. ($/10^6$)	C	CY_2
122292- 1A	3.8322	288.53	45.08	3.710	2.2318	1.0161	0.6028	0.6030
122292- 2A	3.8264	288.22	45.06	3.688	2.2256	1.0140	0.6031	0.6032
122292- 3A	3.7883	287.99	44.65	4.292	2.3816	1.0863	0.6010	0.6011
122292- 4A	3.7854	287.72	44.66	4.281	2.3818	1.0871	0.6018	0.6019
122292- 5A	3.8686	287.51	45.69	3.039	2.0346	0.9282	0.6032	0.6033
122292- 6A	3.8678	287.79	45.63	3.050	2.0339	0.9272	0.6024	0.6025
122292- 7A	3.9155	287.83	46.19	2.453	1.8398	0.8382	0.6039	0.6040
122292- 8A	3.9144	287.84	46.17	2.462	1.8416	0.8390	0.6035	0.6036
122392- 1A	3.8288	288.56	45.03	2.966	1.9951	0.9083	0.6031	0.6032
122392- 2A	3.8251	287.77	45.13	2.942	1.9926	0.9089	0.6041	0.6042
122392- 3A	3.7645	288.21	44.33	3.739	2.2194	1.0120	0.6022	0.6023
122392- 4A	3.7625	288.12	44.32	3.733	2.2144	1.0100	0.6014	0.6015
122392- 5A	3.8493	288.03	45.37	2.574	1.8629	0.8490	0.6022	0.6023
122392- 6A	3.8489	288.77	45.23	2.588	1.8621	0.8471	0.6012	0.6013
122392- 7A	3.7296	287.71	44.00	4.216	2.3464	1.0717	0.6018	0.6019
122392- 8A	3.7271	287.74	43.97	4.208	2.3438	1.0704	0.6019	0.6021
122392- 9A	3.8349	288.04	45.19	2.635	1.8805	0.8571	0.6020	0.6021
122392- 10A	3.8160	288.01	44.98	2.891	1.9640	0.8954	0.6018	0.6019
122292- 1C	3.8322	288.53	45.08	3.730	2.2318	1.0161	0.6013	0.6014
122292- 2C	3.8264	288.22	45.06	3.705	2.2256	1.0140	0.6017	0.6019
122292- 3C	3.7883	287.99	44.65	4.304	2.3816	1.0863	0.6002	0.6003
122292- 4C	3.7854	287.72	44.66	4.291	2.3818	1.0871	0.6010	0.6012
122292- 5C	3.8686	287.51	45.69	3.061	2.0346	0.9282	0.6011	0.6012
122292- 6C	3.8678	287.79	45.63	3.074	2.0339	0.9272	0.6000	0.6001
122292- 7C	3.9155	287.83	46.19	2.472	1.8398	0.8382	0.6015	0.6016
122292- 8C	3.9144	287.84	46.17	2.470	1.8416	0.8390	0.6025	0.6026
122392- 1C	3.8288	288.56	45.03	2.967	1.9951	0.9083	0.6030	0.6031
122392- 2C	3.8251	287.77	45.13	2.947	1.9926	0.9089	0.6036	0.6037
122392- 3C	3.7645	288.21	44.33	3.741	2.2194	1.0120	0.6020	0.6021
122392- 4C	3.7625	288.12	44.32	3.734	2.2144	1.0100	0.6013	0.6014
122392- 5C	3.8493	288.03	45.37	2.578	1.8629	0.8490	0.6018	0.6019
122392- 6C	3.8489	288.77	45.23	2.589	1.8621	0.8471	0.6011	0.6012
122392- 7C	3.7296	287.71	44.00	4.219	2.3464	1.0717	0.6016	0.6018
122392- 8C	3.7271	287.74	43.97	4.212	2.3438	1.0704	0.6016	0.6018
122392- 9C	3.8349	288.04	45.19	2.638	1.8805	0.8571	0.6017	0.6018
122392- 10C	3.8160	288.01	44.98	2.897	1.9640	0.8954	0.6011	0.6012

Table 58. Measured and calculated quantities for 0.37 beta ratio, tee at 18 pipe diameters, 19 tube bundle at 12D, 2 flange tap locations, 154 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
010893- 1A	4.0576	287.74	47.89	7.643	1.3234	0.6020	0.6000	0.6003
010893- 2A	4.0554	287.86	47.84	7.663	1.3219	0.6012	0.5989	0.5991
010893- 3A	3.7757	286.55	44.75	26.115	2.3536	1.0774	0.5965	0.5974
010893- 4A	3.7549	287.04	44.42	26.635	2.3643	1.0812	0.5955	0.5964
010893- 5A	3.9832	287.57	47.03	4.870	1.0477	0.4772	0.6006	0.6007
010893- 6A	3.9876	287.79	47.05	4.778	1.0377	0.4724	0.6005	0.6006
010893- 7A	3.8948	286.83	46.12	16.181	1.8828	0.8601	0.5975	0.5981
010893- 8A	3.8920	286.95	46.06	16.088	1.8760	0.8567	0.5974	0.5980
011193- 1A	3.8764	286.87	45.89	16.193	1.8811	0.8594	0.5982	0.5988
011193- 2A	3.8770	287.05	45.87	16.212	1.8793	0.8582	0.5975	0.5980
011193- 3A	3.9639	287.50	46.82	7.603	1.3022	0.5934	0.5987	0.5989
011193- 4A	3.9620	287.52	46.79	7.596	1.3065	0.5953	0.6011	0.6013
011193- 5A	3.7230	286.46	44.14	27.223	2.3885	1.0943	0.5970	0.5979
011193- 6A	3.7208	286.12	44.17	27.074	2.3816	1.0920	0.5967	0.5976
011193- 7A	3.9662	288.08	46.74	4.784	1.0327	0.4699	0.5991	0.5992
011193- 8A	3.9704	288.02	46.80	4.810	1.0412	0.4738	0.6020	0.6022
010893- 1C	4.0576	287.74	47.89	7.626	1.3234	0.6020	0.6007	0.6009
010893- 2C	4.0554	287.86	47.84	7.655	1.3219	0.6012	0.5992	0.5994
010893- 3C	3.7757	286.55	44.75	26.125	2.3536	1.0774	0.5964	0.5973
010893- 4C	3.7549	287.04	44.42	26.634	2.3643	1.0812	0.5955	0.5964
010893- 5C	3.9832	287.57	47.03	4.872	1.0477	0.4772	0.6005	0.6006
010893- 6C	3.9876	287.79	47.05	4.783	1.0377	0.4724	0.6002	0.6003
010893- 7C	3.8948	286.83	46.12	16.187	1.8828	0.8601	0.5974	0.5979
010893- 8C	3.8920	286.95	46.06	16.091	1.8760	0.8567	0.5974	0.5979
011193- 1C	3.8764	286.87	45.89	16.193	1.8811	0.8594	0.5982	0.5988
011193- 2C	3.8770	287.05	45.87	16.202	1.8793	0.8582	0.5976	0.5982
011193- 3C	3.9639	287.50	46.82	7.590	1.3022	0.5934	0.5992	0.5994
011193- 4C	3.9620	287.52	46.79	7.589	1.3065	0.5953	0.6013	0.6016
011193- 5C	3.7230	286.46	44.14	27.221	2.3885	1.0943	0.5970	0.5979
011193- 6C	3.7208	286.12	44.17	27.069	2.3816	1.0920	0.5967	0.5977
011193- 7C	3.9662	288.08	46.74	4.788	1.0327	0.4699	0.5988	0.5990
011193- 8C	3.9704	288.02	46.80	4.816	1.0412	0.4738	0.6016	0.6018

Table 59. Measured and calculated quantities for 0.37 beta ratio, tee at 18 pipe diameters, 19 tube bundle at 7D, 2 flange tap locations, 154 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY_2
010793- 1A	3.8665	287.02	45.75	16.049	1.8658	0.8522	0.5970	0.5975
010793- 2A	3.8671	286.75	45.80	16.011	1.8670	0.8533	0.5977	0.5982
010793- 3A	3.9529	287.47	46.69	7.788	1.3164	0.6000	0.5987	0.5990
010793- 4A	3.9470	287.32	46.65	7.737	1.3101	0.5974	0.5981	0.5984
010793- 5A	3.7059	287.00	43.84	27.246	2.3792	1.0888	0.5964	0.5973
010793- 6A	3.7032	286.22	43.94	27.078	2.3757	1.0893	0.5967	0.5976
010793- 7A	3.9406	287.44	46.55	5.035	1.0570	0.4818	0.5990	0.5991
010793- 8A	3.9452	287.44	46.61	5.223	1.0796	0.4921	0.6003	0.6005
010793- 1C	3.8665	287.02	45.75	16.036	1.8658	0.8522	0.5972	0.5977
010793- 2C	3.8671	286.75	45.80	16.003	1.8670	0.8533	0.5979	0.5984
010793- 3C	3.9529	287.47	46.69	7.788	1.3164	0.6000	0.5987	0.5990
010793- 4C	3.9470	287.32	46.65	7.741	1.3101	0.5974	0.5980	0.5982
010793- 5C	3.7059	287.00	43.84	27.231	2.3792	1.0888	0.5965	0.5975
010793- 6C	3.7032	286.22	43.94	27.072	2.3757	1.0893	0.5967	0.5977
010793- 7C	3.9406	287.44	46.55	5.048	1.0570	0.4818	0.5981	0.5983
010793- 8C	3.9452	287.44	46.61	5.235	1.0796	0.4921	0.5996	0.5998

Table 60. Measured and calculated quantities for 0.57 beta ratio, tee at 18 pipe diameters, 19 tube bundle at 12D, 2 flange tap locations, 154 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
010893- 1A	3.8925	286.86	46.08	2.623	1.8943	0.8653	0.6020	0.6021
010893- 2A	3.8844	286.97	45.97	2.625	1.8952	0.8655	0.6028	0.6029
010893- 3A	3.8443	286.74	45.53	3.090	2.0394	0.9324	0.6006	0.6007
010893- 4A	3.8430	287.17	45.44	3.092	2.0446	0.9338	0.6027	0.6028
010893- 5A	3.7861	286.67	44.85	3.779	2.2436	1.0266	0.6021	0.6022
010893- 6A	3.7842	286.63	44.84	3.767	2.2378	1.0241	0.6016	0.6017
010893- 7A	3.7194	287.02	44.00	4.555	2.4372	1.1151	0.6014	0.6015
010893- 8A	3.7276	286.36	44.21	4.540	2.4399	1.1180	0.6017	0.6018
011193- 1A	3.9344	287.16	46.53	3.048	2.0528	0.9365	0.6022	0.6023
011193- 2A	3.9129	286.90	46.32	3.044	2.0500	0.9360	0.6031	0.6032
011193- 3A	3.9774	286.86	47.09	2.460	1.8601	0.8488	0.6038	0.6039
011193- 4A	3.9882	286.96	47.20	2.453	1.8587	0.8478	0.6036	0.6036
011193- 5A	3.7947	286.92	44.91	3.882	2.2810	1.0430	0.6035	0.6036
011193- 6A	3.7865	286.81	44.83	3.882	2.2741	1.0402	0.6023	0.6024
011193- 7A	3.7449	286.15	44.45	4.425	2.4201	1.1093	0.6028	0.6030
011193- 8A	3.7396	286.62	44.31	4.422	2.4137	1.1052	0.6024	0.6026
010893- 1C	3.8925	286.86	46.08	2.626	1.8943	0.8653	0.6016	0.6017
010893- 2C	3.8844	286.97	45.97	2.629	1.8952	0.8655	0.6023	0.6023
010893- 3C	3.8443	286.74	45.53	3.096	2.0394	0.9324	0.6001	0.6002
010893- 4C	3.8430	287.17	45.44	3.097	2.0446	0.9338	0.6022	0.6023
010893- 5C	3.7861	286.67	44.85	3.781	2.2436	1.0266	0.6019	0.6020
010893- 6C	3.7842	286.63	44.84	3.772	2.2378	1.0241	0.6011	0.6012
010893- 7C	3.7194	287.02	44.00	4.568	2.4372	1.1151	0.6005	0.6007
010893- 8C	3.7276	286.36	44.21	4.549	2.4399	1.1180	0.6010	0.6012
011193- 1C	3.9344	287.16	46.53	3.054	2.0528	0.9365	0.6016	0.6017
011193- 2C	3.9129	286.90	46.32	3.053	2.0500	0.9360	0.6023	0.6024
011193- 3C	3.9774	286.86	47.09	2.465	1.8601	0.8488	0.6032	0.6033
011193- 4C	3.9882	286.96	47.20	2.460	1.8587	0.8478	0.6027	0.6028
011193- 5C	3.7947	286.92	44.91	3.892	2.2810	1.0430	0.6027	0.6028
011193- 6C	3.7865	286.81	44.83	3.892	2.2741	1.0402	0.6014	0.6016
011193- 7C	3.7449	286.15	44.45	4.434	2.4201	1.1093	0.6022	0.6024
011193- 8C	3.7396	286.62	44.31	4.432	2.4137	1.1052	0.6018	0.6019

Table 61. Measured and calculated quantities for 0.57 beta ratio, tee at 18 pipe diameters, 19 tube bundle at 7D, 2 flange tap locations, 154 mm orifice meter.

Run ID/ Tap	Pressure (MPa)	Temp. (K)	Density (kg/m^3)	Dif Press (kPa)	Flow Rate (kg/s)	Pipe Re No. (/10^6)	C	CY$_2$
010793- 1A	3.7837	286.86	44.79	3.810	2.2407	1.0248	0.5993	0.5994
010793- 2A	3.7859	287.03	44.79	3.834	2.2424	1.0252	0.5978	0.5979
010793- 3A	3.9002	286.85	46.18	2.528	1.8513	0.8456	0.5986	0.5987
010793- 4A	3.8846	286.86	45.99	2.524	1.8512	0.8457	0.6003	0.6003
010793- 5A	3.8869	287.01	45.99	2.542	1.8612	0.8499	0.6014	0.6015
010793- 6A	3.8383	286.98	45.42	3.122	2.0467	0.9352	0.6004	0.6005
010793- 7A	3.8376	287.19	45.37	3.132	2.0422	0.9327	0.5985	0.5986
010793- 8A	3.7412	287.08	44.25	4.407	2.3911	1.0936	0.5981	0.5983
010793- 9A	3.7322	286.26	44.28	4.381	2.3857	1.0935	0.5984	0.5985
010793- 1C	3.7837	286.86	44.79	3.810	2.2407	1.0248	0.5993	0.5994
010793- 2C	3.7859	287.03	44.79	3.832	2.2424	1.0252	0.5980	0.5981
010793- 3C	3.9002	286.85	46.18	2.529	1.8513	0.8456	0.5985	0.5986
010793- 4C	3.8846	286.86	45.99	2.523	1.8512	0.8457	0.6004	0.6004
010793- 5C	3.8869	287.01	45.99	2.542	1.8612	0.8499	0.6014	0.6015
010793- 6C	3.8383	286.98	45.42	3.123	2.0467	0.9352	0.6003	0.6004
010793- 7C	3.8376	287.19	45.37	3.130	2.0422	0.9327	0.5987	0.5988
010793- 8C	3.7412	287.08	44.25	4.405	2.3911	1.0936	0.5983	0.5985
010793- 9C	3.7322	286.26	44.28	4.378	2.3857	1.0935	0.5986	0.5987

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