CALIBRATION OF ORIFICE METERS AT LOW REYNOLDS NUMBERS

by

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ABSTRACT

Seventeen square-edged orifice plates were calibrated to study the effect of varying throat length, both in the absence and in the presence of geometrical similarity, on the coefficient of discharge for pipe Reynolds numbers from 20 to 10,000. The experiments involved the use of hydraulically smooth pipe in test lines of 1 - inch, 1.5 - inch and 2 - inch nominal I.D., corner pressure taps and Beta ratios (orifice diameter/pipe diameter) of 0.2, 0.4 and 0.6.

Six of the plates were built using design criteria recommended by the A.S.M.E. in "Fluid Meters" (1), and with Beta ratios specified at 0.4. Each test line was used with two plates, which were identical except for a variation in throat length within the range of the given design recommendations. A comparison of discharge coefficients as a function of pipe Reynolds number indicated the following:

(1) Reynolds numbers 30 - 3,000.

Consistent differences of 2-6% were observed in the calibration curves due to the variation in throat length allowed by "Fluid Meters". (1).

(2) Reynolds number 3,000 - 10,000.

Geometry appeared to be much less important, as all calibration curves tended to coincide.

Two further plates, for the 1.5 - inch pipe only, were built using the A.S.M.E. "Power Test Code" (2) as a design reference. They were designed to have respectively the minimum and maximum throat length allowable under the code. The results, when plotted, indicated that in a pipe Reynolds number range of 40 - 1,500, plates built identically except for small differences in throat length, still gave distinguishably different calibration curves.

The remaining nine plates were divided into three groups of three plates each, encompassing the three pipe diameters and three Beta ratios. All plates within a group were geometrically similar. The results, for pipe Reynolds numbers from 20 to 2,000, indicated that a total specification of orifice shape gave consistent calibration curves with no apparent absolute size effects.

Thus, both "Fluid Meters" and the "Power Test Code" recommended design criteria for standard orifice plates which do not completely take into account the effect of geometry on the coefficient of discharge at low Reynolds numbers. In particular, the tolerances allowed on throat length are too large.

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INTRODUCTION

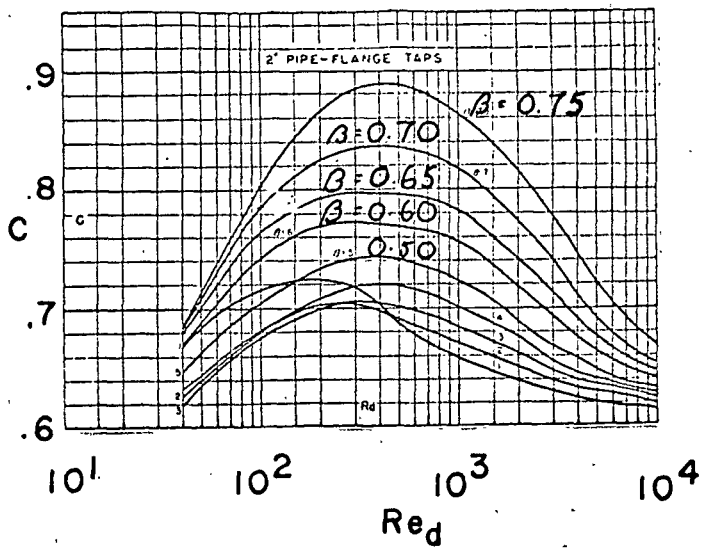
Over the past fifty years, a great deal of research has been concerned with the thin plate orifice meter. The characteristics of the calibration curves have been explored by many workers (5, 9, 10, 16, 17) over a very wide range of Reynolds Numbers. Hereafter, Reynolds numbers based on inside pipe diameter will be abbreviated Re_D while those based on the orifice diameter will be abbreviated Re_d. It is well known that at high Reynolds numbers, which in this study means Reynolds numbers based either on pipe diameter or orifice diameter greater than 10,000, the coefficient of discharge is very nearly independent of both the Reynolds number and the diameter ratio Beta. However, at a low Reynolds number (Re_D or Re_d less than 10,000), the coefficient of discharge appears to be a function of Re_D or Re_d, Beta and a shape factor (6). It is the effect of the shape factor on the coefficient of discharge in the low Reynolds number range which is the primary concern of this study.

A review by Iversen (6) in 1954 attempted to standardize discharge coefficients over this range by comparing the results of sixteen investigators who calibrated orifice plates at Reynolds numbers (Re_D or Re_d) between 4 and 50,000. However, the two different Reynolds numbers used by different authors, and the variability of pressure tap location and orifice plate design, made a direct comparison of most of these data unenlightening. The largest source of reasonably comparable data was that in which the experimenters used corner pressure taps. These data were recalculated using a consistent discharge equation and Re_D, and plotted for Reynolds numbers from 4 to 10,000. Unfortunately, deviations from the mean curves increased from 0.5% at Re_D = 10,000 to between 5 and 10% at Re_D = 4. Iversen concluded that "the essential requirement for the specification of standard coefficients for orifices in the low Reynolds number range appears to be a complete

specific standardization of the orifice shape, not merely upper limits to the size of throat width and of plate thickness".

The American Society of Mechanical Engineers has published (1, 2) standard discharge coefficient data for commercial pipe, 1.5 inches I.D. and larger, covering a range of Re_D from 1,000 to 10,000,000. The publications include data for corner, flange, vena-contracta and pipe pressure taps for Beta from 0.1 to 0.75. For such data to be accurate, standard orifice meters must be built according to design specifications also found in (1, 2). It is of interest to orifice meter users to fully understand the implications of using both standard calibration data and standard design criteria at low Reynolds numbers. Their use implies that variation of orifice meter shape within the upper and lower limits allowed by the design has no measurable effect on the discharge coefficient. This assumption has been amply justified for Reynolds numbers greater than 10,000 (5, 6, 8, 9, 14). However, for Reynolds numbers smaller than 10,000, evidence of an effect of geometry on the coefficient of discharge has been shown (10, 16, 14).

Ambrosius and Spink (10) reported discharge coefficient data for Re_d from 40 to 10,000 and Beta below 0.75, using flange pressure taps. The orifice plates were of standard A.S.M.E. design, with a variety of orifice throat lengths and plate thicknesses, and were installed in 2 - inch, 3 - inch and 4 - inch nominal I.D. commercial pipe. Coefficients of discharge when compared at equal Betas for the three pipe sizes, did not correspond. This may be seen for the 2 - inch and 3 - inch pipes in Fig. 1, taken from the original paper.



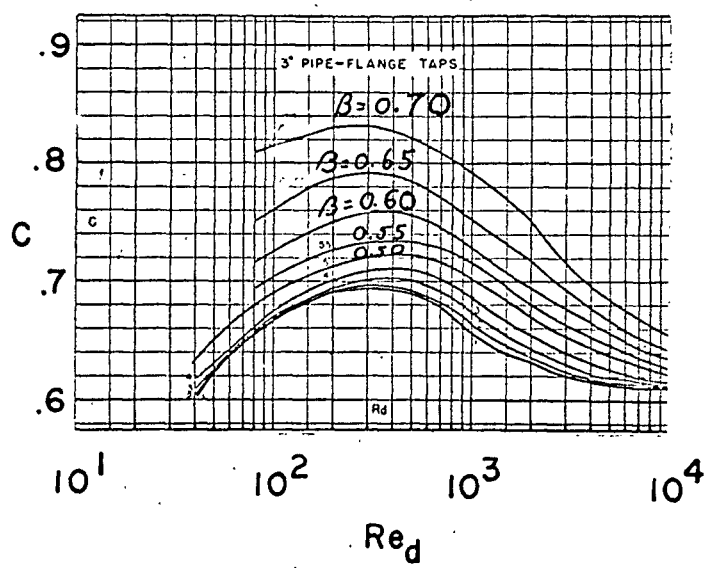


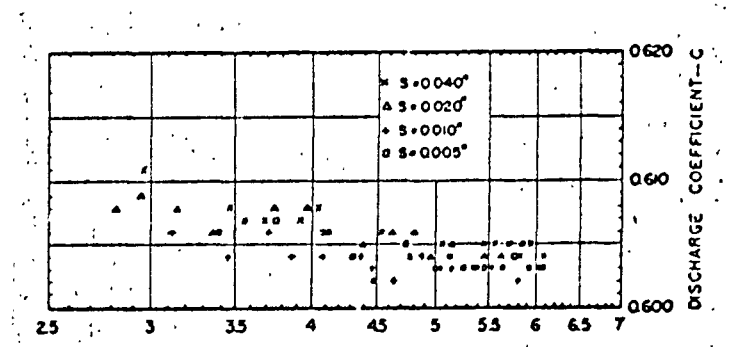
Figure 1; CALIBRATION RESULTS - AMBROSIUS AND SPINK (10)
2 - inch and 3 - inch pipe

Each pipe size appears to give a separate set of calibration curves. The authors suggested that the lack of geometric similarity due to the use of commercial pipe, the variation in orifice shapes and the use of flange taps caused the calibration curves to vary appreciably with pipe diameter for any given Beta.

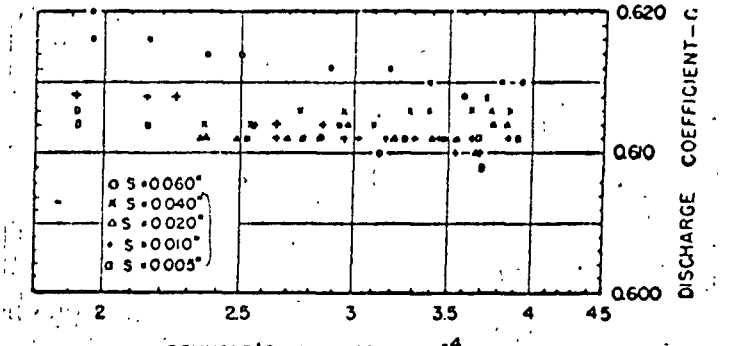
A more specific geometry effect was observed by Thrasher and Binder (16), who studied the effect of orifice throat length on the coefficient of discharge using Betas of 0.2, 0.5 and 0.7 and a Re_d range of 2,800 - 80,000. Their work indicated that if the orifice throat length was kept smaller than 1/40 of the inside pipe diameter, no effect of the pipe diameter would be observed. Also, discharge coefficients increased with orifice throat lengths, the greatest increase occurring at the largest Beta and the smallest Reynolds number. The preceding generalizations were based on graphs obtained from the original paper and recorded in Fig. 2.

Galloway (14) designed and built two orifice meters in accordance with the design recommendations contained in (1), for use in 1.5 and 2 - inch nominal I.D. copper water pipe. All dimension ratios between the two meters were approximately equal, except for the plate thickness to inside pipe diameter ratio. In calibrating these two plates, Galloway found that the two curves of discharge coefficient as a function of Re_D were coincident over a range of Re_D from 800 to 30,000. Below 800, however, two separate curves were observed, with consistent differences in discharge coefficient between the two plates of 2-3%. The pertinent part of Galloway's data, obtained from his Ph.D. thesis, is recorded in Fig. 3. Galloway concluded that the two curves resulted from the geometric dissimilarity of these two orifice plates.

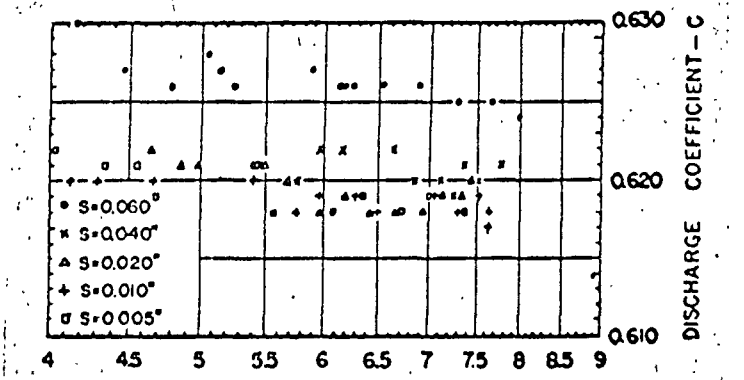
The present investigation was conceived as an attempt to extend the general usefulness of standard orifice plates to Re_D of 100, and to gain



C vs. RN for plates with beta ratio of 0.2



C vs. RN for plates with beta ratio of 0.5



C vs. RN for plates with beta ratio of 0.7

Figure 2: CALIBRATION RESULTS - THRASHER AND BINDER (16)
1 - inch pipe
For Reynold's read Reynolds

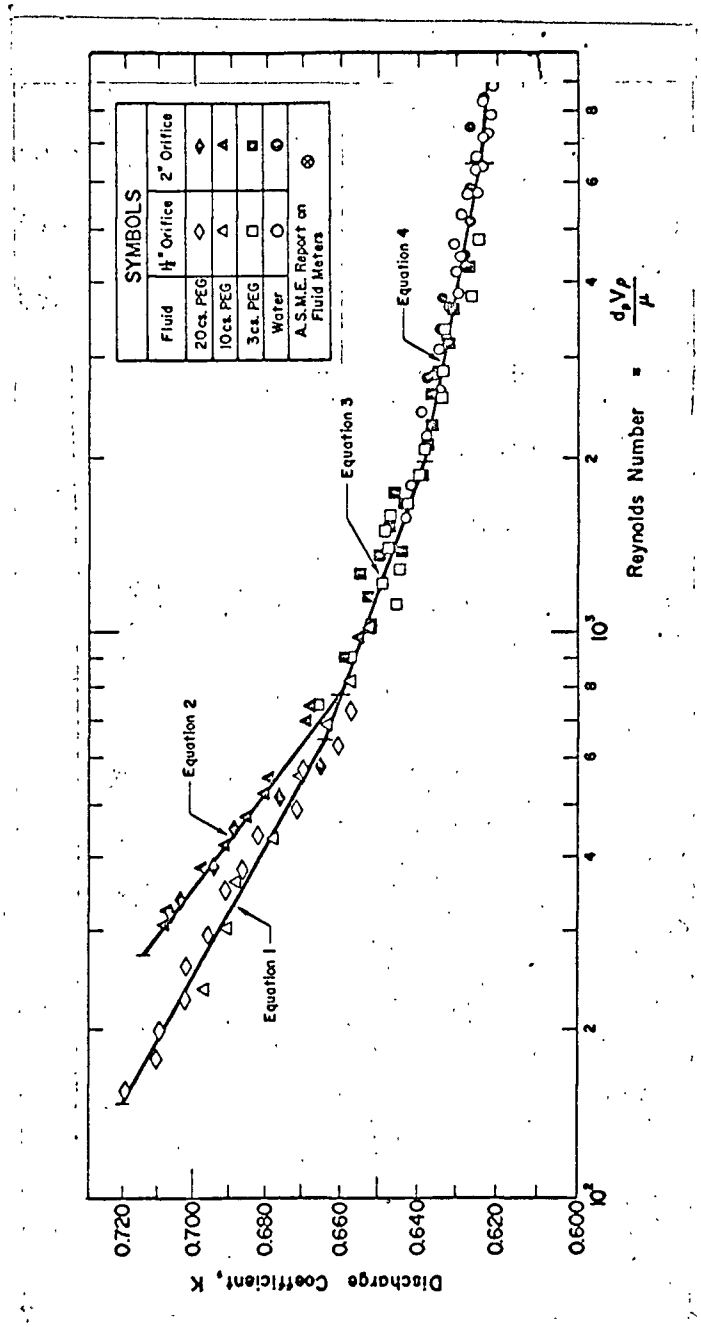


Figure 3: CALIBRATION RESULTS - GALLOWAY (14)
1.5 and 2 - inch pipe

some understanding of the effect of geometry on the coefficient of discharge at low Reynolds numbers. This was accomplished by designing and calibrating standard A.S.M.E. orifice plates and observing the effect on the discharge coefficient due to geometry differences. These differences could then be eliminated between orifice plates if they were built with exacting geometrical similarity.

EXPERIMENTAL

I Apparatus See Fig. 4

a) General

The purpose of the experimental apparatus was to circulate water or a solution of polyethylene-glycol and water (known hereafter as PEG), at a constant hydrostatic head, and constant temperature, through a test section. The solution was then returned to a supply tank for recycle.

The apparatus consists essentially of three flow loops connected in parallel. Loop 1 includes the primary centrifugal pump and the heat exchanger. A globe valve, situated at position 11 in Fig. 4, controls to a major degree the pump discharge pressure, which in turn, controls the rate at which fluid is pumped into the constant head tank. Loop 2 returns overflow fluid from the constant head tank to the main supply tank by means of a small gear pump and an overflow tank. Loop 3 supplies fluid to the test section and the weighing station (see Fig. 4), flow being controlled by valve 21. At the completion of a run, fluid collected in the weighing tank is pumped to the main supply tank.

b) Pumps

A Peerless, Model B centrifugal pump supplied the primary motive power for the flow loops. Its design capacity was 150 U.S. gallons per minute against a 70 foot head. It was run by a 7 1/2 H.P. 3-phase constant speed A.C. electric motor.

A second centrifugal pump, Lemco Model FL 1 1/4, emptied the weighing tank after each experimental run. It was driven by a 1/2 H.P. single phase A.C. electric motor.

A small gear pump, a Worthington Model 11F165B, emptied the overflow tank. This pump, which was powered by a 1/4 H.P. single phase A.C. electric

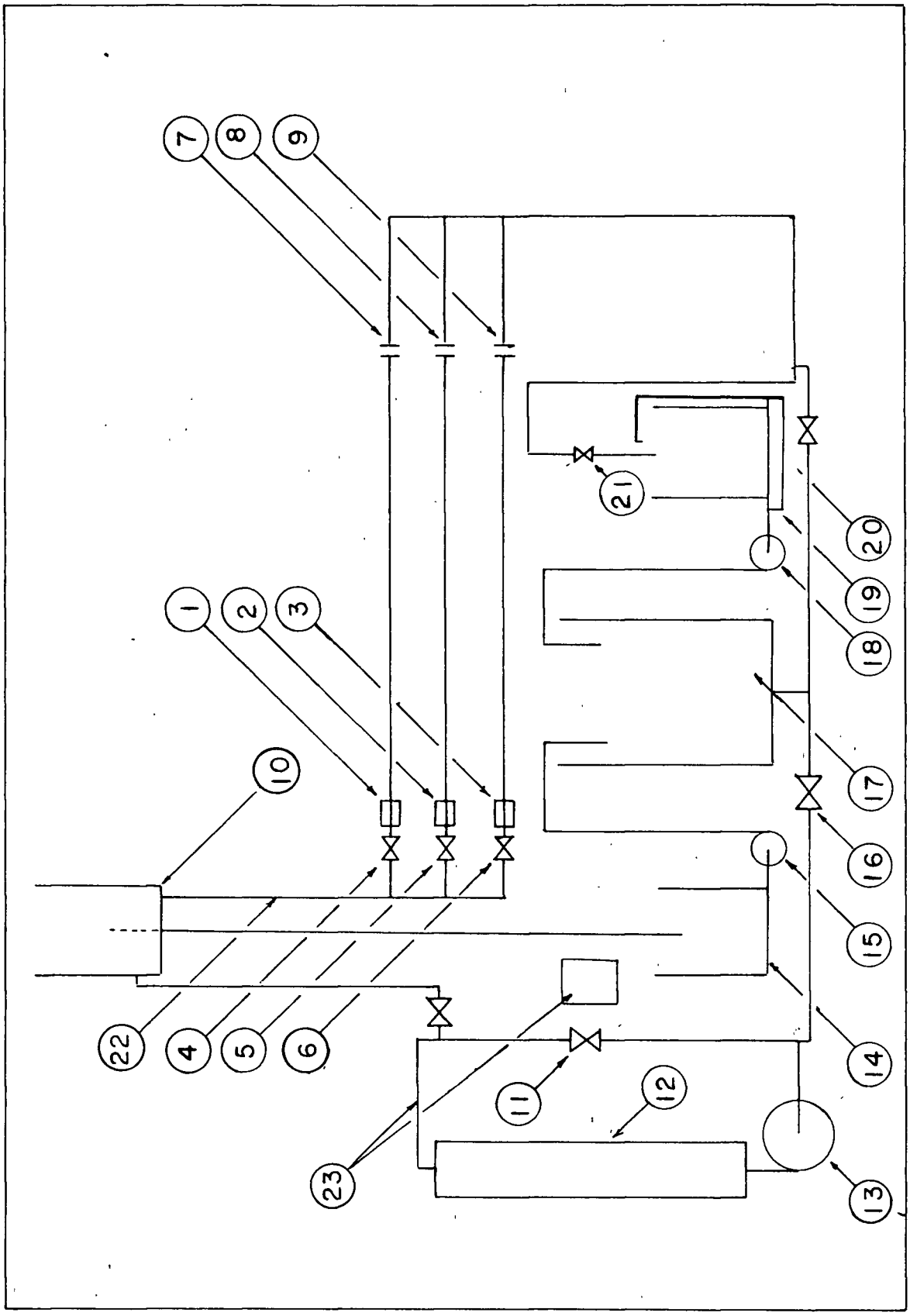


FIGURE 4: SCHEMATIC DRAWING OF APPARATUS

Key to Figure 4.

(1) Multi-plate flow straightener 1 - inch line

(2) Multi-plate flow straightener 2 - inch line

(3) Multi-plate flow straightener 1.5 - inch line

(4) Control valve 1 - inch line

(5) Control valve 2 - inch line

(6) Control valve 1.5 - inch line

(7) Orifice assembly 1 - inch line

(8) Orifice assembly 2 - inch line

(9) Orifice assembly 1.5 inch line

(10) Constant head tank

(11) Control valve in heat exchanger loop

(12) Heat exchanger

(13) Primary pump

(14) Overflow tank

(15) Secondary pump to empty overflow tank

(16) Check valve

(17) Supply tank - 100 Imperial gallons

(18) Secondary pump to empty weighing tank

(19) Beam balance scales

(20) Weighing tank

(21) Control valve

(22) Thermocouple 5

(23) Thermocouple 4 on the heat exchanger loop and thermocouple 6 on the control board

motor, ran continuously.

c) Heat Exchanger

Temperature control was provided by circulating cooling water through a single-pass shell-and-tube heat exchanger mounted above the primary pump outlet.

d) Tankage.

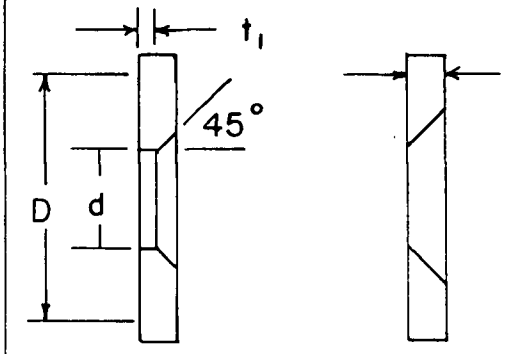
A 100 Imperial gallon glass-lined supply tank, a 50 U.S. gallon aluminum constant head tank, a 50 U.S. gallon aluminum overflow tank and a 50 U.S. gallon steel weighing barrel were used in the experimental apparatus. The steel barrel was tygon-coated inside prior to use, to ensure a non-corrodable surface. The other tanks were chemically inert to the experimental fluid.

e) Piping

Both 2-inch and 3-inch nominal diameter Type L copper water pipe was used throughout the main flow loops of the apparatus. The test section, which will be described in greater detail subsequently, contained 1 - inch, 1 1/2 - inch and 2 - inch Type L copper water pipe. All joints were soldered. A glass window, installed by a previous worker (14), ensured that no undesirable entrained air passed through the test section during a run. Venting was allowed for at the top of the heat exchanger loop, and in each orifice flange in the test section.

f) Design of Orifice Plates

Seventeen orifice plates were designed and built to carry out the experimental program. Design criteria for the Standard, Sharp and Special plates can be found in "Fluid Meters" (1), and in "Flow Measurement, Power Test Code" (2). This information is summarized in Fig. 5 along with design information for the geometrically similar (abbreviated G.S.) orifice meter series and the slit width, t_s, for the corner pressure taps. Specific

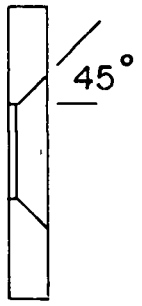


a

A·S·M·E·— FLUID METERS

$t_2 \leq D/30, (D-d)/8, d/8$

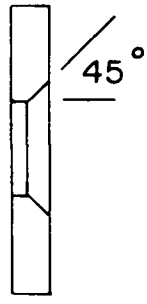
If $t_2 > D/30, (D-d)/8, d/8$,
Downstream Edge Is Bevelled
At A 45° Angle Until
$t_1 \leq D/30, (D-d)/8, d/8$



b SPECIAL

A·S·M·E·— POWER TEST CODE

For $D \leq 3"$
$0.01D \leq t_1 \leq 0.02D$
$t_2 = 3/32" \pm 1/32"$

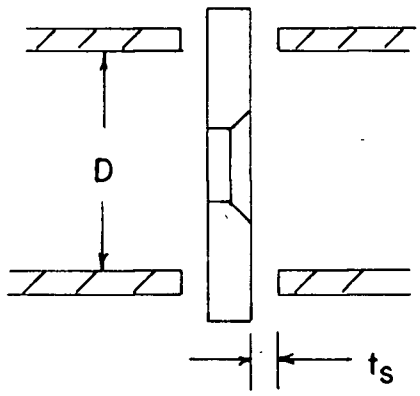


c G·S·

GEOMETRICALLY SIMILAR

$t_2 = 1/16\ D$

$t_1 = 1/32D$



d

CORNER PRESSURE TAPS

$t_s = 0.02\ D$

FIGURE 5: SUMMARY OF ORIFICE PLATE DESIGN CRITERIA

dimensions for each orifice plate are contained in Tables 1 and 2.

Six plates, three each of the "Standard" and "Sharp" types, were constructed of 1/8 - inch brass plate. They were designed with reference to (1), the more important geometric specifications of which are contained in Fig. 5 (a).

Two further plates, Special 15 and Special 30 were designed with reference to (2). 1/8 - inch brass plate was again used; Fig. 5 (b) specifies their geometry.

The final nine plates, the "G.S." series, were machined from 2 3/4 inch brass bar stock. Design criteria were based on the requirements of reference 1 and geometric similarity, as illustrated by Fig. 5 (c).

Pressure drop was measured in the orifice flange by corner taps. A schematic drawing of their design is shown in Fig. 5(d).

TABLE 1
DIMENSIONS OF G. S. ORIFICE SERIES AND ASSOCIATED EQUIPMENT

Orifice Type	G. S. Beta = 0.2			G. S. Beta = 0.4			G. S. Beta = 0.6		
Inside diameter of pipe D, in.	1.0232	1.0232	1.0232	1.5058	1.5058	1.5058	1.9851	1.9851	1.9851
Orifice diameter d, in.	0.2032	0.4079	0.6134	0.3012	0.6027	0.9011	0.3969	0.7944	1.1912
Beta d/D	0.198	0.399	0.599	0.200	0.399	0.598	0.200	0.400	0.600
Orifice throat length t_1, in.	0.0339	0.0300	0.0339	0.0472	0.0439	0.0471	0.0586	0.0595	0.0602
Design throat length (1/32)D in.	0.0320	0.0320	0.0320	0.0471	0.0471	0.0471	0.0620	0.0670	0.0620
Ratio t_1/D	0.0342	0.0293	0.0331	0.0314	0.0292	0.0339	0.0295	0.0299	0.0303
Orifice plate thickness t_2, in	0.0644	0.0644	0.0644	0.0932	0.0933	0.0939	0.1257	0.1253	0.1272
Design plate thickness (1/16)D in.	0.0640	0.0640	0.0640	0.0941	0.0941	0.0941	0.1240	0.1240	0.1240
Ratio t_2/D	0.0630	0.0630	0.0630	0.0619	0.0619	0.0619	0.0624	0.0633	0.0640
Width of slit, t_s, in.	0.02045	0.02045	0.02045	0.0301	0.0301	0.0301	0.0397	0.0397	0.0397
Design width of slit 0.02D in.	0.0204	0.0204	0.0204	0.0301	0.0301	0.0301	0.0397	0.0397	0.0397
Ratio t_s/D	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
Entrance length, L_1, in.	85.13	85.13	85.13	88.56	88.56	88.56	39.87	89.87	89.87
Ratio L_1/D	83.2	83.2	83.2	58.8	58.8	58.8	45.3	45.3	45.3
Exit length, L_2, in.	39.56	39.56	39.56	48.75	48.75	48.75	48.75	48.75	48.75
Ratio L_2/D	32.96	32.96	32.96	31.6	31.6	31.6	29.6	24.6	24.6

TABLE 2

DIMENSIONS OF STANDARD, SHARP AND SPECIAL ORIFICE SERIES AND ASSOCIATED EQUIPMENT

Orifice Type	Standard Beta = 0.4			Sharp Beta = 0.4			Special Beta=0.4	
Inside diameter of pipe D, in.	1.0232	1.5058	1.9851	1.0232	1.5058	1.9851	1.5058	1.5058
Orifice diameter d, in.	0.409	0.616	0.795	0.411	0.613	0.793	0.605	0.603
Beta d/D	0.400	0.403	0.400	0.401	0.407	0.402	0.402	0.401
Orifice throat length t_1, in.	0.0268	0.0481	0.0587	0.0	0.0	0.0	0.0166	0.0299
Ratio t_1/D	0.0262	0.0320	0.0296	0.0	0.0	0.0	0.0110	0.0230
Recommended Maximum, in.	0.0342	0.0502	0.0662	0.0	0.0	0.0	------	0.0301
Recommended Minimum, in.	-----	-----	----	----	----	----	0.0151	----
Orifice plate thickness t_2, in.	0.121	0.125	0.124	0.124	0.120	0.127	0.1240	0.122
Design plate thickness, in.	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Ratio t_2/D	0.119	0.0795	0.0619	0.121	0.0798	0.0645	0.0823	0.0810
Width of slit t_s, in.	0.0204	0.0301	0.0397	0.0204	0.0301	0.0397	0.0301	0.0301
Design width of slit, in. 0.02D in.	0.0204	0.0301	0.0397	0.0204	0.0301	0.0397	0.0301	0.0301
Ratio t_s/D	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Entrance length, L_1, in.	88.56	88.56	88.56	88.56	88.56	88.56	88.56	88.56
Ratio L_1/D	58.8	58.8	58.8	58.8	58.8	58.8	58.8	58.8
Exit Length, L_2, in	48.75	48.75	48.75	48.75	48.75	48.75	48.75	48.75
Ratio L_2/D	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6

g) Test Section See Fig. 6

The test section consists of three parallel horizontal test lines made from 1 - inch, 1 1/2 - inch and 2 - inch copper water pipe. Each of the test lines contained the following components:

(1) Globe valve

(2) Multi-plate flow straightener

(3) Calming section

(4) Orifice flange assembly

(5) Exit section

(6) Thermocouple well

In working out the design for the test section, there was some question as to the positioning of the multiplate flow straighteners. Sprenkle (7) recommended installing them approximately eight pipe diameters upstream of the orifice plates for turbulent flow. Galloway (14) concluded that his discharge coefficient calibration curves had the least scatter at 8 1/2 diameters upstream. Unfortunately, due to technical difficulties, it was virtually impossible to build the flow straighteners geometrically similar to each other. Hence, there was no guarantee that the velocity profiles produced at the orifice plates would be identical for different sized pipes. Therefore, it was decided to install the flow straighteners immediately following the globe valves in each line. It was reasoned that the flow profiles would then, in all probability, be fully developed in traversing the calming section.

Empirically, the situation is as follows: For laminar flow, assuming a flat velocity profile at the entrance, the following equation (8, 13) predicts the approximate length of straight pipe required to produce a fully developed velocity profile

$$X_t/D = 0.05\ Re_D \qquad (1)$$

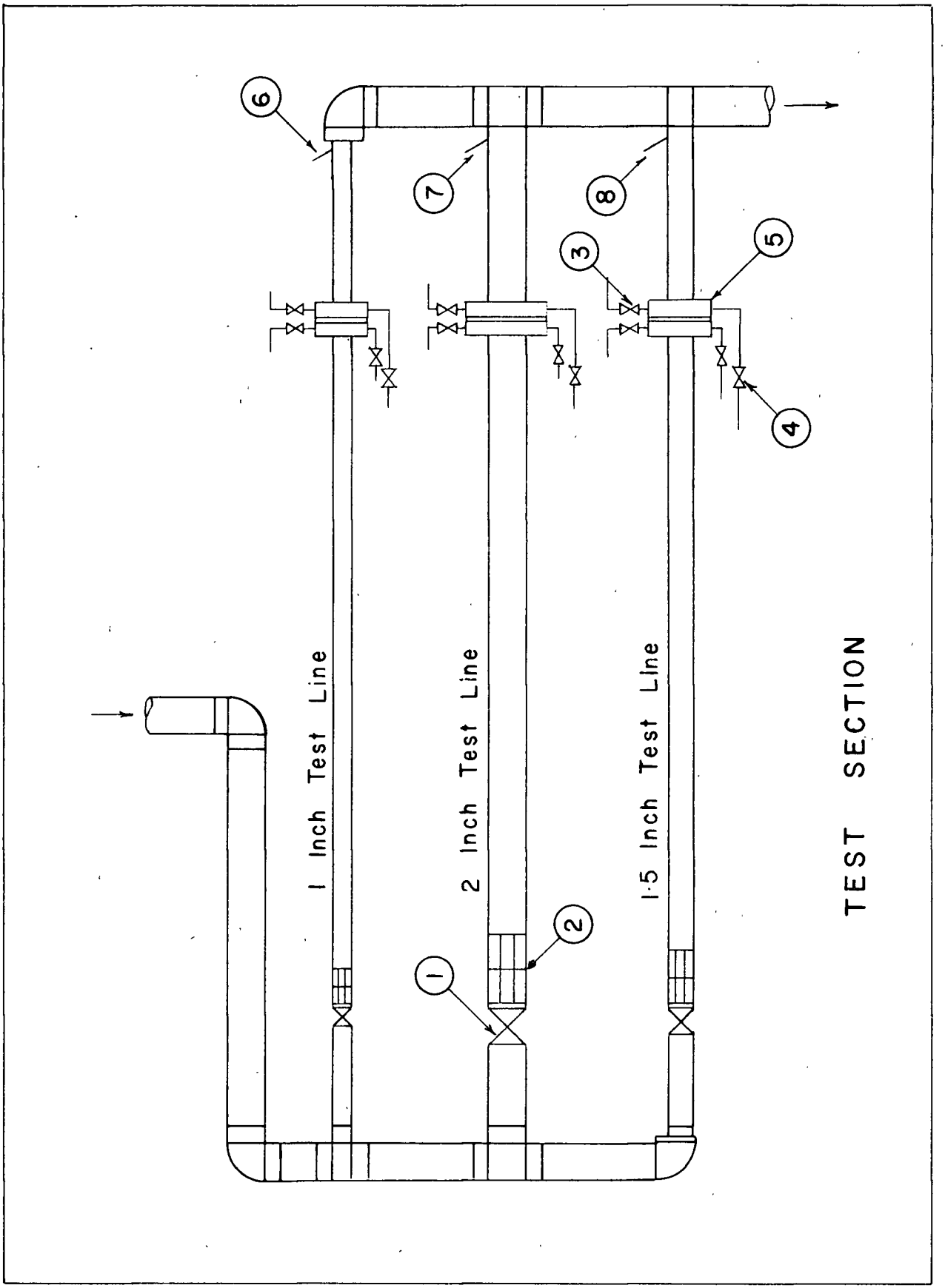


FIGURE 6: SCHEMATIC DRAWING OF THE TEST SECTION

Key to Figure 6.

(1) Control valve.

(2) Multi-plate flow straightener.

(3) Orifice flange vents.

(4) Pressure line to manometers.

(5) Orifice assembly.

(6) Thermocouple for 1 - inch line.

(7) Thermocouple for 2 - inch line.

(8) Thermocouple for 1 1/2 - inch line.

In turbulent flow, an entrance length of from 40 to 50 pipe diameters is considered sufficient to produce a fully developed turbulent velocity profile (3). A comparison of the theoretical requirements with the actual entrance lengths is supplied in Table 3.

TABLE 3

Comparison of Actual and Theoretically Maximum Entry Lengths for Laminar and Turbulent Flows

Nominal Pipe Size in.	$\frac{X}{D}$ Actual	$\frac{X}{D}$ eq. 1 $Re_D = 2100$	$\frac{X}{D}$ turbulent $Re_D > 2100$
1 "	83.2	105	40 - 50
1.5 "	58.8	105	40 - 50
2 "	45.3	105	40 - 50

Obviously, for Reynolds numbers greater than 2100, assuming turbulent flow, there is sufficient entrance length available. However, for Reynolds numbers close to but less than 2100, not even the one - inch pipe provides sufficient entrance length for a complete profile development.

According to Sprenkle (7), however, the multi-plate flow straightener produces a well rounded velocity profile immediately downstream. It is therefore reasonable to assume that this rounded rather than flat starting profile should radically shorten the entrance length necessary for a fully developed velocity profile.

A minimum of 25 pipe diameters was recommended by the A.S.M.E. report on Fluid Meters (2), for the exit section. All three flow lines satisfied this requirement.

Working drawings of the multi-plate flow straightener and the orifice flange assembly for the 1 - inch test line may be found respectively in Figs. 7 and 8. Drawings for the 1.5 and 2 - inch test lines are contained in reference (14).

h) Pressure Measurement

Differential pressures were measured using one or more of four U-tube manometers. A description of each follows in Table 4.

TABLE 4

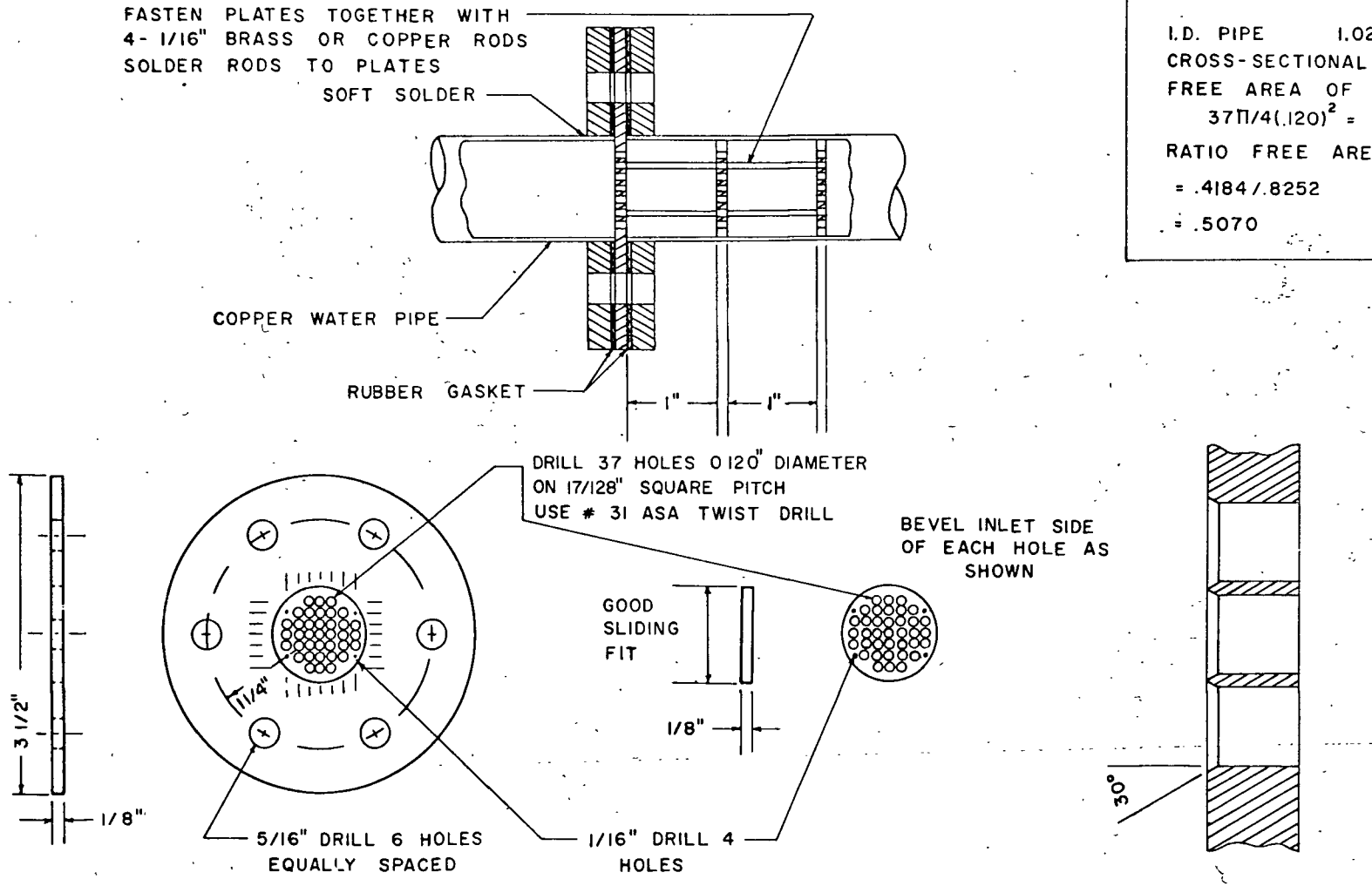
DESCRIPTION OF THE MANOMETERS

No.	Type	Liquid	Length
1	U-tube upright	Mercury	75 cm.
2	U-tube inverted	Air	150 cm.
3	U-tube upright	$C\,Cl_4$	52 cm.
4	U-tube inverted	C_6H_6	150 cm.

The manometers were connected to the orifice flanges by 3/8 - inch O.D. copper tubing. Pressure head differences were measured by means of a cathetometer to 0.005 inches for the first 130 runs. For the remaining runs, differential heads were measured to 0.05 cm. without special viewing equipment.

i) Temperature Measurement - See Fig. 4 and Fig. 5.

Temperature was measured using six copper-constantan thermocouples and three research quality thermometers. The six thermocouples and thermometer #1 were calibrated against Platinum Resistance Thermometer #169314. The other two thermometers were calibrated using thermometer #1 as a standard. A Leeds and Northrup # 8662 Portable Precision Potentiometer, with external Standard Weston Cell # 116644, was used to



LOCATING PLATE

SCALE:- FULL, MATERIAL BRASS

1 REQUIRED

PLATE

SCALE:- FULL, MATERIAL BRASS

2 REQUIRED

SECTION THROUGH

HOLE

SCALE:- NONE

FIGURE 7: 1" MULTIPLATE FLOW STRAIGHTENER ASSEMBLY

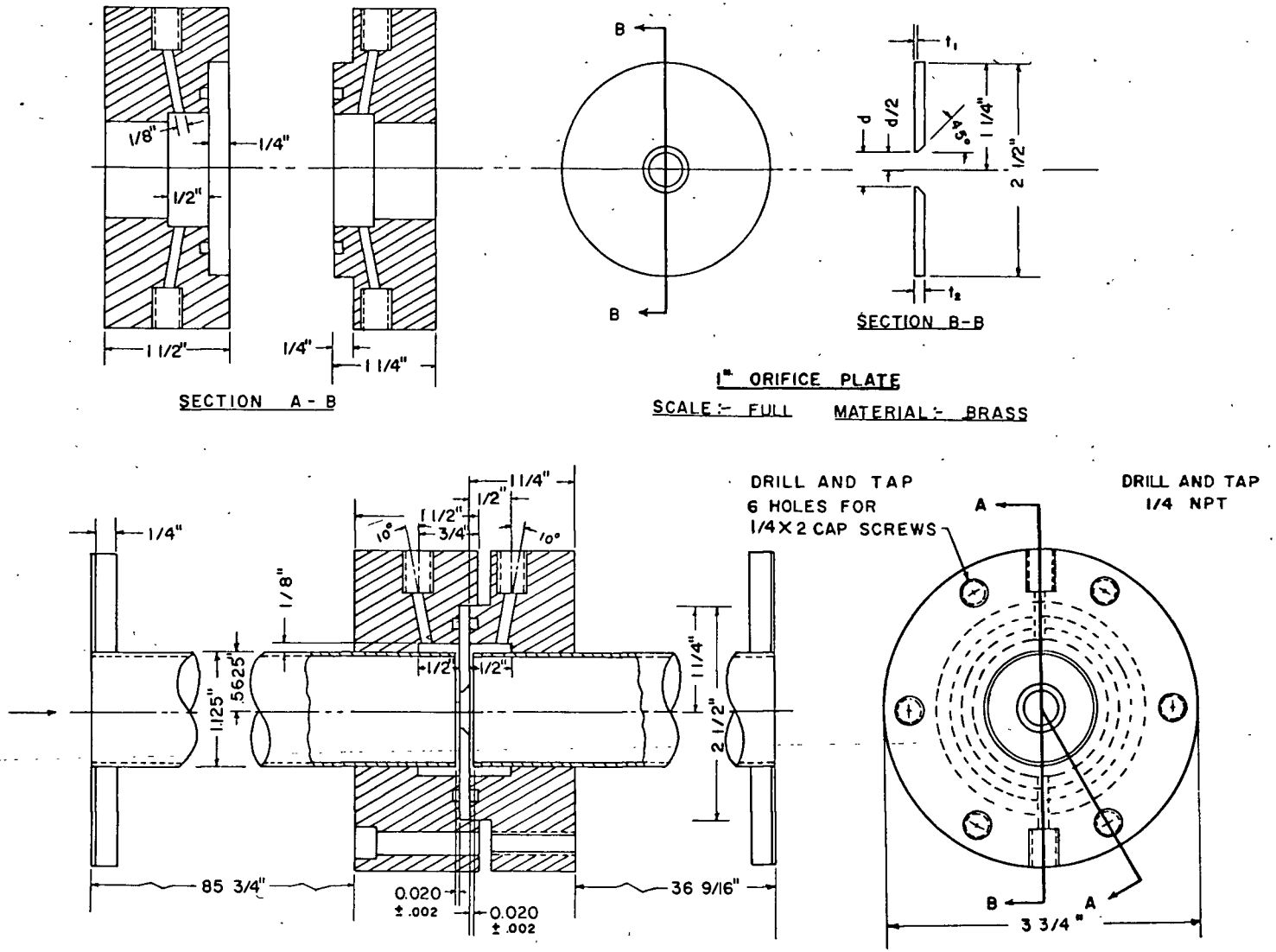


FIGURE 8: 1" ORIFICE ASSEMBLY

SCALE :- FULL MATERIAL :- BRASS

1 REQUIRED

measure thermocouple E.M.F. This was the same equipment used originally to calibrate the temperature measuring equipment.

Thermocouples 1, 2 and 3 indicated fluid temperatures at the orifice meters. Thermocouples 4 and 5 measured, respectively, the heat exchanger loop and the upstream header temperatures.

Thermocouple # 6 and thermometer # 1 measured the temperature at the control board. The remaining thermometers, # 2 and # 3, were used respectively in the density and viscosity measurements of the fluid samples removed during a run.

Temperature control was maintained in the flow loop by two methods. One method was to compare the E.M.F. of thermocouple 6 with the E.M.F. of one of thermocouples 1, 2 or 3, depending on which test line was being used, on a Scalamp galvanometer. Temperature could be maintained within 0.5°F. using this method, as long as room temperature fluctuations remained small.

However, due to large temperature variations during some days in the summer, the above method could not always be used. In this case, the cooling water rate was set at a reasonable level and the fluid temperature was allowed to vary slowly with room temperature. This method also gave good results, as the temperature change for any one run was always small. A non-weighted average of from 3 to 7 E.M.F. readings over a run was accepted as the correct temperature measurement by both methods.

j) Weighing.

A platform scale, with a capacity of 500 pounds, was used for all the calibration runs. This scale was last calibrated by Galloway (14) in 1963, and found to be accurate to ± 2 oz. over its entire range.

II Viscosity and Density Measurements

The first 130 runs were carried out using tap water as the test fluid. Densities and viscosities were obtained from reference (18), assuming the physical properties of tap water were very nearly those of distilled water. For the remaining runs, one-litre samples of the test fluid were removed from the experimental apparatus at the beginning and at the end of each day's experimental runs. Approximately 150 ml. was set aside for viscosity measurements. The remainder was used in the density determination.

a) Viscosity

The kinematic viscosity measurements of the samples were carried out by means of two Cannon - Fenske precision viscometers, C-8 and C-3. Normally, four duplicate readings were taken for each sample over a temperature range of 70 - 80°F.

To obtain the viscosity of the fluid for a specific experimental run, the following procedure was adhered to.

(1) The viscosity was plotted as a function of temperature for each of the two samples on arithmetic graph paper.

(2) Two lines which appeared to best fit the data were drawn through the two sets of points.

(3) This graph was entered with the average temperature recorded at the orifice for the specified run and the run number.

(4) A double interpolation was used to obtain the correct viscosity based on the run number and the average temperature.

b) Density

A Cenco #16752-C precision hydrometer was used to measure the density of the PEG solution. Its accuracy was checked against a Westphal Balance and found to be correct within 0.3%. The density measurements were taken and plotted in the same manner as described previously for viscosity.

However, fluid density at the orifice (ρ_o) and in the manometer (ρ_{bo}) were obtained in slightly different ways. Density in the flow loop gradually increased during the day due to water evaporation. Hence (ρ_o) was obtained by interpolation. However, evaporation was not possible in the manometers. Therefore the densities of the test fluid in the manometer were obtained using only the morning sample. The manometers were flushed out and refilled each working day.

It should be noted that in the given open system, concentration of the experimental solution was always taking place due to the evaporation of water. Thus, both the viscosity and density of the circulating test fluid increased during a day's runs. Spot checks indicated the increase to be not more than 0.7% for viscosity and 0.1% for the density.

III Experimental Procedure See Fig. 4.

The following procedure was carried out on start-up. The supply tank was initially filled with approximately 100 Imperial gallons of either water or PEG. This automatically primed the Peerless pump. All vents and valves in the test section were opened. After switching on the primary pump, valve 21 was fully opened and valve 11 was partially closed. The heat exchanger was adjusted as described previously. Test fluid was pumped into the constant head tank, and flowed out through both the test section and the overflow line into the weighing tank and overflow tank, respectively. These tanks were emptied as required into the supply tank. Usually, one-half hour was required to remove most of the entrained air from the system. This was considered to be almost complete when air was no longer in evidence upon venting the test section. The primary pump was then shut down and any remaining air allowed to coalesce for approximately 15 - 30 minutes. The pump was then started again and the lines once more vented. Usually,

a small additional amount of air bubbled from the test section vents. The system was then deemed ready for an experimental run.

The steps taken to complete an experimental run were as follows.

(1) Valve 11 was adjusted to supply adequate liquid to maintain a constant hydraulic head during the experimental run.

(2) The test section was checked to ensure that liquid was flowing through the correct test line.

(3) Flow into the weighing tank was adjusted by valve 21.

(4) The platform scale was set somewhat in excess of the tare weight, and a stopwatch was activated when the lever arm passed through the zero point. The same procedure was used at the end of a run.

(5) The manometers, thermocouples and thermometer were read as often as practicable during a run.

(6) The weighing tank contents were returned to the supply tank at the completion of a run.

Derivation of the Orifice Plate Meter Equation

Assumption ρ = constant

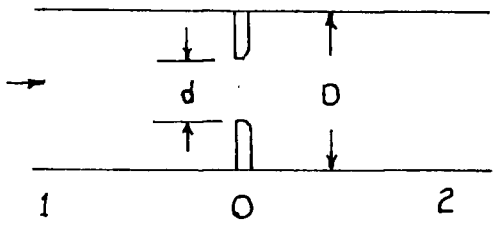


Fig. 9 Schematic Drawing of an Orifice Plate for the Meter Equation Derivation

Mechanical Energy Balance for Steady State:

$$\frac{\bar{U}_1^2}{2\alpha_1 gc} + \frac{P1}{\rho'} = \frac{\bar{U}_2^2}{2\alpha_2 gc} + \frac{P2}{\rho'} + lwf \text{ , } \frac{lbf - ft}{lb.m} \qquad (2)$$

Re-arranging equation 2,

$$\frac{\bar{U}_2^2}{2\alpha_2 gc} - \frac{\bar{U}_1^2}{2\alpha_1 gc} = \frac{P_1 - P_2}{\rho'} - lwf \qquad (3)$$

Let

$$Cv^2 \left(\frac{P_1 - P_2}{\rho'} \right) = \frac{P_1 - P_2}{\rho'} - lwf \qquad (4)$$

Now

$$\beta = \frac{d}{D} \qquad (5)$$

$$\beta^2 = \frac{\frac{\pi d^2}{4}}{\frac{\pi D^2}{4}} = \frac{A_0}{A1} \qquad (6)$$

$$C_c = \frac{A2}{A_o} \quad \text{by definition} \tag{7}$$

From equation 6,

$$\bar{U}_o^2 = \frac{1}{\beta^4} \bar{U}_1^2 \tag{8}$$

and from equation 7,

$$\bar{U}_2^2 = \frac{\bar{U}_o^2}{C_c^2} \tag{9}$$

Combining equations 3, 4, 8 and 9,

$$\bar{U}_o = \frac{C_v}{\left[\frac{1}{C_c^2 \alpha_2} - \frac{\beta^4}{\alpha_1}\right]^{1/2}} \sqrt{2g_c \frac{(P_1 - P_2)}{\rho'}} \tag{10}$$

α_1 and α_2 are functions of Reynolds number the effects of which are included in C_v', a modified coefficient of velocity.

Then

$$\bar{U}_o = \frac{C_v'}{\left[\frac{1}{C_c^2} - \beta^4\right]^{\frac{1}{2}}} \sqrt{2g_c \frac{(P_1 - P_2)}{\rho'}} \tag{11}$$

Now, by re-arranging equation 11,

$$\bar{U}_o = \frac{C_v' C_c}{\left[1 - C_c^2 \beta^4\right]^{\frac{1}{2}}} \sqrt{2g_c \frac{(P_1 - P_2)}{\rho'}} \tag{12}$$

or

$$U_o = \frac{C_v' C_c \sqrt{1-\beta^4}}{\sqrt{1-C_c^2\beta^4}} \sqrt{\frac{2g_c (P_1-P_2)/\rho'}{1-\beta^4}} \quad (13)$$

That is,

$$U_o = \frac{C}{\sqrt{1-\beta^4}} \sqrt{2g_c \frac{(P_1-P_2)}{\rho'}} \quad (14)$$

where

$$C = C_v' C_c \sqrt{1-\beta^4} \Big/ \sqrt{1-C_c^2\beta^4} \quad (15)$$

Now

$$W = U_o A_o \rho' = \frac{A_o C}{\sqrt{1-\beta^4}} \sqrt{2g_c \rho' (P_1-P_2)} \quad (16)$$

Define

$$K = C/\sqrt{1-\beta^4} \quad (17)$$

Then

$$W = K A_o \sqrt{2g_c \rho' (P_1-P_2)} \quad (18)$$

Equations 16 and 18 are the same as equations 98 and 99 respectively in Fluid Meters (1).

To obtain working equations the following substitutions were made. For a two-liquid vertical manometer, $P_1 - P_2$ is the pressure drop across the orifice plate in lb F/ ft.^{2}

Then

$$P_1 - P_2 = \frac{144 \times (2.54)^2}{453.59} \quad H\,(|\rho_{bo} - \rho_c|)$$

or

$$P_1 - P_2 = 2.04818 \quad H(|\rho_{bo} - \rho_c|) \qquad (19)$$

where

H = difference in levels of the orifice manometer, cm.

A_o = cross-sectional area of orifice, ft.^{2}

$$= \frac{\pi}{4}\left(\frac{d}{12}\right)^2$$

$$= 0.005452\ d^2 \quad , \quad \text{ft.}^2$$

d = diameter of orifice, inches

K = discharge coefficient, velocity of approach factor included, dimensionless

W = mass flow rate, lb M/sec.

D = diameter of test line, inches

ρ' = density of fluid at orifice, lb M/ft.^{3}

$$= \frac{(2.54)^3}{453.59} \times 1728\ \rho_o$$

$$= 62.4287\ \rho_o$$

ρ_o = density of fluid at orifice, gm./cm.^{3}

ρ_c = density of manometer fluid, gm./cm.^{3}

ρ_{bo} = density of test fluid in manometer, gm./cm.^{3}

C = discharge coefficient, velocity of approach factor not included, dimensionless.

The substitution of the above conversions into equation (19) gives

$$W = K A_o \sqrt{2\,(32.1740)\,(62.4287\,\rho_o)\,(2.04818\,H\,(|\rho_{bo} - \rho_c|)} \qquad (20)$$

Re-arranging equation 20,

$$K = \frac{183.346\ W}{d^2\ \sqrt{8227.8708\ H\,\rho_o\,(|\rho_{bo} - \rho_c|)}} \qquad (21)$$

and from equation 17,

$$C = K\ \sqrt{1 - \beta^4} \qquad (22)$$

The Reynolds number based in pipe diameter is given by,

$$Re_D = \frac{4\,W}{\pi\ D\ U_o} \qquad (23)$$

where U_o = absolute viscosity

ν_o = kinematic viscosity, centistokes

The working equation, based on the experimental units, then becomes

$$Re_D = \frac{4\,W}{\pi}\ \frac{12}{D}\ \frac{1488.16}{\nu_o\,\rho_o}$$

or

$$Re_D = 22{,}737\ \frac{W}{D\,\nu_o\,\rho_o} \qquad (24)$$

The corresponding orifice Reynolds number is

$$Re_d = 22{,}737\ \frac{W}{d\,\nu_o\,\rho_o} \qquad (25)$$

All calculations for C, K, Re_D and Re_d were carried out in an I.B.M. 7040 electronic computer.

RESULTS AND DISCUSSION

Discharge coefficients, both with and without the velocity of approach factor included, and Reynolds number based on both pipe and orifice diameter, were calculated for each run by an I.B.M. 7040 Computer and may be found in Appendix II. The original data, which were used in the above calculations, may be found in Appendix III. Discharge coefficient K was plotted as a function of Reynolds number, Re_D. The results in this form, were easily compared with standard A.S.M.E. orifice plate calibration data available in references (1) and (2), as well as with Galloway's (14) data.

Figures 10, 11 and 12 compare discharge coefficient calibration curves for the minimum and approximately maximum values of t_1 allowed by the A.S.M.E. - Fluid Meters (1) orifice plate design, for each of the three pipe diameters studied. It is obvious that a difference in calibration curves of from 2 to 6% exists between each of the two plates at a given pipe diameter, Re_D between 100 and 1000.

The calibration curves of the three Sharp and the three Standard orifice plates are compared in Fig. 13. The curves for the three Sharp plates are nearly co-incident. Since these three plates are also very nearly geometrically similar, except for the t_2/D ratio, one can conclude that the effect of the t_2/D ratio on the calibration curves is small. On the other hand, the Standard plates are dissimilar in both the t_1/D and t_2/D ratios. Since the spread of the three Standard calibration curves is about the same as the spread for the Sharp plates, it appears that the t_1/D ratio does not affect the discharge coefficient to a significantly larger degree than does the t_2/D ratio. However, scrutiny of Table 2 indicates a correlation between the t_1/D ratio and the three Standard calibration curves. For instance, considering the three Standard orifice

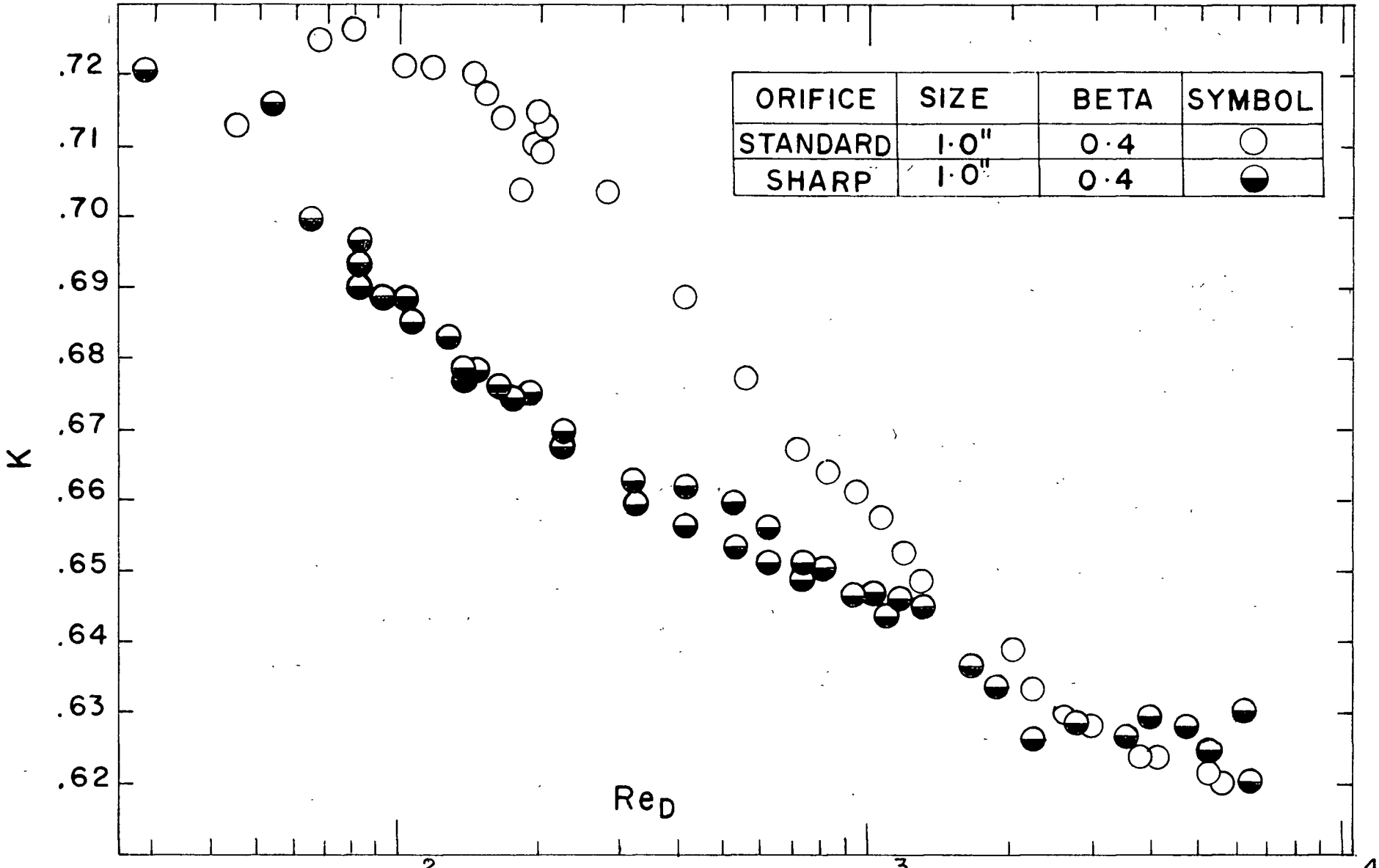


FIGURE 10: CALIBRATION RESULTS - STANDARD AND SHARP ORIFICE PLATES 1-INCH TEST LINE

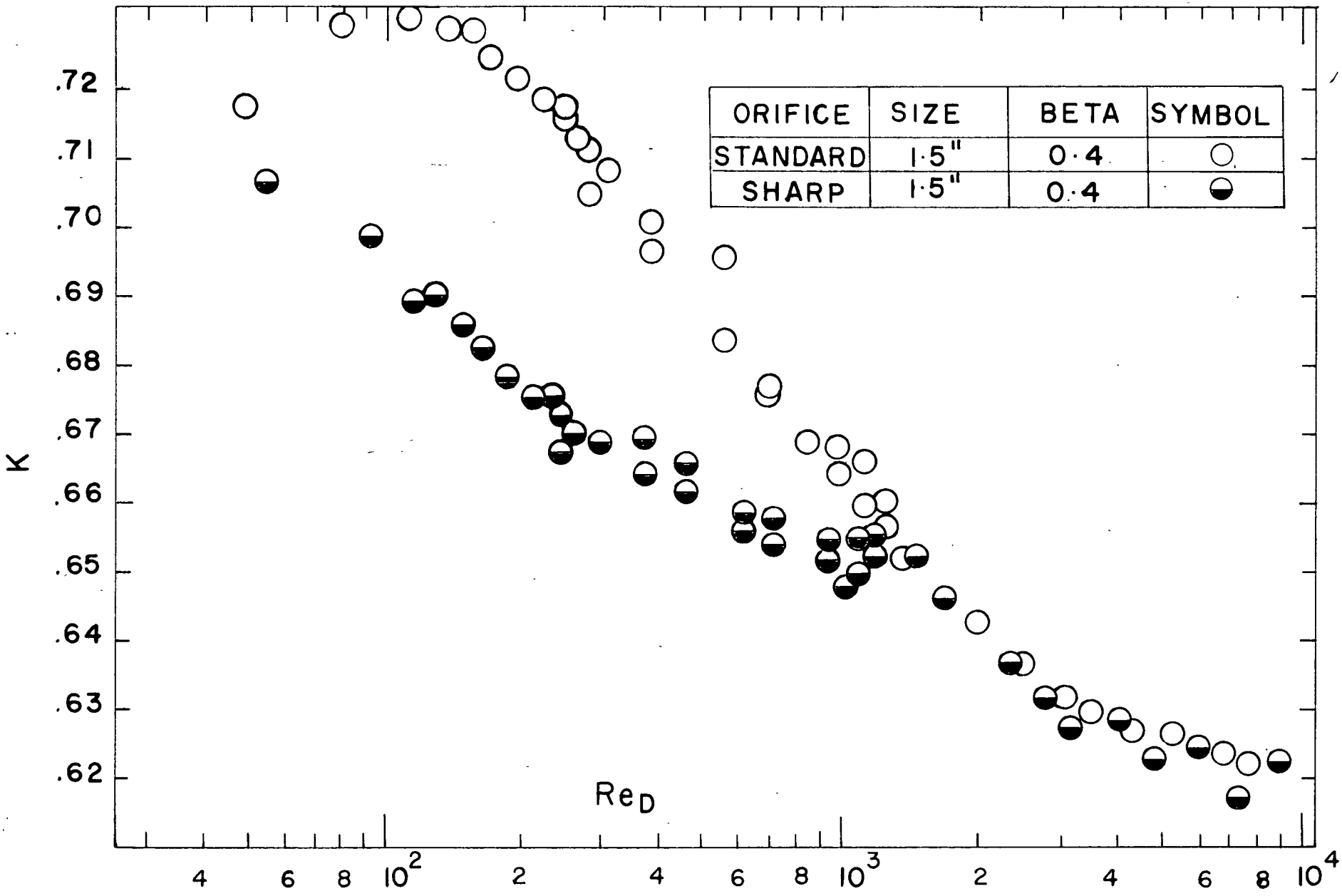


FIGURE 11 - CALIBRATION RESULTS - STANDARD AND SHARP ORIFICE PLATES 1.5 INCH TEST LINE

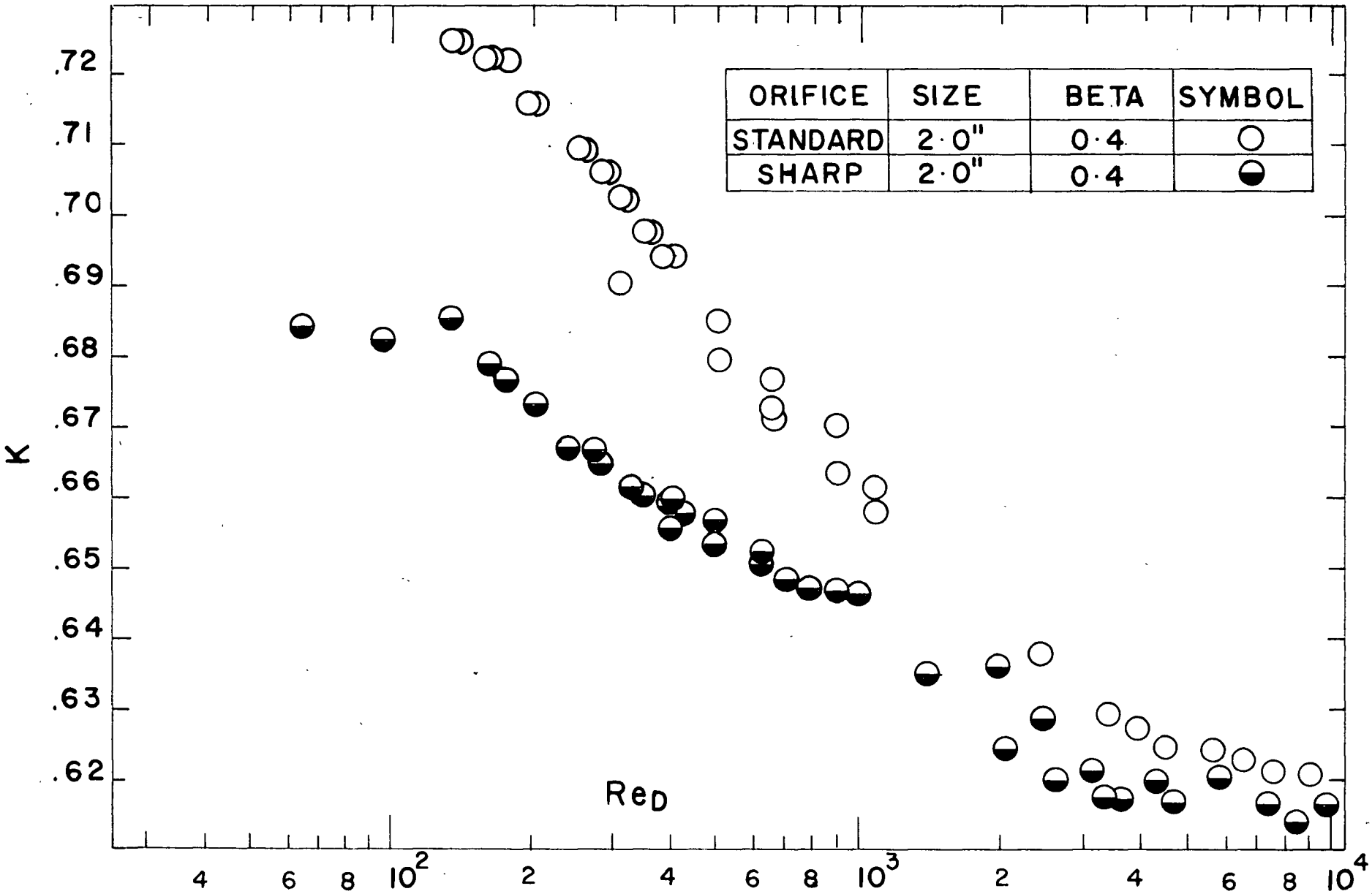


FIGURE 12: CALIBRATION RESULTS - STANDARD AND SHARP ORIFICE PLATES - 2.0 INCH TEST LINE

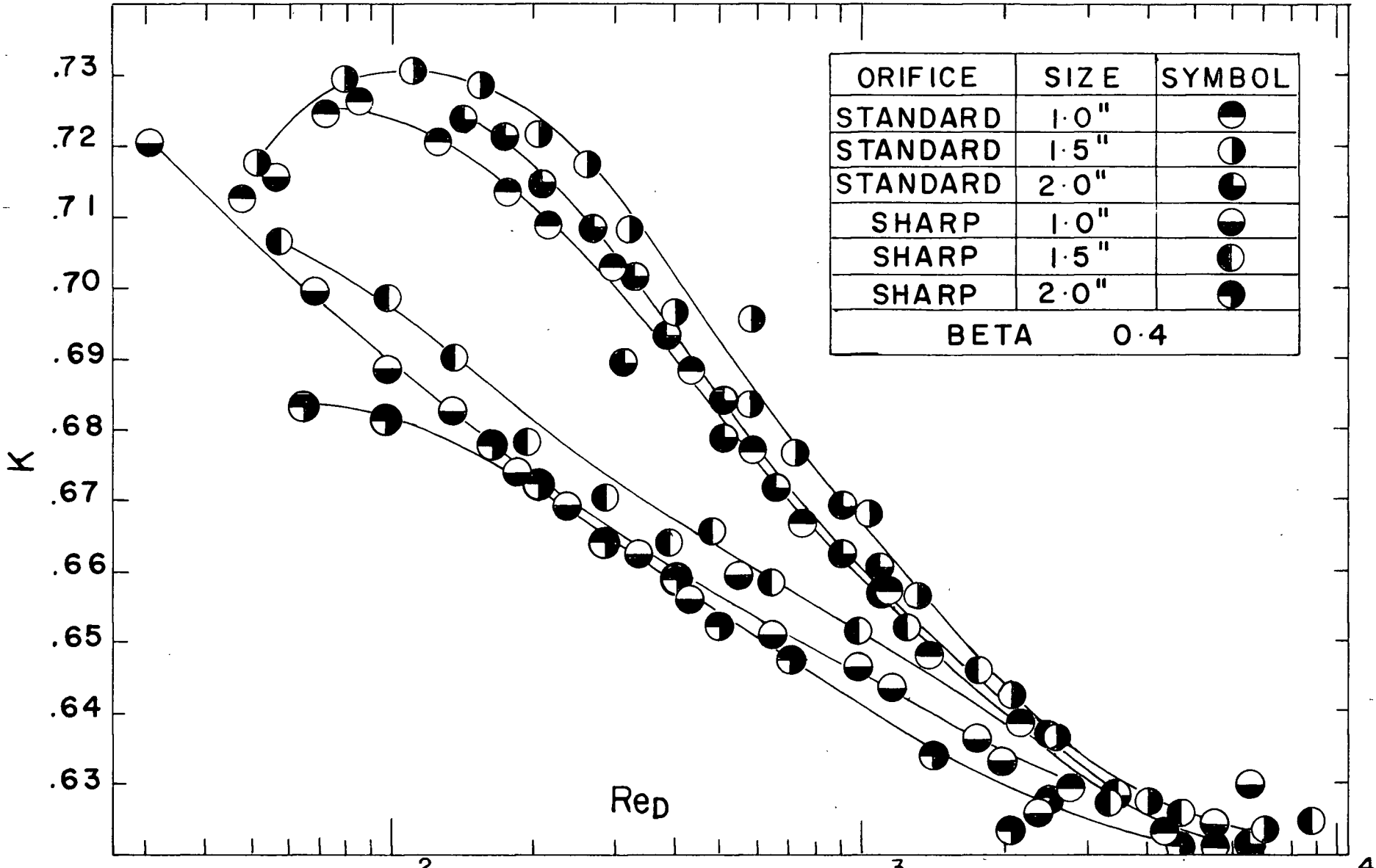


FIGURE 13: CALIBRATION RESULTS - STANDARD AND SHARP ORIFICE PLATES 1.0, 1.5 AND 2.0 INCH TEST LINES

plates, the highest calibration curve in terms of K was obtained in the 1.5 - inch test line. This corresponded to the highest t_1/D ratio of the three Standard plates. The 2 - inch and 1 - inch test lines gave corresponding results. There was no similar pattern for the t_2/D ratio. Therefore, there does in fact appear to be an effect of t_1/D regardless of the effect of t_2/D.

The results plotted on Fig. 14 represent calibration curves based on design recommendations of the A.S.M.E. - Power Test Code (2). Special 15 and Special 30, the two orifice plates involved, have respectively the minimum and maximum values of t_1 recommended in (2). Both plates were built for the 1.5 - inch test line only. It is interesting that even under the more rigorous specifications of reference (2) for t_1, geometry effects on the discharge coefficient, although smaller than those between the sharp and standard plates, are still observable.

Figures 15, 16 and 17 contain the calibration curves of the nine plates designated G.S. The G.S. series includes diameter ratios of 0.2, 0.4 and 0.6. The three plates included in each diameter ratio were geometrically similar. Figures 15 and 16, with Betas of 0.2 and 0.4 respectively, yielded single curves. Fig. 17, however, with a Beta of 0.6, had a much larger data spread. Since experimentally, accurate data were difficult to gather for the $\beta = 0.6$ plates due to the small clocking time for the fixed throughput of fluid required to fill the weigh tank, and the relatively small manometer differentials, a larger spread in the data was to be expected.

A comparison of some of the results of this study for the 1.5 - inch pipe with data from Galloway's calibration curves, and with standard A.S.M.E. calibration data, is recorded in Fig. 18. For Re_D between 100

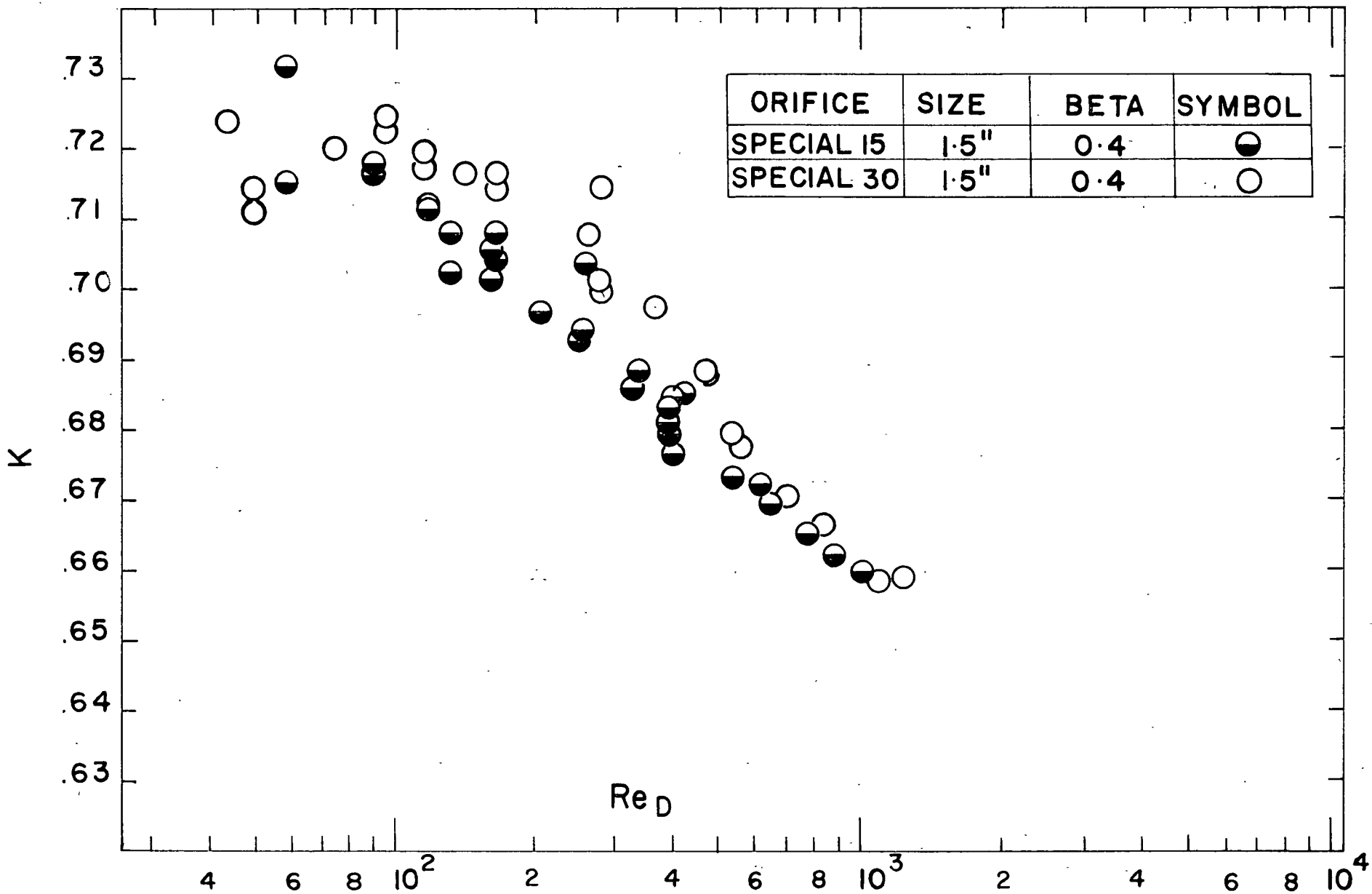


FIGURE 14: CALIBRATION RESULTS - SPECIAL 15 AND SPECIAL 30 ORIFICE PLATES

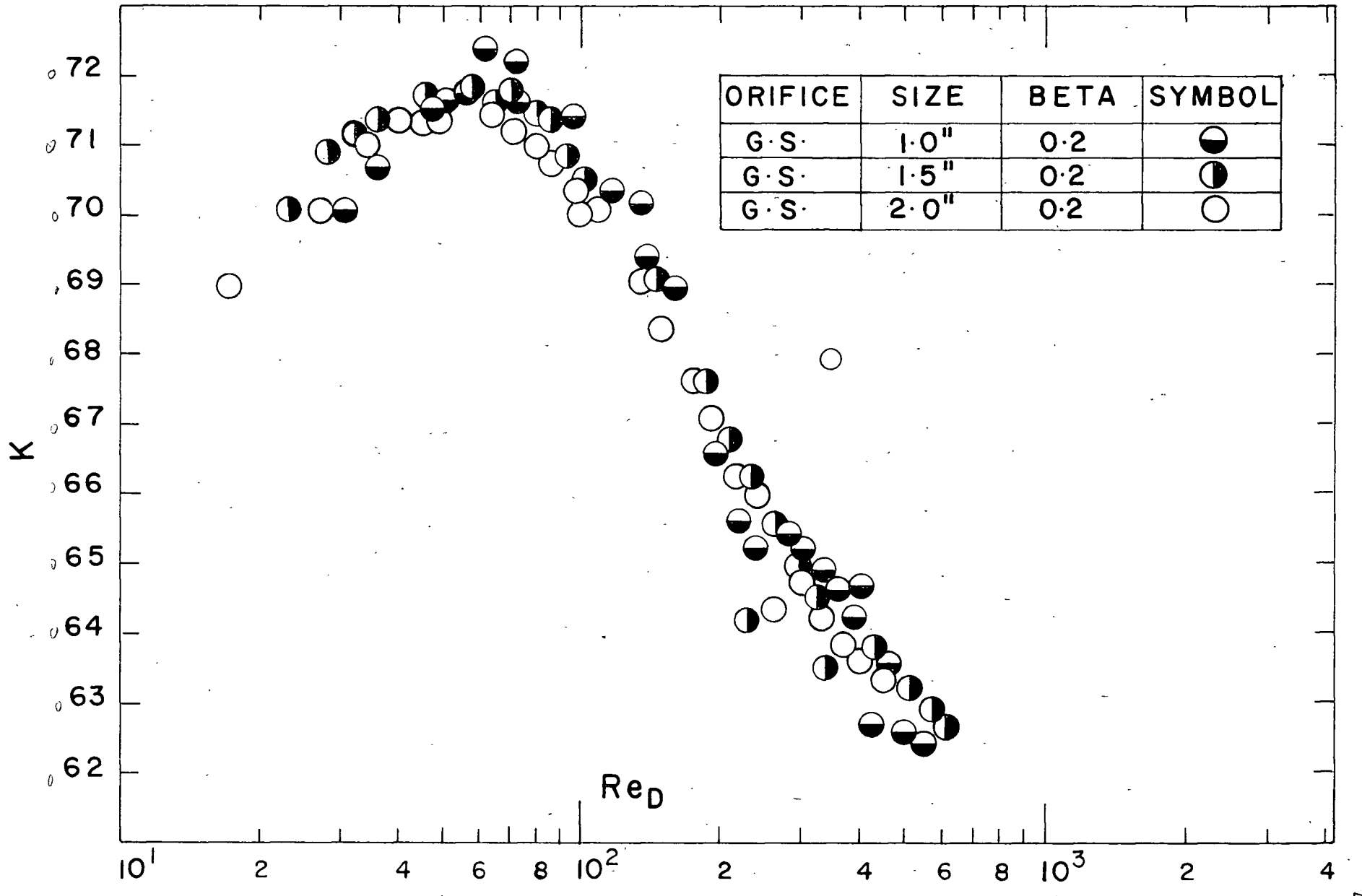


FIGURE 15: CALIBRATION RESULTS - G.S., BETA = 0.2, 1.0, 1.5 AND 2.0 INCH TEST LINES

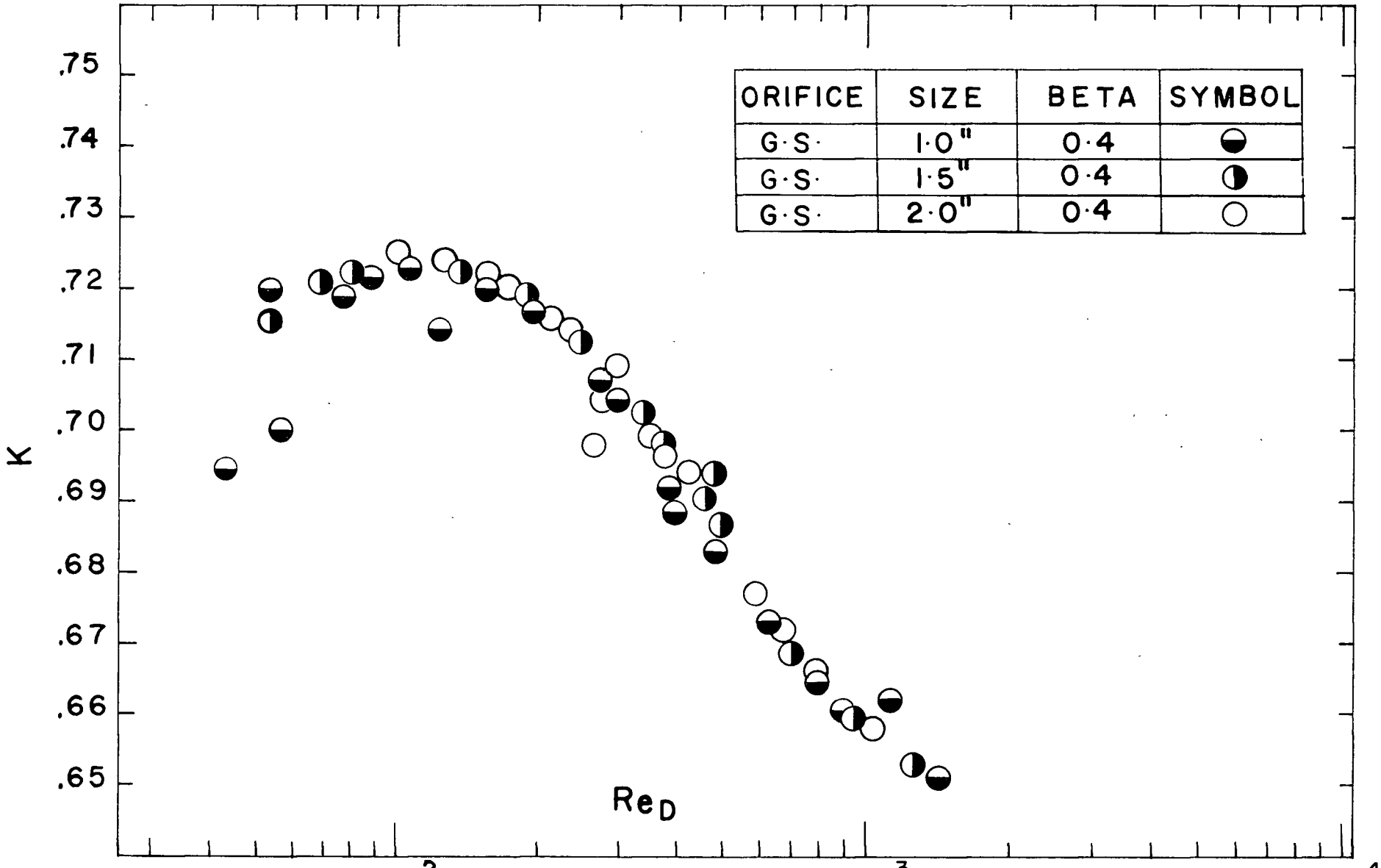


FIGURE 16: CALIBRATION RESULTS - G.S., BETA = 0.4, 1.0, 1.5 AND 2.0 INCH TEST LINES

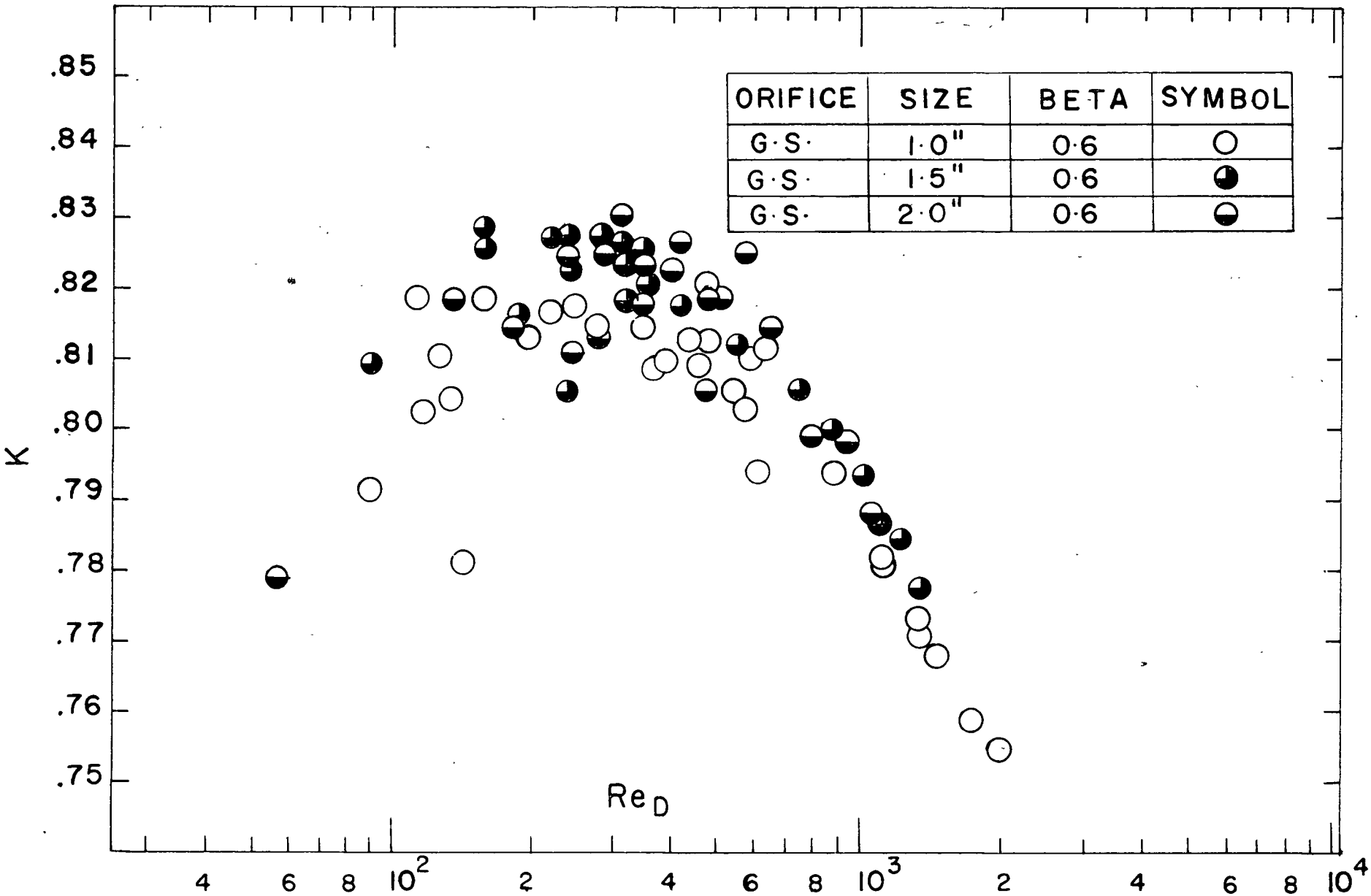


FIGURE 17: CALIBRATION RESULTS - G.S., BETA = 0.6, 1.0, 1.5 AND 2.0 INCH TEST LINES

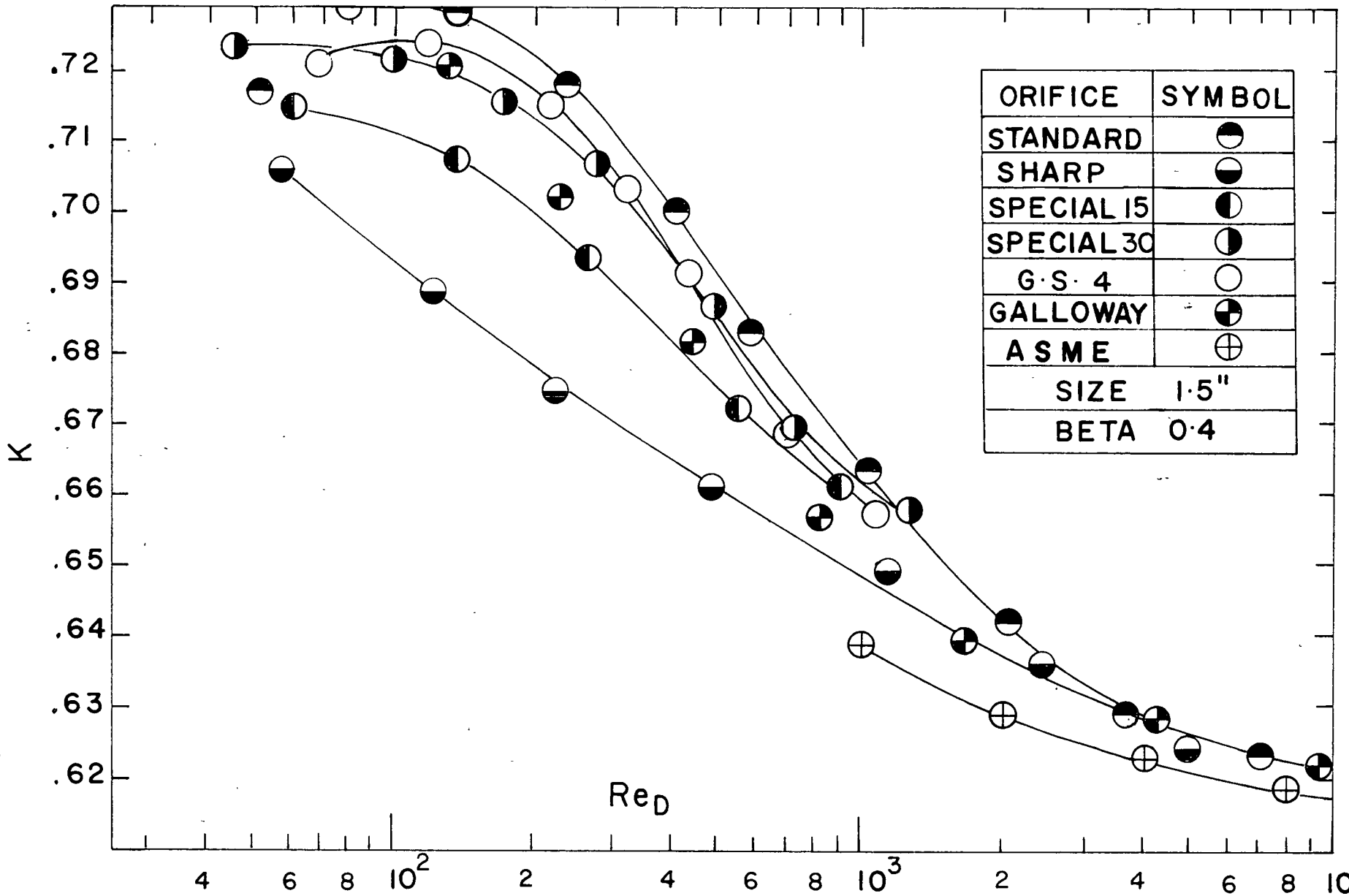


FIGURE 18: CALIBRATION RESULTS - STANDARD, SHARP, G.S., GALLOWAY AND A.S.M.E.

and 1,000, all data fall between the Sharp and Standard calibration curves. Between Re_D of 1,000 and 10,000, the same generalization applies with two exceptions. Firstly, the curves which were separate and distinct at a Reynolds number of 1,000, gradually merged by Reynolds number of 10,000. Secondly, the A.S.M.E. standard calibration data curve plotted lower than the Sharp plate calibration curve between Re_D of 1,000 and 10,000. This difference appears to increase slightly at lower Reynolds numbers, and might indicate a slight unreliability of the standard A.S.M.E. discharge coefficients over this range. The apparent unreliability of the standard A.S.M.E. data may be connected with the shape of the orifice plates used in the original study by Marchetti (15), who built his plates with a 30° bevel rather than a 45° bevel as was used in this study. Both bevel angles are acceptable under A.S.M.E. standards (2). Considering the effect of other small geometry changes observed from the discharge coefficient data in the low Reynolds number region, it seems possible that the 15° difference in the angle of downstream bevel could cause the discharge coefficients given in reference (1) for corner taps to be lower than those found in both this study and Galloway's work.

A.S.M.E. design criteria allow a range of orifice plate thickness of 1/16 - 1/8 inch and an orifice throat length, depending on the reference used, of either (i) t_1 between 0.01D and 0.02D (2) or (ii) t_1 less than

$$\begin{matrix} 1/30\ D \\ 1/8\ \ d \\ 1/8\ (D-d) \end{matrix} \qquad (1)$$

for inside pipe diameter up to 3 inches. Similar design criteria are available for pipe sizes greater than 3 inches. It is the implication of the design codes that variation of geometry within the limits specified should have no discernible effect on the discharge coefficient. Results presented here have shown this implication to be

untenable, in general, for pipe Reynolds numbers less than 10,000.

Thrasher (16) and Galloway (14) have shown the effect of orifice geometry on calibration curves. Both suggested that more specific orifice plate criteria were needed.

The G.S. series was designed to stay within the A.S.M.E. - Fluid Meters (1) design standards within the over-riding criterion of geometric similarity. The aim was to arrive at design criteria for orifice plates which could be used with confidence and without calibration as low as Re_D of 100. The results indicate that this is possible for plates designed similar to the G.S. series with the use of corner taps. That is, for plates designed using the same geometrical shape as the G.S. series, Beta will be the only parameter.

The preceding results indicate a strong effect of orifice geometry, primarily orifice throat length, on the coefficient of discharge for pipe Reynolds numbers from 100 to 10,000. Orifice throat length can also be discussed with reference to other workers in the field. Iversen (6) plotted Johansen's (9) Sharp type and Tuve and Sprenkle's (5) Standard type orifice plate results, along with others, for comparative purposes. Careful scrutiny of the curves indicates that Johansen's plates have slightly lower discharge coefficients for the same Reynolds number and Beta. Thrasher (16) too observed a trend of increased discharge coefficient with throat length, as was observed also in the present study. A more extreme comparison was carried out by Grace and Lapple (17), whose calibrations of Sharp and Thick Standard ($t_1 = d$) plates further confirmed that discharge coefficient increased with throat length.

Further light is thrown on the present results by considering the "Standard Short Tube" discussed in Perry (4). For a Short Tube running full, the discharge coefficient is about 0.82. However, when a short tube

is running free, the value of the coefficient is about 0.62. The liquid in a tube "running free" separates at the upstream sharp edge and does not touch the walls. A tube running full, on the other hand, has little or no separation upstream, and the whole vessel is filled with fluid. Since there is less contraction with a "full" tube, the coefficient of discharge is larger. Comparison of the data from the Sharp and Standard series shows a similar increase of discharge coefficient. The Sharp plates tend to act like standard short tubes "running free", whereas the Standard and Special plates act like tubes "running full".

An explanation for this behaviour arises from speculation as to the exact point at which flow separation takes place. For a sharp plate, separation can only occur at the knife edge. However, for the Standard and Special plates, separation is possible at both the upstream and downstream ends of the orifice throat. It seems plausible that at low Reynolds numbers, separation would occur at the downstream edge, while higher Reynolds numbers would shift the point of separation to the upstream edge due to the increased fluid inertia. Hence, at the downstream pressure tap for a Sharp plate, contraction will be equal to or greater than that allowed by a Standard or Special plate. Therefore discharge coefficients for Sharp plates should be less than (low Re_D), or at the most equal to (high Re_D) those obtained for orifice plates with finite throat length. The actual results conformed to this pattern.

NOMENCLATURE

A = constant in resistance thermometer equation, $(^{o}C.)^{-1}$

Ao = orifice cross-sectional area, $ft.^2$

Al = upstream pipe inside cross-sectional area

A_2 = downstream pipe inside cross-sectional area

Ap = pipe inside cross-sectional area, $in.^2$

B = constant in resistance thermometer equation, $(^{o}C.)^{-2}$

Beta = ratio, d/D dimensionless

C = coefficient of discharge, velocity of approach term $\sqrt{\frac{1}{1-\beta^4}}$ not included, dimensionless

C_c = coefficient of contraction, dimensionless

C_v = coefficient of velocity, dimensionless

C_v' = coefficient of velocity including the effect of α_1, and α_2 dimensionless

d = orifice diameter, in.

D = pipe inside diameter, in.

g = local acceleration due to gravity, $ft./sec.^2$

g_c = gravitational constant, $(lb_M)\ (ft.)/(lb_F)\ (sec.)^2$

H = pressure drop across the orifice, cm. of liquid

I.D. = inside diameter, in. or ft.

K = discharge coefficient, velocity of approach factor included

l_{wf} = internal frictional dissipation $(lb._F\text{-}ft.)/lb$

L_1 = length of unobstructed pipe upstream of the orifice, in.

L_2 = length of unobstructed pipe downstream of the orifice, in.

P_1 = pressure sensed by upstream pressure tap, $lb._F/ft.^2$

P_2 = pressure sensed by downstream pressure tap, $lb._F/ft.^2$

$\frac{P_1 - P_2}{\rho'}$ = pressure drop across orifice $\frac{\text{lb.F-ft.}}{\text{lb.M}}$

PEG = solution of polyethylene glycol (E9000) and water

Re = Reynolds number for flow through circular passage

= $4w/\pi\mu_f$(diameter), dimensionless

RE_d or Re_d = Reynolds number based on orifice diameter and fluid conditions at the orifice

RED or Re_D = Reynolds numbers based on pipe I.D. and fluid conditions at the orifice

R_o = resistance of the platinum resistance thermometer at 0°C., ohms

R_t = resistance of the platinum resistance thermometer at t°C., ohms

ti = time, secs.

t_1 = orifice throat length, in.

t_2 = orifice plate thickness, in.

t_3 = width of pressure measuring slit, in.

T = temperature, °F. or °C.

T_{cs1} = temperature of thermocouple 1

T_{cs2} = temperature of thermocouple 2 - referred to the resistance thermometer

T_{cs3} = temperature of thermocouple 3 - referred to the resistance thermometer

T_{cs4} = temperature of thermocouple 4 - referred to the resistance thermometer

T_{cs5} = temperature of thermocouple 5 - referred to the resistance thermometer

T_{ms1} = temperature of thermometer 1 - referred to the resistance thermometer

T_{ms2} = temperature of thermometer 2 - referred to the resistance thermometer

T_{ms3} = temperature of thermometer 3 - referred to the resistance thermometer

T_{m1} = temperature read by thermometer 1

T_{m2} = temperature read by thermometer 2

T_{m3} = temperature read by thermometer 3

$\bar{U}_1$ = bulk average upstream velocity, ft./sec.

$\bar{U}_2$ = bulk average downstream velocity, ft./sec.

$\bar{U}_o$ = bulk average velocity at the orifice, ft./sec.

W = mass flow rate, lb. /sec.

W_s = weight of working fluid, lb.

X = actual upstream length of unobstructed pipe in test section, in.

X_t = length of unobstructed pipe in test section, in. predicted by equation 1

U_1 = absolute viscosity, $(lb_M)/(ft.)$ (sec.)

U_o = absolute viscosity of fluid at the orifice,

Greek Symbols

ρ' = density, $lb_M/ft.^3$

U or ν_o = kinematic viscosity of fluid at orifice, C.S.

FC or ρ_c = density of manometer fluid, $gm./cm.^3$

PBO or ρ_{bo} = density of test fluid in manometer legs, $gm./cm.^3$

PO or ρ_o = density of test fluid at orifice, $gm./cm.^3$

β = ratio, d/D dimensionless

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APPENDIX 1 - RESULTS

A Sample Calculation

Since an electronic computer was used for all computations, a sample calculation will be presented to indicate the method used. Tables 1 - 11 inclusive contain the results in tabular form.

RUN 321

W_s = 230 lb.

t_i = 636.4 sec.

ρ_o = 1.03576 gm./c.c.

ρ_{bo} = 1.03551 gm./c.c.

ρ_c = 1.586874 gm./c.c.

H = 13.96 cm.

ν_o = 22.11 cm^2/sec.

W = W_s/t_i

d = 0.60267 in.

D = 1.5058 in.

Coefficient of Discharge - refer to equations 21 and 22

$$K = \frac{183.346 \times W}{d^2 \sqrt{8227.8708 \times H \times \rho_o \times |\rho_{bo} - \rho_c|}} \qquad (26)$$

$$= \frac{183.346 \times 230/636.4}{(.60267)^2 \sqrt{8227.8708 \times 13.9 \times 1.03576 \times \left(\left|\frac{1.03551}{1.586874} - \right|\right)}}$$

$$= 0.71036$$

$$C = K\sqrt{1 - \left(\frac{0.60267}{1.5058}\right)^4} \qquad (27)$$

$$= 0.70118$$

Reynolds number - refer to equations 24 and 25

$$Re_D = \frac{22,737\ W}{D\ V_o\ \rho} \qquad (28)$$

$$= \frac{22,737 \times 230/636.4}{1.5058 \times 22.11 \times 1.03576}$$

$$= 238.2953$$

$$Re_d = \frac{22,737 \times 230/636.4}{.60267 \times 22.11 \times 1.03576} \qquad (29)$$

$$= 595.3925$$

TABLE 1-1

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE 1.0 INCH STANDARD				
105	0.62046	0.61248	17870.59	7144.39
106	0.61958	0.61162	16409.13	6560.13
107	0.61971	0.61174	14850.35	5936.95
108	0.62146	0.61347	13740.34	5493.18
109	0.62171	0.61372	12921.98	5166.01
110	0.62131	0.61332	11862.65	4742.51
111	0.62372	0.61570	10812.85	4322.81
112	0.62371	0.61569	9914.63	3963.72
113	0.62670	0.61865	8857.76	3541.20
114	0.62821	0.62014	7835.85	3132.65
115	0.63007	0.62197	6823.55	2727.95
116	0.63374	0.62560	5906.14	2361.19
117	0.63906	0.63085	5448.68	2178.30
118	0.67911	0.67038	5108.94	2042.48
131	0.70911	0.70000	532.89	213.04
132	0.70995	0.70082	513.61	205.33
133	0.71067	0.70154	514.20	205.57
134	0.70357	0.69453	479.84	191.83
135	0.71381	0.70463	442.44	176.88
136	0.71717	0.70795	401.55	160.53
137	0.71985	0.71060	378.13	151.17
138	0.72087	0.71161	310.93	124.31
139	0.72116	0.71189	273.98	109.53
140	0.72645	0.71711	211.55	84.58
141	0.72472	0.71540	179.71	71.85
142	0.71284	0.70367	117.74	47.07
143	0.67352	0.66486	60.49	24.18
505	0.71440	0.70521	523.31	209.21
506	0.70952	0.70040	523.31	209.21
506	0.71245	0.70329	544.41	217.65
506	0.70525	0.69618	544.41	217.65
507	0.70330	0.69426	735.46	294.03

TABLE 1-1 (CONTINUED)

RUN NO.	K	C	REd	RED
507	0.69969	0.69070	735.46	294.03
508	0.68854	0.67969	1069.75	427.67
508	0.69546	0.68652	1069.75	427.67
509	0.67706	0.66836	1457.30	582.60
509	0.68214	0.67337	1457.30	582.60
510	0.66744	0.65886	1868.09	746.83
510	0.67159	0.66296	1868.09	746.83
511	0.66373	0.65520	2153.88	861.09
511	0.66802	0.65943	2153.88	861.09
512	0.66119	0.65269	2484.79	993.38
513	0.65742	0.64897	2807.02	1122.20
514	0.65289	0.64450	3152.25	1260.22
515	0.64859	0.64026	3465.72	1385.54

TABLE 1-2

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE 1.5 INCH STANDARD				
87	0.62085	0.61208	24475.65	10018.14
88	0.62124	0.61246	22863.66	9358.34
89	0.62191	0.61312	21252.59	8698.91
90	0.62223	0.61343	19866.99	8131.77
91	0.62355	0.61474	17531.19	7175.70
92	0.62494	0.61611	15535.87	6359.00
93	0.62657	0.61771	13671.72	5595.98
94	0.62642	0.61757	12264.85	5020.13
95	0.62667	0.61782	11142.61	4560.79
96	0.62723	0.61837	9940.64	4068.81
97	0.62958	0.62068	9015.34	3690.07
98	0.59021	0.58187	9261.79	3790.95
99	0.62826	0.61938	9051.35	3704.82
100	0.63190	0.62297	7876.09	3223.77
101	0.63191	0.62298	7313.32	2993.42
102	0.63644	0.62745	6303.64	2580.15
103	0.64260	0.63352	5121.76	2096.39
104	0.66205	0.65270	3481.27	1424.92
151	0.70805	0.69804	789.43	323.12
152	0.70990	0.69986	739.79	302.80
153	0.71284	0.70277	681.21	278.83
154	0.71529	0.70518	639.78	261.87
155	0.71857	0.70841	577.55	236.40
156	0.72178	0.71157	503.33	206.02
157	0.72444	0.71420	439.36	179.84
158	0.72845	0.71815	380.53	155.76
159	0.72879	0.71849	334.35	136.85
160	0.73028	0.71996	272.55	111.56
161	0.72926	0.71896	194.23	79.50
162	0.71748	0.70734	126.15	51.64
522	0.71756	0.70742	638.24	261.24
522	0.71433	0.70423	638.24	261.24

TABLE 1-3

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE 2.0 INCH STANDARD				
123	0.62077	0.61274	19133.92	7660.89
124	0.62211	0.61406	16532.48	6619.32
125	0.62360	0.61554	14313.22	5730.77
126	0.66456	0.65596	13165.24	5271.13
127	0.62403	0.61596	11113.59	4449.69
128	0.62681	0.61871	9821.69	3932.43
129	0.62889	0.62076	8523.60	3412.70
130	0.63736	0.62912	6195.34	2480.51
144	0.69340	0.68444	972.91	389.54
145	0.69689	0.68788	880.63	352.59
146	0.70142	0.69234	788.40	315.66
147	0.70513	0.69601	709.75	284.17
148	0.70869	0.69953	642.69	257.32
149	0.43668	0.43103	355.81	142.46
150	0.71484	0.70560	497.95	199.37
151	0.72101	0.71168	431.30	172.68
152	0.72113	0.71180	399.75	160.05
153	0.72377	0.71441	339.98	136.12
154	0.84451	0.83358	240.16	96.16
155	0.58198	0.57445	98.24	39.33
516	0.68967	0.68075	791.16	316.77
517	0.68422	0.67537	1274.16	510.15
517	0.67877	0.66999	1274.16	510.15
518	0.67601	0.66727	1655.82	662.96
518	0.67188	0.66319	1655.82	662.96
519	0.66271	0.65414	2266.27	907.38
519	0.66957	0.66091	2266.27	907.38
520	0.65710	0.64860	2753.32	1102.38
119	0.61720	0.60922	29017.75	11618.21
120	0.61908	0.61107	27418.22	10977.78
121	0.61622	0.60825	25298.81	10129.21
122	0.62045	0.61243	23024.33	9218.54

TABLE 1-3 (CONTINUED)

RUN NO.	K	C	REd	RED
523	0.71101	0.70096	714.16	292.31
523	0.70480	0.69484	714.16	292.31
524	0.70072	0.69082	980.00	401.12
524	0.69645	0.68661	980.00	401.12
525	0.69556	0.68573	1434.92	587.33
525	0.68360	0.67393	1434.92	587.33
526	0.67561	0.66606	1795.61	734.96
526	0.67680	0.66724	1795.61	734.96
527	0.66879	0.65934	2172.42	889.20
528	0.66403	0.65464	2547.23	1042.61
528	0.66812	0.65867	2547.23	1042.61
529	0.65971	0.65038	2923.30	1196.54
529	0.66606	0.65664	2923.30	1196.54
530	0.65637	0.64709	3210.59	1314.13
530	0.66016	0.65083	3210.59	1314.13

TABLE 1-3 (CONTINUED) 1-8

RUN NO.	K	C	REd	RED
520	0.66072	0.65217	2753.32	1102.38
521	0.67054	0.66187	1653.41	662.00

TABLE 1-4

RESULTS

RUN NO.	K	C	RE	RED
ORIFICE TYPE 1.0 INCH SHARP				
16	0.63052	0.62227	16936.86	6799.91
17	0.62033	0.61222	16731.18	6717.33
18	0.61947	0.61137	15413.04	6188.11
19	0.62015	0.61204	15770.70	6331.71
20	0.62076	0.61264	14742.55	5918.92
21	0.62017	0.61206	15155.87	6084.86
22	0.62487	0.61670	13768.09	5527.69
23	0.62811	0.61990	12351.68	4959.02
24	0.62851	0.62029	11454.73	4598.91
25	0.62968	0.62144	10382.54	4168.44
26	0.62678	0.61859	9228.73	3705.20
65	0.62853	0.62031	7270.82	2919.13
66	0.59776	0.58994	6748.87	2709.57
67	0.62607	0.61788	5906.86	2371.52
68	0.62937	0.62114	5171.94	2076.46
69	0.63387	0.62558	4938.78	1982.85
70	0.63699	0.62866	4301.39	1726.95
71	0.64364	0.63522	2855.88	1146.59
72	0.63788	0.62954	1856.59	745.39
163	0.67497	0.66614	500.15	200.80
164	0.67445	0.66563	459.91	184.65
165	0.67618	0.66734	427.15	171.50
166	0.67836	0.66949	383.33	153.90

167	0.68306	0.67413	333.47	133.88
168	0.68867	0.67966	272.10	109.24
169	0.68878	0.67978	242.89	97.52
170	0.69662	0.68751	214.93	86.29
172	0.69987	0.69071	169.75	68.15
173	0.71566	0.70630	140.42	56.38
174	0.72070	0.71128	75.23	30.20
537	0.67865	0.66978	361.86	145.28
537	0.67695	0.66809	361.86	145.28
538	0.66971	0.66095	585.96	235.26
538	0.66738	0.65865	585.96	235.26
539	0.66258	0.65392	830.73	333.53
539	0.65949	0.65086	830.73	333.53
540	0.65637	0.64779	1076.46	432.18
540	0.66200	0.65335	1076.46	432.18
541	0.65343	0.64488	1370.13	550.09
541	0.65950	0.65088	1370.13	550.09
542	0.65130	0.64278	1627.06	653.24
542	0.65605	0.64747	1627.06	653.24
543	0.64896	0.64047	1897.44	761.79
543	0.65121	0.64270	1897.44	761.79
544	0.65039	0.64189	2122.90	852.31
545	0.64659	0.63813	2442.51	980.63
546	0.64680	0.63834	2729.45	1095.83
547	0.64608	0.63763	3079.60	1236.41
548	0.64486	0.63643	3442.51	1382.12

TABLE 1-5

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE 1.5 INCH SHARP				
37	0.63002	0.62129	24070.00	9804.79
38	0.62241	0.61378	23310.43	9495.39
39	0.62483	0.61617	21960.13	8945.35
40	0.62433	0.61568	20820.31	8481.05
41	0.61715	0.60860	19019.91	7747.66
42	0.62355	0.61491	17491.17	7124.94
43	0.62453	0.61588	15474.76	6303.56
44	0.62525	0.61658	14042.96	5720.33
45	0.62565	0.61698	12673.94	5162.66
46	0.62253	0.61390	12591.53	5129.09
47	0.62469	0.61603	12376.08	5041.33
48	0.62614	0.61746	11670.46	4753.90
49	0.62823	0.61952	11264.74	4588.63
50	0.62836	0.61965	10416.85	4243.25
51	0.62868	0.61996	9449.70	3849.29
52	0.62902	0.62030	8962.40	3650.79
53	0.62729	0.61859	8179.23	3331.77
54	0.63171	0.62295	7222.65	2942.11
55	0.63666	0.62783	6050.00	2464.44
56	0.64608	0.63712	4369.63	1779.95
57	0.64784	0.63886	2643.86	1076.96
184	0.66881	0.65954	764.94	311.59
185	0.67528	0.66592	600.73	244.70
186	0.67038	0.66108	695.90	283.47
187	0.67006	0.66078	669.51	272.72
188	0.67526	0.66590	550.69	224.32
189	0.67828	0.66887	478.38	194.86
190	0.68264	0.67318	423.80	172.63
191	0.68582	0.67631	383.44	156.19
192	0.69029	0.68072	335.31	136.59
193	0.68938	0.67982	298.51	121.60
194	0.69881	0.68912	239.84	97.70

TABLE 1-5 (CONTINUED) 1-11

RUN NO.	K	C	REd	RED
195	0.70666	0.69687	140.40	57.19
557	0.67239	0.66307	632.27	257.55
557	0.66723	0.65798	632.27	257.55
558	0.66947	0.66019	937.81	382.01
558	0.66400	0.65480	937.81	382.01
559	0.66549	0.65626	1192.34	485.69
559	0.66131	0.65215	1192.34	485.69
560	0.65600	0.64691	1602.23	652.66
560	0.65834	0.64922	1602.23	652.66
561	0.65369	0.64462	1832.61	746.50
561	0.65777	0.64866	1832.61	746.50
562	0.65198	0.64294	2108.74	858.98
562	0.65191	0.64288	2108.74	858.98
563	0.65157	0.64254	2417.08	984.58
563	0.65485	0.64577	2417.08	984.58
564	0.64981	0.64080	2823.35	1150.08
564	0.65482	0.64574	2823.35	1150.08
565	0.65203	0.64299	3081.99	1255.43
565	0.65537	0.64629	3081.99	1255.43

TABLE 1-6

RESULTS

RUN NO.	K	C	RE	RED
ORIFICE TYPE 2.0 INCH SHARP				
73	0.61657	0.60847	30944.83	12438.10
74	0.61710	0.60899	28390.81	11411.53
75	0.61695	0.60885	26945.65	10830.65
76	0.61605	0.60796	24677.14	9918.84
77	0.61884	0.61071	22432.48	9016.61

TABLE 1-6 (CONTINUED)

RUN NO.	K	C	REd	RED
78	0.61603	0.60793	19827.95	7969.73
79	0.62035	0.61220	17034.42	6846.89
80	0.61997	0.61182	14540.36	5844.42
81	0.62064	0.61249	13400.24	5386.15
82	0.62182	0.61365	11714.69	4708.66
83	0.62239	0.61421	10460.65	4204.60
84	0.62074	0.61258	8323.83	3345.72
85	0.62810	0.61985	6225.03	2502.12
86	0.63576	0.62741	4995.21	2007.80
172	0.65714	0.64851	1065.29	428.19
173	0.65901	0.65036	1002.63	403.00
174	0.65971	0.65104	873.00	350.90
175	0.66097	0.65229	830.85	333.95
176	0.66423	0.65551	716.17	287.86
177	0.66621	0.65746	607.10	244.02
178	0.67268	0.66384	511.62	205.64
179	0.67597	0.66709	445.60	179.11
180	0.67810	0.66919	412.75	165.90
181	0.68462	0.67563	342.11	137.51
182	0.68162	0.67266	242.08	97.30
183	0.68353	0.67455	163.67	65.78
549	0.66602	0.65727	684.40	275.09
550	0.65896	0.65031	995.71	400.22
550	0.65501	0.64641	995.71	400.22
549	0.65787	0.64922	684.40	275.09
551	0.65608	0.64746	1290.80	518.83
551	0.65261	0.64404	1290.80	518.83
552	0.65183	0.64327	1565.40	629.20
552	0.64991	0.64137	1565.40	629.20
553	0.64654	0.63805	1978.86	795.39
554	0.64788	0.63937	1775.05	713.47
555	0.64610	0.63761	2274.59	914.26
556	0.64590	0.63741	2506.81	1007.60

TABLE 1-7

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE	G.S.	BETA=0.2		
226	0.72378	0.72322	309.06	61.36
227	0.71729	0.71674	283.91	56.37
228	0.71652	0.71597	258.32	51.29
229	0.71517	0.71462	237.82	47.22
230	0.71341	0.71286	213.93	42.48
231	0.70676	0.70621	183.98	36.53
232	0.70076	0.70021	150.29	29.84
233	0.72605	0.72548	118.73	23.57
384	0.70136	0.70082	693.29	137.65
385	0.71402	0.71347	486.18	96.53
386	0.71574	0.71518	292.46	58.07
396	0.71665	0.71609	360.60	71.60
397	0.70344	0.70289	585.89	116.32
398	0.69750	0.69695	687.52	136.50
399	0.68900	0.68847	797.41	158.32
400	0.67480	0.67428	891.30	176.96
401	0.66534	0.66482	987.07	195.98
402	0.65586	0.65535	1101.00	218.60
403	0.65258	0.65207	1206.72	239.59
404	0.65411	0.65361	1374.07	272.81
405	0.65212	0.65162	1536.46	305.05
406	0.64915	0.64865	1695.16	336.56
407	0.64643	0.64593	1823.78	362.10
408	0.64213	0.64163	1989.61	395.03
409	0.62695	0.62646	2131.20	423.14
410	0.62581	0.62532	2266.35	449.97
411	0.62413	0.62365	2387.62	474.05
211	0.71334	0.71277	425.54	85.11
212	0.71426	0.71369	403.25	80.66
213	0.71598	0.71541	383.91	76.79
214	0.71624	0.71566	372.54	74.51
215	0.71753	0.71695	351.02	70.21

TABLE 1-7 (CONTINUED)

RUN NO.	K	C	REd	RED
216	0.71610	0.71553	329.19	65.84
217	0.71818	0.71761	292.81	58.57
218	0.71689	0.71632	260.16	52.04
219	0.71584	0.71527	234.17	46.84
220	0.71518	0.71460	209.19	41.84
221	0.71364	0.71307	180.70	36.14
222	0.71163	0.71106	163.51	32.70
223	0.70905	0.70848	144.85	28.97
224	0.70094	0.70038	118.79	23.76
393	0.70819	0.70762	468.92	93.79
394	0.70347	0.70291	611.44	122.30
421	0.70492	0.70435	505.24	101.05
422	0.69094	0.69039	732.56	146.52
423	0.67601	0.67547	933.14	186.64
424	0.66781	0.66728	1051.17	210.25
425	0.64692	0.64640	1148.15	229.65
425	0.66264	0.66211	1176.06	235.23
426	0.65579	0.65527	1307.30	261.48
427	0.64510	0.64459	1619.99	324.02
428	0.64974	0.64922	1482.91	296.60
429	0.63482	0.63432	1688.08	337.64
430	0.67960	0.67905	1795.25	359.07
431	0.64365	0.64314	1952.48	390.52
432	0.63809	0.63758	2174.37	434.90
433	0.63542	0.63492	2318.45	463.72
434	0.63210	0.63159	2585.45	517.12
435	0.62901	0.62850	2852.28	570.49
436	0.62625	0.62575	3096.45	619.33
387	0.65988	0.65935	1206.69	241.23
388	0.66237	0.66184	1092.23	218.35
389	0.67054	0.67000	972.18	194.35
390	0.67596	0.67542	870.95	174.12
391	0.68354	0.68299	752.04	150.34
392	0.70003	0.69947	501.44	100.24
196	0.70083	0.70027	546.14	109.18
197	0.70286	0.70230	524.01	104.76

TABLE 1-7 (CONTINUED)

RUN NO.	K	C	REd	RED
198	0.70349	0.70293	494.63	98.88
199	0.70638	0.70582	463.33	92.63
200	0.70756	0.70700	432.71	86.51
201	0.70992	0.70936	402.69	80.50
202	0.71197	0.71140	357.42	71.45
203	0.79539	0.79475	321.99	64.37
204	0.71346	0.71289	249.39	49.86
205	0.71429	0.71372	320.88	64.15
206	0.71312	0.71255	228.20	45.62
207	0.71345	0.71288	201.40	40.26
208	0.70992	0.70935	172.45	34.48
209	0.70086	0.70030	137.86	27.56
210	0.68997	0.68941	89.55	17.90
412	0.69015	0.68960	689.82	137.90
413	0.67471	0.67417	928.13	185.55
414	0.66292	0.66239	1129.73	225.85
415	0.64331	0.64280	1319.19	263.72
415	0.65418	0.65366	1341.48	268.18
416	0.64715	0.64664	1512.90	302.45
417	0.64289	0.64237	1667.22	333.30
418	0.63812	0.63761	1847.13	369.27
419	0.63596	0.63545	2009.08	401.64
420	0.63311	0.63261	2137.98	427.41

TABLE 1-8

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE G.S. BETA=0.4				
278	0.71394	0.70487	510.80	203.62
279	0.71670	0.70759	467.65	186.42
280	0.71804	0.70892	432.32	172.33
281	0.71897	0.70983	396.62	158.10
282	0.72078	0.71162	349.56	139.34
283	0.72278	0.71360	291.59	116.23
284	0.72286	0.71367	252.51	100.66
285	0.72135	0.71218	213.38	85.06
286	0.71853	0.70940	184.17	73.41
287	0.70000	0.69111	136.19	54.29
288	0.71966	0.71051	127.28	50.74
289	0.69434	0.68551	104.90	41.82
290	0.67858	0.66996	62.83	25.05
335	0.69942	0.69053	832.21	331.74
336	0.70158	0.69266	796.34	317.44
337	0.70426	0.69532	715.90	285.37
338	0.70696	0.69798	654.73	260.99
339	0.71006	0.70104	577.21	230.09
340	0.71358	0.70452	502.81	200.43
341	0.71756	0.70844	451.29	179.89
342	0.71967	0.71053	372.30	148.41
343	0.71416	0.70509	297.58	118.62
452	0.97846	0.96603	1012.11	403.45
453	0.68768	0.67894	940.29	374.82
454	0.68299	0.67432	1170.87	466.74
455	0.69180	0.68301	931.20	371.20
456	0.67630	0.66771	1379.75	550.00
457	0.67293	0.66438	1520.09	605.94
458	0.66472	0.65627	1905.70	759.65
459	0.66068	0.65229	2176.82	867.73
460	0.66202	0.65361	2472.26	985.50
461	0.74758	0.73809	3203.33	1276.92

TABLE 1-8 (CONTINUED)

RUN NO.	K	C	REd	RED
462	0.67843	0.66981	3236.59	1290.18
463	0.65051	0.64225	3506.91	1397.93
496	0.71040	0.70137	528.95	210.85
496	0.70358	0.69464	528.95	210.85
497	0.68889	0.68014	1049.96	418.54
497	0.68653	0.67780	1049.96	418.54
498	0.67508	0.66650	1458.86	581.53
498	0.68312	0.67444	1458.86	581.53
499	0.66927	0.66077	1669.02	665.31
500	0.67195	0.66341	1669.02	665.31
500	0.66187	0.65346	2146.14	855.50
500	0.66669	0.65821	2146.14	855.50
501	0.66345	0.65502	2166.24	863.51
502	0.66399	0.65556	2394.86	954.64
503	0.65530	0.64698	2666.39	1062.88
504	0.64984	0.64158	2920.06	1164.00
303	0.70322	0.69414	751.92	300.94
304	0.70541	0.69630	707.81	283.29
305	0.70705	0.69792	650.71	260.44
306	0.71078	0.70160	591.52	236.74
307	0.71468	0.70545	516.56	206.74
308	0.71844	0.70917	448.64	179.56
309	0.71905	0.70976	399.01	159.70
310	0.72188	0.71255	327.04	130.89
311	0.72431	0.71496	279.46	111.85
312	0.72376	0.71441	247.57	99.09
313	0.72274	0.71340	193.77	77.55
314	0.71514	0.70590	127.54	51.05
315	0.69006	0.68115	1105.42	442.42
316	0.69375	0.68479	996.31	398.75
318	0.69789	0.68888	903.03	361.42
319	0.70185	0.69279	799.28	319.90
320	0.70616	0.69704	657.94	263.33
321	0.71232	0.70312	595.39	238.30
322	0.71728	0.70802	523.43	209.49
323	0.71983	0.71054	414.89	166.05

TABLE 1-8 (CONTINUED) 1-18

RUN NO.	K	C	REd	RED
324	0.72441	0.71506	322.06	128.90
325	0.72046	0.71116	166.29	66.55
326	0.68844	0.67955	1105.94	442.63
327	0.69279	0.68384	1027.76	411.34
320	0.70405	0.69496	657.94	263.33
321	0.71036	0.70119	595.39	238.30
322	0.71520	0.70597	523.33	209.45
323	0.71756	0.70830	414.89	166.05
324	0.72577	0.71640	322.06	128.90
325	0.74440	0.73479	166.29	66.55
347	0.69440	0.68544	159.59	63.87
347	0.72841	0.71900	159.59	63.87
348	0.72257	0.71324	350.28	140.19
348	0.70866	0.69951	350.28	140.19
349	0.71570	0.70646	486.70	194.79
349	0.70581	0.69670	486.70	194.79
350	0.71000	0.70083	599.37	239.89
350	0.70207	0.69301	599.37	239.89
351	0.70473	0.69563	704.03	281.77
352	0.70039	0.69135	819.12	327.84
353	0.69559	0.68660	885.49	354.40
354	0.69598	0.68700	939.17	375.89
355	0.69342	0.68446	986.39	394.78
356	0.69132	0.68239	1027.40	411.20
357	0.68956	0.68065	1080.36	432.39
358	0.68979	0.68088	1103.49	441.65
437	0.96660	0.95412	1005.13	402.29
438	0.95361	0.94130	1450.37	580.49
439	0.94671	0.93449	1713.92	685.97
440	0.94056	0.92842	2081.17	832.95
441	0.93743	0.92533	2362.95	945.73
442	0.93401	0.92195	2750.67	1100.91
443	0.93618	0.92409	2579.03	1032.21
444	0.93526	0.92319	2983.54	1194.11
445	0.78782	0.77765	2855.22	1142.75
479	0.71429	0.70506	614.11	245.79

TABLE 1-8 (CONTINUED)

RUN NO.	K	C	REd	RED
479	0.70530	0.69619	614.11	245.79
480	0.69571	0.68673	956.14	382.68
480	0.69203	0.68310	956.14	382.68
481	0.68680	0.67793	1240.47	496.48
481	0.68497	0.67613	1240.47	496.48
482	0.67682	0.66808	1451.76	581.04
483	0.66847	0.65984	1756.44	702.98
483	0.68104	0.67224	1756.44	702.98
484	0.66487	0.65628	1990.83	796.80
484	0.67191	0.66324	1990.83	796.80
485	0.65941	0.65090	2365.10	946.59
485	0.66124	0.65270	2365.10	946.59
486	0.65726	0.64877	2686.18	1075.10
486	0.66105	0.65252	2686.18	1075.10
487	0.65303	0.64460	2910.15	1164.74
487	0.65863	0.65012	2910.15	1164.74
291	0.59829	0.59057	839.70	336.02
292	0.69770	0.68869	921.38	368.70
293	0.69970	0.69067	828.93	331.71
294	0.70559	0.69649	704.39	281.87
295	0.70882	0.69967	630.47	252.29
296	0.71417	0.70495	562.34	225.03
297	0.71546	0.70623	508.82	203.61
298	0.71919	0.70991	450.16	180.14
299	0.72195	0.71264	372.12	148.91
300	0.72368	0.71435	301.33	120.58
301	0.72529	0.71593	239.30	95.76
302	0.74560	0.73597	175.33	70.16
327	0.72650	0.71713	196.67	78.70
327	0.72371	0.71437	196.65	78.69
328	0.71957	0.71028	479.67	191.95
328	0.70878	0.69963	479.67	191.95
329	0.72150	0.71219	358.69	143.53
329	0.71077	0.70160	358.69	143.53
330	0.71460	0.70538	597.20	238.98
330	0.70471	0.69561	597.19	238.98

TABLE 1-8 (CONTINUED)

RUN NO.	K	C	REd	RED
331	0.70964	0.70048	715.13	286.17
331	0.69957	0.69054	715.13	286.17
332	0.70423	0.69514	796.33	318.67
332	0.69557	0.68659	796.33	318.67
334	0.69469	0.68573	1010.86	404.51
334	0.68495	0.67611	1010.86	404.51
344	0.93140	0.91938	447.50	179.07
344	0.91743	0.90559	447.50	179.07
345	0.92150	0.90960	622.56	249.13
345	0.91676	0.90493	622.56	249.13
346	0.78451	0.77438	797.10	318.97
346	0.74688	0.73725	797.10	318.97
447	0.92768	0.91571	1688.34	675.62
446	0.94977	0.93751	1171.90	468.95
448	0.91965	0.90778	2033.71	813.82
449	0.91449	0.90269	2223.48	889.76
450	0.91221	0.90044	2589.40	1036.19
451	0.90931	0.89758	2854.70	1142.35
488	0.69753	0.68853	658.75	263.61
288	0.68742	0.67855	658.75	263.61
289	0.70406	0.69497	679.02	271.72
289	0.69305	0.68411	679.02	271.72
490	0.69617	0.68719	940.16	376.22
490	0.68973	0.68083	940.16	376.22
491	0.67719	0.66845	1451.99	581.04
491	0.67406	0.66536	1451.99	581.04
492	0.67203	0.66335	1666.83	667.01
492	0.66835	0.65973	1666.83	667.01
493	0.66577	0.65718	1987.65	795.39
493	0.67375	0.66506	1987.65	795.39
494	0.66011	0.65159	2287.08	915.21
494	0.65789	0.64940	2287.08	915.21
495	0.65833	0.64984	2571.94	1029.21
495	0.66216	0.65362	2571.94	1029.21

TABLE 1-9

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE G.S. BETA=0.6				
235	0.81264	0.75835	795.45	476.85
236	0.81750	0.76288	755.84	453.11
237	0.81570	0.76121	694.65	416.43
238	0.80851	0.75450	607.07	363.93
239	0.80517	0.75138	520.84	312.23
240	0.81387	0.75950	479.70	287.57
241	0.81614	0.76162	410.63	246.16
242	0.81693	0.76235	366.25	219.56
243	0.81565	0.76116	322.12	193.10
244	0.81858	0.76390	261.44	156.73
245	0.81029	0.75615	210.72	126.32
246	0.79140	0.73853	149.42	89.57
247	0.81497	0.76052	458.49	274.86
248	0.81682	0.76225	525.28	314.89
377	0.78104	0.72886	237.94	142.64
378	0.79917	0.74578	411.00	246.39
379	0.81588	0.76138	514.03	308.15
380	0.80980	0.75570	644.18	386.17
381	0.81278	0.75848	729.78	437.49
382	0.80722	0.75329	831.59	498.52
383	0.80534	0.75154	901.75	540.58
602	0.80778	0.75382	520.49	312.02
603	0.81167	0.75744	1056.82	633.54
604	0.79400	0.74095	1469.88	881.16
605	0.78087	0.72870	1868.42	1120.07
606	0.77322	0.72156	2213.97	1327.22
607	0.76785	0.71655	2426.79	1454.81
608	0.75881	0.70812	2859.21	1714.03
609	0.75469	0.70427	3002.15	1799.72
610	0.78178	0.72956	1845.77	1106.50
611	0.77041	0.71894	2244.26	1345.38
612	0.81098	0.75680	716.84	429.73

TABLE 1-9 (CONTINUED)

RUN NO.	K	C	REd	RED
613	0.79774	0.74444	1301.48	780.21
614	0.79919	0.74580	1258.76	754.60
657	0.69832	0.65166	146.74	87.96
658	0.81305	0.75873	324.50	194.53
658	0.81290	0.75860	324.50	194.53
659	0.80424	0.75051	223.12	133.75
659	0.80471	0.75095	223.12	133.75
660	0.80240	0.74879	193.51	116.00
660	0.79679	0.74356	193.51	116.00
661	0.81740	0.76279	406.57	243.73
661	0.81746	0.76284	406.57	243.73
662	0.81418	0.75978	474.50	284.45
662	0.81568	0.76118	474.50	284.45
663	0.81440	0.75999	581.14	348.38
663	0.81108	0.75690	581.14	348.38
664	0.80903	0.75498	760.04	455.62
664	0.81057	0.75642	760.04	455.62
665	0.80812	0.75413	757.15	453.90
665	0.80861	0.75459	757.15	453.90
666	0.80489	0.75112	888.02	532.35
666	0.80211	0.74853	888.02	532.35
667	0.80281	0.74918	958.51	574.61
667	0.79304	0.74006	958.51	574.61
668	0.79399	0.74094	1014.38	608.10
668	0.79507	0.74196	1014.38	608.10
669	0.82579	0.77062	144.39	86.56
669	0.79538	0.74224	144.39	86.56
670	0.81881	0.76411	189.57	113.64
670	0.80777	0.75381	189.57	113.64
263	0.81015	0.75642	978.47	585.54
264	0.81203	0.75817	920.45	550.82
265	0.81352	0.75956	867.69	519.25
266	0.81395	0.75996	793.79	475.03
267	0.81916	0.76483	728.58	436.00
268	0.81927	0.76494	654.57	391.71
269	0.82261	0.76805	616.93	369.19

TABLE 1-9 (CONTINUED)

RUN NO.	K	C	REd	RED
270	0.82550	0.77075	570.24	341.25
271	0.82652	0.77170	516.78	309.25
272	0.82740	0.77253	465.57	278.61
273	0.82761	0.77272	399.35	238.98
274	0.82714	0.77229	363.06	217.27
275	0.81616	0.76203	310.06	185.55
276	0.82551	0.77076	262.79	157.26
371	0.79936	0.74634	264.77	158.44
372	0.80518	0.75178	393.26	235.34
373	0.81789	0.76365	530.04	317.19
374	0.81749	0.76327	694.17	415.41
375	0.81461	0.76058	789.12	472.23
376	0.81283	0.75892	925.12	553.62
636	0.81439	0.76038	694.21	415.44
637	0.81289	0.75898	939.81	562.41
638	0.80562	0.75219	1244.45	744.71
639	0.79980	0.74676	1458.13	872.58
640	0.79344	0.74082	1686.63	1009.32
641	0.78679	0.73461	1852.85	1108.80
642	0.78450	0.73247	2067.98	1237.54
643	0.77755	0.72598	2234.86	1337.40
644	0.80074	0.74763	1371.66	820.84
699	0.80980	0.75609	150.45	90.03
699	0.79290	0.74031	150.45	90.03
700	0.83938	0.78371	183.52	109.82
700	0.80521	0.75181	183.52	109.82
701	0.82864	0.77369	261.26	156.34
701	0.82058	0.76616	261.26	156.34
702	0.82260	0.76805	401.63	240.35
702	0.82682	0.77198	401.63	240.35
703	0.82324	0.76864	528.94	316.53
703	0.82115	0.76669	528.94	316.53
704	0.82066	0.76623	591.59	354.03
704	0.82046	0.76605	591.59	354.03
705	0.81585	0.76174	703.20	420.81
705	0.81349	0.75954	703.20	420.81

TABLE 1-9 (CONTINUED)

RUN NO.	K	C	REd	RED
706	0.81705	0.76286	815.48	488.01
706	0.81184	0.75799	815.48	488.01
249	0.81829	0.76340	790.78	474.53
250	0.82045	0.76541	783.64	470.24
251	0.87115	0.81271	720.81	432.53
252	0.82062	0.76558	678.25	407.00
253	0.82247	0.76730	659.32	395.64
254	0.82451	0.76920	632.24	379.39
255	0.81370	0.75911	584.31	350.63
256	0.82340	0.76817	572.58	343.59
257	0.83027	0.77458	518.79	311.31
258	0.82495	0.76961	470.81	282.52
259	0.81084	0.75645	403.64	242.21
260	0.81422	0.75960	300.12	180.09
261	0.81861	0.76370	224.19	134.53
262	0.77902	0.72676	94.36	56.62
359	0.81410	0.75949	292.24	175.37
359	0.82799	0.77245	292.24	175.37
360	0.82451	0.76920	395.50	237.33
360	0.82356	0.76832	395.50	237.33
361	0.81963	0.76465	541.28	324.81
361	0.81920	0.76425	541.28	324.81
363	0.81857	0.76366	838.32	503.05
363	0.81944	0.76447	838.32	503.05
366	0.81729	0.76247	812.77	487.72
366	0.81145	0.75702	812.77	487.72
367	0.82509	0.76974	946.60	568.03
367	0.81386	0.75927	946.60	568.03
368	0.81797	0.76310	570.41	342.29
368	0.81251	0.75800	570.41	342.29
369	0.81305	0.75851	462.13	277.31
370	0.79211	0.73897	298.06	178.86
578	1.07401	1.00196	696.75	418.10
578	1.15465	1.07720	696.75	418.10
579	1.06722	0.99563	914.66	548.86
579	1.14944	1.07234	914.66	548.86

TABLE 1-9 (CONTINUED) 1-25

RUN NO.	K	C	REd	RED
580	1.05007	0.97963	1256.91	754.23
580	1.11011	1.03564	1256.91	754.23
581	1.03642	0.96690	1535.11	921.18
581	1.09301	1.01969	1535.11	921.18
582	1.02306	0.95443	1787.14	1072.41
582	1.07882	1.00645	1787.14	1072.41
583	1.02144	0.95292	1886.25	1131.88
583	1.02144	0.95292	1886.25	1131.88
584	1.07783	1.00635	665.98	398.54
584	1.15260	1.07615	665.98	398.54
585	1.07791	1.00642	1082.36	647.71
585	1.13981	1.06421	1082.36	647.71
586	1.05738	0.98725	1438.28	860.70
586	1.11272	1.03892	1438.28	860.70
587	1.04966	0.98004	1699.67	1017.12
587	1.09720	1.02443	1699.67	1017.12
588	1.05283	0.98300	1949.02	1166.34
588	1.08743	1.01531	1949.02	1166.34
589	1.03728	0.96849	2119.11	1268.13
589	1.09437	1.02179	2119.11	1268.13
590	1.02967	0.96138	2300.42	1376.63
590	1.08750	1.01537	2300.42	1376.63
591	1.04821	0.97869	1618.57	968.59
591	1.11026	1.03663	1618.57	968.59
592	1.06753	0.99673	1058.55	633.47
592	1.12516	1.05054	1058.55	633.47
615	0.80546	0.75143	778.62	467.22
616	0.81472	0.76007	1083.77	650.34
617	0.79906	0.74545	1327.06	796.33
618	0.79811	0.74457	1573.45	944.18
619	0.78803	0.73517	1777.80	1066.81
620	0.79216	0.73903	410.71	246.45
621	0.85034	0.79330	537.89	322.77
671	0.86647	0.80835	230.83	138.51
671	0.80937	0.75508	230.83	138.51
672	0.83760	0.78142	335.48	201.31

TABLE 1-9 (CONTINUED)

RUN NO.	K	C	REd	RED
580	1.05007	0.97963	1256.91	754.23
580	1.11011	1.03564	1256.91	754.23
581	1.03642	0.96690	1535.11	921.18
581	1.09301	1.01969	1535.11	921.18
582	1.02306	0.95443	1787.14	1072.41
582	1.07882	1.00645	1787.14	1072.41
583	1.02144	0.95292	1886.25	1131.88
583	1.02144	0.95292	1886.25	1131.88
584	1.07783	1.00635	665.98	398.54
584	1.15260	1.07615	665.98	398.54
585	1.07791	1.00642	1082.36	647.71
585	1.13981	1.06421	1082.36	647.71
586	1.05738	0.98725	1438.28	860.70
586	1.11272	1.03892	1438.28	860.70
587	1.04966	0.98004	1699.67	1017.12
587	1.09720	1.02443	1699.67	1017.12
588	1.05283	0.98300	1949.02	1166.34
588	1.08743	1.01531	1949.02	1166.34
589	1.03728	0.96849	2119.11	1268.13
589	1.09437	1.02179	2119.11	1268.13
590	1.02967	0.96138	2300.42	1376.63
590	1.08750	1.01537	2300.42	1376.63
591	1.04821	0.97869	1618.57	968.59
591	1.11026	1.03663	1618.57	968.59
592	1.06753	0.99673	1058.55	633.47
592	1.12516	1.05054	1058.55	633.47
615	0.80546	0.75143	778.62	467.22
616	0.81472	0.76007	1083.77	650.34
617	0.79906	0.74545	1327.06	796.33
618	0.79811	0.74457	1573.45	944.18
619	0.78803	0.73517	1777.80	1066.81
620	0.79216	0.73903	410.71	246.45
621	0.85034	0.79330	537.89	322.77
671	0.86647	0.80835	230.83	138.51
671	0.80937	0.75508	230.83	138.51
672	0.83760	0.78142	335.48	201.31

TABLE 1-9 (CONTINUED)

RUN NO.	K	C	REd	RED
672	0.82307	0.76786	335.48	201.31
673	0.83937	0.78306	390.84	234.53
673	0.83293	0.77706	390.84	234.53
674	0.82676	0.77130	417.46	250.51
674	0.82522	0.76986	417.46	250.51
675	0.84605	0.78930	501.68	301.04
675	0.83310	0.77721	501.68	301.04
676	0.82930	0.77367	516.78	310.11
677	0.80634	0.75225	585.78	351.51
677	0.82638	0.77094	585.78	351.51
678	0.82966	0.77400	657.07	394.29

TABLE 1-10

RESULTS

RUN NO.	K	C	REd	RED
ORIFICE TYPE SPECIAL 15				
622	0.70271	0.69349	663.83	266.71
623	0.67113	0.66233	1581.29	635.33
624	0.69327	0.68418	650.27	261.27
625	0.68742	0.67840	860.92	345.90
626	0.68393	0.67496	1077.13	432.77
627	0.67216	0.66335	1368.60	549.88
628	0.66851	0.65974	1655.47	665.13
629	0.66401	0.65530	1990.84	799.88
630	0.66104	0.65237	2269.90	912.00
631	0.65852	0.64989	2589.79	1040.52
632	0.65817	0.64953	2899.36	1164.91
633	0.65713	0.64852	2929.81	1177.14
634	0.65864	0.65000	3036.88	1220.16
635	0.68355	0.67458	1025.32	411.95
687	0.73112	0.72153	149.87	60.22
687	0.71479	0.70542	149.87	60.22
688	0.71569	0.70630	232.52	93.42
688	0.71717	0.70777	232.52	93.42
689	0.70720	0.69792	425.12	170.81
689	0.70360	0.69437	425.12	170.81
690	0.69210	0.68302	647.13	260.00
691	0.68498	0.67599	826.78	332.19
692	0.67552	0.66666	1011.26	406.30
692	0.67822	0.66933	1011.26	406.30
693	0.68000	0.67108	996.74	400.47
693	0.68233	0.67338	996.74	400.47
694	0.70733	0.69806	342.02	137.42
694	0.70154	0.69234	342.02	137.42
695	0.69590	0.68678	528.88	212.49
696	0.70486	0.69561	417.87	167.89
696	0.70027	0.69109	417.87	167.89
697	0.71061	0.70129	304.37	122.29

TABLE 1-10 (CONTINUED)

RUN NO.	K	C	REd	RED
697	0.71120	0.70187	304.37	122.29

TABLE 1-11

RESULTS

RUN NO.	K	C	RE	RED
ORIFICE TYPE SPECIAL 30				
645	0.70685	0.69770	679.08	271.98
646	0.69628	0.68726	937.97	375.67
647	0.68713	0.67823	1201.92	481.39
648	0.67637	0.66762	1438.19	576.02
649	0.66948	0.66081	1807.33	723.87
650	0.66508	0.65647	2149.35	860.86
651	0.65996	0.65141	2549.32	1021.05
652	0.65730	0.64878	2851.29	1141.99
653	0.65763	0.64911	3198.12	1280.90
654	0.71599	0.70672	368.64	147.65
655	0.67818	0.66940	1375.46	550.90
656	0.68694	0.67804	1215.86	486.97
679	0.71365	0.70441	129.50	51.87
679	0.71054	0.70134	129.50	51.87
680	0.71634	0.70706	299.95	120.14
680	0.71879	0.70949	299.95	120.14
681	0.71548	0.70622	428.84	171.76
681	0.71505	0.70579	428.84	171.76
681	0.71330	0.70406	428.84	171.76
682	0.69890	0.68985	717.55	287.39
682	0.71350	0.70426	717.55	287.39
683	0.69991	0.69084	688.49	275.75
684	0.72389	0.71451	246.73	98.82

TABLE 1-11 (CONTINUED)

RUN NO.	K	C	RE_d	RED
684	0.72170	0.71235	246.73	98.82
685	0.71954	0.71022	192.75	77.20
685	0.71945	0.71013	192.75	77.20
686	0.62820	0.62007	114.36	45.80
686	0.72351	0.71414	114.36	45.80

APPENDIX 2 - DATA

TABLE 2-1

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE	STANDARD	1.0 INCH					
105	380.00	1216.0	0.997926	0.997478	1.5901	62.590	0.974
106	375.00	1313.0	0.997882	0.997442	1.5898	52.450	0.969
107	265.00	1027.9	0.997860	0.997394	1.5895	42.740	0.967
108	270.00	1127.8	0.997895	0.997701	1.5919	36.520	0.970
109	286.00	1267.0	0.997915	0.997701	1.5919	32.440	0.973
110	300.00	1438.0	0.997981	0.997655	1.5915	27.760	0.980
111	245.00	1286.4	0.997992	0.997597	1.5911	22.970	0.981
112	230.00	1326.6	0.997926	0.997585	1.5910	19.040	0.974
113	220.00	1421.8	0.997915	0.997538	1.5906	15.030	0.973
114	215.00	1575.6	0.997886	0.997490	1.5902	11.640	0.970
115	188.00	1584.6	0.997871	0.997454	1.5900	8.750	0.969
116	169.00	1644.0	0.997882	0.997430	1.5898	6.495	0.969
117	175.00	1912.0	0.997538	0.997369	1.5893	5.069	0.936
118	117.00	1375.2	0.997442	0.997246	1.5884	3.884	0.928
131	235.00	733.2	1.041800	1.042260	1.5940	51.860	32.090
132	240.00	783.5	1.041810	1.042220	1.5937	47.280	31.820
133	240.00	788.1	1.041740	1.041980	1.5932	46.660	31.600
134	220.00	782.1	1.041700	1.041920	1.5926	40.660	31.280
135	255.00	991.4	1.041700	1.041620	1.5921	33.040	31.020
136	255.00	1114.0	1.041600	1.041410	1.5909	25.970	30.420
137	232.00	1108.4	1.041560	1.041450	1.5893	21.620	29.540
138	233.00	1314.6	1.041550	1.041420	1.5910	15.410	30.420
139	181.00	1165.9	1.041520	1.041420	1.5907	11.820	30.240
140	175.00	1308.2	1.042950	1.042700	1.5918	8.640	33.700
141	137.00	1207.4	1.042920	1.042500	1.5913	6.250	33.650
142	93.00	1251.0	1.042950	1.042720	1.5921	2.770	33.650
143	66.00	1727.2	1.042920	1.042730	1.5919	0.820	33.670
505	190.00	1165.2	1.030930	1.031130	1.5945	13.090	16.800
506	190.00	1165.2	1.030930	1.031130	0.0000	7.250	16.800
506	163.00	967.8	1.030920	1.030950	1.5931	14.070	16.680
506	163.00	967.8	1.030920	1.030950	0.0000	7.830	16.680
507	170.00	749.4	1.030930	1.031030	1.5931	26.200	16.630

TABLE 2-1 (CONTINUED) 2-3

RUN NO.	WS	TI	PO	PBO	PC	H	U
507	170.00	749.4	1.030930	1.031030	0.0000	14.430	16.630
508	200.00	610.2	1.030890	1.030990	0.0000	31.110	16.520
508	200.00	610.2	1.030890	1.030990	13.5416	2.513	16.520
509	230.00	519.8	1.030880	1.030950	0.0000	58.630	16.370
509	230.00	519.8	1.030880	1.030950	13.5412	4.760	16.370
510	275.00	485.8	1.030880	1.030920	0.0000	98.780	16.340
510	275.00	485.8	1.030880	1.030920	13.5408	8.040	16.340
511	300.00	461.9	1.030850	1.030990	0.0000	131.480	16.260
511	300.00	461.9	1.030850	1.030990	13.5409	10.697	16.260
512	285.00	381.3	1.030820	1.031050	13.5413	14.460	16.220
513	300.00	356.4	1.030800	1.031130	13.5416	18.550	16.170
514	300.00	317.8	1.030800	1.031220	13.5419	23.660	16.150
515	300.00	289.9	1.030790	1.031220	13.5420	28.800	16.100

TABLE 2-2

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE	STANDARD	1.5 INCH					
87	360.00	556.8	0.997952	0.997970	1.5939	51.630	0.976
88	385.00	634.5	0.997992	0.997992	1.5941	45.400	0.981
89	390.00	690.4	0.998004	0.997701	1.5919	39.390	0.983
90	360.00	684.2	0.997970	0.997802	1.5927	34.100	0.979
91	390.00	831.4	0.998067	0.997848	1.5931	26.970	0.989
92	400.00	950.6	0.998172	0.997893	1.5935	21.590	1.001
93	365.00	978.8	0.998224	0.997882	1.5934	16.870	1.008
94	340.00	1019.4	0.998203	0.997893	1.5935	13.500	1.005
95	375.00	1231.4	0.998244	0.997860	1.5932	11.250	1.010
96	335.00	1230.6	0.998265	0.997792	1.5927	8.980	1.012
97	325.00	1316.4	0.998265	0.997800	1.5928	7.330	1.012

TABLE 2-2 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
98	320.00	1283.4	0.998120	0.997770	1.5925	8.512	0.995
99	165.00	679.9	0.998078	0.997724	1.5921	7.121	0.991
100	315.00	1546.8	0.997747	0.997561	1.5908	4.968	0.956
101	300.00	1564.2	0.997882	0.997608	1.5912	4.403	0.969
102	275.00	1659.2	0.997904	0.997597	1.5911	3.242	0.972
103	340.00	2524.8	0.997882	0.997573	1.5909	2.100	0.972
104	193.00	2114.0	0.997882	0.997514	1.5904	0.910	0.969
151	290.50	390.5	1.042700	1.042680	1.5916	54.600	33.340
152	330.00	474.6	1.042800	1.042720	1.5916	47.450	33.250
153	345.00	540.8	1.042780	1.042700	1.5908	39.670	33.130
154	350.00	585.2	1.042820	1.042700	1.5905	34.650	33.070
155	350.00	648.8	1.042890	1.042820	1.5903	27.950	33.040
156	315.25	674.6	1.042960	1.042850	1.5902	20.790	32.840
157	355.00	872.6	1.043020	1.042900	1.5903	15.640	32.750
158	275.00	780.0	1.043000	1.042980	1.5902	11.620	32.770
159	245.00	792.8	1.043050	1.043060	1.5902	8.920	32.690
160	290.00	1148.6	1.043160	1.043170	1.5903	5.930	32.760
161	195.00	1082.0	1.043250	1.043240	1.5902	3.030	32.810
162	140.00	1191.9	1.043380	1.043340	1.5901	1.330	32.920
522	248.00	798.4	1.031890	1.031950	1.5951	9.130	17.400
522	248.00	798.4	1.031890	1.031950	0.0000	5.028	17.400
523	235.00	694.2	1.031650	1.031960	1.5949	11.050	16.950
523	235.00	694.2	1.031650	1.031960	0.0000	6.135	16.950
524	310.00	671.4	1.031500	1.031980	1.5946	21.180	16.850
524	310.00	671.4	1.031500	1.031980	0.0000	11.690	16.850
525	285.00	430.6	1.031220	1.031880	1.5943	44.200	16.500
525	285.00	430.6	1.031220	1.031880	0.0000	24.940	16.500
526	335.00	405.5	1.031210	1.031850	0.0000	39.790	16.460
526	335.00	405.5	1.031210	1.031850	13.5433	3.270	16.460
527	320.00	323.5	1.031090	1.031800	0.0000	58.210	16.290
528	310.00	268.8	1.031010	1.031800	0.0000	80.280	16.200
528	310.00	268.8	1.031010	1.031800	13.5429	6.540	16.200
529	340.00	259.8	1.030900	1.031770	0.0000	104.750	16.020
529	340.00	259.8	1.030900	1.031770	13.5423	8.475	16.020
530	330.00	227.6	1.031020	1.031730	0.0000	129.900	16.160
530	330.00	227.6	1.031020	1.031730	13.5420	10.590	16.160

TABLE 2-3

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE	STANDARD	2.0 INCH					
119	330.00	330.6	0.998035	0.998110	1.5953	44.930	0.986
120	360.00	391.1	0.997815	0.998029	1.5947	38.020	0.962
121	375.00	445.5	0.997724	0.997992	1.5943	32.110	0.954
122	370.00	484.0	0.997718	0.997926	1.5941	26.130	0.952
123	375.00	590.6	0.997701	0.997915	1.5937	18.020	0.951
124	400.00	732.6	0.997655	0.997849	1.5931	13.280	0.947
125	360.00	763.2	0.997632	0.997792	1.5927	9.870	0.945
126	350.00	809.3	0.997595	0.997692	1.5921	7.312	0.942
127	400.00	1098.6	0.997573	0.997514	1.5907	5.890	0.939
128	315.00	980.0	0.997561	0.997550	1.5907	4.550	0.939
129	285.00	1020.6	0.997573	0.997490	1.5902	3.414	0.939
130	298.00	1468.2	0.997573	0.997490	1.5902	1.756	0.939
144	335.00	292.2	1.042380	1.042620	1.5897	49.080	32.340
145	335.40	322.8	1.042400	1.041890	1.5895	39.870	32.380
146	375.00	404.4	1.042350	1.042100	1.5894	31.370	32.280
147	325.00	389.2	1.042350	1.042000	1.5889	25.190	32.290
148	330.00	437.8	1.042300	1.042000	1.5889	20.320	32.190
149	325.00	778.8	1.042300	1.041900	1.5886	16.410	32.190
150	290.00	495.0	1.042350	1.041900	1.5889	12.060	32.290
151	305.00	596.2	1.042450	1.041920	1.5882	9.050	32.550
152	360.00	776.4	1.042160	1.041960	1.5894	7.420	31.840
153	345.00	865.5	1.042300	1.041960	1.5887	5.450	32.180
154	245.00	865.2	1.042360	1.042000	1.5887	2.020	32.360
155	120.00	992.5	1.042920	1.042180	1.5896	0.774	33.760
516	270.00	586.8	1.030810	1.031220	0.0000	4.287	16.140
517	305.00	415.2	1.030800	1.031300	1.5925	20.400	16.000
517	305.00	415.2	1.030800	1.031300	0.0000	11.280	16.000
518	360.00	375.0	1.030810	1.031380	1.5928	35.680	16.090
518	360.00	375.0	1.030810	1.031380	0.0000	19.660	16.090
519	365.00	277.4	1.030840	1.031400	0.0000	37.950	16.110
519	365.00	277.4	1.030840	1.031400	13.5416	3.065	16.110
520	350.00	219.1	1.030810	1.031450	0.0000	56.900	16.100

TABLE 2-3 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
520	350.00	219.1	1.030810	1.031450	13.5417	4.640	16.100
521	210.00	217.6	1.030910	1.031560	0.0000	19.950	16.200

TABLE 2-4

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE		SHARP	1.0 INCH				
16	295.00	1019.5	0.997442	0.997585	1.5909	51.048	0.948
17	280.25	1008.7	0.997369	0.997970	1.5941	48.400	0.921
18	275.00	1071.5	0.997394	0.997992	1.5943	41.400	0.924
19	275.00	1049.6	0.997271	0.997678	1.5917	43.223	0.922
20	255.00	1064.4	0.997146	0.997418	1.5897	36.183	0.902
21	280.00	1136.9	0.997146	0.997246	1.5884	38.383	0.902
22	250.00	1119.9	0.997120	0.997196	1.5800	31.507	0.900
23	230.00	1145.9	0.997146	0.997171	1.5765	25.360	0.902
24	210.00	1130.7	0.997120	0.997146	1.5765	21.685	0.900
25	200.00	1176.2	0.997221	0.997120	1.5745	18.170	0.909
26	160.00	1052.0	0.997992	0.997171	1.5780	14.573	0.914
65	240.00	1663.8	0.998244	0.997345	1.5891	12.792	1.100
66	205.00	1684.3	0.998162	0.998345	1.5975	9.945	1.000
67	260.00	2264.0	0.998224	0.998424	1.5982	8.063	1.078
68	210.00	2046.3	0.998405	0.998244	1.5979	6.371	1.100
69	170.00	1927.1	0.998078	0.998305	1.5971	4.649	0.991
70	130.00	1717.1	0.997948	0.998224	1.5964	3.395	0.976
71	100.00	1949.9	0.998120	0.998203	1.5962	1.526	0.996
72	90.00	2786.4	0.997837	0.998141	1.5956	0.617	0.965
163	265.00	858.0	1.042680	1.042390	1.5874	52.860	32.780
164	290.00	1020.4	1.042750	1.042580	1.5878	44.810	32.800
165	248.00	938.5	1.042960	1.042780	1.5880	38.530	32.830
166	258.00	1087.0	1.042920	1.042860	1.5882	30.880	32.860
167	250.00	1208.0	1.043110	1.043000	1.5883	23.150	32.930

TABLE 2-4 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
168	210.00	1243.4	1.043250	1.043150	1.5883	15.170	32.930
169	180.00	1191.6	1.043420	1.043280	1.5884	12.130	32.990
170	180.00	1356.5	1.043410	1.043180	1.5878	9.160	32.750
172	132.00	1306.2	1.042700	1.042500	1.5858	5.280	31.600
173	230.00	2718.2	1.042900	1.042590	1.5858	3.540	31.980
174	85.00	1877.8	1.042980	1.042590	1.5852	1.000	31.930
537	89.00	756.4	1.031400	1.031320	1.5926	7.450	17.450
537	89.00	756.4	1.031400	1.031320	0.0000	4.075	17.450
538	122.00	649.7	1.031250	1.031270	1.5939	19.440	17.200
538	122.00	649.7	1.031250	1.031270	0.0000	10.680	17.200
539	179.00	676.3	1.031210	1.031800	1.5915	39.660	17.100
539	179.00	676.3	1.031210	1.031800	0.0000	21.716	17.100
540	199.00	583.7	1.031180	1.031220	0.0000	36.400	17.000
540	199.00	583.7	1.031180	1.031220	13.5400	2.950	17.000
541	244.00	567.7	1.031100	1.031100	0.0000	58.390	16.840
541	244.00	567.7	1.031100	1.031100	13.5395	4.725	16.840
542	245.00	479.4	1.031120	1.031110	0.0000	83.080	16.860
542	245.00	479.4	1.031120	1.031110	13.5391	6.750	16.860
543	293.00	494.9	1.031070	1.031080	0.0000	112.320	16.750
543	293.00	494.9	1.031070	1.031080	13.5390	9.195	16.750
544	295.00	446.7	1.031010	1.030980	13.5384	11.470	16.700
545	303.00	398.3	1.031060	1.031100	13.5390	15.400	16.720
546	285.00	335.0	1.031050	1.031210	13.5398	19.240	16.730
547	280.00	292.6	1.031020	1.031280	13.5401	24.400	16.680
548	275.00	257.9	1.030980	1.031310	13.5402	30.420	16.630

TABLE 2-5

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE		SHARP	1.5 INCH				
37	290.00	488.4	0.997196	0.997146	1.5765	44.376	0.917
38	315.00	560.7	0.997069	0.997345	1.5891	39.855	0.896
39	325.00	612.0	0.997105	0.997296	1.5888	35.352	0.899
40	270.00	538.1	0.997069	0.997296	1.5888	31.615	0.896
41	280.00	613.6	0.997018	0.997246	1.5882	26.782	0.892
42	250.00	595.7	0.997018	0.997246	1.5882	22.187	0.892
43	245.00	652.5	0.997146	0.997394	1.5895	17.670	0.902
44	250.00	724.0	0.997296	0.997490	1.5902	14.894	0.914
45	235.00	747.8	0.997369	0.997514	1.5904	12.313	0.921
46	290.00	941.8	0.997221	0.997538	1.5906	11.940	0.909
47	265.00	890.5	0.997044	0.997345	1.5891	11.102	0.894
48	285.00	1008.7	0.997120	0.997271	1.5886	9.968	0.900
49	290.00	1065.8	0.997095	0.997538	1.5906	9.156	0.898
50	225.00	879.8	0.997271	0.997724	1.5921	8.065	0.913
51	265.00	1131.7	0.997369	0.997490	1.5902	6.774	0.921
52	235.00	1062.8	0.997320	0.997701	1.5919	6.018	0.917
53	240.00	1189.3	0.997320	0.997538	1.5906	5.050	0.917
54	225.00	1283.9	0.997146	0.997724	1.5921	3.748	0.902
55	200.00	1346.6	0.997271	0.997724	1.5921	2.650	0.913
56	190.00	1775.5	0.997246	0.997120	1.5874	1.345	0.910
57	129.00	1977.7	0.997320	0.997320	1.5889	0.496	0.917
184	375.00	539.8	1.042900	1.043120	1.5890	54.700	32.280
185	385.00	707.0	1.042900	1.043090	1.5888	32.980	32.220
186	360.00	562.4	1.043040	1.043090	1.5889	46.220	32.690
187	310.00	512.4	1.042850	1.043190	1.5891	41.330	32.120
188	365.00	735.8	1.042820	1.043170	1.5891	27.360	32.020
189	415.00	964.6	1.042780	1.043080	1.5887	20.410	31.970
190	395.00	1038.6	1.042790	1.043080	1.5886	15.750	31.900
191	345.00	1045.4	1.042270	1.042900	1.5877	11.770	30.610
192	335.00	1146.0	1.042440	1.042760	1.5872	9.120	31.000
193	250.00	952.6	1.042520	1.043460	1.5901	7.340	31.260
194	205.00	969.4	1.042540	1.042780	1.5863	4.665	31.350

TABLE 2-5 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
195	135.00	1088.4	1.042570	1.042450	1.5857	1.570	31.410
557	165.00	562.8	1.031080	1.031400	1.5916	9.500	16.670
557	165.00	562.8	1.031080	1.031400	0.0000	5.240	16.670
558	230.00	530.5	1.031060	1.031420	1.5915	20.960	16.620
558	230.00	530.5	1.031060	1.031420	0.0000	11.570	16.620
559	275.00	498.6	1.031080	1.031420	1.5915	34.330	16.630
559	275.00	498.6	1.031080	1.031420	0.0000	18.878	16.630
560	305.00	410.5	1.031120	1.031450	0.0000	34.810	16.670
560	305.00	410.5	1.031120	1.031450	13.5401	2.850	16.670
561	370.00	438.1	1.031050	1.031480	0.0000	45.310	16.570
561	370.00	438.1	1.031050	1.031480	13.5402	3.690	16.570
562	295.00	303.3	1.031070	1.031510	0.0000	60.380	16.580
562	295.00	303.3	1.031070	1.031510	13.5406	4.980	16.580
563	300.00	268.8	1.031090	1.031520	0.0000	79.620	16.600
563	300.00	268.8	1.031090	1.031520	13.5408	6.500	16.600
564	300.00	230.0	1.031100	1.031590	0.0000	109.350	16.610
564	300.00	230.0	1.031100	1.031590	13.5411	8.880	16.610
565	300.00	211.3	1.031080	1.031640	0.0000	128.630	16.560
565	300.00	211.3	1.031080	1.031640	13.5411	10.500	16.560

TABLE 2-6

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE	SHARP	2.0-INCH					
73	265.00	254.8	0.997792	0.998035	1.5947	48.190	0.960
74	350.00	361.8	0.997915	0.997948	1.5940	41.650	0.973
75	385.00	424.4	0.997821	0.997815	1.5928	36.712	0.961
76	385.00	465.6	0.997759	0.997918	1.5937	30.550	0.957
77	390.00	509.7	0.997926	0.997666	1.5916	26.000	0.974

TABLE 2-6 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
78	380.00	554.4	0.998045	0.997826	1.5930	21.010	0.987
79	385.00	646.2	0.993193	0.997826	1.5930	15.730	1.003
80	390.00	763.8	0.998183	0.997826	1.5930	11.510	1.002
81	385.00	825.2	0.998130	0.997735	1.5922	9.600	0.994
82	370.00	911.8	0.998067	0.997804	1.5927	7.230	0.989
83	370.00	1023.2	0.998045	0.997644	1.5914	5.742	0.987
84	360.00	1270.6	0.997904	0.997618	1.5911	3.546	0.972
85	260.00	1229.6	0.997886	0.997618	1.5911	1.929	0.970
86	280.00	1650.2	0.997886	0.997644	1.5913	1.212	0.970
172	320.00	267.0	1.041570	1.041780	1.5860	59.150	30.780
173	320.00	283.4	1.041600	1.041840	1.5862	52.190	30.810
174	365.00	351.3	1.041920	1.041600	1.5850	44.160	32.550
175	360.00	376.8	1.041920	1.041570	1.5848	37.210	31.450
176	390.00	473.4	1.041950	1.041580	1.5847	27.400	31.460
177	350.00	501.0	1.041980	1.041670	1.5850	19.580	31.470
178	345.00	589.8	1.041900	1.041700	1.5852	13.460	31.270
179	320.00	627.9	1.041910	1.041700	1.5851	10.120	31.280
180	240.00	526.1	1.041510	1.041750	1.5852	8.060	30.240
181	350.00	908.6	1.041760	1.041670	1.5848	5.640	30.800
182	275.00	1002.2	1.041610	1.041530	1.5842	2.890	31.010
183	255.00	1366.2	1.041930	1.041610	1.5840	1.330	31.190
549	260.00	636.4	1.030910	1.031380	1.5922	6.560	16.500
550	295.00	496.0	1.030930	1.031320	1.5918	14.210	16.510
550	295.00	496.0	1.030930	1.031320	0.0000	7.816	16.510
549	260.00	636.4	1.030910	1.031380	0.0000	3.656	16.500
551	355.00	462.4	1.030900	1.031300	1.5917	23.890	16.440
551	355.00	462.4	1.030900	1.031300	0.0000	13.120	16.440
552	350.00	373.9	1.030970	1.031400	1.5917	35.995	16.530
552	350.00	373.9	1.030970	1.031400	0.0000	19.670	16.530
553	310.00	261.8	1.031000	1.031420	0.0000	31.800	16.540
554	300.00	282.6	1.030980	1.031420	0.0000	25.450	16.530
555	350.00	256.2	1.031010	1.031370	0.0000	42.380	16.600
556	350.00	232.3	1.031040	1.031390	0.0000	51.570	16.610

TABLE 2-7

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE		G.S.	BETA=0.2				
226	148.00	1611.6	1.042190	1.042270	1.5899	67.660	31.910
227	100.00	1187.6	1.042200	1.042030	1.5882	58.070	31.850
228	100.00	1294.9	1.042360	1.041990	1.5878	48.980	32.100
229	101.00	1427.8	1.042300	1.041970	1.5874	41.280	31.940
230	114.00	1791.4	1.042350	1.041920	1.5871	33.590	31.940
231	80.00	1472.9	1.042320	1.041850	1.5866	24.950	31.700
232	72.00	1622.6	1.042400	1.041870	1.5862	16.950	31.700
233	65.00	1856.0	1.042440	1.041890	1.5860	9.840	31.670
384	72.00	797.8	1.028550	1.028350	1.5877	69.040	14.165
385	54.00	853.8	1.028600	1.028370	1.5872	32.740	14.155
386	68.00	1786.0	1.028650	1.028400	1.5871	11.810	14.165
396	87.00	1709.4	1.029760	1.030580	0.0000	11.400	15.340
397	87.00	1054.2	1.029730	1.030310	0.0000	31.120	15.310
398	90.00	941.8	1.029550	1.030020	0.0000	42.460	15.110
399	89.00	807.9	1.029430	1.030060	0.0000	57.830	15.020
400	110.00	893.3	1.029480	1.030000	0.0000	75.330	15.020
401	146.00	1077.2	1.029350	1.029870	0.0000	93.900	14.930
402	158.00	1045.8	1.029360	1.029860	0.0000	120.070	14.920
403	144.00	870.8	1.029360	1.029830	13.5413	11.960	14.900
404	194.00	1034.5	1.029310	1.029840	13.5411	15.310	14.840
405	205.00	977.6	1.029330	1.029840	13.5411	19.260	14.840
406	193.00	834.2	1.029340	1.029850	13.5410	23.660	14.840
407	248.00	997.0	1.029340	1.029890	13.5412	27.580	14.830
408	218.00	802.8	1.029350	1.029910	13.5412	33.310	14.840
409	194.00	667.4	1.029360	1.029930	13.5411	40.040	14.830
410	226.00	730.1	1.029410	1.029950	13.5409	45.570	14.850
411	268.00	821.8	1.029420	1.029910	13.5408	50.850	14.850
211	168.00	897.5	1.042300	1.042510	1.5901	59.900	31.860
212	160.00	902.9	1.042260	1.042410	1.5898	53.570	31.830
213	186.00	1107.8	1.042190	1.042360	1.5897	47.870	31.680
214	130.00	801.5	1.042100	1.042220	1.5897	44.630	31.540
215	133.00	871.4	1.042070	1.042170	1.5895	39.390	31.500

TABLE 2-7 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
216	145.00	1017.3	1.042000	1.042110	1.5890	34.520	31.370
217	103.00	813.0	1.041910	1.042090	1.5887	27.130	31.350
218	100.00	890.4	1.041880	1.042020	1.5888	21.390	31.280
219	188.00	1865.2	1.041800	1.042000	1.5885	17.290	31.190
220	95.00	1056.5	1.041770	1.041860	1.5878	13.800	31.150
221	94.00	1208.6	1.041760	1.041810	1.5877	10.370	31.190
222	103.00	1440.0	1.041800	1.041890	1.5898	8.788	31.700
223	95.00	1494.0	1.042160	1.042150	1.5895	7.001	31.800
224	86.00	1647.6	1.042140	1.042170	1.5893	4.829	31.830
393	227.00	2540.8	1.028850	1.028450	1.5858	13.780	13.980
394	125.00	1081.2	1.028790	1.028460	1.5858	23.390	13.875
421	92.00	877.7	1.029730	1.030140	0.0000	10.350	15.210
422	200.00	1324.8	1.029630	1.030070	0.0000	22.350	15.110
423	154.00	805.4	1.029570	1.030000	0.0000	37.460	15.025
424	216.00	1008.6	1.029480	1.029930	0.0000	48.160	14.940
425	187.00	801.6	1.029450	1.029900	0.0000	60.900	14.900
425	187.00	782.6	1.029450	1.029900	0.0000	60.900	14.900
426	304.00	1141.4	1.029480	1.029840	0.0000	77.250	14.940
427	194.00	589.8	1.029430	1.029790	0.0000	121.770	14.890
428	197.00	653.4	1.029440	1.029740	0.0000	100.860	14.910
429	225.00	657.8	1.029400	1.029670	0.0000	136.000	14.860
430	310.00	852.2	1.029400	1.029630	13.5363	11.050	14.860
431	195.00	495.6	1.029320	1.029510	13.5390	14.410	14.780
432	203.00	463.6	1.029310	1.029500	13.5387	18.160	14.770
433	244.00	508.3	1.029690	1.029570	13.5389	22.000	15.180
434	245.00	466.4	1.029420	1.029560	13.5388	26.630	14.900
435	250.00	431.4	1.029410	1.029580	13.5386	32.730	14.900
436	250.00	397.9	1.029400	1.029550	13.5382	38.810	14.880
196	235.00	743.8	1.041960	1.042160	1.5895	58.700	31.810
197	255.00	842.5	1.041970	1.042160	1.5894	53.570	31.760
198	240.00	837.9	1.042010	1.042410	1.5902	47.840	31.840
199	200.00	744.7	1.042030	1.042360	1.5902	41.710	31.870
200	215.00	854.5	1.042060	1.042410	1.5902	36.490	31.970
201	190.00	809.1	1.042130	1.042440	1.5901	31.580	32.060
202	180.00	861.4	1.042200	1.042340	1.5900	24.860	32.140
203	155.00	818.8	1.042500	1.042340	1.5901	16.340	32.310

TABLE 2-7 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
204	155.00	1058.4	1.042250	1.042380	1.5900	12.160	32.280
205	150.00	794.8	1.042290	1.042240	1.5898	20.150	32.330
206	115.00	857.6	1.042310	1.042230	1.5895	10.210	32.300
207	103.00	870.3	1.042340	1.042150	1.5891	7.950	32.300
208	97.00	962.0	1.042300	1.041860	1.5885	5.832	32.140
209	77.00	957.0	1.042330	1.041830	1.5882	3.812	32.080
210	80.00	1530.6	1.042380	1.041800	1.5878	1.661	32.080
387	260.00	834.4	1.028850	1.028350	1.5869	63.920	14.380
388	235.00	839.0	1.028890	1.024420	1.5865	50.930	14.280
389	185.00	742.3	1.028910	1.028450	1.5864	39.640	14.275
390	236.00	1058.8	1.028950	1.028380	1.5859	31.220	14.250
391	159.00	825.5	1.029020	1.028380	1.5856	22.810	14.260
392	157.00	1219.0	1.029080	1.028460	1.5859	9.720	14.300
412	156.00	838.4	1.029590	1.030030	0.0000	11.290	15.010
413	190.00	764.6	1.029510	1.030050	0.0000	21.070	14.900
414	220.00	724.4	1.029540	1.030050	0.0000	32.600	14.960
415	270.00	762.0	1.029360	1.030060	0.0000	47.130	14.950
415	270.00	749.3	1.029360	1.030060	0.0000	47.130	14.950
416	270.00	663.4	1.029590	1.030070	0.0000	61.430	14.970
417	293.00	654.6	1.029570	1.030080	0.0000	75.290	14.940
418	305.00	614.2	1.029600	1.030130	0.0000	94.050	14.960
419	275.00	508.8	1.029610	1.030090	0.0000	112.180	14.970
420	290.00	504.2	1.029620	1.030190	0.0000	128.170	14.970

TABLE 2-8

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE		G.S.	BETA=0.4				
278	252.00	730.7	1.045490	1.045710	1.5918	60.340	36.000
279	375.00	1192.1	1.045380	1.045630	1.5916	49.830	35.870
280	245.00	843.5	1.045290	1.045500	1.5916	42.320	35.830
281	301.00	1127.5	1.045160	1.045140	1.5903	35.720	35.900
282	230.00	972.8	1.045030	1.044930	1.5897	27.900	36.080
283	330.00	1669.5	1.045060	1.044970	1.5893	19.410	36.160
284	182.00	1054.2	1.045070	1.044870	1.5889	14.810	36.470
285	160.00	1095.3	1.044980	1.044730	1.5887	10.650	36.520
286	121.00	949.8	1.045000	1.044780	1.5890	8.160	36.900
287	170.00	1829.2	1.044780	1.044480	1.5885	4.578	36.410
288	130.00	1494.4	1.044690	1.044250	1.5876	3.800	36.470
289	152.00	2122.6	1.044610	1.044000	1.5871	2.768	36.430
290	105.00	2458.4	1.044480	1.043980	1.5871	1.031	36.280
335	225.00	643.5	1.036350	1.036220	1.5886	64.450	22.600
336	215.00	660.7	1.036380	1.036250	1.5885	55.490	21.980
337	310.00	1037.5	1.036380	1.036220	1.5883	46.440	22.450
338	245.00	901.4	1.036350	1.036180	1.5881	38.150	22.330
339	165.00	682.4	1.036480	1.036340	1.5880	29.940	22.530
340	175.00	830.8	1.036540	1.036300	1.5879	22.500	22.530
341	157.00	830.4	1.036590	1.036400	1.5878	17.930	22.530
342	150.00	959.6	1.036570	1.036400	1.5876	12.190	22.580
343	140.00	1115.4	1.036720	1.036500	1.5877	7.980	22.680
452	160.00	579.8	1.029070	1.029870	0.0000	11.080	14.770
453	168.00	624.0	1.029780	1.030170	0.0000	21.330	15.500
454	180.00	541.5	1.029680	1.030060	0.0000	32.970	15.370
455	230.00	870.0	1.029680	1.029880	0.0000	20.330	15.370
456	220.00	566.5	1.029550	1.029870	0.0000	45.910	15.240
457	231.00	531.8	1.029710	1.029930	0.0000	58.000	15.470
458	220.00	416.5	1.029400	1.029880	0.0000	87.930	15.010
459	265.00	441.6	1.029310	1.029880	0.0000	114.890	14.930
460	260.00	380.2	1.029360	1.029810	13.5426	12.230	14.980
461	235.00	265.4	1.029330	1.029670	13.5421	16.080	14.970

TABLE 2-8 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
462	300.00	335.1	1.029340	1.029740	13.5419	19.960	14.980
463	275.00	283.6	1.029310	1.029720	13.5419	25.470	14.975
496	122.00	793.5	1.030100	1.030680	0.0000	6.640	15.730
496	122.00	793.5	1.030100	1.030680	1.5929	11.940	15.730
497	170.00	561.4	1.030010	1.030620	1.5927	49.280	15.610
497	170.00	561.4	1.030010	1.030620	0.0000	27.060	15.610
498	223.00	531.0	1.030010	1.030610	0.0000	53.820	15.580
498	223.00	531.0	1.030010	1.030610	13.5407	4.330	15.580
499	305.00	635.2	1.030000	1.030590	0.0000	71.580	15.570
500	305.00	635.2	1.030000	1.030590	13.5405	5.850	15.570
500	205.00	331.0	1.030030	1.030580	0.0000	121.800	15.620
500	205.00	331.0	1.030030	1.030580	13.5400	9.890	15.620
501	265.00	385.7	1.031000	1.031700	13.5483	12.270	17.150
502	300.00	393.8	1.031030	1.031580	13.5480	15.060	17.200
503	250.00	296.8	1.030970	1.031500	13.5477	18.900	17.080
504	300.00	327.2	1.030900	1.031420	13.5471	22.780	16.980
303	350.00	482.2	1.043810	1.043610	1.5862	58.260	34.890
304	380.00	557.4	1.043880	1.043820	1.5866	51.050	34.810
305	375.00	596.9	1.043980	1.043830	1.5864	43.170	34.890
306	390.00	682.9	1.043980	1.043800	1.5860	35.320	34.890
307	365.00	732.0	1.044100	1.043990	1.5858	26.650	34.880
308	400.00	923.0	1.044200	1.044930	1.5856	19.960	34.900
309	279.00	723.4	1.044280	1.043900	1.5849	15.770	34.920
310	290.00	916.8	1.044370	1.043950	1.5847	10.530	34.940
311	208.00	768.6	1.044430	1.044000	1.5844	7.660	34.980
312	293.00	1223.5	1.044470	1.044980	1.5839	6.024	34.940
313	195.00	1046.4	1.044400	1.043900	1.5834	3.654	34.740
314	300.00	2452.0	1.044500	1.044050	1.5831	1.610	34.650
315	400.00	583.0	1.036120	1.035660	1.5876	53.540	22.600
316	380.00	610.4	1.036210	1.035680	1.5874	43.620	22.750
318	284.50	504.2	1.036210	1.035620	1.5872	35.420	22.750
319	365.00	744.8	1.035900	1.035580	1.5871	26.430	22.330
320	280.00	699.8	1.035800	1.035510	1.5869	17.410	22.150
321	230.00	636.4	1.035760	1.035510	1.5869	13.960	22.110
322	340.00	1070.6	1.035750	1.035480	1.5869	10.630	22.100
323	225.00	899.2	1.035650	1.035230	1.5869	6.550	21.970

TABLE 2-8 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
324	215.00	1106.4	1.035640	1.035120	1.5869	3.900	21.980
325	115.00	1146.7	1.035640	1.035140	1.5870	1.050	21.970
326	290.00	436.4	1.035590	1.035180	1.5869	50.500	21.890
327	255.00	413.5	1.035560	1.035180	1.5872	42.930	21.860
320	280.00	699.8	1.035800	1.035510	0.8739	59.760	22.150
321	230.00	636.4	1.035760	1.035510	0.8739	47.890	22.110
322	340.00	1070.8	1.035750	1.035480	0.8738	36.460	22.100
323	225.00	899.2	1.035650	1.035230	0.8733	22.460	21.970
324	215.00	1106.4	1.035640	1.035120	0.8731	13.230	21.980
325	115.00	1146.7	1.035640	1.035140	0.8731	3.350	21.970
347	101.00	1049.3	1.035720	1.035110	0.8719	3.520	21.970
347	101.00	1049.3	1.035720	1.035110	1.5847	0.950	21.970
348	174.00	827.0	1.035700	1.035020	1.5844	4.615	21.880
348	174.00	827.0	1.035700	1.035020	0.8716	16.130	21.880
349	225.00	768.2	1.035770	1.034980	1.5841	9.120	21.920
349	225.00	768.2	1.035770	1.034980	0.8714	31.480	21.920
350	265.00	732.3	1.035830	1.035010	1.5839	14.150	21.990
350	265.00	732.3	1.035830	1.035010	0.8714	48.550	21.990
351	265.00	620.0	1.035930	1.035000	1.5837	20.040	22.110
352	270.00	543.4	1.035990	1.035090	1.5838	27.420	22.090
353	235.00	437.7	1.036010	1.035100	1.5836	32.470	22.080
354	290.00	506.0	1.036130	1.035190	1.5834	36.970	22.220
355	305.00	507.6	1.036150	1.035130	1.5832	40.950	22.180
356	280.00	448.2	1.036150	1.035160	1.5829	44.560	22.140
357	315.00	478.4	1.036210	1.035280	1.5830	49.750	22.190
358	290.00	430.2	1.036280	1.035360	1.5832	52.100	22.240
437	224.00	538.4	1.029410	1.030250	0.0000	5.410	15.170
438	250.00	417.4	1.029390	1.030230	0.0000	11.520	15.135
439	320.00	454.4	1.029320	1.030230	0.0000	16.160	15.060
440	320.00	377.0	1.029230	1.030080	0.0000	23.790	14.950
441	315.00	327.3	1.029210	1.030080	0.0000	30.790	14.930
442	330.00	298.4	1.029040	1.029830	0.0000	40.970	14.740
443	320.00	308.4	1.029060	1.029810	0.0000	35.900	14.750
444	265.00	222.6	1.028960	1.029890	0.0000	47.350	14.630
445	280.00	245.6	1.028970	1.029880	0.0000	61.200	14.640
479	190.00	681.0	1.030680	1.031130	1.5957	8.120	16.630

TABLE 2-8 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
479	190.00	681.0	1.030680	1.031130	0.0000	4.560	16.630
480	273.00	625.8	1.030720	1.031070	1.5952	20.940	16.700
480	273.00	625.8	1.030720	1.031070	0.0000	11.580	16.700
481	265.00	475.7	1.030570	1.030940	1.5945	35.080	16.440
481	265.00	475.7	1.030570	1.030940	0.0000	19.280	16.440
482	275.00	420.0	1.030610	1.030900	0.0000	27.280	16.510
483	290.00	367.2	1.030590	1.030830	0.0000	40.690	16.460
483	290.00	367.2	1.030590	1.030830	13.5420	3.230	16.460
484	250.00	282.4	1.030480	1.030800	0.0000	51.690	16.280
484	250.00	282.4	1.030480	1.030800	13.5416	4.170	16.280
485	300.00	288.3	1.030350	1.030700	0.0000	72.620	16.110
485	300.00	288.3	1.030350	1.030700	13.5411	5.950	16.110
486	300.00	254.0	1.030340	1.030730	0.0000	94.170	16.100
486	300.00	254.0	1.030340	1.030730	13.5409	7.670	16.100
487	325.00	256.4	1.030250	1.030620	0.0000	109.890	15.950
487	325.00	256.4	1.030250	1.030620	13.5405	8.900	15.950
291	310.00	283.9	1.044060	1.043870	1.5884	60.110	35.650
292	345.00	289.0	1.044050	1.043810	1.5880	52.870	35.520
293	335.00	312.0	1.044080	1.043760	1.5875	42.560	35.510
294	390.00	424.9	1.044150	1.043760	1.5873	30.590	35.720
295	370.00	448.2	1.044250	1.043630	1.5869	24.530	35.890
296	350.00	476.3	1.044180	1.043790	1.5867	19.160	35.820
297	350.00	527.3	1.044150	1.043820	1.5867	15.580	35.760
298	275.00	470.4	1.044140	1.043900	1.5863	11.970	35.600
299	200.00	414.9	1.044140	1.043880	1.5861	8.080	35.510
300	290.00	742.7	1.044190	1.043770	1.5860	5.276	35.520
301	305.00	975.8	1.044300	1.043620	1.5852	3.369	35.800
302	332.00	1460.0	1.044250	1.043480	1.5846	1.689	35.550
327	140.00	868.5	1.036230	1.035990	0.8735	3.000	22.640
327	140.00	868.5	1.036320	1.035990	1.5879	0.890	22.640
328	250.00	636.4	1.036300	1.036020	1.5876	5.350	22.620
328	250.00	636.4	1.036300	1.036020	0.8733	18.690	22.620
329	230.00	786.4	1.036360	1.036080	1.5876	2.950	22.520
329	230.00	786.4	1.036360	1.036080	0.8733	10.300	22.520
330	375.00	777.0	1.036350	1.036100	1.5875	8.190	22.320
330	375.00	777.0	1.036360	1.036100	0.8733	28.520	22.320

TABLE 2-8 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
331	280.00	493.6	1.036250	1.036190	1.5873	11.480	21.910
331	280.00	493.6	1.036250	1.036190	0.8733	39.970	21.910
332	345.00	544.4	1.036310	1.036210	1.5873	14.550	21.980
332	345.00	544.4	1.036310	1.036210	0.8734	50.470	21.980
334	315.00	396.1	1.036250	1.036410	1.5874	23.550	21.730
334	315.00	396.1	1.036250	1.036410	0.8736	82.000	21.730
344	225.00	604.2	1.036950	1.036600	1.5877	2.870	22.970
344	225.00	604.2	1.036950	1.036600	0.8741	10.030	22.970
345	280.00	536.4	1.037130	1.036580	1.5877	5.760	23.140
345	280.00	536.4	1.037130	1.036580	0.8739	19.720	23.140
346	240.00	357.2	1.037260	1.036620	1.5876	13.170	23.260
346	240.00	357.2	1.037260	1.036620	0.8740	49.220	23.260
447	325.00	365.0	1.028990	1.029850	0.0000	8.920	14.670
446	300.00	485.4	1.028990	1.029850	0.0000	4.100	14.670
448	340.00	317.0	1.028990	1.029820	0.0000	13.170	14.670
449	360.00	307.0	1.028990	1.029870	0.0000	15.920	14.670
450	375.00	274.6	1.028990	1.029830	0.0000	21.700	14.670
451	390.00	259.4	1.028980	1.029830	0.0000	26.470	14.650
488	236.00	630.0	1.030160	1.030570	1.5927	5.110	15.800
288	236.00	630.0	1.030160	1.030570	0.0000	2.870	15.800
289	245.00	634.5	1.030160	1.030570	1.5923	5.333	15.800
289	245.00	634.5	1.030160	1.030570	0.0000	3.000	15.800
490	325.00	611.4	1.030130	1.030660	1.5928	10.330	15.710
490	325.00	611.4	1.030130	1.030660	0.0000	5.740	15.710
491	320.00	389.3	1.030110	1.030770	1.5935	26.080	15.730
491	320.00	389.3	1.030110	1.030770	0.0000	14.370	15.730
492	315.00	333.4	1.030110	1.030810	1.5938	34.970	15.750
492	315.00	333.4	1.030110	1.030810	0.0000	19.310	15.750
493	325.00	289.2	1.030100	1.030850	0.0000	27.530	15.710
493	325.00	289.2	1.030100	1.030850	13.5416	2.215	15.710
494	365.00	283.0	1.030070	1.030800	0.0000	36.890	15.670
494	365.00	283.0	1.030070	1.030800	13.5415	3.060	15.670
495	370.00	255.1	1.030080	1.030670	0.0000	46.910	15.670
495	370.00	255.1	1.030080	1.030670	13.5414	3.820	15.670

TABLE 2-9

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE		G.S.	BETA=0.6				
235	355.00	430.1	1.044350	1.044390	1.5930	51.970	36.830
236	335.00	433.4	1.044280	1.044380	1.5925	45.080	36.300
237	330.00	470.5	1.044000	1.044200	1.5920	37.310	35.850
238	400.00	655.0	1.043920	1.044090	1.5916	28.810	35.720
239	390.00	746.9	1.043870	1.044030	1.5912	21.250	35.600
240	305.00	645.6	1.043630	1.044070	1.5906	17.050	34.980
241	280.00	688.2	1.043700	1.043990	1.5903	12.580	35.190
242	265.00	728.4	1.043680	1.043890	1.5902	10.040	35.280
243	230.00	718.0	1.043680	1.043810	1.5900	7.810	35.320
244	252.00	964.6	1.043710	1.043700	1.5896	5.160	35.490
245	197.00	930.0	1.043760	1.043790	1.5900	3.460	35.700
246	140.00	932.9	1.043710	1.043780	1.5901	1.820	35.670
247	245.00	531.6	1.043710	1.043980	1.5902	16.190	35.700
248	290.00	549.4	1.043700	1.043770	1.5903	21.130	35.690
377	180.00	1152.8	1.037320	1.037210	1.5877	2.020	23.450
378	190.00	699.0	1.037450	1.037240	1.5874	5.850	23.630
379	245.00	716.6	1.037660	1.037310	1.5873	8.880	23.760
380	275.00	641.6	1.037600	1.037350	1.5896	14.110	23.770
381	330.00	681.1	1.037520	1.037380	1.5866	18.000	23.720
382	280.00	505.8	1.037670	1.037450	1.5864	23.830	23.780
383	285.00	473.8	1.037620	1.037540	1.5864	28.270	23.830
602	240.00	941.2	1.031790	1.032090	1.5918	4.980	17.600
603	210.00	409.4	1.031680	1.032110	1.5916	19.970	17.440
604	245.00	344.0	1.031700	1.032090	1.5916	40.230	17.410
605	300.00	330.6	1.031690	1.032080	0.0000	36.605	17.450
606	360.00	337.3	1.031670	1.032080	0.0000	51.640	17.320
607	300.00	256.0	1.031610	1.032080	0.0000	63.130	17.350
608	340.00	245.7	1.031640	1.032070	0.0000	90.150	17.390
609	330.00	228.2	1.031590	1.032070	0.0000	99.550	17.310
610	300.00	337.2	1.031590	1.032000	0.0000	35.110	17.320
611	300.00	278.0	1.031550	1.032040	0.0000	53.200	17.280
612	145.00	420.7	1.031950	1.032090	1.5915	9.030	17.270

TABLE 2-9 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
613	140.00	224.9	1.031490	1.032110	1.5915	30.465	17.190
614	200.00	330.6	1.031550	1.032080	1.5915	28.660	17.270
657	191.00	1114.7	1.046800	1.048050	1.5950	3.035	41.350
658	295.00	761.0	1.046850	1.047750	0.8767	36.640	42.300
658	295.00	761.0	1.046850	1.047750	1.5934	11.490	42.300
659	328.00	1237.8	1.046940	1.047710	0.8763	17.460	42.050
659	328.00	1237.8	1.046940	1.047710	1.5932	5.480	42.050
660	245.00	1072.0	1.046890	1.047730	0.8767	13.075	41.820
660	245.00	1072.0	1.046890	1.047730	1.5930	4.160	41.820
661	285.00	596.8	1.046830	1.047720	1.5929	17.260	41.590
661	285.00	596.8	1.046830	1.047720	0.0000	8.980	41.590
662	262.00	465.4	1.046940	1.047770	1.5929	24.180	42.010
662	262.00	465.4	1.046940	1.047770	0.0000	12.535	42.010
663	280.00	406.6	1.046920	1.047800	1.5933	36.145	41.960
663	280.00	406.6	1.046920	1.047800	0.0000	18.970	41.960
664	295.00	326.6	1.046940	1.047760	0.0000	32.800	42.080
664	295.00	326.6	1.046940	1.047760	13.5426	2.740	42.080
665	310.00	341.2	1.047030	1.047800	0.0000	33.250	42.480
665	310.00	341.2	1.047030	1.047800	13.5423	2.785	42.480
666	285.00	268.6	1.046990	1.047880	0.0000	45.710	42.300
666	285.00	268.6	1.046990	1.047880	13.5429	3.860	42.300
667	340.00	295.6	1.047040	1.047880	0.0000	53.990	42.480
667	340.00	295.6	1.047040	1.047880	13.5431	4.640	42.480
668	300.00	246.5	1.047020	1.047900	0.0000	61.816	42.480
668	300.00	246.5	1.047020	1.047900	13.5431	5.170	42.480
669	110.00	632.6	1.047080	1.047810	0.8769	7.150	42.630
669	110.00	632.6	1.047080	1.047810	1.5933	2.415	42.630
670	189.00	817.9	1.047190	1.048120	0.8778	12.890	43.150
670	189.00	817.9	1.047190	1.048120	1.5943	4.130	43.150
263	365.00	250.1	1.044240	1.044560	1.5924	35.150	36.040
264	340.00	248.0	1.044240	1.044640	1.5927	30.860	35.990
265	375.00	290.0	1.044240	1.044730	1.5931	27.340	36.010
266	375.00	317.0	1.044230	1.044740	1.5933	22.850	36.010
267	365.00	335.6	1.044250	1.044670	1.5929	19.080	36.070
268	390.00	399.8	1.044240	1.044630	1.5927	15.350	36.010
269	365.00	397.0	1.044240	1.044540	1.5924	13.530	36.010

TABLE 2-9 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
270	335.00	394.2	1.044240	1.044590	1.5924	11.480	36.010
271	250.00	323.8	1.044260	1.044630	1.5926	9.450	36.100
272	325.00	469.6	1.044500	1.044580	1.5922	7.580	35.910
273	320.00	538.0	1.044220	1.044510	1.5918	5.600	35.990
274	375.00	696.8	1.044170	1.044400	1.5914	4.593	35.820
275	375.00	812.7	1.044210	1.044400	1.5913	3.468	35.960
276	290.00	743.2	1.044190	1.044390	1.5911	2.425	35.880
371	230.00	919.2	1.036760	1.037200	1.5897	1.060	23.000
372	250.00	678.0	1.036740	1.037190	1.5894	2.270	22.820
373	280.00	568.4	1.036710	1.037140	1.5889	3.930	22.620
374	325.00	505.3	1.036760	1.037150	1.5885	6.710	22.550
375	290.00	396.6	1.036840	1.037130	1.5881	8.740	22.550
376	295.00	340.0	1.037010	1.037200	1.5880	12.360	22.820
584	145.00	314.3	1.031890	1.031280	1.5918	1.963	16.940
584	145.00	314.3	1.031890	1.031280	0.0000	0.933	16.940
585	265.00	356.8	1.031780	1.032260	1.5917	5.096	16.780
585	265.00	356.8	1.031780	1.032260	0.0000	2.470	16.780
586	230.00	233.5	1.031840	1.032350	1.5917	9.320	16.750
586	230.00	233.5	1.031840	1.032350	0.0000	4.560	16.750
587	335.00	287.4	1.031850	1.032380	1.5917	13.240	16.770
587	335.00	287.4	1.031850	1.032380	0.0000	6.565	16.770
588	360.00	269.0	1.031980	1.032430	1.5917	17.350	16.790
588	360.00	269.0	1.031980	1.032430	0.0000	8.810	16.790
589	335.00	229.8	1.031980	1.032420	1.5917	21.205	16.820
589	335.00	229.8	1.031980	1.032420	0.0000	10.320	16.820
590	365.00	230.8	1.032080	1.032600	1.5917	25.340	16.810
590	365.00	230.8	1.032080	1.032600	0.0000	12.300	16.810
591	335.00	301.2	1.032060	1.032590	1.5917	12.090	16.800
591	335.00	301.2	1.032060	1.032590	0.0000	5.835	16.800
592	235.00	320.8	1.032120	1.032620	1.5920	5.055	16.920
592	235.00	320.8	1.032120	1.032620	0.0000	2.465	16.920
636	200.00	402.7	1.032200	1.033090	1.5927	3.990	17.490
637	230.00	342.8	1.032180	1.032950	1.5923	7.310	17.450
638	340.00	381.4	1.032210	1.032960	1.5923	13.140	17.510
639	355.00	340.1	1.032210	1.032800	1.5916	18.300	17.500
640	310.00	255.4	1.032230	1.032730	1.5912	25.150	17.590

TABLE 2-9 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
641	350.00	262.8	1.032250	1.032710	1.5910	30.810	17.570
642	390.00	262.7	1.032800	1.032750	1.5910	38.490	17.540
643	330.00	205.2	1.032230	1.032700	0.0000	24.866	17.590
644	295.00	298.9	1.032280	1.032700	1.5907	16.346	17.590
699	330.00	1166.2	1.047680	1.048000	0.8765	4.210	45.300
699	330.00	1166.2	1.047680	1.048000	1.5911	1.387	45.300
700	307.00	913.8	1.047410	1.048100	0.8767	5.530	44.100
700	307.00	913.8	1.047410	1.048100	1.5916	1.895	44.100
701	295.00	628.0	1.047250	1.048160	0.8769	11.100	43.320
701	295.00	628.0	1.047250	1.048160	1.5920	3.565	43.320
702	300.00	416.2	1.047220	1.048160	1.5922	8.350	43.240
702	300.00	416.2	1.047220	1.048160	0.0000	4.290	43.240
703	340.00	358.3	1.047230	1.048210	1.5924	14.450	43.230
703	340.00	358.3	1.047230	1.048210	0.0000	7.540	43.230
704	375.00	356.9	1.047120	1.048190	1.5923	17.830	42.800
704	375.00	356.9	1.047120	1.048190	0.0000	9.260	42.800
705	410.00	327.6	1.047280	1.048210	1.5924	25.586	42.880
705	410.00	327.6	1.047280	1.048210	0.0000	13.360	42.880
706	405.00	280.8	1.047090	1.048170	1.5924	33.885	42.620
706	405.00	280.8	1.047090	1.048170	0.0000	17.820	42.620
249	370.00	235.0	1.044340	1.044790	1.5939	13.100	36.390
250	370.00	238.4	1.044280	1.044590	1.5917	12.710	36.200
251	350.00	244.9	1.044290	1.044720	1.5935	9.530	36.240
252	345.00	258.5	1.044190	1.044780	1.5933	9.370	35.970
253	345.00	265.7	1.044190	1.044810	1.5933	8.830	36.000
254	360.00	290.1	1.044160	1.044700	1.5929	8.030	35.880
255	365.00	318.8	1.044130	1.044690	1.5928	7.020	35.820
256	370.00	331.0	1.044090	1.044490	1.5922	6.540	35.690
257	330.00	325.0	1.044110	1.044490	1.5919	5.310	35.780
258	325.00	353.8	1.044060	1.044420	1.5915	4.405	35.670
259	400.00	506.9	1.044100	1.044280	1.5910	3.367	35.740
260	350.00	594.0	1.044160	1.044330	1.5912	1.861	35.890
261	290.00	662.2	1.044100	1.044200	1.5906	1.018	35.710
262	285.00	1539.2	1.044180	1.044100	1.5903	0.201	35.870
359	245.00	655.0	1.036500	1.035990	1.5870	0.750	23.570
359	245.00	655.0	1.036500	1.035990	0.8736	2.460	23.570

TABLE 2-9 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
360	340.00	671.6	1.036590	1.036000	1.5867	1.340	23.570
360	340.00	671.6	1.036590	1.036000	0.8734	4.550	23.570
361	275.00	398.6	1.036590	1.036020	1.5864	2.520	23.470
361	275.00	398.6	1.036590	1.036020	0.8733	8.530	23.470
363	285.00	267.4	1.036620	1.036400	1.5872	6.025	23.410
363	285.00	267.4	1.036620	1.036400	0.8737	20.350	23.410
366	260.00	249.4	1.036960	1.036580	1.5865	5.790	23.610
366	260.00	249.4	1.036960	1.036580	0.8733	19.780	23.610
367	225.00	184.9	1.037080	1.037640	1.5864	7.755	23.660
367	225.00	184.9	1.037080	1.037640	0.8733	26.610	23.660
368	300.00	408.4	1.037170	1.036900	1.5867	2.870	23.700
368	300.00	408.4	1.037170	1.036900	0.8734	9.780	23.700
369	220.00	369.3	1.037310	1.036990	0.8734	6.420	23.720
370	240.00	623.8	1.037390	1.037090	0.8735	2.820	23.750
578	220.00	342.4	1.031710	1.032120	1.5925	1.256	17.060
578	220.00	342.4	1.031710	1.032120	0.0000	0.590	17.060
579	210.00	249.7	1.031690	1.032110	1.5923	2.180	17.010
579	210.00	249.7	1.031690	1.032110	0.0000	1.020	17.010
580	325.00	281.2	1.031760	1.032190	1.5927	4.250	17.010
580	325.00	281.2	1.031760	1.032190	0.0000	2.065	17.010
581	330.00	233.5	1.031770	1.032180	1.5921	6.530	17.030
581	330.00	233.5	1.031770	1.032180	0.0000	3.185	17.030
582	350.00	213.2	1.031800	1.032250	1.5922	9.040	16.990
582	350.00	213.2	1.031800	1.032250	0.0000	4.410	16.990
583	360.00	208.8	1.031760	1.032210	1.5920	10.010	16.910
583	360.00	208.8	1.031760	1.032210	1.5920	10.010	16.910
615	280.00	381.7	1.031670	1.032080	1.5913	2.917	17.430
616	310.00	305.4	1.031590	1.032160	1.5914	5.460	17.330
617	330.00	266.3	1.031550	1.032160	1.5915	8.460	17.280
618	380.00	257.4	1.031620	1.032170	1.5914	12.035	17.360
619	375.00	223.9	1.031680	1.032170	1.5917	15.880	17.430
620	200.00	517.2	1.031670	1.032170	1.5915	0.838	17.420
621	265.00	525.7	1.031600	1.032200	1.5915	1.236	17.340
671	287.00	534.6	1.047010	1.048190	0.8780	4.372	42.400
671	287.00	534.6	1.047010	1.048190	1.5948	1.560	42.400
672	300.00	383.6	1.047030	1.048260	0.8783	9.940	42.500

TABLE 2-9 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
672	300.00	383.6	1.047030	1.048260	1.5951	3.200	42.500
673	310.00	311.4	1.048250	1.048720	0.8778	15.930	46.380
673	310.00	311.4	1.048250	1.048720	1.5949	5.063	46.380
674	340.00	331.2	1.047710	1.048470	0.8773	17.445	44.800
674	340.00	331.2	1.047710	1.048470	1.5944	5.490	44.800
675	365.00	295.2	1.047740	1.048330	0.8770	24.150	44.900
675	365.00	295.2	1.047740	1.048330	1.5939	7.820	44.900
676	390.00	309.7	1.047500	1.048210	0.8768	26.060	44.400
677	405.00	285.4	1.047500	1.048490	0.8773	35.050	44.140
677	405.00	285.4	1.047500	1.048490	1.5932	10.485	44.140
678	415.00	269.4	1.047020	1.048130	1.5924	12.276	42.740

TABLE 2-10

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE	SPECIAL 15						
622	135.00	423.8	1.031700	1.032170	1.5915	10.860	17.480
623	210.00	278.2	1.031640	1.032150	0.0000	36.230	17.390
624	257.00	813.4	1.031640	1.031950	1.5901	11.000	17.700
625	240.00	575.4	1.031600	1.031880	1.5899	19.505	17.650
626	250.00	480.7	1.031550	1.031870	1.5897	30.640	17.590
627	268.00	407.2	1.031510	1.032100	0.0000	27.460	17.520
628	250.00	311.9	1.031600	1.032360	0.0000	41.170	17.640
629	340.00	355.6	1.031500	1.032360	0.0000	59.390	17.500
630	280.00	255.8	1.031550	1.032250	0.0000	78.540	17.570
631	320.00	257.4	1.031490	1.032310	0.0000	102.070	17.490
632	310.00	222.6	1.031510	1.032300	0.0000	128.220	17.500
633	280.00	199.2	1.031490	1.032310	0.0000	131.035	17.480
634	290.00	196.2	1.031670	1.031340	13.5411	11.900	17.730
635	235.00	475.8	1.031540	1.032300	1.5919	27.580	17.550
687	137.00	778.2	1.046840	1.047910	0.8763	9.840	42.170
687	137.00	778.2	1.046840	1.047910	1.5916	3.250	42.170
688	210.00	772.0	1.046770	1.047930	0.8763	24.520	42.000
688	210.00	772.0	1.046770	1.047930	1.5915	7.710	42.000
689	240.00	484.9	1.046710	1.047970	1.5916	26.250	41.800
689	240.00	484.9	1.046710	1.047970	0.0000	13.756	41.800
690	290.00	384.0	1.046740	1.048000	0.0000	33.100	41.900
691	285.00	295.0	1.046760	1.048030	0.0000	55.290	41.950
692	350.00	295.9	1.046760	1.048100	0.0000	85.246	42.000
692	350.00	295.9	1.046760	1.048100	13.5407	7.095	42.000
693	385.00	330.2	1.046780	1.048090	0.0000	81.730	42.000
693	385.00	330.2	1.046780	1.048090	13.5409	6.810	42.000
694	205.00	511.4	1.046800	1.048190	1.5922	17.200	42.080
694	205.00	511.4	1.046800	1.048190	0.0000	9.075	42.080
695	247.00	401.2	1.046710	1.048120	0.0000	21.760	41.800
696	245.00	504.8	1.046670	1.048170	1.5922	25.390	41.700
696	245.00	504.8	1.046670	1.048170	0.0000	13.350	41.700
697	205.00	572.3	1.046860	1.048240	1.5925	13.600	42.250

TABLE 2-10 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
697	205.00	572.3	1.046860	1.048240	0.0000	7.050	42.250

TABLE 2-11

DATA

RUN NO.	WS	TI	PO	PBO	PC	H	U
ORIFICE TYPE. SPECIAL 30							
679	100.00	640.8	1.047240	1.048040	0.8765	8.220	43.380
679	100.00	640.8	1.047240	1.048040	1.5916	2.617	43.380
680	240.00	682.5	1.046850	1.047930	0.8763	41.417	42.220
680	240.00	682.5	1.046850	1.047930	1.5912	12.995	42.220
681	302.00	595.7	1.046970	1.047880	1.5909	27.275	42.570
681	302.00	595.7	1.046970	1.047880	0.8792	87.900	42.570
681	302.00	595.7	1.046970	1.047880	0.0000	14.220	42.570
682	200.00	237.1	1.046900	1.047870	0.0000	41.000	42.330
682	200.00	237.1	1.046900	1.047870	13.5392	3.300	42.330
683	340.00	420.1	1.046900	1.047790	0.0000	37.640	42.330
684	150.00	515.6	1.046930	1.047690	1.5903	8.780	42.460
684	150.00	515.6	1.046930	1.047690	0.8758	27.890	42.460
685	170.00	746.2	1.046970	1.047750	1.5903	5.450	42.560
685	170.00	746.2	1.046970	1.047750	0.8760	17.215	42.560
686	118.00	868.1	1.047040	1.047740	1.5904	2.545	42.800
686	118.00	868.1	1.047040	1.047740	0.8759	6.060	42.800
645	180.00	531.7	1.032620	1.033490	1.5953	12.210	18.200
646	200.00	433.5	1.032500	1.033210	1.5937	23.430	17.960
647	260.00	440.3	1.032500	1.033400	1.5947	39.356	17.940
648	250.00	355.2	1.032450	1.033450	0.0000	31.340	17.870
649	290.00	328.8	1.032440	1.033490	0.0000	50.233	17.820
650	270.00	258.0	1.032400	1.033500	0.0000	71.660	17.780
651	350.00	284.4	1.032300	1.033320	0.0000	100.670	17.630

TABLE 2-11 (CONTINUED)

RUN NO.	WS	TI	PO	PBO	PC	H	U
652	350.00	254.3	1.032300	1.033190	0.0000	126.970	17.630
653	360.00	235.7	1.032220	1.033170	13.5430	12.896	17.440
654	135.00	761.6	1.032290	1.033100	1.5933	3.273	17.560
655	300.00	462.1	1.032110	1.033030	0.0000	26.540	17.240
656	205.00	354.1	1.032200	1.033090	1.5931	37.940	17.390

APPENDIX 3 - ERROR ANALYSIS

Tabulation of the Statistical Results

A statistical analysis was carried out on each experimental run based on a method given by Parratt (19) and summarized by Ratkowsky (20). A 95% confidence interval was calculated in each case for K and Re_D.

The error analysis results were used in two different ways. Firstly, the 95% confidence interval allowed a decesion to be made as to whether an expermental run, represented by an apparently wild point, should be repeated or not. Secondly, it allowed a check on the experimental graphs such as Figure 10 in which a comparison between two curves gave the required information. In Figure 10, the non-intersection of confidence intervals on K for the Sharp and Standard Orifice plates confirmed with 95% confidence that there was a significant difference between curves. The other graphs were checked in a similar manner.

The results of these calculations are contained in Tables 3-1 to 3-11 inclusive.

TABLE 3-1

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE 1.0 INCH STANDARD						
105	0.6205	0.6246	0.6163	7144.39	7150.54	7138.25
106	0.6196	0.6237	0.6154	6560.13	6565.84	6554.41
107	0.6197	0.6239	0.6155	5936.95	5944.27	5929.62
108	0.6215	0.6256	0.6173	5493.18	5499.83	5486.53
109	0.6217	0.6259	0.6175	5166.01	5171.92	5160.11
110	0.6213	0.6255	0.6171	4742.51	4747.68	4737.35
111	0.6237	0.6279	0.6195	4322.81	4328.58	4317.05
112	0.6237	0.6279	0.6195	3963.72	3969.35	3958.09
113	0.6267	0.6310	0.6225	3541.20	3546.46	3535.94
114	0.6282	0.6325	0.6240	3132.65	3137.41	3127.89
115	0.6301	0.6344	0.6258	2727.95	2732.69	2723.21
116	0.6337	0.6381	0.6294	2361.19	2365.75	2356.62
117	0.6391	0.6435	0.6347	2178.30	2182.37	2174.23
118	0.6791	0.6840	0.6742	2042.48	2048.18	2036.77
131	0.7091	0.7139	0.7043	213.04	213.34	212.75
132	0.7100	0.7148	0.7051	205.33	205.61	205.05
133	0.7107	0.7155	0.7058	205.57	205.85	205.29
134	0.7036	0.7084	0.6988	191.83	192.12	191.55
135	0.7138	0.7187	0.7090	176.88	177.11	176.65
136	0.7172	0.7220	0.7123	160.53	160.74	160.33
137	0.7199	0.7248	0.7149	151.17	151.38	150.96
138	0.7209	0.7258	0.7159	124.31	124.48	124.13
139	0.7212	0.7262	0.7161	109.53	109.73	109.33
140	0.7264	0.7316	0.7212	84.58	84.73	84.42
141	0.7247	0.7302	0.7193	71.85	72.02	71.68
142	0.7128	0.7196	0.7060	47.07	47.24	46.91
143	0.6735	0.6880	0.6590	24.18	24.30	24.06
505	0.7144	0.7194	0.7094	209.21	209.57	208.85
506	0.7095	0.7145	0.7045	209.21	209.57	208.85
506	0.7124	0.7175	0.7074	217.65	218.08	217.21
506	0.7053	0.7103	0.7002	217.65	218.08	217.21

TABLE 3-1 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
507	0.7033	0.7082	0.6984	294.03	294.59	293.46
507	0.6997	0.7045	0.6949	294.03	294.59	293.46
508	0.6885	0.6932	0.6839	427.67	428.37	426.97
508	0.6955	0.7019	0.6890	427.67	428.37	426.97
509	0.6771	0.6816	0.6725	582.60	583.43	581.78
509	0.6821	0.6872	0.6771	582.60	583.43	581.78
510	0.6674	0.6719	0.6630	746.83	747.72	745.95
510	0.6716	0.6762	0.6670	746.83	747.72	745.95
511	0.6637	0.6681	0.6593	861.09	862.03	860.15
511	0.6680	0.6725	0.6635	861.09	862.03	860.15
512	0.6612	0.6656	0.6568	993.38	994.52	992.24
513	0.6574	0.6618	0.6531	1122.20	1123.43	1120.98
514	0.6529	0.6572	0.6486	1260.22	1261.60	1258.85
515	0.6486	0.6529	0.6443	1385.54	1387.05	1384.03

TABLE 3-2

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE 1.5 INCH STANDARD						
87	0.6209	0.6238	0.6179	10018.14	10027.25	10009.03
88	0.6212	0.6241	0.6183	9358.34	9366.30	9350.39
89	0.6219	0.6248	0.6190	8698.91	8706.21	8691.61
90	0.6222	0.6251	0.6193	8131.77	8139.16	8124.38
91	0.6235	0.6265	0.6206	7175.70	7181.72	7169.69
92	0.6249	0.6278	0.6220	6359.00	6364.19	6353.80
93	0.6266	0.6295	0.6236	5595.98	5600.99	5590.97
94	0.6264	0.6293	0.6235	5020.13	5024.96	5015.31

95	0.6267	0.6296	0.6238	4560.79	4564.76	4556.81
96	0.6272	0.6302	0.6243	4068.81	4072.78	4064.84
97	0.6296	0.6325	0.6266	3690.07	3693.78	3686.36
98	0.5902	0.5930	0.5874	3790.95	3794.82	3787.08
99	0.6283	0.6314	0.6251	3704.82	3712.15	3697.48
100	0.6319	0.6349	0.6289	3223.77	3227.11	3220.43
101	0.6319	0.6349	0.6289	2993.42	2996.68	2990.16
102	0.6364	0.6395	0.6334	2580.15	2583.21	2577.08
103	0.6426	0.6456	0.6396	2096.39	2098.41	2094.38
104	0.6621	0.6655	0.6586	1424.92	1427.33	1422.51
151	0.7080	0.7115	0.7046	323.12	323.48	322.76
152	0.7099	0.7133	0.7065	302.80	303.10	302.50
153	0.7128	0.7162	0.7094	278.83	279.09	278.56
154	0.7153	0.7187	0.7119	261.87	262.11	261.63
155	0.7186	0.7220	0.7151	236.40	236.62	236.18
156	0.7218	0.7252	0.7183	206.02	206.23	205.80
157	0.7244	0.7279	0.7209	179.84	180.00	179.67
158	0.7284	0.7321	0.7248	155.76	155.94	155.57
159	0.7288	0.7325	0.7250	136.85	137.03	136.67
160	0.7303	0.7343	0.7263	111.56	111.68	111.43
161	0.7293	0.7346	0.7239	79.50	79.64	79.37
162	0.7175	0.7270	0.7079	51.64	51.76	51.52
522	0.7176	0.7212	0.7139	261.24	261.58	260.89
522	0.7143	0.7183	0.7103	261.24	261.58	260.89
523	0.7110	0.7146	0.7074	292.31	292.72	291.91
523	0.7048	0.7086	0.7010	292.31	292.72	291.91
524	0.7007	0.7041	0.6974	401.12	401.55	400.70
524	0.6964	0.6998	0.6931	401.12	401.55	400.70
525	0.6956	0.6989	0.6922	587.33	588.00	586.66
525	0.6836	0.6868	0.6804	587.33	588.00	586.66
526	0.6756	0.6787	0.6725	734.96	735.68	734.24
526	0.6768	0.6813	0.6723	734.96	735.68	734.24
527	0.6688	0.6719	0.6657	889.20	890.10	888.29
528	0.6640	0.6671	0.6609	1042.61	1043.71	1041.51
528	0.6681	0.6716	0.6646	1042.61	1043.71	1041.51
529	0.6597	0.6628	0.6566	1196.54	1197.69	1195.39
529	0.6661	0.6694	0.6628	1196.54	1197.69	1195.39
530	0.6564	0.6595	0.6533	1314.13	1315.43	1312.83
530	0.6602	0.6634	0.6569	1314.13	1315.43	1312.83

TABLE 3-3

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE 2.0 INCH STANDARD						
119	0.6172	0.6196	0.6148	11618.21	11629.77	11606.65
120	0.6191	0.6215	0.6167	10977.78	10987.79	10967.78
121	0.6162	0.6186	0.6138	10129.21	10138.07	10120.35
122	0.6205	0.6228	0.6181	9218.54	9226.71	9210.38
123	0.6208	0.6231	0.6184	7660.89	7667.58	7654.20
124	0.6221	0.6245	0.6197	6619.32	6624.74	6613.91
125	0.6236	0.6260	0.6212	5730.77	5735.97	5725.56
126	0.6646	0.6671	0.6620	5271.13	5276.06	5266.21
127	0.6240	0.6264	0.6217	4449.69	4453.33	4446.05
128	0.6268	0.6292	0.6244	3932.43	3936.52	3928.35
129	0.6289	0.6314	0.6264	3412.70	3416.62	3408.79
130	0.6374	0.6399	0.6348	2480.51	2483.23	2477.79
144	0.6934	0.6962	0.6906	389.54	389.92	389.16
145	0.6969	0.6997	0.6941	352.59	352.93	352.25
146	0.7014	0.7042	0.6986	315.66	315.94	315.39
147	0.7051	0.7080	0.7023	284.17	284.46	283.89
148	0.7087	0.7115	0.7058	257.32	257.58	257.07
149	0.4367	0.4384	0.4349	142.46	142.60	142.32
150	0.7148	0.7178	0.7118	199.37	199.60	199.15
151	0.7210	0.7241	0.7179	172.68	172.87	172.50
152	0.7211	0.7243	0.7179	160.05	160.20	159.91
153	0.7238	0.7273	0.7202	136.12	136.25	135.99
154	0.8445	0.8521	0.8369	96.16	96.28	96.03
155	0.5820	0.5946	0.5694	39.33	39.44	39.23
516	0.6897	0.6933	0.6860	316.77	317.15	316.39
517	0.6842	0.6870	0.6815	510.15	510.70	509.60
517	0.6788	0.6815	0.6761	510.15	510.70	509.60
518	0.6760	0.6787	0.6733	662.96	663.56	662.36
518	0.6719	0.6744	0.6693	662.96	663.56	662.36
519	0.6627	0.6652	0.6602	907.38	908.19	906.56
519	0.6696	0.6739	0.6652	907.38	908.19	906.56

TABLE 3-3 (CONTINUED)

520	0.6571	0.6597	0.6545	1102.38	1103.41	1101.35
520	0.6607	0.6641	0.6573	1102.38	1103.41	1101.35
521	0.6705	0.6733	0.6677	662.00	663.03	660.97

TABLE 3-4

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE 1.0 INCH SHARP						
16	0.6305	0.6347	0.6263	6799.91	6807.44	6792.37
17	0.6203	0.6245	0.6162	6717.33	6725.16	6709.49
18	0.6195	0.6236	0.6153	6188.11	6195.47	6180.76
19	0.6201	0.6243	0.6160	6331.71	6339.23	6324.18
20	0.6208	0.6249	0.6166	5918.92	5926.51	5911.34
21	0.6202	0.6243	0.6160	6084.86	6091.96	6077.76
22	0.6249	0.6291	0.6207	5527.69	5534.91	5520.46
23	0.6281	0.6324	0.6239	4959.02	4966.07	4951.98
24	0.6285	0.6328	0.6243	4598.91	4606.06	4591.75
25	0.6297	0.6340	0.6254	4168.44	4175.25	4161.63
26	0.6268	0.6311	0.6225	3705.20	3712.77	3697.64
65	0.6285	0.6328	0.6243	2919.13	2923.10	2915.16
66	0.5978	0.6018	0.5937	2709.57	2713.89	2705.25
67	0.6261	0.6303	0.6219	2371.52	2374.50	2368.54
68	0.6294	0.6336	0.6251	2076.46	2079.69	2073.23
69	0.6339	0.6382	0.6295	1982.85	1986.66	1979.04
70	0.6370	0.6415	0.6325	1726.95	1731.29	1722.61
71	0.6436	0.6484	0.6389	1146.59	1150.34	1142.85
72	0.6379	0.6430	0.6328	745.39	748.10	742.69
163	0.6750	0.6795	0.6704	200.80	201.05	200.56
164	0.6745	0.6790	0.6699	184.65	184.86	184.44
165	0.6762	0.6808	0.6716	171.50	171.72	171.27
166	0.6784	0.6829	0.6738	153.90	154.10	153.71

TABLE 3-4 (CONTINUED)

RUN NO.	K	95 % CONFIDENCE INTERVAL		RED	95 % CONFIDENCE INTERVAL	
167	0.6831	0.6877	0.6784	133.88	134.06	133.71
168	0.6887	0.6934	0.6839	109.24	109.41	109.07
169	0.6888	0.6936	0.6840	97.52	97.69	97.34
170	0.6966	0.7016	0.6917	86.29	86.45	86.13
172	0.6999	0.7053	0.6945	68.15	68.32	67.99
173	0.7157	0.7215	0.7098	56.38	56.46	56.30
174	0.7207	0.7337	0.7077	30.20	30.32	30.09
537	0.6787	0.6840	0.6733	145.28	145.82	144.75
537	0.6769	0.6827	0.6712	145.28	145.82	144.75
538	0.6697	0.6745	0.6649	235.26	235.89	234.63
538	0.6674	0.6722	0.6626	235.26	235.89	234.63
539	0.6626	0.6671	0.6580	333.53	334.14	332.92
539	0.6595	0.6640	0.6550	333.53	334.14	332.92
540	0.6564	0.6608	0.6520	432.18	432.89	431.47
540	0.6620	0.6677	0.6563	432.18	432.89	431.47
541	0.6534	0.6578	0.6491	550.09	550.82	549.35
541	0.6595	0.6644	0.6546	550.09	550.82	549.35
542	0.6513	0.6556	0.6470	653.24	654.11	652.37
542	0.6560	0.6606	0.6515	653.24	654.11	652.37
543	0.6490	0.6532	0.6447	761.79	762.64	760.94
543	0.6512	0.6556	0.6468	761.79	762.64	760.94
544	0.6504	0.6547	0.6460	852.31	853.26	851.37
545	0.6466	0.6509	0.6423	980.63	981.69	979.58
546	0.6468	0.6511	0.6425	1095.83	1097.09	1094.58
547	0.6461	0.6504	0.6418	1236.41	1237.86	1234.97
548	0.6449	0.6491	0.6406	1382.12	1383.76	1380.48

TABLE 3-5

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE 1.5 INCH SHARP						
37	0.6300	0.6330	0.6270	9804.79	9815.86	9793.72
38	0.6224	0.6254	0.6195	9495.39	9505.25	9485.52
39	0.6248	0.6278	0.6219	8945.35	8954.35	8936.34
40	0.6243	0.6273	0.6213	8481.05	8491.33	8470.77
41	0.6172	0.6201	0.6142	7747.66	7756.71	7738.61
42	0.6236	0.6265	0.6206	7124.94	7134.26	7115.62
43	0.6245	0.6275	0.6215	6303.56	6311.98	6295.15
44	0.6253	0.6282	0.6223	5720.33	5727.81	5712.85
45	0.6257	0.6287	0.6226	5162.66	5169.84	5155.48
46	0.6225	0.6255	0.6196	5129.09	5134.87	5123.31
47	0.6247	0.6277	0.6217	5041.33	5047.55	5035.12
48	0.6261	0.6291	0.6232	4753.90	4759.35	4748.45
49	0.6282	0.6312	0.6253	4588.63	4593.81	4583.46
50	0.6284	0.6314	0.6253	4243.25	4249.41	4237.09
51	0.6287	0.6317	0.6257	3849.29	3854.03	3844.54
52	0.6290	0.6320	0.6260	3650.79	3655.86	3645.71
53	0.6273	0.6303	0.6243	3331.77	3336.30	3327.23
54	0.6317	0.6348	0.6287	2942.11	2946.38	2937.84
55	0.6367	0.6398	0.6335	2464.44	2468.46	2460.41
56	0.6461	0.6493	0.6428	1779.95	1783.01	1776.89
57	0.6478	0.6518	0.6438	1076.96	1079.69	1074.23
184	0.6688	0.6720	0.6656	311.59	311.86	311.32
185	0.6753	0.6785	0.6721	244.70	244.91	244.50
186	0.6704	0.6736	0.6672	283.47	283.73	283.21
187	0.6701	0.6733	0.6668	272.72	273.01	272.44
188	0.6753	0.6785	0.6720	224.32	224.52	224.12
189	0.6783	0.6815	0.6750	194.86	195.02	194.71
190	0.6826	0.6859	0.6793	172.63	172.78	172.49
191	0.6858	0.6892	0.6824	156.19	156.34	156.04
192	0.6903	0.6938	0.6868	136.59	136.72	136.46
193	0.6894	0.6930	0.6857	121.60	121.76	121.44

TABLE 3-5 (CONTINUED)

RUN NO.	K	95 % CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
194	0.6988	0.7030	0.6946	97.70	97.85	97.54
195	0.7067	0.7149	0.6984	57.19	57.33	57.05
557	0.6724	0.6760	0.6688	257.55	258.06	257.04
557	0.6672	0.6711	0.6634	257.55	258.06	257.04
558	0.6695	0.6728	0.6662	382.01	382.55	381.47
558	0.6640	0.6672	0.6608	382.01	382.55	381.47
559	0.6655	0.6687	0.6623	485.69	486.27	485.12
559	0.6613	0.6644	0.6582	485.69	486.27	485.12
560	0.6560	0.6590	0.6530	652.66	653.36	651.96
560	0.6583	0.6631	0.6535	652.66	653.36	651.96
561	0.6537	0.6567	0.6507	746.50	747.16	745.84
561	0.6578	0.6619	0.6536	746.50	747.16	745.84
562	0.6520	0.6550	0.6489	858.98	859.94	858.03
562	0.6519	0.6556	0.6482	858.98	859.94	858.03
563	0.6516	0.6546	0.6485	984.58	985.66	983.51
563	0.6548	0.6583	0.6514	984.58	985.66	983.51
564	0.6498	0.6529	0.6467	1150.08	1151.33	1148.82
564	0.6548	0.6581	0.6515	1150.08	1151.33	1148.82
565	0.6520	0.6552	0.6489	1255.43	1256.80	1254.07
565	0.6554	0.6586	0.6521	1255.43	1256.80	1254.07

TABLE 3-6

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95 % CONFIDENCE INTERVAL	
ORIFICE TYPE 2.0 INCH SHARP						
73	0.6166	0.6191	0.6140	12438.10	12453.53	12422.68
74	0.6171	0.6195	0.6147	11411.53	11422.23	11400.83
75	0.6170	0.6193	0.6146	10830.65	10839.88	10821.42
76	0.6161	0.6184	0.6137	9918.84	9927.29	9910.39

TABLE 3-6 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
77	0.6188	0.6212	0.6165	9016.61	9024.19	9009.04
78	0.6160	0.6184	0.6137	7969.73	7976.60	7962.87
79	0.6204	0.6227	0.6180	6846.89	6852.71	6841.07
80	0.6200	0.6223	0.6176	5844.42	5849.32	5839.51
81	0.6206	0.6230	0.6183	5386.15	5390.73	5381.58
82	0.6218	0.6242	0.6194	4708.66	4712.82	4704.49
83	0.6224	0.6248	0.6200	4204.60	4208.31	4200.89
84	0.6207	0.6231	0.6184	3345.72	3348.76	3342.68
85	0.6281	0.6306	0.6256	2502.12	2505.26	2498.97
86	0.6358	0.6384	0.6332	2007.80	2010.14	2005.45
172	0.6571	0.6598	0.6545	428.19	428.62	427.75
173	0.6590	0.6617	0.6563	403.00	403.41	402.59
174	0.6597	0.6623	0.6571	350.90	351.21	350.58
175	0.6610	0.6636	0.6583	333.95	334.26	333.65
176	0.6642	0.6669	0.6616	287.86	288.10	287.62
177	0.6662	0.6689	0.6635	244.02	244.25	243.79
178	0.6727	0.6754	0.6699	205.64	205.84	205.45
179	0.6760	0.6788	0.6731	179.11	179.29	178.92
180	0.6781	0.6812	0.6750	165.90	166.13	165.67
181	0.6846	0.6879	0.6813	137.51	137.64	137.38
182	0.6816	0.6863	0.6769	97.30	97.42	97.19
183	0.6835	0.6923	0.6747	65.78	65.87	65.70
549	0.6660	0.6691	0.6629	275.09	275.44	274.74
550	0.6590	0.6617	0.6563	400.22	400.66	399.78
550	0.6550	0.6578	0.6522	400.22	400.66	399.78
549	0.6579	0.6617	0.6540	275.09	275.44	274.74
551	0.6561	0.6587	0.6535	518.83	519.31	518.35
551	0.6526	0.6551	0.6501	518.83	519.31	518.35
552	0.6518	0.6544	0.6492	629.20	629.79	628.62
552	0.6499	0.6524	0.6475	629.20	629.79	628.62
553	0.6465	0.6490	0.6440	795.39	796.23	794.55
554	0.6479	0.6504	0.6454	713.47	714.25	712.69
555	0.6461	0.6486	0.6436	914.26	915.11	913.40
556	0.6459	0.6484	0.6434	1007.60	1008.54	1006.66

TABLE 3-7

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE G.S. BETA=0.2						
226	0.7238	0.7333	0.7142	61.36	61.50	61.23
227	0.7173	0.7269	0.7077	56.37	56.55	56.19
228	0.7165	0.7261	0.7069	51.29	51.46	51.12
229	0.7152	0.7248	0.7056	47.22	47.37	47.06
230	0.7134	0.7229	0.7039	42.48	42.60	42.35
231	0.7068	0.7164	0.6971	36.53	36.68	36.38
232	0.7008	0.7104	0.6911	29.84	29.98	29.70
233	0.7260	0.7362	0.7159	23.57	23.69	23.45
384	0.7014	0.7110	0.6917	137.65	138.27	137.02
385	0.7140	0.7243	0.7038	96.53	97.11	95.94
386	0.7157	0.7257	0.7058	58.07	58.34	57.79
396	0.7167	0.7263	0.7070	71.60	71.86	71.33
397	0.7034	0.7129	0.6940	116.32	116.76	115.89
398	0.6975	0.7069	0.6881	136.50	137.00	136.01
399	0.6890	0.6983	0.6797	158.32	158.90	157.74
400	0.6748	0.6837	0.6659	176.96	177.49	176.44
401	0.6653	0.6741	0.6566	195.98	196.42	195.54
402	0.6559	0.6644	0.6473	218.60	219.05	218.15
403	0.6526	0.6612	0.6440	239.59	240.13	239.04
404	0.6541	0.6626	0.6456	272.81	273.27	272.35
405	0.6521	0.6606	0.6436	305.05	305.54	304.57
406	0.6492	0.6576	0.6407	336.56	337.13	335.99
407	0.6464	0.6548	0.6381	362.10	362.58	361.62
408	0.6421	0.6505	0.6338	395.03	395.62	394.43
409	0.6269	0.6351	0.6188	423.14	423.85	422.42
410	0.6258	0.6339	0.6177	449.97	450.62	449.32
411	0.6241	0.6322	0.6161	474.05	474.63	473.47
211	0.7133	0.7198	0.7069	85.11	85.28	84.95
212	0.7143	0.7208	0.7078	80.66	80.82	80.49
213	0.7160	0.7225	0.7095	76.79	76.92	76.65
214	0.7162	0.7228	0.7096	74.51	74.70	74.33

TABLE 3-7(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
215	0.7175	0.7241	0.7109	70.21	70.38	70.04
216	0.7161	0.7227	0.7095	65.84	65.99	65.69
217	0.7182	0.7250	0.7114	58.57	58.75	58.38
218	0.7169	0.7237	0.7101	52.04	52.21	51.87
219	0.7158	0.7223	0.7093	46.84	46.92	46.76
220	0.7152	0.7220	0.7083	41.84	41.98	41.70
221	0.7136	0.7205	0.7068	36.14	36.27	36.02
222	0.7116	0.7185	0.7048	32.70	32.81	32.60
223	0.7091	0.7160	0.7021	28.97	29.07	28.87
224	0.7009	0.7081	0.6938	23.76	23.85	23.67
393	0.7082	0.7146	0.7018	93.79	93.93	93.66
394	0.7035	0.7100	0.6970	122.30	122.61	121.98
421	0.7049	0.7117	0.6982	101.05	101.41	100.70
422	0.6909	0.6971	0.6848	146.52	146.76	146.28
423	0.6760	0.6821	0.6699	186.64	187.04	186.24
424	0.6678	0.6737	0.6619	210.25	210.57	209.93
425	0.6469	0.6527	0.6411	229.65	230.05	229.24
425	0.6626	0.6686	0.6567	235.23	235.64	234.82
426	0.6558	0.6616	0.6500	261.48	261.76	261.20
427	0.6451	0.6509	0.6393	324.02	324.57	323.47
428	0.6497	0.6555	0.6439	296.60	297.09	296.11
429	0.6348	0.6405	0.6292	337.64	338.13	337.15
430	0.6796	0.6856	0.6736	359.07	359.45	358.69
431	0.6437	0.6494	0.6379	390.52	391.18	389.87
432	0.6381	0.6438	0.6324	434.90	435.60	434.20
433	0.6354	0.6411	0.6298	463.72	464.34	463.10
434	0.6321	0.6377	0.6265	517.12	517.81	516.43
435	0.6290	0.6346	0.6234	570.49	571.24	569.75
196	0.7008	0.7057	0.6959	109.18	109.33	109.03
197	0.7029	0.7078	0.6980	104.76	104.89	104.62
198	0.7035	0.7084	0.6986	98.88	99.02	98.75
199	0.7064	0.7114	0.7014	92.63	92.78	92.48
200	0.7076	0.7125	0.7026	86.51	86.64	86.37
201	0.7099	0.7149	0.7049	80.50	80.64	80.37
202	0.7120	0.7170	0.7069	71.45	71.58	71.32

TABLE 3-7(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
203	0.7954	0.8011	0.7896	64.37	64.51	64.24
204	0.7135	0.7186	0.7083	49.86	49.96	49.75
205	0.7143	0.7194	0.7091	64.15	64.29	64.01
206	0.7131	0.7185	0.7077	45.62	45.75	45.49
207	0.7134	0.7190	0.7079	40.26	40.39	40.14
208	0.7099	0.7157	0.7042	34.48	34.59	34.36
209	0.7009	0.7073	0.6945	27.56	27.68	27.44
210	0.6900	0.6987	0.6812	17.90	17.98	17.83
387	0.6599	0.6645	0.6553	241.23	241.54	240.93
388	0.6624	0.6670	0.6577	218.35	218.66	218.05
389	0.6705	0.6753	0.6658	194.35	194.70	194.01
390	0.6760	0.6807	0.6712	174.12	174.36	173.88
391	0.6835	0.6884	0.6786	150.34	150.65	150.04
392	0.7000	0.7052	0.6949	100.24	100.45	100.04
412	0.6902	0.6951	0.6852	137.90	138.19	137.62
413	0.6747	0.6794	0.6700	185.55	185.87	185.23
414	0.6629	0.6675	0.6584	225.85	226.19	225.51
415	0.6433	0.6477	0.6389	263.72	264.04	263.41
415	0.6542	0.6586	0.6497	268.18	268.50	267.86
416	0.6472	0.6516	0.6427	302.45	302.82	302.08
417	0.6429	0.6473	0.6385	333.30	333.67	332.93
418	0.6381	0.6425	0.6338	369.27	369.66	368.87
419	0.6360	0.6403	0.6316	401.64	402.12	401.17
420	0.6331	0.6374	0.6288	427.41	427.89	426.93

TABLE 3-8

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE G.S. BETA=0.4						
278	0.7139	0.7188	0.7091	203.62	203.88	203.35
279	0.7167	0.7215	0.7119	186.42	186.58	186.25
280	0.7180	0.7229	0.7132	172.33	172.56	172.10
281	0.7190	0.7238	0.7141	158.10	158.27	157.93
282	0.7208	0.7257	0.7158	139.34	139.54	139.14
283	0.7228	0.7277	0.7179	116.23	116.35	116.12
284	0.7229	0.7279	0.7178	100.66	100.84	100.48
285	0.7213	0.7265	0.7162	85.06	85.23	84.89
286	0.7185	0.7239	0.7132	73.41	73.61	73.22
287	0.7000	0.7055	0.6945	54.29	54.39	54.19
288	0.7197	0.7256	0.7137	50.74	50.86	50.61
289	0.6943	0.7007	0.6880	41.82	41.91	41.73
290	0.6786	0.6904	0.6667	25.05	25.12	24.97
335	0.6994	0.7042	0.6946	331.74	332.22	331.25
336	0.7016	0.7064	0.6968	317.44	317.92	316.96
337	0.7043	0.7090	0.6995	285.37	285.67	285.07
338	0.7070	0.7118	0.7021	260.99	261.34	260.64
339	0.7101	0.7150	0.7051	230.09	230.54	229.63
340	0.7136	0.7185	0.7086	200.43	200.81	200.06
341	0.7176	0.7226	0.7125	179.89	180.27	179.52
342	0.7197	0.7248	0.7145	148.41	148.73	148.08
343	0.7142	0.7194	0.7089	118.62	118.90	118.35
452	0.9785	0.9853	0.9716	403.45	404.27	402.63
453	0.6877	0.6924	0.6830	374.82	375.55	374.09
454	0.6830	0.6876	0.6784	466.74	467.58	465.89
455	0.6918	0.6964	0.6872	371.20	371.72	370.67
456	0.6763	0.6808	0.6718	550.00	550.82	549.18
457	0.6729	0.6774	0.6684	605.94	606.80	605.09
458	0.6647	0.6692	0.6603	759.65	760.78	758.53
459	0.6607	0.6651	0.6563	867.73	868.80	866.66
460	0.6620	0.6665	0.6576	985.50	986.73	984.26

TABLE 3-8(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
461	0.7476	0.7527	0.7425	1276.92	1278.69	1275.14
462	0.6784	0.6829	0.6739	1290.18	1291.58	1288.77
463	0.6505	0.6549	0.6462	1397.93	1399.59	1396.27
496	0.7104	0.7156	0.7052	210.85	211.42	210.29
496	0.7036	0.7088	0.6983	210.85	211.42	210.29
497	0.6889	0.6937	0.6841	418.54	419.34	417.73
497	0.6865	0.6912	0.6818	418.54	419.34	417.73
498	0.6751	0.6796	0.6706	581.53	582.38	580.68
498	0.6831	0.6883	0.6779	581.53	582.38	580.68
499	0.6693	0.6737	0.6648	665.31	666.02	664.59
500	0.6719	0.6767	0.6672	665.31	666.02	664.59
500	0.6619	0.6663	0.6574	855.50	856.86	854.14
500	0.6667	0.6713	0.6621	855.50	856.86	854.14
501	0.6634	0.6679	0.6590	863.51	864.58	862.45
502	0.6640	0.6684	0.6596	954.64	955.68	953.60
503	0.6553	0.6597	0.6509	1062.88	1064.27	1061.49
504	0.6498	0.6542	0.6455	1164.00	1165.27	1162.73
291	0.5983	0.6007	0.5959	336.02	336.37	335.66
292	0.6977	0.7005	0.6949	368.70	369.05	368.35
293	0.6997	0.7025	0.6969	331.71	332.03	331.38
294	0.7056	0.7084	0.7028	281.87	282.11	281.64
295	0.7088	0.7116	0.7060	252.29	252.51	252.07
296	0.7142	0.7170	0.7113	225.03	225.24	224.82
297	0.7155	0.7184	0.7126	203.61	203.80	203.42
298	0.7192	0.7222	0.7162	180.14	180.35	179.92
299	0.7220	0.7253	0.7186	148.91	149.15	148.67
300	0.7237	0.7273	0.7201	120.58	120.72	120.45
301	0.7253	0.7298	0.7208	95.76	95.86	95.66
302	0.7456	0.7534	0.7378	70.16	70.23	70.09
327	0.7265	0.7330	0.7201	78.70	78.88	78.52
327	0.7237	0.7374	0.7100	78.69	78.88	78.51
328	0.7196	0.7232	0.7159	191.95	192.20	191.70
328	0.7088	0.7136	0.7040	191.95	192.20	191.70
329	0.7215	0.7264	0.7166	143.53	143.74	143.33
330	0.7146	0.7177	0.7115	238.98	239.19	238.77

TABLE 3-8 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
329	0.7108	0.7157	0.7058	143.53	143.74	143.33
330	0.7047	0.7094	0.7000	238.98	239.19	238.77
331	0.7096	0.7126	0.7066	286.17	286.51	285.84
331	0.6996	0.7043	0.6949	286.17	286.51	285.84
332	0.7042	0.7071	0.7014	318.67	318.97	318.36
332	0.6956	0.7002	0.6909	318.67	318.97	318.36
334	0.6947	0.6975	0.6919	404.51	404.93	404.09
334	0.6850	0.6896	0.6803	404.51	404.93	404.09
344	0.9314	0.9379	0.9249	179.07	179.33	178.81
344	0.9174	0.9238	0.9110	179.07	179.33	178.81
345	0.9215	0.9260	0.9170	249.13	249.42	248.84
345	0.9168	0.9230	0.9105	249.13	249.42	248.84
346	0.7845	0.7879	0.7812	318.97	319.41	318.54
346	0.7469	0.7520	0.7418	318.97	319.41	318.54
447	0.9277	0.9315	0.9238	675.62	676.30	674.94
446	0.9498	0.9549	0.9446	468.95	469.47	468.44
448	0.9196	0.9233	0.9160	813.82	814.60	813.04
449	0.9145	0.9180	0.9109	889.76	890.57	888.95
450	0.9122	0.9157	0.9087	1036.19	1037.09	1035.29
451	0.9093	0.9128	0.9058	1142.35	1143.31	1141.40
488	0.6975	0.7011	0.6940	263.61	263.97	263.24
288	0.6874	0.6921	0.6827	263.61	263.97	263.24
289	0.7041	0.7076	0.7005	271.72	272.08	271.36
289	0.6931	0.6976	0.6885	271.72	272.08	271.36
490	0.6962	0.6991	0.6932	376.22	376.60	375.84
490	0.6897	0.6929	0.6865	376.22	376.60	375.84
491	0.6772	0.6799	0.6745	581.04	581.63	580.44
491	0.6741	0.6767	0.6714	581.04	581.63	580.44
492	0.6720	0.6747	0.6693	667.01	667.70	666.32
492	0.6684	0.6709	0.6658	667.01	667.70	666.32
493	0.6658	0.6683	0.6632	795.39	796.19	794.59
493	0.6738	0.6793	0.6682	795.39	796.19	794.59
494	0.6601	0.6626	0.6576	915.21	916.03	914.39
494	0.6579	0.6621	0.6536	915.21	916.03	914.39
495	0.6583	0.6608	0.6558	1029.21	1030.11	1028.30

TABLE 3-8(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
495	0.6622	0.6659	0.6584	1029.21	1030.11	1028.30
303	0.7032	0.7066	0.6998	300.94	301.22	300.66
304	0.7054	0.7088	0.7020	283.29	283.53	283.04
305	0.7070	0.7105	0.7036	260.44	260.66	260.21
306	0.7108	0.7142	0.7074	236.74	236.94	236.55
307	0.7147	0.7181	0.7112	206.74	206.93	206.56
308	0.7184	0.7219	0.7150	179.56	179.71	179.42
309	0.7190	0.7226	0.7155	159.70	159.89	159.51
310	0.7219	0.7256	0.7182	130.89	131.04	130.74
311	0.7243	0.7282	0.7204	111.85	112.02	111.67
312	0.7238	0.7278	0.7197	99.09	99.20	98.98
313	0.7227	0.7276	0.7179	77.55	77.68	77.42
314	0.7151	0.7232	0.7071	51.05	51.10	50.99
315	0.6901	0.6934	0.6867	442.42	442.79	442.06
316	0.6937	0.6971	0.6904	398.75	399.10	398.41
318	0.6979	0.7013	0.6945	361.42	361.84	361.01
319	0.7018	0.7052	0.6985	319.90	320.19	319.61
320	0.7062	0.7097	0.7027	263.33	263.64	263.02
321	0.7123	0.7159	0.7087	238.30	238.63	237.96
322	0.7173	0.7209	0.7137	209.49	209.69	209.29
323	0.7198	0.7238	0.7159	166.05	166.29	165.81
324	0.7244	0.7291	0.7197	128.90	129.10	128.70
325	0.7205	0.7323	0.7086	66.55	66.74	66.37
326	0.6884	0.6918	0.6851	442.63	443.13	442.14
327	0.6928	0.6962	0.6894	411.34	411.87	410.82
320	0.7040	0.7092	0.6989	263.33	263.64	263.02
321	0.7104	0.7156	0.7051	238.30	238.63	237.96
322	0.7152	0.7204	0.7100	209.45	209,66	209.25
323	0.7176	0.7229	0.7123	166.05	166.29	165.81
324	0.7258	0.7312	0.7204	128.90	129.10	128.70
325	0.7444	0.7512	0.7376	66.55	66.74	66.37
347	0.6944	0.7007	0.6881	63.87	64.08	63.67
347	0.7284	0.7416	0.7152	63.87	64.08	63.67
348	0.7226	0.7270	0.7181	140.19	140.46	139.93
348	0.7087	0.7140	0.7034	140.19	140.46	139.93

TABLE 3-8(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
349	0.7157	0.7195	0.7119	194.79	195.07	194.51
349	0.7058	0.7110	0.7006	194.79	195.07	194.51
350	0.7100	0.7136	0.7064	239.89	240.18	239.59
350	0.7021	0.7072	0.6970	239.89	240.18	239.59
351	0.7047	0.7082	0.7012	281.77	282.12	281.43
352	0.7004	0.7038	0.6969	327.84	328.23	327.44
353	0.6956	0.6990	0.6921	354.40	354.89	353.91
354	0.6960	0.6994	0.6926	375.89	376.31	375.46
355	0.6934	0.6968	0.6900	394.78	395.21	394.36
356	0.6913	0.6947	0.6879	411.20	411.68	410.72
357	0.6896	0.6929	0.6862	432.39	432.84	431.95
358	0.6898	0.6932	0.6864	441.65	442.15	441.16
437	0.9666	0.9720	0.9612	402.29	402.87	401.70
438	0.9536	0.9583	0.9489	580.49	581.24	579.73
439	0.9467	0.9512	0.9422	685.97	686.67	685.27
440	0.9406	0.9450	0.9361	832.95	833.80	832.10
441	0.9374	0.9419	0.9330	945.73	946.71	944.75
442	0.9340	0.9384	0.9296	1100.91	1102.00	1099.82
443	0.9362	0.9406	0.9317	1032.21	1033.27	1031.16
444	0.9353	0.9398	0.9307	1194.11	1195.58	1192.64
445	0.7878	0.7916	0.7840	1142.75	1144.08	1141.42
479	0.7143	0.7181	0.7104	245.79	246.21	245.36
479	0.7053	0.7095	0.7011	245.79	246.21	245.36
480	0.6957	0.6991	0.6923	382.68	383.14	382.22
480	0.6920	0.6954	0.6887	382.68	383.14	382.22
481	0.6868	0.6902	0.6834	496.48	497.09	495.87
481	0.6850	0.6882	0.6817	496.48	497.09	495.87
482	0.6768	0.6800	0.6736	581.04	581.73	580.35
483	0.6685	0.6716	0.6653	702.98	703.78	702.19
483	0.6810	0.6857	0.6764	702.98	703.78	702.19
484	0.6649	0.6681	0.6617	796.80	797.84	795.75
484	0.6719	0.6760	0.6678	796.80	797.84	795.75
485	0.6594	0.6625	0.6563	946.59	947.62	945.56
485	0.6612	0.6648	0.6577	946.59	947.62	945.56
486	0.6573	0.6604	0.6541	1075.10	1076.27	1073.92

TABLE 3-8(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
486	0.6611	0.6645	0.6576	1075.10	1076.27	1073.92
487	0.6530	0.6561	0.6499	1164.74	1165.91	1163.57
487	0.6586	0.6619	0.6553	1164.74	1165.91	1163.57

TABLE 3-9

95 % CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE G.S. BETA=0.6						
235	0.8126	0.8165	0.8088	476.85	477.29	476.41
236	0.8175	0.8214	0.8136	453.11	453.55	452.67
237	0.8157	0.8196	0.8118	416.43	416.84	416.01
238	0.8085	0.8124	0.8047	363.93	364.22	363.63
239	0.8052	0.8090	0.8013	312.23	312.49	311.97
240	0.8139	0.8178	0.8099	287.57	287.88	287.26
241	0.8161	0.8202	0.8121	246.16	246.45	245.87
242	0.8169	0.8211	0.8128	219.56	219.83	219.29
243	0.8156	0.8200	0.8113	193.10	193.38	192.83
244	0.8186	0.8233	0.8139	156.73	156.93	156.52
245	0.8103	0.8158	0.8048	126.32	126.53	126.11
246	0.7914	0.7996	0.7832	89.57	89.78	89.37
247	0.8150	0.8190	0.8109	274.86	275.22	274.49
248	0.8168	0.8208	0.8128	314.89	315.25	314.54
377	0.7810	0.7885	0.7736	142.64	142.90	142.38
378	0.7992	0.8037	0.7946	246.39	246.81	245.96
379	0.8159	0.8201	0.8117	308.15	308.56	307.74
380	0.8098	0.8138	0.8058	386.17	386.63	385.71
381	0.8128	0.8167	0.8088	437.49	437.92	437.05
382	0.8072	0.8111	0.8033	498.52	499.10	497.94
383	0.8053	0.8092	0.8014	540.58	541.20	539.96
602	0.8078	0.8125	0.8031	312.02	312.45	311.60
603	0.8117	0.8157	0.8076	633.54	634.53	632.55
604	0.7940	0.7979	0.7901	881.16	882.33	879.98
605	0.7809	0.7845	0.7772	1120.07	1121.29	1118.85
606	0.7732	0.7768	0.7697	1327.22	1328.43	1326.02
607	0.7679	0.7715	0.7642	1454.81	1456.39	1453.22
608	0.7588	0.7624	0.7552	1714.03	1715.68	1712.38
609	0.7547	0.7583	0.7511	1799.72	1801.50	1797.94
610	0.7818	0.7854	0.7781	1106.50	1107.70	1105.29
611	0.7704	0.7740	0.7668	1345.38	1346.85	1343.92

TABLE 3-9 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
612	0.8110	0.8154	0.8065	429.73	430.70	428.76
613	0.7977	0.8020	0.7934	780.21	782.03	778.38
614	0.7992	0.8032	0.7952	754.60	755.83	753.37
657	0.6983	0.7034	0.6932	87.96	88.12	87.81
658	0.8131	0.8188	0.8073	194.53	194.74	194.31
658	0.8129	0.8170	0.8089	194.53	194.74	194.31
659	0.8042	0.8099	0.7986	133.75	133.89	133.62
659	0.8047	0.8092	0.8002	133.75	133.89	133.62
660	0.8024	0.8081	0.7967	116.00	116.16	115.85
660	0.7968	0.8018	0.7918	116.00	116.16	115.85
661	0.8174	0.8214	0.8134	243.73	244.01	243.45
661	0.8175	0.8215	0.8134	243.73	244.01	243.45
662	0.8142	0.8182	0.8102	284.45	284.81	284.10
662	0.8157	0.8196	0.8118	284.45	284.81	284.10
663	0.8144	0.8184	0.8104	348.38	348.79	347.98
663	0.8111	0.8149	0.8073	348.38	348.79	347.98
664	0.8090	0.8128	0.8053	455.62	456.13	455.12
664	0.8106	0.8167	0.8045	455.62	456.13	455.12
665	0.8081	0.8119	0.8044	453.90	454.37	453.42
665	0.8086	0.8146	0.8026	453.90	454.37	453.42
666	0.8049	0.8087	0.8011	532.35	532.96	531.74
666	0.8021	0.8071	0.7971	532.35	532.96	531.74
667	0.8028	0.8065	0.7991	574.61	575.16	574.05
667	0.7930	0.7976	0.7885	574.61	575.16	574.05
668	0.7940	0.7977	0.7902	608.10	608.76	607.43
668	0.7951	0.7995	0.7906	608.10	608.76	607.43
669	0.8258	0.8323	0.8193	86.56	86.82	86.30
669	0.7954	0.8023	0.7884	86.56	86.82	86.30
670	0.8188	0.8248	0.8129	113.64	113.84	113.45
670	0.8078	0.8129	0.8027	113.64	113.84	113.45
263	0.8101	0.8132	0.8071	585.54	586.07	585.02
264	0.8120	0.8151	0.8089	550.82	551.35	550.29
265	0.8135	0.8166	0.8105	519.25	519.70	518.80
266	0.8139	0.8170	0.8109	475.03	475.44	474.61
267	0.8192	0.8222	0.8161	436.00	436.39	435.61

TABLE 3-9 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
268	0.8193	0.8224	0.8162	391.71	392.04	391.38
269	0.8226	0.8258	0.8195	369.19	369.52	368.86
270	0.8255	0.8287	0.8223	341.25	341.58	340.92
271	0.8265	0.8300	0.8231	309.25	309.66	308.85
272	0.8274	0.8309	0.8239	278.61	278.89	278.33
273	0.8276	0.8315	0.8238	238.98	239.22	238.74
274	0.8271	0.8313	0.8230	217.27	217.46	217.08
275	0.8162	0.8210	0.8113	185.55	185.71	185.39
276	0.8255	0.8318	0.8192	157.26	157.44	157.09
371	0.7994	0.8120	0.7867	158.44	158.67	158.22
372	0.8052	0.8117	0.7987	235.34	235.64	235.03
373	0.8179	0.8224	0.8134	317.19	317.56	316.82
374	0.8175	0.8211	0.8139	415.41	415.83	414.99
375	0.8146	0.8180	0.8112	472.23	472.76	471.70
376	0.8128	0.8160	0.8096	553.62	554.23	553.01
636	0.8144	0.8190	0.8098	415.44	416.11	414.76
637	0.8129	0.8165	0.8093	562.41	563.21	561.61
638	0.8056	0.8087	0.8025	744.71	745.43	743.99
639	0.7998	0.8028	0.7968	872.58	873.39	871.78
640	0.7934	0.7965	0.7904	1009.32	1010.39	1008.26
641	0.7868	0.7898	0.7838	1108.80	1109.83	1107.76
642	0.7845	0.7874	0.7816	1237.54	1238.57	1236.50
643	0.7776	0.7804	0.7747	1337.40	1338.72	1336.07
644	0.8007	0.8038	0.7976	820.84	821.75	819.93
699	0.8098	0.8157	0.8039	90.03	90.12	89.94
699	0.7929	0.8027	0.7831	90.03	90.12	89.94
700	0.8394	0.8452	0.8336	109.82	109.94	109.71
700	0.8052	0.8127	0.7977	109.82	109.94	109.71
701	0.8286	0.8340	0.8233	156.34	156.52	156.17
701	0.8206	0.8254	0.8158	156.34	156.52	156.17
702	0.8226	0.8260	0.8192	240.35	240.61	240.09
702	0.8268	0.8310	0.8226	240.35	240.61	240.09
703	0.8232	0.8264	0.8201	316.53	316.84	316.23
703	0.8211	0.8244	0.8179	316.53	316.84	316.23
704	0.8207	0.8237	0.8176	354.03	354.33	353.72

TABLE 3-9 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
704	0.8205	0.8236	0.8174	354.03	354.33	353.72
705	0.8158	0.8189	0.8128	420.81	421.15	420.48
705	0.8135	0.8164	0.8106	420.81	421.15	420.48
706	0.8170	0.8201	0.8140	488.01	488.40	487.61
706	0.8118	0.8147	0.8090	488.01	488.40	487.61
249	0.8183	0.8212	0.8154	474.53	474.95	474.11
250	0.8204	0.8233	0.8176	470.24	470.66	469.83
251	0.8711	0.8744	0.8679	432.53	432.94	432.13
252	0.8206	0.8236	0.8176	407.00	407.38	406.61
253	0.8225	0.8255	0.8194	395.64	396.01	395.26
254	0.8245	0.8276	0.8214	379.39	379.73	379.05
255	0.8137	0.8169	0.8105	350.63	350.94	350.31
256	0.8234	0.8267	0.8201	343.59	343.89	343.29
257	0.8303	0.8339	0.8266	311.31	311.62	311.00
258	0.8249	0.8290	0.8209	282.52	282.80	282.24
259	0.8108	0.8155	0.8062	242.21	242.41	242.01
260	0.8142	0.8218	0.8067	180.09	180.26	179.92
261	0.8186	0.8320	0.8052	134.53	134.68	134.38
262	0.7790	0.8424	0.7157	56.62	56.69	56.56
359	0.8141	0.8320	0.7962	175.37	175.60	175.13
359	0.8280	0.8356	0.8204	175.37	175.60	175.13
360	0.8245	0.8349	0.8142	237.33	237.56	237.10
360	0.8236	0.8295	0.8177	237.33	237.56	237.10
361	0.8196	0.8256	0.8137	324.81	325.19	324.42
361	0.8192	0.8246	0.8138	324.81	325.19	324.42
363	0.8186	0.8221	0.8151	503.05	503.63	502.48
363	0.8194	0.8247	0.8142	503.05	503.63	502.48
366	0.8173	0.8209	0.8137	487.72	488.33	487.11
366	0.8114	0.8167	0.8062	487.72	488.33	487.11
367	0.8251	0.8286	0.8216	568.03	568.85	567.20
367	0.8139	0.8192	0.8086	568.03	568.85	567.20
368	0.8180	0.8233	0.8127	342.29	342.66	341.91
368	0.8125	0.8178	0.8073	342.29	342.66	341.91
369	0.8130	0.8186	0.8075	277.31	277.73	276.90
370	0.7921	0.7989	0.7854	178.86	179.10	178.62

TABLE 3-9 (CONTINUED)

RUN NO.	K	95 % CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
578	1.0740	1.0884	1.0596	418.10	418.72	417.48
578	1.1547	1.1868	1.1225	418.10	418.72	417.48
579	1.0672	1.0760	1.0584	548.86	549.72	548.01
579	1.1494	1.1682	1.1307	548.86	549.72	548.01
580	1.0501	1.0553	1.0448	754.23	754.99	753.47
580	1.1101	1.1195	1.1008	754.23	754.99	753.47
581	1.0364	1.0407	1.0321	921.18	922.09	920.27
581	1.0930	1.0995	1.0865	921.18	922.09	920.27
582	1.0231	1.0269	1.0192	1072.41	1073.41	1071.41
582	1.0788	1.0840	1.0736	1072.41	1073.41	1071.41
583	1.0214	1.0252	1.0176	1131.88	1132.91	1130.85
583	1.0214	1.0252	1.0176	1131.88	1132.91	1130.85
615	0.8055	0.8106	0.8003	467.22	467.77	466.68
616	0.8147	0.8183	0.8112	650.34	651.02	649.65
617	0.7991	0.8021	0.7960	796.33	797.12	795.54
618	0.7981	0.8009	0.7953	944.18	945.00	943.37
619	0.7880	0.7907	0.7853	1066.81	1067.74	1065.88
620	0.7922	0.8078	0.7765	246.45	246.86	246.05
621	0.8503	0.8619	0.8388	322.77	323.17	322.38
671	0.8665	0.8726	0.8603	138.51	138.67	138.35
671	0.8094	0.8182	0.8005	138.51	138.67	138.35
672	0.8376	0.8429	0.8324	201.31	201.53	201.09
672	0.8231	0.8280	0.8181	201.31	201.53	201.09
673	0.8394	0.8445	0.8342	234.53	234.78	234.28
673	0.8329	0.8367	0.8291	234.53	234.78	234.28
674	0.8268	0.8318	0.8217	250.51	250.75	250.27
674	0.8252	0.8288	0.8216	250.51	250.75	250.27
675	0.8461	0.8512	0.8409	301.04	301.31	300.77
675	0.8331	0.8363	0.8299	301.04	301.31	300.77
676	0.8293	0.8343	0.8243	310.11	310.37	309.85
677	0.8063	0.8112	0.8015	351.51	351.79	351.22
677	0.8264	0.8293	0.8235	351.51	351.79	351.22
678	0.8297	0.8325	0.8268	394.29	394.60	393.98
678	0.8267	0.8299	0.8236	394.29	394.60	393.98

TABLE 3-10

95% CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
ORIFICE TYPE SPECIAL 15 BETA=0.4						
622	0.7027	0.7066	0.6988	266.71	267.36	266.07
623	0.6711	0.6744	0.6679	635.33	636.32	634.34
624	0.6933	0.6968	0.6898	261.27	261.60	260.93
625	0.6874	0.6908	0.6840	345.90	346.37	345.43
626	0.6839	0.6873	0.6806	432.77	433.34	432.20
627	0.6722	0.6753	0.6690	549.88	550.55	549.20
628	0.6685	0.6717	0.6653	665.13	666.00	664.26
629	0.6640	0.6671	0.6609	799.88	800.65	799.11
630	0.6610	0.6642	0.6579	912.00	913.06	910.94
631	0.6585	0.6617	0.6554	1040.52	1041.59	1039.46
632	0.6582	0.6613	0.6550	1164.91	1166.13	1163.68
633	0.6571	0.6603	0.6539	1177.14	1178.51	1175.77
634	0.6586	0.6619	0.6553	1220.16	1221.53	1218.78
635	0.6835	0.6869	0.6802	411.95	412.52	411.38
687	0.7311	0.7366	0.7256	60.22	60.36	60.07
687	0.7148	0.7200	0.7096	60.22	60.36	60.07
688	0.7157	0.7208	0.7106	93.42	93.57	93.28
688	0.7172	0.7210	0.7133	93.42	93.57	93.28
689	0.7072	0.7107	0.7037	170.81	171.04	170.57
689	0.7036	0.7070	0.7002	170.81	171.04	170.57
690	0.6921	0.6954	0.6889	260.00	260.30	259.71
691	0.6850	0.6882	0.6817	332.19	332.57	331.80
692	0.6755	0.6787	0.6724	406.30	406.68	405.92
692	0.6782	0.6817	0.6747	406.30	406.68	405.92
693	0.6800	0.6832	0.6768	400.47	400.81	400.13
693	0.6823	0.6858	0.6788	400.47	400.81	400.13
694	0.7073	0.7109	0.7037	137.42	137.63	137.20
694	0.7015	0.7051	0.6980	137.42	137.63	137.20
695	0.6959	0.6992	0.6926	212.49	212.77	212.21
696	0.7049	0.7083	0.7014	167.89	168.12	167.67
696	0.7003	0.7037	0.6969	167.89	168.12	167.67

TABLE 3-10(CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
697	0.7106	0.7142	0.7070	122.29	122.49	122.10
697	0.7112	0.7150	0.7074	122.29	122.49	122.10

TABLE 3-11

95 CONFIDENCE INTERVAL FOR K AND RED

RUN NO.	K	95 CONFIDENCE INTERVAL		RED	95 CONFIDENCE INTERVAL	
ORIFICE TYPE SPECIAL 30 BETA=0.4						
645	0.7069	0.7105	0.7032	271.98	272.48	271.49
646	0.6963	0.6998	0.6928	375.67	376.29	375.06
647	0.6871	0.6905	0.6837	481.39	482.00	480.79
648	0.6764	0.6796	0.6731	576.02	576.78	575.27
649	0.6695	0.6726	0.6663	723.87	724.68	723.05
650	0.6651	0.6683	0.6619	860.86	861.90	859.81
651	0.6600	0.6631	0.6569	1021.05	1022.00	1020.09
652	0.6573	0.6604	0.6542	1141.99	1143.06	1140.93
653	0.6576	0.6608	0.6544	1280.90	1282.07	1279.74
654	0.7160	0.7212	0.7108	147.65	148.00	147.29
655	0.6782	0.6814	0.6750	550.90	551.50	550.30
656	0.6869	0.6904	0.6835	486.97	487.75	486.20
679	0.7136	0.7193	0.7080	51.87	52.04	51.70
679	0.7105	0.7166	0.7045	51.87	52.04	51.70
680	0.7163	0.7214	0.7113	120.14	120.30	119.97
680	0.7188	0.7224	0.7151	120.14	120.30	119.97
681	0.7155	0.7190	0.7120	171.76	171.95	171.57
681	0.7151	0.7201	0.7100	171.76	171.95	171.57
681	0.7133	0.7167	0.7099	171.76	171.95	171.57
682	0.6989	0.7024	0.6954	287.39	287.86	286.92

TABLE 3-11 (CONTINUED)

RUN NO.	K	95% CONFIDENCE INTERVAL		RED	95% CONFIDENCE INTERVAL	
682	0.7135	0.7185	0.7085	287.39	287.86	286.92
683	0.6999	0.7032	0.6966	275.75	276.02	275.49
684	0.7239	0.7279	0.7199	98.82	99.04	98.61
684	0.7217	0.7270	0.7164	98.82	99.04	98.61
685	0.7195	0.7238	0.7153	77.20	77.35	77.05
685	0.7194	0.7247	0.7142	77.20	77.35	77.05
686	0.6282	0.6335	0.6229	45.80	45.93	45.67
686	0.7235	0.7293	0.7178	45.80	45.93	45.67

APPENDIX 4 - CALIBRATIONS

The Calibration of Thermocouples and Thermometers.

The calibration of thermocouples 1, 2, 3, 4, 5 and thermometer 1 was carried out using a strain-free Platinum Resistance Thermometer, No. 169 314, made by the American Instrument Company. The thermometer was calibrated by the National Research Council in 1959. The following quadratic equation describes the temperature resistance curve.

$$\frac{R_t}{R_o} = 1 + AT + BT^2 \qquad (30)$$

$A = 0.00393298$

$B = -5.8138 \times 10^{-7}$

$R_o = 2.5121$

where R_o = resistance in ohms at the freezing point of water

R_t = resistance in ohms at temperature T

T = measured temperature, °C

A, B = constants

The method used was essentially that recorded in Appendix II of Galloway's (14) Ph.D. thesis. The results for the 5 thermocouples and thermometer are recorded in Table 4-1

Least-square-fit equations were calculated and appear as follows:

T_{cs1}, °F = 45.29751 x EMF(volts) + 32.372449 (31)

T_{cs2}, °F = 44.289022 x EMF(volts) + 33.574630 (32)

T_{cs3}, °F = 44.337977 x EMF(volts) + 33.483946 (33)

T_{cs4}, °F = 44.236682 x EMF(volts) + 33.418095 (34)

T_{cs5}, °F = 44.475782 x EMF(volts) + 33.304903 (35)

T_{ms1}, °F = 1.789271 x T_{m1}, °C + 31.94788 (36)

TABLE 4-1

DATA FOR THE CALIBRATION OF THERMOCOUPLES 1, 2, 3, 4, 5 AND THERMOMETER 1

Muller Bridge Ohms	Resistance Thermometer °F	Resistance Thermometer °C	Thermometer 1 °F	Thermocouple E.M.F. Volts				
				1	2	3	4	5
2.6850	63.68	17.6	17.70	0.690	0.680	0.681	0.683	0.685
2.6552	58.19	14.55	14.70	0.577	0.562	0.564	0.566	0.565
2.7144	68.99	20.55	20.70	0.805	0.797	0.796	0.799	0.801
2.7419	73.94	23.30	23.55	0.919	0.910	0.913	0.918	0.912
2.7724	79.61	26.45	26.55	1.037	1.034	1.035	1.040	1.035
2.8041	85.37	29.65	29.80	1.168	1.168	1.168	1.172	1.165
2.8313	90.32	32.40	32.65	1.277	1.280	1.282	1.288	1.282
2.8671	96.80	36.00	36.30	1.424	1.430	1.430	1.435	1.430
2.8995	102.74	39.30	39.55	1.558	1.565	1.565	1.568	1.566

TABLE 4-2

CALIBRATION DATA FOR THERMOMETERS 2 AND 3

Thermometer 1 °C	Thermometer 1 Corrected by Eq. 36 °F	Thermometer 2 °F	Thermometer 3 °F
26.25	78.91	79.1	79.2
26.6	79.54	79.9	79.85
28.5	82.94	83.4	83.3
35.1	94.75	95.0	95.1
30.6	86.70	87.0	87.0
29.6	84.91	85.6	85.5
26.4	79.18	79.4	79.4
24.45	75.69	75.8	75.85
22.65	72.47	72.7	72.65
19.4	66.66	66.7	66.65
18.0	64.15	64.2	64.20

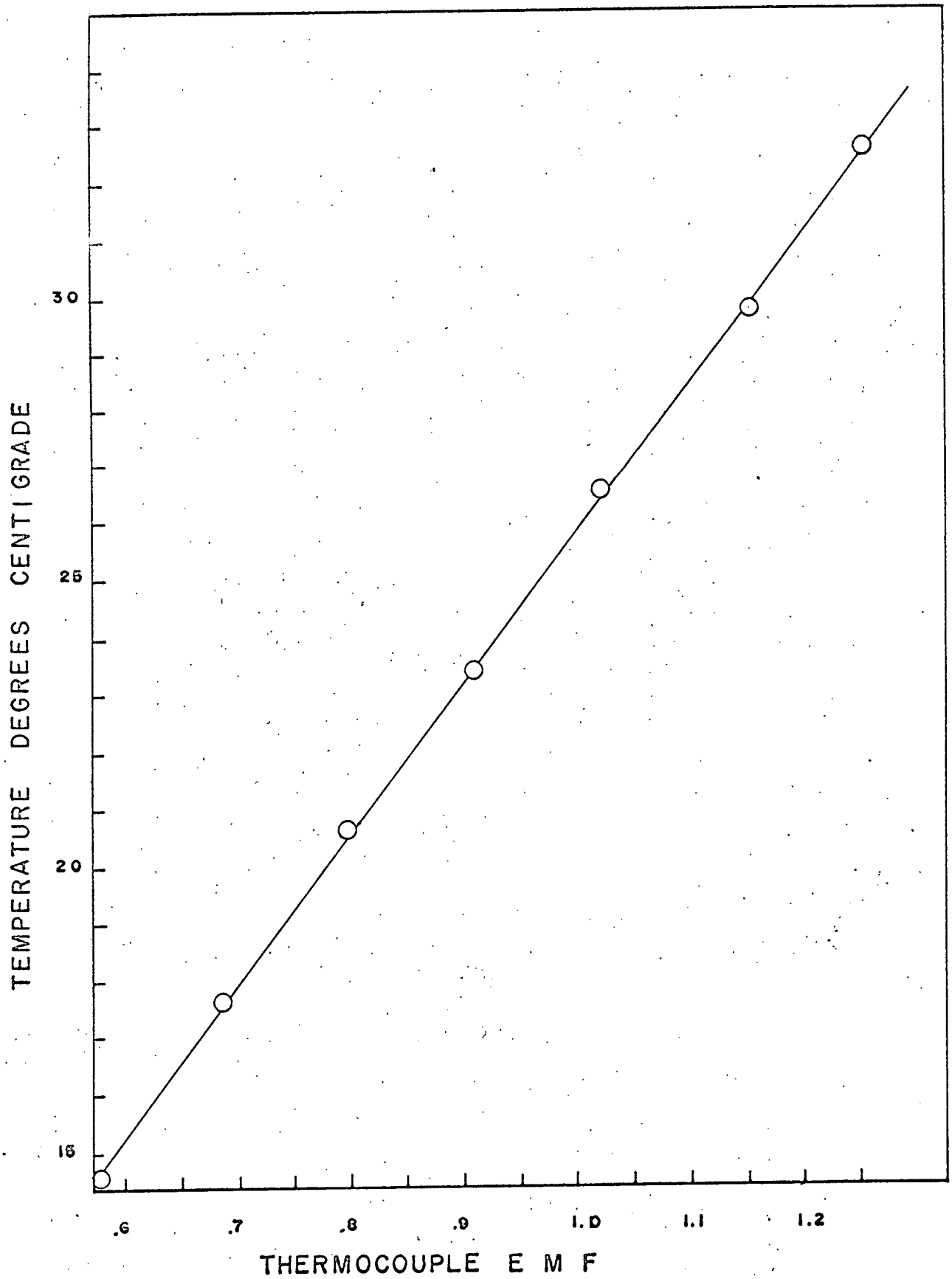

FIGURE 4-1 CALIBRATION OF THERMOCOUPLE 1

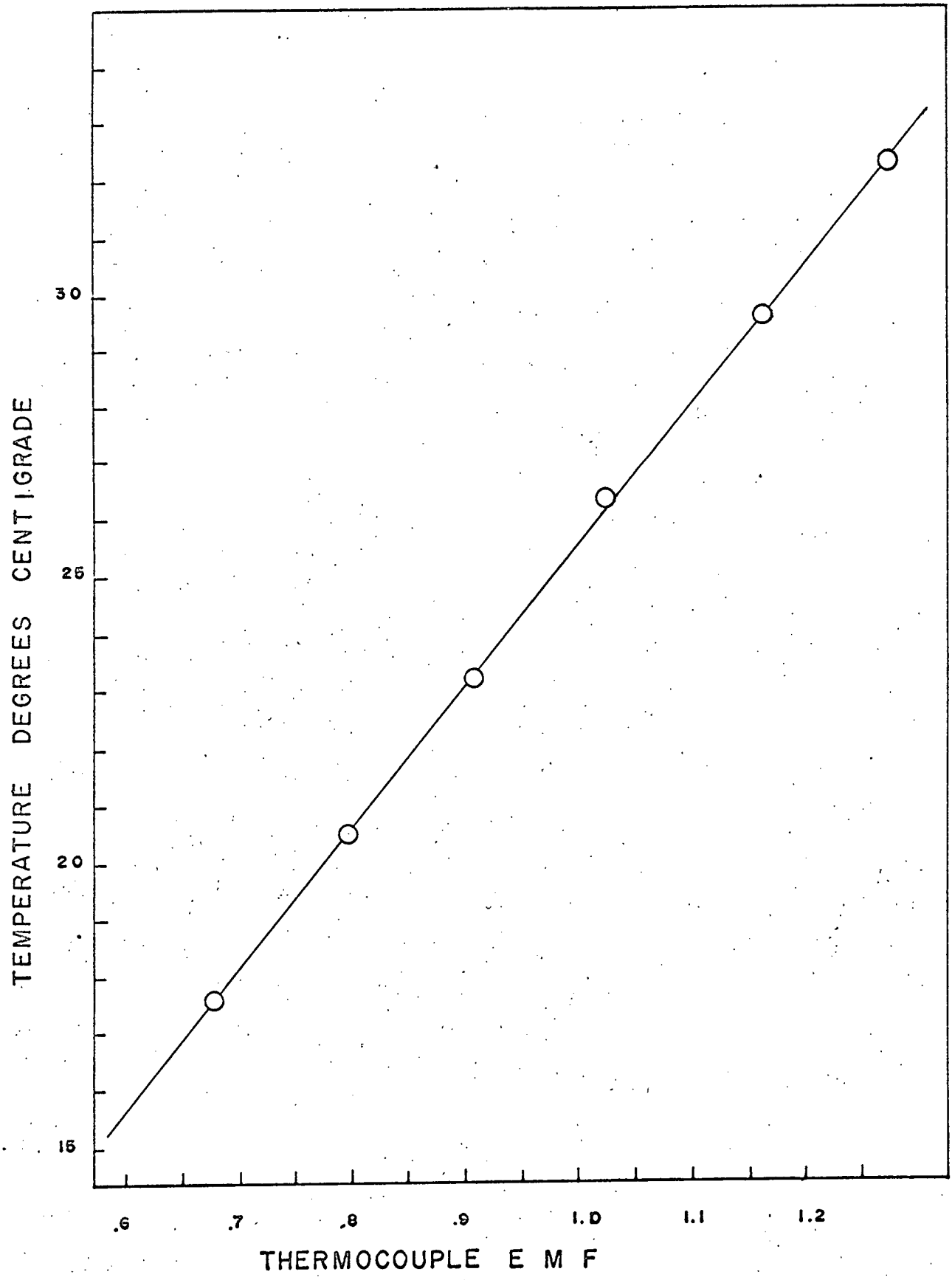

FIGURE 4-2 CALIBRATION OF THERMOCOUPLE 2

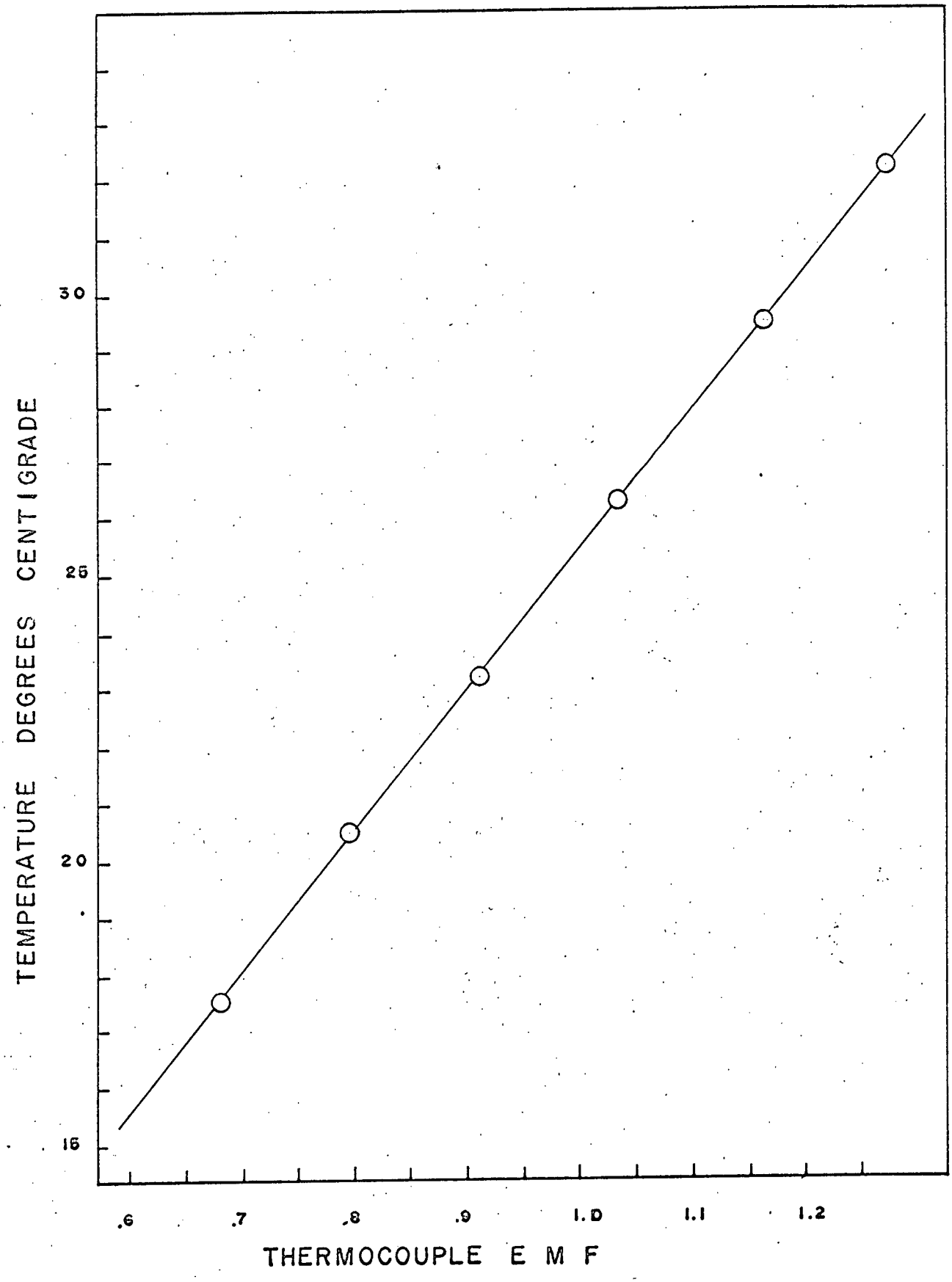

FIGURE 4-3 CALIBRATION OF THERMOCOUPLE 3

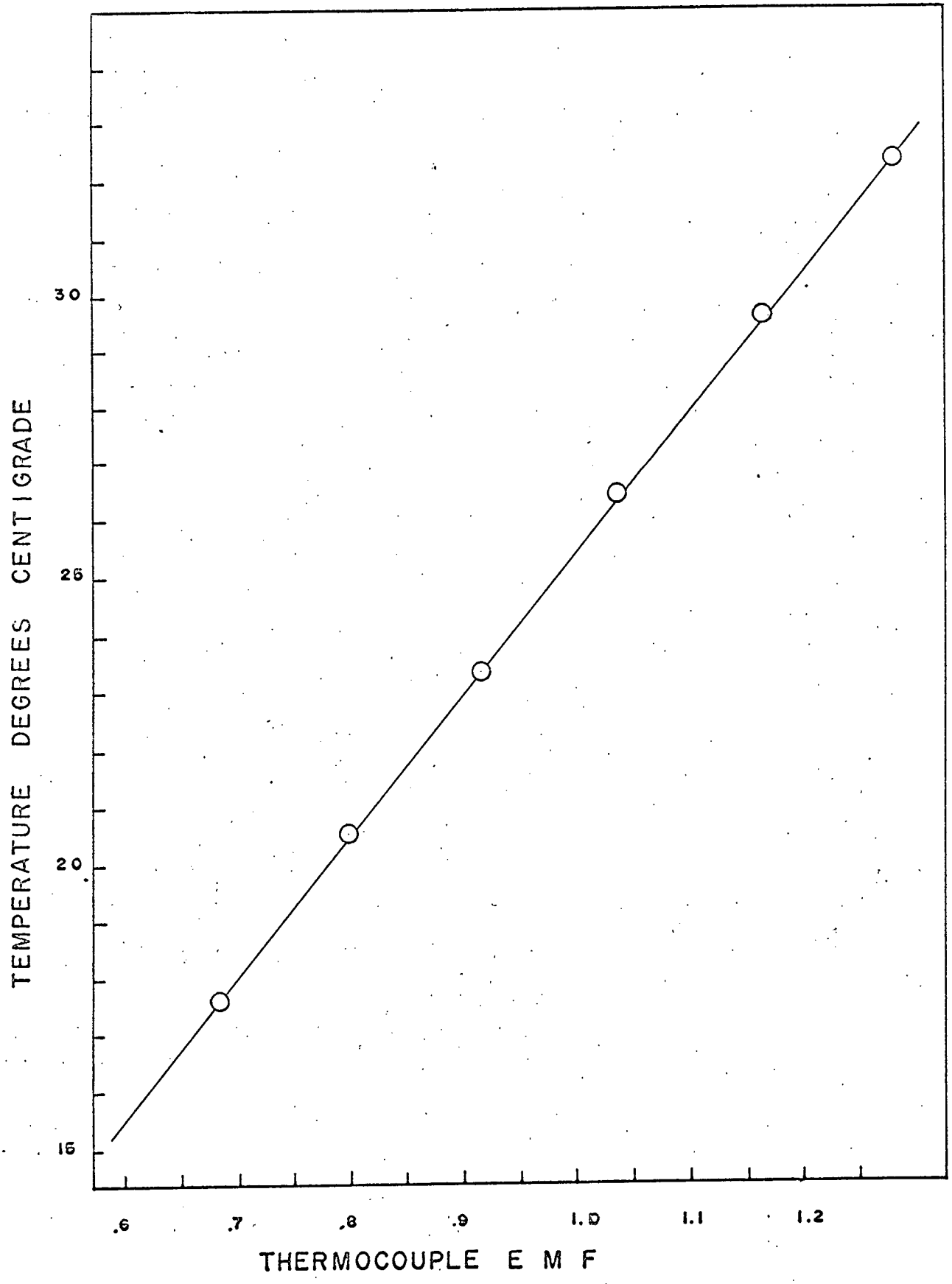

FIGURE 4-4 CALIBRATION OF THERMOCOUPLE 4

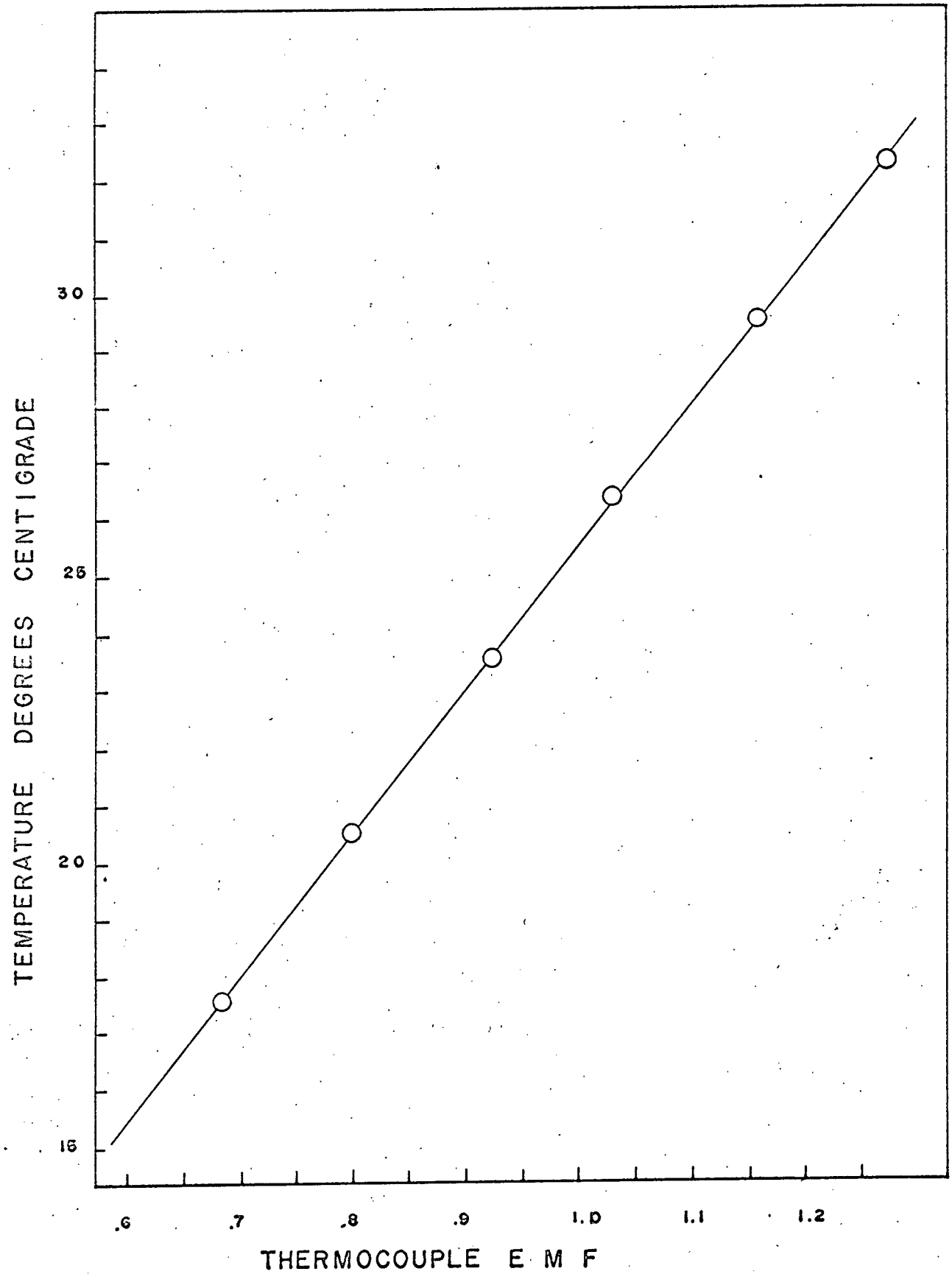

FIGURE 4-5 CALIBRATION OF THERMOCOUPLE 5

TABLE 4-3

CALIBRATION DATA FOR CARBON TETRACHLORIDE

Thermometer 1 °C	Density CCl_4 gm./c.c.
25.0	1.5869
34.2	1.5705
33.5	1.5712
23.4	1.5901
28.9	1.5798
31.95	1.5739
36.40	1.5657
21.75	1.5930
19.20	1.5975
18.40	1.5992
16.52	1.6020
26.10	1.5848

TABLE 4-4

CALIBRATION DATE FOR BENZENE

Thermometer 2 °F	Density C_6H_6 gm./c.c.
79.3	0.8722
77.8	0.8731
76.0	0.8741
74.5	0.8748
73.0	0.8757
69.6	0.8774
71.8	0.8761

Calibration of Thermocouples and Thermometers

The data from Table 4-1 for thermocouples 1, 2, 3, 4, 5 and thermometer 1 are plotted respectively in Figures 4-1, 4-2, 4-3, 4-4, 4-5 and 4-6.

Thermometers 2 and 3 were calibrated using thermometer 1 as a standard. The data are recorded in Table 4-2. Using equation (36), a corrected temperature, based on the resistance thermometer was calculated for thermometer 1 in ^{o}F. The recorded temperatures of thermometers 2 and 3 are compared with the corrected temperature of thermometer 1 to calculate their least squares calibration equations.

Thermometer

2 $$T_{ms1} \ ^{o}F = 0.987034 \times T_{m2} + 0.760447 \qquad (37)$$

3 $$T_{ms2} \ ^{o}F = 0.981782 \times T_{m3} + 1.255604 \qquad (38)$$

The data from Table 4-2 for the calibration of thermometers 2 and 3 are plotted in Figures 4-7 and 4-8.

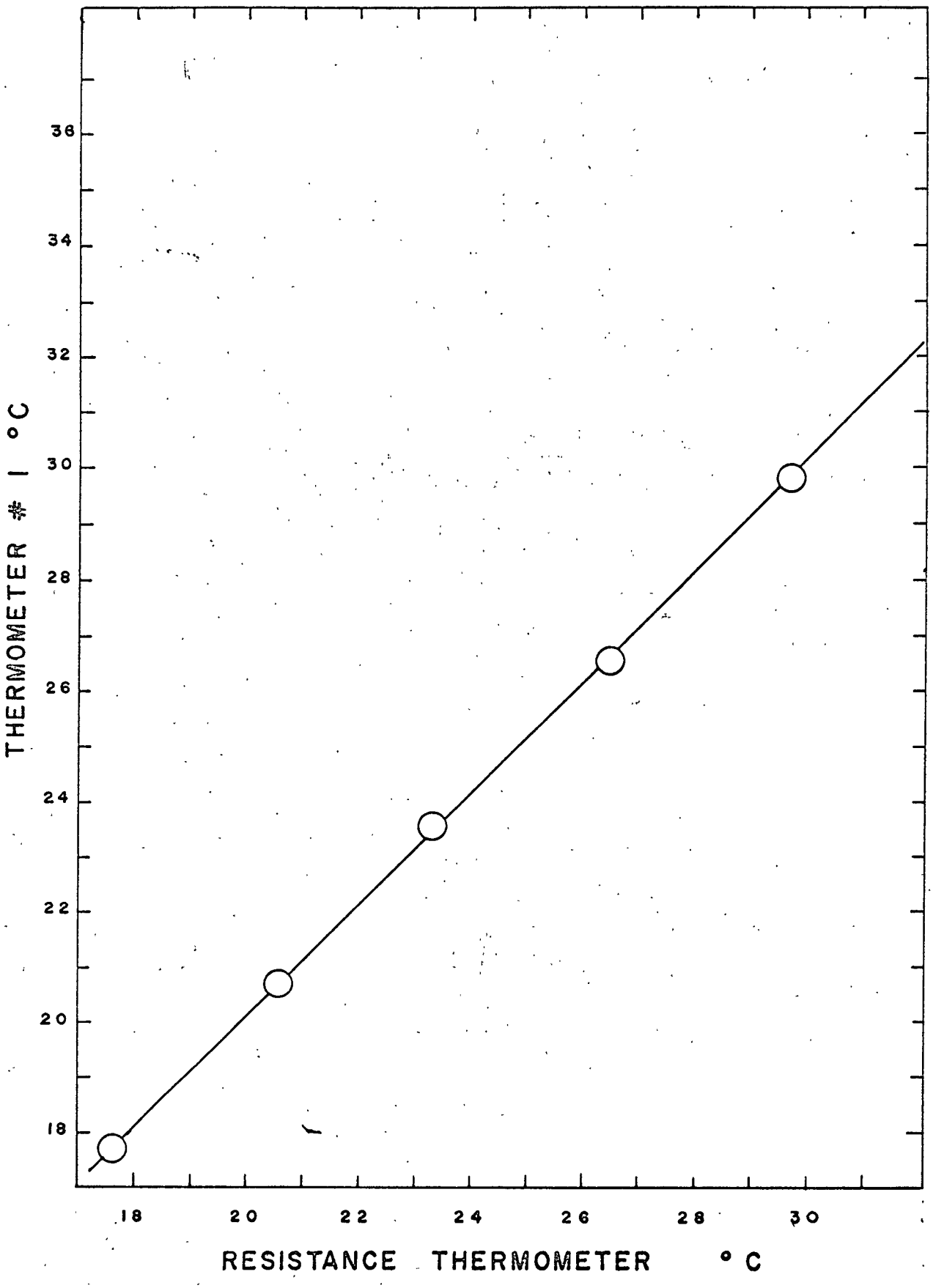

FIGURE 4-6: CALIBRATION OF THERMOMETER #1

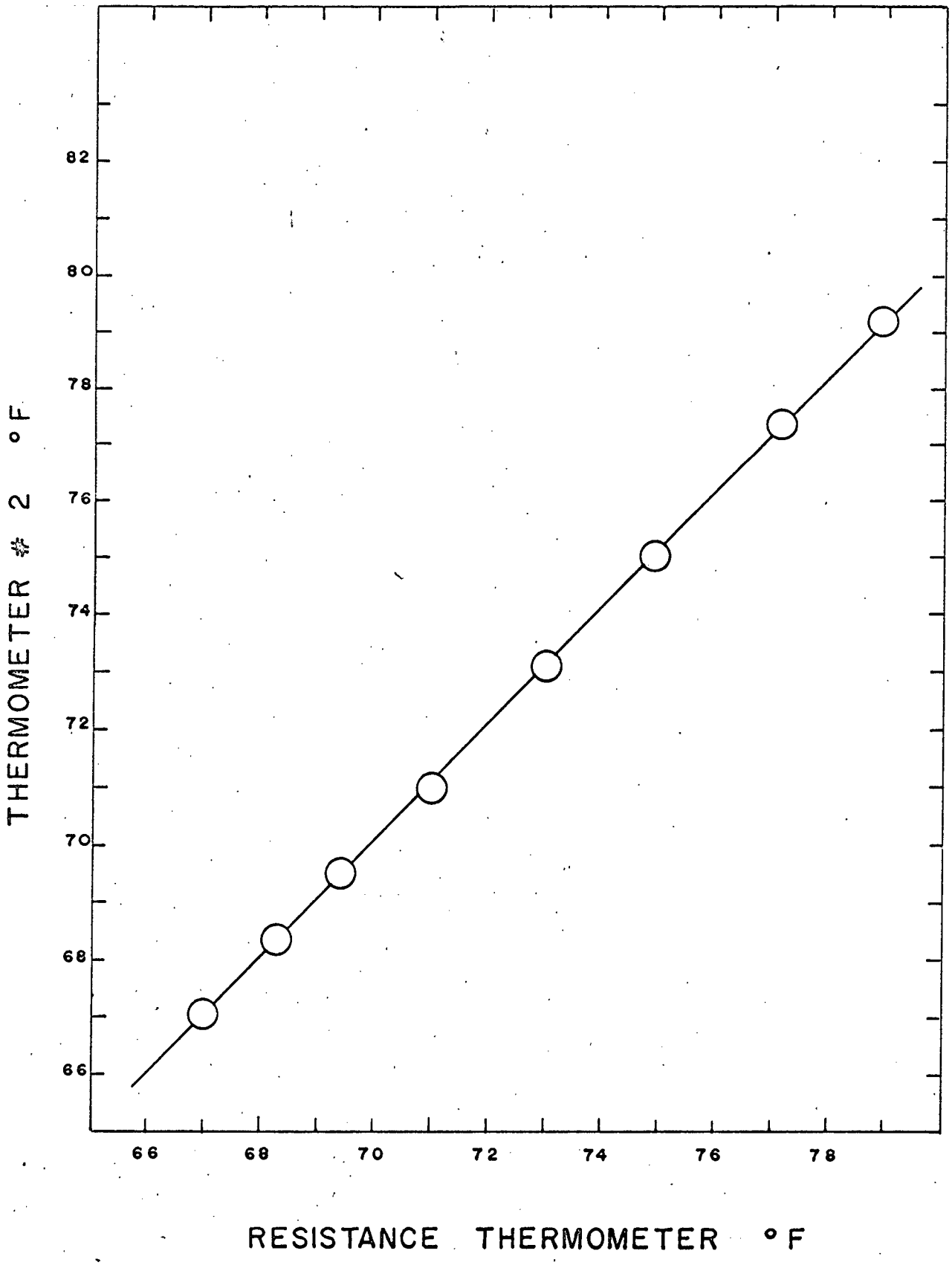

FIGURE 4-7: CALIBRATION OF THERMOMETER #2

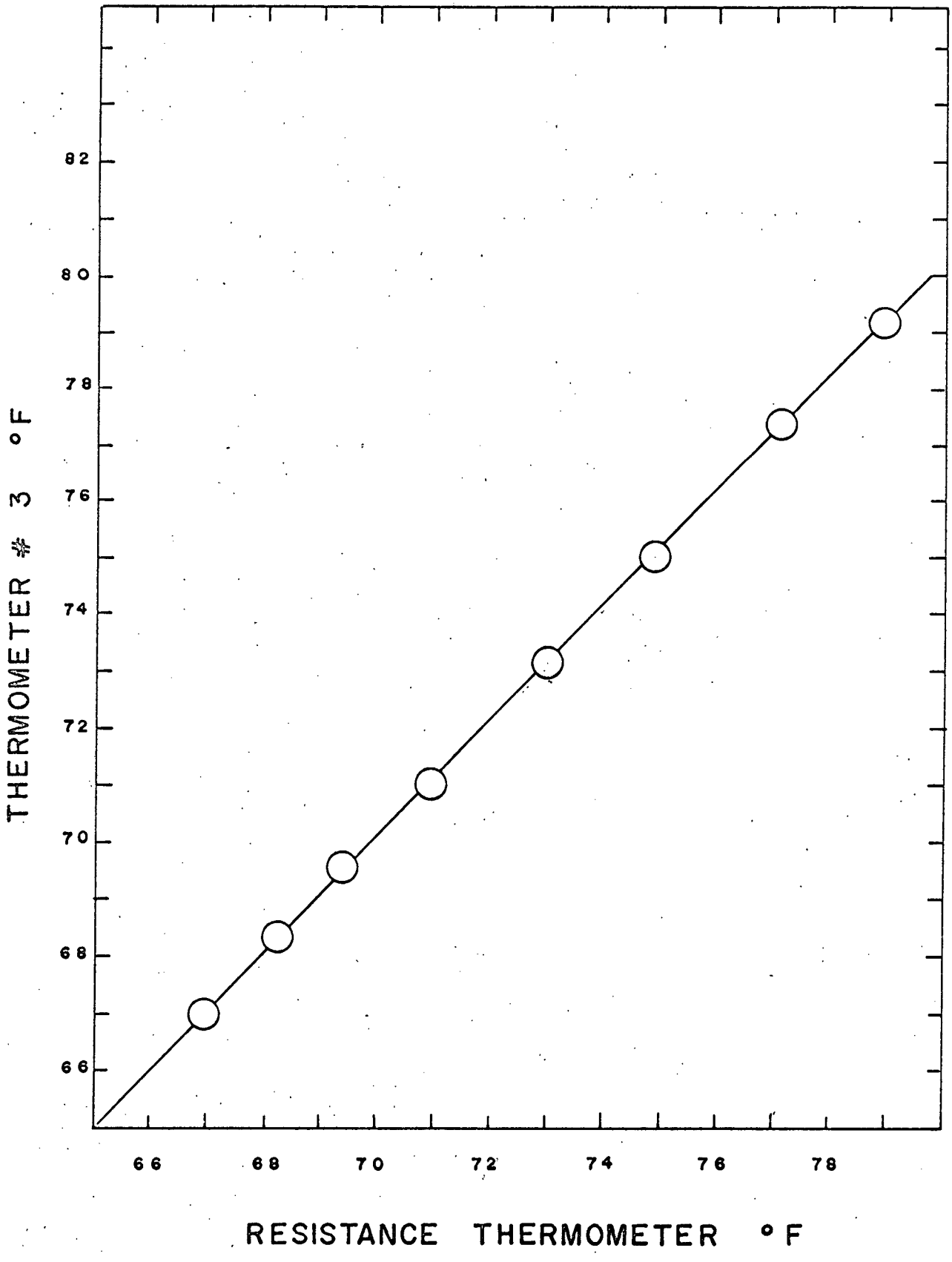

FIGURE 4-8: CALIBRATION OF THERMOMETER #3

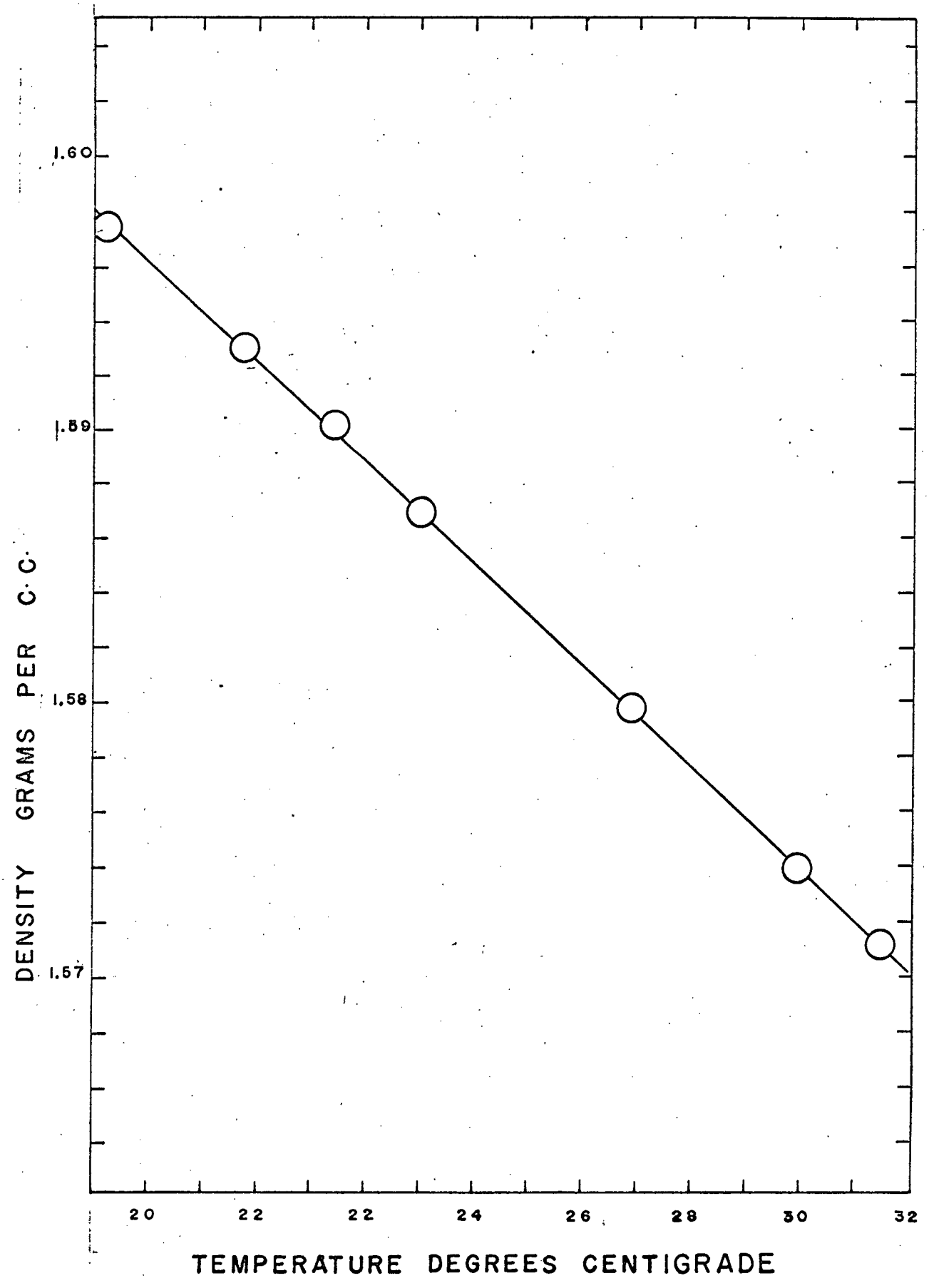

FIGURE 4-9: CALIBRATION OF CARBON TETRACHLORIDE

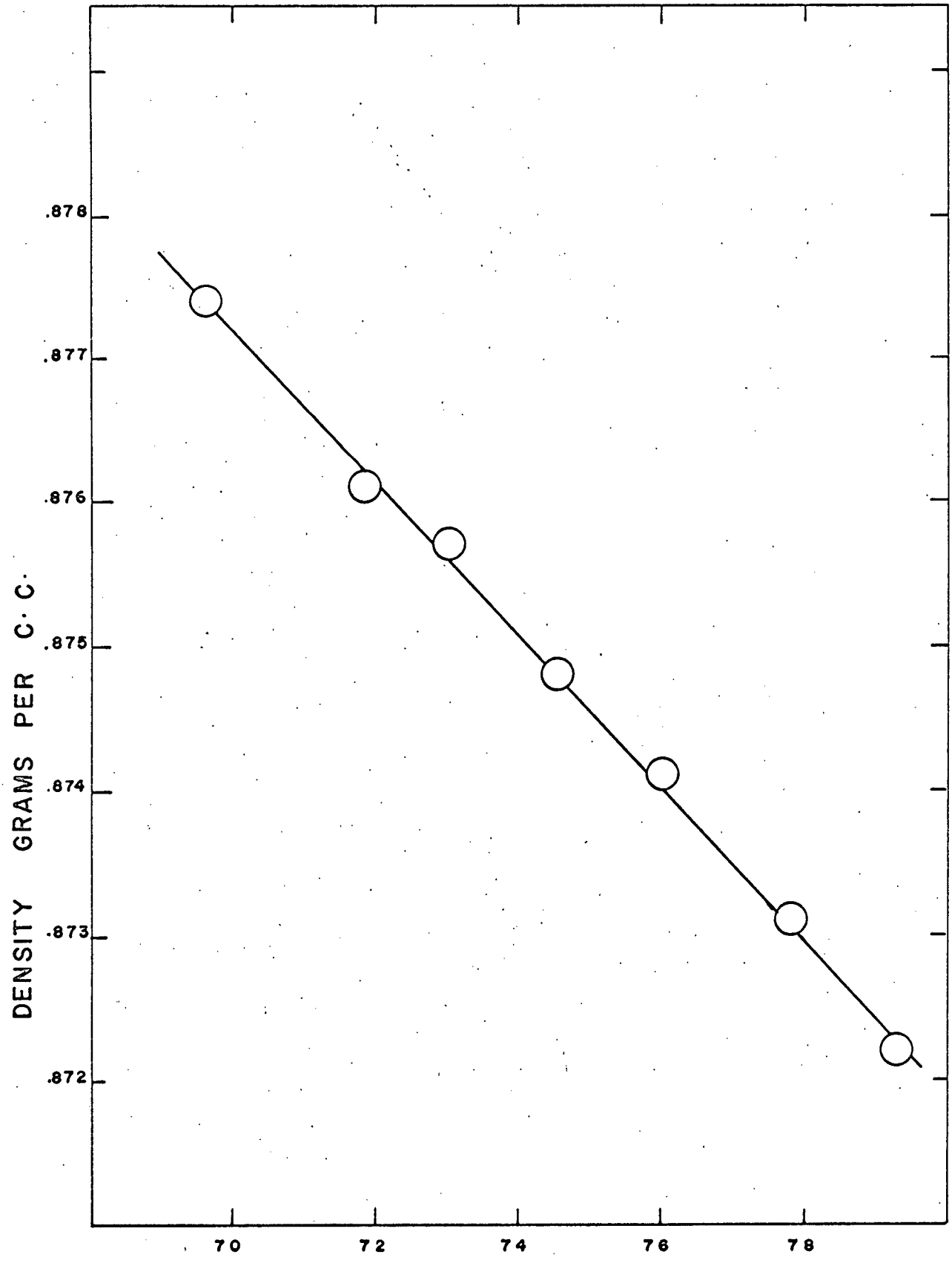

FIGURE 4-10: CALIBRATION OF BENZENE

Calibration of Manometer Fluids

All density calibrations were carried out using the Chemical Engineering Department's set of precision Hydrometers (Ch.E. 1566). The manufacturer calibrated them at 60° F. They were used, however, at temperatures between 60° F and 80° F. A Westphal balance, using distilled water as an absolute standard, was employed to check the hydrometers at the higher temperatures. The hydrometers used were found to be in error by no more than 0.3%. Therefore, the hydrometer density readings were accepted as correct within ±0.3%. The results for the calibration of carbon tetrachloride (saturated with PEG) and benzene (saturated with PEG) appear respectively in Tables 4-3 and 4-4. Least-square equations for the two liquids are

$$\text{DENSITY } (CCl_4) = 1.632717 - 0.001833 \times T_{m2} \qquad (39)$$

$$\text{DENSITY } (C_6H_6) = 0.914061 - 0.000527 \times T_{m3} \qquad (40)$$