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FLOODING IN PERFORATED-PLATE PULSED EXTRACTION COLUMNS: A SURVEY OF REPORTED EXPERIMENTAL DATA AND CORRELATIONS, AND THE PRESENTATION OF NEW CORRELATIONS WITH PHYSICAL PROPERTIES, OPERATING VARIABLES, AND COLUMN GEOMETRY

W. S. Groenier
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OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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MARCH 1966

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ABSTRACT

All of the readily available flow capacity data for pulsed perforated-plate extraction columns have been compiled and correlated with physical properties, mode of operation, and column parameters. About 2200 data points representing over 20 different chemical systems having a wide range of physical properties were used in the correlations for both aqueous- and organic-continuous operation in a variety of columns.

Exact equations describing flooding due to insufficient pulsation are presented for 9 different modes of flow control in and out of the column. In each case, the flow capacity is a function only of flow ratio and pulse velocity.

Flooding in the emulsion regime, however, is much more complex. Correlations were made by combining the variables of physical properties, pulse, and column geometry in dimensionless groups and determining the coefficients by multiple regression. A number of equations gave nearly equal success. The general type is:

$$Y = A + \sum_{i=1}^{n} b_i X_i$$

where Y is the logarithm of the dependent group and the X's represent logarithms of n independent groups, cross products, or powered terms. Using the best equation, the calculated flow capacity is, on the average, 8.6% higher than experimental, with a standard deviation of 45. The new correlations are compared to several in the literature which had been derived from a much narrower range of the variables.

1. INTRODUCTION

This report presents the results of a study of flow capacity at flooding in perforated-plate pulsed extraction columns. Exact equations are presented for the region of flooding known as flooding due to insufficient pulsation. In addition, the preferred equation correlates all types of flooding -- flooding due to insufficient pulsation, flooding due to excessive pulsation (emulsion flooding), and the intermediate flooding regions. Most existing flooding correlations were derived specifically for the case of sinusoidal pulse wave, aqueous phase continuous, and metal sieve plates, where no mass transfer was occurring. The present study examined flooding data in which the aqueous and/or the organic phase were continuous; in which mass transfer was occurring or not occurring; in which metal plates, plastic plates, or combinations of metal and plastic were used; and in which both perforated plates (also called sieve plates) and nozzle plates were used. Methods are also indicated to adapt the equations to pulse shapes other than sinusoidal. The various groups of data included in the study are summarized in Table 1. Further details are given in Tables A-1, A-2, and A-3 of the Appendix.

About 2200 data points representing over 20 different chemical systems were compiled and used in the correlations. The range of variables is broad enough to provide a good base for general correlations. Interfacial tension ranges from 3.7 to 42 dynes/cm, density from 0.68 to 1.45 g/cc, viscosity from 0.41 to 22 centipoises, pulse frequency from 6.8 to 420 cycles/min, pulse amplitude from 0.1 to 3 in., and flow ratio from 0.01 to 100. Column parameters include column diameter from 1 to 12 in., perforated-plate free area from 8 to 62%, and hole diameter from 0.02 to 0.188 in.

Table 1. Data Groups

Data Group	Data Point Nos.	Mass Transfer	Continuous Phase	Pulse Plate	No. of Data Points	Codes* Tr	CP	Ct	Note
1	1-1111	No	Aqueous	Metal sieve	1106	3,4	1	1,2,3,4,7	a
2	1112-1329	Yes	Aqueous	Metal sieve	218	1,2	1	1,2,3,4,7	
3	1330-1337	No	Aqueous	Metal nozzle	8	3,4	1	5,6	
4	1338-1374	Yes	Aqueous	Metal nozzle	37	1,2	1	5,6	
5	1375-1518	No	Aqueous	Zebra	144	3,4	1	35-51	
6	---	Yes	Aqueous	Zebra	0	1,2	1	35-51	
7	---	No	Aqueous	Plastic nozzle	0	3,4	1	52	
8	---	Yes	Aqueous	Plastic nozzle	0	1,2	1	52	
9	1519	No	Organic	Metal sieve	1	3,4	2	1,2,3,4,7	
10	1520-1531	Yes	Organic	Metal sieve	12	1,2	2	1,2,3,4,7	
11	1532-1627	No	Organic	Metal nozzle	96	3,4	2	5,6	
12	1628-1756	Yes	Organic	Metal nozzle	129	1,2	2	5,6	
13	1757-1784	No	Organic	Plastic sieve	28	3,4	2	34	
14	1785-1918	No	Organic	Zebra	134	3,4	2	35-51	
15	1919-1928	Yes	Organic	Plastic sieve	10	1,2	2	31,32,34	
16	1929-1940	No	Organic	Plastic nozzle	12	3,4	2	52	
17	1941-1950	Yes	Organic	Plastic nozzle	10	1,2	2	52	
18	1951-1996	No	Aqueous	Metal sieve	51	3,4	1	1,2,3,4,7	b,c
19	1997-2081	No	Aqueous or Organic	Metal or plastic	85	3,4	1,2	8-12,53	d
20	2082-2252	Yes or No	Aqueous	Metal sieve	171	1-4	1	1,2,3,4,7	e

*Same codes as in Tables A-2 and A-3.

[a]Except data points 859-863.

[b]Includes data points 859-863.

[c]Type V flooding, see Reference 87.

[d]Spiral cartridge. In addition to the regularly spaced perforated plates, a sheet of stainless steel was inserted between the plates to cause the fluids to move up and down the column spirally.

[e]Thornton's square wave and sawtooth wave pulse. See Reference 90 and Table A-4.

All of the correlation equations were derived using Group-1 data (Tables 1 and A-1) only, which are for aqueous-continuous operation of metal sieve-plate columns without mass transfer. Flood equation 122 was used to calculate flow capacities for the other data groups. New constants for the Pike, Thornton, and the Smoot and Babb equations have been derived and are listed in Tables A-7 and A-8 under flood equations 7, 208, and 209, and also as Eqs. (54), (53), and (55). It is recommended that the Thornton and the Smoot and Babb equations be used only for pure emulsion flooding and not for flooding near the insufficient pulsation region.

The pulsed column commonly used for liquid-liquid extraction is a vertical column containing perforated plates. A pair of immiscible liquids is fed continuously into the column, they pass countercurrently, and are removed continuously out of the opposite ends of the column from their point of injection. Both liquids within the column are subjected to a cyclic pulsing action, generally sinusoidal, in which there is a vertical pumping action superimposed on the regular countercurrent flows of the phases. The pulse breaks up one of the liquids into droplets as it is forced through the perforated plates.

If an organic phase is to be dispersed, and it is less dense than the other phase, which usually is an aqueous phase, the organic phase would be introduced into the column at the bottom. It breaks up into droplets as it passes from the inlet port(s) up through the aqueous phase to the underside of the first plate. At low pulse and flow rates, the dispersed phase has the opportunity to coalesce under the plate. Generally the holes in the perforated plates are small enough so that the surface forces between the plate and the two phases are sufficiently high to

prevent passage of either phase, were it not for the pumping action of the pulser. On the up stroke of the pulser, organic phase is forced through the holes on the bottom plate, and subsequently up through each successive plate thereafter. On the return down stroke, aqueous phase is pulled down through the perforations, allowing the aqueous phase to flow through the layer of organic phase under the plates. During this type of operation there are two distinct layers of liquid in between each pair of plates, and some drops of each of the phases which have passed through the other phase and are coalescing on their respective phases.

This operating regime is called the mixer-settler zone since its action is similar to that in a mixer-settler extraction apparatus.[116] Should the organic phase be fed into the bottom of the column faster than it is being pumped through the bottom plate, it will continue to accumulate until it discharges out the bottom of the column along with the aqueous phase. If, on the other hand, the aqueous phase is fed into the top of the column faster than it can be drawn down through the top plate, it will engorge the top section of the column and eventually flow out with the organic phase. Either type of behavior is called flooding due to insufficient pulsation.

As the pulse frequency and amplitude are increased, so is the pulsed-volume velocity, and it is possible to increase the flow rates of each phase correspondingly. As the flow rates and pulsing rates increase, so also do the inertial and shearing forces on the phases. These forces result in the formation of a dispersion or emulsion which has insufficient opportunity to coalesce between plates. The resulting emulsion is

distributed fairly uniformly throughout the height of the column. This kind of regime is referred to as the emulsion zone of operation. The more vigorous the pulsing, in general, the finer the emulsion for a given system. It is of interest to note that during both the up and the down strokes of the pulse, both phases are recycled through each plate during each pulse cycle in the emulsion zone of operation. Again, when one or the other (or both) of the phase flow rates becomes too large, it will result in one of the phases leaving the end of the column into which it was introduced, thus resulting in "emulsion flooding." The same result (emulsion flooding) is obtained at a fixed flow rate of the phases if the pulsed-volume velocity (the frequency-amplitude product) is sufficiently increased.

Geier[39] reports five separate regions of pulsed column operation. Two of the regions are classified as flooding -- one due to insufficient pulsation, the other emulsion flooding. At least four other types of flooding have been described. Defives, Durandet, and Gladel[26] describe one of these types which occurs in the absence of mass transfer. Another type of flooding in which mass transfer was occurring is described by Lowrie[96] as taking place in a compound column 24 ft tall in which the heavy phase was introduced 12 ft from the top of the column. Two other types of flooding were described by McEachern[67] in the region of flooding due to insufficient pulsation. The well-defined regions of pulsed column operation are shown in Fig. 1 in which the overall flow rate of both phases is plotted versus the pulsed-volume velocity (the frequency-amplitude product).

It is doubtful that all the operating regions of the pulsed column have been explored or reported. An example of such unusual operating

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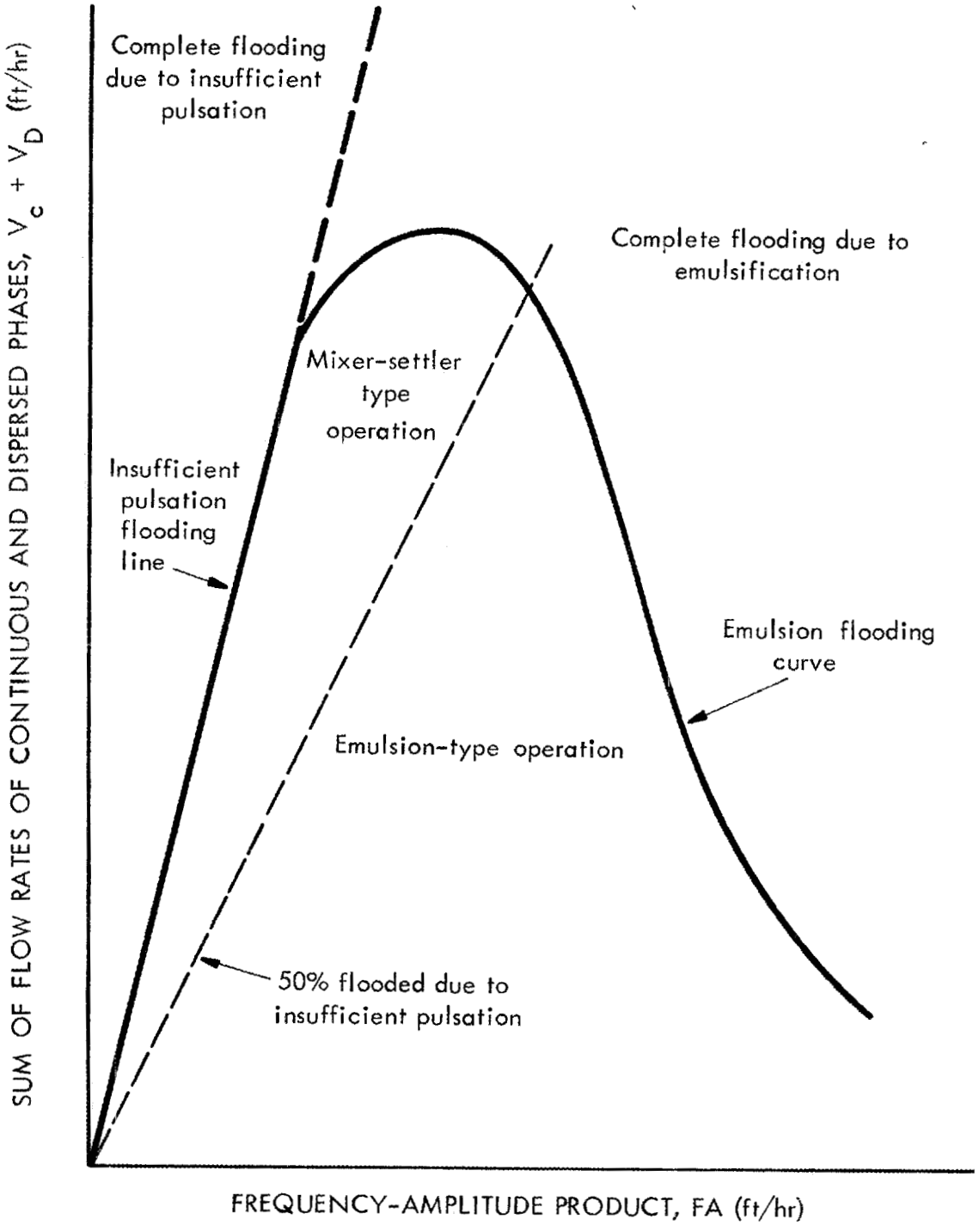

Fig. 1. General Pulsed-Column Operating and Flooding Zones.

conditions is reported by DeWitt[113-115] in which air injection into the column during the regular operation adds a third phase and surprisingly increases, somewhat, the flow capacity of the other two phases.

In the region of insufficient pulsation flooding, the flow capacities have been mathematically described and may be predicted accurately. The phenomena of emulsion flooding are not as yet amenable to rigorous analysis. Not only are the pulse rates and phase flow rates important variables, but the viscous forces and surface forces as well as gravitational, inertial, and shearing forces also become predominant in the description of flooding. In addition, such effects as plate wettability, coalescence, and whether or not there is internal circulation within the droplets all may affect the flow capacity. What physically measurable quantities are necessary to characterize these effects are not known.

Most approaches to a description of emulsion flooding are consequently empirical. Several semitheoretical approaches[64,73,75,83] have already appeared in the literature and are described below. These approaches, while partially empirical, have derived several pertinent concepts and groupings of variables which point the way toward a more complete description and understanding of flooding phenomena. The present study has taken advantage of these guideposts and developed some further, if not entirely new, relationships.

2. LITERATURE SURVEY

Flooding Data

In gathering flooding data, it was decided that at least the following information would be necessary for the data to be useful: V_c, V_D, A, F,

γ, μ_c, μ_D, ρ_c, ρ_D, d, D, ϵ, and S. All the data were converted to the same dimensional system and are presented in Table A-3 in the Appendix. Other information as to the continuous phase, whether or not mass transfer was taking place, the kind of perforated plates used and the composition of the phases also appears in Table A-3, or in supplemental Tables A-1 and A-2. In certain cases it was necessary to read data points from graphs instead of tables. In other cases where physical properties of the phases were not given, solutions were mixed at ORNL and their properties measured. These latter cases are noted in Table A-1, Supplementary Data.

Two excellent reviews[2,65] cover the subject of the use of pulsed columns in solvent extraction. Both include a survey of the literature on flooding. At least two other reviews of the literature[82,108] are primarily concerned with flooding in perforated-plate pulsed columns.

A pulsed extraction column has as its ultimate purpose the transfer of one or more solutes from one phase to the other. For more than half the data on flooding, however, there is no mass transfer, that is, the phases are in equilibrium. These data were often obtained in the course of determining ranges of operation of the column, which includes information on flooding. Table 1 summarizes all the data in this respect.

The usual indices of information were thoroughly explored, from about 1935 to August 1964. Most of the literature on the subject of flooding has appeared since 1950. Chemical Abstracts, British Abstracts, and especially Nuclear Science Abstracts, were the most helpful. A great deal of the development work in the field resulted from the high interest and utility of the perforated-plate extraction columns. Most of the data on flooding and mass transfer have been obtained by, or under the

sponsorship of, the various atomic energy establishments in the United States, Canada, Great Britain, Australia, and France. The report files at the Oak Ridge National Laboratory were a good source of data.

Graduate theses, both at the Master's and Ph.D. levels, have been fruitful sources of information. Fortunately, Dissertation Abstracts carries information regarding most of the recent Ph.D. theses which have been completed. No such index is readily available for master's theses, except for a few isolated cases.[120,121] Several useful master's theses were found, however, and are listed in the references.

Some data were intentionally not included in the current list. For example, point Nos. 1209 and 1722 were deleted from the list of a previous report,[108] since the first had a value of $\lambda = -2.07$, and the second $\lambda = 1.35$, both of which are physically impossible for case-I flooding. The value of λ must be between -1.0 and +1.0 for there to be a physical reality. Other data from the previous list have been rearranged and corrected; consequently the point numbers no longer coincide.

A large block of data which do not appear in the flooding data of this report are in the classified literature. Stoller[119] gives many graphs showing flooding data previously available only in the classified literature of the United States Atomic Energy Commission. Most of these data are still classified, and since one or more of the components is radioactive, no attempt was made to use these data, since it was felt that the radioactivity would cast doubt on the physical properties of the systems resulting from an unknown amount of radioactive degradation, primarily of the solvent. The effect of radioactivity on interfacial tension or coalescence is not well characterized.

Other data were labeled questionable by the original experimenters (see ref. 73) or by the present authors. Such data considered to be of doubtful value were not used; for example, the data of Jones.[118] None of the data reported after September 1964 were used. Thus, the very recent data of Logsdail and Larner[122] and Wrench[123] were not included.

The most common reason for not listing data that were found was that the physical properties of the phases were not given. In most of these cases the compositions of the phases were also uncertain, and so it was not possible to measure the properties of simulated solutions at ORNL.

Flooding Due to Insufficient Pulsation

Flooding in the region of low pulse energy marks the lower boundary of the mixer-settler operating zone. As previously discussed, the flows of each phase through the plate perforations are dependent on the pumping action of the pulse. Swift[87] was one of the first to recognize the importance of how the streams were introduced to and removed from the column. Swift considered nine cases in which the dispersed phase was the light phase. He based his analysis on a material balance around the bottom end section, the pulse generator, and the bottom plate. It was assumed that only dispersed phase moved upward past the plate on the upstroke, and that only the continuous phase moved downward past the plate on the downstroke. Further, the resulting expressions are valid only for equal flow of each phase ($V_C/V_D = 1.0$). Table 2 summarizes the cases considered by Swift. Case I is probably the most common and can be accomplished by positive displacement pumps in the dispersed-phase influent line and the continuous-phase effluent line. Some small fluctuation in these flow rates is certain to occur, due to the fluctuations in static

Table 2. Flooding Due to Insufficient Pulsation[87] - $V_c/V_D = 1.0$

Case	Continuous Phase	Dispersed Phase	Resulting Capacity Equation[a]
I	Removed continuously	Introduced continuously	$(V_c + V_D)$ ft/hr = $\frac{2\ (60\ \text{min/hr})}{(12\ \text{in./ft})}\ (F\ \frac{\text{cycles}}{\text{min}})(A\ \text{in.})$ = 10 FA
II	Removed continuously	Introduced on downstroke	$(V_c + V_D) = 10\ FA - V_D$
III	Removed continuously	Introduced on upstroke	$(V_c + V_D) = 10\ FA + V_D$
IV	Removed on downstroke	Introduced continuously	$(V_c + V_D) = 10\ FA + V_c$
V	Removed on upstroke	Introduced continuously	$(V_c + V_D) = 10\ FA - V_c$
VI	Removed on upstroke	Introduced on downstroke	$(V_c + V_D) = 5\ FA$
VII	Removed on downstroke	Introduced on upstroke	$(V_c + V_D) = (V_c + V_D)$
VIII	Removed on upstroke	Introduced on upstroke	$(V_c + V_D) = 5\ FA + V_D$
IX	Removed on downstroke	Introduced on downstroke	$(V_c + V_D) = 5\ FA + V_c$

[a]Symbols and their dimensions are defined in the table of nomenclature.

pressure resulting from the pulsing action, even with positive displacement pumps. It is felt that in most cases this effect is minor, and that case I is very closely realized.

Edwards and Beyer[31] derived an equation for the limiting flow capacity for a sinusoidal pulse wave operating under conditions required by case V. Their derivation allowed V_c/V_D to have values other than unity. They also confirmed the calculations by operating a column; the results are classed as group 18 in Table A-1. In 1959, Claybaugh[19] derived an equation for case I for values of V_c/V_D other than 1.0. In 1964, Groenier[117] presented the equations for cases I, II, V, and VI.

The general equations for all of Swift's cases are summarized in Table 3. As before, mixer-settler operation is assumed; that is to say, the lighter phase moves only upward during the upward portion of the pulse, and the heavier (or more dense) phase moves only downward during the downward stroke. This requires that there be no recycle of either phase, and means that there is no flow at any time during the pulse, up or down, of either phase in a direction opposite to the net flow of that phase in the column. The equations given in Table 2 are in terms of the continuous and dispersed phases rather than the light and heavy phases. Note that the general equations take care of all cases whether the continuous phase is light or heavy. The equations are rigorous for the conditions given. In all cases where an external pulser is used, the equations given in Table 3 refer to the sinusoidal pulse wave. Equations may be derived for other pulse wave shapes, such as square wave or saw-tooth wave, etc., but it generally involves a graphical integration which requires that a knowledge of the pulse-velocity profile with time

Table 3. Flooding Due to Insufficient Pulsation - General Equations

Swift's[87] Case No.	Limiting Flow Capacity Equation
I	$V_H + V_L = 2V_p \cos \phi' + 2(V_L - V_H)\frac{\phi'}{\pi}, \quad \phi' = \sin^{-1}\frac{V_L - V_H}{\pi V_p}$
II	$V_H + V_L = V_p \cos \phi'' + \frac{V_H \phi''}{\pi} + \frac{V_H}{2}, \quad \phi'' = \sin^{-1}\frac{V_H}{\pi V_p}$
III	$V_H = 2V_p \cos \phi'' + \frac{2V_H \phi''}{\pi}, \quad \phi'' = \sin^{-1}\frac{V_H}{\pi V_p}$
IV	$V_L = 2V_p \cos \phi''' + \frac{2V_L \phi'''}{\pi}, \quad \phi''' = \sin^{-1}\frac{V_L}{\pi V_p}$
V	$V_H + V_L = V_p \cos \phi''' + \frac{V_L \phi'''}{\pi} + \frac{V_L}{2}, \quad \phi''' = \sin^{-1}\frac{V_L}{\pi V_p}$
VI	$V_H + V_L = V_p$
VII	No pulse required
VIII	$V_H = V_p$
IX	$V_L = V_p$

Note: Cases I through V are for sinusoidal pulse shapes, but the equations may be modified for any pulse shape. Case VII has no external pulse; cases VI, VIII, and IX are for any pulse shape.

must be accurately known. All the equations in Table 3 reduce, of course, to those in Table 2 when $V_c/V_D = 1.0$.

Correlations by Swift, Claybaugh, Thornton, Smoot and Babb, and Baillie

W. H. Swift[87] proposed the first important correlation which relates the effect of cartridge geometry, pulse characteristics, and flow variables in the region of emulsion flooding. The equation is empirical and does not include the physical properties of the systems used. Swift suggests that the two constants in the equation contain the effect of the physical properties of the system. The Swift correlation is:

$$\ln\left[\frac{(V_c + V_D)\,\epsilon^{0.34}}{d^{0.64}}\right] = C_1 - C_2\,\frac{FAd^{0.28}}{S^{0.32}\,\epsilon^{0.82}} \quad . \qquad (1)$$

The correlation was based on 180 runs using as an organic phase a petroleum fraction, Amsco 125-90W, manufactured by the American Mineral Spirits Company, in equilibrium with water. Swift had the foresight to record the physical properties of the mutually saturated phases.

B. E. Claybaugh[19] determined a similar equation for the methyl isobutyl ketone--water system. Claybaugh also demonstrated how Thornton's equation, given below, could be used to derive an equation similar in form to Swift's equation, in which C_1 and C_2 were related to the physical properties of the system.

J. D. Thornton[64,90] and his associates report an extensive study in which six organic-water systems, eleven column cartridges, and six columns of different dimension were studied for both flooding and mass-transfer characteristics. Thornton's correlation for flooding uses the characteristic droplet velocity ($\overline{V}_o$) introduced by Gayler, Roberts, and Pratt in

an earlier paper.[38] This droplet velocity is related to the dispersed-phase holdup (x) and the phase flow rates by the following equation:

$$\frac{V_D}{x} + \frac{V_c}{(1 - x)} = \bar{V}_o \ (1 - x) \ , \qquad (2)$$

provided that there is a uniform distribution of the dispersed phase along the height of the column, and provided that there is little net coalescence of the dispersed phase. Flood-point flow rates of the two phases were obtained by taking the partial derivatives of Eq. (2) with respect to time and setting them equal to zero. Thus at flooding,

$$V_{D(f)} = 2 \ \bar{V}_o \ x_f^2 \ (1 - x_f) \ , \qquad (3)$$

and

$$V_{c(f)} = \bar{V}_o \ (1 - x_f)^2 \ (1 - 2 \ x_f) \ . \qquad (4)$$

Equations (3) and (4) may be combined to give:

$$x_f = \frac{2}{3 + \sqrt{1 + 8 \ V_c/V_D}} \ , \qquad (5)$$

which demonstrates the result that the holdup at emulsion flooding is a function only of the flow-rate ratio regardless of the physical properties of the phases or the column or pulse parameters. Equation (5) has been demonstrated valid, not only by Thornton, but by many other investigators.[26, 29,94-102,105-108,110] The most recent data verifying Eq. (5) were obtained for values of V_c/V_D ranging from 0.01 to 100.

The equation was challenged by Jones,[118] whose derivation resulted in:

$$x_f = \frac{1}{1 + \sqrt{V_c/V_D}} \ . \qquad (6)$$

The two equations are not equivalent, the latter yielding a value of

$x_f = 0.5$ when $V_c/V_D = 1.0$, and a value of 1.0 when V_c/V_D is very small. Thornton's criterion, Eq. (5), gives values of $x_f = 0.333$ and 0.500, respectively, for $V_c/V_D = 1.0$ and very small, approaching zero. Equation (6) consistently gives larger values of x_f than Thornton's equation. It is believed that Jones' criterion for flooding is invalid since his derivation is based on Edwards and Beyer's approximate flooding equation rather than their rigorous one.[31]

To complete the flooding correlation, Thornton gives the characteristic droplet velocity by the following equation:

$$\frac{\bar{V}_o \mu_c}{\gamma} = 0.60 \left[\frac{\psi_f \mu_c^5}{\rho_c \gamma^4}\right]^{-0.24} \left[\frac{d \rho_c \gamma}{\mu_c^2}\right]^{0.90} \left[\frac{\mu_c^4 g}{\Delta\rho \gamma^3}\right]^{1.01} \left[\frac{\Delta\rho}{\rho_c}\right]^{1.80} \left[\frac{\mu_D}{\mu_c}\right]^{0.30} . \quad (7)$$

L. D. Smoot and A. L. Babb[83] combined the data of Swift,[87] Thornton,[64,90] and Pike,[73-75] into another equation, which follows:

$$\frac{(V_c + V_D)\,\mu_c}{\gamma} = 0.527 \left[\frac{V_c}{V_D}\right]^{-0.014} \left[\frac{\Delta\rho}{\rho_c}\right]^{0.63} \left[\frac{\psi_f \mu_c^5}{\rho_c \gamma^4}\right]^{-0.207} \left[\frac{d \gamma \rho_c}{\mu_c^2}\right]^{0.458} \left[\frac{D}{d}\right]^{0.000} \left[\frac{g \mu_c^4}{\rho_c \gamma^3}\right]^{0.81} \left[\frac{\mu_D}{\mu_c}\right]^{-0.20} . \quad (8)$$

It will be noticed that nearly all the dimensionless groups on the right-hand side of the equation are identical with those Thornton used. In the term $(g\mu_c^4/\rho_c\gamma^3)$, used by Smoot and Babb, the density term in the denominator is ρ_c, whereas Thornton's equation uses $\Delta\rho$.

M. G. Baillie[3,4] pointed out that the range of physical properties used in the Thornton and Smoot-Babb correlations was not large, especially the properties of the continuous phase. Baillie then determined emulsion-flooding data over a much wider range of properties of the two phases.

Baillie's correlation was not designed to be general, but for his specific column ($D = 1.00$ in., $S = 1.94$ in., $F = 70$ cycles/min, $d = 0.111$ in., and $\epsilon = 0.230$).

$$\frac{(V_c + V_D)\,\mu_c}{\gamma} = 0.165 \left[\frac{\mu_D}{\mu_c}\right]^{0.36} \left[\frac{\Delta\rho}{\rho_c}\right]^{0.32} \left[\frac{\mu_c{}^4 g}{\rho_c \gamma^3}\right]^{0.21} . \qquad (9)$$

Notice that Baillie's characteristic of flooding on the left-hand side of the equation is the same as Smoot and Babb's. Baillie also used ρ_c in the denominator of the fourth term on the right-hand side instead of $\Delta\rho$.

Pike's Correlation

Perhaps the most important contributions to the theory of flooding were made by F. P. Pike in 1954 and 1955.[73-75] These contributions probably reflect the earliest work in flooding-data correlations. In his own words,[75] "An intensive study of the available pulse-column flooding data on two binary systems has led to the evolution of a theoretical picture of flooding behavior, and the demonstration that the equations thus derived aid greatly in expressing and interpreting flooding data on binary systems.

"Reliance was placed mainly on the flooding data for the benzene--water system,[74] with auxiliary use being made of the data on trichloroethylene--water.[73] Ideas concerning suitable ways of expressing and relating flooding capacity were derived by dimensional analysis, intuition and a detailed analysis of the flow patterns within a pulse column. These ideas were tested by a mathematical procedure previously developed, and evaluated by means of a statistical criterion called the F statistic. The use of this F statistic served to evaluate one idea as better or worse than another and thus to point towards the more pertinent concepts."

Theoretical Development

Pike realized that understanding of the flooding phenomenon depended on proper grouping of the variables, which depends directly on a theoretical foundation. To aid in the development of the theory, full use was made of the statistical procedure called analysis of variance. To begin with, the flooding data from the benzene--water system were taken in a systematic way using an experimental design called the cube-octahedron-cuboctahedron.[124] This design calls for a regular spacing of the variables and also requires replication of each data point so that an accurate estimate of the experimental error may be made.

With a given column and a given liquid-liquid system the primary operating variables are F, A, V_D, V_c, and the shape of the pulse wave itself. In all of Pike's work the pulse was almost sinusoidal,[a] and in all the equations given below a sinusoidal pulse was taken. It is possible, however, by graphical integration to incorporate any pulse shape into Pike's equations.

Flow capacity at flooding can be characterized in several ways.[b] If C is the flow capacity one may write:

$$C = (V_D + V_c) , \tag{10}$$

$$C = \frac{V_D + V_c}{FA} , \tag{11}$$

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[a] In conversation with Dr. Pike, he pointed out that all his results and data needed a slight correction since the pulse was measured to be not exactly sinusoidal. By the use of the integrals shown in ref 75 it will be possible to make this correction by performing a graphical integration.

[b] Much of the discussion which follows was taken directly from ref 75.

$$C = \frac{V_D}{FA} , \tag{12}$$

$$C = \frac{V_D}{\Delta_D} , \tag{13}$$

$$C = \frac{FA}{V_D} , \tag{14}$$

$$C = \ln (V_D/FA) , \tag{15}$$

$$C = \ln (V_D/\pi_D) , \tag{16}$$

$$C = \ln (V_D/\Delta_D) . \tag{17}$$

Among the various possible formulations of the relationships between C and the operating variables are these:

$$C = f (AF, A, V_D/V_c) , \tag{18}$$

$$C = f (A, F, V_D/V_c) , \tag{19}$$

$$C = f (\ln A, F, V_D/V_c) , \tag{20}$$

$$C = f (\ln FA, \ln A, \ln V_D/V_c) , \tag{21}$$

$$C = f (\ln \pi_D, \ln A, \ln V_D/V_c) , \tag{22}$$

$$C = f [\ln (\Delta_D/FA), \ln (V_c/FA), \ln (V_D/V_c)] , \tag{23}$$

and so on. Obviously one might write a very large number of such equations. Note, furthermore, that the use of ln F instead of F results in a more uniform distribution of data, lessening the relative importance of the high and low values of F. The choice of three independent or operating variables was arbitrary. The use of V_D/V_c as an independent variable by Pike instead of V_D, V_c, $(V_D + V_c)$, or some other expression was partly intuitive and partly based on his success in using the flow rate ratio as a primary operating variable in an earlier report.[73]

The next step is the selection of the particular function to fit the equation: $C = f(X_1, X_2, X_3)$. In the absence of a theoretical relationship among the variables, an arbitrary relationship could be assumed. For example, a second- or third-degree polynomial might be chosen. The expression Pike selected was a Taylor series of the following form:

$$C = A_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X_1^2 + b_{22}X_2^2 + b_{33}X_3^2 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + b_{222}X_2^3 \quad (24)$$

The F Statistic

Once the functional form of the equation was selected, the coefficients of the equation could then be determined by the method of least squares. Then an analysis of variance was made for each definition of C, X_1, X_2, and X_3. The powerful feature of this analysis was the calculation of the lack of fit of the equation to the data, and the ratio of this lack of fit to the experimental error. This ratio, called the F statistic, was taken as a measure of the combined ability of the definitions employed to express adequately the observed flooding behavior. If the equation fits the data within the experimental error of those data, the F statistic would be 1.000. The larger the statistic the poorer does the equation fit the data.

The F statistic is always a ratio of variances, or their estimates. The particular statistic suggested here by Box and Hunter[73] is the ratio of the variance due to lack of fit to the variance of the experimental error of the dependent variable. The variance due to lack of fit is computed by subtracting from the sums of squares of the deviation about regression,[a] the sums of squares of the within treatments of the dependent

[a] For the exact formulation of these quantities, see standard texts on statistics.[124,125]

variable, and dividing by the proper degrees of freedom. The former quantity includes the variation between the calculated and experimental values of the dependent variable due to lack of fit of the model, and also includes the experimental error of the dependent variable. By subtracting from this quantity the sums of squares within treatments, which is a measure of the experimental error, one is left with the sums of squares due to lack of fit. When divided by the proper degrees of freedom, a variance of the lack of fit results. This quantity divided by the variance of the experimental error is the F statistic used. A sample calculation of this quantity is given in the Appendix. A low value of this statistic, near 1.0, indicates that the model fits the data as well as can be expected in the light of the experimental error involved.

The usual F statistic calculated in multiple regression and correlation[126] is generally very large when the multiple-regression coefficient is larger than 0.70 or 0.80. This statistic is very different from the one previously discussed in that it ratios the variance of the degree of fit (rather than the lack of fit) to the variance of the deviation about regression. A large value of this statistic is a measure of a high degree of fit between the data and the model. This statistic is not as sensitive a measure of goodness of fit as the one described previously.

By means of the F statistic (ratio of the estimate of variance due to lack of fit to the estimate of variance of experimental error) Pike showed that the best fit of the data was obtained using the following form of the flooding equation:

$$C = \ln \frac{100\ V_D}{\Delta_D}, \qquad X_2 = \ln \pi_D ,$$
$$X_1 = \ln A , \qquad X_3 = \ln (V_D/V_c) , \tag{25}$$

resulting in the following equation:

$$C = \ln \frac{100\ V_D}{\Delta_D} = 4.826373 + 0.680200 \ln A - 0.063354 (\ln A)^2 -$$
$$- 4.338677 \ln \pi_D + 2.419305 [\ln (\pi_D)]^2 -$$
$$- 0.479592 [\ln (\pi_D)]^3 - 0.333357 \ln (V_D/V_c) - \qquad (26)$$
$$- 0.241265 [\ln (V_D/V_c)]^2 - 0.266134 (\ln A) (\ln \pi_D) -$$
$$- 0.000575 (\ln A) \ln (V_D/V_c) + 0.212904 (\ln \pi_D) \ln (V_D/V_c) .$$

One of the most interesting facts resulting from the analysis of variance is that the test of a third-order form of the Taylor series, as shown below, did not significantly improve the F statistic or the degree of fit.

$$C = A_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{11}X_1^2 + b_{22}X_2^2 + b_{33}X_3^2 +$$
$$+ b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + b_{111}X_1^3 + b_{222}X_2^3 +$$
$$+ b_{333}X_3^3 + b_{112}X_1^2X_2 + b_{122}X_1X_2^2 + b_{113}X_1^2X_3 + \qquad (27)$$
$$+ b_{133}X_1X_3^2 + b_{223}X_2^2X_3 + b_{233}X_2X_3^2 + b_{123}X_1X_2X_3 .$$

Dimensional analysis has long been a useful tool to aid in the grouping of variables. In general it is more effective when it is assisted by a parallel theoretical analysis. The statistical development described above therefore points the way toward a more effective use of dimensional analysis. Pike suggested the following two dimensionless equations to correlate flooding data:

$$\frac{V_D}{FA} = A_0 \left(\frac{V_D}{V_c}\right)^{b_1} \left(\frac{A}{S}\right)^{b_2} \left(\frac{dV_D\rho_D}{\mu_D}\right)^{b_3} \left(\frac{dV_c\rho_c}{\mu_c}\right)^{b_4} \left(\frac{d}{D}\right)^{b_5} \left(\frac{\Delta\rho}{\rho_c}\right)^{b_6}$$
$$\left(\frac{\mu_D}{\mu_c}\right)^{b_7} \left(\frac{\rho_D V_D^2 d}{\gamma}\right)^{b_8} \left(\frac{V_D^2\rho_D}{gA\Delta\rho}\right)^{b_9} , \qquad (28)$$

and

$$\frac{V_D}{\Delta_D} = B_o \left(\frac{V_D}{V_c}\right)^{a_1} \left(\frac{A}{S}\right)^{a_2} \left(\frac{d\pi_D\rho_D}{\mu_D}\right)^{a_3} \left(\frac{d\pi_c\rho_c}{\mu_c}\right)^{a_4} \left(\frac{d}{D}\right)^{a_5} \left(\frac{\Delta\rho}{\rho_c}\right)^{a_6}$$

$$\left(\frac{\mu_D}{\mu_c}\right)^{a_7} \left(\frac{\rho_D\pi_D{}^2 d}{\gamma}\right)^{a_8} \left(\frac{\pi_D{}^2\rho_D}{gA\Delta\rho}\right)^{a_9} . \qquad (29)$$

It is expected that the second of these equations would give a much better fit to the data than the first. This follows from the fact that V_D/Δ_D was shown to be a much better expression for fitting the data than V_D/FA.

One observation is pertinent in regard to these two equations. They are much different from those used by Smoot and Babb, Thornton, and Baillie. Smoot and Babb used the groups V_D/V_c, d/D, $\Delta\rho/\rho_c$, and μ_D/μ_c. Other forms of the dimensionless groupings are also different, particularly in the definition of the flooding characteristic, which has been made dimensionless without the use of the physical properties of either phase. In Pike's equations, one recognizes the independent variable Reynolds number, $dV_D\rho_D/\mu_D$; the Froude number, $V_D{}^2\rho_D/(A\Delta\rho)$; and the Weber number, $\rho_D V_D{}^2 d/\gamma$.

Application of the Correlation to Insufficient Pulsation Flooding

One further comment about Pike's development of a flooding correlation: The equations that were derived allowed one to take into account flows of both phases through the plates on both the upstroke and downstroke of the pulse. Such would be the case when emulsion flooding is obtained. In the limiting case of flooding due to insufficient pulsation, nothing about the equations needed to be changed. The only further requirement was that there be no recycle of the phases, which is the usual assumption made for insufficient pulsation flooding.

Pike's Δ_c is identified with V_c, and Δ_D with V_D, so that for Swift's case I (continuous injection of the dispersed phase and removal of the continuous phase at insufficient pulsation flooding), the flow capacity at flooding becomes:

$$(\Delta_c + \Delta_D) = (V_c + V_D) = 2\ (5FA)\ [\sqrt{1 - \lambda^2} + \lambda \text{ arc sin } \lambda] \ . \qquad (30)$$

Claybaugh's equation[19] for flow capacity at insufficient pulsation is:

$$G + L = 2\ [V_p \cos \phi + (G - L)(\phi/\pi)] \ . \qquad (31)$$

The two equations are identical for $\phi = \text{arc sin } (-\lambda)$.

Groenier[117] generalized Pike's and Claybaugh's equations in terms of the recycle velocity and the velocities of the light and heavy phases. For the instance of Swift's case I (see Table 2), the general equation in terms of the recycle velocity (V_R), heavy- and light-phase velocities (V_H and V_L, respectively) is:

$$V_H + V_L = 2\ [V_p \cos \phi' + (V_L - V_H)\ \phi'/\pi - V_R] \ , \qquad (32)$$

where

$$\phi' = \text{arc sin } [(V_L - V_H)/\pi V_p] \ .$$

For the instance in which the recycle rate is zero, insufficient pulsation flooding is obtained and the equation becomes:

$$V_H + V_L = 2\ V_p \cos \phi' + 2\ (V_L - V_H)\ \phi'/\pi \ . \qquad (33)$$

Equation (33) can be shown to be the same as Eqs. (30) and (31). V_L here is identified with G which is equal to V_D. Likewise, the heavy phase is usually identified with L and V_c. For case I, continuous removal of the heavy phase and injection of the light phase, the insufficient pulsation equations are not changed regardless of whether the heavy phase is continuous or dispersed. This is not true for the other cases, as indicated in Table 3.

Pike had developed the use of certain parameters for flooding which were identical with those derived later specifically for flooding due to insufficient pulsation. Pike has shown earlier that the parameters Δ_c, Δ_D, π_c, and π_D, were useful in describing the emulsion-flooding region, although he knew it was not necessary to so restrict their use to this region. Here was, for the first time, in 1955, parameters that would be useful over the entire range of flooding—flooding due to insufficient pulsation, the intermediate zone, and emulsion flooding.

3. CORRELATION PROCEDURE

One of the biggest problems involved in attempting to correlate data on flooding is in the definition of flooding itself. Most of the flooding data reported in the literature are the result of visual observations by the experimenter. It is almost inevitable that differences exist among investigators as to what is labeled flooding. In certain systems, investigators[39] have reported an unstable zone of operation which indistinctly fades into a flooding region. This would imply a "range" of incipient flooding, rather than a distinct boundary between flooding and stable operation. Other investigators[73,74] report no hysteresis at all, and are able to approach the flooding point from any direction. As long as a visual observation is the criterion for the definition of flooding there will be an uncertainty in defining the flooding point. Logsdail and Larner,[111] using nozzle plates, take a phase inversion as a sign of incipient flooding. Claybaugh[19] used the flow rate of the organic phase into the column as a measure of flooding. In his column the flow rate of the organic phase was sensitive to the holdup, or volume fraction of the

organic phase. At the flooding point, a rapid increase in the holdup resulted in a rapid increase in organic flow rate to the column. The point where such a rapid change took place in the organic flow rate was taken to be the flooding point. It is apparent that with some systems it is more difficult to detect flooding than with others.

A more quantitative measure of flooding was reported by McNamee.[33] The volume fraction of the dispersed phase; that is, the holdup, is measured at a given set of operating conditions. Holdup measurements are made after 30 min of steady-state operation. The measurement is repeated after, say, 60 min of operation. If the two holdup readings agree, the flooding region has not yet been reached. If the 60-min reading is significantly higher, then the flooding point has been passed. If one plots holdup versus pulse frequency (holding flow rates and pulse amplitude constant), the flooding point will be defined by the frequency at which the 30-min-holdup curve diverges from the 60-min-holdup curve.

A similar criterion of flooding has been useful at the Oak Ridge National Laboratory. For a given V_c/V_D ratio and pulsing conditions, the dispersed-phase holdup, x, may be measured at increasing values of total flow $(V_c + V_D)$. Holdup values are obtained after 30 and 60 min of operating time. When the holdups at the two time intervals disagree, or approach x_f as calculated by Eq. (5) above, the flooding throughput is assumed to be reached.

Another problem which one faces in attempting to correlate existing flooding data is that the data often are incomplete. Data on the physical properties of the systems used are frequently missing. For some of the data reported here, physical property measurements were made at the Oak

Ridge National Laboratory by mixing the solutions to the compositions reported in the literature and taking measurements on these solutions. Such a procedure is not entirely satisfactory since small differences in composition may make a great difference in some of the properties measured. A striking example of this is the interfacial tension of the n-heptane--water system used by Defives and Durandet.[26] The latter report the interfacial tension to be 33.6 dynes/cm, while the accepted value[27,47] is 50.5 ± 0.4. Hu[52] reports an interfacial tension of 41 dynes/cm for the same system.

Another major problem in correlating flooding data is that it is not yet known what all the important variables are, and how to characterize or measure them. Plate wetting, coalescence, and mass transfer are all known to affect the flooding point. Dispersed-phase holdup is another possibility for an important variable. While all these factors are undoubtedly related, it is not known what the relationship is. Edwards[30] and Pike[74] both report that for high-purity systems in which there is no mass transfer, small traces of grease contamination can make a difference of as much as a factor of 4 in the flooding rate.

Due to some of these uncertainties, especially in regard to a measure of plate wetting and mass transfer and their effects on coalescence and flooding, it was decided to separate the flooding data into the groups indicated in Table 1. By far the most data fell in group 1, which is the case of aqueous phase continuous, metal sieve plates, and no mass transfer. The primary efforts at developing a correlation were concentrated on this group of data since it covered the wider range of physical properties and operating conditions. Over two hundred correlating equations were tested

with the group-1 data before any of the other groups were added to see their effect on the correlation. With some of the apparently better correlations resulting from the group-1 study, a combination of groups was used to test its effect on the correlation, and to see how well it fit a particular correlation.

In the absence of a complete theoretical model for the whole of the flooding phenomenon, it was necessary to use a semi-empirical approach, clutching at any theoretical straw that might evolve. The dimensional analysis approach was exploited to the fullest, incorporating physical relationships which seemed most reasonable. The primary measure of "goodness of fit" of a particular equation, or model, was the coefficient of multiple regression, R. The mathematical formulation of the "multiple-R" can be found in any standard text on statistics.[127] Parallel to the evaluation based on the multiple-R, use was made of the F statistic described above.[73]

The usual type of dimensionless equation that has been used extensively, especially in engineering, has the following form:

$$Y = A_0 \, (X_1)^{b_1} \, (X_2)^{b_2} \, (X_3)^{b_3} \, (X_4)^{b_4} \, . \, . \, . \, (X_n)^{b_n} \, . \qquad (34)$$

Taking the logarithms of such an equation results in a linear equation:

$$\ln (Y) = \ln A_0 + b_1 \ln X_1 + b_2 \ln X_2 + \, . \, . \, . + b_n \ln X_n \, . \qquad (35)$$

Examination of the flooding curves shown in Fig. 1 shows that a linear relationship between $(V_c + V_D)$ as a dependent variable, and FA as an independent variable, could not hope to describe the physical situation.

Following the lead of Pike,[73-75] a Taylor's series including powers of the independent variables at first up to three, and eventually up to six, was tried. For the most part, the dependent variables were made

dimensionless, and also the independent variables were dimensionless. Both Pike's early studies with the F statistic and the further studies made here confirmed the fact that the logarithms of both independent and dependent variables resulted in a better fit of the data. One reason for this was that usually the logarithm of a dimensionless group had a much better distribution of the data than the number itself. However, one exponential function, used by Box,[73] was shown to be quite good.

The correlation procedure was approximately as follows: using the replicated data on a single chemical system (Pike's benzene-water data[73]), various dimensionless dependent variable groups (Y in Eq. 35) were tested with several key dimensionless independent variable groups by comparing values of the F statistic. Promising dependent variables were then used in many equations with many different independent variables (including cross-products and higher-powered terms) and all group-1 flooding data for a determination of multiple regression coefficients (R) and equation coefficients.

The correlation development followed something of a pattern in spite of its somewhat trial-and-error appearance in the first 100 (or so) flooding equations. Confidence that Pike's fundamental variables π_D, π_c, Δ_D, and Δ_c were significant variables, plus a great deal of imagination, intuition, and computer time were devoted to the correlations.

Equations having high values for R were then studied. The few having the most simple mathematical structures in addition to a high value for R were used to predict actual flow capacities at flooding for the conditions represented by each of the data points. Deviations between experimental and calculated flooding velocities were determined for all data points in

all groups, using these few equations. The shape of the curves resulting from a plot of flow capacity versus pulsed-volume velocity as calculated from these equations was considered in the selection of a single equation to represent all flooding data. The recommended equations are therefore the result of several criteria for goodness of fit, represent the best independent and dependent variables from among those tested, and produce the smallest deviations between calculated and experimental flow capacities.

Multiple Regression Analysis

The multiple-regression computer program used here was originally written by the Division of Biostatistics of the Department of Preventive Medicine and Public Health at the University of California at Los Angeles and was called BIMD-29 Multiple Regression No. 3. One powerful feature of this program is that it ranks the independent variables according to how much each variable contributes to the overall regression. In this way it was possible to compare any rival variables as $\ln (\pi_M^2 \rho_c / A\epsilon^2 \Delta\rho)$ with $\ln (\pi_M^2 \rho_c / A\Delta\rho)$. Both these variables are the same except for the epsilon-square term in the denominator. By putting both quantities in as independent variables, the BIMD-29 program would rank them according to their relative worth. If the two were ranked third and fourth out of, say, ten independent variables, then one would have little choice between the two. If they ranked first and last, then unquestionably the tenth ranking one is much, much less significant. At intermediate distances apart, it becomes the judgment of the investigator as to their relative worth. Another way to compare the relative value of the two factors given above would be to run two regressions in which all the Y's and X's are identical, with the exception of the two given above. One could then examine the two resulting

regression analyses to compare the contribution of this variable to the sums of squares, or to the correlation coefficient. The sums of squares would be larger for that variable which contributed most to the correlation, and the incremental increase in the multiple-regression coefficient would be correspondingly greater for the more important variable.

Development of a Correlation

In developing a correlation equation, the goal was an equation which would predict the flow capacity at flooding ($V_c + V_D$) from a knowledge of the system parameters μ_c, μ_D, ρ_c, ρ_D, and γ, and the column operating parameters d, D, F, A, S, ϵ, and V_c/V_D. Such a correlation would then have to be compared with the existing correlations developed by Pike, Smoot and Babb, and Thornton, as discussed earlier.

It was decided (1) that the independent and dependent variables should primarily be dimensionless with as much physical significance as possible, and (2) that the flooding characteristic (the dependent variable) should not contain physical properties of the systems. The first consideration has long been a useful tool in science and engineering and its use requires no justification. The second guide was an arbitrary choice. If one examines the flood equations that have μ_c, for example, in the flooding characteristic (Eqs. 4, 5, 6, 22, 24, 167, 168, 169, 208, 209, and 210) one finds that the most important independent variable (or the second most important one) contains μ_c. Thus it would seem that a covariance exists which would mask other effects.

As a starting point in the development of a flooding equation, it was felt that the work done by Pike[73-75] formed the best basis. Pike showed that for the systems and equations he studied, the following model was by far the most significant:

$$Y = f(X_1, X_2, X_3) , \tag{36}$$

$$Y = \ln \frac{V_D}{\Delta_D} , \tag{37}$$

$$X_1 = \ln A , \tag{38}$$

$$X_2 = \ln \pi_D , \tag{39}$$

$$X_3 = \ln V_c/V_D , \tag{40}$$

$$\begin{aligned} Y = A_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + \\ + b_{11}X_1^2 + b_{22}X_2^2 + b_{33}X_3^2 + b_{222}X_2^3 . \end{aligned} \tag{41}$$

The dependent variable above is already dimensionless and contains no physical properties. Physically, it is the ratio of the superficial velocity of the dispersed phase to the superficial velocity of both phases during that portion of the pulse in which the net velocity in the column is flowing in the direction of the dispersed phase flow. The independent variables can be made dimensionless in several ways. It seemed reasonable that A/S would be a significant dimensionless ratio. The velocity term π_D could be incorporated into any number of dimensionless groups. Initially the Weber and the Froude numbers were used:

$$X_2 = \ln (\text{Weber}) = \ln (\rho_D \pi_D^2/\gamma) , \tag{42}$$

and

$$X_2 = \ln (\text{Froude}) = \ln [\rho_D \pi_D^2/(gA\Delta\rho)] . \tag{43}$$

Either of these definitions of X_2, along with $X_1 = \ln (A/S)$, and $X_3 = \ln (V_c/V_D)$, would give an F statistic for Pike's data, at least, which was the same as before. It also seemed reasonable that both the Froude and Weber numbers should be used together, since the Froude number is the ratio of inertial forces to gravity forces, and the Weber number is a ratio of inertial to surface-tension forces. The equation still would not

account for viscous forces, which would probably be important. Therefore the use of a Reynolds number, either

$$X = \ln \left(\frac{d\pi_D \rho_D}{\mu_D} \right) \tag{44}$$

or

$$X = \ln \left(\frac{d\pi_c \rho_c}{\mu_c} \right) , \tag{45}$$

or both, should also be pertinent. The first few flooding equations tested this idea, unfortunately without the second and third powers of the independent variables as suggested by Pike. Various combinations of these variables were also tested.

One significant early development which seemed reasonable, and which could be tested very nicely by comparing the resulting multiple-R, was the use of π_D and π_D/ϵ. The quantity π_D represents the average velocity of both phases with respect to the column during that period of the pulse when there is an overall velocity in the direction of flow of the dispersed phase. By dividing π_D by ϵ, this makes it now the velocity through the perforations in the plate. It would be at the plate perforations that the viscous, inertial, and surface forces would interact most vigorously, so that every term involving velocity should include the fractional free area ϵ. Flood equations 7 and 8 demonstrate that the addition of ϵ makes a significant increase in the multiple-R, from 0.880 to 0.885. From that point on, ϵ was used with most definitions of velocity.

Early in the development of the correlation, reluctance was exercised in using a Taylor's series type of expansion, as flood equation 16 suggests. It was hoped that a matter of four to six terms, not involving squares and cubes of logarithms, could be used. The obviously poor values

(< 0.900) of the multiple-R (in flood equations 2 through 30) attest to the failure of such a hope.

A comment is appropriate here in regard to all the flooding equations. Startlingly high multiple-R values are suspicious and suggest further inspection of the equations. For those equations whose multiple-R is higher than 0.960, and especially those of 0.999, it follows that one term contributes to more than 0.900 on the partial cumulative correlation coefficient.

Compare flood equations 32 and 33 for examples:

F1-32:

$$\ln \frac{\overline{V}_o}{(\Delta_D + \Delta_c)} = -1.312 - 0.4384 \ln \left(\frac{\Delta\rho\pi_M^2 d}{\epsilon^2\gamma}\right) - 0.5612 \ln (A/S) - $$

$$- 0.06278 \ln (V_c/V_D) \qquad (46)$$

$$R = 0.790 \ .$$

F1-33:

$$\ln \frac{\overline{V}_o}{(\Delta_D + \Delta_c)} = 0.4843 - 1.001 \ln \left(\frac{FA}{V_D + V_c}\right) - 0.1748 \ln (V_c/V_D) + $$

$$+ 0.002576 \ln \left(\frac{\Delta\rho\pi_M^2 d}{\epsilon^2\gamma}\right) \qquad (47)$$

$$R = 0.999 \ .$$

The equations are not so very much different, and so the difference in R is suspicious. Since the quantity $(\Delta_D + \Delta_c) = 10\ FA\ [\sqrt{1 - \lambda^2} + \lambda \arcsin \lambda]$, notice that there is FA in the denominator of the dependent variable, and FA in the numerator of the first independent variable of flood equation 33; in other words, Y = Y should give a good multiple-R! The other suspicious result noticed between flood equations 32 and 33 is the shift of the Weber

number from first in equation 32 to last in 33 in the order of importance. The BIMD-29 multiple-regression computer code ranks the variables in the order of their contribution to the regression. Such large changes in rank from one equation to the next should be looked upon with suspicion. Therefore, flood equation 33, and incidentally also 31, 34, and 35, are not valid, since FA appears as a primary variable on both sides of the equation.

Flood equation 214 is probably not valid for similar reasons. Examine the dependent variable, ln $(V_D/\bar{V}_o)$. Now,

$$\bar{V}_o = \frac{V_D}{x_f(1 - x_f)} + \frac{V_c}{(1 - x_f)^2} , \tag{48}$$

so

$$\frac{V_D}{\bar{V}_o} = \frac{V_D}{\dfrac{V_D}{x_f(1 - x_f)} + \dfrac{V_c}{(1 - x_f)^2}} , \tag{49}$$

or

$$\frac{V_D}{\bar{V}_o} = \frac{x_f\,(1 - x_f)}{(1 - x_f) + V_c/V_D\,(x_f)} . \tag{50}$$

But x_f itself is a function only of V_c/V_D:

$$x_f = \frac{2}{3 + \sqrt{1 + 8\,V_c/V_D}} . \tag{51}$$

It is obvious, then, why the independent variables in equation 214 involving only V_c/V_D should jump to first place significance, from a very low significance in previous and succeeding equations.

Beginning with flood equation 36, and running through equation 175, a systematic study was made, using some new dimensionless numbers. These numbers, along with the Weber, Reynolds, and Froude numbers, are listed

in Table 4. In general, when an inertial force was involved, the variable definition contained π_M^2 since this quantity is proportional to the average kinetic energy due to the pulsing action; whenever a viscous force was involved, the average pulsing velocity π_V was the preferred velocity. In fact, π_M^2 was generally changed to an average kinetic energy through the perforations by dividing it by ϵ^2, and π_V was often converted to (π_V/ϵ) for similar reasons. Care was exercised in forming the cross products of the variables. For example, in using X20 and X21 (see Tables A-5 and A-6) in any flood equation, it was recognized that an increase in the gravitational force should increase the flow capacity, while an increase in the inertial forces should decrease the flow capacity at flooding (hence the indicated ratio for the drag coefficient). The viscous forces should decrease the flow capacity while the surface-tension forces should increase it. Hence whenever X20 and X21 were used as a cross product it was always a ratio, or the product of X20 and (1/X21). Likewise, the ratios of X17/X19 and X18/X20 seemed more realistic than the products. If one follows the groups of equations presented in Tables A-11 through A-20, more of the plan of attack in the development of the flooding equations will be evident. In some of the tables of equations, however, the purpose of the calculation may be obscure. For example, in Table A-16 is shown the series of runs for flood equations 177 through 190. For the group from 178 through 186 it will be noted that one additional independent variable was dropped for each successive equation. It will be recalled that the BIMD-29 program rates and lists the independent variables according to their relative contribution to the overall sums-of-squares due to regression. In equation 178 all 15 variables shown in Table A-16 were used; in 179, the least

Table 4. Dimensionless Numbers and Their Significance

Name	General Formula	Force Proportionalities	Variable Definitions, This Study
Reynolds number	$LV\rho/\mu$	Inertial force/Viscous force	X13, X14, X15, X16
Weber number	$V^2\rho L/g_c\gamma$	Inertial force/Surface-tension force	X05, X06, X07, X08 X09, X29, X35
Froude number	V^2/gL	Inertial force/Gravitational force	X10, X11, X12, X19
Ohnesorge number	$\mu/(\rho g_c L\gamma)^{1/2}$	Viscous force/(Inertial x surface-tension force)$^{1/2}$	X18
Drag coefficient	$\Delta\rho Lg/\rho V^2$	Gravitational force/Inertial force	X20, X34
Capillary number	$\mu V/g_c\gamma$	Viscous force/Surface-tension force	X21

important one, X23, was dropped from the equation; and in the next equation, 180, the next two least important variables, X23 and X20 2, were dropped; and so on. This was an effort to see how many variables could be dropped without affecting the cumulative multiple-R. It was found that one could delete more than half the variables without seriously affecting the cumulative multiple-R values. Thereafter, a large number of variables were used, even though their contributions were very small, because one could always cut off the lowest variables without seriously affecting the cumulative multiple-R.

In the series of equations shown in Table A-19, it is apparent that not only is group 1 being compared with the combined groups 1 and 2, but the effect of the dependent-variable definition is being studied.

Computer Programs Developed

In the course of the correlation, several programs were developed specifically for the calculations, but they are sufficiently versatile so that they could be used for many other types of calculations. Two of the programs (GRØEN3 and GRØEN4) are listed in the Appendix in FØRTRAN-63, with instructions for their use.

The GRØEN1 and GRØEN2 programs allow a sort of the basic data into 2- or 3-level (2^n or 3^n factorial) experimental designs for up to 7 factors or independent variables. The computer seeks the data points that fall into each level of the array a_{ij}, where the subscript i is the level (1, 2, or 1, 2, 3), and the subscript j is the factor (1, 2, 3, . . . 7). It was found to be almost impossible, with the existing data and variables, to find even a fractional factorial design that was balanced, and so these programs were not included in the Appendix.

GRØEN3 is the program used to prepare a 25-level sort of the variables. Input to the program includes the basic data points. The computer can perform calculations on the variables to calculate independent or dependent variables (up to 36) and perform sorts and distributions of these data. The program is listed in the Appendix after a description of its operation.

GRØEN4 is the program required to calculate $(V_c + V_D)$ from a given flood equation. Input data to the program may be either the independent or dependent variable values, or sufficient factors necessary for their calculation. Most of the flooding equations require a trial-and-error technique to calculate $(V_c + V_D)$. Best possible estimates of $(V_c + V_D)$ are used as input values to the GRØEN4 program. The program will then use these values as an initial starting point in the iteration and finally calculate $(V_c + V_D)$ as dictated by whatever flooding equation is desired. In doing this calculation, it will retain the same flow ratio (V_c/V_D) as was originally given the estimated input values. That is, if one wants a 10-to-1 V_c/V_D ratio, then the original estimates of V_c and V_D that are put into GRØEN4 should be in that ratio.

Also enclosed in the Appendix is a description of the BIMD-29 program used in this study. The original program was slightly modified especially for use in flooding equations. Details of the calculation of the various statistics which the program generates may be obtained from the Department of Preventive Medicine and Public Health, School of Medicine, University of California at Los Angeles.

4. RESULTS

The Preferred Equations

The selection of a single, unique equation, one that is better than any other, was not possible. As will be pointed out below, the fact that the multiple-R is high does not automatically guarantee that the $(V_c + V_D)$ calculated from a given equation will be the most accurate value. In Table A-7, all the equations whose multiple-R is above 0.900 are listed, 92 equations. As has been pointed out previously, equations 31, 33, 34, 35, 214, and 215 should be ignored as being invalid. Of the 86 remaining, only a few have been studied on the basis of the $(V_c + V_D)$ back calculation to compare experimental and calculated flow capacities.

Specifically, flood equation 122 has been selected as preferable. The choice is admittedly somewhat arbitrary but is based on all the criteria described above. Flood equation 122, valid for the entire flooding region, with coefficients based on group-1 data is:

$$\ln \frac{V_c + V_D}{\Delta_c + \Delta_D} = -3.741 + 0.2568 \ln \frac{\Delta\rho d \epsilon^2}{\rho_c \pi_M^2} - 0.07194 \left[\ln \frac{\Delta\rho d \epsilon^2}{\rho_c \pi_M^2}\right]^2 +$$

$$+ 0.006191 \left[\ln \frac{\Delta\rho d \epsilon^2}{\rho_c \pi_M^2}\right]^3 - 1.034 \ln \frac{\mu_c \pi_V}{\epsilon\gamma} + 0.09096 \left[\ln \frac{\mu_c \pi_V}{\epsilon\gamma}\right]^2 + \quad (52)$$

$$+ 0.1424 \ln \frac{V_c}{V_D} - 0.1807 \ln \frac{A}{S} + 0.07198 \left[\ln \frac{\Delta\rho d \epsilon^2}{\rho_c \pi_M^2} \Big/ \ln \frac{\mu_c \pi_V}{\epsilon\gamma}\right].$$

This equation may be used to predict flow capacities with an average error of 8.56% (predicted value high by this amount) with a standard deviation of 44.70, as seen in Table 5. Note that the confidence band specified in Table 5 is a measure of how well the data represent an infinite population and is not the interval within which the error of a single prediction would fall.

Table 5. Comparison of Selected Flooding Equations

Flood Equation No.	Multiple-R	Mean % Difference ($\bar{d}_i$)	Standard Deviation (s_i)	95% Confidence Interval for the Mean % Difference $\left[\delta_i = \bar{d}_i \pm \left(t_{\alpha/2,\nu_i}\right)\left(\frac{s_i}{\sqrt{n_i}}\right)\right]$
122	0.9310	-8.56	44.70	$-11.19 < \delta_{122} < -5.93$[a]
208	0.9175	-10.04	51.13	$-13.30 < \delta_{208} < -6.78$[a]
7	0.8804	-14.82	80.01	$-19.58 < \delta_{7} < -10.06$
180	0.9382	-7.90	44.71	$-10.53 < \delta_{180} < -5.27$[a]
207	0.9443	-73.56	152.54	$-82.55 < \delta_{207} < -64.57$
209	0.9261	-8.93	46.48	$-11.89 < \delta_{209} < -5.97$[a]

[a]All statistically indistinguishable.

The reasons for selecting flood equation 122 as a recommended equation include the fact that the equation gives approximately the proper shape over the entire range of flooding. See, for example, Figs. 2 and A-18 through A-28. Those equations having higher powers of certain independent variables have a tendency to exhibit maxima or minima that have no significance (see Fig. A-29).

Flood equation 208 is the correlation developed by Thornton[90] with newly evaluated coefficients based on group-1 data in the region of 0 to 50% of flooding due to insufficient pulsation. This equation, valid for emulsion flooding only is:

$$\ln \frac{\bar{V}_o \mu_c}{\gamma} = -3.897 - 0.3191 \ln \frac{\psi_f \mu_c^5}{\rho_c \gamma^4} + 0.4688 \ln \frac{d \rho_c \gamma}{\mu_c^2} + \\ + 0.8088 \ln \frac{\mu_c^4 g}{\Delta\rho \gamma^3} + 0.9760 \ln \frac{\Delta\rho}{\rho_c} + 0.1224 \ln \frac{\mu_D}{\mu_c} . \tag{53}$$

In the region of emulsion flooding both equations 122 and 208 are very similar (see Fig. 2).

Examples of the fit expected from equations 122 and 208 may be seen from Figs. A-30 through A-45. It is to be noted that the data in Figs. A-44 and A-45 show the new data of Christensen,[129] not listed in Table A-3.

Comparison of Calculated and Experimental Velocities at Flooding - Group-1 Data

Calculations were made to predict $(V_c + V_D)$ at flooding using several of the flooding equations for nearly all of the data groups. The flood equations were, of course, derived using only the group-1 data. In general it is believed that the calculation of $(V_c + V_D)$ at flooding will be more accurate for equations with a high multiple-R, but making a choice

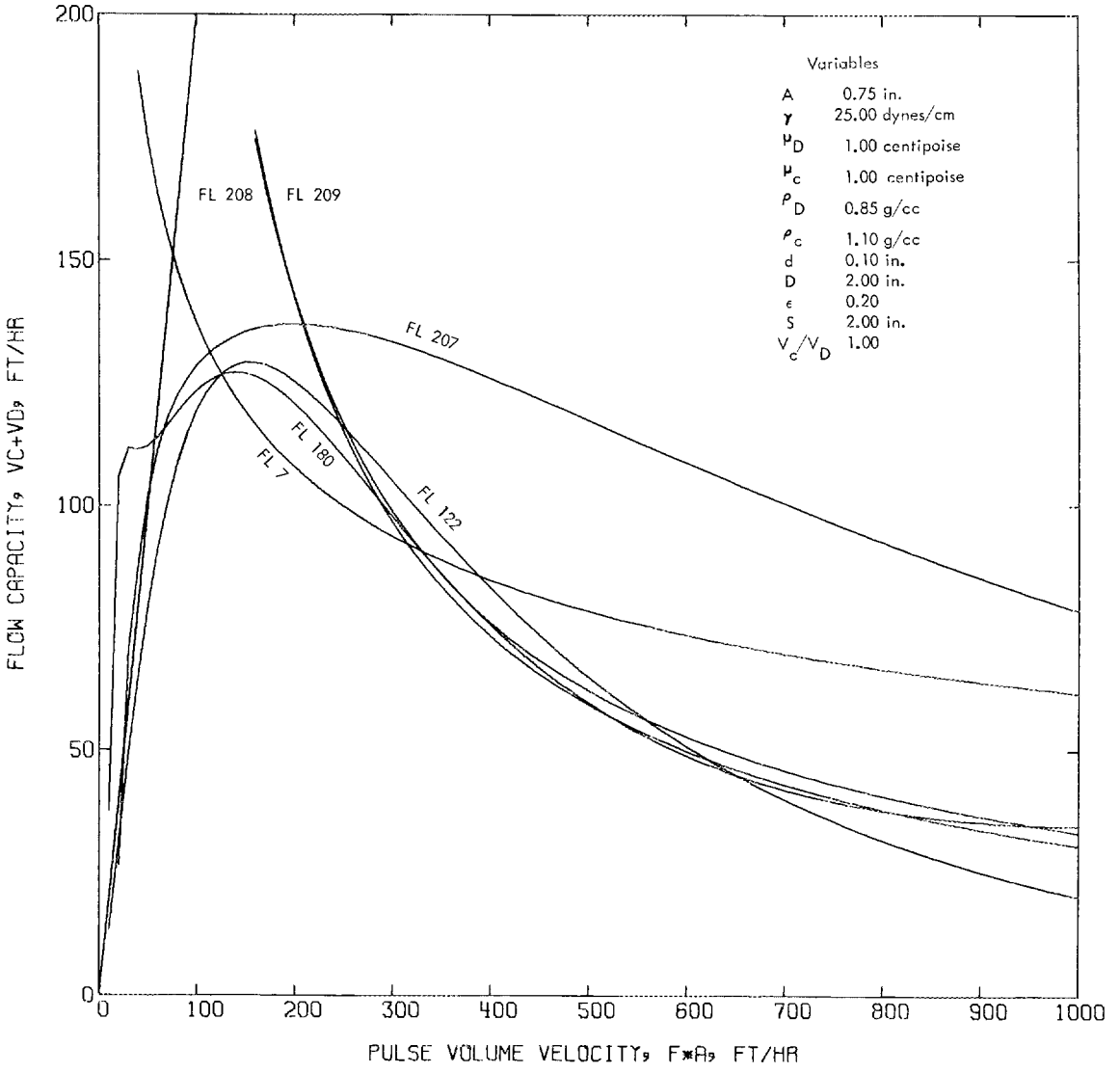

Fig. 2. Comparison of Flood Equations 7, 122, 180, 207, 208 and 209.

between two equations whose multiple-R is as close as 0.9245 and 0.9250 is not possible without first calculating $(V_c + V_D)$ and comparing the means and the standard error of estimates between calculated and experimental values for the two equations. A t test can then be applied to decide whether the mean difference between calculated and experimental $(V_c + V_D)$ for one equation is significantly different from another, and then the equation having the smaller value of a mean deviation can be selected as the better equation.

The calculation of $(V_c + V_D)$ for a given equation generally involves a trial-and-error procedure, and was done by using the GRØEN4 program described above and in the Appendix. The results of these calculations are shown in Figs. 3 and A-1 through A-17, and in Table A-10. The graphs show the calculated $(V_c + V_D)$ as an abscissa and experimental $(V_c + V_D)$ as an ordinate. Figures 3 and A-1 through A-5 show the results of the calculation with the group-1 data points (see Table 1) for selected flood equation Nos. 7, 122, 180, 207, 208, and 209. Flood equation 7 is the one suggested by Pike,[75] with new coefficients based on the group-1 data.

$$\ln \frac{V_D}{\Delta_D} = -6.435 - 0.2698 \ln \left[\frac{\rho_D \pi_D^2 d}{\gamma}\right] - 0.8799 \ln \frac{A}{S} -$$

$$- 0.1881 \ln \frac{V_c}{V_D} - 0.5476 \ln \left[\frac{\rho_D \pi_D^2}{gA\Delta\rho}\right] + 1.130 \ln \frac{\mu_D}{\mu_c} + \qquad (54)$$

$$+ 0.9411 \ln \left[\frac{d\pi_D \rho_D}{\mu_D}\right] - 0.6538 \ln \left[\frac{d\pi_c \rho_c}{\mu_c}\right] - 0.2751 \ln \frac{\Delta\rho}{\rho_c} .$$

Flood equation 122 is the preferred equation listed above as Eq. (53). Flood equation 180 is similar to flood 122 but contains higher powers of the independent variables (see Tables A-7 and A-8). Flood equation 207

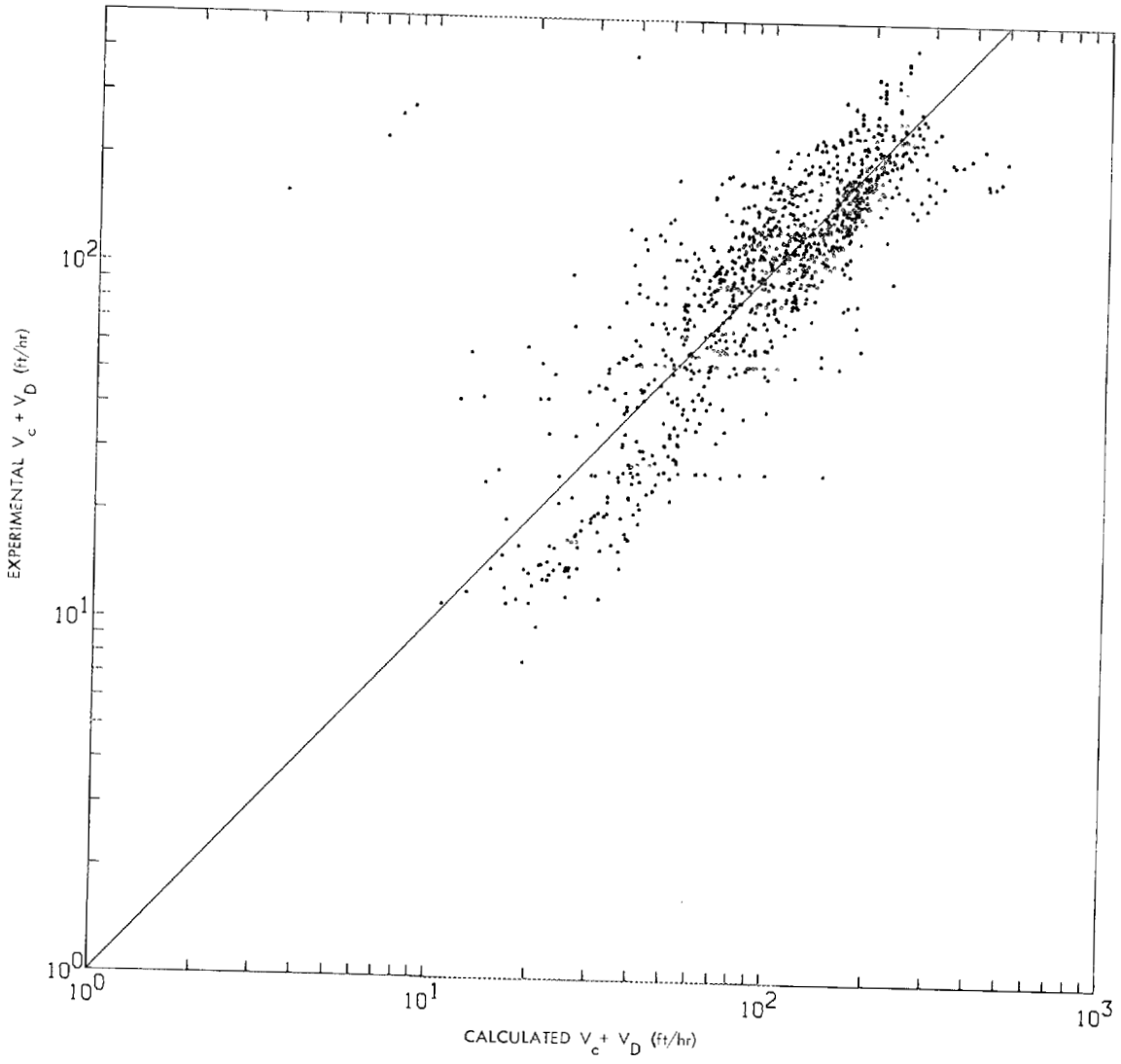

Fig. 3. Experimental vs Calculated Throughput for Flood Equation 122 and Group-1 Data.

was one developed in this study which had a rather complex mathematical structure and a very high multiple-R (0.944 compared with R = 0.931 for flood equation 122). Flood equation 208 is Thornton's equation[90] using the data in the range of 0 to 50% flooded due to insufficient pulsation (F.I.P.). Thornton's equation, with new coefficients applicable to group-1 type of data is given above as Eq. (54). Flood equation 209 is the Smoot and Babb equation,[83] also using the 0 to 50% F.I.P. data. For group-1 type of data, this equation with new coefficients is:

$$\ln \frac{(V_c + V_D)\,\mu_c}{\gamma} = -5.210 - 0.3020 \ln \frac{\psi_f \mu_c^5}{\rho_c \gamma^4} + 0.5650 \ln \frac{d\rho_c \gamma}{\mu_c^2} + $$

$$+ 0.8443 \ln \frac{\mu_c{}^4 g}{\rho_c \gamma^3} + 0.2167 \ln \frac{\Delta\rho}{\rho_c} + 0.1818 \ln \frac{\mu_D}{\mu_c} + \qquad (55)$$

$$+ 0.2484 \ln \frac{V_c}{V_D} - 0.1249 \ln \frac{d}{D} .$$

Figures A-6 through A-17 give the results of the calculation using flood equation 122 with most of the other data groups.

Table A-10 gives a more detailed analysis of the comparison of the calculated and experimental $(V_c + V_D)$. The table gives an estimate of the variance of the percentage difference between the calculated and experimental values of $(V_c + V_D)$, and the mean percentage difference. If

$$d_i' = \left[(V_c + V_D)_{exptl.} - (V_c + V_D)_{calc.}\right] , \qquad (56)$$

and

$$d_i = \frac{\left[(V_c + V_D)_{exptl.} - (V_c + V_D)_{calc.}\right]}{(V_c + V_D)_{exptl.}} \times 100 , \qquad (57)$$

then d_i' is an actual difference, and d_i is a percentage difference. A basic need is to decide whether one expects an experimental error which is

proportional to the value or level of $(V_c + V_D)$ or whether the error is independent of the value of $(V_c + V_D)$. If the error is proportional to $(V_c + V_D)$, then one should be concerned with d_i, and if the error is independent of $(V_c + V_D)$ then d_i' is the more meaningful difference. The only set of data from which a measure of the error was available was the benzene--water data of Pike.[75] For each pair of replicated data points it was possible to calculate an estimate of the variance and plot this quantity as a function of $(V_c + V_D)$. The estimate of the variance is a measure of the variability of the data and hence a measure of the error. Pike's data (points No. 552 through 605, Table A-3) are in replicated pairs. For each pair of points one may get an average throughput, $(\overline{V_c + V_D})$. Then the estimate of the variance for that pair of data points is:

$$(s_i^2)_{(V_c + V_D)} = \frac{\sum_{i=1}^{2} \left[(V_c + V_D)_i - (\overline{V_c + V_D})_i\right]^2}{(2 - 1)} \quad . \tag{58}$$

Figure 4 shows a plot of s_i^2 as a function of the throughput, $(V_c + V_D)$. It is apparent why an error proportional to the level of $(V_c + V_D)$ was chosen as the more meaningful difference to examine.

Therefore the results are given in Table A-10 on the basis of d_i, the percentage difference.

Table 5 gives a summary of the information presented in Table A-10 for the group-1 data. The table shows the multiple-regression coefficient R for the six flood equations selected. The column labeled $\overline{d}_i$ gives the average percentage difference between the experimental and calculated values of throughput, where

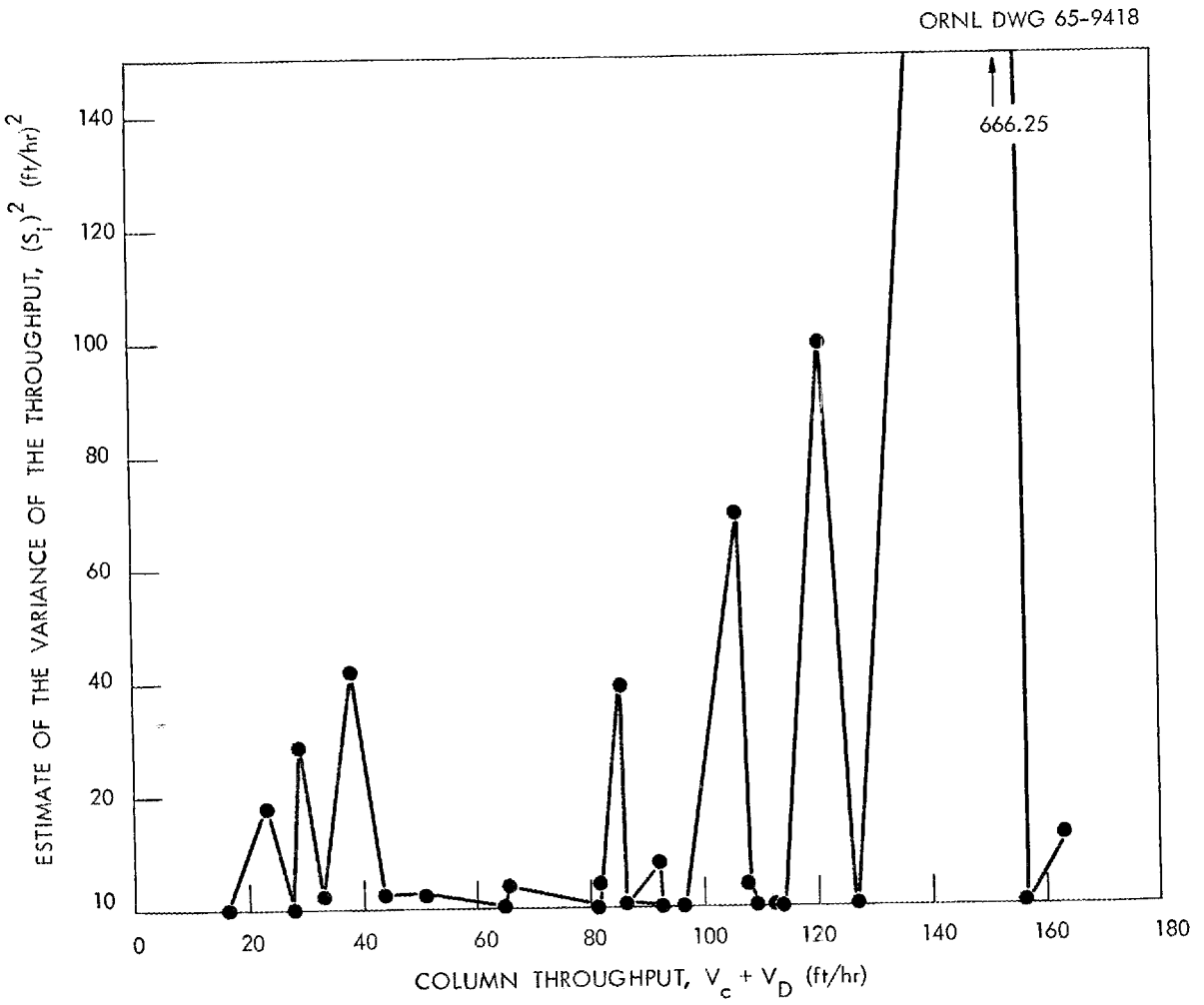

Fig. 4. Estimate of the Variance of the Throughput, $V_c + V_D$ (Benzene-Water System).

$$\bar{d}_i = \frac{\sum_{i=1}^{n} d_i}{n} = \sum_{i=1}^{n} \left[\frac{(V_c + V_D)_{exptl.} - (V_c + V_D)_{calc.}}{(V_c + V_D)_{exptl.}} (100) \right] \Big/ n \ . \quad (59)$$

It is of interest here to note that all the values of $\bar{d}_i$ are negative. This means, of course, that on the average the calculated values of the throughput are too high; for flood equation 122, for example, the calculated $(V_c + V_D)$ is 8.56% too high. One should multiply the calculated value of $(V_c + V_D)$ by $[1/(1 + 0.0856)]$ to get a more accurate measure of $(V_c + V_D)$.

By the rules of statistical inference it is possible to compare the flood equations in Table 5 by testing the so called null hypothesis that the mean percentage differences $\bar{d}_i$ are equal.[127] If the null hypothesis H_o is accepted, then the data indicate there is insufficient evidence to indicate a difference. The alternative hypothesis H_1 must be accepted if H_o is rejected. To test the hypothesis $H_o: \bar{d}_i = \bar{d}_j$, one calculates a t statistic as follows:

$$t = \frac{\bar{d}_i - \bar{d}_j}{\sqrt{\frac{s_i^2}{n_i} + \frac{s_j^2}{n_j}}} \ . \quad (60)$$

The alternative hypothesis is $H_1: \bar{d}_i \neq \bar{d}_j$. The critical statistic for comparison is Student's $t_{\alpha/2,\nu}$, which may be found among any set of statistical tables. For this case, the degrees of freedom ν is defined as:

$$\nu = \frac{\left(s_i^2/n_i + s_j^2/n_j\right)^2}{\frac{\left(s_i^2/n_i\right)^2}{n_i + 1} + \frac{\left(s_j^2/n_j\right)^2}{n_j + 1}} - 2 \ . \quad (61)$$

Here $(1 - \alpha)$ is the level of significance, or α is the probability that one will reject the null hypothesis when it is true.

On comparing the mean percentage difference $\bar{d}_i$ for flood equations 122 and 180, the null hypothesis was accepted; that is to say, one may be 95% sure that the true mean difference for the two equations is the same. Another way of viewing this conclusion is that, in view of the scatter of the percentage differences, it is not possible to say which equation gives the best result. The same conclusion was found when flood equation 122 was compared with 208 and with 209.

For the comparisons of flood equation 122 with 7 and 207, however, one had to reject the null hypothesis and accept the alternative, which was that the mean percentage differences were not equal. In fact, the final result was that one may be 95% sure that the true differences of equations 7 and 207 are indeed smaller (larger negative number) than for flood equation 122. This was done with a one-sided test in which the critical student's t was $t_{\alpha,\nu}$.

Similar conclusions may be reached by constructing a 95% confidence interval about the mean percentage difference, which is tabulated in Table 5 for flood equations 7, 122, 180, 207, 208, and 209. The quantity δ_i here is the symbol for the true value of the mean percentage difference between experimental and calculated flooding throughput, of which the value $\bar{d}_i$ is an estimate.

When one compares the confidence interval for equations 122 and 208, for example, one finds $(-11.19 < \delta_{122} < -5.93)$ and $(-13.30 < \delta_{208} < -6.78)$. Since most of the confidence interval for the two δ's is overlapping it is not unreasonable that one cannot distinguish between the two δ's with any measure of confidence. In comparing equations 122 and 207, on the other hand, one finds $(-82.55 < \delta_{207} < -64.57)$, which is

completely out of the 95% confidence interval for δ_{122}. For comparing δ_7 with δ_{122}, one finds some overlapping of the 95% confidence intervals, and so one must resort to the null hypothesis test described above in order to compare the δ's.

Tests of hypotheses were also made on the variances (s_i^2) of the percentage differences by means of the conventional F statistic. In all cases (except when comparing flood equations 122 and 180) there was a significant difference between the variances of the percentage differences.

It is of interest to note the range and values of the multiple-regression coefficients for the six equations. If one were to select a flooding equation solely on the basis of the multiple-R, equation 207 with an R = 0.944 would be the best. However, on the basis of the calculated ($V_c + V_D$) values, this equation is the poorest of the six shown in Table 5. On the average, the value of ($V_c + V_D$) calculated from equation 207 must be divided by 1.736 to give the best estimate of the throughput ($V_c + V_D$). The fact that equation 208 has an R as low as 0.917 demonstrates in an emphatic manner that even with a range of R from, say 0.900 to 0.950, it is not possible to choose which equation will predict the throughput better.

Equations Restricted to Emulsion Flooding

One further comment in regard to flood equations 208 and 209: These equations were derived originally for the emulsion-flooding region, and so to ensure that they would represent only the emulsion-flooding region, all points lying in the range from 50 to 100% of insufficient pulsation flooding (or > 100%) were screened from the group-1 data prior to doing any of the calculations. The data points so screened are given in

Table A-21. At this point it may be well to consider what is meant by more than 50% flooded due to insufficient pulsation. Quite simply when $\left\{\left[(V_c + V_D)_{exptl.}/\Delta_G\right] \times 100\right\} \geq 50$, the data point is said to be in the region equal to or more than 50% flooded due to insufficient pulsation (F.I.P.). This figure, 50% F.I.P., has been the arbitrary boundary between insufficient pulsation and emulsion-flooding zones as set by the authors.

Data Groups Other Than Group 1

Calculations were made using data groups other than group 1 in only two ways. Table 6 shows a comparison of the multiple-regression coefficient calculated first with group-1 data only, and then with groups 1 and 2 combined. In each case, except with flood equations 214 and 225, it is noted that the multiple-R decreased when the combined data were used in the regression analysis. This is an indication that the fit of the data from group 2 is poorer than that from group 1, or that the error or variance of the data in group 2 is larger, or both.

Flood equations 214 and 225, as is the case with all the equations studied whose multiple-R is greater than 0.950, are not valid and should be discounted. Examination of the independent variable (Tables A-7, A-5, and A-6) shows it to be ln $(V_D/\overline{V}_o)$. This ratio $(V_D/\overline{V}_o)$ can be shown to be a function of (V_c/V_D) alone and is therefore not a useful flooding characteristic since (V_c/V_D) or its logarithm has been considered to be a primary and fundamental independent variable.

No comparison may be drawn between equations 220 and 231 since the BIMD-29 program would not operate on the ORNL Control Data Computer, CDC-1604A, using groups 1 and 2 combined in flood equation 231. The

Table 6. Comparison of Regressions with Data Groups 1 and 2

Group-1 Data		Groups-1 and -2 Data	
Flood Eq.	Multiple-R	Flood Eq.	Multiple-R
211	0.9362	222	0.9272
212	0.9427	223	0.9331
213	0.9424	224	0.9327
214	0.9628	225	0.9633
215	0.8507	226	0.8249
216	0.9394	227	0.9291
217	0.9336	228	0.9260
218	0.9314	229	0.9252
219	0.9401	230	0.9300
220	0.9414	231	-
221	0.9309	232	0.9240

program was terminated in the midst of the matrix inversion and so apparently an unstable matrix was generated.

More useful results can be derived from Table A-10 in which comparisons were made on the basis of the calculated $(V_c + V_D)$ for the various data groups using GRØEN4 (see Appendix) and flood equations 122 and 208. The regression equations (equations 122 and 208) derived using group-1 data were used to calculate flow capacities for the other data groups. For each data point in the other data groups shown, a calculation of Δ_G was made to determine if the point represented flooding in the emulsion flooding region. If it did, then $(V_c + V_D)$ was calculated by GRØEN4 for both flood equations 122 and 208. If the particular data point represented flooding that was more than 50% flooded due to insufficient pulsation, then the calculation of $(V_c + V_D)$ by GRØEN4 was done for flood equation 122 only. The quantities d_i, the percentage difference between experimental and calculated throughputs, its mean $(\bar{d}_i)$, and variance (s_i^2) were calculated as described earlier and were tabulated in Table A-10. Table 7 below summarizes part of Table A-10 for the specific purpose of comparing data groups. The table lists the mean percentage differences $\bar{d}_i$ for each data group shown for flood equations 122 and 208. The results of the hypothesis tests comparing the mean percentage differences of group 1 with each of the other groups are also shown. Note that the results of the hypothesis tests are the same for the two flood equations used except for group 4. There is an apparent real difference between the two equations for group 4 since the number of data points is large and there is very little overlap of the confidence intervals.

Table 7. Comparison of the Data Groups

Data Group	Flood Equation 122 For $\alpha = 0.05$ $H_o: \bar{d}_1 = \bar{d}_i$	$\bar{d}_i$	Flood Equation 208 For $\alpha = 0.05$ $H_o: \bar{d}_1 = \bar{d}_i$	$\bar{d}_i$
1	-	-8.56	-	-10.04
2	Reject	-29.15	Reject	-42.24
3	Accept	4.03	Accept	-15.38
4	Reject	37.77	Accept	0.58
5	Reject	-76.31	Reject	-69.90
10	Reject	17.56	Reject	19.71
11	Reject	15.82	Reject	23.41
12	Reject	54.00	Reject	45.66
13	Accept	-7.31	Accept	5.27
14	Reject	-114.31	Reject	-75.90
15	Accept	-21.87	Accept	-23.63
16	Accept	-36.63	Accept	-4.59
17	Reject	29.96	Reject	29.37

For the other data groups there is agreement not only in whether or not there is a significant difference in the mean percentage differences, but also in the value of the percentage difference. This represents a rather rigorous test, considering that the flood equations were derived using group-1 data only. Based on these trends it is therefore recommended that the best estimates of $(V_c + V_D)$ for the various data groups should be made either with flood equation 122 or 208 and adjusted by the following formula:

$$(V_c + V_D) = \frac{(V_c + V_D)_{calc.}}{(1 - \bar{d}_i/100)} \quad . \tag{62}$$

The proper $\bar{d}_i$ is obtained from Table 7 for the particular flood equation and group used. It is recognized that the scatter of the data is in many cases wider than within group 1 itself, but for the present the best estimate of the throughput is obtained by the above formula. The value of $(V_c + V_D)_{calc.}$ is obtained from GRØEN4 or other iterative procedures. One could easily incorporate the correction factors $\bar{d}_i$ into GRØEN4 to give $(V_c + V_D)$ directly, but at the present time it did not seem worth doing. At this point it is well to remember that flood equation 122 may be used over the entire range of flooding, whereas flood equation 208 is only for the range 0 to 50% of flooding due to insufficient pulsation (i.e., $[100\ (V_c + V_D)/\Delta_G] \geq 50$).

Multiple-Regression Analysis

Much reliance was placed in the multiple-regression coefficient R to decide the relative merit of one flooding equation correlation compared to another. For two equations which have the same dependent variable, but

different independent variables, the equation with the higher multiple-regression coefficient fits the data better. Also, when comparing two equations having the same independent variables, but different dependent variables, the equation having the higher multiple-regression coefficient fits the data better.

If, however, both the dependent variables and the independent variables are different for two equations, it becomes a question of judgment which equation represents the better correlation. The equation with the higher multiple-regression coefficient is the one whose independent variables better account for the variability of the dependent variable. It is not, however, the paramount goal to fit a set of equations to a set of data. The desired result is prediction of the flow capacity, given the system and certain other parameters. Given the organic-aqueous system to be used, the continuous phase, the physical properties of the system (viscosities, densities, interfacial tension), the column dimensions, the type of plates, the flow ratio (V_c/V_D), A, and F, what value of V_c and V_D (or the sum of these) causes flooding in the column? When comparing two flooding equations having multiple-R values of 0.9245 and 0.9250, for example, it is not possible to predict which equation will do a better job of predicting ($V_c + V_D$) at flooding under the circumstances outlined above. Thus, the direct comparisons based on ($V_c + V_D$) were used to advantage, as described previously.

Group-1 Data and Its Distribution

Table A-8 lists all the flooding equations tested, showing the dependent and independent variables used and the resulting coefficient of multiple regression, R (called "multiple-R"). The variables are coded,

since most of the forms are complicated dimensionless groups. The code for the dependent variables is given in Table A-5, and the list of independent variables is given in Table A-6.

Those equations having a multiple-R higher than 0.900 are listed in more detail in Table A-7. In this table are also listed the intercept (A) and the coefficients (b_i) for the regression equation, which is:

$$Y = A + \sum_{i=1}^{n} b_i X_i \ , \ i = 1,2,3 \ . \ . \ . \ n \text{ independent variables} \ . \qquad (63)$$

Also listed for each independent variable is the cumulative coefficient of multiple regression up to and including the coefficient for that variable. As was pointed out earlier, the BIMD-29 computer program ranks the variables according to the magnitudes of their contribution to the correlation. The last figure in this column for each equation is the overall multiple-R reported in Table A-8. Table A-7 also lists the mean value of Y ($\bar{Y}$) and the standard deviation (s_y) of Y. The error analysis in terms of percentage difference is given on the antilogarithm of Y, since the Y's have nearly always been the logarithm of some expression, as $[(V_c + V_D)\ \mu_c/\gamma]$ in the Smoot-Babb equation. The term Δz is the range of the residuals:

$$\Delta z = \left\{ \left[(Y_i)_{\text{exptl.}} - (\hat{Y}_i)_{\text{calc.}} \right]_{\text{max.}} - \left[(Y_j)_{\text{exptl.}} - (\hat{Y}_j)_{\text{calc.}} \right]_{\text{min}} \right\} . \qquad (64)$$

Note that Δz will always be positive since it is the largest z less the smallest z. Regardless of whether the largest and smallest residuals are positive or negative, Δz will be positive. The expression $\Delta z/\bar{s}_{y \cdot f(x)}$ is symbolic for the ratio of the range of the residuals to the standard error of estimate. Both these quantities are measures of the variability of the residuals. When these quantities are compared with the mean of Y

and its standard deviation, a better understanding is obtained of the goodness of fit of the regression model.

The three quantities labeled % Deviation are the average deviations between the antilogarithms of $Y_{experimental}$ (Y_i) and $Y_{calculated}$ $(\hat{Y}_i)$. If $Y = \ln [(V_c + V_D)\ \mu_c/\gamma]$, for example, the residuals discussed above will be:

$$z_i = \left\{\ln[(V_c + V_D)\ \mu_c/\gamma]\right\}_{i\ experimental} - \left\{\ln[(V_c + V_D)\ \mu_c/\gamma]\right\}_{i\ calculated}. \quad (65)$$

The antilogarithm $(Y) = (V_c + V_D)\ \mu_c/\gamma$, so that

$$\%\ Dev. = 100 \times \frac{[(V_c + V_D)\ \mu_c/\gamma]_{exptl.} - [(V_c + V_D)\ \mu_c/\gamma]_{calc.}}{[(V_c + V_D)\ \mu_c/\gamma]_{exptl.}}\ . \quad (66)$$

The three quantities listed under the heading are (1) the average of the positive per cent deviations, (2) the average of the negative per cent deviations, and (3) the overall average per cent deviation (allowing positive and negative deviations to cancel). Notice that the average of the positive deviations is always higher than the average of the negative ones. Such a result is to be expected since the regression is done on the logarithms of the variables rather than the variables themselves. It is the square of the residuals of the logarithms that is minimized and should be near zero. The average of the positive and negative residuals would be equal (or the sum near zero) if logarithms of the residuals were used.

Table A-9 gives the distribution of data within group 1. In the table are listed the high and low values for 15 of the dependent variables, 27 of the independent variables, and several other variables. Each variable is subdivided into 25 levels by dividing the range of the variable by 25 and then sorting all of those variables into the appropriate level. The numbers appearing in the table for each level under each variable signify

the number of data points that fall within the particular level. For example, for Y01 [which is Thornton's flooding characteristic, ln $(\bar{V}_o \mu_c/\gamma)$] 18 of the data points (see Table A-3) give values of Y01 in the lowest level, 30 in level 2, 16 in level 3, etc. The distribution of points for Y01 can be seen to follow closely a normal distribution, as do the points for Y02. Independent variable Y03, however, shows a skewed distribution having no data points in 12 of the levels, and only one point in the highest level. One interesting thing to note is that for many of the variables, for example V_c in Table A-9, the variable itself shows a severe skewness, but the logarithm of the variable tends more nearly to a normal distribution. This, of course, is one of the reasons that the logarithmic function was used for so many of the variables, and it nearly always follows that only those variables having a good distribution, either normal or fairly flat, consistently contributed significantly to the correlations.

One other fact to notice about Table A-9 is that 1111 data points were used in its construction. Five of these points, Nos. 859-863, should not have appeared in group 1 as noted in Table A-1, but should, instead, be located in group 18. This adjustment will not affect Table A-9 seriously but will cause some adjustments of the boundaries and the populations in several levels.

Data Groups Other than Group 1

Data groups 1 and 2 were combined for one series of calculations from flood equations 222 through 232. Although group 2 had data from runs in which mass transfer was taking place, it was always assumed that the column flooded at the end where little mass transfer was occurring. It was at these locations that the physical properties of the phases were selected

for use in the calculations, and it seemed reasonable to expect that these data would not be far from the values in group 1.

Equations 222 through 232 should be compared with flood equations 211 through 221, respectively, since the definitions of all the independent variables are the same. The equations go in pairs (No. 222 with No. 211; No. 223 with No. 212; . . . ; No. 232 with No. 221), with each pair having one definition of the dependent variable. From one pair to the next, only the dependent variable changed in definition.

In each case (except for flood equations 214 and 225, see below) the multiple-regression coefficient R for the group-1 points only, was superior to the multiple-R for the combined groups 1 and 2. At best, however, the superiority was only marginal. If one compares the cumulative multiple-R for the first eight independent variables in each pair, one finds that the difference in the multiple-R is in the third significant figure. Such a difference in itself is not significant, but the fact that all of them (except Nos. 214 and 225) showed a superior multiple-R for group-1 data only, (that fact alone) is significant. Such a conclusion is supported by examining Table A-10, where it is noted that the test of the difference of two mean residuals $[\Delta(V_c + V_D)_{calc. - exptl.}]$ showed that there was a statistical difference. Furthermore, it is noted from the same table that the estimate of the variance of the residuals is greater for the group-2 data than for the group-1 data. Both these facts would tend to make the multiple-R for the combined groups 1 and 2 smaller than for group-1 data only.

Notice that the multiple-R is very high for both flood equations 214 and 225. Both these equations should be ignored since the left-hand

side of the equation [ln $(V_D/\bar{V}_o)$] can be shown to be a function of (V_c/V_D) alone. It is therefore not surprising that the independent variable X22 [ln (V_c/V_D)] contributes over 95% of the multiple-R. Notice also that X20X22 [ln (Drag No.) · ln (V_c/V_D)] is the next most prominent variable in each case. The effects of all other variables are therefore masked, since we have an equation which correlates $f_1(V_c/V_D) = f_2(V_c/V_D)$.

Special attention should be attracted by flood equations 215 and 226, which have particularly low values for multiple-R. These two equations have Y12 as the independent variable, which is ln $(\bar{V}_o)$. In the first place, the parameter is not dimensionless, and all the independent variables are dimensionless. Note also that flood equation 237, in which ln $(\bar{V}_o)$ was again used as the dependent variable, also exhibits a very low multiple-R. The indication is therefore very clear that $\bar{V}_o$ by itself is not a good correlating parameter. But when used in a ratio, such as ln $(\bar{V}_o/\Delta_G)$ or ln $[\bar{V}_o/(\Delta_D + \Delta_c)]$, it gives excellent results (see flood equations 164, 165, 205, 216, 227, and 241).

Flood equation 231 could not be studied using the BIMD-29 program on the Control Data Corporation 1604 computer for the combined groups-1 and -2 data because the program would not perform. The most common cause for such an occurrence is that within the BIMD-29 program (as for any multiple-regression algorithm) there is a matrix-inversion technique, and for certain sets of data and regression equations it is possible to get a near singular matrix which makes the whole calculation unstable and impossible to do on any computer. No other data groups were combined for regression analysis with any other group or run separately. It was felt that no further meaningful correlation could be developed at this time by this means.

Analysis of Variance - The F Statistic

The evaluation of various possible correlating equations and grouping of variables by means of the F statistic was continued in this study. Thirty-five cases were tested and the results are given in Table A-4. The table gives the results on the analysis with the benzene--water system and with the heptane--water system.

The purpose of these calculations was to determine the groupings of variables that gave the best description of the flooding phenomenon, using many different dependent variables with some variation in the independent variable groupings. The model used was:

$$Y = A_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_1X_2 + b_6X_1X_3 + b_7X_1X_4 + b_8X_1^2 + b_9X_2^2 + b_{10}X_3^2 + b_{11}X_4^2 + b_{12}X_2^3 + b_{13}X_2^4 + b_{14}X_2^5 + b_{15}X_2^6 \quad (67)$$

The full model was used with only four cases, XXXI through XXXIV. For all other cases $b_{13} = b_{14} = b_{15} = 0$. Also as noted in the table, for all except cases XXVI and XXVIII, $X_4 = 0$. That is to say, for most of the cases, only three independent variables were used. A sample calculation for a typical value of F is given in the Appendix.

The benzene--water data were those of Pike[73] and were gathered, with replication, according to a carefully selected experimental design. The replication allowed an accurate analysis of the error of the data, and the experimental design assured a good distribution of data. The heptane--water data[26] were not gathered following an experimental design, but there was some replication apparent. These sets of data were used to conduct the analysis of variance. The results with heptane--water closely paralleled those of the benzene--water system when compared on the basis

of the multiple-R. When one compares the two systems on the basis of their F statistics, however, the conclusions are quite different. This is a striking example not only of the power of the statistic, but also of the comparative insensitivity of the multiple-R.

The F statistic shown in the tables is the ratio of the lack of fit to the experimental error. The statistic is therefore a sensitive measure of how well a model or regression equation fits the data, and it is compared with $F_{(1-\alpha),\nu_1,\nu_2}$, which is a critical value taken from a table of the F-distribution (for example, see refs 127, 128). If the calculated value of the F statistic is greater than the critical value, then there is a significant lack of fit. If the calculated value is less than or equal to the critical value, then one must infer that there is insufficient evidence to say that there is a lack of fit.

The square of the multiple-regression coefficient measures the fraction of the variation in the dependent variable which is accounted for by the combined contributions of the independent variables. If there is a perfect correlation, the multiple-regression coefficient is 1.0; if there is no correlation, the value is zero. The difference between 1.0 and the square of the multiple-regression coefficient is a fractional measure of experimental error and lack of fit. It is not possible to separate experimental error and lack of fit by use of the multiple-regression coefficient. It is thus seen that the previous analysis, using the F statistic, should be a more powerful one to indicate what sort of correlating equation gives the best results.

One can observe that in each case there are no physical properties or column dimensions used for the independent or dependent variables.

Therefore each particular system, benzene--water, heptane--water, etc., would be expected to have different values for the regression coefficients. One could, however, turn each of the equations into dimensionless flood equations by including the physical properties and column dimensions in the variables. The important thing to recognize is that when this addition is made, it does not change the analysis of variance for the particular system.

For example, one might compare the variable definitions for case IX with those for flood 9.

Case IX	Flood 9
$Y = \ln (V_D/\Delta_D)$	$Y = \ln (V_D/\Delta_D)$
$X_1 = \ln (A)$	$X_1 = \ln (A/S)$
$X_2 = \ln (\pi_D)$	$X_2 = \ln [\Delta\rho\pi_D^2 d/(\epsilon^2\gamma)]$
$X_3 = \ln (V_c/V_D)$	$X_3 = \ln (V_c/V_D)$
	$X_4 = \ln (\mu_D/\mu_c)$

The dependent variables in each case are identical. For ln A, the addition of the plate spacing S produces a dimensionless variable having a column dimension in it. Furthermore, it is a physically significant parameter, giving the fractional ratio of pulse amplitude to plate spacing. One changes $\ln \pi_D$ into the logarithm of the Weber number by adding $\Delta\rho$, d, ϵ, and γ, as shown above. Since π_D^2 is needed in the Weber number also, it may be derived from $\ln \pi_D$ by remembering the relation:

$$b_2 \ln \pi_D = \left(\frac{b_2}{2}\right) \ln \pi_D^2 \ . \qquad (68)$$

For the benzene--water data, all the column dimensions remained constant, and the physical properties remained approximately constant. The term X_4, or $\ln (\mu_D/\mu_c)$, of course, is also approximately a constant for the

benzene--water data. Therefore any conclusions arrived at from the analysis of variance would apply to flood equation 9.

The F statistic listed in Table A-4 for case IX is 3.35. It will be recalled that this F statistic is the ratio of the variance of the lack of fit to the variance of the error. The lack of fit in this case has 16 degrees of freedom, and the error has 27. The critical value of F at the 95% confidence level, $F_{0.05,16,27} = 2.36$. Since the calculated F is larger than the critical one, then we reject the hypothesis that the variance due to lack of fit equals the variance due to error. That is to say there is a significant lack of fit, not accounted for by the error. The lack of fit referred to is between the model and the data.

Closer examination of the table shows that only cases I, XII, XIII, XIV, XV, XXXI, XXXIII, and XXXV produce F statistics below the critical values for the benzene--water data.

Cases I, XII, and XIII all have as their dependent variable ln (V_D/Δ_D). Although these cases show no lack of fit for the benzene--water data, the use of (V_D/Δ_D) in the flood equations with all of the group-1 data has not been good. For example, one may compare flood equation 195 with 194, 201 with 200, and 233 with 204. For each pair of equations, the independent variables are identical; the equations differ only in the dependent variable. For equations 195, 201, and 233, the dependent variable was ln (V_D/Δ_D). For equation 194 the dependent variable was ln $\bar{V}_o/\Delta_G$, for equation 200 the dependent variable was ln $(V_c/\Delta_c + V_D/\Delta_D)$, and for equation 233, the dependent variable was ln $[(V_c + V_D)/(\Delta_c + \Delta_D)]$. In each pair of equations the multiple-R for the equation having ln (V_D/Δ_D) as the dependent variable was 1 to 4% less. It is therefore concluded that ln (V_D/Δ_D) is not a good

dependent variable to use for all the data, although for the benzene--water data it provides a good description of the flooding phenomenon.

Cases XIV and XV show no significant lack of fit for the benzene--water data, but the use of the independent variables was not explored with all of the data in a flood equation because of the strange definition of the parameter π_D':

$$\pi_D' \equiv 10FA + (V_D - V_c) = -(2/\pi - \lambda)(5\pi FA) \ . \qquad (69)$$

This parameter was first used by Pike,[74] but its physical significance is obscure.

It is interesting to compare cases XXVII and XXXI with flood equations 146 and 122.

Benzene--Water System Analysis of Variance	Group-1 Data Multiple-Regression Analysis
Case XXVII $R = 0.9976$, $F = 3.40$	Flood 146 $R = 0.9304$
$Y = \ln [(V_c + V_D)/\Delta_G]$	$Y = \ln [(V_c + V_D)/\Delta_G]$
$X_1 = \ln (A)$	$X_1 = \ln (A/S)$
$X_2 = \ln (\pi_M)$	$X_2 = \ln [\Delta \rho d\epsilon^2/(\rho_c \pi_M^2)]$
$X_3 = \ln (V_c/V_D)$	$X_3 = \ln (\mu_c \pi_V/\epsilon\gamma)$
	$X_4 = \ln (V_c/V_D)$
Case XXXI $R = 0.9983$, $F = 2.16$	Flood 122 $R = 0.9310$
$Y = \ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$	$Y = \ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$
$X_1 = \ln (A)$	$X_1 = \ln (A/S)$
$X_2 = \ln (\pi_M)$	$X_2 = \ln [\Delta\rho d\epsilon^2/(\rho_c \pi_M^2)]$
$X_3 = \ln (V_c/V_D)$	$X_3 = \ln (\mu_c \pi_V/\epsilon\gamma)$
	$X_4 = \ln (V_c/V_D)$

Notice that the definition of the variables for case XXVII is very similar to flood 146, and case XXXI is very similar to flood 122. When one compares the multiple-R for the two flood equations (or the two cases for that matter), there is very little basis for making a definitive choice. Comparison of the F statistic, however, shows the superiority of $\ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$ over $\ln [(V_c + V_D)/\Delta_G]$ for the benzene--water data, since the latter dependent variable shows a singificant lack of fit ($F > F_{0.05,16,27} = 2.36$). The fact that the multiple-R for all the group-1 data is poorer, even though marginally, for flood equation 146 when compared with flood equation 122, might lead one to conclude that Y07 is superior to Y09 for all the data. Such a conclusion based on the evidence so far presented might not be justified, but further study shows that when one compares flooding equation 191 with 193, 197 with 200, 202 with 204, 212 with 217, one finds that in 4 cases out of 5, the equation having $\ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$ is superior to the one having $\ln [(V_c + V_D)/\Delta_G]$, when compared on the basis of the multiple-R. For all the pairs of equations cited, the independent variables are the same, but the dependent variables are either $\ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$ or $\ln [(V_c + V_D)/\Delta_G]$. The conclusion that $\ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$ is best, seems more justified in the light of these considerations.

The analysis with only the benzene--water data shows that $\ln (V_c/\Delta_c + V_D/\Delta_D)$ should be a significant grouping (see case XXXIII). Here again the F statistic is below the critical value of 2.36, which signifies that there is no lack of fit for this model. If one examines the flood equations that include this independent variable, one finds a good multiple-R, but one consistently less than for $\ln [(V_c + V_D)/(\Delta_D + \Delta_c)]$.

Case XXXV seems to be an anomaly. The analysis of variance with the benzene--water data shows no significant lack of fit. If, however, one compares these results with flood equations 215 and 212 there is seen to be a larger difference in flood 215 (multiple-R = 0.851) and flood 212 (multiple-R = 0.943). Both have independent variables identical and comparable to case XXXV. For flood equation 215, the independent variable is ln $\bar{V}_o$, and for flood equation 212 the independent variable is again ln $[(V_c + V_D)/(\Delta_c + \Delta_D)]$. Further evidence that ln $\bar{V}_o$ by itself is not a good correlating variable can be seen by comparing flood equations 237 and 234. The former with this dependent variable has a multiple-R = 0.844, while the latter has a dependent variable ln $[(V_c + V_D)/(\Delta_D + \Delta_c)]$ and a multiple-R = 0.948. Both equations have the same independent variables.

The quantity $\bar{V}_o$ gives better results when used in a dimensionless group than when used alone. For example, flood 216 (with same independent variables as flood equations 212 and 215) has a multiple-R of 0.939. The dependent variable is ln $(\bar{V}_o/\Delta_G)$. Flood equation 241, multiple-R = 0.946, may be compared with flood 237 having a multiple-R of 0.844. Both equations have the same independent variables, but flood 241 uses ln $[\bar{V}_o/(\Delta_c + \Delta_D)]$, compared with ln $\bar{V}_o$ for flood 237.

Table A-4 also shows the analysis of variance for the heptane--water system. These data were not run on an experimental design, and for the first 14 cases it was assumed that the error measured in the benzene--water work could be used for the heptane--water system (and other systems as well). Extensive calculations in this manner were made with the heptane--water system and a number of other systems. That the results of these calculations were inconsistent is demonstrated by comparing the F statistics

for the first 14 cases. Cases XII and XIII are quite high for heptane--water, while low for benzene--water. Case X is high for benzene--water, low for heptane--water.

Beginning with case XVIII, the calculations were based on 19 apparent replications within the heptane--water system. The F statistics thus calculated are compared with a critical value of 2.20 (or more in certain cases), and it is seen that all the equations, except XXXIV, XIX, and XX, show no significant lack of fit. What these results probably show is that the error term is so large that no lack of fit can be detected. It may also mean that the data assumed to be replications were not really intended to be and are thus not actually a measure of experimental error.

5. CONCLUSIONS

1. Flooding equation 122 is recommended for the purpose of correlating the flooding phenomena in pulsed perforated-plate extraction columns employing two liquid phases. Throughputs at flooding $(V_c + V_D)$ calculated from equation 122 must be multiplied by the factor 1.094 for the best results for group-1 type of data, or by the appropriate factor for other groups [Table 7, Eq. (62)].

2. Other equations, such as 180, have been shown to be nearly equally as good as 122 in calculating $(V_c + V_D)$ when the proper correction factors are applied (see Table 5).

3. New coefficients have been developed for the existing correlation by Thornton (flood equation 208) based on a larger mass of data.

4. Eighty-six equations were generated which correlated the flooding phenomenon about equally as well (see Table A-7), as judged by their multiple-regression coefficient.

Suggestions for Future Work

It is suggested that in order to make a significant improvement on flood equation 122, or perhaps a dozen others in Table A-7, some variable is needed to characterize pulse-plate wetting and droplet coalescence. One general observation is that in many cases flood 122 does not peak sharply enough, or the maximum of the peak is not high enough. It very often happens that the correct curve lies between flood 122 and 208, especially in the zone of flooding near the peak value of $(V_c + V_D)$. No specific recommendations along this line can be made at this time.

It is also suggested that another form of the flooding equation, such as an exponential of the type:

$$Y = A_o \exp \left[X_1^{b_1} X_2^{b_2} X_3^{b_3} \ . \ . \ . \right] \quad , \qquad (70)$$

might be worth looking into.

Possibly, some of the data should be eliminated, especially some of the earlier data for which the physical properties are uncertain. The screening ought to be done so as to improve the range and distribution of data. It may also be desirable to obtain some additional data on a carefully planned experimental design involving not only pulsing parameters, but also physical properties of the systems. Such quantities as interfacial viscosity, mean droplet size (or other parameters of the drop-size distribution), and various wetting angles may need to be included for a significantly better correlation.

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7. NOMENCLATURE

a_i = Constants, i = 1, 2, 3, etc.

A = Intercept (Tables A-7 and A-8 only)

A = Pulse amplitude (in.), overall for entire pulse stroke

A_o = Intercept

b_i = Constants, i = 1, 2, 3, etc.

C = Characteristic of flooding, variously expressed

C_o = Orifice coefficient of pulse-plate perforations

d = Pulse-plate hole or perforation diameter (in.)

d_i = Percentage difference between calculated and experimental flow capacities [see Eq. (57)]

d_i' = Absolute difference between calculated and experimental flow capacities [see Eq. (56)]

$\bar{d}_i$ = Average or mean value of d_i defined as $\sum_{i=1}^{n_i} d_i/n_i$

D = Pulsed-column internal diameter (in.)

f = Function notation

F = Pulse frequency (cycles/min)

$F_{(1-\alpha),\nu_1,\nu_2}$ = The F statistic defined as the ratio of the variance due to lack of fit divided by the variance due to error

g = Gravitational acceleration (ft/hr^2)

g_c = Gravitational constant (32.17 ft lb_m/sec^2 lb_f)

H_o: = Hypothesis notation

L = Length or height notation (ft)

n_i = No. of data points in population i

R = Coefficient of multiple regression

s_i^2 = Estimate of the variance between replicated data points or between experimental and calculated data points

s_y = Standard deviation of Y

$\bar{s}_{y \cdot f(x)}$ = Standard error of estimate of Y

S = Pulse plate spacing (in.)

t = The t statistic, to be compared with Student's t

$t_{\alpha/2,\nu_i}$ = Student's t of statistics

V = Velocity notation (ft/hr)

V_c = Continuous-phase velocity (ft/hr)

V_D = Dispersed-phase velocity (ft/hr)

V_H = Heavy-phase velocity (ft/hr)

V_L = Light-phase velocity (ft/hr)

V_p = Pulsed-volume velocity (V_p = 5FA ft/hr)

V_R = Recycle rate (ft/hr)

$\bar{V}_o$ = Characteristic droplet velocity (ft/hr)

x = Dispersed-phase holdup, fraction of total volume

x_f = Dispersed-phase holdup at flooding, fraction of total volume

X_i = Independent variables, i = 1, 2, 3, etc.

Y = Dependent variable

Y_i = Experimental value of dependent variable

$\bar{Y}$ = Average value of dependent variable, defined as $\sum_{i=1}^{n_i} \hat{Y}_i/n_i$

$\hat{Y}_i$ = Calculated value of dependent variable, i = 1, 2, 3, etc.

z_i = Residual, $Y_i - \hat{Y}_i$

Greek Letters

α = Confidence level (% or fraction)

γ = Interfacial tension (dynes/cm)

δ_i = The true percentage difference between experimental and calculated flow capacities

Δ = Difference notation

Δ_c = Average flow rate of all material past the pulse plates in the direction of the continuous-phase flow, averaged over the entire pulse cycle (ft/hr), see Note 2, Table A-6

Δ_D = Average flow rate of all material past the pulse plates in the direction of the dispersed-phase flow, averaged over the entire pulse cycle (ft/hr), see Note 2, Table A-6

Δ_G = Flow capacity, $V_c + V_D$, due to insufficient pulsation (ft/hr); see Note 2, Table A-6

$\Delta\rho$ = Absolute density difference between phases (lb_m/ft^3)

ϵ = Fractional free area of the pulse plates

λ = Ratio of velocity difference to pulse volume velocity times π, $(V_c - V_D)/(5\pi FA)$

μ = Viscosity notation (centipoise)

μ_c = Viscosity of continuous phase (centipoise)

μ_D = Viscosity of dispersed phase (centipoise)

ν_1 = Degrees of freedom associated with lack of fit

ν_2 = Degrees of freedom associated with error

ν_c = Continuous-phase kinematic viscosity, μ_c/ρ_c

ν_D = Dispersed-phase kinematic viscosity, μ_D/ρ_D

π = 3.14159. . .

π_c = Average flow rate of all material past the pulse plates in the direction of the continuous-phase flow, averaged over the actual time of flow in that direction (ft/hr); see Note 2, Table A-6

π_D = Average flow rate of all material past the pulse plates in the direction of the dispersed-phase flow, averaged over the actual time of flow in that direction (ft/hr); see Note 2, Table A-6

$\pi'_D = 10FA + V_D - V_c$ (ft/hr)

π_M = RMS of π_c and π_D, $\pi_M = \sqrt{0.5(\pi_D^2 + \pi_c^2)}$ (ft/hr)

π_V = Average of π_c and π_D, $\pi_V = 0.5(\pi_D + \pi_c)$ (ft/hr)

ρ = Density notation (g/cc)

ρ_c = Density of continuous phase (g/cc)

ρ_D = Density of dispersed phase (g/cc)

Σ = Summing notation

ψ_f = Maximum frictional power absorbed per unit mass of fluid in the pulse-plate perforations (ft^3/hr^3 in.); see Note 2, Table A-6

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Other Information

Program GRØEN3
Program GRØEN4
Program BIMD 29
Insufficient Pulsation Flooding
Sample Calculation: F Statistic

Table A-1. Supplementary Data

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes*
Group 1. No Mass Transfer, Aqueous Phase Continuous, Metal Sieve Plates.								
1-110	3	5% TBP-Kerosene	Basic $Al(NO_3)_3$-H_2O	-	12	0.187	1/16 in.	f,g,h
111-191	90	White Spirit	H_2O	-	3.5	-	16 swg[u]	j
192-353	90	Toluene	H_2O	-	3.5	-	16 swg	j
354-367	90	Butyl Acetate	H_2O	-	3.5	-	16 swg	j
368-387	90	Methyl Isobutyl Ketone	H_2O	-	3.5	-	16 swg	j
388-397	90	Iso-Octane	H_2O	-	3.5	-	16 swg	j
398-419	90	Ethyl Acetate	H_2O	-	3.5	-	16 swg	j
420-464	64	Toluene	H_2O	-	3.0	-	12 swg	a,i
465-499	64	White Spirit	H_2O	-	3.0	-	10 swg	a,i
500-551	64	White Spirit	H_2O	-	6.0	-	10 swg	a,i
552-605	74,75	Benzene	H_2O	-	4.0	0.250	20 bwg[v]	i
606-675	75	Trichloroethylene	H_2O	-	4.0	0.250	20 bwg	b,i
676-853	87	Amsco 125-90W	H_2O	-	2.25	-	See note	k
854-858	55	4.5% TBP-Amsco	0.7 M $Al(NO_3)_3$	-	24	-	-	b,g,i
859-863	(See Group 18)							
864-866	86	10% TBP-Amsco 123-15	0.7 M $Al(NO_3)_3$	-	8.0	0.250	3/64 in.	b,g,i
867-879	19,20	Methyl Isobutyl Ketone	H_2O	-	3.0	0.078	0.024 in.	i
880-891	24	30% TBP-Shell E-2342 Spray Base, 73 g U/ℓ, 0.2 M HNO_3	2 M HNO_3, 10 g U/ℓ	-	6.0	-	20 gage	g,i
892-896	24	30% TBP-Shell E, 0.005 g U/ℓ, 0.02 M HNO_3	0.02 M HNO_3, 0.02 g U/ℓ	-	6.0	-	20 gage	g,i
897-933	24	30% TBP-Shell E, 0.0016 g U/ℓ, 0.01 M HNO_3	0.01 M HNO_3, 0.014 g U/ℓ	-	6.0	-	20 gage	g,i
934-1045	26	Heptane	H_2O	-	3.0	-	0.04 in.	j
1046-1060	4	Caltex Kerosene	$Al(NO_3)_3$-H_2O (Basic)	-	12	3/16	1/16 in.	h
1061-1071	20,21	Methyl Isobutyl Ketone	H_2O	-	1.5	-	1/16 in.	i
1072-1075	20,21	Methyl Isobutyl Ketone	38% Ethylene Glycol-H_2O	-	1.5	-	1/16 in.	g,i
1076-1079	20,21	Methyl Isobutyl Ketone	62% Ethylene Glycol-H_2O	-	1.5	-	1/16 in.	g,i
1080-1083	20,21	Methyl Isobutyl Ketone	82% Ethylene Glycol-H_2O	-	1.5	-	1/16 in.	g,i
1084-1086	20,21	Toluene	H_2O	-	1.5	-	1/16 in.	i
1087-1093	97	5% TBP-Amsco 125-82	1.8 M $Al(NO_3)_3$	-	24	-	0.031 in.	g,i
1094-1098	106	30% TBP-Amsco 125-82	4.1 M $NaNO_3$, 0.1 M HNO_3	-	12	-	0.059 in.	g,i,m
1099	107	30.9% TBP-Amsco 125-82	4.0 M $NaNO_3$, 0.05 M HNO_3	-	12	-	0.059 in.	g,i,m
1100-1103	109	"Carbitol," HNO_3	HNO_3	-	20	-	0.020 in.	j
1104-1107	110	1 M BAMBP (4-sec-butyl-2(α-methyl) benzyl-phenol)-Amsco 125-82	Purex 1WW, Tartrate complexed, Diluted 3-fold, and adjusted to pH 13 (0.4 M OH^-, 0.3 M $SO_4^=$, 1.5 M NO_3^-, 3.0 M Na^+, 0.2 M Fe^{3+}, 0.3 M $C_6H_4O_6^=$, lesser amounts of Cr, Ni, Al)	-	24	-	0.060 in.	i,m
1108-1109	110	Same as Nos. 1104-1107	0.1 M NaOH, 0.002 M $Na_2C_4H_4O_6$	-	12	-	0.060 in.	i,m
1110-1111	110	Same as Nos. 1104-1107	0.2 M HNO_3	-	12	-	0.060 in.	i,m

*See end of table for notes.

Table A-1. (Continued)

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes
Group 2. Mass Transfer, Aqueous Phase Continuous, Metal Sieve Plates.								
1112-1113	85	Methyl Isobutyl Ketone	2 M HCl, 0.37 M $Al(NO_3)_3$, 0.01 M $FeCl_3$	Fe^{3+}	3.0	33 Holes	1/16 in.	b,1
1114-1126	43	Methyl Isobutyl Ketone	2.8 g $NiCl_2/\ell$, 0.415 M NH_4CNS, 4.4 g $CoCl_2/\ell$	Co^{2+}	12	-	-	b,j
1127-1132	78,79	30% TBP-CCl_4	2.4 M HNO_3, 0.8 M $UO_2(NO_3)_2$	$UO_2(NO_3)_2$, HNO_3	9.0	-	-	b,g,j
1133-1149	29	40% TBP-Petroleum (170-248°C)	0.1 M HNO_3, 140 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	3.0	-	-	b,g,j
1150-1157	28	40% TBP-Amsco, 120 g U/ℓ	H_2O	$UO_2(NO_3)_2$	3.0-12	-	-	b,g,j
1158-1164	28	10% TBP-Amsco, $UO_2(NO_3)_2$	H_2O, $UO_2(NO_3)_2$	$UO_2(NO_3)_2$	3.0-12	-	-	b,g,j
1165-1173	28	20% TBP-Amsco, $UO_2(NO_3)_2$	H_2O, $UO_2(NO_3)_2$	$UO_2(NO_3)_2$	3.0-12	-	-	b,g,j
1174-1182	28	30% TBP-Amsco, $UO_2(NO_3)_2$	H_2O, $UO_2(NO_3)_2$	$UO_2(NO_3)_2$	3.0-12	-	-	b,g,j
1183-1191	28	40% TBP-Amsco, $UO_2(NO_3)_2$	H_2O, $UO_2(NO_3)_2$	$UO_2(NO_3)_2$	3.0-12	-	-	b,g,j
1192-1193	28	60% TBP-Amsco, $UO_2(NO_3)_2$	H_2O, $UO_2(NO_3)_2$	$UO_2(NO_3)_2$	3.0-12	-	-	b,g,j
1194-1207	68	35% TBP-Decalin	0.5 M Basic $Al(NO_3)_3$, $Th(NO_3)_4$, $UO_2(NO_3)_2$	$Th(NO_3)_4$, $UO_2(NO_3)_2$	26	-	-	b,g,i
1208-1211	68	42.5% TBP-Amsco	0.5 M Basic $Al(NO_3)_3$, $Th(NO_3)_4$, $UO_2(NO_3)_2$	$Th(NO_3)_4$, $UO_2(NO_3)_2$	26	-	-	b,g,i
1212-1221	50	42.5% TBP-Decalin	0.65 M Basic $Al(NO_3)_3$, $Th(NO_3)_4$, $UO_2(NO_3)_2$	$Th(NO_3)_4$, $UO_2(NO_3)_2$	26	-	-	b,f,g,i
1222-1224	34	42% TBP-Special Naptha No. 1	0.5 M Basic $Al(NO_3)_3$, 350 g Th/ℓ	$Th(NO_3)_4$	24	-	-	b,f,g,i
1225-1228	33	42% TBP-Special Naptha No. 1	0.4 M Basic $Al(NO_3)_3$, 0.003 M H_3PO_4, 350 g Th/ℓ	$Th(NO_3)_4$	24	-	-	b,f,g,i
1229-1234	55	4.5% TBP-Amsco	1.5 M $Al(NO_3)_3$, 1 M HNO_3, 2.2 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	-	b,g,i
1235-1238	55	4.5% TBP-Amsco, 2 g U/ℓ	H_2O	$UO_2(NO_3)_2$	24	-	-	b,g,i
1239-1247	86	10% TBP-Amsco 123-15	0.75 M $Al(NO_3)_3$, 1.0 M HNO_3, 3 M HF, 0.55 M Zr, 0.02 M Cr, 0.5 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	14	0.25	3/64 in.	b,g,i
1248-1255	86	10% TBP-Amsco 123-15	3 M HNO_3, 0.3 M H_2SO_4, 3 g/ℓ stainless steel, 2 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	14	0.25	3/64 in.	b,g,i
1256-1259	86	10% TBP-Amsco, 0.1 M HNO_3, 1 g U/ℓ	H_2O	$UO_2(NO_3)_2$, HNO_3	8.0	0.25	3/64 in.	b,g,i
1260-1263	86	10% TBP-Amsco, 0.002 M HNO_3	H_2O	HNO_3	8.0	0.25	3/64 in.	b,g,i
1264-1266	86	10% TBP-Amsco, 0.01 M HNO_3	H_2O	HNO_3	8.0	0.25	3/64 in.	
1267-1271	86	10% TBP-Amsco, 0.1 M HNO_3	H_2O	HNO_3	8.0	0.25	3/64 in.	b,g,i
1272-1273	86	10% TBP-Amsco, 1.53 g U/ℓ	H_2O	$UO_2(NO_3)_2$	8.0	0.25	3/64 in.	b,g,i
1274-1276	86	10% TBP-Amsco, 0.1 M HNO_3, 3.25 g U/ℓ	H_2O	$UO_2(NO_3)_2$, HNO_3	8.0	0.25	3/64 in.	b,g,i
1277-1279	9	30% TBP-Amsco 125-82	2.0 M HNO_3, 321 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	f,g,i
1280-1286	9	30% TBP-Amsco 125-82, 100 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i
1287-1290	10	30% TBP-Amsco 125-82, 100 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i

Table A-1. (Continued)

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes
1291	94	30% TBP-Amsco 125-82	0.1 M Acid Deficient, 20 g U/ℓ, 250 g Th/ℓ	$UO_2(NO_3)_2$, $Th(NO_3)_4$	24	-	0.031 in.	f,g,i
1292	94	30% TBP-Amsco 125-82, 2 g U/ℓ	0.01 M $Al(NO_3)_3$	$UO_2(NO_3)_2$	24	-	0.031 in.	g,i
1293-1296	95	30% TBP-Amsco 125-82, 3 g U/ℓ 35 g Th/ℓ	0.01 M HNO_3	$UO_2(NO_3)_2$, $Th(NO_3)_4$	24	-	0.031 in.	f,g,i
1297-1299	96	5% TBP-Amsco 125-82	2.0 M HNO_3, 10 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	f,g,i
1300-1303	96	5% TBP-Amsco 125-82, 10 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	12	-	0.031 in.	g,i
1304-1306	97	5% TBP-Amsco 125-82	1.8 M $Al(NO_3)_3$, 0.2 M HNO_3, 2 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	f,g,i
1307-1309	100	0.3 M Alamine 304-Diethyl Benzene	1.5-2.0 M HNO_3	HNO_3	24	-	0.060 in.	f,i
1310-1316	100	0.3 M Alamine 304-Diethyl Benzene, 0.5 M HNO_3	2.0 M CH_3COOH	HNO_3	12	-	0.060 in.	i
1317-1318	100	0.3 M Alamine 304-Diethyl Benzene, 0.3 M HNO_3	1.0 M Na_2CO_3	HNO_3	12	-	0.060 in.	i
1319-1323	102	2.5% Di-sec-butylphenyl-phosphonate-Diethyl Benzene	0.8 M $Al(NO_3)_3$, 260 g Th/ℓ, 5 g U/ℓ	$Th(NO_3)_4$, $UO_2(NO_3)_2$	24	-	0.060 in.	f,g,i
1324-1329	102	Same as Above, + 2 g U/ℓ	0.004 M HNO_3	$UO_2(NO_3)_2$	24	-	0.060 in.	i
Group 3. No Mass Transfer, Aqueous Phase Continuous, Metal Nozzle Plates.								
1330-1337	111	20% TBP-Odorless Kerosene (OK), (Boiling Range 200-240°C, Sp. Gr. 0.79)	0.01 M HNO_3	-	10	1.75	-	g,i,n,o,p
Group 4. Mass Transfer, Aqueous Phase Continuous, Metal Nozzle Plates.								
1338-1340	10	30% TBP-Amsco 125-82, 100 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i
1341	94	30% TBP-Amsco 125-82, 2 g U/ℓ, HNO_3	0.01 M $Al(NO_3)_3$	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i
1342-1344	96	5% TBP-Amsco 125-82, 10 g U/ℓ	0.01 M HNO_3	$UO_2(NO_3)_2$	12	-	0.031 in.	g,i
1345-1350	101	30% TBP-Amsco 125-82, 80 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	12	-	0.031 in.	g,i
1351-1359	111	20% TBP-Odorless Kerosene, 14-65 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1360-1366	111	20% TBP-OK, 66 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1367-1374	111	20% TBP-OK, 15 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p

Table A-1. (Continued)

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes
Group 5. No Mass Transfer, Aqueous Phase Continuous, Zebra Sieve Plates.								
1375-1399	45	30% TBP-Shell E-2342, 73 g U/ℓ, 11 g HNO_3/ℓ	10 g U/ℓ, 146 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1400-1429	45	30% TBP-Shell E-2342, 55 g U/ℓ, 13 g HNO_3/ℓ	7 g U/ℓ, 126 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1430-1458	45	30% TBP-Shell E-2342, 0.001 g U/ℓ	0.01 g U/ℓ, 1.0 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1459-1497	45	30% TBP-Shell E-2342, 0.005 g U/ℓ, 20 g HNO_3/ℓ	93 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1498-1518	45	30% TBP-Shell E-2342, 0.005 g U/ℓ, 19 g HNO_3/ℓ	703 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
Group 9. No Mass Transfer, Organic Phase Continuous, Metal Sieve Plates.								
1519	94	30% TBP-Amsco 125-82	H_2O	-	24	-	0.031 in.	f,g,i
Group 10. Mass Transfer, Organic Phase Continuous, Metal Sieve Plates.								
1520-1522	9	30% TBP-Amsco 125-82	2 M HNO_3, 321 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	f,g,i
1523-1526	9	30% TBP-Amsco 125-82, 100 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i
1527-1530	10	30% TBP-Amsco 125-82, 100 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i
1531	94	30% TBP-Amsco 125-82, 2 g U/ℓ, HNO_3	0.01 M $Al(NO_3)_3$	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	f,g,i
Group 11. No Mass Transfer, Organic Phase Continuous, Metal Nozzle Plates.								
1532-1534	94	30% TBP-Amsco 125-82, 3 g U/ℓ, 35 g Th/ℓ	3 M HNO_3, 10 g U/ℓ, 120 g Th/ℓ	-	24	-	0.031 in.	f,g,i
1535-1539	106	30% TBP-Amsco 125-82	4 M $NaNO_3$	-	12	-	0.059 in.	g,i,m
1540	110	1 M SAMBP (4-sec-butyl-2(α-methyl) benzylphenol)-Amsco 125-82	0.05 M HNO_3	-	24	-	0.060 in.	i,m
1541-1543	110	Same as Point No. 1540	0.2 M HNO_3	-	24	-	0.060 in.	i,m
1544-1555	111	20% TBP-Odorless Kerosene (OK), $UO_3(NO_3)_2$, HNO_3	3 M HNO_3, 74 g U/ℓ	-	10	See Note	-	g,i,n,o,p
1556-1581	111	20% TBP-OK, $UO_2(NO_3)_2$, HNO_3	3 M HNO_3, 18 g U/ℓ	-	10	See Note	-	g,i,n,o,p
1582-1591	111	20% TBP-OK, $UO_2(NO_3)_2$, HNO_3	3 M HNO_3, 41 g U/ℓ	-	10	See Note	-	g,i,n,o,p
1592-1594	111	20% TBP-OK, $UO_2(NO_3)_2$, HNO_3	3 M HNO_3, 40 g U/ℓ	-	10	See Note	-	g,i,n,o,p
1595-1599	111	20% TBP-OK, $UO_2(NO_3)_2$, HNO_3	3 M HNO_3, 72 g U/ℓ	-	10	See Note	-	g,i,n,o,p
1600-1605	111	20% TBP-OK, $UO_2(NO_3)_2$, HNO_3	3 M HNO_3, 73 g U/ℓ	-	10	See Note	-	g,i,n,o,p
1606-1627	111	20% TBP-OK	0.01 M HNO_3	-	10	See Note	-	g,i,n,o,p

**See Table A-2, Cartridge Nos. 35-50.

Table A-1. (Continued)

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes
Group 12. Mass Transfer, Organic Phase Continuous, Metal Nozzle Plates.								
1628-1631	10	30% TBP-Amsco 125-82, 100 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	g,i
1632	94	30% TBP-Amsco 125-82, 2 g U/ℓ	0.01 M $Al(NO_3)_3$	$UO_2(NO_3)_2$	24	-	0.031 in.	g,i
1633-1635	96	5% TBP-Amsco 125-82	2 M HNO_3, 10 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	0.031 in.	f,g,i
1636-1638	96	5% TBP-Amsco 125-82, 10 g U/ℓ	0.01 M HNO_3	$UO_2(NO_3)_2$	24	-	0.031 in.	g,i
1639-1644	100	0.3 M Alamine 304-Diethyl Benzene	1.5-2.0 M HNO_3	HNO_3	24	-	0.060 in.	f,i
1645-1647	100	0.3 M Alamine 304-Diethyl Benzene, 0.5 M HNO_3	2 M CH_3COOH	HNO_3	12	-	0.060 in.	i
1648-1649	100	0.3 M Alamine 304-Diethyl Benzene, 0.3 M HNO_3	1 M Na_2CO_3	HNO_3	12	-	0.060 in.	i
1650-1659	101	30% TBP-Amsco 125-82	2 M HNO_3, 65 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	24	-	0.060 in.	g,f,i
1660-1668	111	20% TBP-Odorless Kerosene (OK) 52 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1669-1678	111	20% TBP-OK	3 M HNO_3, 24 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1679-1689	111	20% TBP-OK	3 M HNO_3, 204 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1690-1703	111	20% TBP-OK	3 M HNO_3, 100 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1704-1706	111	20% TBP-OK	3 M HNO_3, 300 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1707-1711	111	20% TBP-OK, 52 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1712-1715	111	20% TBP-OK, 14 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1716-1719	111	20% TBP-OK, 17 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1720-1722	111	20% TBP-OK, 41 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1723-1736	111	20% TBP-OK, 23 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p
1737-1747	111	20% TBP-OK	3 M HNO_3, 100-312 g U/ℓ	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p,q
1748-1756	111	20% TBP-OK, 39-62 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Note	-	g,i,n,o,p,r
Group 13. No Mass Transfer, Organic Phase Continuous, Plastic Sieve Plates.								
1757-1784	4	Caltex Kerosene	$Al(NO_3)_3$-H_2O		12	3/16	1/16 in.	h

Table A-1. (Continued)

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes
Group 14. No Mass Transfer, Organic Phase Continuous, Zebra Sieve Plates.								
1785-1809	45	30% TBP-Shell E-2342, 73 g U/ℓ, 11 g HNO_3/ℓ	11 g U/ℓ, 146 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1810-1834	45	30% TBP-Shell E-2342, 55 g U/ℓ, 13 g HNO_3/ℓ	7.3 g U/ℓ, 126 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1835-1864	45	30% TBP-Shell E-2342, 0.001 g U/ℓ	0.012 g U/ℓ, 0.95 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1865-1904	45	30% TBP-Shell E-2342, 0.005 g U/ℓ, 20 g HNO_3/ℓ	0.0005 g U/ℓ, 3 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
1905-1918	45	30% TBP-Shell E-2342, 0.005 g U/ℓ, 19 g HNO_3/ℓ	0.0005 g U/ℓ, 703 g HNO_3/ℓ	-	3.0	**	0.070 in.	g,i
Group 15. Mass Transfer, Organic Phase Continuous, Plastic Sieve Plates.								
1919-1928	78,79	30% TBP-CCl_4, 0.2 M HNO_3	0.03 M HNO_3	HNO_3	9.0	-	-	b,g,j
Group 16. No Mass Transfer, Organic Phase Continuous, Plastic Nozzle Plates.								
1929-1940	111	20% TBP-Odorless Kerosene, $UO_2(NO_3)_2$, HNO_3	3 M HNO_3, 74 g U/ℓ	-	10	See Notes	-	g,i,n,o,p
Group 17. Mass Transfer, Organic Phase Continuous, Plastic Nozzle Plates.								
1941-1950	111	20% TBP-Odorless Kerosene, 52 g U/ℓ, HNO_3	0.01 M HNO_3	$UO_2(NO_3)_2$, HNO_3	10	See Notes	-	g,i,n,o,p
Group 18. No Mass Transfer, Aqueous Phase Continuous, Metal Sieve Plates, Case V Flooding.* **								
859-863	30,31	Methylisobutylketone	H_2O	-	1.5	0.055	26 gage	l
1951-1996	30,31	Methylisobutylketone	H_2O	-	1.5	0.055	26 gage	i
Group 19. No Mass Transfer, Aqueous Phase Continuous (except as noted), Spiral Cartridge.								
1997-2016	24	30% TBP-Shell E-2342, 73 g U/ℓ, 11 g HNO_3/ℓ	10 g U/ℓ, 146 g HNO_3/ℓ	-	6.0	1/4	0.0375 in.	g,i
2017-2053	24	30% TBP-Shell E-2342, 0.002 g U/ℓ, 0.5 g HNO_3/ℓ	0.014 g U/ℓ, 0.7 g HNO_3/ℓ	-	6.0	1/4	0.0375 in.	g,i
2054-2056	24	Same as Point Nos. 1997-2016	Same as Point Nos. 1997-2016	-	6.0	3/16	0.0375 in.	i,s
2057-2068	24	Same as Point Nos. 1997-2016	Same as Point Nos. 1997-2016	-	6.0	1/4	0.0375 in.	i
2069-2073	24	Same as Point Nos. 1997-2016	Same as Point Nos. 1997-2016	-	6.0	3/16	0.0375 in.	i
2074-2077	24	Same as Point Nos. 1997-2016	Same as Point Nos. 1997-2016	-	6.0	1/4	-	i,t
2078-2081	24	Same as Point Nos. 1997-2016	Same as Point Nos. 1997-2016	-	6.0	3/8	0.0375 in.	i

**See Table A-2.
***See Reference 87.

Table A-1. (Continued)

Data Point Nos.	Ref. No.	System: Organic Phase	System: Aqueous Phase	Distributing Species	Column Height (ft)	Pulse Plate: Hole Spacing (in.)	Pulse Plate: Plate Thickness	Notes
Group 20. Aqueous Phase Continuous, Metal Sieve Plates, Square Wave and Sawtooth Wave Pulse.								
2082-2172	90	Toluene	H_2O	-	3.5	-	16 swg	e,i
2173-2210	90	Toluene	H_2O	-	3.5	-	16 swg	c,i
2211-2215	104	Toluene, 0.8 g C_6H_5COOH/ℓ	H_2O, 0.4 g C_6H_5COOH/ℓ	-	3.0	-	-	b,c,i
2216-2245	67	10 wt % Acetone-Toluene	H_2O	-	-	-	-	b,d,i
2246-2252	62	15% TBP-Amsco 125-90W	0.2 M $Al(NO_3)_3$, 0.4 M HNO_3	HNO_3	-	-	0.031 in.	c,g,i

[a]Stainless steel column; all others are glass.

[b]Where no physical property data were reported, solutions were made up and the physical properties measured at ORNL in 1962.

[c]Pulse wave, semisquare. See Table A-2.

[d]Pulse wave, truncated sine.

[e]Pulse wave, sawtooth. See Table A-2.

[f]Compound column--extraction and scrub, flooding points were interpreted to occur in the extraction section.

[g]The symbol % is generally volume percent, unless otherwise specified, interpreted as follows: 5% TBP (tributylphosphate)--kerosene means that kerosene was added to 50 ml pure TBP until the solution was a liter in volume.

[h]Square hole pattern.

[i]Triangular hole pattern.

[j]Hole pattern not given.

[k]Nos. 825 through 830, 0.010-in. thick perforated plate; Nos. 850-853, 0.070-in. thick plate; all others 0.020 in. thick. Point Nos. 825-827, 831-843, 847-849 square grid hole pattern; all others triangular grid.

[l]"Staggered" hole pattern, presumably triangular.

[m]Velocities in original reference not corrected for area of center rod. V_c, V_D reported here are corrected for area of center rod.

[n]Physical property data were estimated from data in references (96), (112).

[o]Plate thickness not given. Nozzle depth 0.102 cm.

[p]Height to 1/2 base ratio 1.75.

[q]Flooding assumed to be at bottom of column in extraction runs.

[r]Flooding assumed to be at top of column in backwash runs.

[s]Organic phase continuous is assumed here. Original reference unclear.

[t]Note that S = 0.000 in data since there were no horizontal plates in the column, only a vertical sieve plate. One could calculate a "Plate Spacing" based on a 2-in. spiral pitch.

[u]Standard wire gage.

[v]British wire gage.

Table A-2. Code for Flooding Data, Table A-3

Column	Code	Meaning of Code Numbers
Transfer	Tr	1--Solute being transferred primarily from organic to aqueous phase
		2--Solute being transferred primarily from aqueous to organic phase
		3--Mass transfer in only a part of the column as in the end of a scrub tower where scrub is introduced
		4--No mass transfer; phases are thought to be in equilibrium
Continuous Phase	CP	1--Aqueous phase continuous
		2--Organic phase continuous
		3--Zebra formation, alternate organic-continuous and aqueous-continuous sections in same column, with flooding due primarily to aqueous phase
		4--Zebra formation with flooding due primarily to organic phase
Cartridge	Ct	1--Stainless steel
		2--Brass
		3--Steel
		4--Hastelloy C
		5--Nozzle cartridge, protrusions oriented downward
		6--Nozzle cartridge, protrusions oriented upward
		7--Aluminum
		8--Spiral cartridge - 6 in. pitch, stainless steel - horizontal stainless steel perforated plates
		9--Spiral cartridge - 3 in. pitch, stainless steel - horizontal stainless steel perforated plates
		10--Spiral cartridge like 8 and 9 - 3 in. pitch in upper 3 ft column, 6 in. pitch in lower 3 ft

Table A-2. (Continued)

Column	Code	Meaning of Code Numbers
Cartridge	Ct	11--Spiral cartridge, 2 in. pitch, stainless steel - horizontal stainless steel perforated plates
		12--Spiral cartridge, 2 in. pitch, stainless steel - vertical stainless steel sieve plate with no horizontal sieve plate
		31--Florothene - (Kel-F) polytrifluoromonochloroethylene
		32--Lucoflex (Cohen and Beyer) - chlorinated polyvinyl chloride
		33-Zebra in scrub, nozzle in extraction sections. Scrub: 4 stainless steel sieve plates, $\epsilon = 0.21$ followed by 2 plastic sieve (high density linear polyethylene) plates, 0.188-in.-holes, $\epsilon = 0.23$
		34--Teflon - polytetrafluoroethylene
		35--"Super Dylan" linear polyethylene standard zebra cartridge
		36--"Marlex" linear polyethylene, 2 test plates in cartridge 35
		37--"Hifax" linear polyethylene, 2 test plates in cartridge 35
		38--"Hifax" linear polyethylene zebra cartridge
		39--"Hifax" linear polyethylene zebra cartridge
		40--Regular polyethylene "Whirlclad" coated, 2 plates in cartridge 35
		41--Regular polyethylene "Whirlclad" coated, 2 plates in cartridge 35
		42--"Super Dylan" linear polyethylene, "Whirlclad" coated, 2 plates in cartridge 35
		43--Plates of cartridge No. 42 pressed between sheets of Teflon at 135°C, holes drilled to metal, 2 plates in cartridge 35

Table A-2. (Continued)

Column	Code	Meaning of Code Numbers
Cartridge	Ct	44--"Super Dylan" linear polyethylene dispersion coated, 2 plates in cartridge 35
		45--Cartridge No. 44 with holes drilled to metal, 2 plates in cartridge 35
		46--Cartridge No. 45 with all 4 surfaces lapped on oil stone, 2 plates in cartridge 35
		47--Chlorinated polyether, "Whirlclad" coated, 2 plates in cartridge 35
		48--Chlorinated polyether, "Whirlclad" coated, 2 plates in cartridge 35
		49--"Super Dylan" linear polyethylene zebra cartridge: Holes edges rounded on one side (up)
		50--"Super Dylan" linear polyethylene zebra cartridge: Hole edges rounded on one side (down)
		51--Linear polyethylene, 0.070 in. thick, zebra cartridge
		52--Polytetrafluoroethylene (PTFE) coated nozzle plates, oriented down
		52--Florothene sieve plates with stainless steel spiral cartridge, 6 in. pitch on spiral

Table A-3. Flooding Data

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
Group-1 Data:																
1	46.60	60.30	100.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
2	46.60	17.50	100.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
3	46.60	93.40	100.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
4	35.00	93.40	200.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
5	46.60	31.20	75.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
6	46.60	41.70	50.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
7	46.60	83.40	50.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
8	70.00	49.80	100.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
9	70.00	65.40	50.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
10	70.00	93.40	50.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
11	35.00	91.90	200.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
12	46.60	66.50	75.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
13	46.60	77.90	200.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
14	46.60	46.60	50.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
15	70.00	71.00	100.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
16	35.00	81.10	75.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
17	70.00	25.40	75.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
18	70.00	54.20	100.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
19	35.00	26.80	100.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
20	70.00	23.30	50.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
21	35.00	55.00	50.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
22	70.00	95.70	75.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
23	70.00	51.90	75.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
24	35.00	57.10	75.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
25	35.00	102.00	100.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
26	35.00	57.10	75.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
27	46.60	83.00	100.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
28	70.00	74.80	200.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
29	35.00	66.40	100.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
30	46.60	15.60	165.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
31	70.00	40.70	75.0	0.125	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
32	70.00	44.80	200.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
33	70.00	103.70	25.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
34	70.00	97.40	40.0	1.000	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
35	70.00	44.80	25.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
36	70.00	81.10	150.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
37	46.60	62.30	25.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
38	46.60	98.80	50.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
39	46.60	99.60	150.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
40	46.60	77.60	200.0	0.250	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
41	35.00	75.70	25.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
42	35.00	83.40	150.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
43	35.00	37.00	200.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
44	46.60	107.00	75.0	0.500	1.240	0.772	3.310	3.420	15.10	0.1110	0.230	1.938	1.002	4	1	1
45	70.00	21.50	26.0	0.500	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1

*See Table A-2 for meaning of code for Tr(Transfer), CP(Continuous Phase), and Ct(Cartridge).

*See Table A-2 for meaning of code for Tr(Transfer), CP(Continuous Phasd

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
46	70.00	43.70	50.0	0.500	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
47	70.00	46.70	72.0	0.500	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
48	70.00	35.50	98.0	0.500	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
49	70.00	13.60	154.0	0.500	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
50	70.00	21.70	53.0	0.250	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
51	70.00	37.50	100.0	0.250	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
52	70.00	39.70	150.0	0.250	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
53	70.00	28.10	200.0	0.250	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
54	70.00	31.20	28.0	0.500	1.124	0.828	1.720	2.480	10.50	0.1110	0.230	1.938	1.002	4	1	1
55	70.00	66.00	50.0	0.500	1.124	0.828	1.720	2.480	10.50	0.1110	0.230	1.938	1.002	4	1	1
56	70.00	67.00	76.0	0.500	1.124	0.828	1.720	2.480	10.50	0.1110	0.230	1.938	1.002	4	1	1
57	70.00	42.80	98.0	0.500	1.124	0.828	1.720	2.480	10.50	0.1110	0.230	1.938	1.002	4	1	1
58	70.00	21.90	150.0	0.500	1.124	0.828	1.720	2.480	10.50	0.1110	0.230	1.938	1.002	4	1	1
59	46.60	13.60	70.0	0.500	1.362	0.773	9.200	1.480	14.80	0.1110	0.230	1.938	1.002	4	1	1
60	46.60	12.00	70.0	0.500	1.366	0.773	10.630	1.560	15.60	0.1110	0.230	1.938	1.002	4	1	1
61	46.60	12.10	70.0	0.500	1.362	0.773	9.470	1.460	14.80	0.1110	0.230	1.938	1.002	4	1	1
62	46.60	17.90	70.0	0.500	1.347	0.773	7.270	1.370	15.30	0.1110	0.230	1.938	1.002	4	1	1
63	46.60	32.20	70.0	0.500	1.323	0.773	4.620	1.180	15.40	0.1110	0.230	1.938	1.002	4	1	1
64	46.60	24.90	70.0	0.500	1.299	0.773	4.990	1.210	14.40	0.1110	0.230	1.938	1.002	4	1	1
65	46.60	33.80	70.0	0.500	1.277	0.773	4.020	1.230	15.00	0.1110	0.230	1.938	1.002	4	1	1
66	46.60	36.10	70.0	0.500	1.264	0.773	3.510	1.140	15.50	0.1110	0.230	1.938	1.002	4	1	1
67	46.60	43.50	70.0	0.500	1.248	0.773	3.120	1.150	15.10	0.1110	0.230	1.938	1.002	4	1	1
68	46.60	52.90	70.0	0.500	1.234	0.773	3.110	1.390	15.70	0.1110	0.230	1.938	1.002	4	1	1
69	46.60	54.00	70.0	0.500	1.221	0.773	2.880	1.370	14.70	0.1110	0.230	1.938	1.002	4	1	1
70	46.60	54.80	70.0	0.500	1.221	0.773	2.760	1.280	15.10	0.1110	0.230	1.938	1.002	4	1	1
71	46.60	58.20	70.0	0.500	1.211	0.773	2.560	1.310	14.90	0.1110	0.230	1.938	1.002	4	1	1
72	46.60	62.20	70.0	0.500	1.202	0.773	2.370	1.250	15.80	0.1110	0.230	1.938	1.002	4	1	1
73	46.60	66.40	70.0	0.500	1.173	0.773	2.210	1.250	14.80	0.1110	0.230	1.938	1.002	4	1	1
74	46.60	59.00	70.0	0.500	1.175	0.773	2.600	1.480	14.60	0.1110	0.230	1.938	1.002	4	1	1
75	46.60	63.40	70.0	0.500	1.154	0.773	2.260	1.320	14.50	0.1110	0.230	1.938	1.002	4	1	1
76	46.60	64.80	70.0	0.500	1.141	0.773	2.100	1.190	14.90	0.1110	0.230	1.938	1.002	4	1	1
77	46.60	65.20	70.0	0.500	1.128	0.773	1.860	1.100	14.90	0.1110	0.230	1.938	1.002	4	1	1
78	46.60	19.70	70.0	0.500	1.353	0.828	7.630	3.220	8.90	0.1110	0.230	1.938	1.002	4	1	1
79	46.60	28.00	70.0	0.500	1.338	0.828	7.080	3.600	10.80	0.1110	0.230	1.938	1.002	4	1	1
80	46.60	31.10	70.0	0.500	1.326	0.828	6.490	3.510	10.50	0.1110	0.230	1.938	1.002	4	1	1
81	46.60	41.50	70.0	0.500	1.307	0.828	5.360	3.610	10.50	0.1110	0.230	1.938	1.002	4	1	1
82	46.60	47.70	70.0	0.500	1.297	0.828	4.120	3.180	10.90	0.1110	0.230	1.938	1.002	4	1	1
83	46.60	54.90	70.0	0.500	1.276	0.828	4.350	3.520	12.20	0.1110	0.230	1.938	1.002	4	1	1
84	46.60	64.20	70.0	0.500	1.270	0.828	3.710	3.560	11.00	0.1110	0.230	1.938	1.002	4	1	1
85	46.60	71.50	70.0	0.500	1.257	0.828	3.450	3.780	10.90	0.1110	0.230	1.938	1.002	4	1	1
86	46.60	62.20	70.0	0.500	1.272	0.828	3.800	3.580	10.70	0.1110	0.230	1.938	1.002	4	1	1
87	46.60	69.50	70.0	0.500	1.246	0.828	3.400	3.820	10.60	0.1110	0.230	1.938	1.002	4	1	1
88	46.60	72.50	70.0	0.500	1.239	0.828	3.150	3.320	10.90	0.1110	0.230	1.938	1.002	4	1	1
89	46.60	73.60	70.0	0.500	1.216	0.828	2.750	3.190	12.40	0.1110	0.230	1.938	1.002	4	1	1
90	46.60	80.90	70.0	0.500	1.189	0.828	2.490	3.190	10.80	0.1110	0.230	1.938	1.002	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
91	46.60	80.90	70.0	0.500	1.175	0.828	2.350	3.160	10.70	0.1110	0.230	1.938	1.002	4	1	1
92	46.60	67.40	70.0	0.500	1.197	0.828	2.420	2.260	11.60	0.1110	0.230	1.938	1.002	4	1	1
93	46.60	74.70	70.0	0.500	1.157	0.828	2.140	2.480	10.60	0.1110	0.230	1.938	1.002	4	1	1
94	46.60	73.60	70.0	0.500	1.143	0.828	2.060	2.400	11.00	0.1110	0.230	1.938	1.002	4	1	1
95	46.60	73.60	70.0	0.500	1.130	0.828	1.940	2.220	11.00	0.1110	0.230	1.938	1.002	4	1	1
96	46.60	13.50	70.0	0.500	1.362	0.877	7.910	2.210	9.66	0.1110	0.230	1.938	1.002	4	1	1
97	46.60	17.60	70.0	0.500	1.323	0.877	5.670	2.020	9.60	0.1110	0.230	1.938	1.002	4	1	1
98	46.60	24.90	70.0	0.500	1.302	0.877	4.880	2.540	9.82	0.1110	0.230	1.938	1.002	4	1	1
99	46.60	42.60	70.0	0.500	1.283	0.877	4.020	3.530	9.30	0.1110	0.230	1.938	1.002	4	1	1
100	46.60	46.60	70.0	0.500	1.285	0.877	4.500	3.560	8.90	0.1110	0.230	1.938	1.002	4	1	1
101	46.60	58.00	70.0	0.500	1.276	0.877	3.820	4.460	9.48	0.1110	0.230	1.938	1.002	4	1	1
102	46.60	72.50	70.0	0.500	1.261	0.877	3.380	4.750	9.54	0.1110	0.230	1.938	1.002	4	1	1
103	46.60	86.00	70.0	0.500	1.231	0.877	2.980	5.690	9.63	0.1110	0.230	1.938	1.002	4	1	1
104	46.60	72.50	70.0	0.500	1.224	0.877	2.950	4.920	8.89	0.1110	0.230	1.938	1.002	4	1	1
105	46.60	82.90	70.0	0.500	1.226	0.877	2.950	5.130	9.75	0.1110	0.230	1.938	1.002	4	1	1
106	31.10	59.10	70.0	0.500	1.285	0.877	4.500	3.560	8.90	0.1110	0.230	1.938	1.002	4	1	1
107	38.80	52.50	70.0	0.500	1.285	0.877	4.500	3.560	8.90	0.1110	0.230	1.938	1.002	4	1	1
108	46.60	46.60	70.0	0.500	1.285	0.877	4.500	3.560	8.90	0.1110	0.230	1.938	1.002	4	1	1
109	58.30	38.10	70.0	0.500	1.285	0.877	4.500	3.560	8.90	0.1110	0.230	1.938	1.002	4	1	1
110	70.00	28.80	70.0	0.500	1.285	0.877	4.500	3.560	8.90	0.1110	0.230	1.938	1.002	4	1	1
111	83.00	94.20	180.0	0.350	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
112	105.00	83.30	180.0	0.350	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
113	126.80	74.40	180.0	0.350	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
114	149.50	66.50	180.0	0.350	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
115	176.40	63.90	180.0	0.350	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
116	62.00	83.50	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
117	84.50	72.80	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
118	106.00	68.90	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
119	129.50	52.90	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
120	154.10	43.00	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
121	176.40	39.70	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
122	21.80	67.00	180.0	0.720	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
123	40.80	59.70	180.0	0.720	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
124	84.00	44.80	180.0	0.720	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
125	106.00	35.80	180.0	0.720	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
126	124.20	50.20	180.0	0.720	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
127	84.60	115.80	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
128	95.80	98.40	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
129	106.80	104.80	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
130	118.30	89.60	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
131	130.70	87.90	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
132	152.90	79.30	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
133	176.30	74.70	210.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	2.000	2.875	4	1	2
134	41.80	68.40	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
135	52.30	63.20	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
136	61.10	56.10	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
137	62.40	55.10	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
138	84.10	48.70	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
139	105.70	42.40	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
140	131.70	38.50	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
141	154.20	26.40	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
142	22.00	61.30	180.0	0.375	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
143	41.80	51.30	180.0	0.375	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
144	61.00	42.10	180.0	0.375	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
145	85.40	31.90	180.0	0.375	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
146	106.70	24.30	180.0	0.375	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
147	21.70	45.70	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
148	21.90	42.30	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
149	42.00	37.10	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
150	61.10	29.10	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
151	84.60	24.40	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
152	107.00	16.60	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
153	41.70	74.30	90.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
154	60.60	61.40	90.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
155	84.00	52.60	90.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
156	106.20	45.30	90.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
157	131.50	39.00	90.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
158	41.80	67.50	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
159	60.80	50.40	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
160	62.20	51.60	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
161	75.20	44.00	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
162	84.70	45.30	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
163	95.10	36.40	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
164	106.50	28.70	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
165	131.70	22.10	120.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
166	22.10	55.20	150.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
167	42.20	41.60	150.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
168	62.30	31.60	150.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
169	84.30	25.40	150.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
170	107.00	20.40	150.0	0.500	0.998	0.772	1.060	0.926	36.00	0.0625	0.246	2.000	2.875	4	1	2
171	92.20	70.70	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	0.500	2.875	4	1	2
172	117.50	56.80	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	0.500	2.875	4	1	2
173	144.10	46.60	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	0.500	2.875	4	1	2
174	169.70	28.50	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	0.500	2.875	4	1	2
175	196.90	20.80	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	0.500	2.875	4	1	2
176	106.00	62.50	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.000	2.875	4	1	2
177	107.00	61.60	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.000	2.875	4	1	2
178	130.00	55.10	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.000	2.875	4	1	2
179	153.00	52.80	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.000	2.875	4	1	2
180	153.00	47.20	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
181	178.00	41.90	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.000	2.875	4	1	2
182	50.80	53.10	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.500	2.875	4	1	2
183	105.40	40.00	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.500	2.875	4	1	2
184	128.50	33.10	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.500	2.875	4	1	2
185	152.00	28.40	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.500	2.875	4	1	2
186	176.30	23.30	180.0	0.500	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	1.500	2.875	4	1	2
187	103.50	98.30	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	3.000	2.875	4	1	2
188	127.00	86.40	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	3.000	2.875	4	1	2
189	149.90	80.70	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	3.000	2.875	4	1	2
190	173.90	75.20	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	3.000	2.875	4	1	2
191	199.90	68.30	180.0	0.250	0.998	0.772	1.060	0.926	36.00	0.1250	0.246	3.000	2.875	4	1	2
192	22.60	106.40	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
193	43.70	90.00	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
194	64.20	80.00	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
195	76.60	67.30	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
196	87.20	63.50	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
197	105.50	45.80	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
198	105.60	48.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
199	127.00	35.90	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
200	57.30	101.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
201	79.10	88.30	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
202	93.60	66.60	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
203	97.00	62.20	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
204	127.40	55.20	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
205	148.30	40.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
206	22.90	68.40	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
207	44.20	54.10	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
208	85.00	44.50	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
209	129.00	27.70	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
210	148.20	23.40	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
211	22.40	58.60	180.0	0.520	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
212	43.40	51.40	180.0	0.520	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
213	63.60	39.40	180.0	0.520	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
214	84.20	27.30	180.0	0.520	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
215	105.60	23.00	180.0	0.520	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
216	7.90	44.40	180.0	0.870	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
217	22.50	23.00	180.0	0.870	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
218	32.40	14.80	180.0	0.870	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
219	43.40	10.90	180.0	0.870	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
220	53.00	4.10	180.0	0.870	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
221	23.00	76.00	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
222	42.80	59.20	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
223	43.80	77.70	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
224	63.80	55.60	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
225	85.00	49.50	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
226	106.30	39.30	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
227	126.70	31.50	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
228	22.50	60.30	300.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
229	32.90	52.20	300.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
230	43.80	49.30	300.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
231	84.90	33.90	300.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
232	128.30	20.90	300.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
233	22.50	51.80	360.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
234	43.70	41.30	360.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
235	64.00	28.80	360.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
236	85.10	22.80	360.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
237	128.30	13.20	360.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
238	22.80	46.70	420.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
239	32.20	37.20	420.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
240	43.10	35.00	420.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
241	62.70	16.70	420.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
242	85.50	12.10	420.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
243	22.90	86.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
244	30.90	71.30	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
245	31.30	188.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
246	43.90	58.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
247	45.10	151.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
248	55.80	56.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
249	66.80	66.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
250	67.00	50.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
251	76.20	53.90	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
252	78.30	42.60	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
253	91.80	38.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
254	92.40	38.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
255	119.40	28.20	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
256	121.50	28.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
257	149.60	24.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
258	152.30	25.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
259	181.00	15.30	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
260	184.10	15.60	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	0.500	2.875	4	1	2
261	81.60	123.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
262	82.40	135.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
263	104.40	106.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
264	128.00	97.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
265	151.50	77.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
266	176.70	71.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
267	191.10	65.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	3.000	2.875	4	1	2
268	43.40	89.40	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
269	85.10	71.70	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
270	125.20	52.30	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
271	167.20	46.40	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
272	63.60	73.90	120.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
273	73.40	78.70	120.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
274	87.30	56.00	120.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
275	104.40	47.00	120.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
276	125.40	41.30	120.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
277	146.50	30.80	120.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
278	62.80	81.40	150.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
279	84.80	52.30	150.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
280	95.90	54.80	150.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
281	114.70	39.50	150.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
282	127.00	25.20	150.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.131	2.000	2.875	4	1	2
283	43.30	92.40	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
284	65.10	84.40	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
285	80.90	71.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
286	84.50	85.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
287	86.40	74.20	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
288	105.30	59.30	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
289	108.50	62.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
290	127.00	52.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
291	130.20	50.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
292	149.70	40.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
293	163.50	36.50	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
294	22.80	50.30	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
295	22.90	84.10	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
296	43.30	39.00	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
297	43.50	64.90	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
298	62.50	32.90	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
299	65.10	33.90	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
300	84.30	22.00	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
301	105.40	13.30	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
302	108.30	7.70	180.0	0.390	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
303	43.30	60.20	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
304	43.80	71.80	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
305	62.50	53.50	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
306	62.50	63.40	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
307	65.50	50.10	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
308	74.60	45.50	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
309	84.80	40.70	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
310	86.00	38.60	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
311	103.90	30.90	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
312	106.10	23.90	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
313	107.90	25.40	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
314	116.70	18.30	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
315	126.60	15.10	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
316	126.70	9.90	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
317	126.70	9.50	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
318	130.00	16.00	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.172	2.000	2.875	4	1	2
319	63.90	85.80	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
320	84.80	75.30	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
321	104.50	64.10	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
322	125.10	58.30	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
323	165.80	38.90	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
324	82.50	126.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
325	91.90	106.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
326	127.60	92.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
327	160.20	78.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
328	177.80	69.90	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
329	60.90	130.20	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
330	74.50	146.10	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
331	82.80	74.50	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
332	91.60	106.50	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
333	103.70	54.80	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
334	104.70	79.70	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
335	119.10	62.20	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
336	128.30	42.80	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
337	136.80	44.10	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
338	150.80	32.30	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
339	151.70	34.20	180.0	0.750	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
340	63.60	80.00	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
341	84.80	66.30	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
342	104.50	83.10	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
343	104.50	56.90	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
344	127.80	47.20	240.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.390	2.000	2.875	4	1	2
345	82.40	118.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
346	102.80	98.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
347	127.00	82.60	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
348	160.00	63.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
349	127.10	47.50	210.0	0.500	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
350	127.80	50.80	210.0	0.500	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
351	137.60	38.20	210.0	0.500	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
352	149.00	32.00	210.0	0.500	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
353	177.30	29.10	210.0	0.500	0.998	0.864	1.060	0.585	34.00	0.1250	0.621	2.000	2.875	4	1	2
354	60.80	104.10	180.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
355	84.30	86.70	180.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
356	106.20	72.20	180.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
357	129.10	58.80	180.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
358	155.90	48.70	180.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
359	21.90	97.60	180.0	0.500	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
360	41.40	59.00	180.0	0.500	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
361	61.20	33.50	180.0	0.500	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
362	82.70	20.50	180.0	0.500	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
363	61.00	131.00	120.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
364	82.70	117.10	120.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
365	106.40	99.70	120.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
366	129.50	84.90	120.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
367	154.10	77.10	120.0	0.250	0.997	0.881	1.060	0.748	14.20	0.1250	0.246	2.000	2.875	4	1	2
368	83.90	145.10	180.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
369	104.60	124.10	180.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
370	128.50	109.60	180.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
371	178.60	76.60	180.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
372	82.00	124.20	180.0	0.370	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
373	104.00	112.50	180.0	0.370	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
374	129.20	86.40	180.0	0.370	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
375	153.30	70.40	180.0	0.370	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
376	177.50	57.60	180.0	0.370	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
377	41.30	141.50	180.0	0.500	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
378	61.40	113.20	180.0	0.500	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
379	83.10	90.50	180.0	0.500	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
380	106.60	71.70	180.0	0.500	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
381	129.80	49.70	180.0	0.500	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
382	130.10	54.70	180.0	0.500	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
383	82.60	146.40	210.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
384	103.30	117.60	210.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
385	128.50	97.20	210.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
386	152.90	83.10	210.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
387	178.00	67.10	210.0	0.250	0.996	0.805	1.060	0.614	10.10	0.1250	0.246	2.000	2.875	4	1	2
388	97.40	137.50	180.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
389	105.80	130.40	180.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
390	128.60	119.30	180.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
391	151.60	108.30	180.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
392	175.80	105.20	180.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
393	95.50	126.00	210.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
394	119.60	101.50	210.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
395	129.80	99.60	210.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
396	153.70	89.20	210.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
397	177.50	84.90	210.0	0.250	0.998	0.691	1.060	0.486	40.00	0.1250	0.246	2.000	2.875	4	1	2
398	40.00	136.20	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
399	61.40	112.50	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
400	82.60	77.80	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
401	104.50	62.80	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
402	125.90	46.20	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
403	151.20	28.30	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
404	20.30	60.50	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
405	32.50	53.60	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
406	39.80	44.10	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
407	47.30	33.10	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
408	60.40	29.10	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	2.000	2.875	4	1	2
409	39.10	107.00	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
410	59.60	83.10	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
411	80.10	86.50	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
412	127.40	50.90	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
413	149.10	46.20	180.0	0.250	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
414	24.30	105.00	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
415	38.50	83.30	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
416	38.80	74.80	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
417	59.90	65.50	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
418	81.20	54.20	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
419	124.00	53.90	180.0	0.500	0.998	0.905	1.060	0.490	8.50	0.1250	0.246	3.000	2.875	4	1	2
420	76.50	74.40	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
421	50.80	85.40	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
422	91.60	69.70	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
423	111.00	64.30	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
424	127.00	59.20	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
425	144.10	54.30	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
426	42.40	90.50	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
427	169.80	45.40	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
428	215.50	25.20	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
429	75.20	76.80	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
430	107.90	62.10	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
431	136.50	48.70	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
432	179.00	36.10	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
433	215.50	18.50	180.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
434	107.90	62.10	180.0	0.310	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
435	126.00	56.60	180.0	0.310	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
436	136.50	52.50	180.0	0.310	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
437	179.00	43.50	180.0	0.310	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
438	215.50	34.40	180.0	0.310	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
439	75.20	71.50	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
440	108.00	63.00	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
441	137.00	42.50	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
442	179.00	25.40	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
443	215.50	14.30	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
444	51.20	77.70	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
445	59.00	71.50	120.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
446	44.00	94.00	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
447	66.50	74.20	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
448	79.50	74.50	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
449	114.00	61.50	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
450	144.00	48.00	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
451	150.00	46.00	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
452	168.00	39.50	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
453	226.00	27.50	150.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
454	75.20	73.50	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
455	108.00	56.70	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
456	166.00	45.80	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
457	219.00	27.30	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
458	75.20	69.30	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
459	108.00	56.60	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
460	137.00	46.50	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
461	179.00	39.90	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
462	215.00	25.40	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
463	51.30	83.00	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
464	247.00	16.00	210.0	0.250	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	6.250	4	1	1
465	60.90	92.90	180.0	0.220	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
466	90.00	87.10	180.0	0.220	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
467	105.00	82.70	180.0	0.220	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
468	75.50	90.00	180.0	0.220	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
469	47.90	97.20	180.0	0.220	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
470	31.90	119.00	180.0	0.220	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
471	120.00	56.80	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
472	103.00	61.50	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
473	88.50	69.60	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
474	73.90	78.30	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
475	60.90	85.80	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
476	46.40	89.90	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
477	32.50	95.70	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
478	16.80	102.90	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
479	52.80	85.30	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
480	110.20	63.20	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
481	96.30	65.20	180.0	0.484	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
482	103.00	60.40	180.0	0.522	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
483	90.00	62.10	180.0	0.522	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
484	75.50	68.50	180.0	0.522	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
485	59.50	76.00	180.0	0.522	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
486	46.40	80.70	180.0	0.522	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
487	103.00	58.60	180.0	0.560	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
488	90.00	60.90	180.0	0.560	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
489	74.30	66.80	180.0	0.560	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
490	60.90	72.50	180.0	0.560	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
491	46.40	76.00	180.0	0.560	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
492	31.90	91.00	180.0	0.560	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
493	90.00	87.50	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
494	103.00	78.50	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
495	119.00	69.70	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
496	128.00	65.00	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
497	75.50	91.50	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
498	78.50	84.20	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
499	95.80	83.00	120.0	0.650	0.998	0.772	1.002	0.926	36.30	0.1250	0.250	2.000	12.000	4	1	2
500	116.00	54.70	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
501	102.00	62.30	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
502	87.30	65.80	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
503	87.30	72.70	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
504	74.20	73.30	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
505	59.60	77.40	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
506	45.10	82.10	180.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
507	33.50	86.30	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
508	102.00	50.00	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
509	87.30	54.60	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
510	87.30	55.00	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
511	74.20	62.20	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
512	59.70	64.60	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
513	46.60	71.00	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
514	33.50	79.50	180.0	0.255	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
515	87.30	37.20	180.0	0.370	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
516	74.20	42.50	180.0	0.370	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
517	59.70	47.70	180.0	0.370	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
518	46.60	54.70	180.0	0.370	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
519	33.50	59.10	180.0	0.370	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
520	21.80	63.10	180.0	0.370	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
521	87.30	29.40	180.0	0.480	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
522	74.20	32.00	180.0	0.480	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
523	59.70	34.60	180.0	0.480	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
524	46.60	37.50	180.0	0.480	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
525	33.50	39.60	180.0	0.480	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
526	21.80	50.10	180.0	0.480	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
527	102.00	20.70	180.0	0.520	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
528	87.30	25.10	180.0	0.520	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
529	74.20	28.80	180.0	0.520	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
530	59.70	32.00	180.0	0.520	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
531	46.60	37.30	180.0	0.520	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
532	46.60	23.30	180.0	0.610	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
533	33.50	28.80	180.0	0.610	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
534	21.80	36.70	180.0	0.610	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
535	16.60	43.10	180.0	0.610	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
536	14.00	46.00	180.0	0.610	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
537	114.00	58.30	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
538	94.60	64.00	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
539	107.00	65.20	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
540	87.30	66.30	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
541	74.20	72.70	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
542	53.80	80.90	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
543	59.70	83.80	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
544	47.40	84.40	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
545	48.00	88.20	150.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
546	116.40	44.80	240.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
547	102.00	46.30	240.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
548	87.30	47.40	240.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
549	74.20	55.00	240.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
550	59.70	58.80	240.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
551	33.50	72.50	240.0	0.240	0.998	0.864	1.002	0.585	34.00	0.1250	0.250	2.000	12.000	4	1	2
552	35.60	14.50	24.8	0.240	0.997	0.872	0.866	0.587	34.60	0.1250	0.210	2.000	1.920	4	1	1
553	37.30	15.10	25.0	0.240	0.997	0.873	0.874	0.599	34.70	0.1250	0.210	2.000	1.920	4	1	1
554	111.50	44.50	24.5	1.650	0.996	0.871	0.853	0.583	34.60	0.1250	0.210	2.000	1.920	4	1	1
555	112.50	45.10	24.8	1.650	0.997	0.875	0.914	0.613	34.80	0.1250	0.210	2.000	1.920	4	1	1
556	85.30	34.10	75.3	0.240	0.997	0.875	0.914	0.611	34.80	0.1250	0.210	2.000	1.920	4	1	1
557	83.00	33.60	75.4	0.240	0.998	0.878	0.960	0.636	34.90	0.1250	0.210	2.000	1.920	4	1	1
558	19.90	8.00	75.2	1.650	0.997	0.875	0.916	0.613	34.80	0.1250	0.210	2.000	1.920	4	1	1
559	19.70	8.00	76.3	1.650	0.997	0.874	0.896	0.607	34.70	0.1250	0.210	2.000	1.920	4	1	1
560	13.10	31.90	24.5	0.240	0.997	0.874	0.908	0.609	34.80	0.1250	0.210	2.000	1.920	4	1	1
561	12.20	30.60	25.1	0.240	0.998	0.877	0.969	0.632	34.90	0.1250	0.210	2.000	1.920	4	1	1
562	28.00	69.10	24.8	1.650	0.996	0.872	0.860	0.587	34.60	0.1250	0.210	2.000	1.920	4	1	1
563	27.60	68.60	24.7	1.650	0.996	0.871	0.836	0.576	34.50	0.1250	0.210	2.000	1.920	4	1	1
564	24.80	62.00	75.2	0.240	0.997	0.873	0.876	0.594	34.80	0.1250	0.210	2.000	1.920	4	1	1
565	24.40	61.20	75.4	0.240	0.996	0.870	0.829	0.573	34.50	0.1250	0.210	2.000	1.920	4	1	1
566	7.20	18.90	74.3	1.650	0.997	0.875	0.914	0.617	34.80	0.1250	0.210	2.000	1.920	4	1	1
567	5.90	14.20	75.2	1.650	0.996	0.870	0.818	0.571	34.80	0.1250	0.210	2.000	1.920	4	1	1
568	63.60	63.40	50.7	0.630	0.997	0.873	0.874	0.593	34.80	0.1250	0.210	2.000	1.920	4	1	1
569	63.60	63.40	50.2	0.630	0.997	0.875	0.921	0.616	34.80	0.1250	0.210	2.000	1.920	4	1	1
570	45.10	45.00	50.0	0.280	0.997	0.875	0.916	0.612	34.80	0.1250	0.210	2.000	1.920	4	1	1
571	47.10	47.00	50.2	0.280	0.997	0.873	0.880	0.598	34.80	0.1250	0.210	2.000	1.920	4	1	1
572	32.10	32.20	50.0	1.440	0.997	0.875	0.914	0.613	34.80	0.1250	0.210	2.000	1.920	4	1	1
573	33.60	33.50	50.0	1.440	0.996	0.871	0.843	0.581	34.80	0.1250	0.210	2.000	1.920	4	1	1
574	56.10	55.70	28.1	0.630	0.997	0.875	0.912	0.609	34.90	0.1250	0.210	2.000	1.920	4	1	1
575	56.10	56.50	28.5	0.630	0.996	0.871	0.853	0.584	34.80	0.1250	0.210	2.000	1.920	4	1	1
576	50.10	50.30	71.6	0.630	0.997	0.875	0.934	0.618	34.90	0.1250	0.210	2.000	1.920	4	1	1
577	56.80	56.40	72.0	0.630	0.996	0.871	0.831	0.575	34.50	0.1250	0.210	2.000	1.920	4	1	1
578	110.70	50.40	50.5	0.630	0.997	0.875	0.912	0.612	34.80	0.1250	0.210	2.000	1.920	4	1	1
579	114.20	51.90	50.0	0.630	0.997	0.874	0.892	0.601	34.70	0.1250	0.210	2.000	1.920	4	1	1
580	34.70	75.20	50.0	0.630	0.996	0.869	0.811	0.568	34.50	0.1250	0.210	2.000	1.920	4	1	1
581	34.60	74.60	50.8	0.630	0.996	0.870	0.832	0.574	34.50	0.1250	0.210	2.000	1.920	4	1	1
582	16.20	15.90	20.0	0.200	0.997	0.874	0.914	0.609	34.80	0.1250	0.210	2.000	1.920	4	1	1
583	17.10	17.10	20.6	0.200	0.996	0.871	0.847	0.581	34.60	0.1250	0.210	2.000	1.920	4	1	1
584	46.20	46.80	80.0	0.200	0.997	0.874	0.900	0.603	34.70	0.1250	0.210	2.000	1.920	4	1	1
585	46.30	46.40	80.0	0.200	0.997	0.875	0.914	0.613	34.80	0.1250	0.210	2.000	1.920	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
586	62.50	20.90	49.5	0.200	0.996	0.871	0.838	0.575	34.50	0.1250	0.210	2.000	1.920	4	1	1
587	60.00	20.50	50.0	0.200	0.996	0.872	0.853	0.586	34.60	0.1250	0.210	2.000	1.920	4	1	1
588	16.10	48.60	50.0	0.200	0.997	0.876	0.929	0.618	34.80	0.1250	0.210	2.000	1.920	4	1	1
589	16.30	49.00	50.0	0.200	0.996	0.869	0.815	0.568	34.50	0.1250	0.210	2.000	1.920	4	1	1
590	64.30	63.70	20.0	1.980	0.997	0.872	0.870	0.591	34.60	0.1250	0.210	2.000	1.920	4	1	1
591	56.90	57.00	19.9	1.980	0.997	0.875	0.906	0.609	34.80	0.1250	0.210	2.000	1.920	4	1	1
592	8.20	8.10	79.9	1.980	0.995	0.871	0.791	0.579	34.40	0.1250	0.210	2.000	1.920	4	1	1
593	8.40	8.10	80.3	1.980	0.996	0.872	0.840	0.587	34.60	0.1250	0.210	2.000	1.920	4	1	1
594	39.40	13.50	50.2	1.980	0.996	0.870	0.832	0.574	34.50	0.1250	0.210	2.000	1.920	4	1	1
595	32.70	11.00	49.9	1.980	0.998	0.877	0.951	0.626	34.10	0.1250	0.210	2.000	1.920	4	1	1
596	8.20	24.60	50.0	1.980	0.997	0.873	0.886	0.600	34.70	0.1250	0.210	2.000	1.920	4	1	1
597	6.50	18.70	50.0	1.980	0.996	0.872	0.851	0.584	34.60	0.1250	0.210	2.000	1.920	4	1	1
598	85.60	28.60	20.0	0.630	0.997	0.873	0.888	0.594	34.70	0.1250	0.210	2.000	1.920	4	1	1
599	85.10	28.90	20.0	0.630	0.997	0.873	0.874	0.594	34.70	0.1250	0.210	2.000	1.920	4	1	1
600	22.60	67.30	19.9	0.630	0.997	0.874	0.902	0.606	34.70	0.1250	0.210	2.000	1.920	4	1	1
601	20.40	60.60	20.3	0.630	0.997	0.873	0.888	0.599	34.70	0.1250	0.210	2.000	1.920	4	1	1
602	127.30	43.00	80.0	0.630	0.996	0.871	0.849	0.580	34.60	0.1250	0.210	2.000	1.920	4	1	1
603	100.10	33.70	80.0	0.630	0.997	0.873	0.886	0.595	34.70	0.1250	0.210	2.000	1.920	4	1	1
604	20.40	60.90	80.0	0.630	0.997	0.875	0.908	0.609	34.80	0.1250	0.210	2.000	1.920	4	1	1
605	20.20	61.10	80.1	0.630	0.997	0.873	0.874	0.594	34.80	0.1250	0.210	2.000	1.920	4	1	1
606	113.00	65.00	45.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
607	114.20	65.80	45.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
608	200.40	115.60	45.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
609	221.50	127.50	45.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
610	222.10	127.90	45.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
611	167.00	96.00	75.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
612	184.00	106.00	75.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
613	181.60	104.40	75.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
614	189.90	109.10	75.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
615	191.00	110.00	75.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
616	63.70	110.30	45.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
617	71.10	122.90	45.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
618	68.10	117.90	45.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
619	106.20	183.80	45.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
620	105.50	182.50	45.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
621	83.10	143.90	75.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
622	96.40	166.60	75.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
623	96.00	166.00	75.0	0.441	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
624	70.40	121.60	75.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
625	71.40	123.60	75.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
626	70.00	121.00	75.0	1.395	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
627	161.50	161.50	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
628	171.50	171.50	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
629	164.00	164.00	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
630	157.00	157.00	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
631	152.00	152.00	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
632	64.50	64.50	60.0	0.248	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
633	70.00	70.00	60.0	0.248	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
634	66.00	66.00	60.0	0.248	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
635	66.00	66.00	60.0	2.480	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
636	50.50	50.50	60.0	2.480	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
637	52.50	52.50	60.0	2.480	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
638	104.00	104.00	30.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
639	106.50	106.50	30.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
640	137.00	137.00	90.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
641	130.00	130.00	90.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
642	138.00	138.00	90.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
643	291.70	97.30	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
644	290.30	96.70	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
645	279.00	93.00	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
646	288.00	96.00	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
647	68.20	204.80	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
648	65.50	196.50	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
649	65.90	198.10	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
650	66.20	198.80	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
651	70.20	210.80	60.0	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
652	51.00	51.00	37.5	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
653	56.50	56.50	37.5	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
654	107.50	107.50	82.5	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
655	108.00	108.00	82.5	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
656	120.90	53.10	60.0	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
657	124.30	54.70	60.0	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
658	55.50	126.50	60.0	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
659	55.80	127.20	60.0	0.331	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
660	119.00	119.00	37.5	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
661	125.00	125.00	37.5	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
662	38.50	38.50	82.5	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
663	39.50	39.50	82.5	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
664	118.10	51.90	60.0	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
665	117.40	51.60	60.0	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
666	37.50	85.50	60.0	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
667	42.10	95.90	60.0	1.849	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
668	182.00	80.00	37.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
669	182.70	80.30	37.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
670	71.60	163.40	37.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
671	76.50	174.50	37.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
672	231.50	101.50	82.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
673	241.20	105.80	82.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
674	68.30	155.70	82.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1
675	72.60	165.40	82.5	0.784	1.000	1.454	0.902	0.591	37.60	0.1250	0.210	2.000	1.920	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
676	51.90	49.40	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
677	39.50	59.90	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
678	20.10	69.00	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
679	58.10	54.30	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
680	69.90	54.60	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
681	98.40	49.20	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
682	142.90	37.70	60.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
683	36.50	33.50	94.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
684	49.20	28.60	94.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
685	78.70	22.80	94.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
686	15.30	41.00	94.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
687	58.10	63.10	40.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
688	78.70	60.10	40.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
689	132.80	33.80	40.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
690	20.40	73.00	40.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
691	39.40	42.60	78.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
692	60.20	40.10	78.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
693	97.70	31.10	78.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
694	13.50	55.00	78.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
695	20.00	78.80	50.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
696	60.30	63.40	50.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
697	100.30	50.20	50.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
698	40.60	19.20	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
699	19.80	26.10	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
700	11.30	28.70	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
701	11.60	29.30	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
702	70.00	10.20	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
703	20.40	24.70	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
704	54.20	14.80	122.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
705	100.40	15.80	94.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
706	29.60	15.10	144.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
707	39.90	50.50	20.0	0.750	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
708	38.90	14.70	60.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
709	20.10	22.70	60.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
710	10.50	25.90	60.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
711	59.20	11.30	60.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
712	59.10	36.00	40.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
713	41.30	38.90	40.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
714	19.70	46.90	40.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
715	88.60	28.80	40.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
716	87.10	51.90	25.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
717	58.30	59.10	25.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
718	30.50	66.80	25.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
719	30.55	3.45	94.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
720	10.64	8.86	94.0	1.600	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
721	39.90	68.80	94.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
722	59.10	58.00	94.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
723	59.00	50.10	122.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
724	78.80	47.80	122.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
725	143.30	30.50	122.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
726	30.10	61.20	122.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
727	15.50	65.10	122.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
728	15.60	54.10	144.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
729	30.00	53.00	144.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
730	60.00	42.30	144.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
731	98.50	34.00	144.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
732	152.40	22.20	144.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
733	34.90	33.30	180.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
734	15.50	41.50	180.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
735	23.20	37.80	180.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
736	58.40	28.10	180.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
737	98.60	12.80	180.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
738	40.10	26.60	200.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
739	20.70	37.20	200.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
740	20.60	31.90	200.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
741	58.30	19.20	200.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
742	100.00	8.80	200.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
743	11.00	39.80	200.0	0.375	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
744	10.80	15.10	110.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
745	20.30	13.30	110.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
746	39.65	6.45	110.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
747	37.40	33.70	71.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
748	23.10	31.00	71.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
749	59.20	20.60	71.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
750	78.75	15.95	70.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
751	50.30	63.60	22.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
752	64.30	57.40	22.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
753	77.00	52.70	22.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
754	99.40	42.90	22.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
755	31.30	76.10	22.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
756	31.30	62.20	14.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
757	49.30	53.20	14.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
758	70.70	46.80	14.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
759	20.90	62.90	14.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
760	98.50	29.00	14.5	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	1.000	2.000	4	1	1
761	49.20	24.60	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
762	26.00	31.50	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
763	16.40	32.80	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
764	101.60	13.40	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
765	13.00	34.70	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
766	12.00	53.10	40.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
767	40.40	46.20	40.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
768	99.60	27.10	40.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
769	11.72	10.88	100.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
770	16.76	14.84	80.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	0.500	2.000	4	1	1
771	60.20	39.40	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
772	40.10	46.80	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
773	21.40	55.60	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
774	98.50	26.60	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
775	49.04	14.16	100.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
776	32.75	21.65	100.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
777	21.30	24.70	100.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
778	12.30	32.60	100.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
779	50.70	68.80	40.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
780	65.00	60.90	40.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
781	78.00	70.70	25.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
782	8.60	60.10	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
783	45.20	44.50	60.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
784	30.60	30.50	100.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
785	21.70	21.00	144.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
786	54.20	52.20	50.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	2.000	2.000	4	1	1
787	46.30	52.00	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	3.000	2.000	4	1	1
788	55.50	47.60	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	3.000	2.000	4	1	1
789	30.10	26.20	100.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	3.000	2.000	4	1	1
790	29.50	65.00	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	4.000	2.000	4	1	1
791	60.10	54.20	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	4.000	2.000	4	1	1
792	15.80	70.30	60.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	4.000	2.000	4	1	1
793	15.80	41.40	90.0	1.125	0.998	0.751	0.910	1.320	42.00	0.0400	0.227	4.000	2.000	4	1	1
794	41.10	92.50	80.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
795	65.00	83.70	80.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
796	88.90	78.80	80.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
797	136.20	65.20	80.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
798	185.70	54.30	80.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
799	24.50	104.90	80.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
800	24.60	70.90	110.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
801	40.30	64.10	110.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
802	68.90	53.80	110.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
803	24.20	26.20	180.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
804	99.60	96.70	50.0	0.625	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	1.000	2.000	4	1	1
805	102.60	102.60	45.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	2.000	2.000	4	1	1
806	66.60	65.20	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	2.000	2.000	4	1	1
807	34.90	34.90	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	2.000	2.000	4	1	1
808	25.60	25.20	144.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1250	0.242	2.000	2.000	4	1	1
809	118.30	116.30	50.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
810	40.30	36.40	100.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
811	69.10	68.50	75.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
812	29.10	29.10	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
813	127.70	127.70	35.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
814	60.10	61.00	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
815	29.70	73.90	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
816	118.60	118.60	30.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
817	122.30	122.30	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
818	27.40	27.10	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.1860	0.224	2.000	2.000	4	1	1
819	74.90	73.50	60.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.235	2.000	2.000	4	1	1
820	49.20	48.20	100.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.235	2.000	2.000	4	1	1
821	56.00	55.00	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.235	2.000	2.000	4	1	1
822	33.30	33.30	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.235	2.000	2.000	4	1	1
823	91.10	89.40	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.235	2.000	2.000	4	1	1
824	25.10	24.60	140.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.235	2.000	2.000	4	1	1
825	34.10	34.50	100.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0270	0.229	2.000	2.000	4	1	1
826	45.80	45.00	75.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0270	0.229	2.000	2.000	4	1	1
827	28.60	28.60	144.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0270	0.229	2.000	2.000	4	1	1
828	23.60	23.20	70.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0200	0.226	2.000	2.000	4	1	1
829	21.30	21.20	90.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0200	0.226	2.000	2.000	4	1	1
830	21.90	20.20	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0200	0.226	2.000	2.000	4	1	1
831	82.30	80.80	63.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.410	2.000	2.000	4	1	1
832	47.40	46.50	100.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.410	2.000	2.000	4	1	1
833	31.20	29.20	144.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.410	2.000	2.000	4	1	1
834	98.60	98.60	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.410	2.000	2.000	4	1	1
835	67.80	70.60	50.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.157	2.000	2.000	4	1	1
836	27.40	26.70	90.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.157	2.000	2.000	4	1	1
837	45.20	44.40	70.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.157	2.000	2.000	4	1	1
838	48.20	47.40	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.081	2.000	2.000	4	1	1
839	21.60	21.20	60.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.081	2.000	2.000	4	1	1
840	30.10	29.50	50.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.081	2.000	2.000	4	1	1
841	85.80	85.80	50.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.315	2.000	2.000	4	1	1
842	51.20	49.30	90.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.315	2.000	2.000	4	1	1
843	36.50	36.50	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0790	0.315	2.000	2.000	4	1	1
844	62.10	61.00	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.345	2.000	2.000	4	1	1
845	103.20	104.00	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.345	2.000	2.000	4	1	1
846	41.40	39.40	120.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.345	2.000	2.000	4	1	1
847	48.20	47.40	60.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
848	80.20	80.20	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
849	25.70	25.10	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
850	61.10	59.80	60.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
851	79.90	79.20	40.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
852	34.50	34.20	80.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
853	25.00	25.00	100.0	1.000	0.998	0.751	0.910	1.320	42.00	0.0940	0.124	2.000	2.000	4	1	1
854	49.00	98.00	40.0	1.000	1.112	0.794	2.730	1.270	20.80	0.1250	0.230	2.000	1.920	3	1	1
855	40.00	80.00	50.0	1.000	1.112	0.794	2.730	1.270	20.80	0.1250	0.230	2.000	1.920	3	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
856	31.20	62.30	65.0	1.000	1.112	0.794	2.730	1.270	20.80	0.1250	0.230	2.000	1.920	3	1	1
857	22.20	44.50	78.0	1.000	1.112	0.794	2.730	1.270	20.80	0.1250	0.230	2.000	1.920	3	1	1
858	10.90	21.80	97.8	1.000	1.112	0.794	2.730	1.270	20.80	0.1250	0.230	2.000	1.920	3	1	1
859	40.90	352.00	59.9	0.770	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
860	41.60	118.00	59.9	2.900	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
861	40.50	187.00	59.9	2.180	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
862	80.50	182.20	59.9	2.180	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
863	120.80	157.00	59.9	2.180	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
864	11.45	28.65	70.0	1.000	1.112	0.802	1.590	1.300	16.00	0.1250	0.230	2.000	2.000	4	1	1
865	19.10	47.70	55.0	1.000	1.112	0.802	1.590	1.300	16.00	0.1250	0.230	2.000	2.000	4	1	1
866	30.60	76.30	22.0	1.000	1.112	0.802	1.590	1.300	16.00	0.1250	0.230	2.000	2.000	4	1	1
867	41.00	1.65	11.5	0.218	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
868	42.60	46.60	41.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
869	41.00	143.60	52.0	0.355	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
870	7.04	46.40	15.0	0.404	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
871	19.85	155.50	62.0	0.295	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
872	100.50	18.31	13.5	0.830	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
873	44.60	50.00	33.5	0.256	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
874	23.60	17.38	35.5	0.095	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
875	39.20	50.90	22.0	0.395	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
876	13.64	42.10	12.2	0.395	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
877	11.08	13.66	6.8	0.256	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
878	88.90	40.50	45.0	0.290	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
879	12.40	67.50	56.5	0.132	0.994	0.803	0.926	0.605	10.70	0.0400	0.230	1.500	1.000	4	1	1
880	8.20	45.30	60.0	1.000	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
881	12.30	68.00	45.0	1.000	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
882	14.30	79.30	43.0	1.000	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
883	8.20	45.30	75.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
884	12.30	68.00	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
885	14.30	79.30	50.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
886	4.00	22.70	65.0	1.500	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
887	8.20	45.30	45.0	1.500	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
888	12.30	68.00	35.0	1.500	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	1
889	4.00	22.70	95.0	0.600	1.088	0.950	0.980	3.080	14.50	0.0938	0.230	2.000	3.000	4	1	1
890	8.20	45.30	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.0938	0.230	2.000	3.000	4	1	1
891	12.30	68.00	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.0938	0.230	2.000	3.000	4	1	1
892	28.10	72.10	85.0	1.000	0.999	0.849	0.802	2.400	10.60	0.1250	0.230	2.000	3.000	4	1	1
893	4.40	22.30	95.0	1.000	0.999	0.849	0.802	2.400	10.60	0.1250	0.230	2.000	3.000	4	1	1
894	9.00	44.50	85.0	1.000	0.999	0.849	0.802	2.400	10.60	0.1250	0.230	2.000	3.000	4	1	1
895	13.40	66.90	75.0	1.000	0.999	0.849	0.802	2.400	10.60	0.1250	0.230	2.000	3.000	4	1	1
896	17.80	89.10	65.0	1.000	0.999	0.849	0.802	2.400	10.60	0.1250	0.230	2.000	3.000	4	1	1
897	4.45	22.35	85.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
898	9.00	44.50	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
899	13.40	66.90	55.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
900	17.80	89.10	45.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
901	9.00	44.50	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
902	26.75	26.75	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
903	35.68	17.82	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
904	4.45	22.35	105.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
905	9.00	44.50	85.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
906	13.40	66.90	75.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
907	17.80	89.10	75.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	1
908	4.45	22.35	80.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
909	9.00	44.50	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
910	13.40	66.90	45.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
911	17.80	89.10	40.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
912	4.45	22.35	75.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1875	0.230	2.000	3.000	4	1	1
913	9.00	44.50	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1875	0.230	2.000	3.000	4	1	1
914	13.40	66.90	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1875	0.230	2.000	3.000	4	1	1
915	17.80	89.10	55.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1875	0.230	2.000	3.000	4	1	1
916	4.45	22.35	75.0	1.000	0.999	0.849	0.802	2.400	10.70	0.0625	0.230	2.000	3.000	4	1	1
917	9.00	44.50	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.0625	0.230	2.000	3.000	4	1	1
918	13.40	66.90	45.0	1.000	0.999	0.849	0.802	2.400	10.70	0.0625	0.230	2.000	3.000	4	1	1
919	17.80	89.10	45.0	1.000	0.999	0.849	0.802	2.400	10.70	0.0625	0.230	2.000	3.000	4	1	1
920	4.45	22.35	85.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
921	9.00	44.50	75.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
922	13.40	66.90	65.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
923	17.80	89.10	55.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	1
924	4.45	22.35	65.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	1
925	9.00	44.50	45.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	1
926	13.40	66.90	45.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	1
927	17.80	89.10	35.0	0.440	0.999	0.849	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	1
928	4.45	22.35	55.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	1
929	9.00	44.50	45.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	1
930	4.45	22.35	95.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	1
931	9.00	44.50	75.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	1
932	13.40	66.90	55.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	1
933	17.80	89.10	45.0	1.000	0.999	0.849	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	1
934	26.30	33.85	103.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
935	24.50	26.25	111.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
936	26.45	15.95	130.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
937	23.45	17.00	133.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
938	19.42	17.71	131.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
939	16.88	18.42	131.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
940	8.94	23.45	131.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
941	13.40	12.41	149.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
942	16.91	11.58	149.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
943	4.31	17.50	149.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
944	2.88	13.17	163.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
945	15.95	6.40	163.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
946	11.95	7.26	175.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
947	8.94	5.41	187.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
948	5.39	6.40	191.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
949	13.28	4.05	191.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
950	0.84	8.94	202.0	1.102	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
951	28.22	32.92	60.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
952	27.73	31.39	61.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
953	24.51	29.43	65.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
954	25.19	26.94	67.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
955	21.79	21.58	70.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
956	23.75	19.96	71.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
957	26.81	20.61	71.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
958	22.50	22.45	71.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
959	18.47	24.59	71.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
960	22.97	12.69	80.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
961	8.14	21.97	80.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
962	25.24	12.82	80.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
963	12.74	19.25	80.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
964	19.57	16.30	81.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
965	13.86	17.97	81.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
966	9.23	19.36	81.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
967	5.36	17.13	87.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
968	5.76	14.65	87.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
969	24.33	7.72	87.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
970	5.23	17.53	87.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
971	9.68	13.60	87.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
972	19.88	10.07	87.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
973	13.08	10.73	89.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
974	4.26	15.62	89.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
975	14.65	10.20	89.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
976	22.63	6.72	89.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
977	18.31	8.63	89.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
978	7.01	9.73	100.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
979	10.33	7.66	100.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
980	15.43	5.76	100.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
981	0.91	10.99	100.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
982	1.24	12.30	100.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
983	2.01	12.30	101.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
984	9.55	6.54	110.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
985	5.89	11.12	111.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
986	3.79	10.33	111.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
987	16.74	3.79	120.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
988	10.78	7.06	120.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
989	10.46	7.19	120.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
990	8.63	8.50	120.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Cr*
991	4.97	9.16	123.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
992	4.05	9.16	121.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
993	4.58	6.80	132.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
994	4.39	6.93	141.0	1.890	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
995	23.94	10.33	73.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
996	20.59	13.16	70.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
997	7.64	18.89	71.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
998	18.65	6.54	93.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
999	12.69	7.74	90.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1000	9.42	8.76	90.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1001	4.53	12.43	91.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1002	2.96	11.12	91.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1003	13.34	6.15	100.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1004	7.32	7.06	100.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1005	4.26	9.42	100.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1006	9.23	4.92	131.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1007	1.70	9.55	131.0	2.244	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1008	24.90	27.55	45.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1009	26.94	13.66	50.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1010	20.93	18.50	50.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1011	11.77	25.24	50.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1012	17.34	18.70	51.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1013	7.59	23.28	54.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1014	20.27	8.69	55.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1015	10.99	17.13	55.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1016	26.03	4.84	68.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1017	20.59	7.59	68.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1018	16.27	9.68	68.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1019	6.15	13.13	68.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1020	18.65	3.09	91.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1021	7.80	8.63	91.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1022	5.02	10.46	92.0	2.795	0.998	0.684	1.010	0.411	33.90	0.0790	0.230	1.970	1.575	4	1	1
1023	24.90	15.75	45.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1024	22.76	19.10	45.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1025	20.40	22.31	45.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1026	12.30	12.56	54.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1027	19.93	9.42	55.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1028	17.34	10.86	55.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1029	14.65	11.51	55.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1030	11.98	10.86	60.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1031	11.64	10.41	60.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1032	7.61	12.58	60.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1033	4.45	13.86	60.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1034	7.09	9.29	65.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1035	3.71	10.99	65.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1036	5.70	9.16	71.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1037	4.39	8.89	71.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1038	4.26	10.33	71.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1039	2.82	10.99	71.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1040	7.32	7.32	75.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1041	5.00	7.74	75.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1042	2.75	8.89	75.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1043	7.61	6.54	80.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1044	4.03	8.50	80.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1045	4.03	8.11	90.0	3.150	0.998	0.684	1.010	0.411	33.90	0.0788	0.230	1.970	1.575	4	1	1
1046	46.60	5.05	106.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1047	46.60	15.55	88.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1048	46.60	21.75	74.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1049	46.60	24.85	62.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1050	46.60	31.10	50.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1051	46.60	26.80	38.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1052	46.60	18.68	32.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1053	46.60	17.50	30.0	0.500	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1054	46.60	11.63	128.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1055	46.60	16.71	104.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1056	46.60	18.68	64.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1057	46.60	12.06	40.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1058	46.60	10.50	39.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1059	46.60	8.16	34.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1060	46.60	6.60	25.0	0.250	1.403	0.780	22.200	1.330	18.90	0.1110	0.230	1.938	1.002	4	1	1
1061	89.40	71.00	114.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1062	87.50	40.40	182.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1063	53.95	42.80	152.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1064	19.42	30.15	190.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1065	48.52	34.00	190.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1066	55.40	60.60	137.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1067	87.90	79.10	114.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1068	34.95	54.40	220.0	0.250	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1069	89.40	70.90	172.0	0.250	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1070	53.90	56.40	205.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1071	87.90	77.10	152.0	0.218	0.994	0.803	0.926	0.605	10.70	0.0860	0.200	1.895	2.000	4	1	1
1072	34.00	17.49	190.0	0.218	1.046	0.803	2.170	0.605	7.60	0.0860	0.200	1.895	2.000	4	1	1
1073	16.02	10.20	209.0	0.218	1.046	0.803	2.170	0.605	7.60	0.0860	0.200	1.895	2.000	4	1	1
1074	29.15	54.90	137.0	0.218	1.046	0.803	2.170	0.605	7.60	0.0860	0.200	1.895	2.000	4	1	1
1075	68.00	63.10	114.0	0.218	1.046	0.803	2.170	0.605	7.60	0.0860	0.200	1.895	2.000	4	1	1
1076	19.42	15.05	167.0	0.218	1.073	0.803	4.230	0.605	6.00	0.0860	0.200	1.895	2.000	4	1	1
1077	50.50	45.60	114.0	0.218	1.073	0.803	4.230	0.605	6.00	0.0860	0.200	1.895	2.000	4	1	1
1078	8.74	8.74	236.0	0.218	1.073	0.803	4.230	0.605	6.00	0.0860	0.200	1.895	2.000	4	1	1
1079	52.90	59.30	91.0	0.218	1.073	0.803	4.230	0.605	6.00	0.0860	0.200	1.895	2.000	4	1	1
1080	6.41	7.96	129.0	0.218	1.092	0.803	7.860	0.605	3.70	0.0860	0.200	1.895	2.000	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1081	3.59	4.18	215.0	0.218	1.092	0.803	7.860	0.605	3.70	0.0860	0.200	1.895	2.000	4	1	1
1082	10.49	9.33	98.8	0.218	1.092	0.803	7.860	0.605	3.70	0.0860	0.200	1.895	2.000	4	1	1
1083	11.18	15.05	61.0	0.218	1.092	0.803	7.860	0.605	3.70	0.0860	0.200	1.895	2.000	4	1	1
1084	26.70	25.75	198.0	0.218	0.994	0.892	0.926	0.550	28.00	0.0860	0.200	1.895	2.000	4	1	1
1085	59.20	52.95	129.0	0.218	0.994	0.892	0.926	0.550	28.00	0.0860	0.200	1.895	2.000	4	1	1
1086	20.40	20.40	236.0	0.218	0.994	0.892	0.926	0.550	28.00	0.0860	0.200	1.895	2.000	4	1	1
1087	95.90	28.80	70.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1088	68.40	20.50	90.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1089	41.10	41.10	70.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1090	17.83	35.67	70.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1091	9.59	28.77	70.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1092	15.06	45.14	50.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1093	97.60	29.40	70.0	1.000	1.275	0.765	3.425	1.420	16.50	0.1250	0.230	2.000	1.920	4	1	1
1094	69.00	1.38	90.0	1.000	1.206	0.813	1.380	1.760	13.80	0.1250	0.230	2.000	2.000	4	1	1
1095	162.80	3.25	70.0	1.000	1.206	0.813	1.380	1.760	13.80	0.1250	0.230	2.000	2.000	4	1	1
1096	315.50	6.30	50.0	1.000	1.206	0.813	1.380	1.760	13.80	0.1250	0.230	2.000	2.000	4	1	1
1097	414.00	8.31	35.0	1.000	1.206	0.813	1.380	1.760	13.80	0.1250	0.230	2.000	2.000	4	1	1
1098	167.80	1.68	70.0	1.000	1.206	0.813	1.380	1.760	13.80	0.1250	0.230	2.000	2.000	4	1	1
1099	120.80	24.25	70.0	1.000	1.210	0.819	1.390	1.780	13.80	0.1250	0.230	2.000	2.000	4	1	1
1100	25.70	13.39	90.0	0.620	1.360	0.925	5.050	3.120	14.90	0.0450	0.210	1.019	1.243	4	1	1
1101	69.90	33.40	42.0	0.620	1.360	0.925	5.050	3.120	14.90	0.0450	0.210	1.019	1.243	4	1	1
1102	102.80	35.60	67.0	0.620	1.360	0.925	5.050	3.120	14.90	0.0450	0.210	1.019	1.243	4	1	1
1103	76.00	26.80	90.0	0.620	1.360	0.925	5.050	3.120	14.90	0.0450	0.210	1.019	1.243	4	1	1
1104	128.60	25.70	50.0	1.000	1.168	0.820	2.210	3.270	9.40	0.1250	0.230	2.000	2.000	4	1	1
1105	63.70	12.70	70.0	1.000	1.168	0.820	2.210	3.270	9.40	0.1250	0.230	2.000	2.000	4	1	1
1106	108.30	21.70	50.0	1.000	1.168	0.820	2.210	3.270	9.40	0.1250	0.230	2.000	2.000	4	1	1
1107	49.80	10.00	70.0	1.000	1.168	0.820	2.210	3.270	9.40	0.1250	0.230	2.000	2.000	4	1	1
1108	9.80	48.70	50.0	1.000	0.997	0.820	0.920	3.270	12.60	0.1250	0.230	2.000	2.000	4	1	1
1109	5.90	29.20	70.0	1.000	0.997	0.820	0.920	3.270	12.60	0.1250	0.230	2.000	2.000	4	1	1
1110	8.70	87.50	50.0	1.000	1.003	0.820	0.920	3.270	20.20	0.1250	0.230	2.000	2.000	4	1	1
1111	5.40	53.50	70.0	1.000	1.003	0.820	0.920	3.270	20.20	0.1250	0.230	2.000	2.000	4	1	1
Group-2 Data:																
1112	15.80	21.50	52.5	2.500	1.092	0.807	1.460	0.637	8.20	0.1067	0.288	1.500	1.500	2	1	4
1113	20.90	20.90	45.0	3.000	1.092	0.807	1.460	0.637	8.20	0.1067	0.288	1.500	1.500	2	1	4
1114	15.50	24.40	140.0	0.500	1.002	0.807	1.000	0.637	10.70	0.0313	0.230	0.980	2.000	2	1	1
1115	15.50	24.40	120.0	0.750	1.002	0.807	1.010	0.637	10.60	0.0313	0.230	0.980	2.000	2	1	1
1116	15.50	24.40	80.0	1.125	1.002	0.807	1.010	0.637	10.60	0.0313	0.230	0.980	2.000	2	1	1
1117	24.80	38.90	138.0	0.500	1.003	0.807	1.030	0.637	10.30	0.0313	0.230	0.980	2.000	2	1	1
1118	24.80	38.90	117.0	0.750	1.002	0.807	1.005	0.637	10.70	0.0313	0.230	0.980	2.000	2	1	1
1119	24.80	38.90	74.0	1.125	1.002	0.807	1.005	0.637	10.60	0.0313	0.230	0.980	2.000	2	1	1
1120	37.20	58.50	55.0	0.500	1.002	0.807	1.020	0.637	10.50	0.0313	0.230	0.980	2.000	2	1	1
1121	37.20	58.50	55.0	0.750	1.002	0.807	1.005	0.637	10.70	0.0313	0.230	0.980	2.000	2	1	1
1122	37.20	58.50	55.0	1.125	1.002	0.807	1.005	0.637	10.70	0.0313	0.230	0.980	2.000	2	1	1
1123	49.60	78.00	40.0	0.500	1.003	0.807	1.025	0.637	10.40	0.0313	0.230	0.980	2.000	2	1	1
1124	49.60	78.00	44.0	0.750	1.003	0.807	1.025	0.637	10.40	0.0313	0.230	0.980	2.000	2	1	1
1125	49.60	78.00	44.0	1.125	1.002	0.807	1.002	0.637	10.70	0.0313	0.230	0.980	2.000	2	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1126	37.20	58.50	15.0	0.750	1.002	0.807	1.010	0.637	10.60	0.0313	0.230	0.980	2.000	2	1	1
1127	44.50	89.10	110.0	0.500	1.079	1.411	1.090	1.400	17.20	0.1250	0.230	2.000	3.000	2	1	1
1128	71.10	142.80	90.0	0.500	1.079	1.411	1.090	1.400	17.20	0.1250	0.230	2.000	3.000	2	1	1
1129	23.30	46.30	80.0	1.000	1.079	1.411	1.090	1.400	17.20	0.1250	0.230	2.000	3.000	2	1	1
1130	53.50	107.00	75.0	1.000	1.079	1.411	1.090	1.400	17.20	0.1250	0.230	2.000	3.000	2	1	1
1131	55.60	111.50	46.6	1.500	1.079	1.411	1.090	1.400	17.20	0.1250	0.230	2.000	3.000	2	1	1
1132	85.60	171.20	42.6	1.500	1.079	1.411	1.090	1.400	17.20	0.1250	0.230	2.000	3.000	2	1	1
1133	39.00	18.50	160.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1134	31.20	14.50	165.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1135	23.20	11.60	170.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1136	20.40	10.30	180.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1137	15.70	7.90	240.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1138	16.50	8.30	240.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1139	15.70	7.90	270.0	0.433	1.002	0.845	1.030	2.130	10.10	0.1181	0.230	1.968	1.575	1	1	1
1140	41.00	20.50	66.0	1.575	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1141	30.70	15.40	70.0	1.575	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1142	20.60	10.20	75.0	1.575	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1143	10.30	5.10	85.0	1.575	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1144	15.40	7.60	330.0	0.394	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1145	20.60	10.20	310.0	0.394	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1146	41.00	20.50	273.0	0.394	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1147	15.40	7.60	185.0	0.787	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1148	20.60	10.20	180.0	0.787	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1149	41.00	20.50	160.0	0.787	1.002	0.845	1.030	2.130	10.10	0.0786	0.230	1.968	1.575	1	1	1
1150	7.90	15.70	67.0	1.575	1.000	0.851	1.000	2.140	10.00	0.1181	0.230	1.968	1.575	1	1	1
1151	11.80	23.60	49.6	1.575	1.000	0.851	1.000	2.140	10.00	0.1181	0.230	1.968	1.575	1	1	1
1152	15.80	31.50	43.5	1.575	1.000	0.851	1.000	2.140	10.00	0.1181	0.230	1.968	1.575	1	1	1
1153	15.70	7.90	69.4	1.575	1.000	0.843	1.000	2.010	10.10	0.1181	0.230	1.968	1.575	1	1	1
1154	23.60	11.80	55.6	1.575	1.000	0.843	1.000	2.010	10.10	0.1181	0.230	1.968	1.575	1	1	1
1155	31.50	15.80	49.6	1.575	1.000	0.843	1.000	2.010	10.10	0.1181	0.230	1.968	1.575	1	1	1
1156	39.40	19.70	47.9	1.575	1.000	0.843	1.000	2.010	10.10	0.1181	0.230	1.968	1.575	1	1	1
1157	47.20	23.70	40.0	1.575	1.000	0.843	1.000	2.010	10.10	0.1181	0.230	1.968	1.575	1	1	1
1158	5.20	42.00	95.0	1.575	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	2	1	1
1159	5.70	45.90	93.0	1.575	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	2	1	1
1160	67.60	33.80	230.0	0.433	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	1	1	1
1161	84.20	42.10	215.0	0.433	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	1	1	1
1162	99.80	49.90	200.0	0.433	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	1	1	1
1163	108.00	54.00	190.0	0.433	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	2	1	1
1164	117.20	58.60	180.0	0.433	1.000	0.778	1.000	1.630	24.10	0.1181	0.230	1.968	1.575	2	1	1
1165	5.90	23.80	105.0	1.575	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	2	1	1
1166	7.40	29.60	100.0	1.575	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	2	1	1
1167	10.50	42.00	95.0	1.575	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	2	1	1
1168	13.10	52.40	93.0	1.575	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	1	1	1
1169	34.00	17.00	230.0	0.433	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	1	1	1
1170	46.60	23.30	215.0	0.433	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	1	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1171	58.00	29.00	200.0	0.433	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	1	1	1
1172	64.40	32.20	190.0	0.433	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	2	1	1
1173	74.00	37.00	180.0	0.433	1.000	0.801	1.000	1.680	11.30	0.1181	0.230	1.968	1.575	2	1	1
1174	6.10	16.30	105.0	1.575	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1175	6.90	18.40	100.0	1.575	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1176	10.00	26.80	95.0	1.575	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1177	13.10	35.00	93.0	1.575	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1178	22.60	11.30	230.0	0.433	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	1	1	1
1179	29.20	14.60	215.0	0.433	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	1	1	1
1180	38.40	19.20	200.0	0.433	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1181	45.20	22.60	190.0	0.433	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1182	52.40	26.20	180.0	0.433	1.000	0.820	1.000	1.830	10.50	0.1181	0.230	1.968	1.575	2	1	1
1183	5.90	11.80	105.0	1.575	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1184	6.60	13.10	100.0	1.575	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1185	8.70	17.70	95.0	1.575	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1186	10.80	21.60	93.0	1.575	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1187	16.90	8.40	230.0	0.433	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	1	1	1
1188	18.30	9.20	215.0	0.433	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	1	1	1
1189	21.40	10.70	200.0	0.433	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1190	23.00	11.50	190.0	0.433	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1191	24.80	12.40	180.0	0.433	1.000	0.842	1.000	2.140	10.50	0.1181	0.230	1.968	1.575	2	1	1
1192	2.00	2.70	95.0	1.575	1.000	0.890	1.000	2.750	10.00	0.1180	0.230	1.968	1.575	2	1	1
1193	3.00	4.00	93.0	1.575	1.000	0.890	1.000	2.750	10.00	0.1180	0.230	1.968	1.575	2	1	1
1194	7.60	17.00	80.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1195	10.00	22.40	70.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1196	12.90	28.60	60.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1197	15.80	34.80	50.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1198	12.40	27.70	35.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1199	8.80	24.20	80.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1200	11.50	31.60	60.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1201	13.00	35.40	35.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1202	12.30	30.70	80.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1203	16.40	40.50	60.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1204	19.50	48.60	50.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1205	20.10	50.10	40.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1206	11.90	29.50	80.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1207	20.70	51.80	50.0	0.800	1.077	0.919	1.390	2.790	10.40	0.1250	0.230	2.000	1.920	2	1	1
1208	14.70	36.90	80.0	0.800	1.077	0.845	1.390	2.120	9.30	0.1250	0.230	2.000	1.920	2	1	1
1209	17.00	42.40	70.0	0.800	1.077	0.845	1.390	2.120	9.30	0.1250	0.230	2.000	1.920	2	1	1
1210	20.90	52.00	60.0	0.800	1.077	0.845	1.390	2.120	9.30	0.1250	0.230	2.000	1.920	2	1	1
1211	25.10	62.90	50.0	0.800	1.077	0.845	1.390	2.120	9.30	0.1250	0.230	2.000	1.920	2	1	1
1212	10.20	25.50	80.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1213	12.60	31.30	70.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1214	15.40	38.40	60.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1215	18.60	46.50	50.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1216	20.70	51.80	40.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1217	7.80	17.30	80.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1218	11.40	25.30	70.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1219	13.50	29.90	60.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1220	15.10	33.40	50.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1221	15.50	34.50	40.0	0.800	1.104	0.925	1.620	2.830	10.00	0.1250	0.230	2.000	1.920	2	1	1
1222	27.50	68.60	50.0	0.800	1.072	0.840	1.200	1.520	9.80	0.1250	0.230	2.000	1.920	2	1	1
1223	20.10	50.40	60.0	0.800	1.072	0.840	1.200	1.520	9.80	0.1250	0.230	2.000	1.920	2	1	1
1224	14.80	36.80	70.0	0.800	1.072	0.840	1.200	1.520	9.80	0.1250	0.230	2.000	1.920	2	1	1
1225	25.50	63.50	50.0	0.800	1.061	0.840	1.170	1.520	10.20	0.1250	0.230	2.000	1.920	2	1	1
1226	20.90	52.00	60.0	0.800	1.061	0.840	1.170	1.520	10.20	0.1250	0.230	2.000	1.920	2	1	1
1227	17.00	42.40	70.0	0.800	1.061	0.840	1.170	1.520	10.20	0.1250	0.230	2.000	1.920	2	1	1
1228	13.70	34.40	80.0	0.800	1.061	0.840	1.170	1.520	10.20	0.1250	0.230	2.000	1.920	2	1	1
1229	73.50	73.50	33.0	1.000	1.244	0.794	3.060	1.270	20.80	0.1250	0.230	2.000	1.920	2	1	1
1230	66.90	66.90	38.5	1.000	1.244	0.794	3.060	1.270	20.80	0.1250	0.230	2.000	1.920	2	1	1
1231	48.50	48.50	50.0	1.000	1.244	0.794	3.060	1.270	20.80	0.1250	0.230	2.000	1.920	2	1	1
1232	43.50	43.50	60.0	1.000	1.244	0.794	3.060	1.270	20.80	0.1250	0.230	2.000	1.920	2	1	1
1233	33.50	33.50	70.0	1.000	1.244	0.794	3.060	1.270	20.80	0.1250	0.230	2.000	1.920	2	1	1
1234	23.50	23.50	80.0	1.000	1.244	0.794	3.060	1.270	20.80	0.1250	0.230	2.000	1.920	2	1	1
1235	45.90	114.30	40.0	1.000	1.000	0.794	0.961	1.270	20.80	0.1250	0.230	2.000	1.920	1	1	1
1236	34.40	85.80	55.0	1.000	1.000	0.794	0.961	1.270	20.80	0.1250	0.230	2.000	1.920	1	1	1
1237	22.90	57.30	70.0	1.000	1.000	0.794	0.961	1.270	20.80	0.1250	0.230	2.000	1.920	1	1	1
1238	11.50	28.60	80.0	1.000	1.000	0.794	0.961	1.270	20.80	0.1250	0.230	2.000	1.920	1	1	1
1239	40.11	13.39	104.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1240	80.20	26.80	85.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1241	110.20	36.80	65.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1242	120.20	40.10	55.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1243	35.68	17.82	90.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1244	89.30	44.50	70.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1245	106.80	53.50	50.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1246	115.90	57.90	35.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1247	130.30	43.50	45.0	1.000	1.195	0.802	1.960	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1248	23.45	23.45	85.0	1.000	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1249	40.05	40.05	60.0	1.000	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1250	60.10	60.10	40.0	1.000	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1251	80.15	80.15	35.0	1.000	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1252	86.90	86.90	32.0	1.000	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1253	86.90	86.90	35.0	0.500	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1254	80.15	80.15	95.0	0.500	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1255	85.15	85.15	70.0	0.750	1.118	0.802	1.210	1.300	16.00	0.1250	0.230	2.000	2.000	2	1	1
1256	10.70	42.80	75.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1257	13.38	52.52	70.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1258	18.72	74.88	45.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1259	26.70	107.10	35.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1260	8.02	32.08	70.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1261	10.70	42.80	60.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1262	16.02	64.08	40.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1263	21.40	85.60	25.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1264	10.70	42.80	65.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1265	16.02	64.08	45.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1266	18.72	74.88	35.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1267	8.02	31.08	80.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1268	12.02	48.08	65.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1269	16.02	64.08	50.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1270	21.40	85.60	45.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1271	29.40	117.60	35.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1272	8.02	31.08	72.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1273	21.40	85.60	25.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1274	10.70	42.80	85.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1275	18.72	74.88	50.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1276	29.40	117.60	35.0	1.000	1.013	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	2.000	1	1	1
1277	19.50	43.10	70.0	1.000	1.060	0.814	1.120	1.630	10.50	0.1250	0.230	2.000	1.920	2	1	1
1278	32.80	72.50	50.0	1.000	1.060	0.814	1.120	1.630	10.50	0.1250	0.230	2.000	1.920	2	1	1
1279	37.00	81.70	30.0	1.000	1.060	0.814	1.120	1.630	10.50	0.1250	0.230	2.000	1.920	2	1	1
1280	61.90	34.10	70.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1281	79.10	43.60	50.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1282	79.10	43.60	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1283	94.60	52.10	25.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1284	61.90	34.10	100.0	0.500	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1285	94.60	52.10	70.0	0.500	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1286	94.60	52.10	50.0	0.500	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1287	94.60	52.10	25.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1288	79.10	43.60	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1289	79.10	43.60	50.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1290	62.00	34.20	70.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1291	36.20	101.50	50.0	1.000	1.092	0.814	1.120	1.630	10.50	0.1250	0.230	2.000	1.920	2	1	1
1292	103.40	69.00	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.230	2.000	1.920	1	1	1
1293	31.30	68.90	50.0	1.000	1.000	0.819	1.000	1.787	13.30	0.1250	0.230	2.000	1.920	1	1	1
1294	39.60	87.40	30.0	1.000	1.000	0.819	1.000	1.787	13.30	0.1250	0.230	2.000	1.920	1	1	1
1295	35.40	78.30	50.0	1.000	1.000	0.819	1.000	1.787	13.30	0.1250	0.230	2.000	1.920	1	1	1
1296	40.70	90.40	30.0	1.000	1.000	0.819	1.000	1.787	13.30	0.1250	0.230	2.000	1.920	1	1	1
1297	97.00	100.00	50.0	1.000	1.063	0.757	0.960	1.420	16.00	0.1250	0.230	2.000	1.920	2	1	1
1298	64.00	66.00	70.0	1.000	1.063	0.757	0.960	1.420	16.00	0.1250	0.230	2.000	1.920	2	1	1
1299	36.10	37.20	90.0	1.000	1.063	0.757	0.960	1.420	16.00	0.1250	0.230	2.000	1.920	2	1	1
1300	20.80	82.80	30.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.230	2.000	1.920	1	1	1
1301	12.70	50.80	50.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.230	2.000	1.920	1	1	1
1302	7.40	29.40	70.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.230	2.000	1.920	1	1	1
1303	3.00	11.97	90.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.230	2.000	1.920	1	1	1
1304	206.20	61.50	50.0	1.000	1.275	0.765	3.425	1.420	17.10	0.1250	0.230	2.000	1.920	2	1	1
1305	105.10	31.20	70.0	1.000	1.275	0.765	3.425	1.420	17.10	0.1250	0.230	2.000	1.920	2	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1306	59.73	17.77	90.0	1.000	1.275	0.765	3.425	1.420	17.10	0.1250	0.230	2.000	1.920	2	1	1
1307	202.50	44.70	70.0	1.000	1.050	0.870	1.000	2.410	20.40	0.1250	0.230	2.000	2.000	2	1	1
1308	126.20	28.80	90.0	1.000	1.050	0.870	1.000	2.410	20.40	0.1250	0.230	2.000	2.000	2	1	1
1309	175.10	40.10	70.0	1.000	1.050	0.870	1.000	2.410	20.40	0.1250	0.230	2.000	2.000	2	1	1
1310	12.03	60.17	25.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1311	12.03	60.17	35.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1312	6.69	33.41	50.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1313	2.90	14.48	70.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1314	14.48	72.42	25.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1315	12.48	62.41	35.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1316	8.92	44.58	50.0	1.000	1.010	0.870	1.030	2.600	15.10	0.1250	0.230	2.000	2.000	1	1	1
1317	16.70	33.40	35.0	1.000	1.090	0.850	1.400	1.280	1.00	0.1250	0.230	2.000	2.000	1	1	1
1318	12.03	24.07	50.0	1.000	1.090	0.850	1.400	1.280	1.00	0.1250	0.230	2.000	2.000	1	1	1
1319	67.00	111.90	35.0	1.000	1.420	0.865	4.200	0.870	23.00	0.1250	0.230	2.000	2.000	2	1	1
1320	45.50	76.00	50.0	1.000	1.420	0.865	4.200	0.870	23.00	0.1250	0.230	2.000	2.000	2	1	1
1321	35.00	58.50	70.0	1.000	1.420	0.865	4.200	0.870	23.00	0.1250	0.230	2.000	2.000	2	1	1
1322	24.50	40.90	90.0	1.000	1.420	0.865	4.200	0.870	23.00	0.1250	0.230	2.000	2.000	2	1	1
1323	54.40	77.90	50.0	1.000	1.420	0.865	4.200	0.870	23.00	0.1250	0.230	2.000	2.000	2	1	1
1324	16.20	82.41	35.0	1.000	1.000	0.865	0.920	0.870	23.90	0.1250	0.230	2.000	2.000	1	1	1
1325	10.90	54.59	50.0	1.000	1.000	0.865	0.920	0.870	23.90	0.1250	0.230	2.000	2.000	1	1	1
1326	8.40	42.41	70.0	1.000	1.000	0.865	0.920	0.870	23.90	0.1250	0.230	2.000	2.000	1	1	1
1327	22.90	92.00	35.0	1.000	1.000	0.865	0.920	0.870	23.90	0.1250	0.230	2.000	2.000	1	1	1
1328	14.10	56.40	50.0	1.000	1.000	0.865	0.920	0.870	23.90	0.1250	0.230	2.000	2.000	1	1	1
1329	10.70	42.80	70.0	1.000	1.000	0.865	0.920	0.870	23.90	0.1250	0.230	2.000	2.000	1	1	1
Group-3 Data:																
1330	59.50	118.50	40.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1331	158.00	79.00	40.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1332	15.20	15.30	100.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1333	30.50	30.50	80.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1334	57.80	57.70	60.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1335	61.00	61.00	60.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1336	94.20	94.30	40.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
1337	105.00	105.00	30.0	0.909	1.000	0.814	1.002	1.800	11.00	0.1180	0.230	2.000	3.000	4	1	6
Group-4 Data:																
1338	118.00	65.10	25.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	5
1339	96.40	53.30	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	5
1340	47.40	26.10	50.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	5
1341	166.80	111.20	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1875	0.230	2.000	1.920	1	1	5
1342	10.00	40.10	30.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.100	2.000	1.920	1	1	5
1343	6.95	27.80	50.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.100	2.000	1.920	1	1	5
1344	3.66	14.65	70.0	1.000	1.111	0.760	1.040	1.450	17.10	0.1250	0.100	2.000	1.920	1	1	5
1345	101.10	55.70	25.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	6
1346	72.50	39.80	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	6
1347	51.80	28.50	50.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	6
1348	118.20	65.00	25.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	5
1349	96.80	53.10	35.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	5
1350	47.40	26.10	50.0	1.000	1.000	0.814	1.000	1.630	10.50	0.1250	0.100	2.000	2.000	1	1	5

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1351	133.50	149.50	60.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1352	146.00	158.80	50.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1353	66.50	70.50	80.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1354	147.50	160.50	40.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1355	66.50	70.50	80.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1356	87.00	89.00	41.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1357	72.00	74.00	61.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1358	46.00	45.10	80.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1359	82.90	81.10	50.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1360	24.30	24.30	100.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1361	36.50	36.50	80.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1362	50.20	50.20	80.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1363	62.20	62.30	60.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1364	76.00	76.00	60.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1365	79.70	79.80	40.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1366	91.20	91.30	40.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1367	91.30	91.20	30.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1368	30.50	30.50	100.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1369	38.00	38.00	94.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1370	65.50	65.50	80.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1371	140.00	140.00	60.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1372	142.00	142.00	60.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1373	150.50	150.50	50.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
1374	152.40	152.40	40.0	0.909	1.001	0.814	1.002	1.800	11.20	0.1180	0.230	2.000	3.000	1	1	6
Group-5 Data:																
1375	6.80	49.40	80.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1760	0.294	1.070	3.000	4	1	35
1376	13.50	98.60	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1760	0.294	1.070	3.000	4	1	35
1377	6.80	49.40	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1950	0.237	1.129	3.000	4	1	36
1378	13.50	98.60	60.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1950	0.237	1.129	3.000	4	1	36
1379	6.80	49.40	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1950	0.237	1.147	3.000	4	1	37
1380	13.50	98.60	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1950	0.237	1.147	3.000	4	1	37
1381	6.80	49.40	87.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1850	0.303	1.080	3.000	4	1	38
1382	6.80	49.40	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1850	0.303	1.128	3.000	4	1	39
1383	6.80	49.40	80.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1770	0.297	1.094	3.000	4	1	40
1384	13.50	98.60	55.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1770	0.297	1.094	3.000	4	1	40
1385	6.80	49.40	80.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1750	0.200	1.047	3.000	4	1	41
1386	6.80	49.40	80.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1700	0.274	1.094	3.000	4	1	42
1387	13.50	98.60	55.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1700	0.274	1.094	3.000	4	1	42
1388	6.80	49.40	90.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1880	0.274	1.080	3.000	4	1	43
1389	13.50	98.60	70.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1880	0.274	1.080	3.000	4	1	43
1390	6.80	49.40	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1650	0.258	1.087	3.000	4	1	44
1391	13.50	98.60	70.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1650	0.258	1.087	3.000	4	1	44
1392	6.80	49.40	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1880	0.333	1.087	3.000	4	1	45
1393	13.50	98.60	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1880	0.333	1.087	3.000	4	1	45
1394	6.80	49.40	88.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1880	0.333	1.100	3.000	4	1	46
1395	13.50	98.60	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1880	0.333	1.088	3.000	4	1	46

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1396	6.80	49.40	85.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1700	0.274	1.100	3.000	4	1	47
1397	6.80	49.40	75.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1800	0.212	1.430	3.000	4	1	48
1398	6.80	49.40	80.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1750	0.154	1.210	3.000	4	1	49
1399	6.80	49.40	78.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1750	0.154	1.210	3.000	4	1	50
1400	6.80	49.40	90.0	0.600	1.072	0.929	1.020	2.890	13.00	0.2500	0.405	1.070	3.000	4	1	51
1401	6.80	49.40	90.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1880	0.410	1.070	3.000	4	1	51
1402	13.50	98.60	65.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1880	0.410	1.070	3.000	4	1	51
1403	6.80	49.40	90.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1404	6.80	49.40	83.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1130	0.327	1.070	3.000	4	1	51
1405	6.80	49.40	88.0	0.600	1.072	0.929	1.020	2.890	13.00	0.2500	0.231	1.070	3.000	4	1	51
1406	6.80	49.40	83.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1880	0.236	1.070	3.000	4	1	51
1407	6.80	49.40	85.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1250	0.231	1.070	3.000	4	1	51
1408	6.80	49.40	83.0	0.600	1.072	0.929	1.020	2.890	13.00	0.0800	0.258	1.070	3.000	4	1	51
1409	6.80	49.40	85.0	0.600	1.072	0.929	1.020	2.890	13.00	0.2500	0.108	1.070	3.000	4	1	51
1410	6.80	49.40	85.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1250	0.103	1.070	3.000	4	1	51
1411	6.80	49.40	85.0	0.600	1.072	0.929	1.020	2.890	13.00	0.0620	0.103	1.070	3.000	4	1	51
1412	6.80	49.40	85.0	0.600	1.072	0.929	1.020	2.890	13.00	0.0520	0.465	1.070	3.000	4	1	51
1413	12.30	43.90	85.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1414	34.30	77.80	65.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1415	16.90	39.30	90.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1416	33.50	78.60	65.0	0.600	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1417	6.80	49.40	105.0	0.300	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1418	13.50	98.60	85.0	0.300	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1419	12.30	43.90	105.0	0.300	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1420	34.30	77.80	90.0	0.300	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1421	16.90	39.30	103.0	0.300	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1422	33.50	76.60	85.0	0.300	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1423	6.80	49.40	70.0	0.900	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1424	13.50	98.60	60.0	0.900	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1425	12.30	43.90	75.0	0.900	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1426	34.30	77.80	55.0	0.900	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1427	16.90	39.30	70.0	0.900	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1428	16.90	39.30	38.0	0.900	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1429	6.80	49.40	60.0	1.200	1.072	0.929	1.020	2.890	13.00	0.1760	0.294	1.070	3.000	4	1	51
1430	6.80	49.40	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1431	13.50	98.60	80.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1432	6.80	49.40	100.0	0.600	1.000	0.849	0.900	2.210	10.70	0.0620	0.103	1.070	3.000	4	1	51
1433	6.80	49.40	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.2500	0.108	1.070	3.000	4	1	51
1434	6.80	49.40	103.0	0.600	1.000	0.849	0.900	2.210	10.70	0.0800	0.258	1.070	3.000	4	1	51
1435	6.80	49.40	100.0	0.600	1.000	0.849	0.900	2.210	10.70	0.2500	0.231	1.070	3.000	4	1	51
1436	6.80	49.40	100.0	0.600	1.000	0.849	0.900	2.210	10.70	0.2500	0.405	1.070	3.000	4	1	51
1437	16.90	39.30	100.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1438	33.50	78.60	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1439	6.80	49.40	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1440	13.50	98.60	75.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1441	16.90	39.30	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1442	33.50	78.60	70.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1443	6.80	49.40	115.0	0.300	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1444	13.50	98.60	102.0	0.300	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1445	16.90	39.30	115.0	0.300	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1446	33.50	78.60	95.0	0.300	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1447	6.80	49.40	70.0	0.900	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1448	13.50	98.60	57.0	0.900	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1449	16.90	39.30	66.0	0.900	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1450	33.50	78.60	45.0	0.900	1.000	0.849	0.900	2.210	10.70	0.1760	0.294	1.070	3.000	4	1	51
1451	6.80	49.40	80.0	0.600	1.000	0.849	0.900	2.210	10.70	0.0620	0.103	1.070	3.000	4	1	51
1452	6.80	49.40	80.0	0.600	1.000	0.849	0.900	2.210	10.70	0.2500	0.108	1.070	3.000	4	1	51
1453	6.80	49.40	85.0	0.600	1.000	0.849	0.900	2.210	10.70	0.0800	0.258	1.070	3.000	4	1	51
1454	6.80	49.40	85.0	0.600	1.000	0.849	0.900	2.210	10.70	0.2500	0.231	1.070	3.000	4	1	51
1455	6.80	49.40	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.2500	0.405	1.070	3.000	4	1	51
1456	6.80	49.40	90.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1880	0.410	1.070	3.000	4	1	51
1457	6.80	49.40	83.0	0.600	1.000	0.849	0.900	2.210	10.70	0.0520	0.465	1.070	3.000	4	1	51
1458	6.80	49.40	87.0	0.600	1.000	0.849	0.900	2.210	10.70	0.1880	0.236	1.070	3.000	4	1	51
1459	33.50	78.60	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1460	6.80	49.40	95.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1461	13.50	98.60	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1462	6.80	49.40	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.0620	0.103	1.070	3.000	4	1	51
1463	6.80	49.40	95.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1464	6.80	49.40	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.0620	0.103	1.070	3.000	4	1	51
1465	6.80	49.40	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1250	0.101	1.070	3.000	4	1	51
1466	6.80	49.40	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.2500	0.108	1.070	3.000	4	1	51
1467	6.80	49.40	100.0	0.600	1.046	0.858	0.920	2.390	10.60	0.0800	0.258	1.070	3.000	4	1	51
1468	6.80	49.40	100.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1250	0.231	1.070	3.000	4	1	51
1469	6.80	49.40	95.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1880	0.236	1.070	3.000	4	1	51
1470	6.80	49.40	95.0	0.600	1.046	0.858	0.920	2.390	10.60	0.2500	0.231	1.070	3.000	4	1	51
1471	6.80	49.40	100.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1130	0.327	1.070	3.000	4	1	51
1472	6.80	49.40	95.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1473	13.50	98.60	85.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1474	6.80	49.40	100.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1880	0.410	1.070	3.000	4	1	51
1475	6.80	49.40	100.0	0.600	1.046	0.858	0.920	2.390	10.60	0.2500	0.405	1.070	3.000	4	1	51
1476	12.30	43.90	90.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1477	33.50	78.60	80.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1478	26.00	30.20	92.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1479	38.80	45.30	85.0	0.600	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1480	6.80	49.40	120.0	0.300	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1481	13.50	98.60	110.0	0.300	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1482	16.90	39.30	120.0	0.300	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1483	33.50	78.60	110.0	0.300	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1484	26.00	30.20	120.0	0.300	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1485	38.80	45.30	110.0	0.300	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1486	6.80	49.40	80.0	0.900	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1487	13.50	98.60	65.0	0.900	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1488	16.90	39.30	75.0	0.900	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1489	33.50	78.60	65.0	0.900	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1490	26.00	30.20	80.0	0.900	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1491	38.80	45.30	70.0	0.900	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1492	6.80	49.40	70.0	1.200	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1493	13.50	98.60	60.0	1.200	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1494	16.90	39.30	65.0	1.200	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1495	33.50	78.60	55.0	1.200	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1496	26.00	30.20	65.0	1.200	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1497	38.80	45.30	60.0	1.200	1.046	0.858	0.920	2.390	10.60	0.1760	0.294	1.070	3.000	4	1	51
1498	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1499	13.50	98.60	90.0	0.600	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1500	16.90	39.30	95.0	0.600	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1501	26.00	30.20	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1502	6.80	49.40	120.0	0.300	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1503	6.80	49.40	120.0	0.300	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1504	13.50	98.60	110.0	0.300	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1505	16.90	39.30	115.0	0.300	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1506	26.00	30.20	115.0	0.300	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1507	6.80	49.40	90.0	0.900	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1508	13.50	98.60	80.0	0.900	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1509	16.90	39.30	85.0	0.900	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1510	26.00	30.20	80.0	0.900	1.327	0.882	1.740	2.290	12.00	0.1760	0.294	1.070	3.000	4	1	51
1511	6.80	49.40	85.0	0.600	1.327	0.882	1.740	2.290	12.00	0.0620	0.103	1.070	3.000	4	1	51
1512	6.80	49.40	85.0	0.600	1.327	0.882	1.740	2.290	12.00	0.2500	0.108	1.070	3.000	4	1	51
1513	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.0800	0.258	1.070	3.000	4	1	51
1514	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.1880	0.236	1.070	3.000	4	1	51
1515	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.2500	0.231	1.070	3.000	4	1	51
1516	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.0520	0.465	1.070	3.000	4	1	51
1517	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.1880	0.410	1.070	3.000	4	1	51
1518	6.80	49.40	100.0	0.600	1.327	0.882	1.740	2.290	12.00	0.2500	0.405	1.070	3.000	4	1	51
Group-9 Data:																
1519	197.50	28.20	50.0	1.000	0.814	1.092	1.630	1.120	10.50	0.1250	0.230	2.000	1.920	3	2	1
Group-10 Data:																
1520	53.20	24.10	70.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	1.920	2	2	1
1521	72.50	32.80	50.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	1.920	2	2	1
1522	104.00	46.90	30.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	1.920	2	2	1
1523	34.10	61.90	70.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1524	43.60	79.10	50.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1525	52.10	94.60	35.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1526	52.10	94.60	25.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1527	52.10	94.60	25.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1528	52.10	94.60	35.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1529	43.60	79.10	50.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1530	34.10	61.90	70.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1
1531	69.00	103.40	35.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.230	2.000	1.920	1	2	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
Group-11 Data:																
1532	163.90	23.40	30.0	1.000	0.814	1.092	1.630	1.120	10.50	0.1250	0.100	2.000	1.920	3	2	5
1533	146.20	20.90	50.0	1.000	0.814	1.092	1.630	1.120	10.50	0.1250	0.100	2.000	1.920	3	2	5
1534	58.40	8.35	70.0	1.000	0.814	1.092	1.630	1.120	10.50	0.1250	0.100	2.000	1.920	3	2	5
1535	0.49	24.70	70.0	1.000	0.816	1.213	1.750	1.400	13.60	0.1250	0.100	2.000	2.000	4	2	5
1536	0.98	49.00	50.0	1.000	0.816	1.213	1.750	1.400	13.60	0.1250	0.100	2.000	2.000	4	2	5
1537	2.18	108.50	35.0	1.000	0.816	1.213	1.750	1.400	13.60	0.1250	0.100	2.000	2.000	4	2	5
1538	8.39	41.40	50.0	1.000	0.816	1.213	1.750	1.400	13.60	0.1250	0.100	2.000	2.000	4	2	5
1539	18.82	98.60	35.0	1.000	0.816	1.213	1.750	1.400	13.60	0.1250	0.100	2.000	2.000	4	2	5
1540	95.40	9.60	50.0	1.000	0.820	1.003	3.270	0.920	20.20	0.1250	0.100	2.000	2.000	4	2	5
1541	77.30	7.70	50.0	1.000	0.820	1.003	3.270	0.920	20.20	0.1250	0.100	2.000	2.000	4	2	5
1542	59.90	6.00	70.0	1.000	0.820	1.003	3.270	0.920	20.20	0.1250	0.100	2.000	2.000	4	2	5
1543	87.30	1.70	50.0	1.000	0.820	1.003	3.270	0.920	20.20	0.1250	0.100	2.000	2.000	4	2	5
1544	13.70	13.70	50.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	2.000	3.000	3	2	5
1545	33.50	33.40	60.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	2.000	3.000	3	2	5
1546	27.90	27.80	80.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	2.000	3.000	3	2	5
1547	29.50	29.50	100.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	2.000	3.000	3	2	5
1548	39.50	39.40	100.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	2.000	3.000	3	2	5
1549	27.90	54.80	120.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	2.000	3.000	3	2	5
1550	61.00	61.00	50.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	4.000	3.000	3	2	5
1551	71.50	71.50	60.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	4.000	3.000	3	2	5
1552	83.80	83.70	60.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	4.000	3.000	3	2	5
1553	80.80	80.70	70.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	4.000	3.000	3	2	5
1554	83.80	83.70	80.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	4.000	3.000	3	2	5
1555	39.50	39.50	100.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1780	0.330	4.000	3.000	3	2	5
1556	61.20	61.20	100.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1557	114.50	114.50	80.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1558	117.00	117.00	80.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1559	132.00	132.00	70.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1560	126.00	126.00	60.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1561	158.50	158.50	60.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1562	152.40	152.40	50.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1563	140.50	140.50	40.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1564	111.70	55.80	100.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1565	193.00	96.00	80.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1566	230.50	115.50	60.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1567	223.00	112.00	50.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1568	193.00	96.00	40.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1569	114.40	28.60	100.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1570	131.10	32.90	100.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1571	214.40	53.60	80.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1572	308.80	77.20	60.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1573	316.00	79.00	60.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1574	294.20	73.80	50.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1575	275.20	68.80	50.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1576	236.80	59.20	40.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1577	132.90	22.10	100.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1578	231.50	38.50	80.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1579	358.30	59.70	60.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1580	367.80	61.20	50.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1581	295.00	49.00	40.0	0.909	0.837	1.100	1.970	1.170	16.00	0.1180	0.230	2.000	3.000	3	2	5
1582	59.30	59.20	100.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1583	86.70	86.80	80.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1584	126.00	126.00	60.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1585	110.50	110.50	50.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1586	83.70	83.80	40.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1587	64.70	32.50	100.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1588	121.50	61.00	80.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1589	178.70	89.10	60.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1590	163.00	81.00	46.5	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1591	136.80	68.20	40.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1592	124.00	31.00	100.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1593	300.80	75.20	60.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1594	299.80	75.20	50.0	0.909	0.843	1.150	2.000	1.240	23.00	0.1180	0.230	2.000	3.000	3	2	5
1595	85.10	21.40	100.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1596	164.00	41.00	80.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1597	236.80	59.20	60.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1598	248.00	62.00	60.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1599	260.00	65.00	40.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1600	117.40	19.60	100.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1601	239.10	39.90	70.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1602	190.20	31.80	80.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1603	289.60	48.40	60.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1604	294.90	49.10	50.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1605	295.50	49.50	40.0	0.909	0.872	1.190	2.270	1.350	26.00	0.1180	0.230	2.000	3.000	3	2	5
1606	36.50	73.00	100.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1607	65.80	132.00	80.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1608	66.50	134.50	70.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1609	70.00	140.00	60.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1610	74.00	148.00	49.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1611	79.50	156.00	44.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1612	62.30	62.20	100.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1613	79.00	79.00	89.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1614	105.00	105.00	80.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1615	115.50	115.50	70.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1616	112.50	112.50	70.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1617	125.50	125.50	60.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1618	132.50	132.50	60.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1619	126.50	126.50	52.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1620	120.00	120.00	51.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1621	132.50	132.50	45.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1622	110.20	110.30	43.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1623	117.20	117.30	35.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1624	91.00	45.50	100.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1625	162.80	81.20	80.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1626	206.50	103.50	60.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
1627	223.50	111.50	45.0	0.909	0.814	1.000	1.800	1.002	11.00	0.1180	0.230	2.000	3.000	4	2	5
Group-12 Data:																
1628	72.70	131.80	25.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.100	2.000	1.920	1	2	5
1629	65.10	118.00	35.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.100	2.000	1.920	1	2	5
1630	33.20	60.40	50.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.100	2.000	1.920	1	2	5
1631	14.25	25.85	70.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1250	0.100	2.000	1.920	1	2	5
1632	121.90	182.80	35.0	1.000	0.814	1.000	1.630	1.000	10.50	0.1880	0.230	2.000	1.920	1	2	5
1633	121.00	117.00	50.0	1.000	0.760	1.063	1.450	0.960	16.00	0.1250	0.100	2.000	1.920	2	2	5
1634	55.30	53.60	70.0	1.000	0.760	1.063	1.450	0.960	16.00	0.1250	0.100	2.000	1.920	2	2	5
1635	25.70	24.90	90.0	1.000	0.760	1.063	1.450	0.960	16.00	0.1250	0.100	2.000	1.920	2	2	5
1636	101.70	25.30	50.0	1.000	0.757	0.997	1.420	1.000	15.80	0.1250	0.100	2.000	1.920	1	2	5
1637	58.80	14.70	70.0	1.000	0.757	0.997	1.420	1.000	15.80	0.1250	0.100	2.000	1.920	1	2	5
1638	34.65	8.75	90.0	1.000	0.757	0.997	1.420	1.000	15.80	0.1250	0.100	2.000	1.920	1	2	5
1639	39.40	173.00	30.0	1.000	0.870	1.050	2.410	1.000	20.40	0.1250	0.100	2.000	2.000	2	2	5
1640	24.80	100.00	50.0	1.000	0.870	1.050	2.410	1.000	20.40	0.1250	0.100	2.000	2.000	2	2	5
1641	17.33	76.00	70.0	1.000	0.870	1.050	2.410	1.000	20.40	0.1250	0.100	2.000	2.000	2	2	5
1642	36.20	159.00	30.0	1.000	0.870	1.050	2.410	1.000	20.40	0.1250	0.100	2.000	2.000	2	2	5
1643	21.55	94.50	50.0	1.000	0.870	1.050	2.410	1.000	20.40	0.1250	0.100	2.000	2.000	2	2	5
1644	16.10	70.60	70.0	1.000	0.870	1.050	2.410	1.000	20.40	0.1250	0.100	2.000	2.000	2	2	5
1645	49.00	9.80	35.0	1.000	0.870	1.010	2.600	1.030	15.10	0.1250	0.100	2.000	2.000	1	2	5
1646	31.34	6.46	50.0	1.000	0.870	1.010	2.600	1.030	15.10	0.1250	0.100	2.000	2.000	1	2	5
1647	53.91	10.79	35.0	1.000	0.870	1.010	2.600	1.030	15.10	0.1250	0.100	2.000	2.000	1	2	5
1648	35.90	10.90	35.0	1.000	0.850	1.090	1.280	1.400	1.00	0.1250	0.100	2.000	2.000	1	2	5
1649	29.80	9.00	50.0	1.000	0.850	1.090	1.280	1.400	1.00	0.1250	0.100	2.000	2.000	1	2	5
1650	46.80	69.90	35.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	2.000	2	2	6
1651	28.60	42.70	50.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	2.000	2	2	6
1652	46.80	69.90	35.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	2.000	2	2	6
1653	36.40	54.30	50.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	2.000	2	2	6
1654	29.90	44.70	35.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.100	2.000	2.000	2	2	6
1655	18.70	28.00	50.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.100	2.000	2.000	2	2	6
1656	141.00	63.60	35.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	2.000	2	2	5
1657	80.90	36.60	50.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.230	2.000	2.000	2	2	5
1658	107.00	48.30	35.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.100	2.000	2.000	2	2	5
1659	72.70	32.90	50.0	1.000	0.814	1.060	1.630	1.120	10.50	0.1250	0.100	2.000	2.000	2	2	5
1660	63.90	63.90	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1780	0.330	2.000	3.000	1	2	5
1661	74.50	74.50	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1780	0.330	2.000	3.000	1	2	5
1662	79.80	79.70	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1780	0.330	2.000	3.000	1	2	5
1663	79.80	79.70	90.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1780	0.330	2.000	3.000	1	2	5
1664	70.20	70.30	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1780	0.330	2.000	3.000	1	2	5
1665	119.50	119.50	34.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1666	119.50	119.50	49.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1667	101.00	101.00	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1668	37.90	38.00	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1669	52.00	104.00	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1670	95.30	190.70	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1671	130.00	261.00	60.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1672	120.00	240.00	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1673	99.00	198.00	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1674	97.00	97.00	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1675	174.50	174.50	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1676	203.00	203.00	60.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1677	190.00	190.00	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1678	156.00	156.00	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1679	168.90	42.10	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1680	240.80	60.20	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1681	323.80	82.20	60.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1682	286.20	71.80	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1683	273.80	68.20	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1684	130.00	52.00	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1685	178.50	71.50	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1686	243.20	97.80	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1687	304.00	122.00	60.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1688	282.00	113.00	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1689	222.00	89.00	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1690	167.50	167.50	54.5	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1691	163.00	163.00	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1692	152.40	152.40	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1693	111.70	55.80	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1694	111.70	55.80	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1695	210.50	105.50	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1696	230.50	115.50	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1697	272.00	136.00	60.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1698	263.00	132.00	55.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1699	264.00	132.00	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1700	249.50	124.50	50.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1701	210.50	105.50	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1702	283.20	70.80	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1703	148.90	37.10	100.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1704	303.30	60.70	80.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1705	366.00	73.00	60.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1706	325.80	65.20	40.0	0.909	0.814	1.098	1.800	1.150	11.20	0.1180	0.230	2.000	3.000	2	2	5
1707	38.00	38.00	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1708	42.60	42.50	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1709	100.50	100.50	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1710	118.50	118.50	50.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1711	118.50	118.50	34.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1712	75.00	37.50	102.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1713	119.60	59.90	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1714	189.00	94.00	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1715	200.50	100.50	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1716	45.60	45.60	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1717	80.50	80.50	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1718	120.00	120.00	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1719	153.00	153.00	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1720	54.70	54.80	90.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1721	54.70	54.80	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1722	114.00	114.00	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1723	29.20	58.80	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1724	64.50	109.50	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1725	82.00	164.00	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1726	92.00	182.00	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1727	56.30	56.20	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1728	91.30	91.20	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1729	130.50	130.50	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1730	153.00	153.00	50.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1731	133.00	133.00	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1732	67.70	33.80	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1733	126.80	63.20	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1734	203.30	101.50	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1735	213.00	106.00	50.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1736	178.90	89.10	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1737	109.50	219.50	80.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1738	136.00	272.00	61.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1739	111.50	223.50	40.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1740	126.20	253.80	50.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1741	55.80	111.70	100.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1742	69.50	346.50	40.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1743	73.00	365.00	60.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1744	72.00	366.00	60.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1745	58.20	291.80	80.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1746	69.30	346.70	50.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1747	40.50	203.50	100.0	0.909	0.814	1.098	1.800	1.150	11.00	0.1180	0.230	2.000	3.000	2	2	5
1748	54.70	54.80	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1749	97.50	97.50	61.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1750	97.50	97.50	61.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1751	54.70	54.80	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1752	122.00	122.00	50.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1753	126.00	126.00	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1754	39.80	36.20	100.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1755	59.10	50.40	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5
1756	97.50	97.50	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	5

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Cr*
Group-13 Data:																
1757	46.60	155.50	200.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1758	46.60	155.50	166.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1759	46.60	147.80	144.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1760	46.60	132.20	126.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1761	46.60	122.50	108.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1762	46.60	100.10	100.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1763	46.60	80.00	76.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1764	46.60	70.00	66.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1765	46.60	36.90	42.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1766	46.60	14.39	28.0	0.250	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1767	46.60	134.00	240.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1768	46.60	151.80	200.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1769	46.60	159.20	168.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1770	46.60	172.30	140.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1771	46.60	175.00	116.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1772	46.60	162.20	100.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1773	46.60	122.50	62.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1774	46.60	118.70	62.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1775	46.60	75.80	40.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1776	46.60	15.56	20.0	0.500	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1777	46.60	155.60	136.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1778	46.60	178.90	108.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1779	46.60	198.10	86.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1780	46.60	186.70	68.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1781	46.60	178.90	56.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1782	46.60	124.30	40.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1783	46.60	73.90	28.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
1784	46.60	57.10	24.0	1.000	0.780	1.403	1.330	22.200	18.90	0.1110	0.230	1.938	1.002	4	2	34
Group-14 Data:																
1785	49.40	6.80	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1760	0.294	1.070	3.000	4	2	35
1786	98.60	13.50	65.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1760	0.294	1.070	3.000	4	2	35
1787	49.40	6.80	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1950	0.237	1.129	3.000	4	2	36
1788	98.60	13.50	65.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1950	0.237	1.129	3.000	4	2	36
1789	49.40	6.80	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1950	0.237	1.147	3.000	4	2	37
1790	98.60	13.50	65.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1950	0.237	1.147	3.000	4	2	37
1791	49.40	6.80	83.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1850	0.303	1.080	3.000	4	2	38
1792	49.40	6.80	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1850	0.303	1.128	3.000	4	2	39
1793	49.40	6.80	80.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1770	0.297	1.094	3.000	4	2	40
1794	98.60	13.50	55.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1770	0.297	1.094	3.000	4	2	40
1795	49.40	6.80	80.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1750	0.200	1.047	3.000	4	2	41
1796	49.40	6.80	80.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1700	0.274	1.094	3.000	4	2	42
1797	98.60	13.50	55.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1700	0.274	1.094	3.000	4	2	42
1798	49.40	6.80	90.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1880	0.274	1.080	3.000	4	2	43
1799	98.60	13.50	70.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1880	0.274	1.080	3.000	4	2	43
1800	49.40	6.80	90.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1650	0.258	1.087	3.000	4	2	44

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1801	98.60	13.50	70.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1650	0.258	1.087	3.000	4	2	44
1802	49.40	6.80	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1880	0.333	1.087	3.000	4	2	45
1803	98.60	13.50	70.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1880	0.333	1.087	3.000	4	2	45
1804	49.40	6.80	88.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1880	0.333	1.100	3.000	4	2	46
1805	49.40	6.80	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1700	0.274	1.100	3.000	4	2	47
1806	49.40	6.80	70.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1800	0.212	1.430	3.000	4	2	48
1807	49.40	6.80	80.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1750	0.154	1.210	3.000	4	2	49
1808	98.60	13.50	60.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1750	0.154	1.210	3.000	4	2	49
1809	49.40	6.80	78.0	0.600	0.950	1.088	3.080	0.980	14.50	0.1750	0.154	1.210	3.000	4	2	50
1810	49.40	6.80	90.0	0.600	0.929	1.072	2.890	1.020	13.00	0.2500	0.405	1.070	3.000	4	2	51
1811	49.40	6.80	83.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1880	0.410	1.070	3.000	4	2	51
1812	49.40	6.80	90.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1813	49.40	6.80	83.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1130	0.327	1.070	3.000	4	2	51
1814	49.40	6.80	80.0	0.600	0.929	1.072	2.890	1.020	13.00	0.2500	0.231	1.070	3.000	4	2	51
1815	49.40	6.80	83.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1880	0.236	1.070	3.000	4	2	51
1816	49.40	6.80	83.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1250	0.231	1.070	3.000	4	2	51
1817	49.40	6.80	83.0	0.600	0.929	1.072	2.890	1.020	13.00	0.0800	0.258	1.070	3.000	4	2	51
1818	49.40	6.80	85.0	0.600	0.929	1.072	2.890	1.020	13.00	0.2500	0.108	1.070	3.000	4	2	51
1819	49.40	6.80	85.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1250	0.101	1.070	3.000	4	2	51
1820	49.40	6.80	85.0	0.600	0.929	1.072	2.890	1.020	13.00	0.0620	0.103	1.070	3.000	4	2	51
1821	49.40	6.80	85.0	0.600	0.929	1.072	2.890	1.020	13.00	0.0520	0.465	1.070	3.000	4	2	51
1822	43.90	12.30	87.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1823	77.80	34.30	65.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1824	39.30	16.90	90.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1825	78.60	33.50	55.0	0.600	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1826	49.40	6.80	100.0	0.300	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1827	98.60	13.50	85.0	0.300	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1828	43.90	12.30	105.0	0.300	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1829	39.30	16.90	105.0	0.300	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1830	49.40	6.80	70.0	0.900	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1831	98.60	13.50	60.0	0.900	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1832	43.90	12.30	73.0	0.900	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1833	77.80	34.30	55.0	0.900	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1834	39.30	16.90	70.0	0.900	0.929	1.072	2.890	1.020	13.00	0.1760	0.294	1.070	3.000	4	2	51
1835	49.40	6.80	100.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1836	98.60	13.50	90.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1837	49.40	6.80	105.0	0.600	0.849	1.000	2.210	0.900	10.70	0.0620	0.103	1.070	3.000	4	2	51
1838	49.40	6.80	100.0	0.600	0.849	1.000	2.210	0.900	10.70	0.2500	0.108	1.070	3.000	4	2	51
1839	49.40	6.80	100.0	0.600	0.849	1.000	2.210	0.900	10.70	0.0800	0.258	1.070	3.000	4	2	51
1840	49.40	6.80	100.0	0.600	0.849	1.000	2.210	0.900	10.70	0.2500	0.231	1.070	3.000	4	2	51
1841	49.40	6.80	100.0	0.600	0.849	1.000	2.210	0.900	10.70	0.2500	0.405	1.070	3.000	4	2	51
1842	39.30	16.90	100.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1843	78.60	33.50	90.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1844	60.40	51.70	90.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1845	49.40	6.80	90.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1846	98.60	13.50	77.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1847	39.30	16.90	85.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1848	78.60	33.50	70.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1849	49.40	6.80	115.0	0.300	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1850	98.60	13.50	102.0	0.300	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1851	39.30	16.90	115.0	0.300	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1852	78.60	33.50	95.0	0.300	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1853	49.40	6.80	70.0	0.900	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1854	98.60	13.50	57.0	0.900	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1855	39.30	16.90	64.0	0.900	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1856	78.60	33.50	45.0	0.900	0.849	1.000	2.210	0.900	10.70	0.1760	0.294	1.070	3.000	4	2	51
1857	49.40	6.80	80.0	0.600	0.849	1.000	2.210	0.900	10.70	0.0620	0.103	1.070	3.000	4	2	51
1858	49.40	6.80	80.0	0.600	0.849	1.000	2.210	0.900	10.70	0.2500	0.108	1.070	3.000	4	2	51
1859	49.40	6.80	85.0	0.600	0.849	1.000	2.210	0.900	10.70	0.0800	0.258	1.070	3.000	4	2	51
1860	49.40	6.80	85.0	0.600	0.849	1.000	2.210	0.900	10.70	0.2500	0.231	1.070	3.000	4	2	51
1861	49.40	6.80	90.0	0.600	0.849	1.000	2.210	0.900	10.70	0.2500	0.405	1.070	3.000	4	2	51
1862	49.40	6.80	90.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1880	0.410	1.070	3.000	4	2	51
1863	49.40	6.80	86.0	0.600	0.849	1.000	2.210	0.900	10.70	0.0520	0.465	1.070	3.000	4	2	51
1864	49.40	6.80	87.0	0.600	0.849	1.000	2.210	0.900	10.70	0.1880	0.236	1.070	3.000	4	2	51
1865	78.60	33.50	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1866	49.40	6.80	110.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1867	98.60	13.50	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1868	49.40	6.80	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.0620	0.103	1.070	3.000	4	2	51
1869	24.60	31.60	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1870	49.40	6.80	95.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1871	49.40	6.80	90.0	0.600	0.858	1.046	2.390	0.920	10.60	0.0620	0.103	1.070	3.000	4	2	51
1872	49.40	6.80	95.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1250	0.101	1.070	3.000	4	2	51
1873	49.40	6.80	95.0	0.600	0.858	1.046	2.390	0.920	10.60	0.2500	0.108	1.070	3.000	4	2	51
1874	49.40	6.80	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.0800	0.258	1.070	3.000	4	2	51
1875	49.40	6.80	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1250	0.231	1.070	3.000	4	2	51
1876	49.40	6.80	95.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1880	0.236	1.070	3.000	4	2	51
1877	49.40	6.80	95.0	0.600	0.858	1.046	2.390	0.920	10.60	0.2500	0.231	1.070	3.000	4	2	51
1878	49.40	6.80	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1130	0.327	1.070	3.000	4	2	51
1879	49.40	6.80	95.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1880	98.60	13.50	85.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1881	49.40	6.80	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1880	0.410	1.070	3.000	4	2	51
1882	49.40	6.80	100.0	0.600	0.858	1.046	2.390	0.920	10.60	0.2500	0.405	1.070	3.000	4	2	51
1883	43.90	12.30	90.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1884	78.60	33.50	72.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1885	30.20	26.00	92.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1886	45.30	38.80	80.0	0.600	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1887	49.40	6.80	120.0	0.300	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1888	98.60	13.50	110.0	0.300	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1889	39.30	16.90	120.0	0.300	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1890	78.60	33.50	110.0	0.300	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1891	30.20	26.00	120.0	0.300	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1892	45.30	38.80	110.0	0.300	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1893	49.40	6.80	80.0	0.900	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1894	98.60	13.50	65.0	0.900	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1895	39.30	16.90	70.0	0.900	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1896	78.60	33.50	60.0	0.900	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1897	30.20	26.00	70.0	0.900	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1898	45.30	38.80	65.0	0.900	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1899	49.40	6.80	90.0	1.200	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1900	98.60	13.50	60.0	1.200	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1901	39.30	16.90	65.0	1.200	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1902	78.60	33.50	55.0	1.200	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1903	30.20	26.00	65.0	1.200	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1904	45.30	38.80	63.0	1.200	0.858	1.046	2.390	0.920	10.60	0.1760	0.294	1.070	3.000	4	2	51
1905	49.40	6.80	100.0	0.600	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1906	98.60	13.50	90.0	0.600	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1907	39.30	16.90	95.0	0.600	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1908	30.20	26.00	90.0	0.600	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1909	49.40	6.80	120.0	0.300	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1910	49.40	6.80	120.0	0.300	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1911	98.60	13.50	110.0	0.300	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1912	39.30	16.90	115.0	0.300	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1913	30.20	26.00	110.0	0.300	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1914	49.40	6.80	90.0	0.900	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1915	98.60	13.50	80.0	0.900	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1916	39.30	16.90	80.0	0.900	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1917	30.20	26.00	85.0	0.900	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
1918	24.60	31.60	80.0	0.900	0.882	1.327	2.290	1.740	12.00	0.1760	0.294	1.070	3.000	4	2	51
Group-15 Data:																
1919	98.00	171.00	50.0	1.000	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1920	38.90	68.10	60.0	0.500	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1921	24.40	42.50	66.0	0.500	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1922	24.40	42.50	65.0	1.000	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1923	53.50	93.60	50.0	1.000	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1924	60.90	106.20	40.0	1.000	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1925	72.90	127.80	70.0	0.500	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1926	72.90	127.80	100.0	0.500	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1927	72.90	127.80	65.0	1.000	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
1928	68.00	119.20	65.0	1.000	1.002	1.366	1.030	1.570	16.50	0.1250	0.230	2.000	3.000	1	2	31
Group-16 Data:																
1929	66.50	66.50	30.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52
1930	66.80	66.70	50.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52
1931	73.50	73.50	42.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52
1932	51.80	51.70	63.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52
1933	41.70	41.70	70.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52
1934	34.00	34.10	80.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52
1935	21.20	21.30	90.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	2.000	3.000	3	2	52

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1936	73.00	73.00	30.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	4.000	3.000	3	2	52
1937	78.80	78.70	40.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	4.000	3.000	3	2	52
1938	71.50	71.50	50.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	4.000	3.000	3	2	52
1939	62.30	62.20	60.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	4.000	3.000	3	2	52
1940	36.50	36.50	80.0	0.909	0.874	1.196	2.290	1.196	19.50	0.1180	0.230	4.000	3.000	3	2	52
Group-17 Data:																
1941	91.00	91.00	23.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1942	91.20	91.10	30.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1943	73.00	73.00	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1944	57.80	57.70	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1945	34.90	35.00	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1946	105.50	105.50	25.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1947	120.00	120.00	28.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1948	84.20	84.30	40.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1949	68.20	68.30	60.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
1950	41.00	41.00	80.0	0.909	0.814	1.001	1.800	1.002	11.20	0.1180	0.230	2.000	3.000	1	2	52
Group-18 Data:																
1951	39.80	46.10	72.6	0.175	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1952	41.80	6.87	72.6	0.124	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1953	40.40	16.69	72.6	0.132	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1954	40.40	104.10	72.6	0.264	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1955	41.80	57.20	72.6	0.202	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1956	39.90	55.60	72.6	0.179	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1957	40.80	264.50	72.6	0.435	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1958	40.00	41.70	72.6	0.156	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1959	40.70	31.80	72.6	0.148	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1960	41.70	82.40	72.6	0.226	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1961	41.40	203.70	72.6	0.381	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1962	41.20	149.30	72.6	0.303	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1963	41.80	94.60	59.9	0.283	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1964	41.60	134.70	59.9	0.334	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1965	40.40	49.50	59.9	0.204	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1966	40.90	179.10	59.9	0.398	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1967	41.00	211.80	59.9	0.444	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1968	40.30	213.20	59.9	0.449	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1969	41.60	201.20	35.7	0.691	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1970	39.80	26.90	35.7	0.256	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1971	40.20	174.90	35.7	0.724	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1972	40.00	154.20	35.7	0.606	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1973	40.00	149.60	35.7	0.606	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1974	41.60	52.00	35.7	0.294	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1975	41.10	17.65	17.5	0.545	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1976	41.70	31.20	17.5	0.637	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1977	39.80	47.30	17.5	0.708	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1978	40.40	107.70	17.5	1.072	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1979	20.73	33.00	72.6	0.101	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1980	19.92	103.40	72.6	0.210	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
1981	19.47	66.80	72.6	0.171	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1982	18.95	232.30	72.6	0.358	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1983	19.15	8.28	72.6	0.089	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1984	20.52	177.90	72.6	0.303	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1985	20.16	48.70	59.9	0.159	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1986	20.81	83.00	59.9	0.195	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1987	20.60	122.00	59.9	0.246	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1988	20.48	180.80	59.9	0.314	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1989	20.16	200.30	59.9	0.338	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1990	20.32	36.60	17.5	0.421	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1991	78.30	35.10	72.6	0.208	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1992	80.80	41.00	59.9	0.267	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1993	82.90	122.40	59.9	0.450	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1994	116.60	21.21	72.6	0.234	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1995	120.80	42.30	72.6	0.405	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
1996	117.60	13.82	72.6	0.229	0.996	0.805	1.060	0.614	10.10	0.0313	0.250	2.000	1.000	4	1	1
Group-19 Data:																
1997	5.60	31.90	75.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
1998	8.60	56.20	65.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
1999	11.40	75.00	55.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2000	13.60	93.80	45.0	0.600	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2001	2.80	16.00	65.0	1.000	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2002	5.60	31.90	55.0	1.000	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2003	8.60	47.60	45.0	1.000	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2004	2.80	16.00	55.0	1.500	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2005	5.60	31.90	45.0	1.500	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2006	8.60	47.60	45.0	1.500	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	8
2007	4.20	22.60	105.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2008	8.20	45.40	95.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2009	10.40	69.80	75.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2010	16.20	91.00	55.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2011	4.20	22.60	95.0	0.440	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2012	8.20	45.40	85.0	0.440	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2013	10.40	69.80	55.0	0.440	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2014	13.70	39.90	85.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2015	10.00	16.80	105.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2016	11.90	14.90	95.0	0.260	1.088	0.950	0.980	3.080	14.50	0.1250	0.230	2.000	3.000	4	1	9
2017	4.40	22.40	65.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2018	7.00	46.60	55.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2019	13.20	67.00	45.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2020	4.40	22.40	95.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2021	7.00	46.60	85.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2022	13.20	67.00	75.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2023	17.80	89.40	65.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2024	4.40	22.40	95.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2025	7.00	46.60	85.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Cr*
2026	13.20	67.00	85.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2027	17.80	89.40	75.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	9
2028	4.40	22.40	95.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1880	0.230	2.000	3.000	4	1	9
2029	7.00	46.60	85.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1880	0.230	2.000	3.000	4	1	9
2030	13.20	67.00	75.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1880	0.230	2.000	3.000	4	1	9
2031	17.80	89.40	65.0	0.440	1.000	0.849	0.802	2.400	10.70	0.1880	0.230	2.000	3.000	4	1	9
2032	4.40	22.40	95.0	0.440	1.000	0.849	0.802	2.400	10.70	0.0630	0.230	2.000	3.000	4	1	9
2033	7.00	46.60	75.0	0.440	1.000	0.849	0.802	2.400	10.70	0.0630	0.230	2.000	3.000	4	1	9
2034	13.20	67.00	75.0	0.440	1.000	0.849	0.802	2.400	10.70	0.0630	0.230	2.000	3.000	4	1	9
2035	17.80	89.40	65.0	0.440	1.000	0.849	0.802	2.400	10.70	0.0630	0.230	2.000	3.000	4	1	9
2036	4.40	22.40	95.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2037	7.00	46.60	85.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2038	13.20	67.00	85.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2039	17.80	89.40	75.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2040	4.40	22.40	75.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2041	7.00	46.60	65.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2042	13.20	67.00	55.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2043	17.80	89.40	55.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	8
2044	4.40	22.40	95.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	8
2045	7.00	46.60	85.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	8
2046	13.20	67.00	85.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	8
2047	17.80	89.40	75.0	0.700	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	4.000	3.000	4	1	8
2048	4.40	22.40	55.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	11
2049	7.00	46.60	45.0	1.000	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	11
2050	4.40	22.40	105.0	0.250	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	11
2051	7.00	46.60	95.0	0.250	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	11
2052	13.20	67.00	95.0	0.250	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	11
2053	17.80	89.40	85.0	0.250	1.000	0.849	0.802	2.400	10.70	0.1250	0.230	2.000	3.000	4	1	11
2054	5.60	31.90	95.0	0.600	0.950	1.088	3.080	0.980	14.50	0.0940	0.230	2.000	3.000	4	2	53
2055	8.60	47.60	85.0	0.600	0.950	1.088	3.080	0.980	14.50	0.0940	0.230	2.000	3.000	4	2	53
2056	11.40	63.60	75.0	0.600	0.950	1.088	3.080	0.980	14.50	0.0940	0.230	2.000	3.000	4	2	53
2057	31.60	68.90	105.0	0.500	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	10
2058	63.00	138.00	115.0	0.500	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	10
2059	84.50	183.50	120.0	0.500	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	10
2060	29.30	71.20	75.0	1.000	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	10
2061	4.40	22.40	65.0	1.000	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2062	7.00	46.60	55.0	1.000	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2063	13.20	67.00	45.0	1.000	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2064	17.80	89.40	45.0	1.000	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2065	4.40	22.40	95.0	0.440	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2066	7.00	46.60	85.0	0.440	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2067	13.20	67.00	75.0	0.440	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2068	17.80	89.40	65.0	0.440	1.000	0.850	0.810	2.420	11.00	0.1250	0.230	2.000	3.000	4	1	9
2069	4.40	22.40	75.0	1.000	1.000	0.845	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	9
2070	7.00	46.60	65.0	1.000	1.000	0.845	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	9

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
2071	13.20	67.00	55.0	1.000	1.000	0.845	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	9
2072	4.40	22.40	55.0	1.000	1.000	0.845	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	11
2073	7.00	46.60	45.0	1.000	1.000	0.845	0.802	2.400	10.70	0.1250	0.420	2.000	3.000	4	1	11
2074	4.40	22.40	105.0	0.250	1.000	0.845	0.802	2.400	10.70	0.1250	0.230	0.	3.000	4	1	12
2075	7.00	46.60	95.0	0.250	1.000	0.845	0.802	2.400	10.70	0.1250	0.230	0.	3.000	4	1	12
2076	13.20	67.00	85.0	0.250	1.000	0.845	0.802	2.400	10.70	0.1250	0.230	0.	3.000	4	1	12
2077	17.80	89.40	85.0	0.250	1.000	0.845	0.802	2.400	10.70	0.1250	0.230	0.	3.000	4	1	12
2078	4.40	22.40	65.0	0.440	1.000	0.845	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	9
2079	7.00	46.60	55.0	0.440	1.000	0.845	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	9
2080	13.20	67.00	45.0	0.440	1.000	0.845	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	9
2081	17.80	89.40	35.0	0.440	1.000	0.845	0.802	2.400	10.70	0.1250	0.100	4.000	3.000	4	1	9
Group-20 Data:																
2082	22.50	36.00	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2083	32.30	32.70	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2084	44.30	29.90	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2085	52.90	23.70	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2086	63.50	20.70	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2087	63.80	18.60	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2088	21.50	39.80	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2089	32.30	33.50	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2090	44.20	32.80	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2091	52.90	25.50	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2092	63.80	25.30	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2093	74.60	17.20	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2094	85.00	16.30	120.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2095	10.90	33.40	300.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2096	22.50	25.20	300.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2097	32.30	23.40	300.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2098	44.30	19.30	300.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2099	63.80	11.90	300.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2100	22.50	32.70	180.0	0.110	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2101	32.30	37.90	180.0	0.110	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2102	44.10	32.30	180.0	0.110	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2103	52.90	25.50	180.0	0.110	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2104	63.80	18.60	180.0	0.110	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2105	9.10	29.90	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2106	15.30	27.30	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2107	22.50	22.40	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2108	32.30	21.50	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2109	44.30	14.70	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2110	15.20	34.70	180.0	0.480	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2111	22.50	27.00	180.0	0.480	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2112	32.40	20.60	180.0	0.480	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2113	44.20	16.30	180.0	0.480	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2114	20.20	30.00	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2115	43.70	36.50	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
2116	63.00	11.40	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2117	84.60	8.50	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2118	22.80	49.50	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2119	43.30	40.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2120	43.40	37.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2121	53.20	37.10	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2122	63.00	27.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2123	85.40	15.60	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2124	32.40	41.10	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2125	39.40	59.10	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2126	84.80	70.50	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2127	105.00	57.80	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2128	127.20	25.30	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2129	22.80	59.90	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2130	43.40	46.60	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2131	43.40	44.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2132	63.00	34.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2133	85.40	24.20	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2134	27.80	66.90	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2135	84.80	57.60	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2136	105.00	40.10	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2137	127.00	33.40	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2138	44.90	62.90	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2139	84.80	62.80	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2140	105.00	41.80	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2141	130.00	32.80	180.0	0.260	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2142	22.10	54.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2143	43.40	46.80	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2144	63.00	33.90	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2145	85.00	21.90	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2146	22.80	58.70	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2147	43.40	56.40	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2148	43.40	49.00	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2149	63.00	39.40	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2150	74.00	33.90	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2151	85.00	22.90	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2152	103.20	13.10	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2153	32.20	39.40	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2154	43.40	34.70	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2155	63.00	21.00	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2156	85.40	14.80	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2157	22.80	45.90	180.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2158	63.00	94.80	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2159	74.30	77.20	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2160	84.60	45.70	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm³)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
2161	104.60	20.80	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2162	110.70	17.00	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2163	13.10	39.40	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2164	22.80	36.60	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2165	30.10	32.10	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2166	38.70	9.90	180.0	0.230	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2167	10.90	35.00	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2168	22.40	27.70	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2169	32.20	27.70	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2170	44.30	19.60	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2171	63.80	11.90	180.0	0.240	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2172	22.60	44.40	180.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2173	33.50	37.00	180.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2174	43.90	34.50	180.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2175	54.10	27.90	180.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2176	64.00	25.00	180.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2177	85.00	14.70	180.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2178	10.90	41.30	240.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2179	22.50	30.80	240.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2180	32.30	23.40	240.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2181	44.30	18.70	240.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2182	63.80	10.00	240.0	0.250	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2183	10.90	28.00	300.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2184	22.50	22.70	300.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2185	32.30	18.50	300.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2186	44.70	9.70	300.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2187	44.70	14.70	300.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2188	52.90	3.50	300.0	0.270	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2189	8.30	51.00	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2190	22.40	39.60	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2191	30.60	33.60	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2192	43.80	25.40	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2193	52.00	22.80	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2194	63.40	16.90	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2195	76.20	12.50	180.0	0.140	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2196	22.40	31.80	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2197	26.90	29.40	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2198	34.90	26.60	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2199	43.70	21.20	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2200	52.20	15.50	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2201	63.80	9.40	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2202	76.00	4.10	180.0	0.360	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2203	18.00	44.50	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2204	22.40	39.50	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2205	27.00	39.70	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
2206	35.00	32.60	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2207	41.00	21.20	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2208	43.80	25.50	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2209	62.30	14.50	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2210	73.80	11.60	180.0	0.510	0.998	0.864	1.060	0.585	34.00	0.1250	0.246	2.000	2.875	4	1	2
2211	58.40	29.20	8.5	1.125	1.001	0.867	1.020	0.594	29.40	0.0310	0.054	2.000	2.000	2	1	1
2212	58.40	29.20	8.5	1.375	1.001	0.867	1.020	0.594	29.40	0.0310	0.054	2.000	2.000	2	1	1
2213	58.40	29.20	16.0	1.063	1.001	0.867	1.020	0.594	29.40	0.0310	0.054	2.000	2.000	2	1	1
2214	58.40	29.20	16.0	1.250	1.001	0.867	1.020	0.594	29.40	0.0310	0.054	2.000	2.000	2	1	1
2215	70.00	35.00	20.0	1.375	1.001	0.867	1.020	0.594	29.40	0.0310	0.054	2.000	2.000	2	1	1
2216	16.60	115.20	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2217	17.82	96.70	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2218	20.00	71.60	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2219	24.00	45.00	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2220	29.25	29.80	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2221	35.60	24.00	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2222	41.90	24.50	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2223	55.00	20.80	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2224	75.70	13.18	5.3	1.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2225	41.40	123.00	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2226	47.40	80.50	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2227	52.00	57.50	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2228	53.70	48.90	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2229	61.10	46.60	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2230	64.10	48.60	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2231	68.70	51.00	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2232	90.00	46.70	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2233	105.50	42.60	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2234	141.60	35.20	5.3	2.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2235	66.50	124.80	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2236	72.40	95.50	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2237	73.00	82.50	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2238	76.60	81.60	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2239	78.30	77.90	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2240	87.50	75.10	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2241	93.30	72.90	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2242	107.80	74.60	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2243	114.00	74.70	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2244	142.90	67.00	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2245	149.80	63.20	5.3	3.000	1.000	0.860	1.000	0.564	20.00	0.0630	0.230	7.375	2.000	4	1	7
2246	76.60	38.40	70.0	0.700	1.161	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	2	1	1
2247	103.40	51.70	60.0	1.000	1.161	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	2	1	1
2248	137.40	69.10	50.0	1.000	1.161	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	2	1	1
2249	125.40	55.30	40.0	1.375	1.161	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	2	1	1
2250	104.80	47.70	60.0	1.000	1.161	0.802	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	2	1	1

Table A-3 (continued)

Point No.	V_C (ft/hr)	V_D	F (cycles/min)	A (in.)	ρ_C (gm/cm^3)	ρ_D	μ_C (centipoise)	μ_D	γ (dynes/cm)	d (in.)	ϵ	S (in.)	D (in.)	Tr*	CP*	Ct*
2251	102.00	63.90	50.0	1.000	1.035	0.840	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	1	1	1
2252	88.00	55.10	60.0	1.000	1.035	0.840	0.970	1.300	16.00	0.1250	0.230	2.000	1.920	1	1	1

Table A-4. Analysis of Variance Calculations

Case	Dependent Variable (Y)	Independent Variable X_1	X_2	X_3	X_4	Benzene-Water Multiple R	Benzene-Water F Statistic	Heptane-Water Multiple R	Heptane-Water F Statistic
I	Y03[a]	ln A	ln π_D	X22[b]	0	0.9981	1.83	0.9909	1.84
II	Y03	X22	ln A	ln π_D	0	0.9963	5.29	0.990	2.47
III	Y03	ln π_D	X22	ln A	0	0.9961	5.65	0.991	1.90
IV	Y03	ln A	ln $(\Delta_D+\Delta_c)$	X22	0	0.9973	3.39	0.989	2.36
V	Y03	ln A	ln π_c	X22	0	0.9960	5.96	-	-
VI	Y24	ln A	ln π_c	X22	0	0.9969	6.23	0.990	-
VII	Y24	ln A	ln π_c	X22	0	0.9969	6.23	0.990	-
VIII	Y03	ln A	ln π_V	X22	0	0.9974	3.26	-	-
IX	Y03	ln A	ln π_M	X22	0	0.9973	3.35	-	-
X	ln (V_D+V_c)	0	FA	0	0	0.9270	22.2	0.967	2.06
XI	ln (V_D+V_c)	0	ln FA	0	0	0.9540	13.8	0.930	4.44
XII	Y03	A	FA	(V_D/V_c)	0	0.9987	0.71	0.947	12.10
XIII	Y03	A	π_D	(V_D/V_c)	0	0.9988	0.58	0.948	12.9
XIV	Y23	ln A	ln π'_D	X22	0	0.9982	1.75	0.989	2.29
XV	Y03	ln A	ln π'_D	X22	0	0.9982	1.66	-	-
XVI	Y07	ln A	ln π_V	X22	0	0.9976	3.28	-	-
XVII	Y11	ln A	ln π_V	X22	0	0.9978	2.77	-	-
XVIII	ln (V_D+V_c)	X22	ln FA	0	0	0.9855	4.16	0.9665	2.06
XIX	Y12	ln FA	0	0	0	0.9819	4.36	0.9559	6.20
XX	Y12	ln A	ln π_M	ln F	0	0.9874	3.85	0.9772	3.28
XXI	Y08	ln A	ln π_M	ln F	0	0.9973	3.78	0.9900	2.10
XXII	Y07	ln A	ln π_M	X22	0	0.9976	3.28	0.9884	1.80
XXIII	Y11	ln A	ln π_M	X22	0	0.9978	2.81	0.9884	1.26
XXIV	Y07	ln A	ln π_V	X22	0	0.9976	3.22	0.9900	1.54
XXV	Y11	ln A	ln π_V	X22	0	0.9978	2.75	0.9899	1.07
XXVI	Y07	ln A	ln π_V	ln π_M	X22	0.9984	2.41	0.9955	0.59
XXVII	Y09	ln A	ln π_M	X22	0	0.9976	3.40	0.9930	0.84
XXVIII	Y09	ln A	ln π_M	ln π_V	X22	0.9984	2.52	0.9945	0.49
XXIX	Y09	ln A	ln π_V	X22	0	0.9976	3.21	0.9930	0.85
XXX	Y10	ln A	ln π_M	X22	0	0.9976	3.32	0.9927	1.17
XXXI	Y07	ln A	ln π_M	X22	0	0.9983	2.16	0.9929	1.02
XXXII	Y08	ln A	ln π_M	0	0	0.9978	2.45	0.9908	1.88
XXXIII	Y11	ln A	ln π_M	X22	0	0.9984	2.04	0.9929	1.68
XXXIV	Y12	ln A	ln π_M	-	-	0.9901	2.51	0.9794	2.96
XXXV[d]	Y12	ln π_M	ln π_V	X23	0	0.9958	0.20	-	-

[a]See Table A-5.

[b]See Table A-6.

[c]Terms 14 through 16, in parentheses( ), were used only for Cases XXXI through XXIV. For all other cases $b_{13} = b_{14} = b_{15} = 0$.

[d]Instead of the term $b_5 X_1X_2$, the term $b_5 X_1/X_2$ was used in this case.

Regression Model

$$Y = b_o + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_1X_2 + b_6X_1X_3 + b_7X_1X_4 + b_8X_1^2 + b_9X_2^2 + b_{10}X_3^2 + b_{11}X_4^2 + b_{12}X_2^3 + (b_{13}X_2^4 + b_{14}X_2^5 + b_{15}X_2^6)^c.$$

Table A-5. List of Dependent Variables Used, All Dimensionless[a] Except Where Noted

Symbol	Definition
Y01	$\ln (\bar{V}_o \mu_c/\gamma)$
Y02	$\ln [(V_c + V_D) \mu_c/\gamma]$
Y03	$\ln (V_D/\Delta_D)$
Y04	$\ln (\bar{V}_o/\Delta_D)$
Y05	$\ln [(V_c + V_D)/\bar{V}_o]$
Y06	$\ln [(V_c + V_D)/(\epsilon FA)]$
Y07	$\ln [(V_c + V_D)/(\Delta_c + \Delta_D)]$
Y08	$\ln [\bar{V}_o/(\Delta_c + \Delta_D)]$
Y09	$\ln [(V_c + V_D)/\Delta_G]$
Y10	$\ln (\bar{V}_o/\Delta_G)$
Y11	$\ln (V_c/\Delta_c + V_D/\Delta_D)$
Y12	$\ln (\bar{V}_o)^b$
Y13	$\ln (V_s/\Delta_G)$
Y14	$\ln [V_s/(\Delta_c + \Delta_D)]$
Y15	$\ln [V_D/(x_f\Delta_D) + V_c/((1 - x_f) \Delta_c)]$
Y16	$(V_c + V_D)^b$
Y17	$\ln [V_c V_D/(\Delta_c \Delta_D)]$
Y18	$\ln (V_D/\bar{V}_o)$
Y19	$\ln (V_s/\Delta_D)$
Y20	$\ln [V_D/(x_f\Delta_D)]$
Y21	$\ln [V_D V_c/(\Delta_c \Delta_D x_f(1 - x_f))]$

[a] The gravitational constant must be added where appropriate to make the group dimensionless.
[b] Not dimensionless; see notes, Table A-6.

Table A-5. (Continued)

Symbol	Definition
Y22	$\ln [V_D/(FA)]$
Y23	$\ln (V_D/\pi'_D)$
Y24	$\ln (V_c/\Delta_c)$
Y25	$\ln [(V_c + V_D)\ \epsilon^{0.34}/d^{0.64}]^b$
Y26	$\ln [(V_c + V_D)\ \epsilon^{0.34}/(\Delta\rho^{0.32}\gamma^{0.20}d^{0.64})]^b$

See notes at end of Table A-6, which also apply here.

Table A-6. List of Independent Variables, All Dimensionless[a]

Symbol	Definition
X01	$\ln\ [\psi_f \mu_c^5/(\rho_c \gamma^4)]$
X02	$\ln\ [\mu_c^4 g/(\Delta\rho\gamma^3)]$
X03	$\ln\ [\mu_c^4 g/(\rho_c \gamma^3)]$
X04	$\ln\ (d\rho_c \gamma/\mu_c{}^2)$
X05	$\ln\ [\Delta\rho \pi_M^2 d/(\epsilon^2\gamma)]$, Weber No.
X06	$\ln\ [\Delta\rho \pi_D^2 d/(\epsilon^2\gamma)]$, Weber No.
X07	$\ln\ (\rho_D \pi_D^2 d/\gamma)$, Weber No.
X08	$\ln\ [\rho_D \pi_D^2 d/(\epsilon^2\gamma)]$, Weber No.
X09	$\ln\ [\Delta\rho \pi_D'^2 d/(\epsilon^2\gamma)]$, Weber No.
X10	$\ln\ [\rho_D \pi_D^2/(gA\Delta\rho)]$, Froude No.
X11	$\ln\ [\rho_D \pi_D^2/(\epsilon^2 gA\Delta\rho)]$, Froude No.
X12	$\ln\ [\rho_c (\Delta_D + \Delta_c)^2/(\epsilon^2 gA\Delta\rho)]$, Froude No.
X13	$\ln\ (d\pi_D \rho_D/\mu_D)$, Reynolds No.
X14	$\ln\ [d\pi_D \rho_D/(\epsilon\mu_D)]$, Reynolds No.
X15	$\ln\ (d\pi_c \rho_c/\mu_c)$, Reynolds No.
X16	$\ln\ [d\pi_c \rho_c/(\epsilon\mu_c)]$, Reynolds No.
X17	$\ln\ [d(\Delta_D + \Delta_c)\ \rho_{avg}/(\epsilon\mu_{avg})]$, Reynolds No.
X18	$\ln\ [\mu_c/(\Delta\rho d\gamma)^{1/2}]$, Ohnesorge No.
X19	$\ln\ [\rho_c \pi_M^2/(\epsilon^2 gA\Delta\rho)]$, Froude No.
X20	$\ln\ [\Delta\rho d\epsilon^2 g/(\rho_c \pi_M^2)]$, Drag Coefficient
X21	$\ln\ [\mu_c \pi_V/(\epsilon\gamma)]$, Capillary No.
X22	$\ln\ (V_c/V_D)$

[a]The gravitational constant must be added where appropriate to make the group dimensionless.

Table A-6. (Continued)

Symbol	Definition
X23	$\ln (A/S)$
X24	$\ln (d/D)$
X25	$\ln (\mu_D/\mu_c)$
X26	$\ln (\nu_D/\nu_c)$
X27	$\ln (\Delta\rho/\rho_c)$
X28	$\ln (\rho_D/\rho_c)$
X29	$\ln [\Delta\rho(\Delta_D + \Delta_c)^2 d/(\epsilon^2\gamma)]$, Weber No.
X30	$\ln (d/A)$
X31	$\ln (FA/\bar{V}_o)$
X32	$\ln [FA/(V_D + V_c)]$
X33	$e^{(\Delta V/V_c)}$
X34	$\ln [\Delta\rho(1 - x_f)d\epsilon^2 g/((\rho_c - x_f(\rho_c - \rho_D))\pi_M^2)]$, Drag Coefficient
X35	$\ln [\Delta\rho(1 - x_f)\pi_D^2 d/(\epsilon^2\gamma)]$, Weber No.

Note 1: Basic Variables

V_c = Continuous phase velocity, ft/hr

V_D = Dispersed phase velocity, ft/hr

A = Pulse amplitude, in.

F = Pulse frequency, cpm

γ = Interfacial tension, dynes/cm

μ_c = Continuous phase viscosity, centipoise

μ_D = Dispersed phase viscosity, centipoise

$\nu_c = \mu_c/\rho_c$

$\nu_D = \mu_D/\rho_D$

Table A-6. (Continued)

Note 1: Basic Variables (Continued)

ρ_c = Continuous phase density, g/cc

ρ_D = Dispersed phase density, g/cc

d = Pulse plate hole diameter, in.

D = Column diameter, in.

ϵ = Pulse plate free area

S = Pulse plate spacing, in.

Note 2: Developed Variables

$$\psi_f = (1 - \epsilon^2)(5FA)^3/(2\epsilon^2 C_o^2 S), \ ft^3/(hr^3 \ in.)$$

$$\lambda = (V_c - V_D)/(5\pi FA), \ \text{dimensionless}$$

$$\Delta_D = 5FA[\sqrt{1 - \lambda^2} - \lambda\,(\frac{\pi}{2} - \arcsin \lambda)], \ ft/hr$$

$$\Delta_c = 5FA[\sqrt{1 - \lambda^2} + \lambda\,(\frac{\pi}{2} + \arcsin \lambda)], \ ft/hr$$

$$\pi_D = 5\pi FA\left[\frac{\sqrt{1 - \lambda^2}}{\frac{\pi}{2} - \arcsin \lambda} - \lambda\right], \ ft/hr$$

$$\pi_c = 5\pi FA\left[\frac{\sqrt{1 - \lambda^2}}{\frac{\pi}{2} + \arcsin \lambda} + \lambda\right], \ ft/hr$$

$$\pi_M^2 = \frac{1}{2}(\pi_D{}^2 + \pi_c{}^2), \ (ft/hr)^2$$

$$\pi_V = \frac{1}{2}(\pi_D + \pi_c), \ ft/hr$$

$$\pi_D' = 10FA + V_D - V_c, \ ft/hr$$

$$\Delta\rho = |\rho_D - \rho_c|, \ g/cc$$

$$x_f = 2/(3 + \sqrt{1 + 8V_c/V_D}), \ \text{dimensionless}$$

$$\bar{V}_o = \frac{V_c}{(1 - x_f)^2} + \frac{V_D}{x_f(1 - x_f)}, \ ft/hr$$

Table A-6. (Continued)

Note 2: Developed Variables (Continued)

$$\mu_{avg} = \mu_c\ (1 + 0.25x_f)(1 - x_f) + \mu_D\ x_f,\ \text{cp}$$

$$\rho_{avg} = \rho_c\ (1 - x_f) + \rho_D\ x_f,\ \text{g/cc}$$

$$V_S = \frac{V_c}{1 - x_f} + \frac{V_D}{x_f},\ \text{ft/hr}$$

$$\Delta_D + \Delta_c = 10FA[\sqrt{1 - \lambda^2} + \lambda \text{ arc sin } \lambda],\ \text{ft/hr}$$

$$\Delta_G = V_c'\ (R + 1)/R$$

$$R = V_c/V_D = V_c'/V_D'$$ (Primed velocities are those at insufficient pulsation flooding)

$$V_c' = \frac{\frac{10\ AFR}{1 + R} \cos\left[\text{arc sin } \frac{V_c'(1 - R)}{5\pi AFR}\right]}{1 - \frac{2(1 - R)}{\pi(1 + R)}\left[\text{arc sin } \frac{V_c'(1 - R)}{5\pi AFR}\right]}$$

Note 3: Examples of Power or Cross-Product Terms involving the Above Variables

X22 4 means $(X22)^4$ or $[\ln (V_c/V_D)]^4$

X22 means e^{X22} or V_c/V_D

X22/X23 means $(X22)/(X23)$ or $[\ln (V_c/V_D)]/[\ln (A/S)]$

X22X23 means $(X22)(X23)$ or $[\ln (V_c/V_D)][\ln (A/S)]$

X22/X23 means e^{X22}/e^{X23} or $(V_c/V_D)/(A/S)$

X22X23 means $e^{X22}e^{X23}$ or $(V_c/V_D)(A/S)$

X22 3 means $[e^{X22}]^3$ or $(V_c/V_D)^3$

X22/X23 means $\ln [e^{X22}/e^{X23}]$ or $\ln [(V_c/V_D)/(A/S)]$

X22X23 means $\ln [e^{X22}e^{X23}]$ or $\ln [(V_c/V_D)(A/S)]$

X22235 means $[\ln (e^{X22}e^{X23})]^5$ or $\left\{\ln [(V_c/V_D)(A/S)]\right\}^5$

Table A-7. Summary of Flood Equations, $Y = A + \sum^{i} b_i X_i$

Details of equations having a multiple regression coefficient > 0.900, and other equations of interest. Intercepts and coefficients based on all Group 1 data unless noted otherwise.

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{y}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
Thornton Equation:												
4	Y01	-3.312	X02	0.6876	0.762	-6.737	1.124	4.973	8.992	92.4	-25.5	19.8
			X01	-0.1732	0.834							
			X27	0.8056	0.843							
			X04	0.5601	0.866							
			X25	0.1825	0.871							
Smoot-Babb Equation:												
5	Y02	-5.057	X03	0.7876	0.767	-7.898	1.138	5.088	9.650	76.1	-25.3	16.7
			X01	-0.1727	0.835							
			X04	0.7463	0.856							
			X22	0.2358	0.871							
			X25	0.2205	0.879							
			X24	-0.2829	0.883							
			X27	0.2881	0.887							
Pike Equation:												
7	Y03	-6.435	X07	-0.2698	0.668	-1.862	1.267	4.860	8.053	83.5	-31.3	22.3
			X23	-0.8799	0.773							
			X22	-0.1881	0.823							
			X10	-0.5476	0.840							
			X25	1.130	0.852							
			X13	0.9411	0.870							
			X15	-0.6538	0.876							
			X27	-0.2751	0.880							
			X24	-0.01516[d]	0.880							
31	Y07	-1.859	X31	-0.9907	0.991	(This equation redundant, Y07 and X21 too nearly alike.)						
33	Y08	0.4843	X32	-1.001	0.989	(This equation redundant, Y08 defined by X22 and X32.)						
			X22	-0.1748	0.999							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_y \cdot f(z)}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
34	Y07	-1.870	X31	-0.9917	0.991	(This equation redundant, see Eq. 31.)						
			X22	0.1660	0.999							
35	Y07	-1.831	X31	-0.9887	0.991	(This equation redundant, see Eq. 31.)						
78	Y07	-1.324	X20 3	0.01585	0.873	-1.749	1.203	6.009	11.49	55.0	-27.0	13.7
			X20	0.1638	0.887							
			X18	-0.3961	0.895							
			X17	-0.1989	0.898							
			X20 2	-0.05654	0.901							
80	Y07	-1.699	X20	0.5145	0.817	-1.749	1.203	4.208	8.151	56.3	-29.2	13.7
			X23	-0.2947	0.845							
			X18	-0.3797	0.862							
			X17 3	-0.04106	0.883							
			X17 2	0.4729	0.894							
			X22	0.1584	0.903							
			X17	-1.503	0.904							
81	Y07	-1.811	X20 3	0.008147	0.873	-1.749	1.203	5.715	12.41	41.3	-25.4	9.9
			X20	0.08118	0.887							
			X18	-0.5759	0.895							
			X23	-0.3179	0.904							
			X17	-0.3600	0.913							
			X22	0.1484	0.919							
			X20 2	-0.07297	0.924							
82	Y07	0.2923	X20 3	0.006075	0.873	-1.749	1.203	5.269	11.57	41.9	-25.7	9.8
			X20	0.1354	0.887							
			X18	-0.5218	0.895							
			X23	-0.2788	0.904							
			X17 3	-0.02597	0.916							
			X22	0.1447	0.923							
			X20 2	-0.07069	0.925							
			X17	-1.903	0.925							
			X17 2	0.3664	0.926							
83	Y07	2.353	X20 3	0.01075	0.873	-1.749	1.203	5.367	10.64	53.9	-27.7	13.3
			X20	0.2492	0.887							
			X18	-0.3302	0.895							
			X17 3	-0.04781	0.901							
			X17 2	0.6715	0.905							
			X17	-3.037	0.907							
			X20 2	-0.05346	0.909							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (A)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{s_{y \cdot f(x)}}\right]^c$	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
111	Y07	-2.359	X20 3	0.01409	0.873	-1.749	1.203	6.278	12.92	49.8	-26.2	12.5
			X20	0.5805	0.887							
			X18	-0.3253	0.895							
			X23	-0.2030	0.904							
			X22	0.1512	0.910							
			X18/X20	1.332	0.915							
			X20 2	-0.03334	0.915							
113	Y07	-1.842	X20 3	0.01541	0.873	-1.749	1.203	5.961	11.63	51.3	-26.8	12.8
			X20	0.2833	0.887							
			X02	-0.07151	0.902							
			X20 2	-0.05380	0.905							
115	Y07	-2.364	X20 3	0.009989	0.873	-1.749	1.203	5.708	12.21	42.6	-25.9	10.1
			X20	0.2775	0.887							
			X02	-0.07892	0.902							
			X23	-0.2378	0.912							
			X22	0.1349	0.918							
			X20 2	-0.06104	0.922							
117	Y07	-1.777	X20 3	0.01073	0.873	-1.749	1.203	5.964	12.30	46.2	-25.6	10.9
			X20/X21	-0.6013	0.900							
			X21	-0.2407	0.911							
			X20 2	-0.06420	0.915							
			X20	0.07556	0.916							
120	Y07	-2.143	X20 3	0.006175	0.873	-1.749	1.203	5.490	12.29	38.6	-25.0	8.8
			X20/X21	-0.5244	0.900							
			X21	-0.2474	0.911							
			X23	-0.2005	0.919							
			X22	0.1292	0.924							
			X20 2	-0.07131	0.929							
121	Y07	-0.4048	X20/X21	-0.8399	0.863	-1.749	1.203	4.836	9.393	53.2	-28.5	13.2
			X23	-0.2783	0.884							
			X21	1.465	0.892							
			X22	0.1243	0.897							
			X20	0.3779	0.897							
			X21 3	0.04352	0.901							
			X21 2	0.4981	0.905							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{s_y \cdot f(x)}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
122	Y07	-3.741	X20 3	0.006191	0.873	-1.749	1.203	5.473	12.41	37.7	-24.6	8.6
			X20/X21	0.07198[d]	0.900							
			X21	-1.034	0.911							
			X23	-0.1807	0.919							
			X22	0.1424	0.924							
			X20 2	-0.07194	0.929							
			X20	0.2568	0.929							
			X21 2	-0.09096[d]	0.931							
123	Y07	-2.678	X20 3	0.01097	0.873	-1.749	1.203	5.898	12.32	45.1	-24.8	10.8
			X20/X21	0.009243[d]	0.900							
			X21	-0.4628[d]	0.911							
			X20 2	-0.05880	0.915							
			X20	0.2711	0.916							
			X21 3	0.009356[d]	0.918							
135	Y09	-2.421	X20 3	0.01364	0.872	-1.782	1.210	6.196	12.64	51.5	-25.6	12.7
			X20	0.5915	0.887							
			X18	-0.3344	0.895							
			X23	-0.2071	0.904							
			X22	0.1425	0.909							
			X18/X20	1.331	0.914							
			X20 2	-0.03380	0.915							
137	Y09	-1.896	X20 3	0.01488	0.872	-1.782	1.210	6.007	11.68	52.6	-26.4	13.1
			X20	0.2957	0.887							
			X02	-0.07373	0.903							
			X20 2	-0.05478	0.906							
139	Y09	-2.429	X20 3	0.009493	0.872	-1.782	1.210	5.620	11.94	42.3	-26.3	10.3
			X20	0.2894	0.887							
			X02	-0.08130	0.903							
			X23	-0.2425	0.913							
			X22	0.1259	0.918							
			X20 2	-0.06169	0.921							
			X02/X20	0.0003477[d]	0.922							
141	Y09	-1.822	X20 3	0.01016	0.872	-1.782	1.210	6.002	12.33	47.3	-25.0	11.1
			X20/X21	-0.5982	0.900							
			X21	-0.2466	0.911							
			X20 2	-0.06538	0.915							
			X20	0.08568	0.916							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
144	Y09	-2.191	X20 3	0.005635	0.872	-1.782	1.210	5.539	12.30	38.3	-25.6	9.1
			X20/X21	-0.5303	0.900							
			X21	-0.2530	0.911							
			X23	-0.2038	0.919							
			X20 2	-0.07215	0.924							
			X22	0.1202	0.928							
			X20	0.08637	0.929							
145	Y09	-0.3719	X20/X21	-0.8457	0.865	-1.782	1.210	4.891	9.482	52.2	-28.8	13.2
			X23	-0.2797	0.885							
			X21	1.507	0.893							
			X22	0.1147	0.897							
			X20	0.3792	0.898							
			X21 3	0.04388	0.901							
			X21 2	0.5060	0.905							
146	Y09	-3.658	X20 3	0.005695	0.872	-1.782	1.210	5.520	12.40	37.7	-25.3	8.9
			X20/X21	0.04527[d]	0.900							
			X21	-0.9558	0.911							
			X23	-0.1846	0.919							
			X20 2	-0.07220	0.924							
			X22	0.1326	0.928							
			X20	0.2598	0.929							
			X21 2	-0.07458[d]	0.930							
147	Y09	-2.650	X20 3	0.01042	0.872	-1.782	1.210	5.934	12.34	47.4	-23.8	11.0
			X20/X21	0.004211[d]	0.900							
			X21	-0.4197[d]	0.911							
			X20 2	-0.05962	0.915							
			X20	0.2796	0.916							
			X21 3	0.01002[d]	0.918							
151	(Same as Eq. 135, but restricted to emulsion flooding.)											
	Y09	-3.396	X20 2	0.1420	0.868	-2.027	1.139	6.591	13.44	57.8	-24.9	14.6
			X23	-0.2291	0.881							
			X22	0.1561	0.889							
			X18	-0.5766	0.897							
			X18/X20	3.572	0.898							
			X20	1.468	0.900							
			X20 3	0.03460	0.903							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
155	(Same as Eq. 139, but restricted to emulsion flooding.)											
	Y09	-2.601	X20 2	-0.08402	0.868	-2.027	1.139	5.609	11.68	42.8	-26.5	10.7
			X02	-0.07965	0.885							
			X23	-0.2640	0.899							
			X22	0.1389	0.907							
160	(Same as Eq. 144, but restricted to emulsion flooding.)											
	Y09	-2.320	X20 2	-0.1414	0.868	-2.027	1.139	5.451	11.97	38.1	-25.3	9.1
			X21	-0.2236	0.898							
			X23	-0.2276	0.909							
			X22	0.1340	0.916							
			X20/X21	-0.6576	0.917							
161	(Same as Eq. 145, but restricted to emulsion flooding.)											
	Y09	-2.950	X20/X21	-0.1440[d]	0.848	-2.027	1.139	4.666	9.391	50.2	-27.2	11.8
			X23	-0.2834	0.877							
			X21 3	0.01362[d]	0.885							
			X22	0.1445	0.891							
			X20	0.6321	0.896							
			X21	-0.3797[d]	0.901							
162	(Same as Eq. 146, but restricted to emulsion flooding.)											
	Y09	-4.270	X20 2	-0.1320	0.868	-2.027	1.139	5.465	12.06	38.8	-24.7	9.1
			X21	-1.771	0.898							
			X23	-0.2377	0.909							
			X22	0.1400	0.916							
			X20/X21	-0.5810	0.917							
			X21 2	-0.3945	0.917							
			X21 3	-0.03201	0.918							
164[e]	Y08	-3.184	X20 2	-0.1321	0.875	-0.8291	1.117	5.445	12.02	38.0	-25.2	9.1
			X21	-1.855	0.904							
			X23	-0.2327	0.913							
			X20/X21	-0.5380	0.913							
			X21 2	-0.4108	0.914							
			X21 3	-0.03300	0.915							
165[e]	Y08	-1.101	X20 2	-0.1437	0.875	-0.8291	1.117	5.418	11.90	37.8	-25.6	9.1
			X21	-0.2234	0.904							
			X23	-0.2218	0.913							
			X20/X21	-0.6363	0.913							
			X20	-0.1542[d]	0.914							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{s_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
167[e]	Y01	-5.580	X20	0.1030[d]	0.788	-6.825	1.128	5.021	11.75	34.2	-22.2	7.8
			X21 3	-0.04369	0.897							
			X20 2	-0.1068	0.914							
			X23	-0.2223	0.920							
			X21 2	-0.5443	0.925							
			X21	-1.490	0.926							
168[e]	Y01	-2.815	X20	0.07808[d]	0.788	-6.825	1.128	5.088	11.77	33.6	-22.8	7.9
			X21	0.6744	0.894							
			X20 2	-0.1223	0.916							
			X23	-0.2079	0.924							
169[e]	Y01	-4.317	X20	0.7743	0.788	-6.825	1.128	4.459	9.585	43.5	-24.9	10.0
			X21 3	-0.001916[d]	0.897							
			X23	-0.2648	0.910							
			X21 2	-0.09865[d]	0.911							
			X20/X21	0.2873[d]	0.912							
170[e]	Y10	-3.171	X20 2	-0.1307	0.871	-0.8650	1.124	5.478	11.86	40.1	-25.4	9.6
			X21	-1.832	0.901							
			X23	-0.2362	0.910							
			X20/X21	-0.5549	0.911							
			X21 2	-0.4082	0.911							
			X21 3	-0.03311	0.912							
171[e]	Y10	-1.152	X20 2	-0.1408	0.871	-0.8650	1.124	5.454	11.75	39.8	-25.7	9.6
			X21	-0.2309	0.901							
			X23	-0.2246	0.910							
			X20/X21	-0.6293	0.911							
173	Y11	-3.471	X20 3	0.01107	0.858	-1.074	1.227	8.628	17.61	38.1	-25.3	9.3
			X20/X21	0.2191[d]	0.887							
			X21	-1.345	0.900							
			X23	-0.1768	0.907							
			X22	0.1509	0.912							
			X20	0.3101	0.915							
			X21 2	-0.1766	0.916							
			X20 2	-0.04362	0.917							
174	Y11	-1.606	X20 3	0.01141	0.858	-1.074	1.227	8.548	17.31	39.4	-24.9	9.5
			X20/X21	-0.2518[d]	0.887							
			X21	-0.2742	0.900							
			X23	-0.1913	0.907							
			X22	0.1379	0.912							
			X20	0.1791	0.915							
			X20 2	-0.03878	0.916							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{s_{y \cdot f(x)}}\right]^c$	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
177	Y07	-2.154	X20 3	0.02912	0.873	-1.749	1.203	5.119	11.62	38.1	-25.7	8.8
			X20/X21	-0.6559	0.900							
			X21	-0.2351	0.913							
			X23	-0.1830	0.919							
			X22	0.1270	0.924							
			X20 2	0.0007659[d]	0.929							
			X20 5	-0.001470	0.930							
			X20 4	-0.005448	0.931							
178	Y07	-2.121	X20 3	0.03148	0.873	-1.749	1.203	5.137	12.31	35.4	-22.0	8.0
			X20/21	-0.6142	0.900							
			X20X23	0.1445	0.913							
			X21	-0.3381	0.920							
			X20 5	-0.001837	0.928							
			X20X22	-0.03436	0.933							
			X20	0.3430	0.934							
			X21X23	-0.09160	0.935							
			X23 2	0.05868	0.936							
			X21X22	-0.06530	0.937							
			X20 4	-0.006599	0.937							
			X22X23	0.04339	0.938							
			X20 2	0.04976	0.938							
			X22	-0.2051	0.939							
179	Y07	-1.860	X20 3	0.03113	0.873	-1.749	1.203	5.136	12.30	35.9	-21.8	8.0
			X20/X21	-0.6563	0.900							
			X20X23	0.1648	0.913							
			X21	-0.3029	0.920							
			X20 5	-0.001839	0.928							
			X20X22	-0.03424	0.933							
			X20	0.3752	0.934							
			X21X23	-0.07021	0.935							
			X23 2	0.07937	0.936							
			X21X22	-0.06646	0.937							
			X20 4	-0.006698	0.937							
			X22X23	0.04649	0.938							
			X20 2	0.05335	0.938							
			X22	-0.2079	0.939							
180	Y07	-1.850	X203	0.02450	0.873	-1.749	1.203	5.111	12.20	35.6	-22.2	8.0
			X20/X21	-0.6339	0.900							
			X20X23	0.1580	0.913							
			X21	-0.3043	0.920							
			X20 5	-0.001106	0.928							
			X20X22	-0.02943	0.933							
			X20	0.3423	0.934							
			X21X23	-0.6599	0.935							
			X23 2	0.07988	0.936							
			X21X22	-0.06317	0.937							
			X20 4	-0.002630	0.937							
			X22X23	0.04453	0.938							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]^c$	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
181	Y07	-1.835	X20 3	0.03125	0.873	-1.749	1.203	5.133	12.21	36.1	-22.1	8.1
			X20/X21	-0.6974	0.900							
			X20X23	0.1685	0.913							
			X21	-0.3032	0.920							
			X20 5	-0.0008469	0.928							
			X20X22	-0.03383	0.933							
			X20	0.3240	0.934							
			X21X23	-0.07105	0.935							
			X23 2	0.08240	0.936							
			X21X22	-0.06510	0.937							
			X22	-0.2034	0.937							
			X22X23	0.04501	0.937							
182	Y07	-1.910	X20 3	0.03154	0.873	-1.749	1.203	5.107	12.12	36.1	-22.7	8.1
			X20/X21	-0.6670	0.900							
			X20X23	0.1697	0.913							
			X21	-0.3154	0.920							
			X20 5	-0.0008551	0.928							
			X20X22	-0.01803	0.933							
			X20	0.3227	0.934							
			X21X23	-0.07111	0.935							
			X23 2	0.08435	0.936							
			X21X22	-0.03263	0.937							
183	Y07	-1.924	X20 3	0.03146	0.873	-1.749	1.203	5.120	12.11	36.4	-22.5	8.1
			X20/X21	-0.6470	0.900							
			X20X23	0.1674	0.913							
			X21	-0.3184	0.920							
			X20 5	-0.0008455	0.928							
			X20X22	-0.02641	0.933							
			X20	0.3254	0.934							
			X21X23	-0.07101	0.935							
			X23 2	0.08193	0.936							
			X21X22	-0.01486	0.937							
184	Y07	-1.914	X20 3	0.03214	0.873	-1.749	1.203	5.211	12.27	36.9	-22.6	8.2
			X20/X21	-0.6688	0.900							
			X20X23	0.1649	0.913							
			X21	-0.3149	0.920							
			X20 5	-0.0008726	0.928							
			X20X22	-0.04726	0.933							
			X20	0.3151	0.934							
			X21X23	-0.06892	0.935							
			X23 2	0.08155	0.936							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]^{f}$	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
185	Y07	-1.743	X20 3	0.03374	0.873	-1.749	1.203	5.243	12.25	36.7	-23.6	8.4
			X20/X21	-0.7308	0.900							
			X20X23	0.1475	0.913							
			X21	-0.2604	0.920							
			X20 5	-0.0009010	0.928							
			X20X22	-0.04887	0.933							
			X20	0.2663	0.934							
			X21X23	-0.02698	0.935							
186	Y07	-1.763	X20 3	0.03644	0.873	-1.749	1.203	5.232	12.13	37.0	-24.4	8.5
			X20/X21	-0.8015	0.900							
			X20X23	0.1026	0.913							
			X21	-0.2168	0.920							
			X20 5	-0.0009013	0.928							
			X20X22	-0.04855	0.933							
			X20	0.1490	0.934							
187	Y07	-2.426	X20 3	0.02684	0.873	-1.749	1.203	5.025	11.34	39.6	-26.4	9.3
			X21	-0.2841	0.899							
			X20 5	-0.001443	0.914							
			X22	0.1344	0.921							
			X23	-0.2944	0.926							
			X20 2	-0.0009216[d]	0.928							
			X20	0.1479	0.929							
			X20 4	-0.005819	0.930							
188	Y07	-2.215	X20 3	0.02962	0.873	-1.749	1.203	5.124	11.66	37.4	-26.3	8.8
			X20/X21	-0.6501	0.900							
			X21	-0.2410	0.911							
			X23	-0.2936	0.919							
			X22	0.1284	0.924							
			X20 2	0.003484[d]	0.929							
			X20 5	-0.001516	0.930							
			X20 4	-0.005547	0.931							
189	X07	-2.154	X20 3	0.02912	0.873	-1.749	1.203	5.119	11.62	38.1	-25.7	8.8
			X20/X21	-0.6558	0.900							
			X21	-0.2351	0.911							
			X23	-0.1830	0.919							
			X22	0.1270	0.924							
			X20 2	0.0007659[d]	0.929							
			X20 5	-0.001470	0.930							
			X20 4	-0.005448	0.931							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{s_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
190	Y07	-1.853	X20 3	0.02741	0.873	-1.749	1.203	5.084	11.84	36.4	-25.2	8.4
			X20/X21	-0.6737	0.900							
			X20X23	0.09796	0.913							
			X21	-0.2351	0.920							
			X20 5	-0.001536	0.928							
			X22	0.1225	0.933							
			X20	0.2115	0.933							
			X20 4	-0.003584	0.935							
197	Y07	-0.4697	X20 3	0.01818	0.873	-1.749	1.203	6.348	13.50	42.3	-24.9	9.5
			X20/X21	-1.417	0.900							
			X20X23	0.04624	0.912							
			X21	-9.368	0.915							
			X25 2	-0.04187	0.918							
			X21 2	19.16	0.920							
			X20 2	-0.006547[d]	0.920							
			X23	-0.4182	0.921							
198	Y09	-0.4637	X20 3	0.01815	0.872	-1.782	1.210	6.357	13.51	42.2	-24.6	9.5
			X20/X21	-1.428	0.900							
			X20X23	0.04089	0.912							
			X25 2	-0.04971	0.915							
			X21	-9.665	0.919							
			X21 2	20.03	0.921							
			X20 2	-0.006133[d]	0.921							
			X23	-0.4409	0.921							
			X23 2	0.1616	0.922							
199	Y11	0.2072	X20 3	0.01866	0.858	-1.074	1.227	9.078	17.56	44.5	-24.1	10.6
			X20/X21	-1.359	0.887							
			X20X23	0.04152	0.897							
			X21	-9.641	0.900							
			X25 2	-0.04581	0.903							
			X21 2	19.70	0.905							
			X20	0.006068[d]	0.906							
			X20 3	-0.0001023[d]	0.907							
			X20 2	0.004366[d]	0.907							
			X23	-0.4115	0.907							
			X23 2	0.1485	0.908							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]^c$	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
200	Y10	0.7645	X20 3	0.01837	0.871	-0.6208	1.197	6.384	13.46	39.3	-26.0	9.5
			X20/X21	-1.286	0.900							
			X20X23	0.006844[d]	0.909							
			X21	-10.55	0.913							
			X21 2	21.01	0.915							
			X25 2	-0.02760	0.917							
			X23	-0.6472	0.917							
			X20	0.04277[d]	0.918							
			X23 2	0.2025	0.918							
			X20 3	0.0001445	0.919							
202	Y07	-2.043	X20 3	0.007267	0.873	-1.749	1.203	3.960	9.732	39.4	-23.6	7.9
			X20/X21	0.3085	0.910							
			X23 2	-4.173×10^{-7}	0.930							
			X25 2	-0.08563	0.937							
			X21 2	-22.50	0.939							
			X20/X21	-0.00006193	0.941							
			X20 6	1.036×10^{-7}	0.941							
			X21	4.225	0.941							
			X20X23	-0.0001894[d]	0.941							
			X25	0.06883[d]	0.942							
203	Y09	-2.111	X20 3	0.007098	0.872	-1.782	1.210	3.950	9.755	38.7	-23.3	7.8
			X20/X21	0.3151	0.910							
			X23 2	-4.163×10^{-7}	0.930							
			X25 2	-0.1031	0.938							
			X21 2	-22.71	0.940							
			X20/X21	-0.00006078	0.942							
			X20 6	1.071×10^{-7}	0.942							
			X21	4.411	0.942							
			X20X23	-0.0001677[d]	0.943							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
204	Y11	-1.503	X20 3	0.006511	0.858	-1.074	1.227	7.318	16.39	41.9	-23.7	8.9
			X20/X21	0.3535	0.901							
			X23 2	-4.034×10^{-7}	0.919							
			X25 2	-0.09754	0.926							
			X21 2	-28.99	0.928							
			X20 6	2.395×10^{-7}	0.928							
			X20 4	0.0002554	0.929							
			X20X23	-0.0008737	0.930							
			X21	7.168	0.931							
			X20 5	-0.00001658	0.931							
			X20/X21	-0.00004647	0.932							
205	Y10	-1.032	X20 3	0.006664	0.871	-0.6208	1.197	4.384	10.65	35.9	-25.3	7.8
			X20/X21	0.3233	0.911							
			X23 2	-3.964×10^{-7}	0.931							
			X25 2	-0.07567	0.934							
			X21 2	-22.43	0.936							
			X20/X21	-5.218×10^{-5}	0.938							
			X20 6	7.516×10^{-8}[d]	0.939							
			X21	4.367	0.939							
			X20	-0.05609[d]	0.940							
207	Y07	-2.198	X20 3	0.006873	0.873	-1.749	1.203	4.053	10.18	35.1	-24.1	7.3
			X20/X21	0.3135	0.910							
			X23 2	-4.113×10^{-7}	0.930							
			X25 2	-0.04891	0.937							
			X33	0.1311	0.939							
			X21 2	-22.32	0.941							
			X20/X21	-5.732×10^{-5}	0.943							
			X20 6	8.555×10^{-8}[d]	0.944							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
	Thornton Equation:											
208[e]	Y01	-3.897	X02	0.8088	0.802	-6.665	0.9567	4.094	8.568	71.0	-22.7	14.8
			X01	-0.3191	0.889							
			X27	0.9760	0.901							
			X04	0.4688	0.915							
			X25	0.1224	0.917							
	Smoot-Babb Equation:											
209[e]	Y02	-5.210	X03	0.8443	0.771	-7.829	0.9505	4.188	9.042	61.8	-23.2	13.1
			X01	-0.3020	0.890							
			X22	0.2484	0.905							
			X04	0.5650	0.919							
			X25	0.1818	0.924							
			X27	0.2167	0.925							
			X24	-0.1249	0.926							
210[e]	Y02	-5.210	X02	0.8443	0.793	-7.829	0.9505	4.188	9.042	61.8	-23.2	13.1
			X01	-0.3020	0.880							
			X22	0.2484	0.896							
			X27	1.061	0.906							
			X04	0.5650	0.920							
			X25	0.1818	0.925							
			X24	-0.1249	0.926							
211	Y17	-4.750	X20/X21	-1.296	0.862	-3.672	2.475	10.10	11.52	153.1	-38.6	55.1
			X20X23	0.02871[d]	0.896							
			$\boxed{X20/X21}$	-2.781[d]	0.911							
			X20 3	0.05985	0.919							
			X20 5	-0.003156	0.922							
			X25 2	-0.3237	0.927							
			X21X22	-0.01143	0.931							
			X21X23	-0.3285	0.931							
			X23	-1.198	0.935							
			$\boxed{X20X22}$	1.906[d]	0.935							
			X23 2	0.02616[d]	0.935							
			X20X22	0.01691[d]	0.936							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
212	Y07	-2.394	X20 3	0.02987	0.873	-1.749	1.203	5.187	12.82	33.4	-22.7	7.5
			X20/X21	0.5056	0.908							
			X20X23	0.02886[d]	0.921							
			X20X22	0.002394[d]	0.928							
			X25 2	-0.1197	0.931							
			X20 5	-0.001740	0.935							
			X20/X21	-0.4325	0.937							
			X21X23	-0.1361	0.939							
			X23 2	0.007750[d]	0.941							
			X20 4	-0.006243	0.941							
			X20232	0.05083	0.942							
			X23	0.8750[d]	0.942							
			X21X22	-0.02097[d]	0.942							
			X21 3	0.002416	0.943							
213	Y09	-2.313	X20 3	0.02859	0.872	-1.762	1.210	5.319	13.05	34.7	-23.0	8.0
			X20/X21	0.4867	0.910							
			X20X23	0.03442[d]	0.921							
			X20X22	0.0005926[d]	0.928							
			X25 2	-0.1313	0.931							
			X20 5	-0.001660	0.934							
			X20/X21	-0.4845	0.937							
			X21X23	-0.1456	0.938							
			X23 2	0.01605[d]	0.941							
			X20 4	-0.005846	0.941							
			X20232	0.04523	0.941							
			X23	0.1406[d]	0.942							
214	Y18	-1.883	X22	0.3409[d]	0.959	-2.014	0.3730	1.251	12.31	11.2	-5.0	0.6
			X20X22	-0.01017	0.960							
			X23 2	0.01659	0.960	(This equation redundant, Y18 is defined by X22.)						
			X20X23	0.008405[d]	0.961							
			X21X22	-0.005195[d]	0.961							
			X21X23	-0.02077	0.961							
			X21 3	-0.001250	0.961							
			X23	-0.1454	0.961							
			X20X22	-0.7719[d]	0.961							
			X20/X21	-0.1888	0.962							
			X25 2	-0.01477	0.962							
			X21	1.440[d]	0.962							
			X20 3	-0.002621	0.962							
			X20232	-0.01221	0.963							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]^c$	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
216	Y10	-1.134	X20 3	0.02731	0.871	-0.6208	1.197	5.327	12.88	35.0	-22.3	7.9
			X20/X21	0.4624	0.911							
			X20X23	0.04115[d]	0.920							
			X21 3	0.001458[d]	0.926							
			X25 2	-0.1444	0.930							
			X20 5	-0.001578	0.932							
			X21X23	-0.1557	0.934							
			X23 2	0.02582[d]	0.937							
			X22	-0.1444[d]	0.937							
			X20/X21	-0.5522	0.938							
			X23	0.6094[d]	0.939							
217	Y11	-1.388	X20 3	0.03587	0.858	-1.074	1.227	7.154	16.14	36.7	-22.5	8.4
			X20/X21	0.2969[d]	0.901							
			X21X22	-0.07724	0.911							
			X20X23	-0.02684[d]	0.918							
			X20 5	-0.001772	0.923							
			X25 2	-0.1550	0.925							
			X20/X21	-0.5148	0.927							
			X20X22	0.02844	0.928							
			X21X23	-0.1412	0.929							
			X23	-0.4523	0.932							
			X20232	0.08157	0.933							
			X20 4	-0.006145	0.933							
			X22	-0.4648[d]	0.933							
			X20X22	0.3164[d]	0.933							
			X23 2	-0.02637[d]	0.934							
218	Y04	-0.2512	X20/X21	-0.4466	0.847	0.1515	1.268	7.392	15.88	39.7	-24.7	9.7
			X20 3	0.03578	0.877							
			X20/X21	-0.7969[d]	0.893							
			X20X23	-0.01436[d]	0.903							
			X21X22	-0.1238	0.909							
			X20X22	0.09615	0.918							
			X25 2	-0.1571	0.922							
			X20 5	-0.001749	0.926							
			X21X23	-0.1378	0.927							
			X23	-0.3728[d]	0.930							
			X20232	0.08182	0.930							
			X20 4	-0.005872	0.931							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
219	Y13	-1.603	X20 3	0.02725	0.872	-1.015	1.205	5.310	12.82	34.5	-22.5	7.9
			$\boxed{X20/X21}$	0.4611	0.911							
			X20X23	0.04070[d]	0.921							
			X21 3	0.001427[d]	0.927							
			X25 2	-0.1427	0.930							
			X20 5	-0.001579	0.932							
			X21X23	-0.1559	0.934							
			X23 2	0.02538[d]	0.937							
			X22	-0.05665[d]	0.938							
			X20/X21	-0.5587	0.939							
			X23	0.2344[d]	0.939							
			X20 4	-0.005434	0.940							
220	Y14	-1.548	X20 3	0.02853	0.875	-0.9819	1.197	5.195	12.77	33.8	-21.7	7.5
			$\boxed{X20/X21}$	0.4800	0.913							
			X20X23	0.03514[d]	0.923							
			X21 3	0.001886[d]	0.928							
			X25 2	-0.1310	0.931							
			X20 5	-0.001659	0.934							
			X21X23	-0.1464	0.936							
			X23 2	0.01707[d]	0.938							
			X22	-0.05485[d]	0.940							
			X20/X21	-0.5067	0.940							
			X20 4	-0.005832	0.940							
			X23	0.5469[d]	0.941							
221	Y15	-0.1660	X20/X21	-0.5309	0.852	-0.2812	1.248	6.991	15.21	43.6	-25.3	10.8
			X20 3	0.03559	0.883							
			$\boxed{X20/X21}$	-0.2656[d]	0.898							
			X20X23	-0.02156[d]	0.909							
			X21X22	-0.09744	0.914							
			X20 5	-0.001715	0.918							
			X22	-1.242[d]	0.922							
			X25 2	-0.1634	0.925							
			X20X22	0.05442	0.926							
			$\boxed{X20X23}$	-0.4657	0.926							
			$\boxed{X20X32}$	0.07957	0.927							
			X20 4	-0.005801	0.929							
			X21X23	-0.1468	0.930							
			$\boxed{X20X22}$	1.102[d]	0.931							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of - Deviations	Average
222[f]	(Same as Eq. 211)											
	Y17	-5.645	X20/X21	-1.059	0.864	-3.833	2.442	24.43	26.54	> 1000	-71.6	> 1000
			X20X23	0.2396	0.890							
			$\boxed{X20/X21}$	-16.88[d]	0.905							
			$\boxed{X20X22}$	-0.04827[d]	0.911							
			$\boxed{X20232}$	0.01764[d]	0.917							
			X25 2	-0.2939	0.920							
			X23 2	0.2108	0.922							
			X21X23	-0.2372	0.925							
			X20X22	0.04933	0.926							
			X21X22	-0.09108	0.926							
			X20	19.75[d]	0.926							
			X20 5	-0.001642	0.926							
			X20 3	0.03438	0.927							
223[f]	(Same as Eq. 212)											
	Y07	-2.412	X20/X21	-0.3863	0.867	-1.827	1.190	5.203	12.08	36.7	-23.7	8.5
			X20X23	0.1269	0.898							
			$\boxed{X20/X21}$	0.5080	0.910							
			X20 3	0.01710	0.917							
			X21X22	-0.01764[d]	0.923							
			X20 5	-0.0009782	0.926							
			X25 2	-0.1070	0.929							
			X20 4	-0.003199[d]	0.930							
			X21 3	0.002811	0.930							
			X21X23	-0.09670	0.931							
			X23 2	0.09485	0.933							
224[f]	(Same as Eq. 213)											
	Y09	-2.390	X20/X21	-0.4210	0.868	-1.861	1.196	5.215	12.01	38.9	-23.4	8.9
			X20X23	0.1339	0.898							
			$\boxed{X20/X21}$	0.4858	0.910							
			X20 3	0.01570	0.917							
			X21X22	-0.01626[d]	0.923							
			X20 5	-0.0008979	0.925							
			X25 2	-0.1185	0.929							
			X20 4	-0.002838[d]	0.929							
			X21 3	0.002382	0.930							
			X21X23	-0.1032	0.930							
			X23 2	0.1050	0.933							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (ΔZ)	$\left[\frac{\Delta z}{\bar{s}_y \cdot f(x)}\right]$[c]	% Deviation[c] Avg. of + Deviations	Avg. of − Deviations	Average
225[f]	(Same as Eq. 214)											
	Y18	-1.829	X22	-0.3939	0.960	-1.987	0.3625	1.292	13.19	10.5	-4.7	0.5
			X20X22	-0.009072	0.961							
			X23 2	0.02083	0.961	(This equation redundant, see Eq. 214)						
			X23	-0.08813	0.962							
			X20X23	0.01278[d]	0.962							
			X20 3	-0.003184	0.962							
			$\boxed{\text{X20232}}$	-0.01159	0.962							
			X20 5	0.0001475	0.962							
			X20 4	0.0005769[d]	0.962							
			X25 2	-0.01568	0.962							
			X21X23	-0.01405	0.963							
227[f]	(Same as Eq. 216)											
	Y10	-1.067	X20/X21	-0.4734	0.871	-0.6881	1.183	5.192	11.79	46.5	-22.9	10.0
			X20X23	0.1424	0.896							
			$\boxed{\text{X20/X21}}$	0.2305[d]	0.908							
			$\boxed{\text{X20232}}$	-0.006251[d]	0.918							
			X23 2	0.1169	0.921							
			X25 2	-0.1312	0.925							
			X21X23	-0.1095	0.926							
			X21 3	0.001900[d]	0.928							
			X20X22	0.005810[d]	0.928							
			X20 5	-0.0008134	0.928							
			X20 3	0.01426	0.929							
228[f]	(Same as Eq. 217)											
	Y11	-2.061	X20/X21	-0.4533	0.859	-1.153	1.209	6.585	14.34	66.7	-30.2	19.1
			X20X23	0.07576[d]	0.885							
			$\boxed{\text{X20/X21}}$	5.25[d]	0.900							
			$\boxed{\text{X20X22}}$	-0.05120[d]	0.909							
			X20 3	0.02404	0.915							
			X25 2	-0.1382	0.919							
			X20X22	0.04314	0.920							
			X21X23	-0.1059	0.921							
			X23 2	0.06071[d]	0.923							
			X20 5	-0.001035	0.924							
			X21X22	-0.06516	0.925							
			X21	4.625[d]	0.926							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{y} \cdot f(x)}\right]^c$	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
229[f]	(Same as Eq. 218)											
	Y04	-0.1362	X20/X21	-0.3780[d]	0.854	0.07402	1.245	8.329	17.53	42.8	-23.9	10.0
			X20X23	0.08638	0.875							
			$\boxed{X20/X21}$	-0.06641[d]	0.892							
			X20 3	0.02595	0.900							
			X21X22	-0.1113	0.907							
			X20X22	0.1066	0.915							
			X25 2	-0.1383	0.918							
			X20 5	-0.001047	0.921							
			X21X23	-0.1029	0.922							
			X23	-0.06986[d]	0.924							
			X23 2	0.06863	0.925							
230[f]	(Same as Eq. 219)											
	Y13	-3.824	X20/X21	-0.4751	0.870	-1.090	1.192	7.218	16.37	86.8	-35.7	27.6
			X20X23	0.1422	0.898							
			$\boxed{X20/X21}$	-12.00[d]	0.910							
			$\boxed{X20232}$	-0.006383[d]	0.918							
			X23 2	0.1166	0.921							
			X25 2	-0.1298	0.924							
			X21X23	-0.1101	0.926							
			$\boxed{X20X22}$	0.02944[d]	0.928							
			X21 3	0.001886[d]	0.929							
			X20 5	-0.0008117	0.929							
			X20 3	0.01412	0.930							
232[f]	(Same as Eq. 221)											
	Y15	-0.5913	X20/X21	-0.4510	0.857	-0.3599	1.228	8.056	17.06	40.5	-24.6	9.8
			X20X23	0.08171	0.880							
			$\boxed{X20/X21}$	0.3858	0.896							
			X20 3	0.02403	0.904							
			X21X22	-0.08352	0.911							
			X20X22	0.06746	0.914							
			X25 2	-0.1458	0.917							
			X20 5	-0.0009903	0.920							
			$\boxed{X20X23}$	-0.0625[d]	0.921							
			X23 2	0.06840	0.922							
			X21X23	-0.1100	0.923							
			X23	-0.1250[d]	0.924							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
233	Y03	-3.652	X34/X21	3.141[d]	0.824	-1.862	1.267	7.503	16.40	38.4	-23.6	9.7
			X22	-4.258[d]	0.848							
			X23	5.406[d]	0.874							
			X21X23	-0.1561	0.889							
			X34X23	0.2983	0.905							
			X21X22	-0.1304	0.915							
			X21 3	0.001246[d]	0.920							
			X34X22	0.08754	0.922							
			X25 2	-0.1610	0.926							
			$\boxed{X34232}$	-0.09176	0.928							
			X34 4	0.005405	0.930							
			X23 2	0.1250	0.931							
			X34 3	0.03687	0.932							
			X34 5	-0.001589	0.933							
			$\boxed{X34/X21}$	-0.3980[d]	0.934							
234	Y07	-3.465	$\boxed{X34/X21}$	4.594[d]	0.847	-1.749	1.203	4.681	12.14	35.5	-21.0	7.4
			X34 4	0.005051	0.896							
			X23	7.703[d]	0.912							
			X21X23	-0.1449	0.921							
			X25 2	-0.1018	0.928							
			X34X23	0.3096	0.932							
			$\boxed{X34232}$	-0.09869	0.939							
			X21X22	-0.01307[d]	0.941							
			X21 3	0.004555	0.943							
			X23 2	0.1129	0.945							
			X34 5	-0.002117	0.945							
			X34 3	0.04165	0.948							
235	Y09	-3.973	$\boxed{X34/X21}$	4.016[d]	0.850	-1.782	1.210	6.955	17.88	79.3	-35.6	24.2
			X34 4	0.005025	0.897							
			X23	5.656[d]	0.913							
			X21X23	-0.1497	0.922							
			X25 2	-0.1144	0.929							
			X34X23	0.3045	0.933							
			$\boxed{X34232}$	-0.09703	0.939							
			X21X22	-0.01526[d]	0.942							
			X23 2	0.1170	0.943							
			X21 3	0.004088	0.945							
			X34 5	-0.002040	0.945							
			X34 3	0.03980	0.947							
			$\boxed{X34X23}$	-6.500[d]	0.948							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{y} \cdot f(x)}\right]^c$	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
236	Y20	-1.848	$\boxed{X34/X21}$	2.781[d]	0.846	-0.7057	1.256	8.057	17.93	47.3	-23.4	10.7
			X34 4	0.005424	0.871							
			X23	5.031[d]	0.886							
			X34X22	0.09629	0.898							
			X21X23	-0.1516	0.905							
			X25 2	-0.1511	0.916							
			X34X23	0.3040	0.921							
			$\boxed{X34232}$	-0.09332	0.926							
			X21X22	-0.1256	0.929							
			X22	-3.805[d]	0.931							
			X23 2	0.1204	0.931							
			X21 3	0.001834[d]	0.933							
			X34 3	0.03787	0.933							
			X34 5	-0.001617	0.935							
238	Y21	-4.481	$\boxed{X34/X21}$	6.813[d]	0.852	-2.122	2.492	10.13	12.18	140.8	-38.4	51.1
			X34 4	0.01057	0.889							
			X23	11.19[d]	0.905							
			$\boxed{X34X22}$	6.984[d]	0.915							
			X34X23	0.5944	0.920							
			X21 3	0.004627	0.929							
			$\boxed{X34232}$	-0.1848	0.932							
			X23 2	0.2404	0.935							
			X25 2	-0.2908	0.937							
			X21X23	-0.3113	0.940							
			X21X22	-0.1083	0.941							
			X34X22	0.02468[d]	0.941							
			X34 3	0.07621	0.941							
			X34 5	-0.003648	0.943							
			X34/X21	-0.7405[d]	0.944							
239	Y11	-2.386	$\boxed{X34/X21}$	0.5361	0.849	-1.074	1.227	6.223	14.58	66.0	-29.1	18.1
			X34 4	0.005496	0.881							
			X23	1.711[d]	0.898							
			X21X23	-0.1462	0.907							
			X25 2	-0.1423	0.915							
			X34X23	0.3003	0.920							
			$\boxed{X34232}$	-0.09232	0.927							
			X21X22	-0.07075	0.931							
			X34X22	0.03664	0.934							
			X23 2	0.1058	0.934							
			X21 3	0.001964	0.935							
			X34 3	0.04200	0.936							
			X34 5	-0.001835	0.938							
			$\boxed{X34X22}$	3.063[d]	0.939							

Table A-7. (Continued)

Flooding Equation No.	Dependent Variable[a] (Y)	Intercept (A)	Independent Variables[b] (X_i)	Coefficients (b_i)	Cumulative Multiple Regression Coefficients (R)	Mean Value of Dependent Variable ($\bar{Y}$)	Standard Deviation of the Dependent Variable (s_y)	Range of Residuals (Δz)	$\left[\frac{\Delta z}{\bar{s}_{y \cdot f(x)}}\right]$[c]	% Deviation[c] Avg. of + Deviations	% Deviation[c] Avg. of - Deviations	% Deviation[c] Average
240	Y19	-1.635	X34/X21	0.5828	0.840	-0.2424	1.288	7.015	15.73	84.3	-32.5	25.0
			X23	1.719[d]	0.868							
			X21X23	-0.1472	0.884							
			X34X23	0.3097	0.900							
			X21X22	-0.1208	0.912							
			X34X22	0.1050	0.921							
			X25 2	-0.1411	0.928							
			X34232	-0.09489	0.933							
			X34 4	0.005443	0.934							
			X23 2	0.1159	0.935							
			X21 3	0.002422	0.936							
			X34 3	0.03887	0.937							
			X34 5	-0.001645	0.938							
			X22	-4.125[d]	0.939							
241	Y08	17.86	X34/X21	31.00[d]	0.848	-0.5880	1.188	27.23	70.25	> 1000	-84.0	> 1000
			X34 4	0.005045	0.895							
			X21 3	0.004046	0.910							
			X34X23	0.3052	0.929							
			X22	-52.00[d]	0.932							
			X25 2	-0.1164	0.933							
			X34232	-0.09792	0.935							
			X23 2	0.1183	0.940							
			X21X23	-0.1497	0.941							
			X23	46.00[d]	0.943							
			X34 5	-0.002064	0.943							
			X34 3	0.04015	0.946							
242	Y15	-1.665	X34/X21	0.5310	0.849	-0.2812	1.248	7.348	16.58	100.2	-37.0	32.4
			X34 4	0.005481	0.876							
			X23	1.180[d]	0.893							
			X21X23	-0.1499	0.903							
			X25 2	-0.1508	0.911							
			X34X23	0.2998	0.916							
			X34232	-0.09164	0.923							
			X21X22	-0.0933	0.926							
			X34X22	0.06087	0.931							
			X23 2	0.1115	0.932							
			X21 3	0.001715[d]	0.933							
			X34 3	0.03970	0.933							
			X34 5	-0.001706	0.935							
			X22	-2.437[d]	0.936							

Table A-7. (Continued)

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[a]See Table A-5 for the meaning of the symbols.

[b]See Table A-6 for the meaning of the symbols, only variables which contribute significantly to the regression are included; they are listed in order, the most significant variable occurring first.

[c]$\Delta z/\bar{s}_{y \cdot f(x)}$ represents the range of residuals (Δz):

$$\left[(Y_{exptl} - Y_{calc})_{maximum} - (Y_{exptl} - Y_{calc})_{minimum}\right] \text{divided by the standard error of estimate of } \bar{Y}.$$

% Deviation represents the deviations of the antilograthms of Y, or

$$\frac{e^{Y_{exptl}} - e^{Y_{calc}}}{e^{Y_{exptl}}} \times 100$$

Averages are given for positive deviations, negative deviations, and finally for all deviations.

[d]Coefficient not significant.

[e]Restricted to emulsion flooding.

[f]Both group-1 and group-2 data used to develop these coefficients.

Table A-8. Flood Equations, $Y = A + \sum^{i} b_i X_i$

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
1A	Y03	X05, X22, X23.	0.710-0.971[c]
1B	Y03	X06, X22, X23.	0.712-0.971[c]
2	Y03	X05, X23, X22, X25.	0.790
3	Y03	X05, X23, X22, X26.	0.785
4	Y01	X02, X01, X27, X04, X25.	0.871[d]
4A	Y01	X01.	0.067-0.946[c]
4B	Y02	X22, X01.	0.250-0.959[c]
5	Y02	X03, X01, X04, X22, X25, X24, X27.	0.887[d]
6	Y02	X02, X01, X22, X27, X04, X24, X25.	0.887
7	Y03	X07, X23, X22, X10, X25, X13, X15, X27, X24.	0.880[d]
8	Y03	X08, X23, X22, X11, X25, X14, X16, X27, X24.	0.885
9	Y03	X06, X23, X22, X25.	0.816
10	Y03	X06, X23, X22, X06 2.	0.811
11	Y03	X06, X23, X22.	0.799
12	Y03	X09, X23, X22.	0.743
13	Y03	X23, X06 3, X22.	0.660
14	Y03	X06, X12, X23, X22, X17.	0.822
15	Y03	X06, X23, X12, X22, X17.	0.876
16	Y03	X23X16, X14X22, X23X14, X06, X06X16, X14X06, X14 3, X14X16, X06 2, X16 2, X14 2, X16, X23, X23 2, X22 2, X23X02, X22, X22X16, X22X06, X16 3, X23X06, X14, X06 3.	0.860
17	Y03	X23, X06 3, X22, X06 2.	0.660
18	Y03	X23, X06 2, X22.	0.658
19	Y03	X06, X23, X22, X06 4, X06 2, X06 3.	0.835
20	Y04	X06, X23, X12, X17, X22.	0.878

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
21	Y04	X06, X23, X12, X17, X02, X22.	0.881
22	Y01	X02, X23, X12, X06, X17, X22.	0.868
23	Y03	X06, X23, X12, X22, X17, X02.	0.878
24	Y02	X02, X23, X12, X22, X06, X17.	0.873
25	Y03	X06, X23, X22.	0.746
26	Y03	X09, X23, X22.	0.769
27	Y05	X23, X28, X22, X25, X12, X04, X01, X29, X02, X17, X24.	0.781
28	Y16	ρ_D, A, ϵ, γ, μ_c, d, F, μ_D, D, S, ρ_c.	0.663
29	Y06	X30, X23, X22, X04.	0.637
30	Y07	X05, X23, X22.	0.798
31	Y07	X31, X05.	0.991[d]
32	Y08	X05, X23, X22.	0.790
33	Y08	X32, X22, X05.	0.999[d]
34	Y07	X31, X22, X31 2, X31 3, X05.	0.999[d]
35	Y07	X31, X31 2, X05, X31 3.	0.991[d]
36	Y07	X05X18, X18, X05.	0.727
37	Y07	X05X18, X05 2, X05 3, X18, X05.	0.783
38	Y07	X05X18, X23, X22, X18, X05.	0.801
39	Y07	X05X18, X23, X05 2, X05 3, X22, X05, X18.	0.825
40	Y07	X05X17, X17, X05.	0.772
41	Y07	X05X17, X05 2, X05 3, X17, X05.	0.790
42	Y07	X05X17, X17 3, X05, X17, X17 2.	0.780
43	Y07	X05X17, X23, X17, X22, X05.	0.824
44	Y07	X05X17, X23, X17, X05 2, X05 3, X22, X05.	0.833
45	Y07	X05X17, X23, X17 3, X22, X05, X17 2, X17.	0.825
46	Y07	X05X17, X23, X17 3, X22, X05 2, X05 3, X05, X17, X17 2.	0.834
47	Y07	X05X17, X17 3, X05 2, X05 3, X17, X05, X17 2.	0.792
48	Y07	X02X05, X02, X05.	0.755
49	Y07	X02X05, X05 2, X02, X05 3, X05.	0.807

Table A-8. (Continued)

Flooding Equation No.	Dependent Variables[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
50	Y07	X02X05, X23, X02, X22, X05.	0.810
51	Y07	X02X05, X23, X05 2, X02, X05 3, X22, X05.	0.835
52	Y07	X05, X05X21, X21.	0.750
53	Y07	X05, X05 2, X05 3, X21, X05X21.	0.782
54	Y07	X05, X05X21, X21, X21 3, X21 2.	0.785
55	Y07	X05, X23, X05X21, X22, X21.	0.811
56	Y07	X05, X23, X05 2, X05 3, X22, X05X21, X21.	0.825
57	Y07	X05, X23, X05X21, X22, X21 3, X21 2, X21.	0.837
58	Y07	X05, X23, X05 2, X05 3, X22, X21 3, X21 2, X05X21 X21.	0.842
59	Y07	X05, X05 2, X05 3, X21, X21 3, X05X21, X21 2.	0.802
60	Y07	X17, X18, X17X18.	0.619
61	Y07	X17 3, X17X18, X18, X17 2, X17.	0.703
62	Y07	X23, X17, X18, X22, X17X18.	0.826
63	Y07	X23, X17 3, X17X18, X22, X17, X17 2, X18.	0.839
64	Y07	X17, X02, X02X17.	0.574
65	Y07	X17 3, X17 2, X17, X02, X02X17.	0.663
66	Y07	X23, X17, X02, X22, X02X17.	0.788
67	Y07	X23, X17 3, X02, X22, X17 2, X17, X02X17.	0.798
68	Y07	X17, X19, X17/X19.	0.539
69	Y07	X17, X19, X19 3, X19 2, X17/X19.	0.548
70	Y07	X17 3, X17 2, X19, X17, X17/X19.	0.704
71	Y07	X23, X19, X22, X17, X17/X19.	0.831
72	Y07	X23, X19, X22, X19 2, X17, X19 3, X17/X19.	0.841
73	Y07	X23, X19, X22, X17, X17 3, X17 2, X17/X19.	0.879
74	Y07	X23, X19, X22, X19 2, X17, X17 3, X17 2, X19 3, X17/X19.	0.882
75	Y07	X17 3, X17 2, X19 2, X19, X17, X19 3, X17/X19.	0.743
76	Y07	X20, X18, X17.	0.831
77	Y07	X20, X18, X17 3, X17 2, X17.	0.882
78	Y07	X20 3, X20, X18, X17, X20 2.	0.901[d]
79	Y07	X20, X23, X18, X17, X22.	0.879

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
80	Y07	X20, X23, X18, X17 3, X17 2, X22, X17.	0.904[d]
81	Y07	X20 3, X20, X18, X23, X17, X22, X20 2.	0.924[d]
82	Y07	X20 3, X20, X18, X23, X17 3, X22, X20 2, X17, X17 2.	0.926[d]
83	Y07	X20 3, X20, X18, X17 3, X17 2, X17, X20 2.	0.909[d]
84	Y07	X17, X17X21, X21.	0.747
85	Y07	X17 3, X17X21, X21, X17, X17 2.	0.771
86	Y07	X17, X17X21, X21, X21 2, X21 3.	0.754
87	Y07	X23, X17, X17X21, X22, X21.	0.839
88	Y07	X23, X17 3, X17X21, X22, X17, X21, X17 2.	0.846
89	Y07	X23, X21 3, X17, X17X21, X22, X21 2, X21.	0.842
90	Y07	X23, X17 3, X17X21, X22, X17, X21 2, X21 3, X21, X17 2.	0.850
91	Y07	X17 3, X17X21, X21, X17, X17 2, X21 3, X21 2.	0.778
92	Y07	X18X19, X19, X18.	0.510
93	Y07	X18X19, X19, X19 2, X19 3, X18.	0.521
94	Y07	X23, X18X19, X18, X22, X19.	0.860
95	Y07	X23, X18X19, X18, X22, X19 2, X19 3, X19.	0.865
96	Y07	X02X19, X02, X19.	0.516
97	Y07	X02X19, X02, X19, X19 2, X19 3.	0.527
98	Y07	X23, X02X19, X02, X22, X19.	0.864
99	Y07	X23, X02X19, X02, X22, X19 3, X19 2, X19.	0.870
100	Y07	X19, X21, X19X21.	0.675
101	Y07	X19, X21, X19X21, X19 2, X19 3.	0.694
102	Y07	X21 3, X19, X19X21, X21, X21 2.	0.693
103	Y07	X23, X19, X21, X19X21, X22.	0.880
104	Y07	X23, X19, X21, X19X21, X22, X19 3, X19 2.	0.885
105	Y07	X23, X19, X21, X19X21, X22, X21 3, X21 2.	0.885
106	Y07	X23, X19, X21, X19X21, X22, X19 3, X21 3, X21 2, X19 2.	0.890
107	Y07	X21 3, X19, X19X21, X19 2, X19 3, X21, X21 2.	0.710

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
108	Y07	X20, X18, X18/X20.	0.848
109	Y07	X20 3, X20, X18, X18/X20, X20 2.	0.899
110	Y07	X20, X23, X18, X18/X20, X22.	0.883
111	Y07	X20 3, X20, X18, X23, X22, X18/X20, X20 2.	0.915[d]
112	Y07	X20, X02, X02/X20.	0.839
113	Y07	X20 3, X20, X02, X20 2, X02/X20.	0.905[d]
114	Y07	X20, X23, X02, X22, X02/X20.	0.880
115	Y07	X20 3, X20, X02, X23, X22, X20 2, X02/X20.	0.922[d]
116	Y07	X20/X21, X21, X20.	0.871
117	Y07	X20 3, X20/X21, X21, X20 2, X20.	0.916[d]
118	Y07	X20/X21, X21, X20, X21 3, X21 2.	0.883
119	Y07	X20/X21, X23, X21, X22, X20.	0.897
120	Y07	X20 3, X20/X21, X21, X23, X22, X20 2, X20.	0.929[d]
121	Y07	X20/X21, X23, X21, X22, X20, X21 3, X21 2.	0.905[d]
122	Y07	X20 3, X20/X21, X21, X23, X22, X20 2, X20, X21 2, X21 3.	0.931[d]
123	Y07	X20 3, X20/X21, X21, X20 2, X20, X21 3, X21 2.	0.918[d]
124	Y07	X21, X18, X18X21.	0.738
125	Y07	X21 3, X18, X18X21, X21, X21 2.	0.786
126	Y07	X23, X21, X18, X18X21, X22.	0.812
127	Y07	X23, X21 3, X18, X18X21, X22, X21 2, X21.	0.838
128	Y07	X21, X02, X02X21.	0.841
129	Y07	X21 3, X02, X21 2, X02X21, X21.	0.879
130	Y07	X23, X21, X02, X22, X02X21.	0.863
131	Y07	X23, X21 3, X02, X21 2, X02X21, X21, X22.	0.892
132	Y09	X20, X18, X18/X20.	0.850
133	Y09	X20 3, X20, X18, X18/X20, X20 2.	0.900
134	Y09	X20, X23, X18, X18/X20, X22.	0.883
135	Y09	X20 3, X20, X18, X23, X22, X18/X20, X20 2.	0.915[d]
136	Y09	X20, X02, X02/X20.	0.842
137	Y09	X20 3, X20, X02, X20 2, X02/X20.	0.906[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
138	Y09	X20, X23, X02, X22, X02/X20.	0.881
139	Y09	X20 3, X20, X02, X23, X22, X20 2, X02/X20.	0.922[d]
140	Y09	X20/X21, X21, X20.	0.873
141	Y09	X20 3, X20/X21, X21, X20 2, X20.	0.916[d]
142	Y09	X20/X21, X21, X20, X21 3, X21 2.	0.885
143	Y09	X20/X21, X23, X21, X22, X20.	0.898
144	Y09	X20 3, X20/X21, X21, X23, X20 2, X22, X20.	0.929[d]
145	Y09	X20/X21, X23, X21, X22, X20, X21 3, X21 2.	0.905[d]
146	Y09	X20 3, X20/X21, X21, X23, X20 2, X22, X20, X21 2, X21 3.	0.930[d]
147	Y09	X20 3, X20/X21, X21, X20 2, X20, X21 3, X21 2.	0.918[d]
148[e]	Y09	X20, X18, X18/X20.	0.854
149[e]	Y09	X20 2, X18 X18/X20, X20, X20 3.	0.882
150[e]	Y09	X20, X23, X18, X18/X20, X22.	0.887
151[e]	Y09	X20 2, X23, X22, X18, X18/X20, X20, X20 3.	0.903[d]
152[e]	Y09	X20, X02, X02/X20.	0.846
153[e]	Y09	X20 2, X02, X20 3, X20, X02/X20.	0.885
154[e]	Y09	X20, X02, X23, X22, X02/X20.	0.887
155[e]	Y09	X20 2, X02, X23, X22, X20, X20 3, X02/X20.	0.907[d]
156[e]	Y09	X20/X21, X21, X20.	0.870
157[e]	Y09	X20 2, X21, X20/X21, X20, X20 3.	0.899
158[e]	Y09	X20/X21, X21 3, X20, X21 2, X21.	0.875
159[e]	Y09	X20/X21, X23, X21, X20, X22.	0.899
160[e]	Y09	X20 2, X21, X23, X22, X20/X21, X20, X20 3.	0.917[d]
161[e]	Y09	X20/X21, X23, X21 3, X22, X20, X21, X21 2.	0.901[d]
162[e]	Y09	X20 2, X21, X23, X22, X20/X21, X21 2, X21 3, X20, X20 3.	0.918[d]
163[e]	Y09	X20 2, X21, X20/X21, X20, X21 2, X20 3, X21 3.	0.899
164[e]	Y08	X20 2, X21, X23, X20/X21, X21 2, X21 3, X20, X20 3.	0.915[d]
165[e]	Y08	X20 2, X21, X23, X20/X21, X20, X20 3.	0.914[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
166[e]	Y08	X20/X21, X23, X21 3, X20, X21, X21 2.	0.897
167[e]	Y01	X20, X21 3, X20 2, X23, X21 2, X21, X20 3 X20/X21.	0.926[d]
168[e]	Y01	X20, X21, X20 2, X23, X20/X21, X20 3.	0.924[d]
169[e]	Y01	X20, X21 3, X23, X21 2, X20/X21, X21.	0.912[d]
170[e]	Y10	X20 2, X21, X23, X20/X21, X21 2, X21 3, X20, X20 3.	0.912[d]
171[e]	Y10	X20 2, X21, X23, X20/X21, X20, X20 3.	0.911[d]
172[e]	Y10	X20/X21, X23, X21 3, X20, X21, X21 2.	0.895
173	Y11	X20 3, X20/X21, X21, X23, X22, X20, X21 2, X20 2, X21 3.	0.917[d]
174	Y11	X20 3, X20/X21, X21, X23, X22, X20, X20 2.	0.916[d]
175	Y11	X20/X21, X23, X21 2, X22, X20, X21 3, X21.	0.894
176	Y09	X01 3, X01 2, X24, X22, X27, X01.	0.549
177	Y07	X20 3, X20/X21, X21, X23, X22, X20 2, X20 5, X20 4, X20.	0.931[d]
178	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2, X21X22, X20 4, X22X23, X20 2, X22, X23.	0.939[d]
179	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2, X21X22, X20 4, X22X23, X20 2, X22.	0.939[d]
180	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2, X21X22, X20 4, X22X23, X22.	0.938[d]
181	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2, X21X22, X22, X22X23.	0.938[d]
182	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2, X21X22, X22X23.	0.937[d]
183	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2, X21X22.	0.937[d]
184	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23, X23 2.	0.936[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
185	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20, X21X23.	0.935[d]
186	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X20X22, X20.	0.934[d]
187	Y07	X20 3, X21, X20 5, X22, X23, X20 2, X20, X20 4, X23 2.	0.930[d]
188	Y07	X20 3, X20/X21, X21, X23, X22, X20 2, X20 5, X20 4, X23 2, X20.	0.931[d]
189	Y07	X20 3, X20/X21, X21, X23, X22, X20 2, X20 5, X20 4, X20.	0.931[d]
190	Y07	X20 3, X20/X21, X20X23, X21, X20 5, X22, X20, X20 4, X20 2.	0.935[d]
191	Y07	X23, X20X23, X20 2, X23 2, X21, X20, X21 2, X25, X25 2, X20/X21, X20 3.	0.813
192	Y09	X23, X20X23, X20 2, X23 2, X21, X20, X21 2, X25, X25 2, X20/X21, X20 3.	0.814
193	Y11	X23, X20X23, X20 2, X23 2, X21, X20 2, X20, X20 3, X25, X25 2, X20/X21.	0.819
194	Y10	X23, X20X23, X20 2, X21, X23 2, X20 3, X21 2, X25, X25 2, X20/X21, X20.	0.810
195	Y03	X23, X20X23, X20 2, X21, X23 2, X25, X25 2, X21 2, X20, X20 3, X20/X21.	0.787
196	Y07	X23, X20X23, X20 2, X23 2, X21, X20, X33, X21 2, X25 2, X20 3, X20/X21.	0.797
197	Y07	X20 3, X20/X21, X20X23, X21, X25 2, X21 2, X20 2, X23, X23 2, X20 3, X20.	0.921[d]
198	Y09	X20 3, X21/X21, X20X23, X25 2, X21, X21 2, X20 2, X23, X23 2, X20 3, X20.	0.922[d]
199	Y11	X20 3, X20/X21, X20X23, X21, X25 2, X21 2, X20, X20 3, X20 2, X23, X23 2.	0.908[d]
200	Y10	X20 3, X20/X21, X20X23, X21, X21 2, X25 2, X23, X20, X23 2, X20 3, X20 2.	0.919[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
201	Y03	X20/X21, X20 3, (X21), (X23), (X21 2), (X23 2), X20X23, (X25 2), (X20 3), (X20 2), (X20).	0.875
202	Y07	X20 3, [X20/X21], (X23 2), (X25 2), (X21 2), (X20/X21), (X20 6), (X21), (X20X23), (X25), (X20 4), (X20 5), (X20).	0.942[d]
203	Y09	X20 3, [X20/X21], (X23 2), (X25 2), (X21 2), (X20/X21), (X20 6), (X21), (X20X23), (X25), (X20 4), (X20 5), (X20).	0.943[d]
204	Y11	X20 3, [X20/X21], (X23 2), (X25 2), (X21 2), (X20 6), (X20 4), (X20X23), (X21), (X20 5), (X20/X21), (X20), (X25).	0.932[d]
205	Y10	X20 3, [X20/X21], (X23 2), (X25 2), (X21 2), (X20/X21), (X20 6), (X21), (X20), (X25), (X20X23), (X20 4), (X20 5).	0.940[d]
206	Y03	[X20/X21], (X23 2), X20 3, (X21 2), (X20 6), (X20 4), (X20X23), (X21), (X20 5), (X20/X21), (X20), (X25), (X25 2).	0.898
207	Y07	X20 3, [X20/X21], (X23 2), (X25 2), (X33), (X21 2), (X20/X21), (X20 6), (X21), (X20X23), (X20 4), (X20 5), (X20).	0.944[d]
208[e]	Y01	X02, X01, X27, X04, X25.	0.917[d]
209[e]	Y02	X03, X01, X22, X04, X25, X27, X24.	0.926[d]
210[e]	Y02	X02, X01, X22, X27, X04, X25, X24.	0.926[d]
211	Y17	X20/X21, X20X23, [X20/X21], X20 3, X20 5, X25 2, X21X22, X21X23, X23, [X20X22], X23 2, X20X22, X20 4, [X20232], X22, X21 3, X21, X20, [X20X23].	0.936[d]
212	Y07	X20 3, [X20/X21], X20X23, [X20X22], X25 2, X20 5, X20/X21, X21X23, X23 2, X20 4, [X20232], X23, X21X22, X21 3, X20X22, [X20X23], X20, X21, X22.	0.943[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
213	Y09	X20 3, X20/X21, X20X23, X20X22, X25 2, X20 5, X20/X21, X21X23, X23 2, X20 4, X20232, X23, X21X22, X21 3, X20X22, X20X23, X20, X21, X22.	0.942[d]
214	Y18	X22, X20X22, X23 2, X20X23, X21X22, X21X23, X21 3, X23, X20X22, X20/X21, X25 2, X21, X20 3, X20232, X20 5, X20 4, X20/X21, X20, X20X23.	0.963[d]
215	Y12	X20 4, X25 2, X20 5, X20X23, X20/X21, X23, X20 3, X20X23, X21, X21 3, X20232, X21X23, X23 2, X20X22, X21X22, X20X22, X20, X22, X20/X21.	0.851
216	Y10	X20 3, X20/X21, X20X23, X21 3, X25 2, X20 5, X21X23, X23 2, X22, X20/X21, X23, X20 4, X20232, X20X23, X20X22, X21X22, X20, X21, X20X22.	0.939[d]
217	Y11	X20 3, X20/X21, X21X22, X20X23, X20 5, X25 2, X20/X21, X20X22, X21X23, X23, X20232, X20 4, X22, X20X22, X23 2, X21 3, X20, X21, X20X23.	0.934[d]
218	Y04	X20/X21, X20 3, X20/X21, X20X23, X21X22, X20X22, X25 2, X20 5, X21X23, X23, X20232, X20 4, X22, X20, X23 2, X21 3, X21, X20X22, X20X23.	0.931[d]
219	Y13	X20 3, X20/X21, X20X23, X21 3, X25 2, X20 5, X21X23, X23 2, X22, X20/X21, X23, X20 4, X20232, X20X23, X20X22, X21X22, X20, X21, X20X22.	0.940[d]
220	Y14	X20 3, X20/X21, X20X23, X21 3, X25 2, X20 5, X21X23, X23 2, X22, X20/X21, X20 4, X23, X20232, X20X23, X20X22, X21X22, X20, X21, X20X22.	0.941[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
221	Y15	X20/X21, X20 3, $\boxed{\text{X20/X21}}$, X20X23, X21X22, X20 5, X22, X25 2, X20X22, $\boxed{\text{X20X23}}$, $\boxed{\text{X20232}}$, X20 4, X21X23, $\boxed{\text{X20X22}}$, X23 2, X21 3, X21, X20, X23.	0.931[d]
222[f]	Y17	X20/X21, X20X23, $\boxed{\text{X20/X21}}$, $\boxed{\text{X20X22}}$, $\boxed{\text{X20232}}$, X25 2, X23 2, X21X23, X20X22, X21X22, X20, X20 5, X20 3, X20 4, $\boxed{\text{X20X23}}$, X21 3, X21, X22, X23.	0.927[d]
223[f]	Y07	X20/X21, X20X23, $\boxed{\text{X20/X21}}$, X20 3, X21X22, X20 5, X25 2, X20 4, X21 3, X21X23, X23 2, X22, X23, $\boxed{\text{X20X23}}$, X20X22, $\boxed{\text{X20232}}$, X20, X21, $\boxed{\text{X20X22}}$.	0.933[d]
224[f]	Y09	X20/X21, X20X23, $\boxed{\text{X20/X21}}$, X20 3, X21X22, X20 5, X25 2, X20 4, X21 3, X21X23, X23 2, X23, X22, X20X22, X20, $\boxed{\text{X20232}}$, $\boxed{\text{X20X22}}$, X21, $\boxed{\text{X20X23}}$.	0.933[d]
225[f]	Y18	X22, X20X22, X23 2, X23, X20X23, X20 3, $\boxed{\text{X20232}}$, X20 5, X20 4, X25 2, X21X23, X21 3, $\boxed{\text{X20/X21}}$, X20/X21, X21, X21X22, X20, $\boxed{\text{X20X22}}$, $\boxed{\text{X20X23}}$.	0.963[d]
226[f]	Y12	X20 4, X21, X21 3, X20 5, X23, X25 2, X20 3, X20X23, $\boxed{\text{X20232}}$, X22, X23 2, X20X22, X21X23, X21X22, X20/X21, $\boxed{\text{X20X23}}$, X20, $\boxed{\text{X20/X21}}$, $\boxed{\text{X20X22}}$.	0.825
227[f]	Y10	X20/X21, X20X23, $\boxed{\text{X20/X21}}$, $\boxed{\text{X20232}}$, X23 2, X25 2, X21X23, X21 3, X20X22, X20 5, X20 3, X20 4, X23, $\boxed{\text{X20X22}}$, X21X22, X22, X21, X20, $\boxed{\text{X20X23}}$.	0.929[d]
228[f]	Y11	X20/X21, X20X23, $\boxed{\text{X20/X21}}$, $\boxed{\text{X20X22}}$, X20 3, X25 2, X20X22, X21X23, X23 2, X20 5, X21X22, X21, $\boxed{\text{X20X23}}$, X21 3, $\boxed{\text{X20232}}$, X20 4, X20, X22, X23.	0.926[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
229[f]	Y04	X20/X21, X20X23, X20/X21, X20 3, X21X22, X20X22, X25 2, X20 5, X21X23, X23, X23 2, X21 3, X22, X20232, X20 4, X20X22, X21, X20, X20X23.	0.925[d]
230[f]	Y13	X20/X21, X20X23, X20/X21, X20232, X23 2, X25 2, X21X23, X20X22, X21 3, X20 5, X20 3, X20 4, X21X22, X23, X20X22, X21, X20, X22, X20X23.	0.930[d]
231[f]	Y14	Same independent variables as flooding equation No. 220. The regression analysis could not be obtained with the computer program; consequently, no regression coefficient is available.	
232[f]	Y15	X20/X21, X20X23, X20/X21, X20 3, X21X22, X20X22, X25 2, X20 5, X20X23, X23 2, X21X23, X23, X22, X20232, X20 4, X21 3, X20, X20X22, X21.	0.924[d]
233	Y03	X34/X21, X22, X23, X21X23, X34X23, X21X22, X21 3, X34X22, X25 2, X34232, X34 4, X23 2, X34 3, X34 5, X34/X21, X34X23, X34X22, X21, X34.	0.934[d]
234	Y07	X34/X21, X34 4, X23, X21X23, X25 2, X34X23, X34232, X21X22, X21 3, X23 2, X34 5, X34 3, X34X23, X34X22, X34/X21, X34X22, X22, X21, X34.	0.948[d]
235	Y09	X34/X21, X34 4, X23, X21X23, X25 2, X34X23, X34232, X21X22, X23 2, X21 3, X34 5, X34 3, X34X23, X34/X21, X34X22, X22, X34X22, X21, X34.	0.948[d]
236	Y20	X34/X21, X34 4, X23, X34X22, X21X23, X25 2, X34X23, X34232, X21X22, X22, X23 2, X21 3, X34 3, X34 5, X34X23, X34/X21, X34X22, X21, X34.	0.935[d]

Table A-8. (Continued)

Flooding Equation No.	Dependent Variable[a]	Independent Variables,[b] Listed in Order of Their Contribution to the Regression	Coefficient of Multiple Regression (R)
237	Y12	X34 4, $\boxed{X34/X21}$, X34X23, X21 3, X25 2, $\boxed{X34232}$, $\boxed{X34X23}$, X21X23, X34 5, X34 3, X23 2, $\boxed{X34X22}$, X21, X34/X21, X34X22, X21X22, X23, X22, X34.	0.844
238	Y21	$\boxed{X34/X21}$, X34 4, X23, $\boxed{X34X22}$, X34X23, X21 3, $\boxed{X34232}$, X23 2, X25 2, X21X23, X21X22, X34X22, X34 3, X34 5, X34/X21, $\boxed{X34X23}$, X22 X21, X34.	0.944[d]
239	Y11	$\boxed{X34/X21}$, X34 4, X23, X21X23, X25 2, X34X23, $\boxed{X34232}$, X21X22, X34X22, X23 2, X21 3, X34 3, X34 5, $\boxed{X34X22}$, X34, X34/X21, $\boxed{X34X23}$, X22, X21.	0.939[d]
240	Y19	$\boxed{X34/X21}$, X23, X21X23, X34X23, X21X22, X34X22, X25 2, $\boxed{X34232}$, X34 4, X23 2, X21 3, X34 3, X34 5, X22, $\boxed{X34X23}$, X34/X21, $\boxed{X34X22}$, X34, X21.	0.939[d]
241	Y08	$\boxed{X34/X21}$, X34 4, X21 3, X34X23, X22, X25 2, $\boxed{X34232}$, X23 2, X21X23, X23, X34 5, X34 3, $\boxed{X34X23}$, X34/X21, X34X22, X21X22, $\boxed{X34X22}$, X21, X34.	0.946[d]
242	Y15	$\boxed{X34/X21}$, X34 4, X23, X21X23, X25 2, X34X23, $\boxed{X34232}$, X21X22, X34X22, X23 2, X21 3, X34 3, X34 5, X22, X34/X21, $\boxed{X34X23}$, $\boxed{X34X22}$, X34, X21.	0.936[d]

[a]See Table A-5 for the meaning of the symbols.

[b]See Table A-6 for the meaning of the symbols.

[c]Depends upon data subgroup, this equation restricted to a single system, independent variables not necessarily in order.

[d]See Table A-7 for details.

[e]Emulsion flooding region only, data were restricted to those < 50% flooded by insufficient pulsation.

[f]Group-1 and group-2 data.

Table A-9. Distribution of Data in Group 1

	Level	Population at Each Level Variable														
		Y01	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14	Y15
Low	1	18	8	5	34	2	6	6	6	4	7	22	1	2	6	27
	2	30	23	28	39	1	12	9	17	6	11	30	0	7	8	30
	3	16	20	46	43	2	15	16	14	19	19	32	5	22	22	40
	4	26	20	37	61	6	15	14	14	13	13	45	18	10	9	48
	5	29	27	58	124	12	10	12	13	11	13	56	23	14	12	78
	6	42	35	116	219	9	16	13	17	13	18	93	13	12	15	162
	7	39	43	156	277	22	15	15	12	18	11	177	19	16	13	215
	8	42	46	233	242	23	17	17	19	15	19	215	16	17	16	313
	9	87	65	280	66	16	26	20	19	23	17	292	32	23	23	149
	10	92	78	128	4	23	19	21	21	19	23	124	20	20	21	48
	11	118	93	23	1	17	28	26	27	20	31	24	38	21	26	0
	12	183	149	0	0	48	32	26	29	31	28	0	38	34	26	0
	13	59	126	0	0	27	60	40	46	42	45	0	56	39	43	0
	14	76	105	0	0	49	53	50	71	49	75	0	56	59	55	0
	15	28	43	0	0	56	76	67	76	72	76	0	71	76	77	0
	16	19	15	0	0	72	90	82	90	90	87	0	128	92	89	0
	17	24	22	0	0	93	90	91	81	81	82	0	148	81	86	0
	18	33	38	0	0	123	107	99	104	95	112	0	150	87	89	0
	19	42	39	0	0	130	143	106	136	103	129	0	128	119	115	0
	20	30	42	0	0	114	98	142	123	154	119	0	50	148	145	0
	21	25	24	0	0	131	62	99	63	97	63	0	50	92	93	0
	22	26	22	0	0	65	50	59	54	57	54	0	27	52	53	0
	23	15	11	0	0	46	58	53	37	52	38	0	22	46	49	0
	24	7	7	0	0	11	9	24	19	22	18	0	1	19	17	0
High	25	5	10	1	1	13	4	4	3	5	3	1	1	3	3	1
Low Value		-9.230	-10.61	-6.014	-3.549	3.270	-3.403	-5.566	-4.244	-5.687	-4.319	-4.874	3.291	-4.897	-4.776	-4.085
High Value		-3.722	-4.863	8.734	12.46	11.52	2.694	0.3471	1.596	0.3493	1.598	8.734	7.351	1.170	1.167	10.88

Table A-9. (Continued)

	Level	Variable X01	X02	X03	X04	X05	X06	X07	X08	X09	X10	X11	X12	X13	X14	X15
Low	1	2	248	297	19	1	1	1	1	1	1	1	1	1	1	3
	2	4	169	502	0	0	0	0	0	1	0	0	0	0	0	2
	3	7	123	3	0	1	0	0	0	0	0	0	0	0	0	1
	4	18	262	2	0	3	0	0	0	4	0	0	0	0	0	6
	5	26	2	0	3	0	0	0	0	2	0	0	0	0	0	5
	6	47	0	56	7	5	0	0	0	2	0	0	3	0	0	2
	7	142	56	38	7	1	0	0	0	4	0	0	2	0	0	4
	8	198	44	34	2	9	0	0	0	4	0	0	8	0	0	7
	9	182	28	22	6	6	0	0	0	6	0	0	14	0	0	10
	10	101	2	2	7	7	0	0	0	14	0	0	12	0	0	17
	11	87	45	23	10	20	0	0	0	18	0	0	21	0	0	15
	12	98	16	7	48	12	0	0	0	15	0	0	22	0	0	23
	13	49	52	61	14	32	0	0	0	36	0	0	16	0	0	27
	14	39	6	6	14	62	0	0	0	68	0	0	53	2	3	32
	15	26	10	8	24	137	1	1	1	108	0	0	84	4	4	56
	16	20	8	9	14	121	5	1	1	133	2	2	40	20	21	44
	17	24	9	1	0	126	5	5	5	102	3	3	82	38	37	80
	18	9	1	9	69	101	17	13	14	112	11	10	87	78	85	89
	19	16	8	7	20	131	28	21	23	118	25	24	156	114	132	170
	20	7	3	3	200	99	89	52	64	111	57	50	138	139	134	129
	21	7	0	2	115	71	267	115	165	76	151	132	173	145	156	89
	22	3	0	0	168	55	251	326	299	65	193	195	92	249	243	134
	23	4	15	0	229	60	240	243	267	60	373	379	53	122	130	85
	24	3	0	15	125	39	141	213	185	39	241	247	44	151	136	61
High	25	1	4	4	10	12	66	120	86	12	54	68	10	48	29	20
Low Value		-39.39	-22.04	-23.12	4.962	-7.196	-20.75	-22.26	-19.32	-7.599	-22.24	-19.30	-5.689	-6.088	-4.619	0.2494
High Value		-11.94	-5.970	-7.299	12.39	3.080	3.084	0.9228	4.039	3.086	-0.2126	2.592	2.711	6.917	8.477	6.283

Table A-9. (Continued)

	Level	X16	X17	X18	X19	X20	X21	X22	X23	X24	X25	X26	X27	V_c	log V_c	V_D
		Variable														
Low	1	3	1	80	1	6	2	5	10	90	15	19	22	173	2	142
	2	2	4	15	0	22	6	3	17	0	4	0	3	157	1	183
	3	3	0	20	0	45	0	19	1	0	0	0	0	203	1	139
	4	3	3	214	1	43	8	54	18	3	0	0	14	116	1	198
	5	6	3	47	0	50	15	41	277	0	0	4	66	110	3	169
	6	2	5	423	2	102	29	67	6	0	6	0	259	86	3	109
	7	4	4	11	2	78	19	81	21	0	1	3	0	85	25	66
	8	8	9	52	9	118	84	96	37	167	1	1	42	73	12	37
	9	10	11	48	13	101	166	211	15	37	2	4	0	20	14	26
	10	16	16	17	12	132	125	110	183	0	6	73	0	32	33	12
	11	16	14	14	21	99	112	116	17	0	2	25	4	28	31	8
	12	22	36	54	22	77	147	101	35	8	121	113	49	8	38	9
	13	30	29	47	17	75	60	79	70	0	40	311	0	7	54	4
	14	31	55	12	53	56	102	49	5	4	302	108	0	5	66	4
	15	59	47	11	83	23	92	31	141	75	152	9	120	2	50	4
	16	65	82	2	40	24	37	21	34	298	27	85	182	0	84	0
	17	86	86	9	82	20	40	11	21	122	123	44	10	1	146	0
	18	113	105	3	88	3	18	7	45	0	47	3	13	3	138	0
	19	166	163	7	156	18	25	3	8	0	12	52	18	0	119	0
	20	101	102	6	139	7	9	0	55	172	189	192	135	1	121	0
	21	122	121	0	171	4	8	1	33	0	2	5	9	0	99	0
	22	121	106	0	92	4	2	0	16	0	1	2	17	0	49	0
	23	69	52	0	53	3	3	4	36	0	0	0	50	0	15	0
	24	41	47	15	44	0	1	0	0	10	42	54	10	0	5	0
High	25	12	10	4	10	1	1	1	10	125	16	4	88	1	1	1
Low Value		1.719	1.554	-5.553	-5.692	-5.455	-7.808	-2.491	-2.759	-4.605	-2.815	-2.257	-2.373	0.8400	-0.1744	1.380
High Value		7.844	7.882	-1.816	2.710	3.836	-0.8639	4.604	0.8109	-2.200	1.268	1.470	-0.7897	414.0	6.026	352.0

Table A-9. (Continued)

	Level	log V_D	A	log A	F	log F	γ	log γ	μ_D	log μ_D	μ_c	log μ_c	ρ_D	log ρ_D	ρ_c	log ρ_c
		Variable														
Low	1	3	19	1	26	1	4	4	588	112	954	147	122	122	933	933
	2	0	352	9	43	0	4	0	17	32	33	484	0	0	0	0
	3	0	81	1	118	0	4	0	116	3	60	314	373	0	0	0
	4	2	181	0	187	2	42	0	18	441	17	0	84	185	4	4
	5	5	51	0	107	7	110	4	215	3	18	6	37	208	4	0
	6	3	76	40	77	0	5	0	3	14	2	8	301	70	16	4
	7	7	6	293	73	9	21	0	6	0	1	2	86	31	0	16
	8	24	128	13	13	24	87	4	1	116	3	13	26	305	13	0
	9	28	63	14	50	8	10	22	3	0	5	15	12	82	3	13
	10	34	0	45	5	7	15	19	49	3	1	11	0	22	3	2
	11	42	10	36	303	37	2	103	1	24	1	56	0	16	5	3
	12	41	5	160	22	27	5	9	0	205	1	5	0	0	3	5
	13	63	21	21	36	66	0	4	16	4	0	8	0	0	16	4
	14	79	0	51	2	100	0	21	14	6	0	13	0	0	5	11
	15	77	52	49	34	164	0	87	54	0	0	2	0	0	5	10
	16	134	8	33	0	67	3	10	4	1	0	1	0	0	46	5
	17	141	0	128	0	50	0	15	1	46	0	3	0	0	5	46
	18	177	16	63	5	73	0	7	0	7	0	5	0	0	17	5
	19	122	0	0	0	52	0	0	0	0	0	2	0	0	3	17
	20	63	3	15	0	307	372	0	1	30	0	1	0	0	1	4
	21	38	0	21	0	58	53	3	1	57	0	0	0	0	3	3
	22	17	0	60	5	37	116	0	1	2	0	0	0	0	3	1
	23	10	16	16	0	5	70	381	1	1	0	0	0	0	8	9
	24	0	0	3	0	0	10	230	0	2	0	0	0	0	0	1
High	25	1	23	39	5	10	178	188	1	2	15	15	70	70	15	15
Low Value		0.3221	0.0950	-2.354	6.800	1.917	3.700	1.308	0.4110	-0.8891	0.7910	-0.2345	0.6840	-0.3798	0.9940	-0.006018
High Value		5.864	3.150	1.147	420.0	6.040	42.00	3.738	5.690	1.739	22.20	3.100	1.454	0.3743	1.403	0.3386

Table A-9. (Continued)

	Level	Variable								
		d	log d	D	log D	ϵ	log ϵ	S	log S	$V_c + V_D$
Low	1	3	3	147	143	9	3	33	33	69
	2	8	0	112	0	7	0	0	0	73
	3	131	0	357	4	11	6	0	0	84
	4	4	3	0	0	3	0	106	0	74
	5	0	5	363	112	36	0	0	0	89
	6	0	0	0	0	154	18	0	0	113
	7	41	0	0	357	457	0	0	0	118
	8	0	131	0	0	385	0	18	0	103
	9	131	0	0	0	0	3	0	106	75
	10	26	4	0	0	0	36	26	0	75
	11	0	0	0	309	3	0	884	0	73
	12	13	0	45	54	0	154	0	0	41
	13	0	41	0	0	3	457	0	0	34
	14	125	0	0	0	0	385	0	18	27
	15	0	0	0	0	26	0	0	0	20
	16	615	131	0	0	8	0	0	0	15
	17	0	26	0	0	0	3	0	910	7
	18	0	13	0	0	0	3	26	0	5
	19	0	0	0	45	0	0	0	0	3
	20	0	125	0	0	0	30	0	0	3
	21	0	615	0	0	0	4	0	0	4
	22	0	0	0	0	0	0	0	26	1
	23	0	0	0	0	0	0	0	0	3
	24	0	0	0	0	0	0	0	0	1
High	25	14	14	87	87	9	9	18	18	1
Low Value		0.0200	-3.912	1.000	0.0	0.0810	-2.513	0.500	-0.6931	7.77
High Value		0.1880	-1.671	12.00	2.485	0.621	-0.4764	4.00	1.386	422.3

Table A-10. Comparison of $(V_c + V_D)_{calculated}$ with $(V_c + V_D)_{experimental}$

Flood No.	Data Group No.	Estimate of Variance of % Difference (s_i^2)	Mean % Difference $(\bar{d}_i)$	Number of Points (n_i)	Estimate of the Standard Deviation of the Mean % Difference $(s_i/\sqrt{n_i})$	For $\alpha = 0.05$ $(H_o: \bar{d}_i = \bar{d}_j)$	95% Confidence Interval for Mean Percentage Difference $\left[\delta_i = \bar{d}_i \pm \left(t_{A/2,\nu_i}\right)\left(\frac{s_i}{\sqrt{n_i}}\right)\right]$	R
122	1	1,998.01	-8.56	1110	1.342	-	$-11.19 < \delta_{122} < -5.93$	0.931
	2	4,956.55	-29.15	218	4.768	Reject	$-38.55 < \delta_{122} < -19.75$	-
	3	3,340.86	4.03	8	20.438	Accept	$-44.31 < \delta_{122} < +52.37$	-
	4	1,035.96	37.77	37	5.292	Reject	$+27.04 < \delta_{122} < +48.50$	-
	5	6,727.35	-76.31	144	6.835	Reject	$-89.82 < \delta_{122} < -62.80$	-
	10	577.63	17.56	12	6.937	Reject	$+2.29 < \delta_{122} < +32.83$	-
	11	11,118.95	15.82	96	10.762	Reject	$-5.54 < \delta_{122} < +37.18$	-
	12	637.61	54.00	129	2.223	Reject	$+49.60 < \delta_{122} < +58.40$	-
	13	823.74	-7.31	28	5.423	Accept	$-18.44 < \delta_{122} < +3.82$	-
	14	11,494.04	-114.31	134	9.261	Reject	$-132.63 < \delta_{122} < -95.99$	-
	15	4,559.07	-21.87	10	21.354	Accept	$-70.17 < \delta_{122} < +26.43$	-
	16	2,331.91	-36.63	12	13.941	Accept	$-67.31 < \delta_{122} < -5.95$	-
	17	396.78	29.96	10	6.300	Reject	$+15.71 < \delta_{122} < +44.21$	-
208	1	2,614.69	-10.04	947	1.662	Accept	$-13.30 < \delta_{208} < -6.78$	0.917
	2	7,061.62	-42.24	209	5.812	Reject	$-53.70 < \delta_{208} < -30.78$	-
	3	2,795.18	-15.38	5	23.645	Accept	$-81.02 < \delta_{208} < +50.26$	-
	4	2,667.58	0.58	24	10.543	Accept	$-21.23 < \delta_{208} < +22.39$	-
	5	4,278.01	-69.90	144	5.451	Reject	$-80.68 < \delta_{208} < -59.12$	-
	10	428.99	19.71	10	6.550	Reject	$+4.89 < \delta_{208} < +34.53$	-
	11	7,001.89	23.41	64	10.460	Reject	$+2.51 < \delta_{208} < +44.31$	-
	12	1,042.96	45.66	78	3.656	Reject	$+38.38 < \delta_{208} < +52.94$	-
	13	8,432.91	5.27	16	22.958	Accept	$-43.65 < \delta_{208} < +54.19$	-
	14	5,837.35	-75.90	134	6.600	Reject	$-88.95 < \delta_{208} < -62.85$	-
	15	7,013.52	-23.63	8	29.615	Accept	$-93.67 < \delta_{208} < +46.41$	-
	16	422.41	-4.59	11	6.195	Accept	$-18.39 < \delta_{208} < +9.21$	-
	17	89.91	29.37	6	3.871	Reject	$+19.42 < \delta_{208} < +39.32$	-
7	1	6,401.35	-14.82	1089	2.425	Reject	$-19.58 < \delta_7 < -10.06$	0.880
180	1	1,998.63	-7.90	1110	1.342	Accept	$-10.53 < \delta_{180} < -5.27$	0.938
207	1	23,269.28	-73.56	1108	4.583	Reject	$-82.55 < \delta_{207} < -64.57$	0.944
209	1	2,160.15	-8.93	947	1.510	Accept	$-11.89 < \delta_{209} < -5.97$	0.926

Note: Comparisons are between flood equation 122, group 1, and the first group of each of the other equations; then comparisons of group 1 with each of the other data groups were made for equations 122 and 208 only.

Table A-11. Structure of Flood Equations 1-35, 208-210

Variable Code[a]	Flood Equation No. (Group I Data)																																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	208[b]	209[b]	210[b]
Y01				X																		X														X		
Y02					X	X																		X													X	X
Y03	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X				X		X	X												
Y04																				X	X																	
Y05																											X											
Y06																													X									
Y07																														X	X			X	X			
Y08																																X	X					
Y16																												X										
X01				X	X	X																					X									X	X	X
X02				X		X															X	X	X	X			X									X		X
X03					X																																X	
X04				X	X	X																					X		X							X	X	X
X05	X	X	X																											X	X	X	X	X	X			
X06	X								X	X	X				X				X	X	X	X	X	X														
X06														X		X									X													
X07							X																															
X08								X																														
X09																										X												
X09												X																										
X10							X																															
X11								X																														
X12															X					X	X	X	X	X			X											
X12														X																								
X13							X																															
X14								X																														
X14																X																						
X15							X																															
X16								X																														
X16																X																						
X17															X					X	X	X	X	X			X											
X17														X																								
X22	X	X	X		X	X	X	X	X	X			X		X		X	X	X	X	X	X	X	X			X		X	X		X	X	X			X	X
X22											X	X		X		X									X	X												

Table A-11. (Continued)

Variable Code[a]	Flood Equation No. (Group 1 Data)																																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	208[b]	209[b]	210[b]
X23	X	X	X				X	X	X	X			X		X		X	X	X	X	X	X	X	X			X		X	X		X						
(X23)											X	X		X		X									X	X												
X24					X	X	X	X																			X										X	X	X
X25		X		X	X	X	X	X	X																		X									X	X	X
X26			X																																			
X27				X	X	X	X	X																												X	X	X
X28																											X											
X29																											X											
X30																													X									
X31																															X			X	X			
X32																																	X					
X06 2										X							X	X	X																			
(X06 2)																X																						
X06 3													X				X		X																			
(X06 3)																X																						
X06 4																			X																			
(X14 2)																X																						
(X14 3)																X																						
(X16 2)																X																						
(X16 3)																X																						
(X22 2)																X																						
(X23 2)																X																						
X31 2																																		X	X			
X31 3																																		X	X			
(X06X14)																X																						
(X06X16)																X																						
(X06X22)																X																						
(X06X23)																X																						
(X14X16)																X																						
(X14X22)																X																						
(X14X23)																X																						
(X16X22)																X																						
(X16X23)																X																						
(X22X23)																X																						

[a]See Tables A-5 and A-6 for the explanation of these codes.

[b]Emulsion flooding only.

Table A-12. Structure of Flood Equations 36-131.

Variable Code[a]	Flood Equation No. (Group 1 Data)																																							
	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Y07	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X02													X	X	X	X													X	X	X	X								
X05	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																
X17					X	X	X	X	X	X	X	X													X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X18	X	X	X	X																					X	X	X	X												
X19																																	X	X	X	X	X	X	X	X
X20																																								
X21																	X	X	X	X	X	X	X	X																
X22			X	X				X	X	X	X				X	X				X	X	X	X				X	X			X	X				X	X	X	X	
X23			X	X				X	X	X	X				X	X				X	X	X	X				X	X			X	X				X	X	X	X	
X05 2		X		X		X			X		X	X		X		X		X			X		X	X																
X05 3		X		X		X			X		X	X		X		X		X			X		X	X																
X17 2							X			X	X	X														X		X		X		X			X			X	X	X
X17 3							X			X	X	X														X		X		X		X			X			X	X	X
X19 2																																		X			X		X	X
X19 3																																		X			X		X	X
X20 2																																								
X20 3																																								
X21 2																			X			X	X	X																
X21 3																			X			X	X	X																
X02X05													X	X	X	X																								
X02X17																													X	X	X	X								
X02X19																																								
X02/X20																																								
X02X21																																								
X05X17					X	X	X	X	X	X	X	X																												
X05X18	X	X	X	X																																				
X05X21																	X	X	X	X	X	X	X	X																
X17X18																									X	X	X	X												
X17/X19																																	X	X	X	X	X	X	X	X
X17X21																																								
X18X19																																								
X18/X20																																								
X18X21																																								
X19X21																																								
X20/X21																																								

Table A-12. (Continued)

Variable Code[a]	Flood Equation No. (Group 1 Data)																																		
	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
Y07	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X02																					X	X	X	X												
X05																																				
X17	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																				
X18	X	X	X	X	X	X	X	X									X	X	X	X																
X19																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X20	X	X	X	X	X	X	X	X																									X	X	X	X
X21									X	X	X	X	X	X	X	X									X	X	X	X	X	X	X	X				
X22				X	X	X	X					X	X	X	X				X	X			X	X				X	X	X	X				X	X
X23				X	X	X	X					X	X	X	X				X	X			X	X				X	X	X	X				X	X
X05 2																																				
X05 3																																				
X17 2		X			X		X	X		X			X		X	X																				
X17 3		X			X		X	X		X			X		X	X																				
X19 2																		X		X		X		X		X			X		X	X				
X19 3																		X		X		X		X		X			X		X	X				
X20 2			X			X	X	X																										X		X
X20 3			X			X	X	X																										X		X
X21 2											X			X	X	X											X			X	X	X				
X21 3											X			X	X	X											X			X	X	X				
X02X05																																				
X02X17																																				
X02X19																					X	X	X	X												
X02/X20																																				
X02X21																																				
X05X17																																				
X05X18																																				
X05X21																																				
X17X18																																				
X17/X19																																				
X17X21									X	X	X	X	X	X	X	X																				
X18X19																	X	X	X	X																
X18/X20																																	X	X	X	X
X18X21																																				
X19X21																									X	X	X	X	X	X	X	X				
X20/X21																																				

Table A-12. (Continued)

Variable Code[a]	Flood Equation No. (Group 1 Data)																			
	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131
Y07	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X02	X	X	X	X													X	X	X	X
X05																				
X17																				
X18													X	X	X	X				
X19																				
X20	X	X	X	X	X	X	X	X	X	X	X	X								
X21					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X22			X	X				X	X	X	X				X	X			X	X
X23			X	X				X	X	X	X				X	X			X	X
X05 2																				
X05 3																				
X17 2																				
X17 3																				
X19 2																				
X19 3																				
X20 2		X		X		X			X		X	X								
X20 3		X		X		X			X		X	X								
X21 2							X			X	X	X		X		X		X		X
X21 3							X			X	X	X		X		X		X		X
X02X05																				
X02X17																				
X02X19																				
X02/X20	X	X	X	X	X															
X02X21																	X	X	X	X
X05X17																				
X05X18																				
X05X21																				
X17X18																				
X17/X19																				
X17X21																				
X18X19																				
X18/X20																				
X18X21													X	X	X	X				
X19X21																				
X20/X21					X	X	X	X	X	X	X	X								

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-13. Structure of Flood Equations 132-163.

Variable Code[a]	Flood Equation No. 132 148	133 149	134 150	135 151	136 152	137 153	138 154	139 155	140 156	141 157	142 158	143 159	144 160	145 161	146 162	147 163
																- All Group 1 Data / - Emulsion Flooding Only, Group 1
Y09	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X02					X	X	X	X								
X18	X	X	X	X												
X20	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X21									X	X	X	X	X	X	X	X
X22			X	X			X	X				X	X	X	X	
X23			X	X			X	X				X	X	X	X	
X20 2		X		X		X		X		X			X		X	X
X20 3		X		X		X		X		X			X		X	X
X21 2											X			X	X	X
X21 3											X			X	X	X
X02/X20					X	X	X	X								
X18/X20	X	X	X	X												
X20/X21									X	X	X	X	X	X	X	X

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-14. Structure of Flood Equations 164-172.

Variable Code[a]	Flood Equation No.								
	164	165	166	167	168	169	170	171	172 - Emulsion Flooding Only, Group 1
Y01				X	X	X			
Y08	X	X	X						
Y10							X	X	X
X20	X	X	X	X	X	X	X	X	X
X21	X	X	X	X	X	X	X	X	X
X23	X	X	X	X	X	X	X	X	X
X20 2	X	X		X	X		X	X	
X20 3	X	X		X	X		X	X	
X21 2	X		X	X		X	X		X
X21 3	X		X	X		X	X		X
X20/X21	X	X	X	X	X	X	X	X	X

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-15. Structure of Flood Equations 173-176.

Variable Code[a]	Flood Equation No. (Group 1 Data)			
	173	174	175	176
Y09				X
Y11	X	X	X	
X01				X
X20	X	X	X	
X21	X	X	X	
X22	X	X	X	X
X23	X	X	X	
X24				X
X27				X
X01 2				X
X01 3				X
X20 2	X	X		
X20 3	X	X		
X21 2	X		X	
X21 3	X		X	
X20/X21	X	X	X	

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-16. Structure of Flood Equations 177-190.

Variable Code[a]	Flood Equation No. (Group 1 Data)													
	177	178	179	180	181	182	183	184	185	186	187	188	189	190
Y07	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X20	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X21	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X22	X	X	X	X	X						X	X	X	X
X23	X	X									X	X	X	
X20 2	X	X	X								X	X	X	X
X20 3	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X20 4	X	X	X	X							X	X	X	X
X20 5	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X23 2		X	X	X	X	X	X	X			X	X		
X20/X21	X	X	X	X	X	X	X	X	X	X		X	X	X
X20X22		X	X	X	X	X	X	X	X	X				
X20X23		X	X	X	X	X	X	X	X	X				X
X21X22		X	X	X	X	X	X							
X21X23		X	X	X	X	X	X	X	X					
X22X23		X	X	X	X	X								

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-17. Structure of Flood Equations 191-201.

Variable Code[a]	Flood Equation No. (Group 1 Data)										
	191	192	193	194	195	196	197	198	199	200	201
Y03					X						X
Y07	X					X	X				
Y09		X						X			
Y10				X						X	
Y11			X						X		
X20	X	X	X	X	X	X	X	X	X	X	X
X21	X	X	X	X	X	X	X	X	X	X	X
X23	X	X	X	X	X	X	X	X	X	X	X
X25	X	X	X	X	X						
X33						X					
X20 2	X	X	X	X	X	X	X	X	X	X	X
X20 3							X	X	X	X	X
X20 3	X	X	X	X	X	X	X	X	X	X	X
X21 2	X	X	X	X	X	X	X	X	X	X	X
X23 2	X	X	X	X	X	X	X	X	X	X	X
X25 2	X	X	X	X	X	X	X	X	X	X	X
X20/X21							X	X	X	X	X
X20/X21	X	X	X	X	X	X					
X20X23							X	X	X	X	X
X20X23	X	X	X	X	X	X					

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-18. Structure of Flood Equations 202-207.

Variable Code[a]	Flood Equation No. (Group 1 Data)					
	202	203	204	205	206	207
Y03					X	
Y07	X					X
Y09		X				
Y10				X		
Y11			X			
X20	X	X	X	X	X	X
X21	X	X	X	X	X	X
X25	X	X	X	X	X	
X33						X
X20 3	X	X	X	X	X	X
X20 4	X	X	X	X	X	X
X20 5	X	X	X	X	X	X
X20 6	X	X	X	X	X	X
X21 2	X	X	X	X	X	X
X23 2	X	X	X	X	X	X
X25 2	X	X	X	X	X	X
X20/X21	X	X	X	X	X	X
X20/X21	X	X	X	X	X	X
X20X23	X	X	X	X	X	X

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-19. Structure of Flood Equations 211-232.

Variable Code[a]	Flood Equation No. 211 222	212 223	213 224	214 225	215 226	216 227	217 228	218 229	219 230	220 231	221 232
Y04								X			
Y07		X									
Y09			X								
Y10						X					
Y11							X				
Y12					X						
Y13									X		
Y14										X	
Y15											X
Y17	X										
Y18				X							
X20	X	X	X	X	X	X	X	X	X	X	X
X21	X	X	X	X	X	X	X	X	X	X	X
X22	X	X	X	X	X	X	X	X	X	X	X
X23	X	X	X	X	X	X	X	X	X	X	X
X20 3	X	X	X	X	X	X	X	X	X	X	X
X20 4	X	X	X	X	X	X	X	X	X	X	X
X20 5	X	X	X	X	X	X	X	X	X	X	X
X21 3	X	X	X	X	X	X	X	X	X	X	X
X23 2	X	X	X	X	X	X	X	X	X	X	X
X25 2	X	X	X	X	X	X	X	X	X	X	X
X20/X21	X	X	X	X	X	X	X	X	X	X	X
$\boxed{X20/X21}$	X	X	X	X	X	X	X	X	X	X	X
X20X22	X	X	X	X	X	X	X	X	X	X	X
$\boxed{X20X22}$	X	X	X	X	X	X	X	X	X	X	X
X20X23	X	X	X	X	X	X	X	X	X	X	X
$\boxed{X20X23}$	X	X	X	X	X	X	X	X	X	X	X
X21X22	X	X	X	X	X	X	X	X	X	X	X
X21X23	X	X	X	X	X	X	X	X	X	X	X
$\boxed{X20X32}$	X	X	X	X	X	X	X	X	X	X	X

Y04 - Y12: Group 1 Data; Y13 - Y18: Group 1 and Group 2 Data

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-20. Structure of Flood Equations 233-242.

Variable Code[a]	Flood Equation No. (Group 1 Data)									
	233	234	235	236	237	238	239	240	241	242
Y03	X									
Y07		X								
Y08									X	
Y09			X							
Y11							X			
Y12					X					
Y15										X
Y19								X		
Y20				X						
Y21						X				
X21	X	X	X	X	X	X	X	X	X	X
X22	X	X	X	X	X	X	X	X	X	X
X23	X	X	X	X	X	X	X	X	X	X
X34	X	X	X	X	X	X	X	X	X	X
X21 3	X	X	X	X	X	X	X	X	X	X
X23 2	X	X	X	X	X	X	X	X	X	X
X25 2	X	X	X	X	X	X	X	X	X	X
X34 3	X	X	X	X	X	X	X	X	X	X
X34 4	X	X	X	X	X	X	X	X	X	X
X34 5	X	X	X	X	X	X	X	X	X	X
X21X22	X	X	X	X	X	X	X	X	X	X
X21X23	X	X	X	X	X	X	X	X	X	X
X34X21	X	X	X	X	X	X	X	X	X	X
$\boxed{\text{X34X21}}$	X	X	X	X	X	X	X	X	X	X
X34X22	X	X	X	X	X	X	X	X	X	X
$\boxed{\text{X34X22}}$	X	X	X	X	X	X	X	X	X	X
X34X23	X	X	X	X	X	X	X	X	X	X
$\boxed{\text{X34X23}}$	X	X	X	X	X	X	X	X	X	X
$\boxed{\text{X34232}}$	X	X	X	X	X	X	X	X	X	X

[a]See Tables A-5 and A-6 for the explanation of these codes.

Table A-21. Group 1 Data Points 50 to 100% Flooded Due to Insufficient Pulsation

% Flooded Due to Insufficient Pulsation											
50 - 60%		60 - 70%		70 - 80%	80 - 90%	90 - 100%	> 100%
12	441	10	575	14	1	18	6
15	442	23	588	20	37	24	31
16	452	33	589	21	41	35	867
25	453	45	600	29	552	617	873
27	579	50	621	54	553	618	874
28	584	363	627	366	582	633	875
38	585	364	629	367	583	639	876
55	601	365	630	560	598	653	877
189	608	392	631	586	599	868	
190	609	443	707	587	606	869	
191	610	556	757	611	607	872	
266	647	557	804	622	612	878	
267	648	561	817	623	613	879	
273	649	570	927	628	616		
275	650	571	1061	643	632		
276	651	574	1067	644	634		
277	673			645	638		
327	689			646	652		
328	753			654	656		
368	754			655	657		
369	756			670	658		
370	781			758	659		
371	845			760	668		
388	1057			813	669		
389	1058			816	671		
390	1059			870	871		
391	1075			1060	1097		
440	1079						

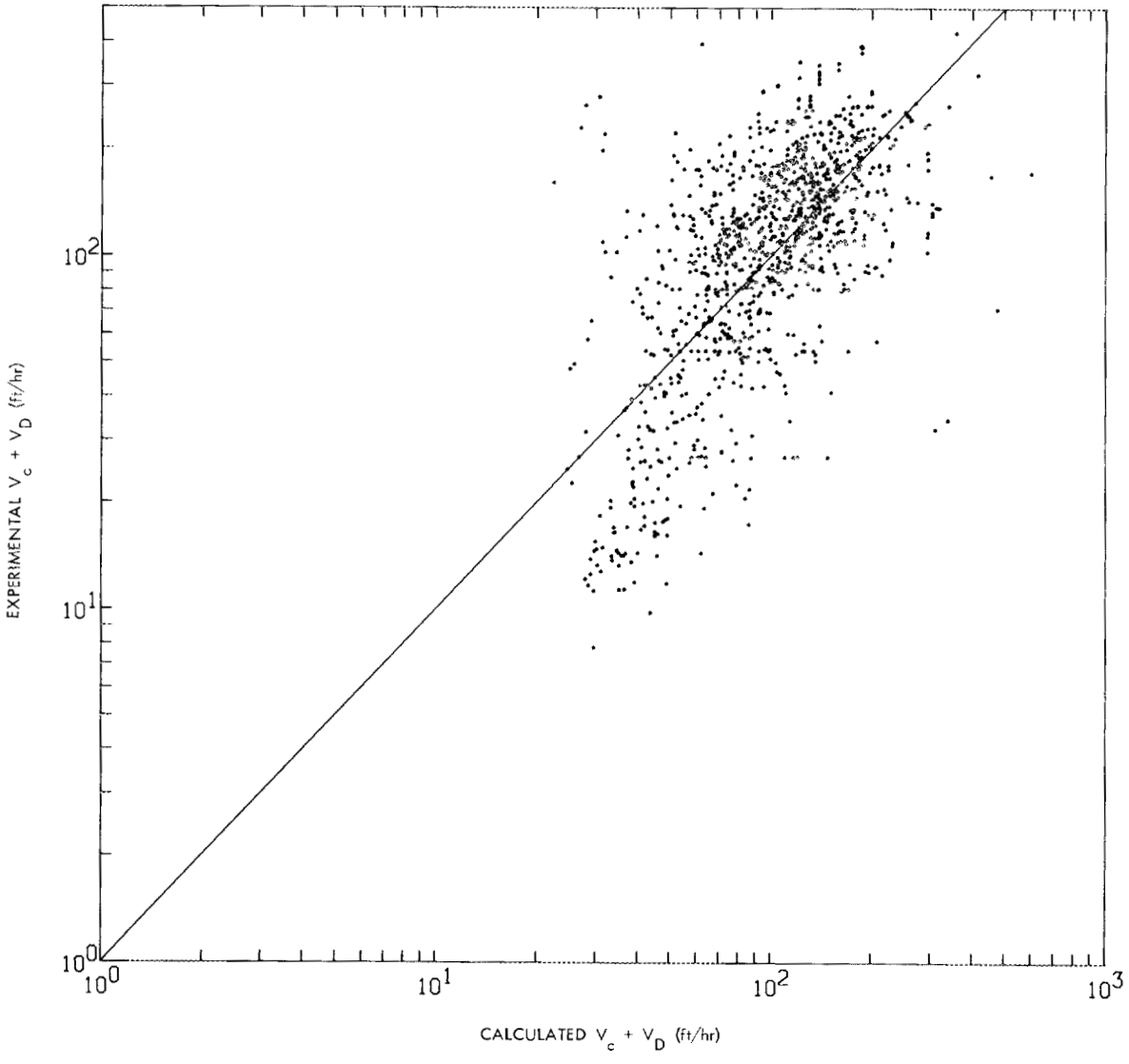

Fig. A-1. Experimental vs Calculated Throughput for Flood Equation 7 and Group-1 Data.

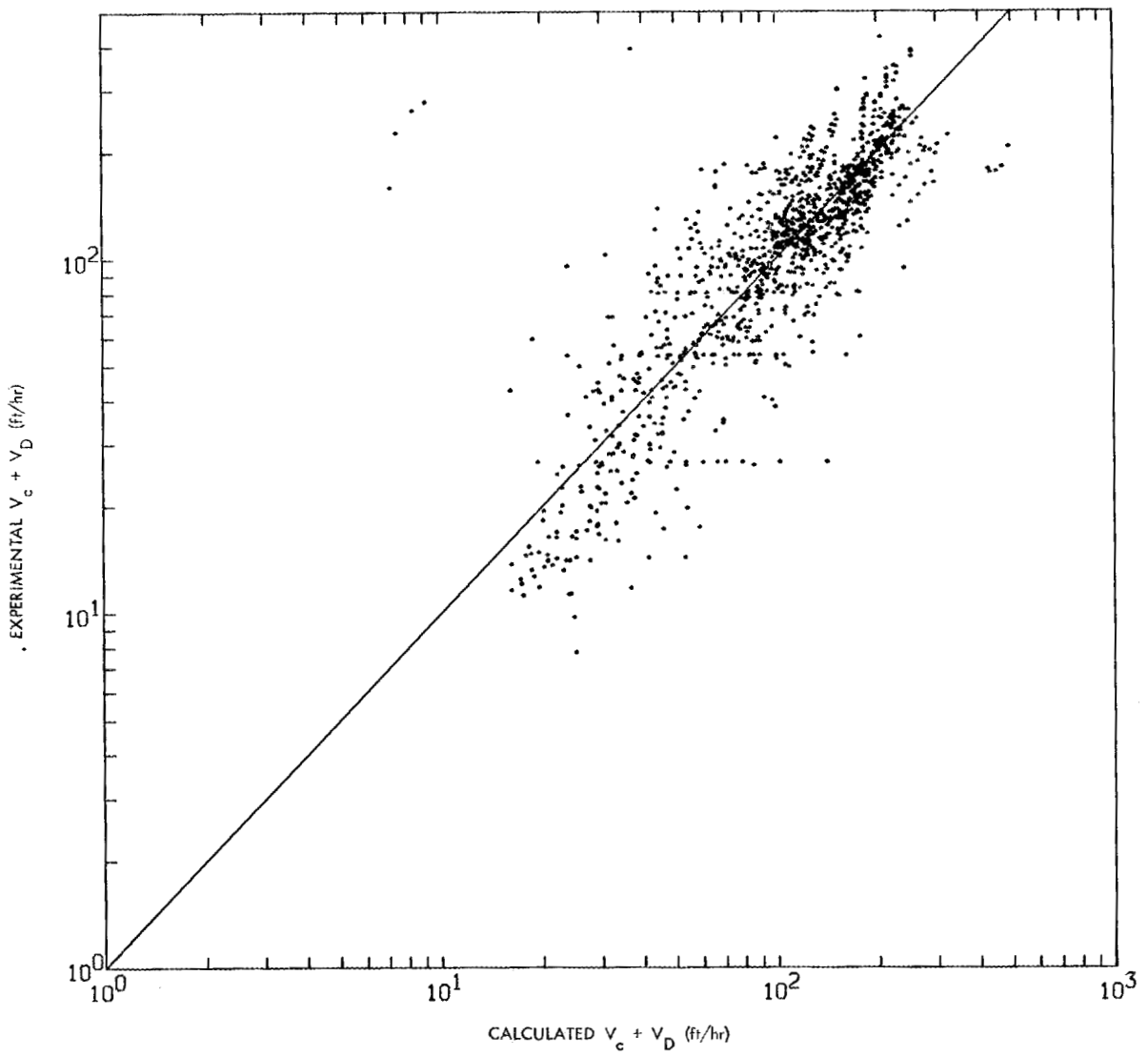

Fig. A-2. Experimental vs Calculated Throughput for Flood Equation 180 and Group-1 Data.

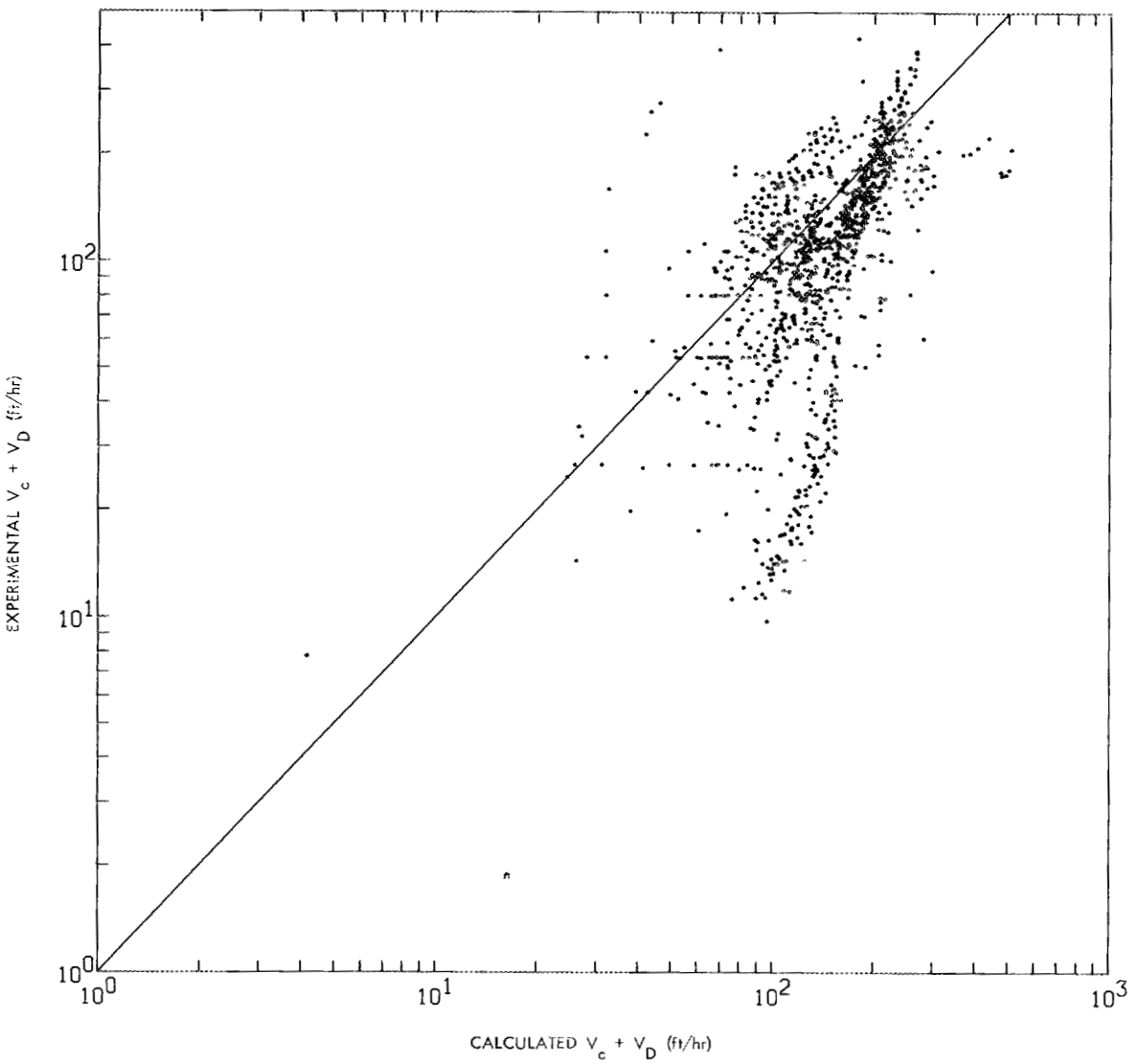

Fig. A-3. Experimental vs Calculated Throughput for Flood Equation 207 and Group-1 Data.

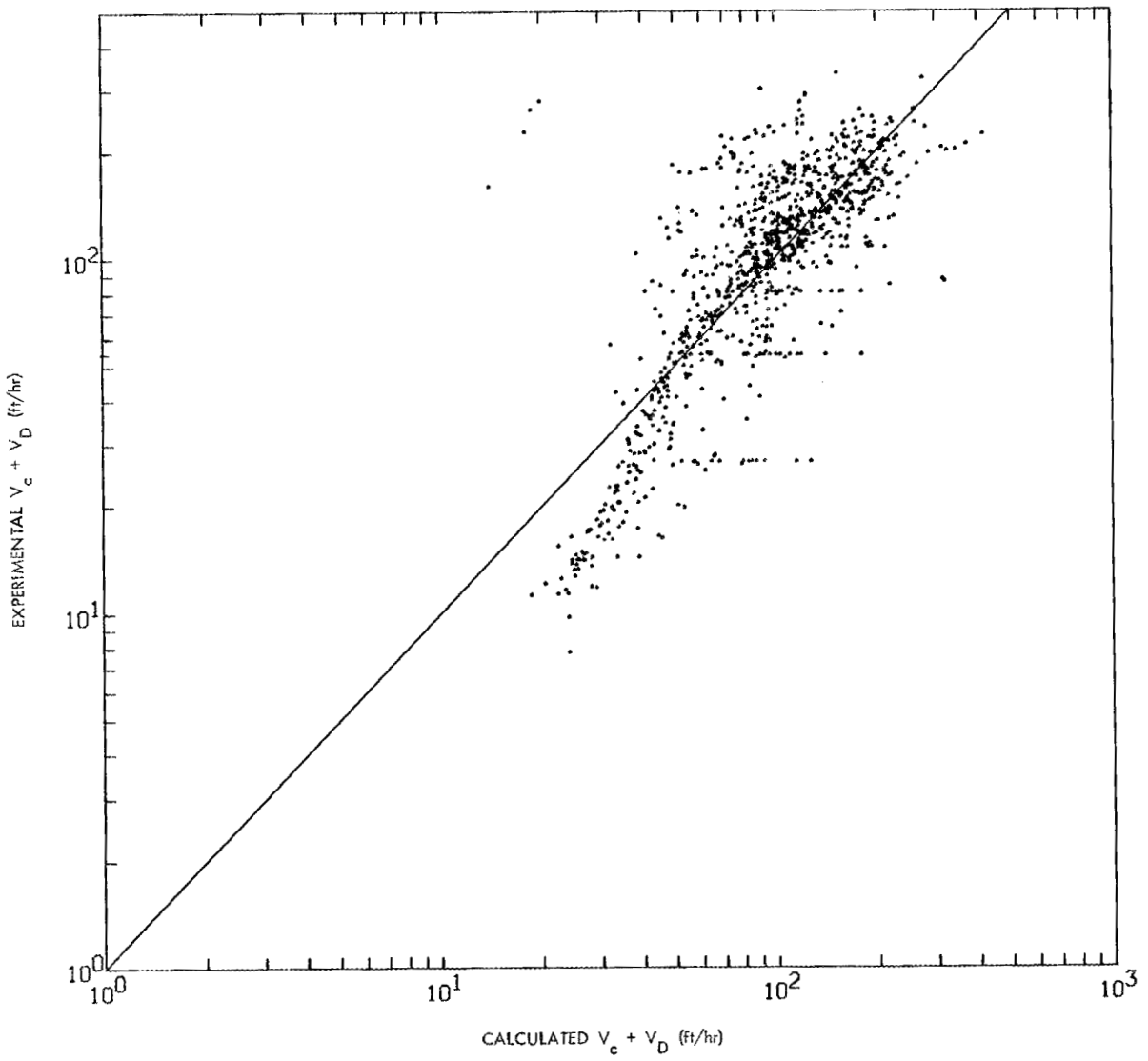

Fig. A-4. Experimental vs Calculated Throughput for Flood Equation 208 and Group-1 Data (0-50% F.I.P.).

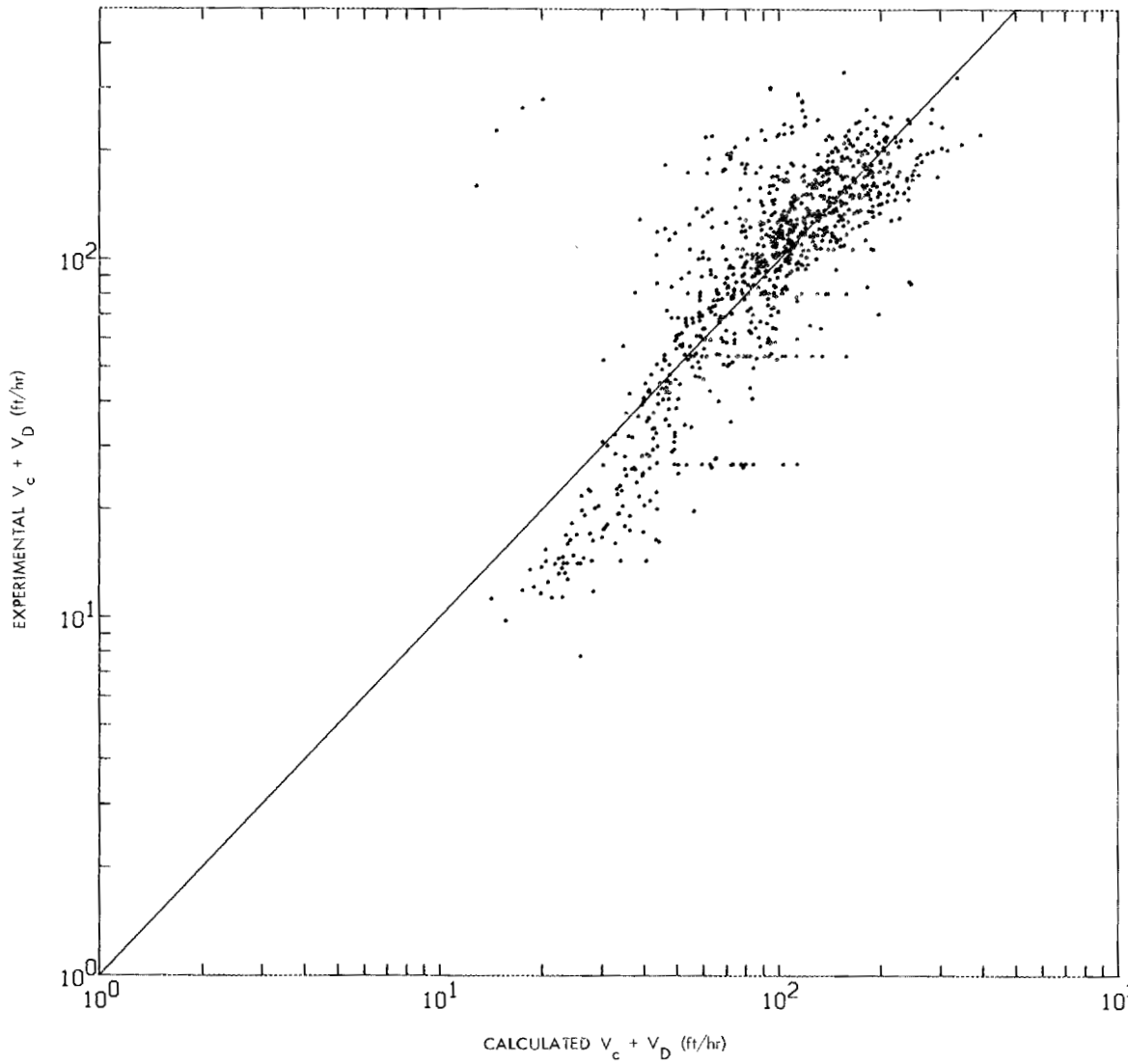

Fig. A-5. Experimental vs Calculated Throughput for Flood Equation 209 and Group-1 Data (0-50% F.I.P.).

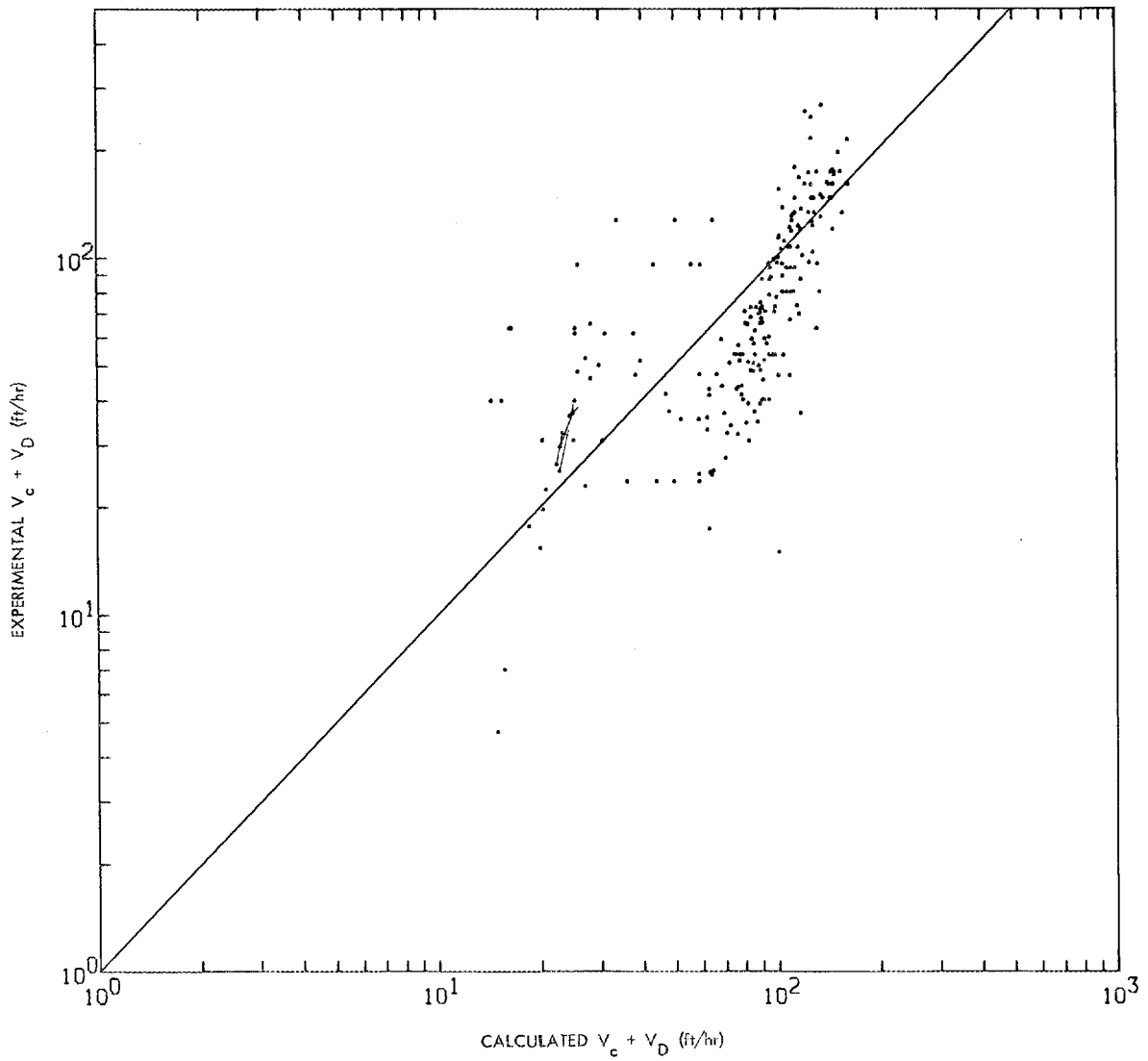

Fig. A-6. Experimental vs Calculated Throughput for Flood Equation 122 and Group-2 Data.

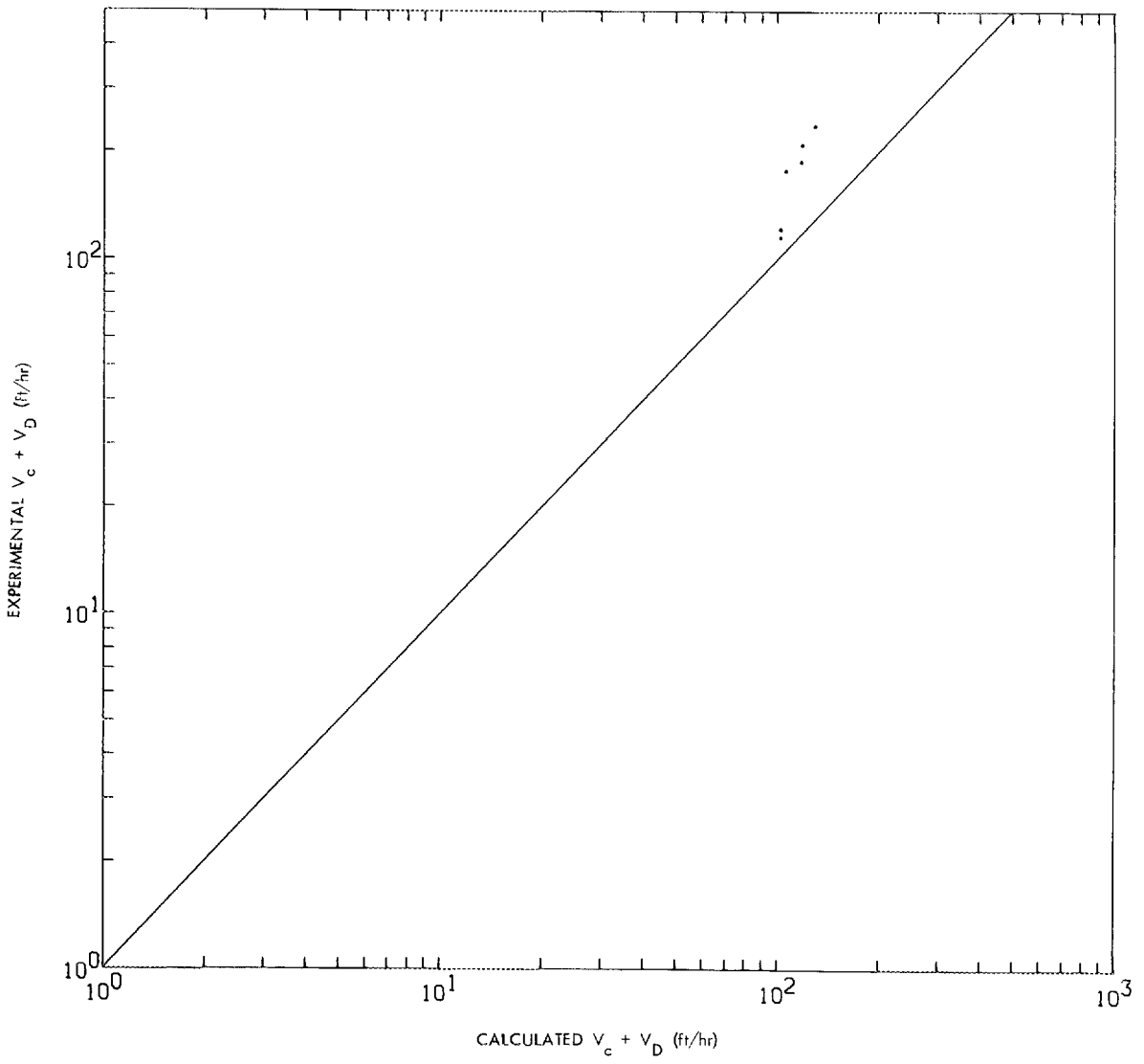

Fig. A-7. Experimental vs Calculated Throughput for Flood Equation 122 and Group-3 Data.

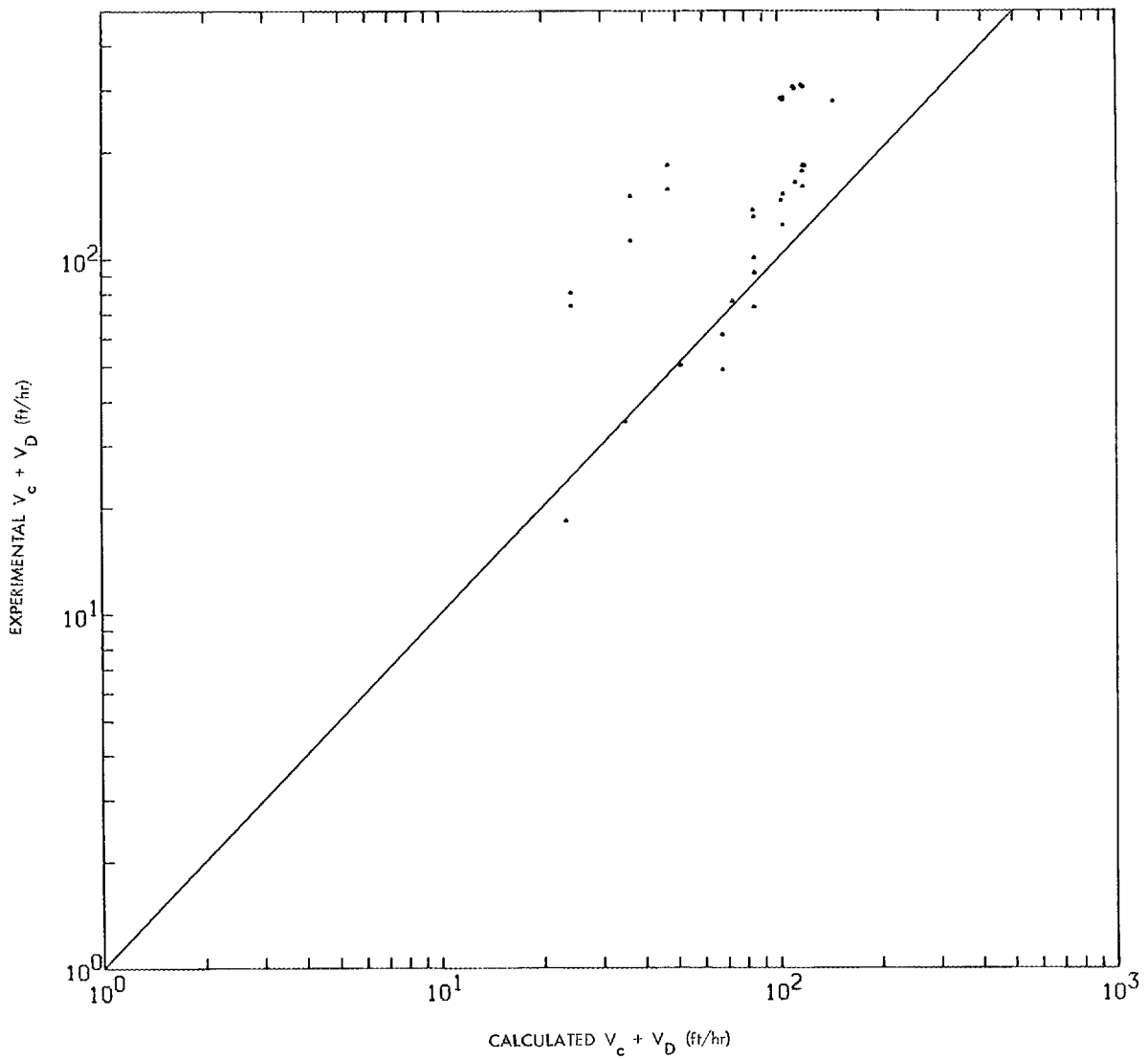

Fig. A-8. Experimental vs Calculated Throughput for Flood Equation 122 and Group-4 Data.

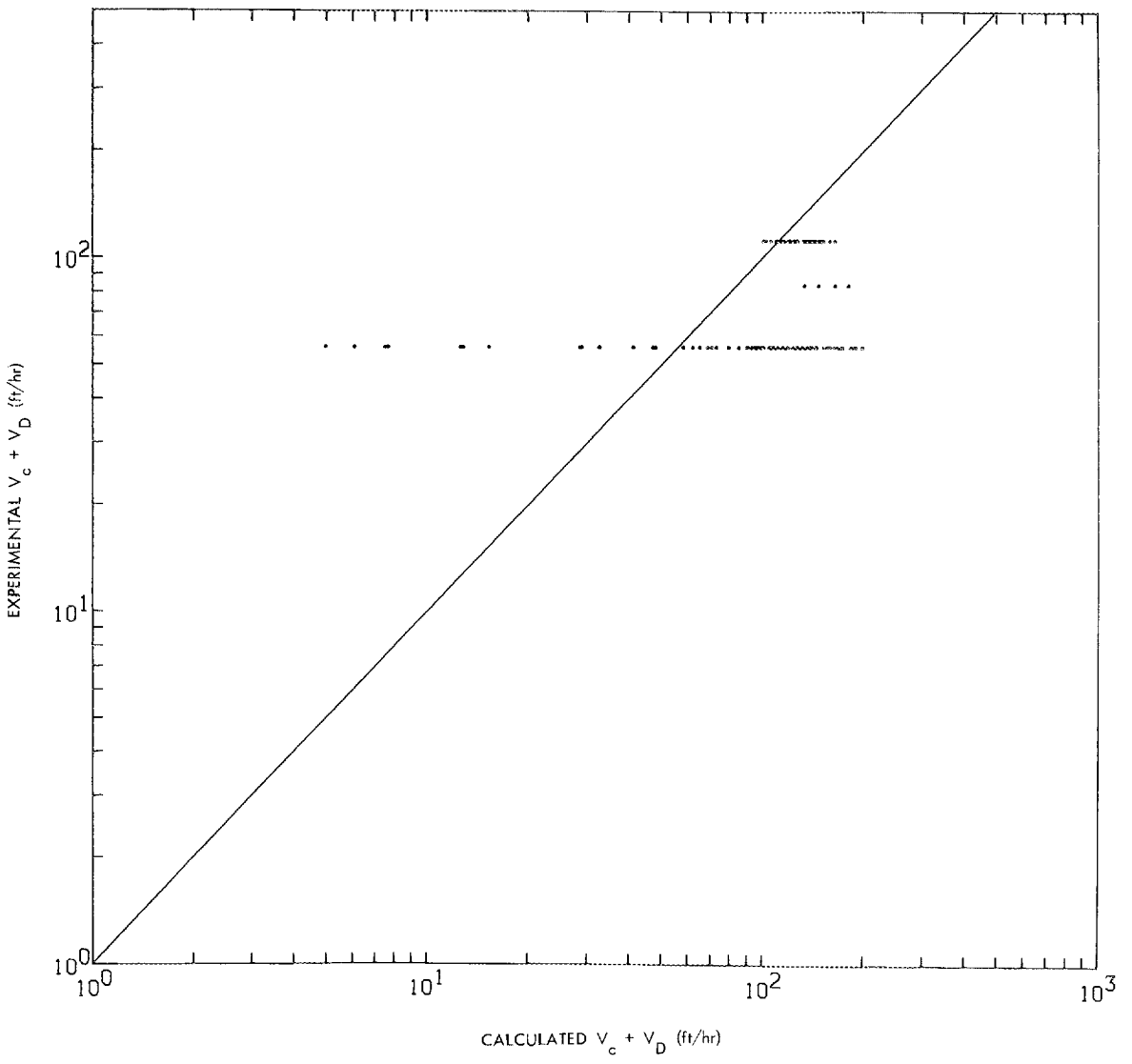

Fig. A-9. Experimental vs Calculated Throughput for Flood Equation 122 and Group-5 Data.

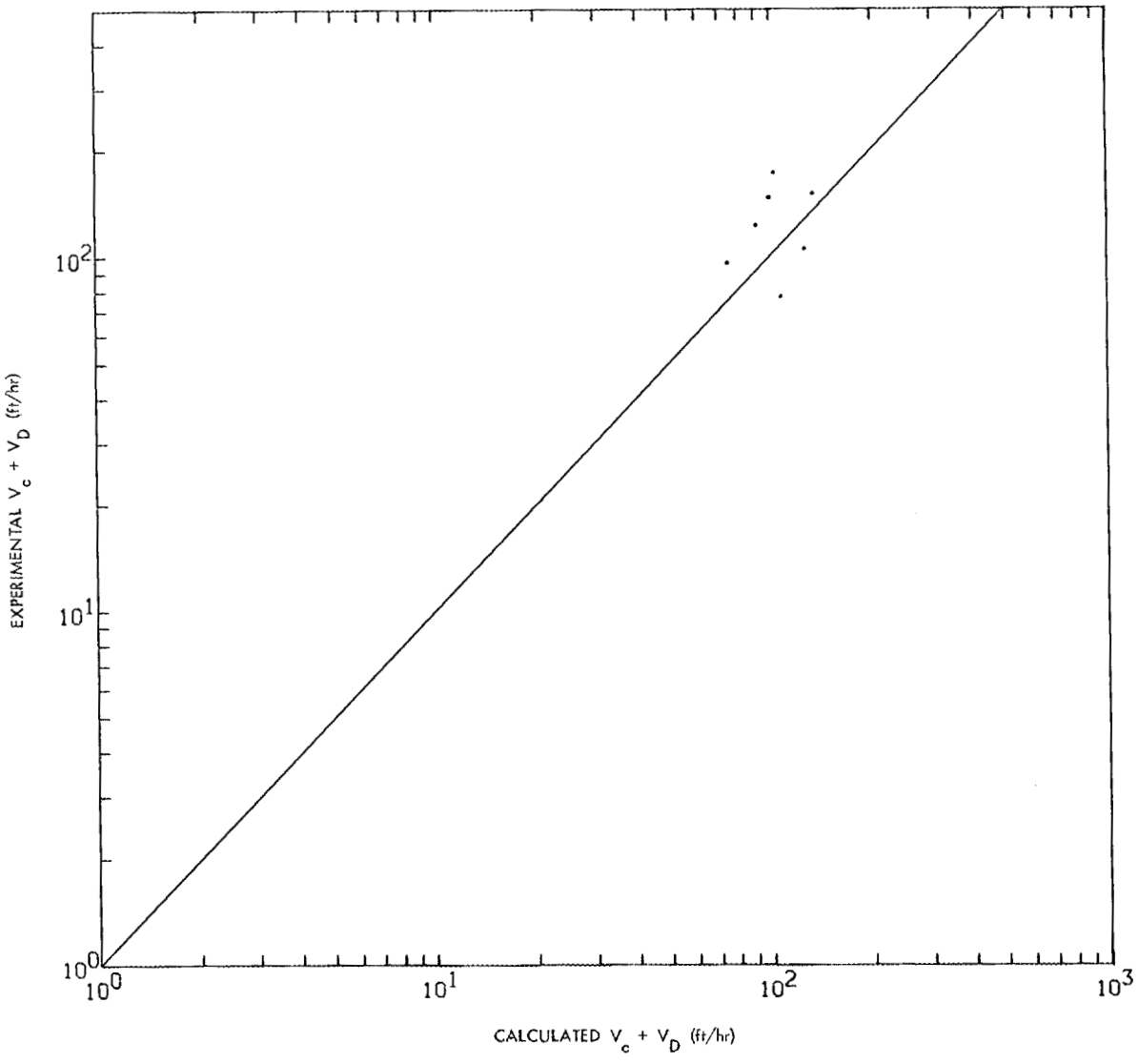

Fig. A-10. Experimental vs Calculated Throughput for Flood Equation 122 and Group-10 Data.

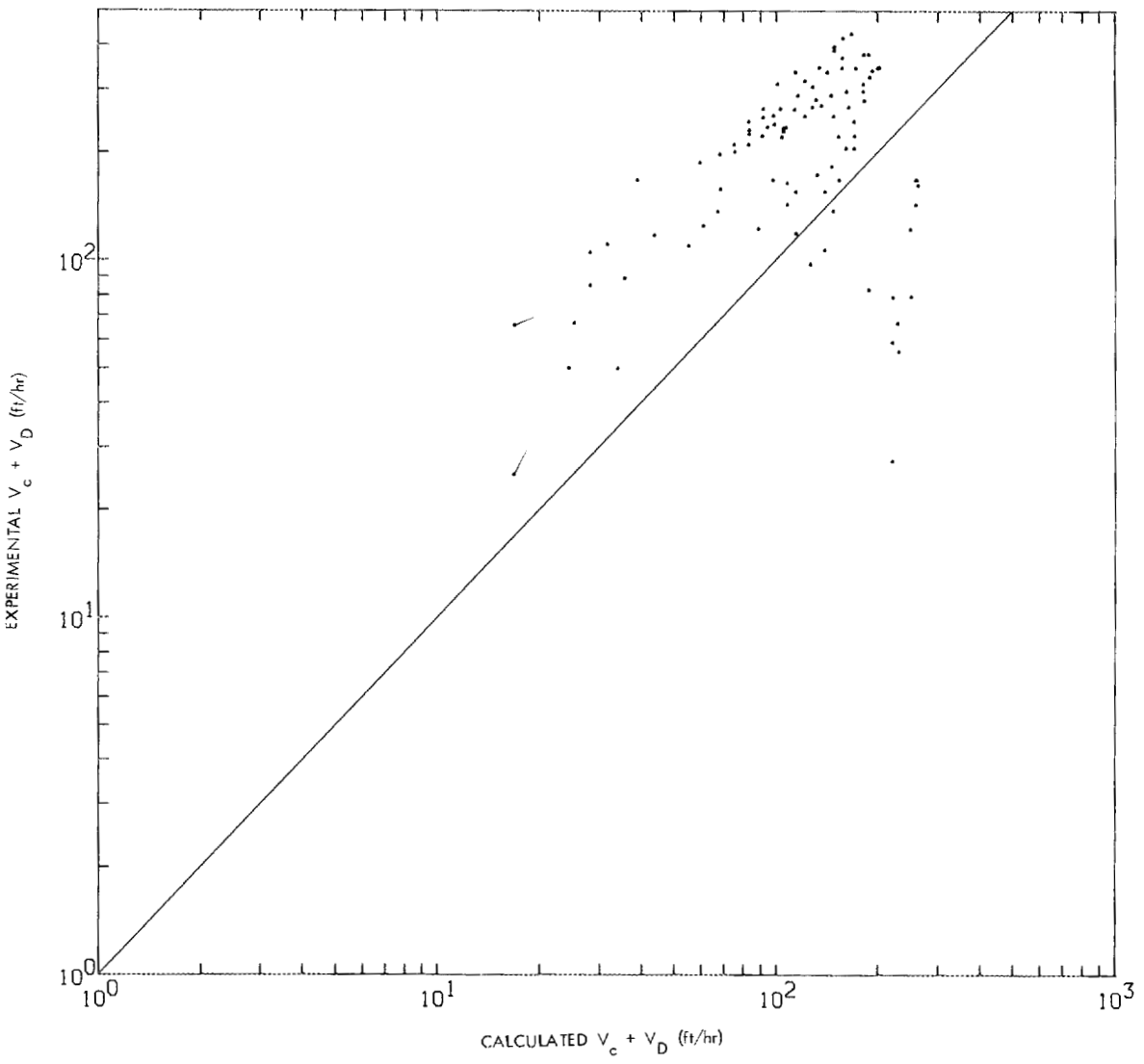

Fig. A-11. Experimental vs Calculated Throughput for Flood Equation 122 and Group-11 Data.

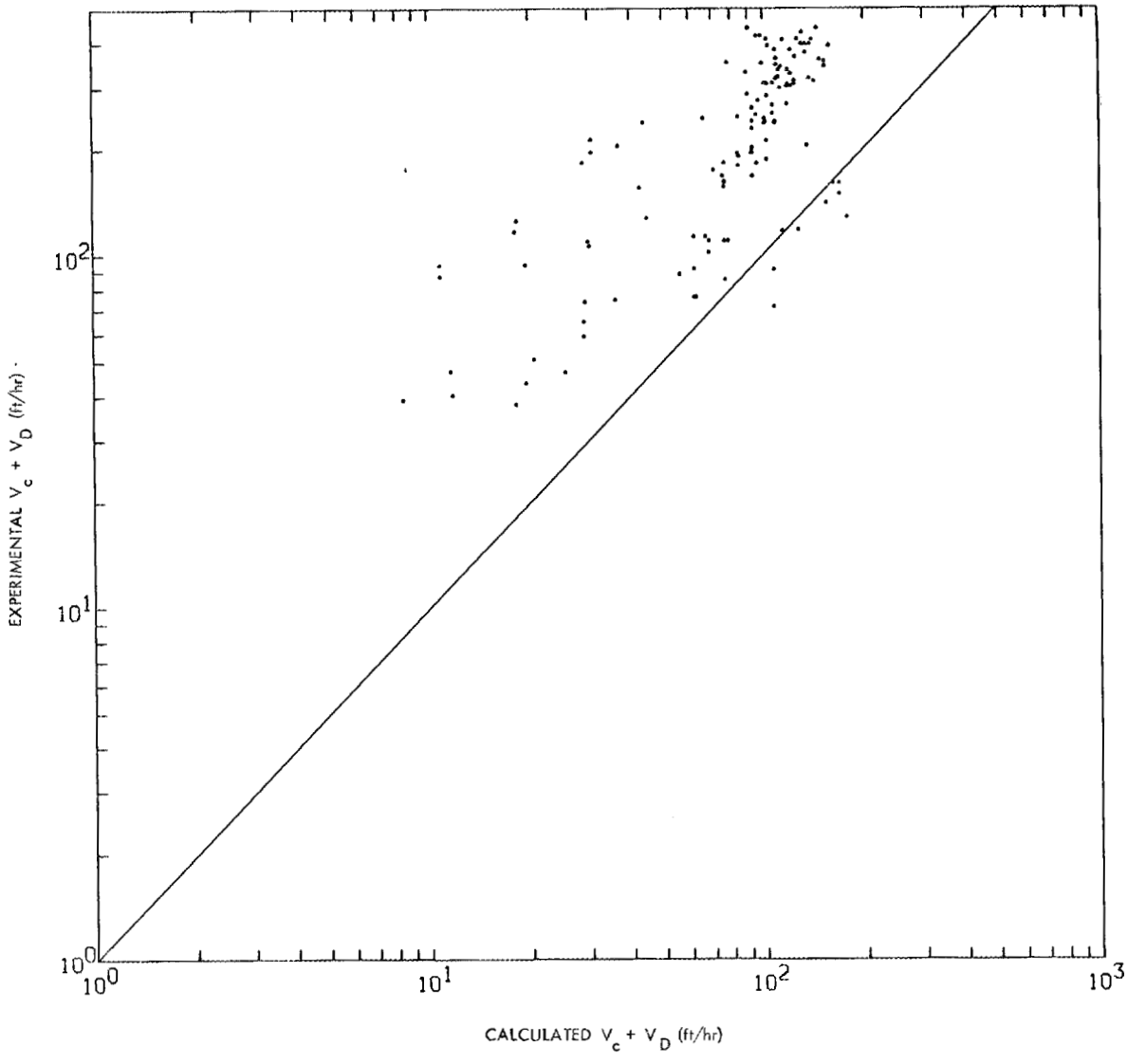

Fig. A-12. Experimental vs Calculated Throughput for Flood Equation 122 and Group-12 Data.

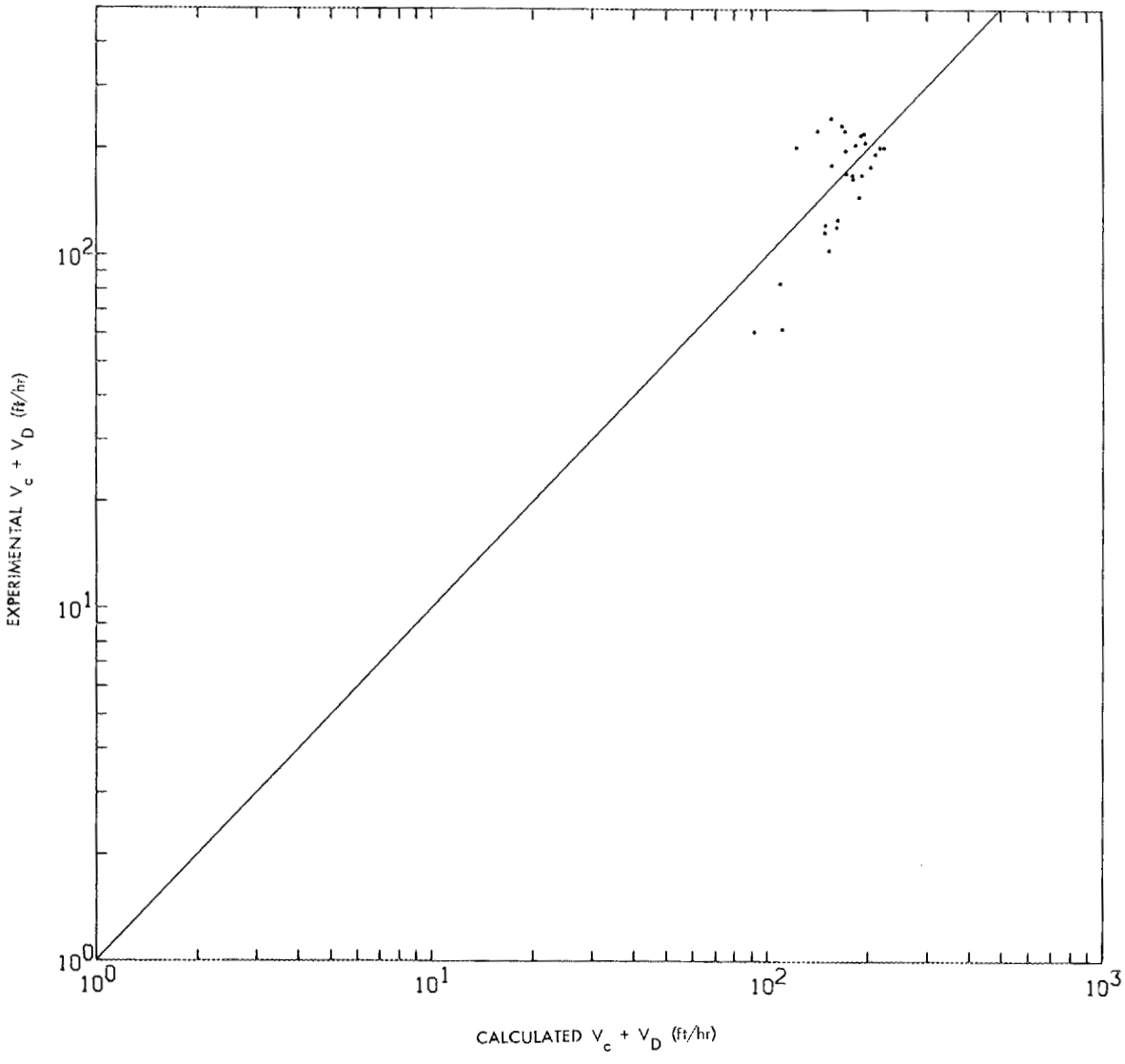

Fig. A-13. Experimental vs Calculated Throughput for Flood Equation 122 and Group-13 Data.

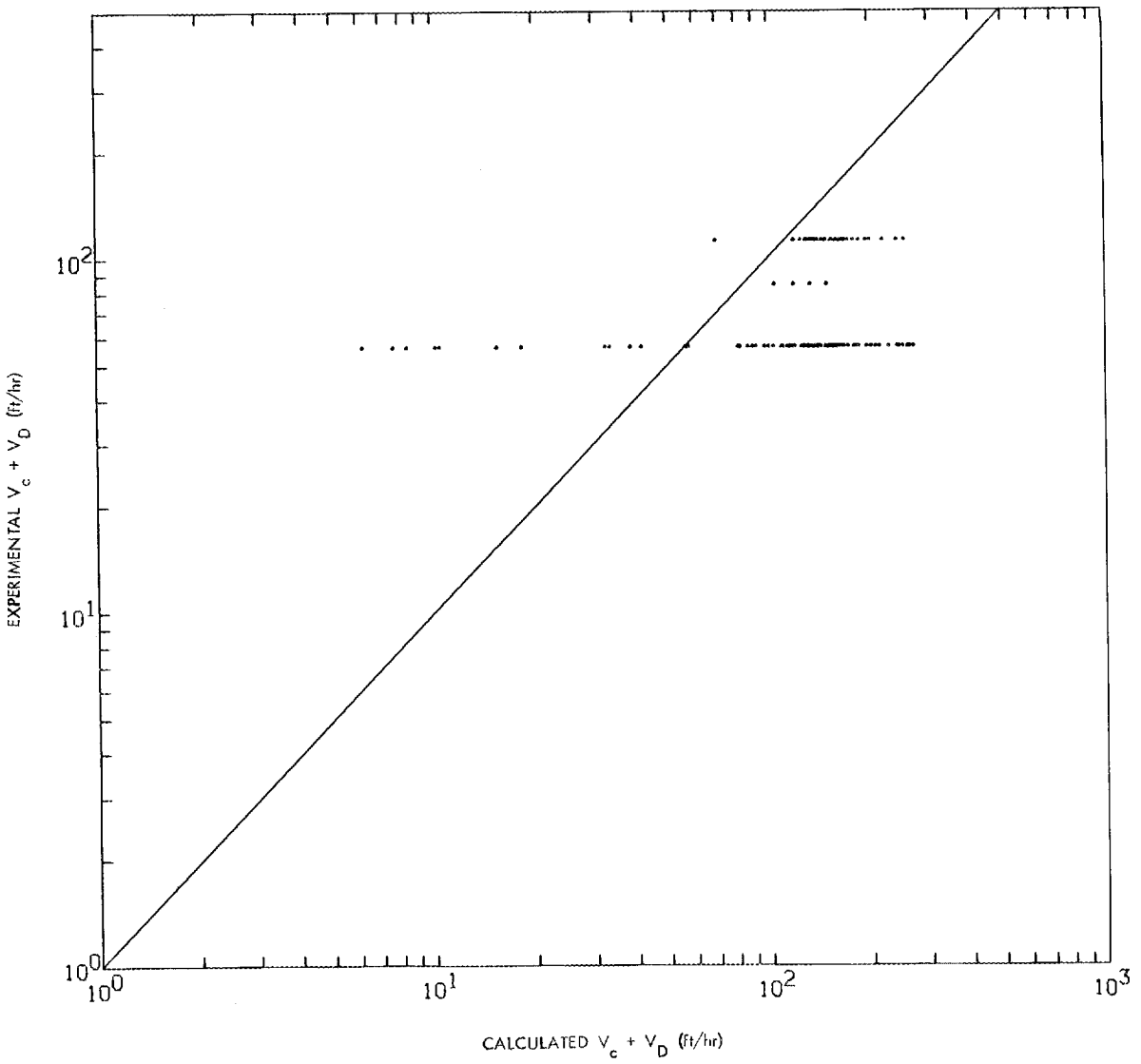

Fig. A-14. Experimental vs Calculated Throughput for Flood Equation 122 and Group-14 Data.

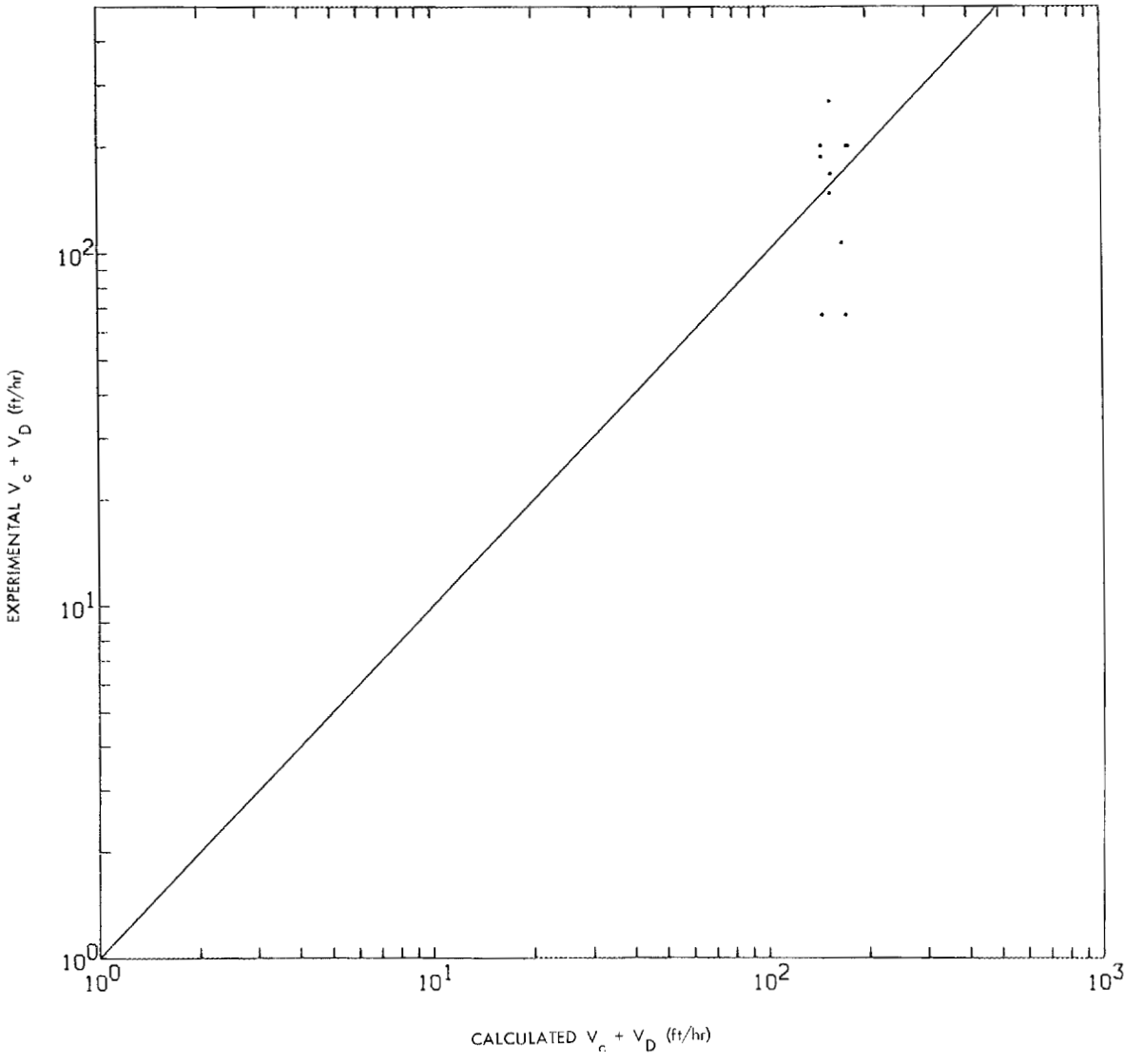

Fig. A-15. Experimental vs Calculated Throughput for Flood Equation 122 and Group-15 Data.

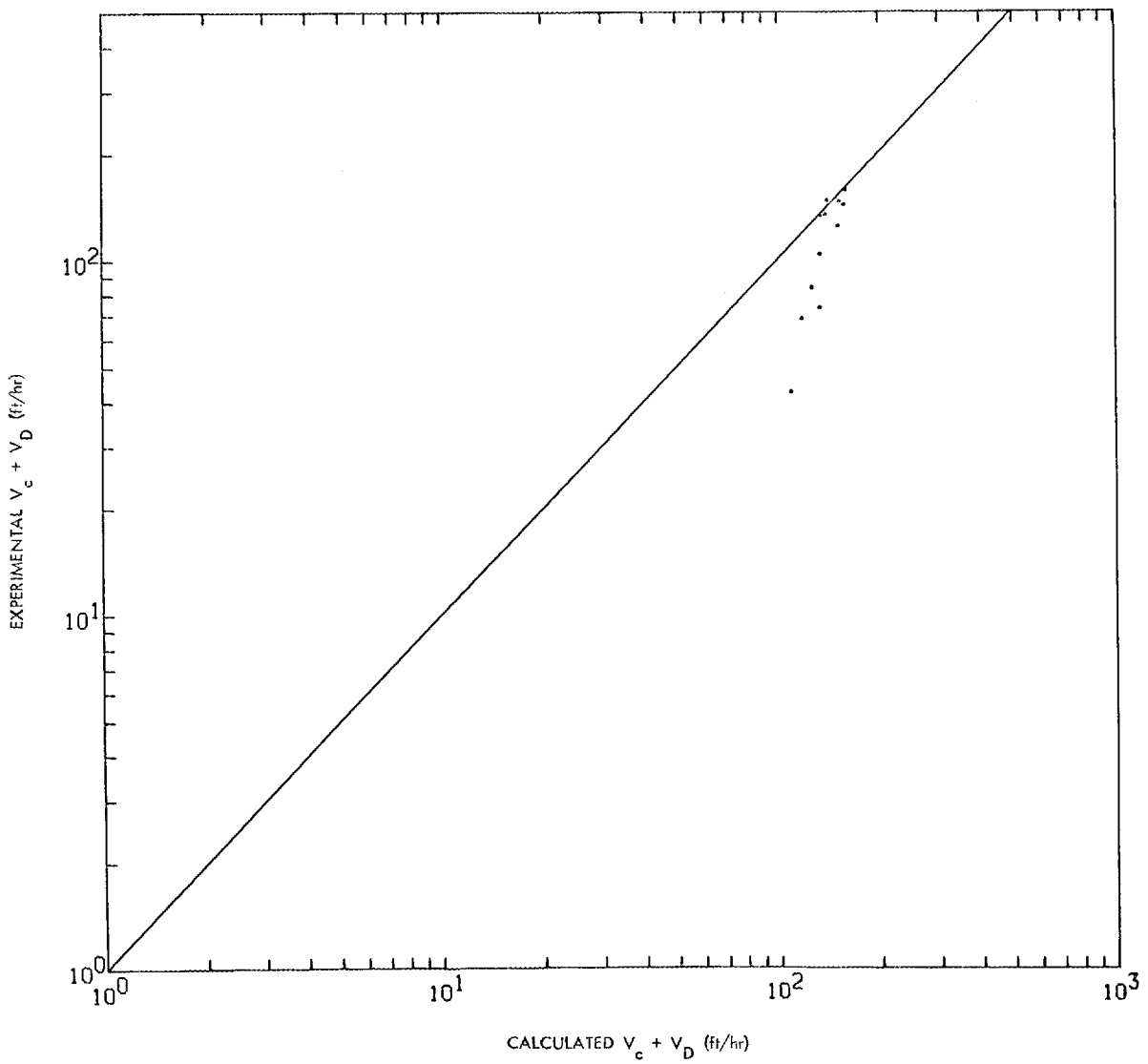

Fig. A-16. Experimental vs Calculated Throughput for Flood Equation 122 and Group-16 Data.

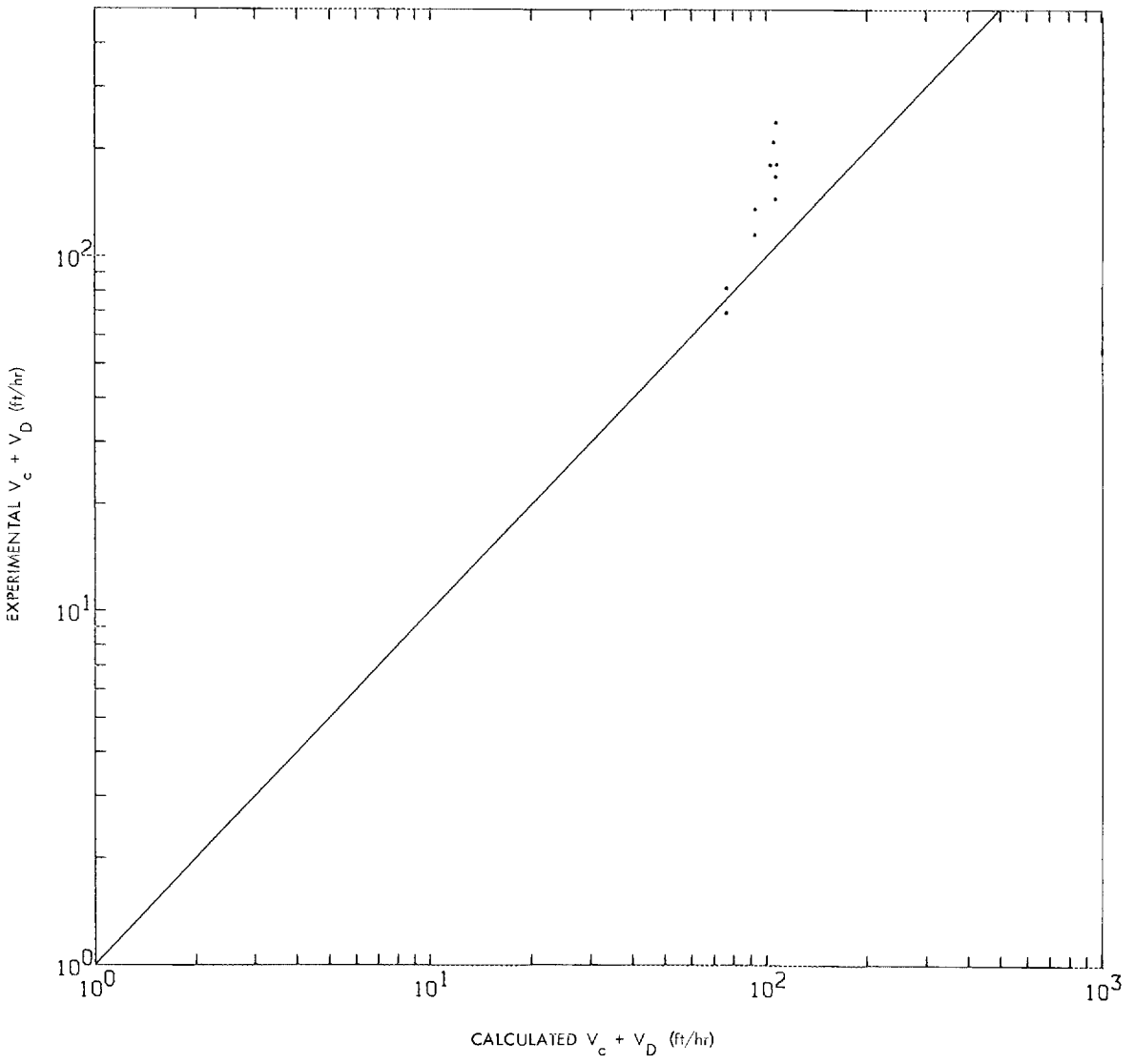

Fig. A-17. Experimental vs Calculated Throughput for Flood Equation 122 and Group-17 Data.

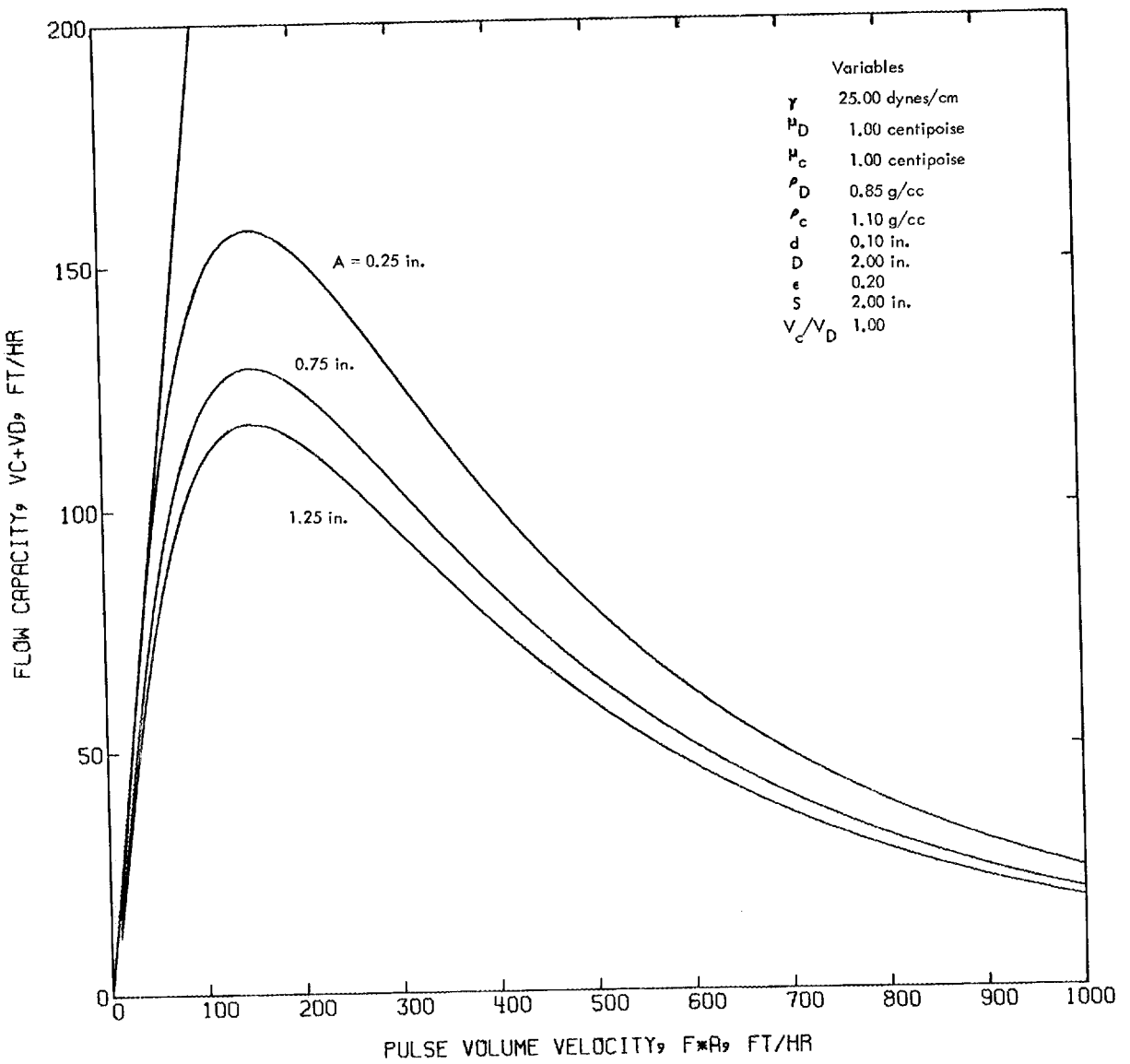

Fig. A-18. Effect of Varying Pulse Amplitude on Flood Equation 122 Flow Capacities.

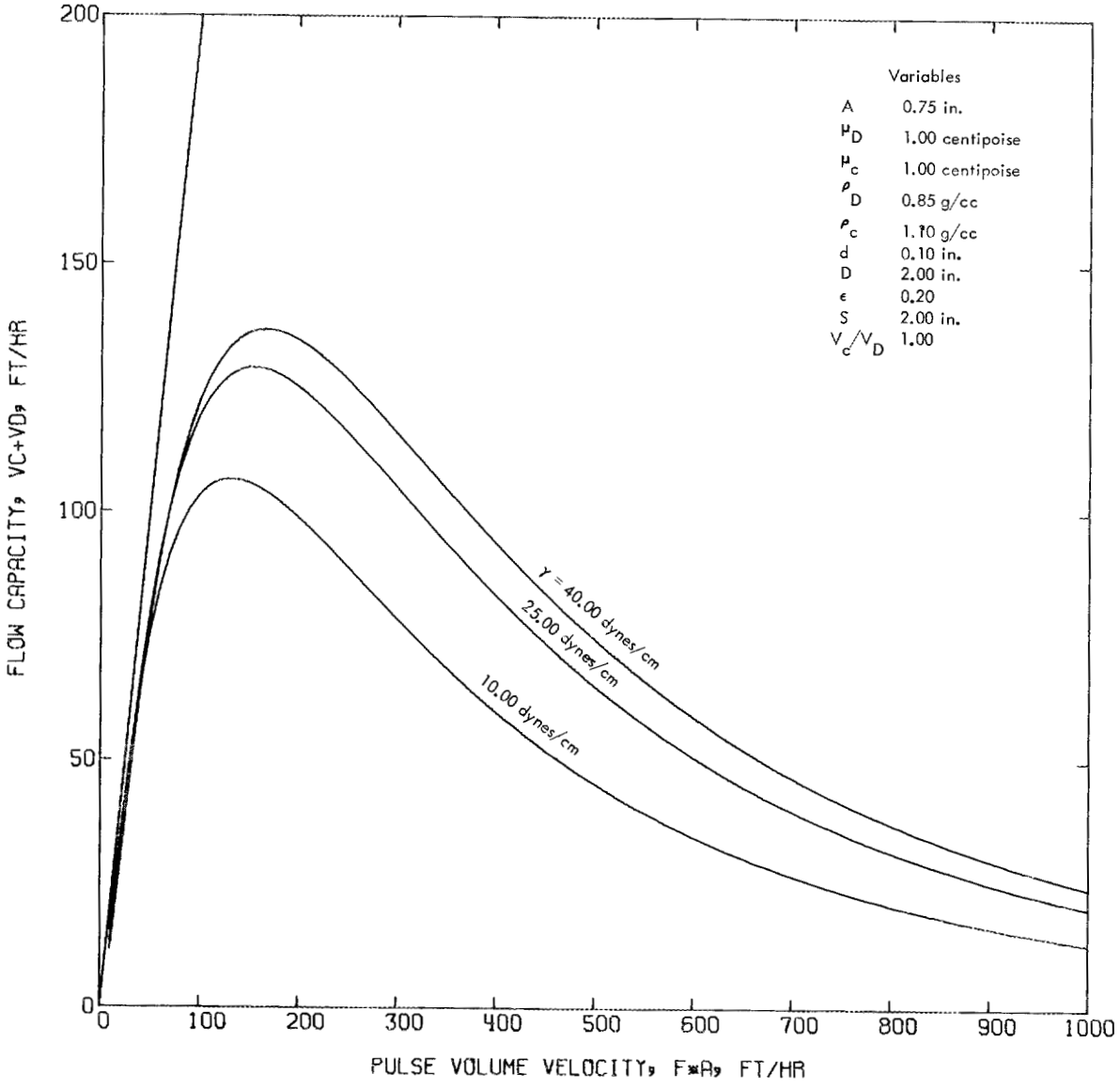

Fig. A-19. Effect of Varying Interfacial Tension on Flood Equation 122 Flow Capacities.

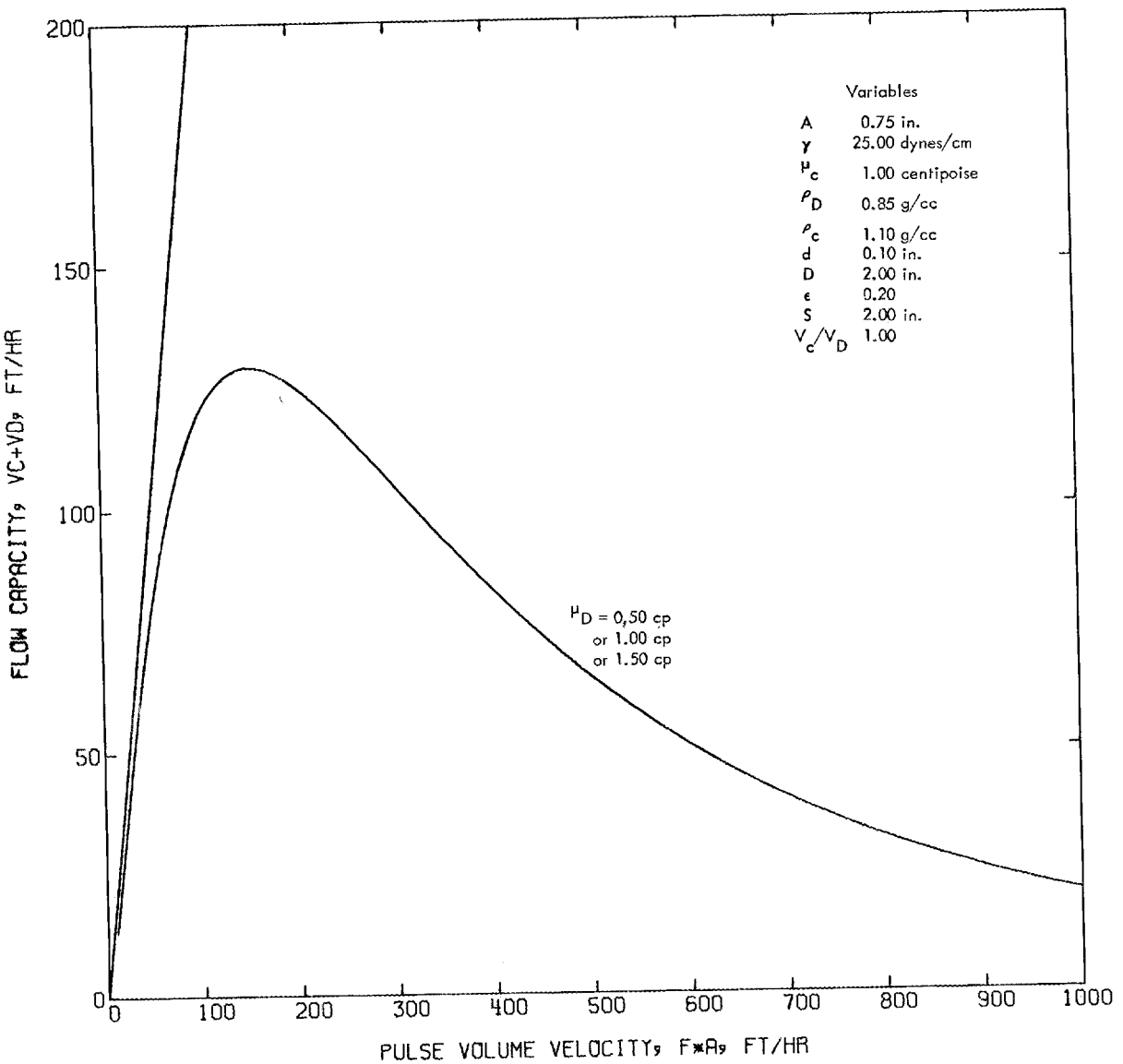

Fig. A-20. Effect of Varying Dispersed Phase Viscosity on Flood Equation 122 Flow Capacities.

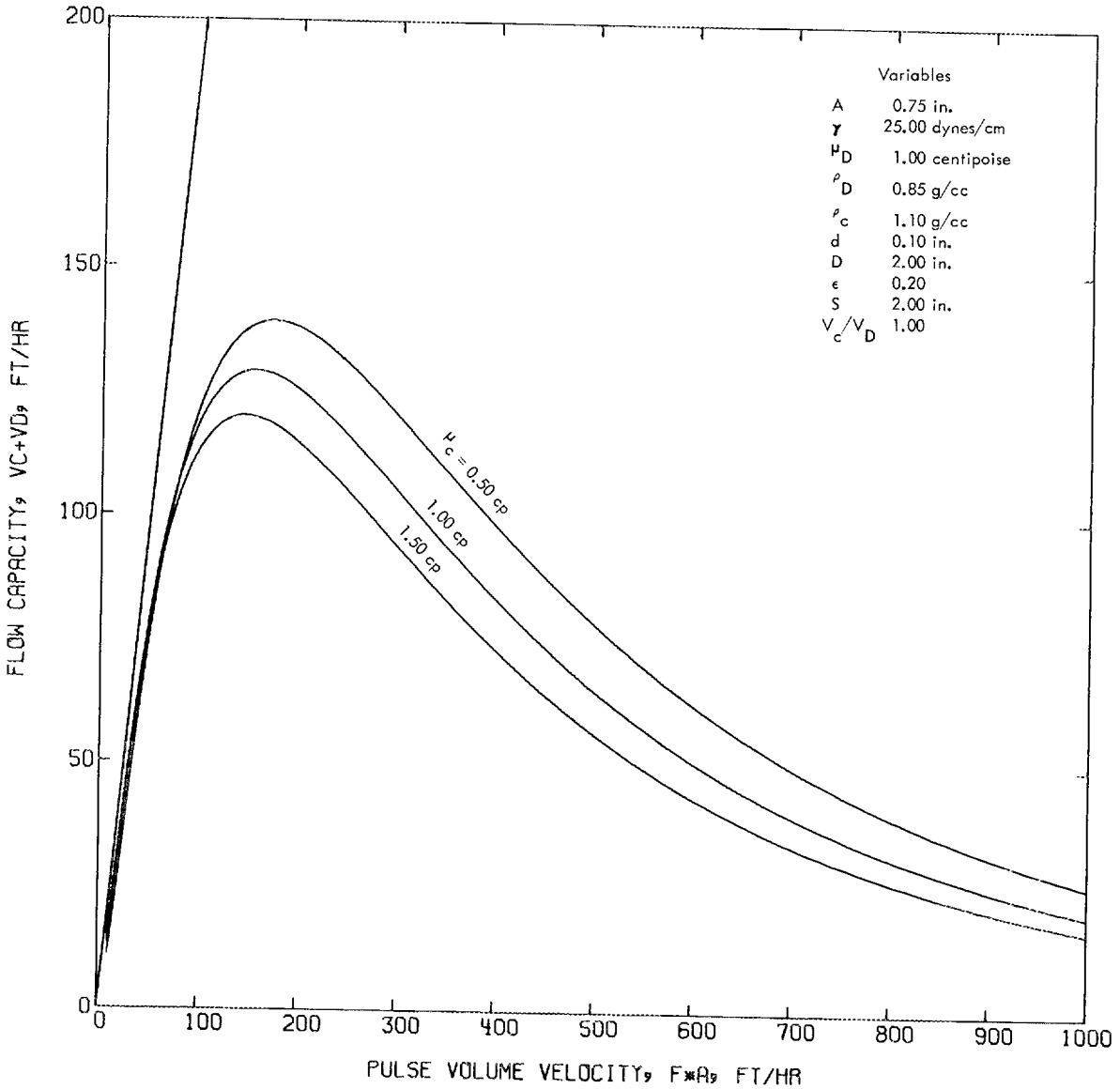

Fig. A-21. Effect of Varying Continuous Phase Viscosity on Flood Equation 122 Flow Capacities.

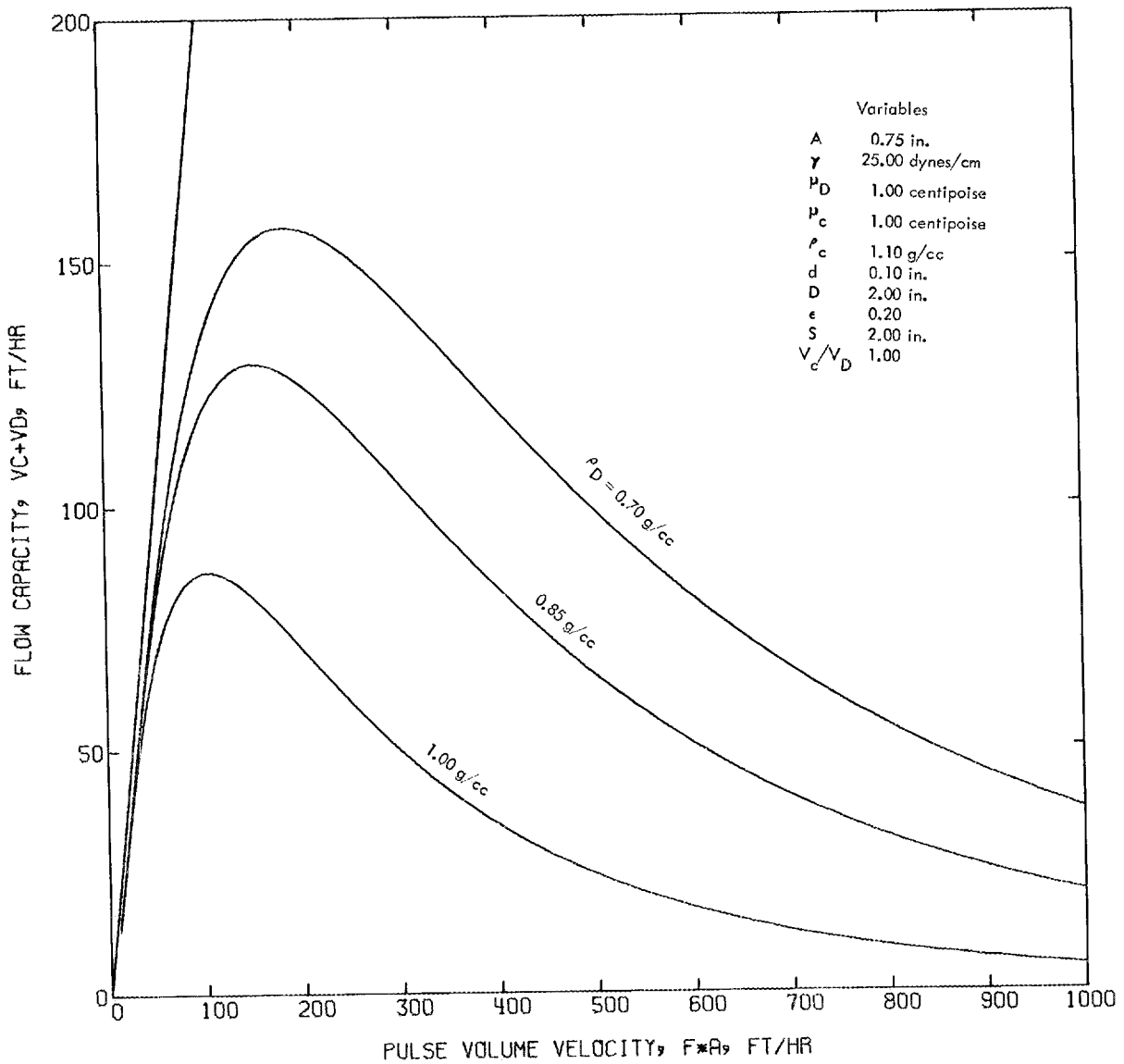

Fig. A-22. Effect of Varying Dispersed Phase Density on Flood Equation 122 Flow Capacities.

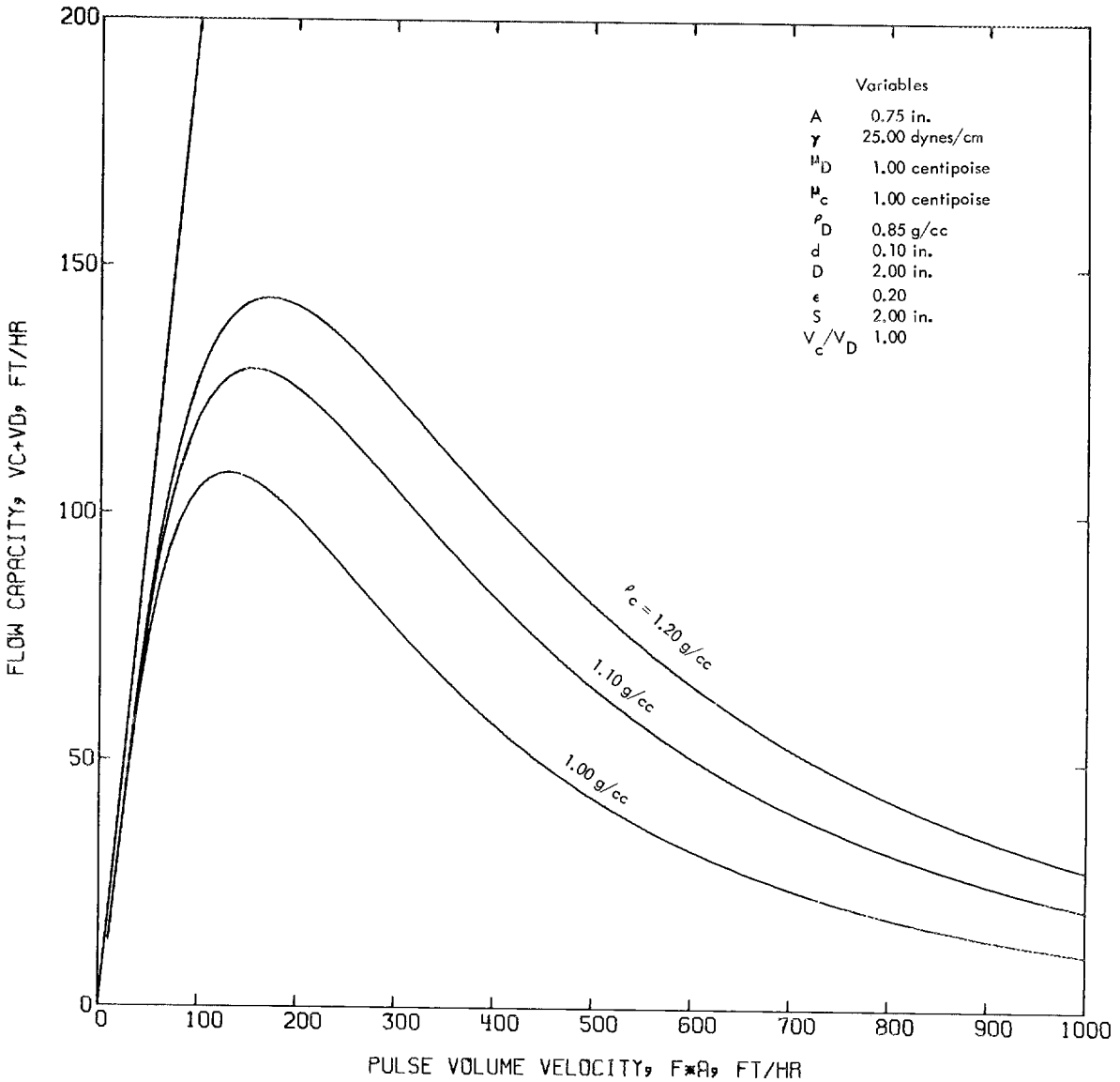

Fig. A-23. Effect of Varying Continuous Phase Density on Flood Equation 122 Flow Capacities.

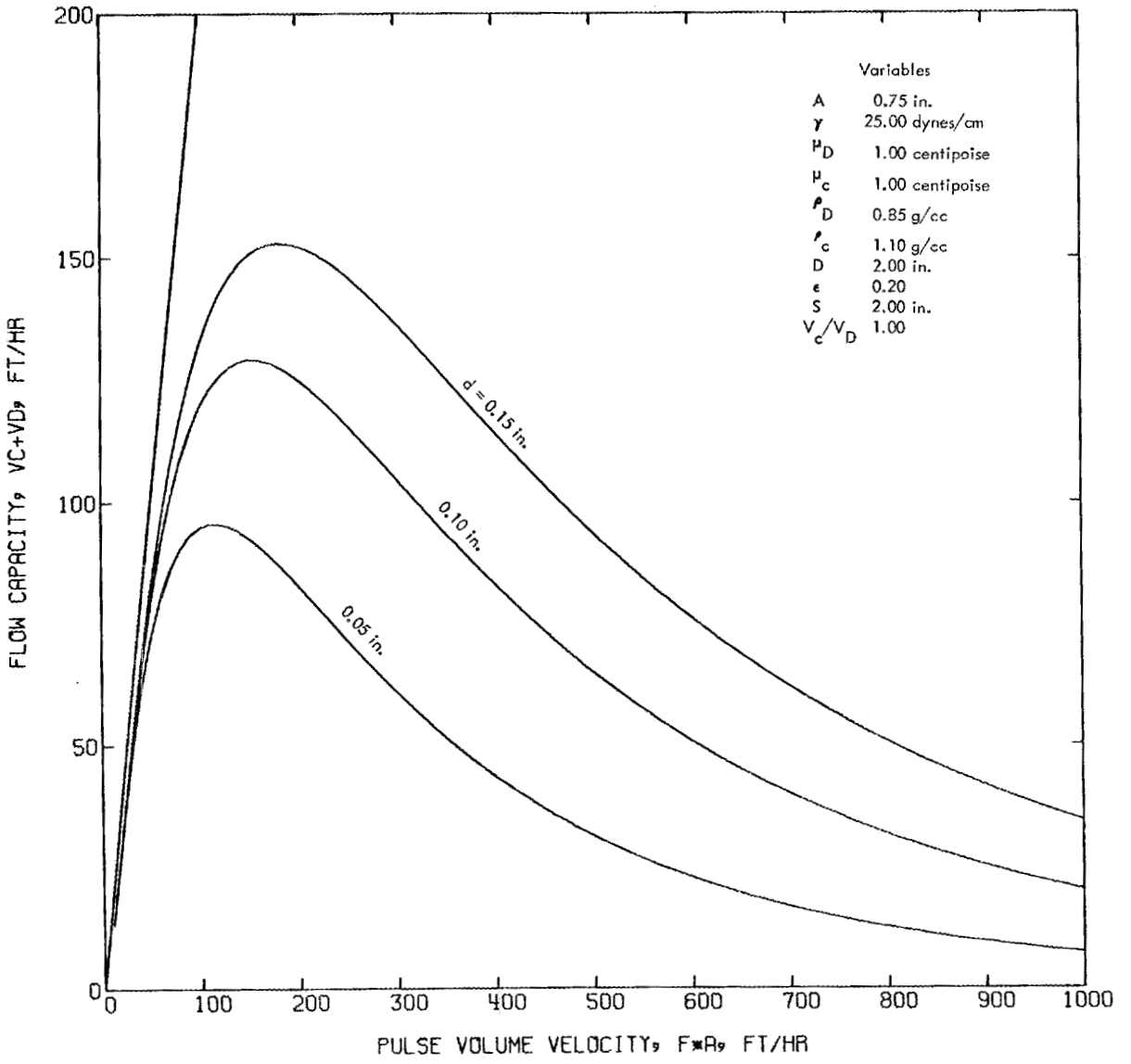

Fig. A-24. Effect of Varying Pulse Plate Hole Diameter on Flood Equation 122 Flow Capacities.

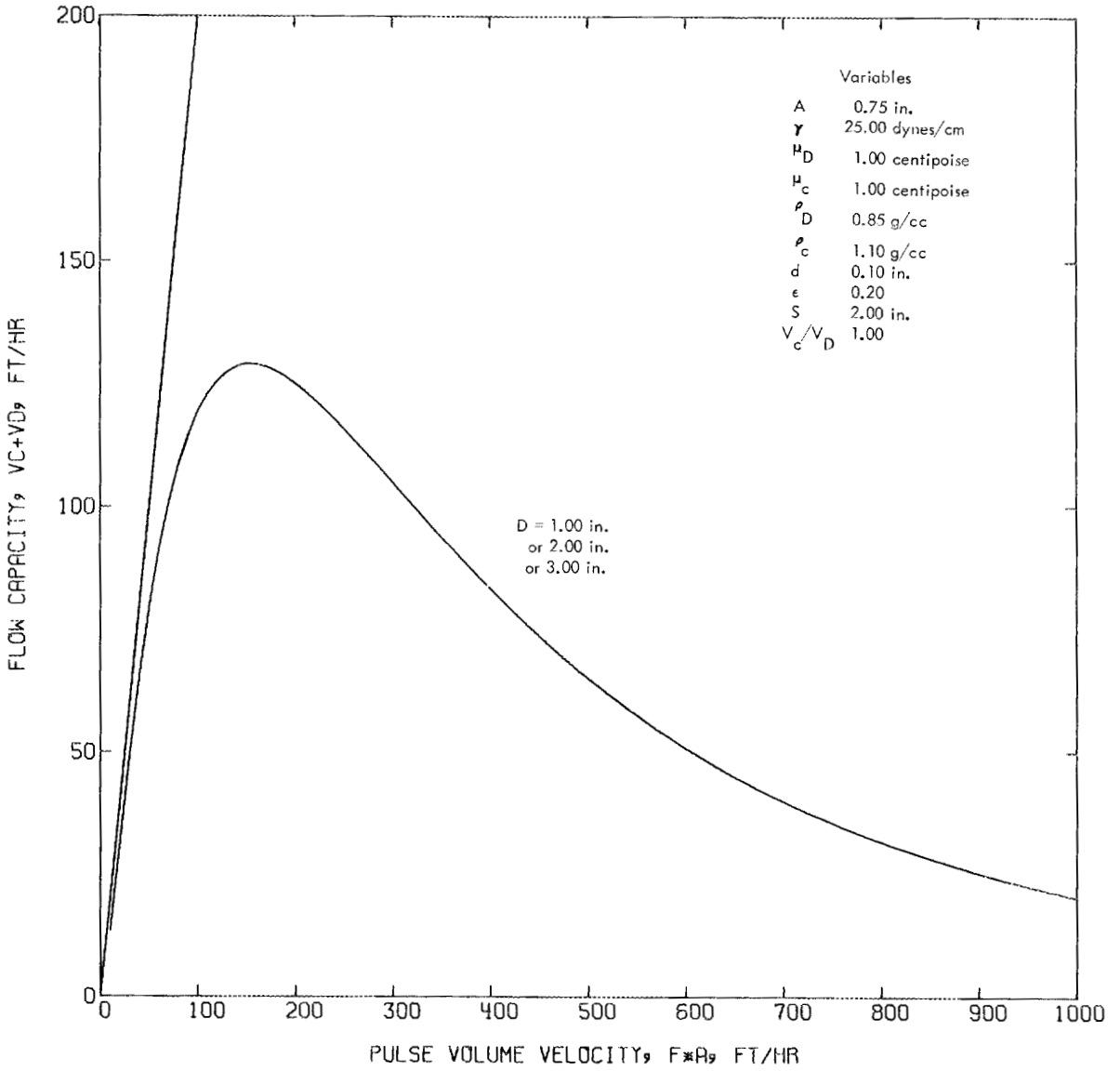

Fig. A-25. Effect of Varying Column Diameter on Flood Equation 122 Flow Capacities.

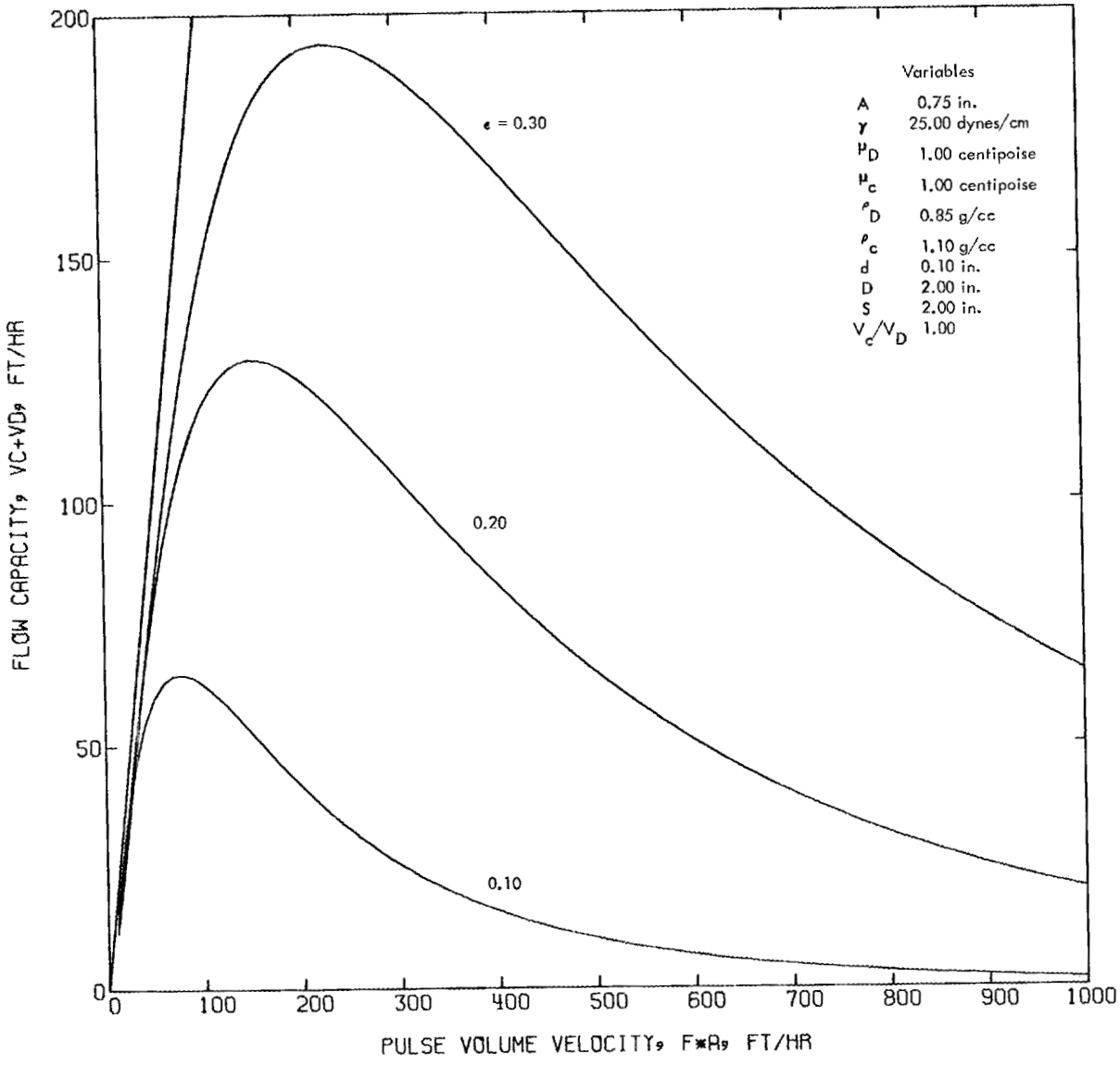

Fig. A-26. Effect of Varying Pulse-Plate Free Area on Flood Equation 122 Flow Capacities.

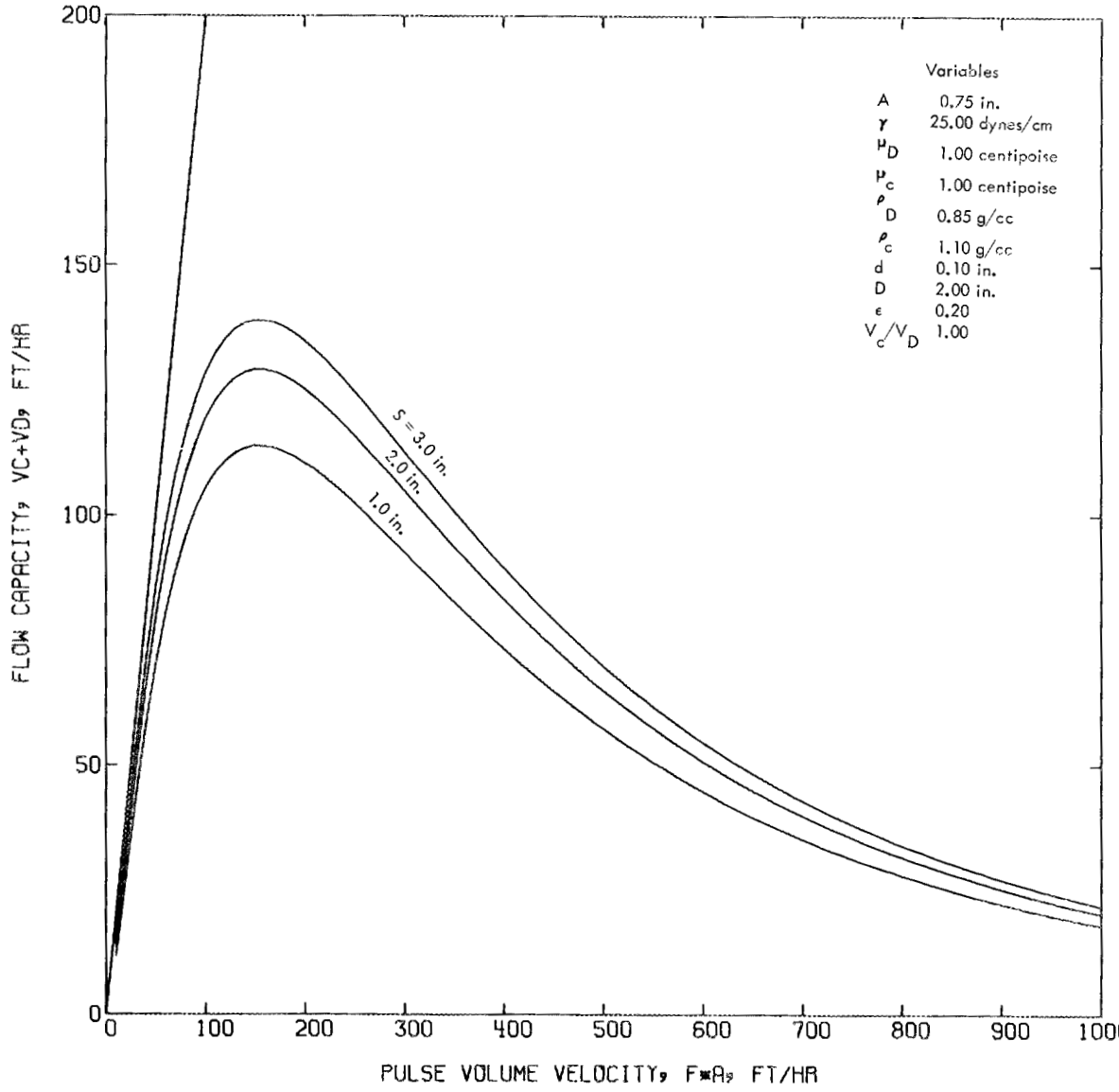

Fig. A-27. Effect of Varying Pulse-Plate Spacing on Flood Equation 122 Flow Capacities.

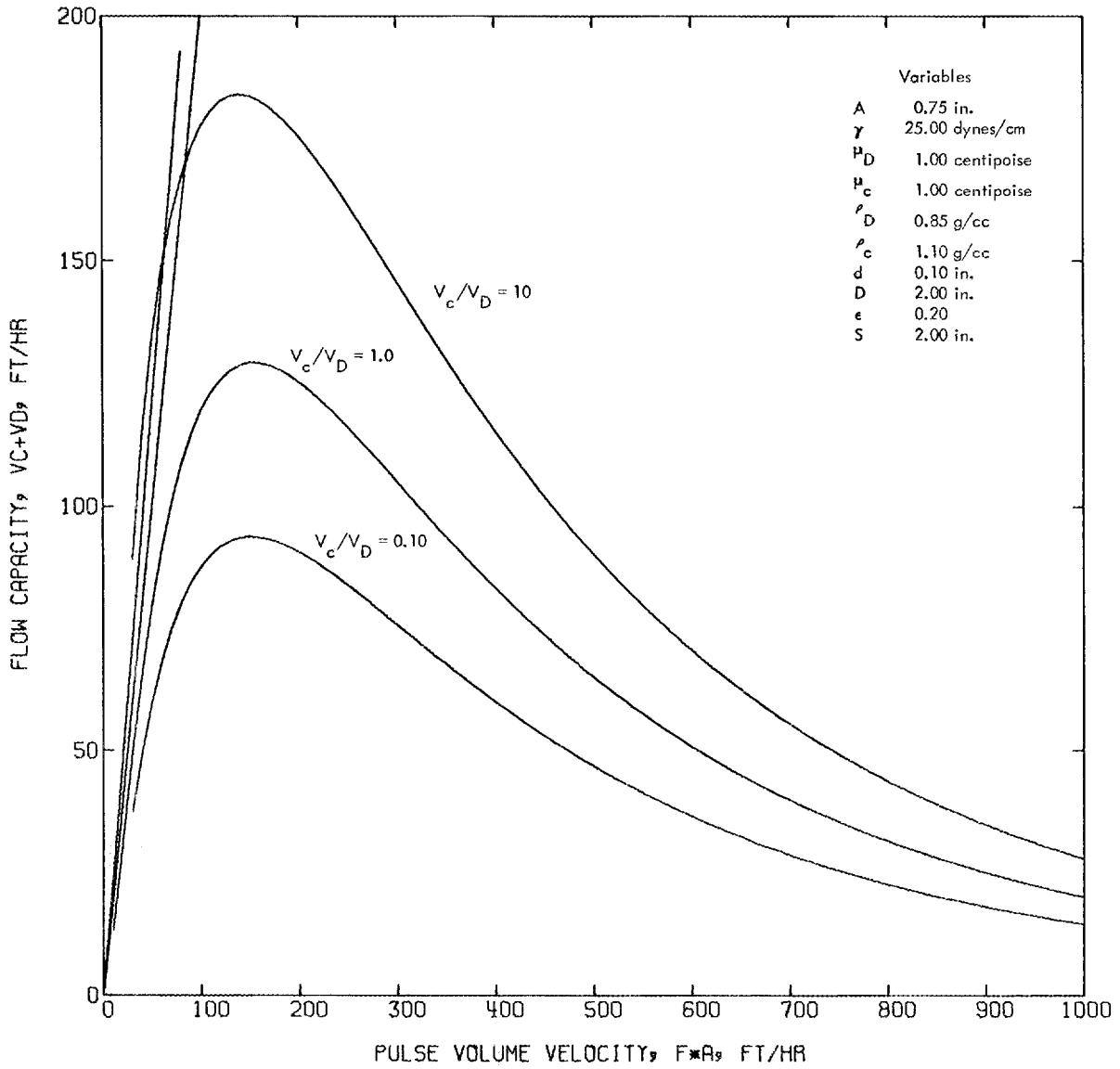

Fig. A-28. Effect of Varying the Flow Ratio on Flood Equation 122 Flow Capacities.

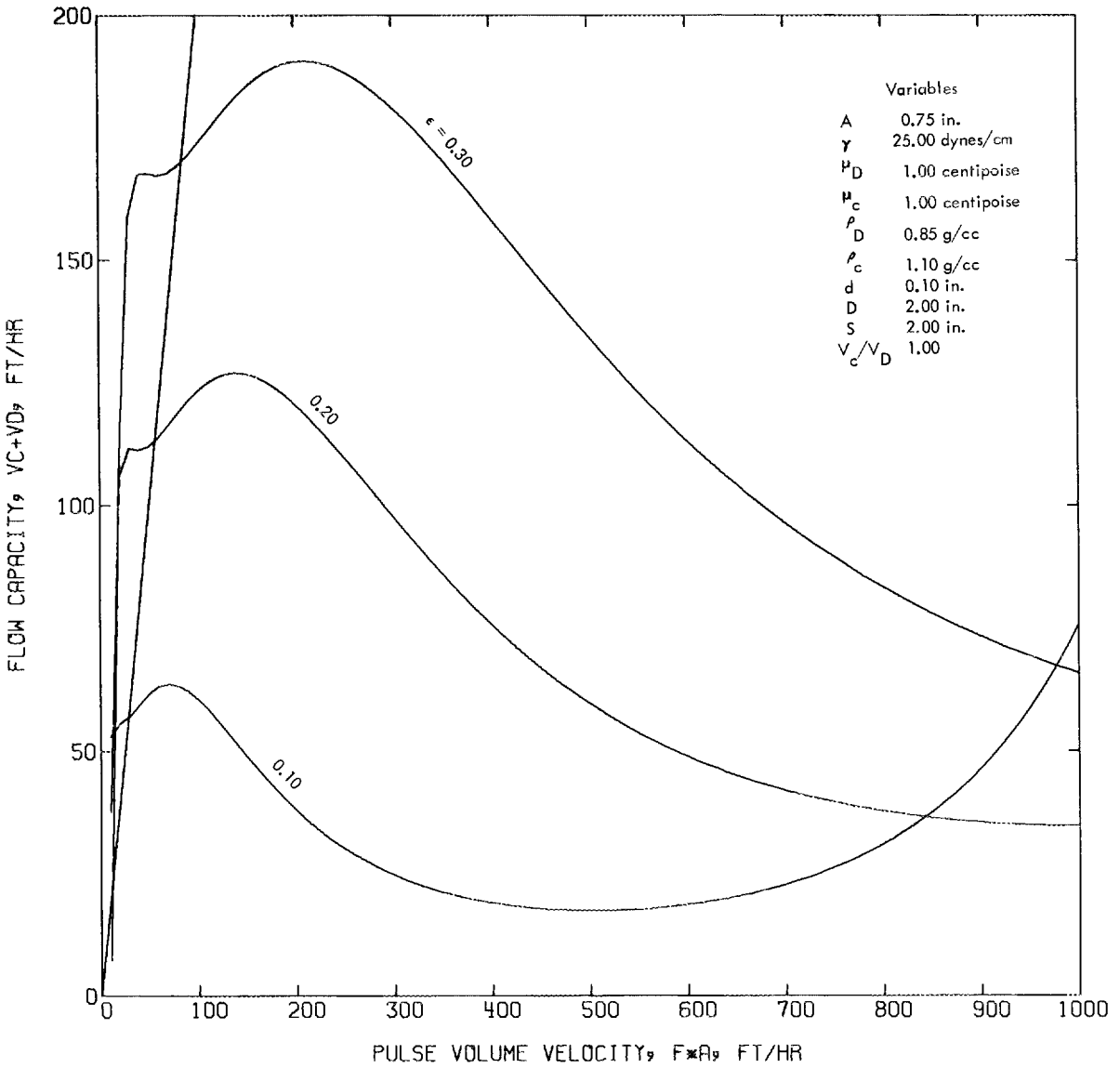

Fig. A-29. Effect of Varying Pulse-Plate Free Area on Flood Equation 180 Flow Capacities.

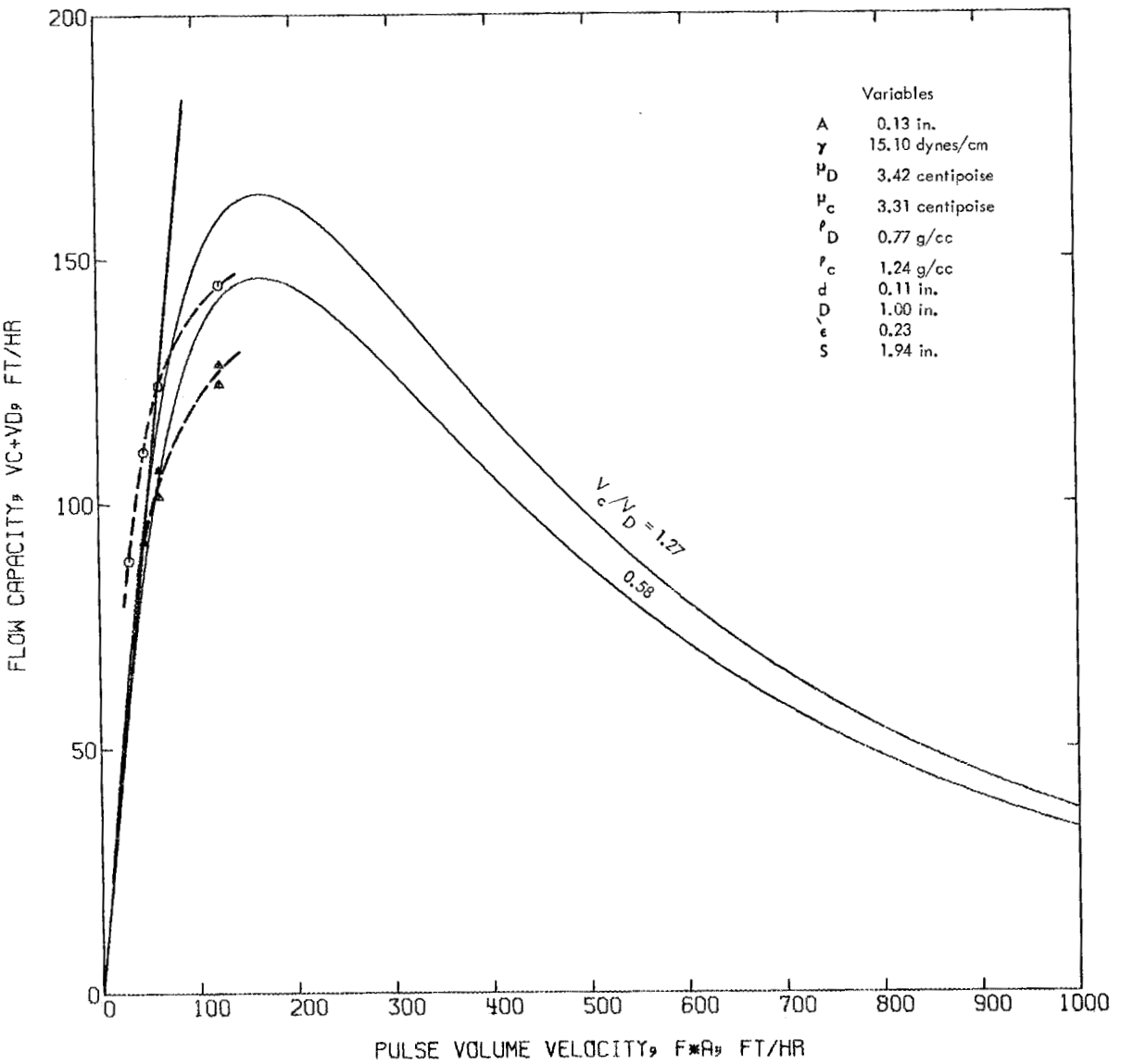

Fig. A-30. Fit of Flood Equation 122 to Some Data from Points 1-44.

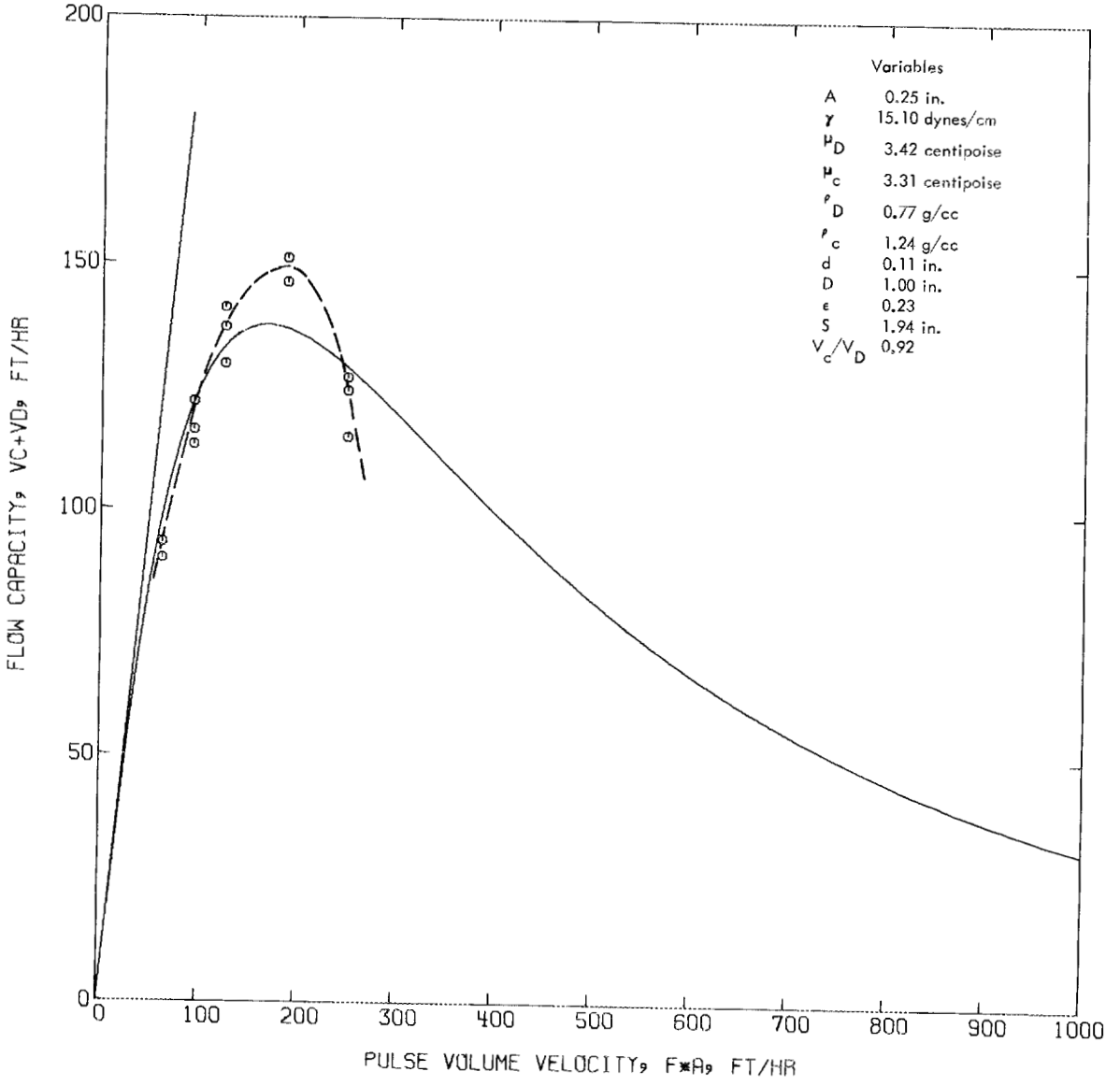

Fig. A-31. Fit of Flood Equation 122 to Some Data from Points 1-44.

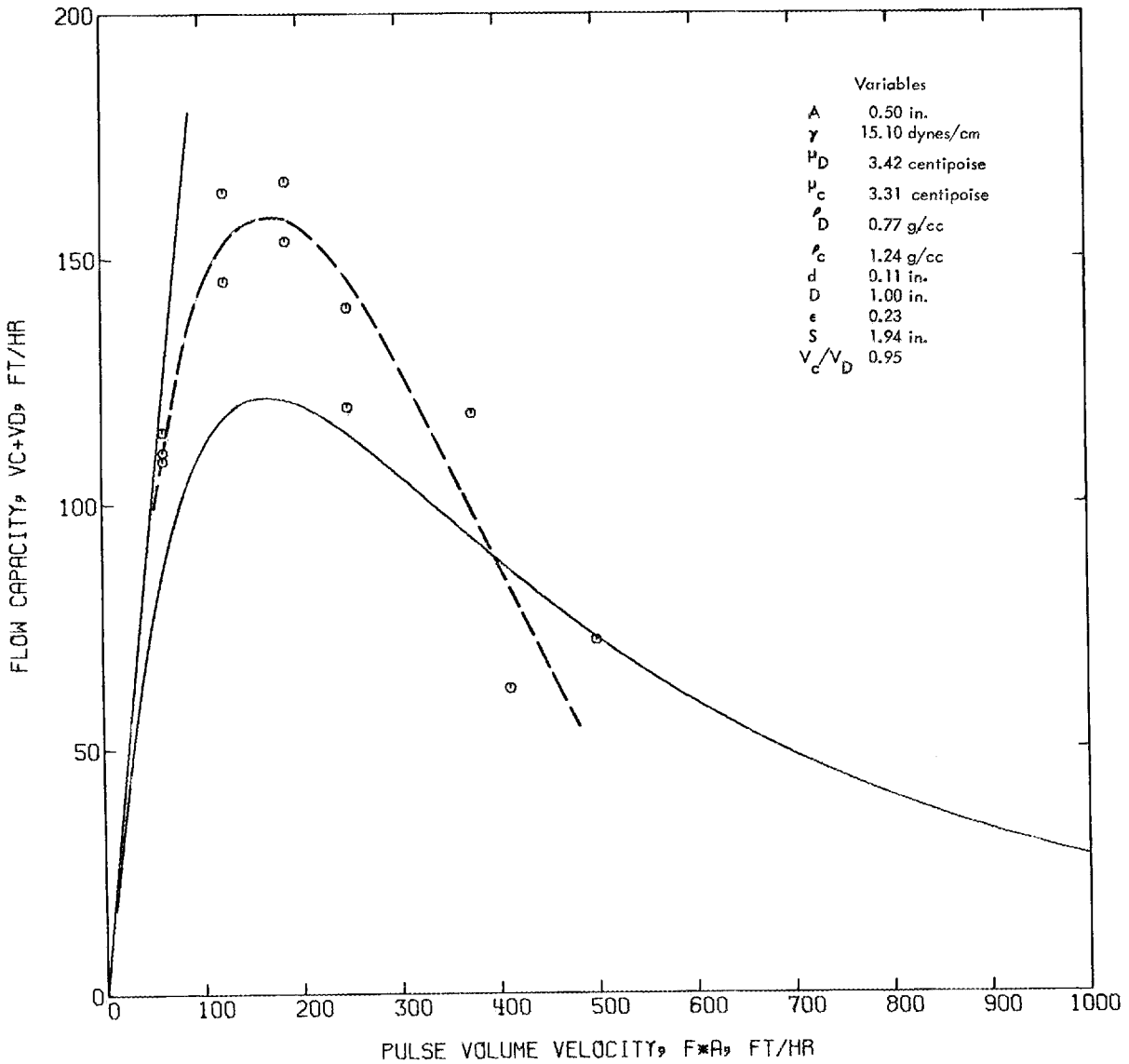

Fig. A-32. Fit of Flood Equation 122 to Some Data from Points 1-44.

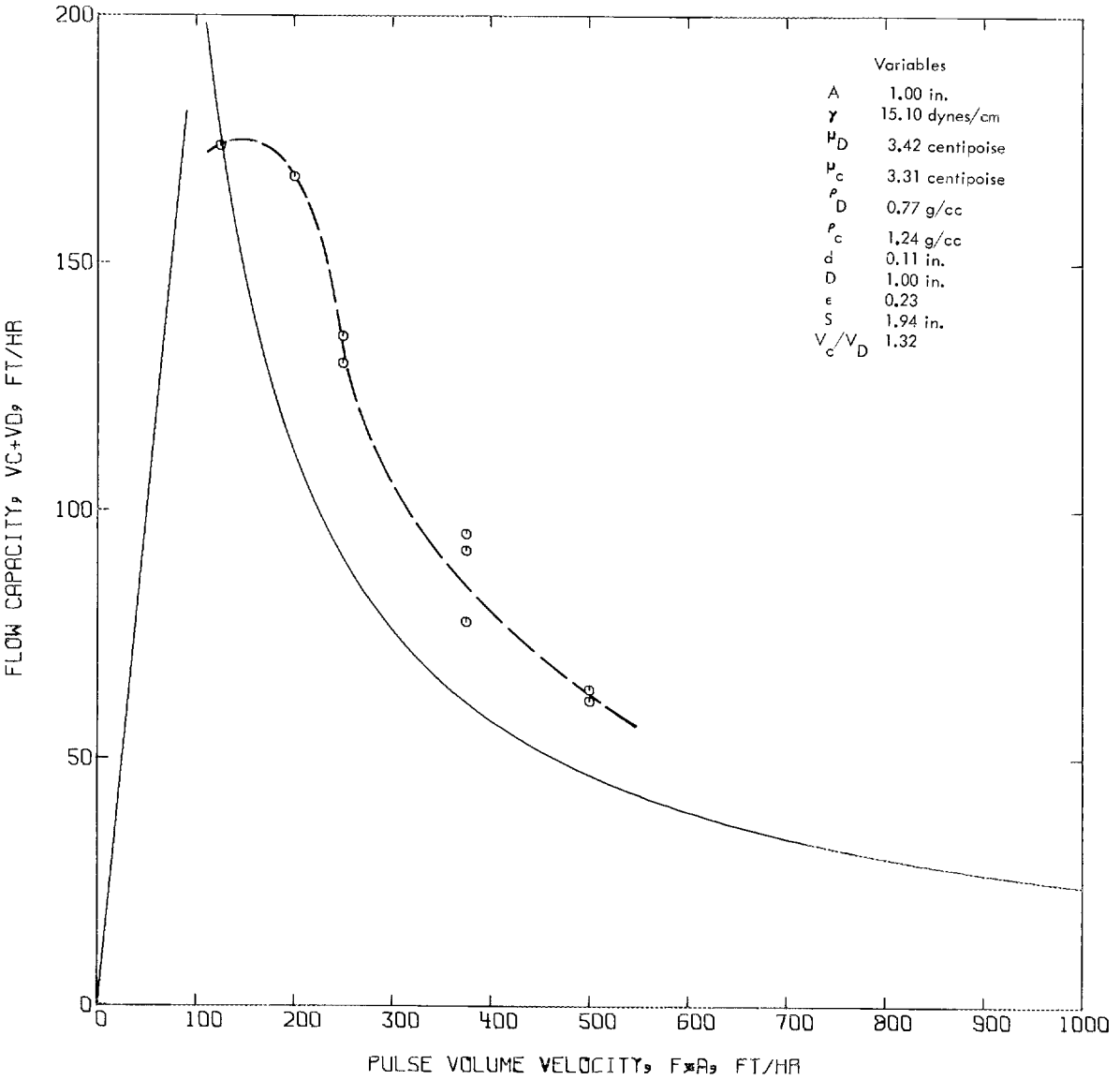

Fig. A-33. Fit of Flood Equation 208 to Some Data from Points 1-44.

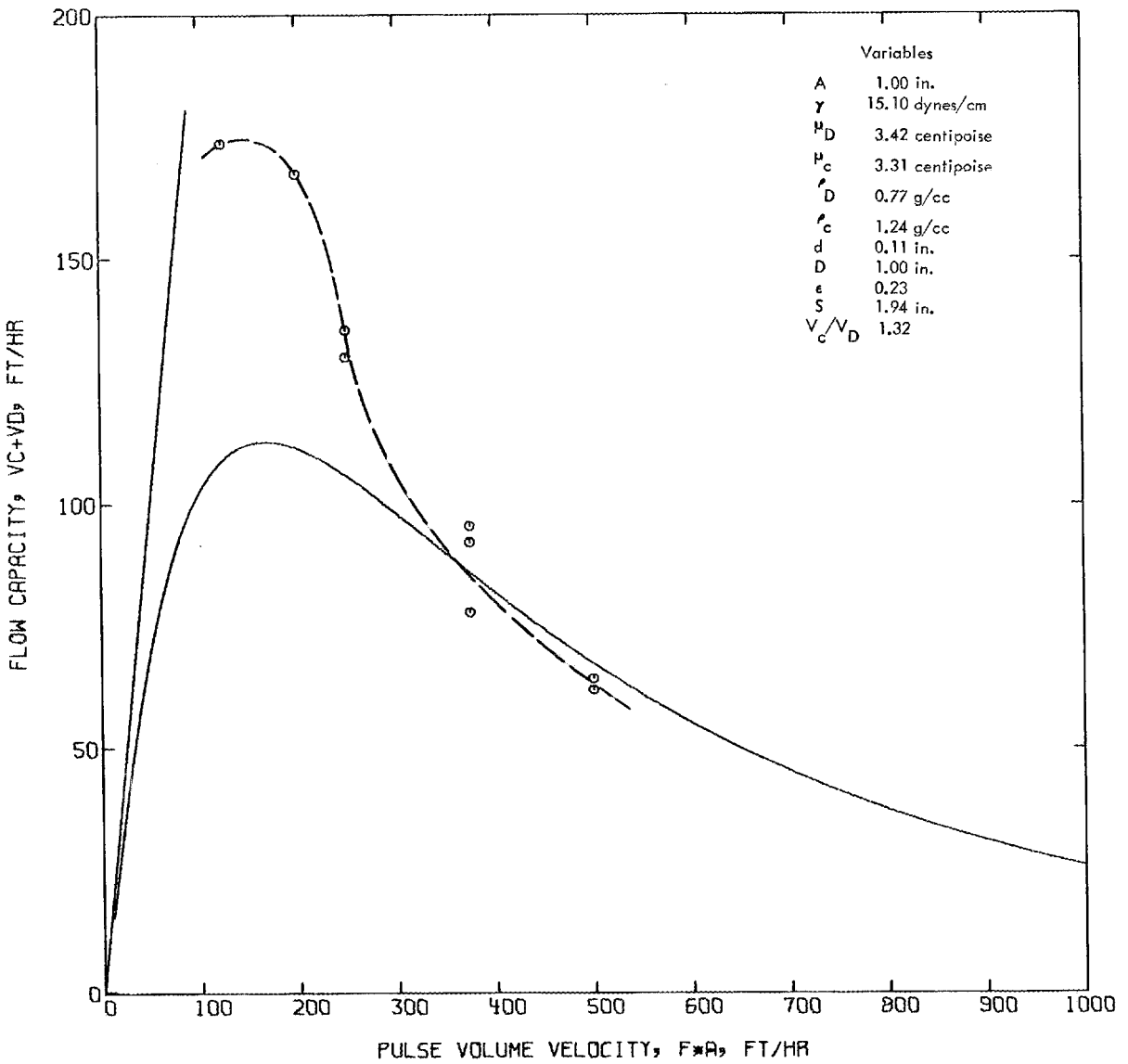

Fig. A-34. Fit of Flood Equation 122 to Some Data from Points 1-44.

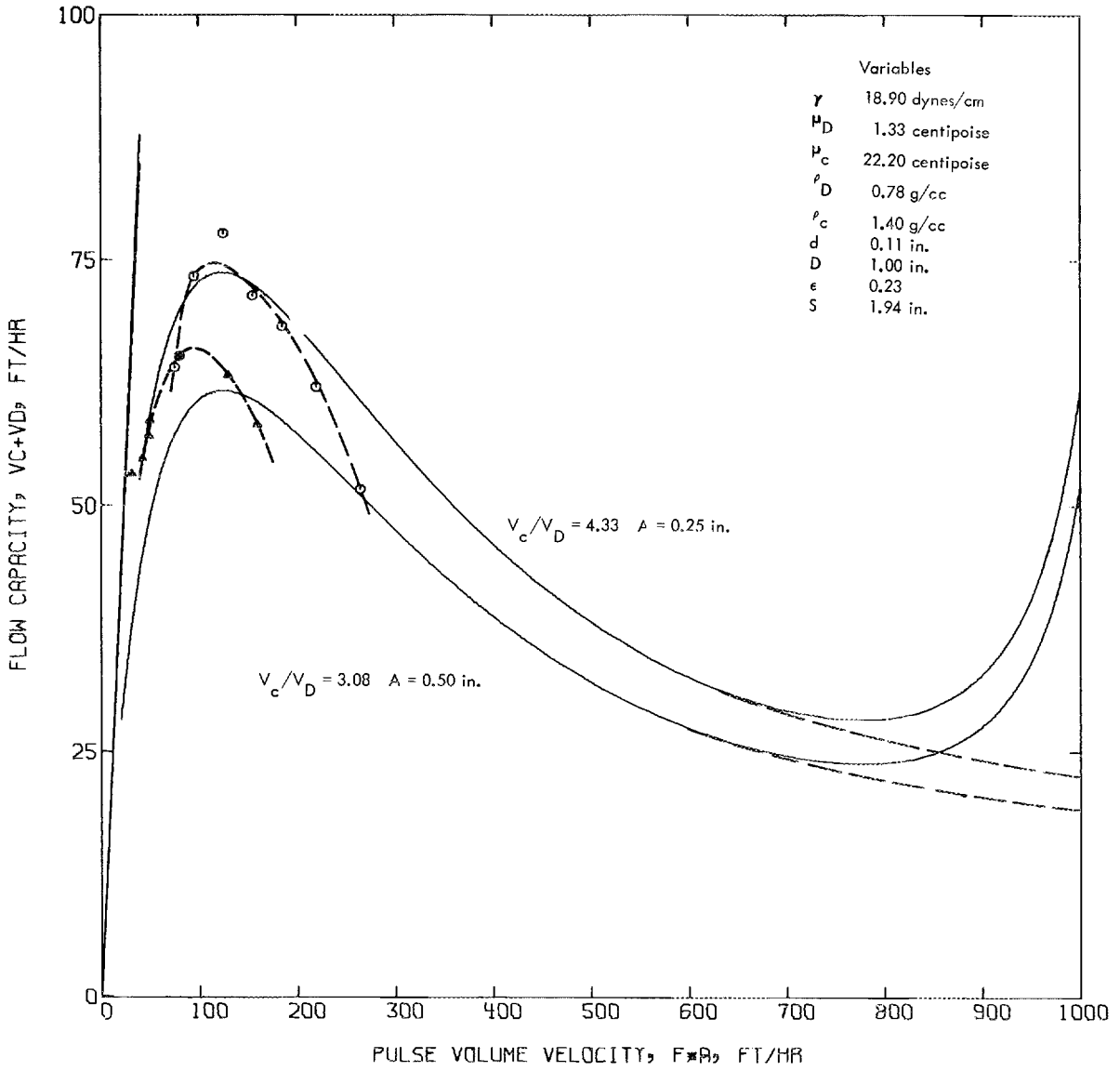

Fig. A-35. Fit of Flood Equation 122 to Data Points 1046-1060.

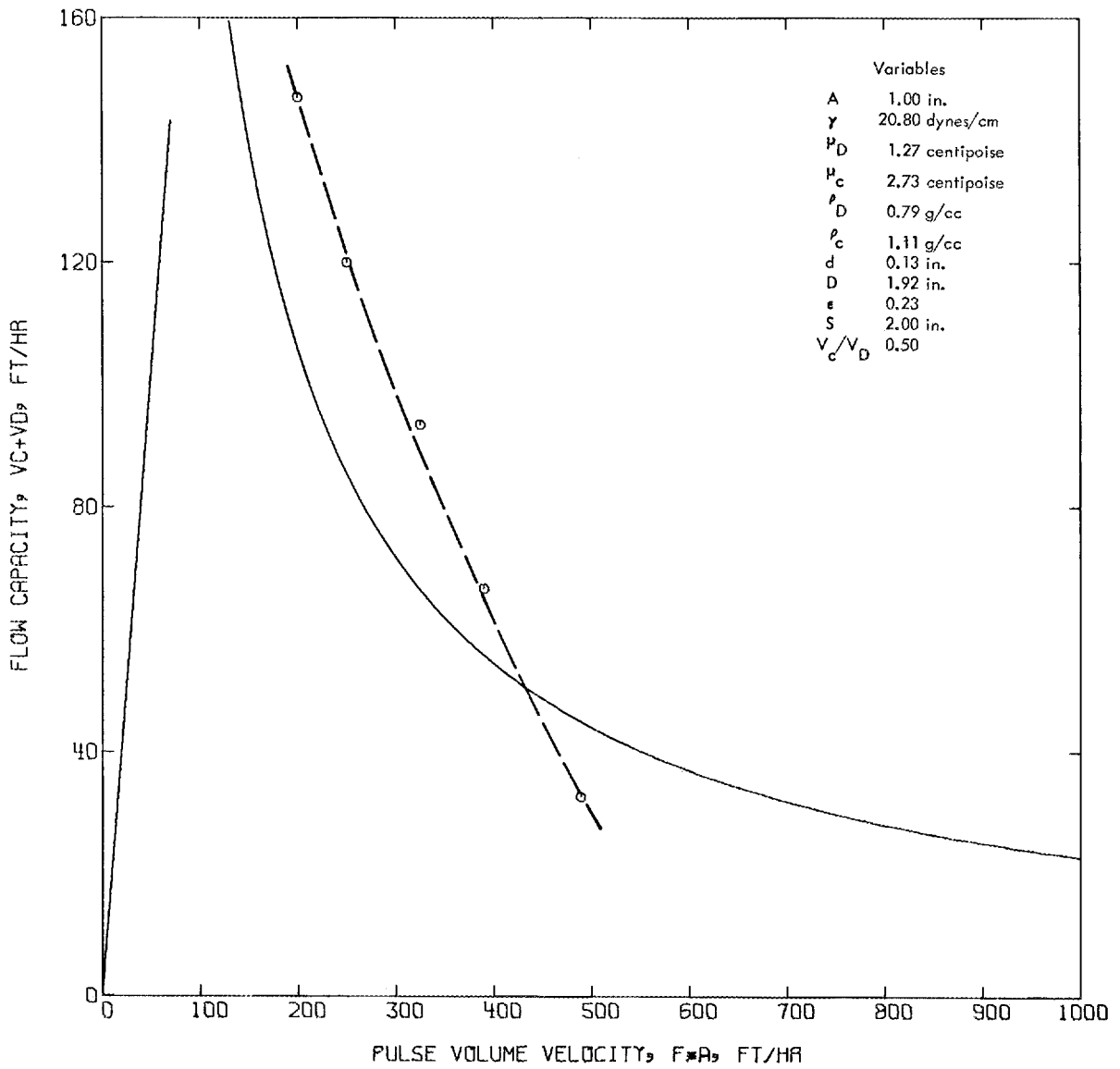

Fig. A-36. Fit of Flood Equation 208 to Data Points 854-858.

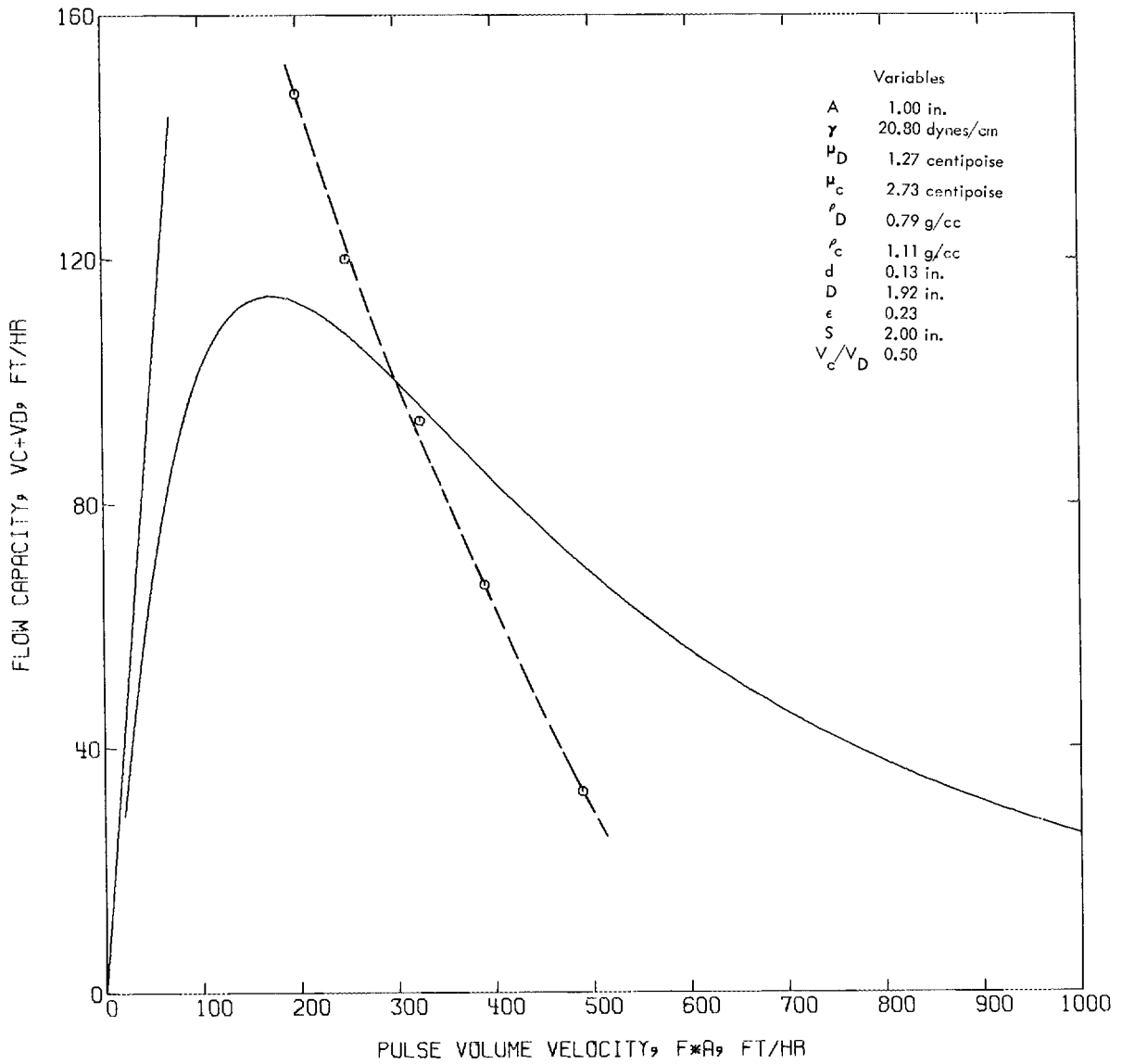

Fig. A-37. Fit of Flood Equation 122 to Data Points 854-858.

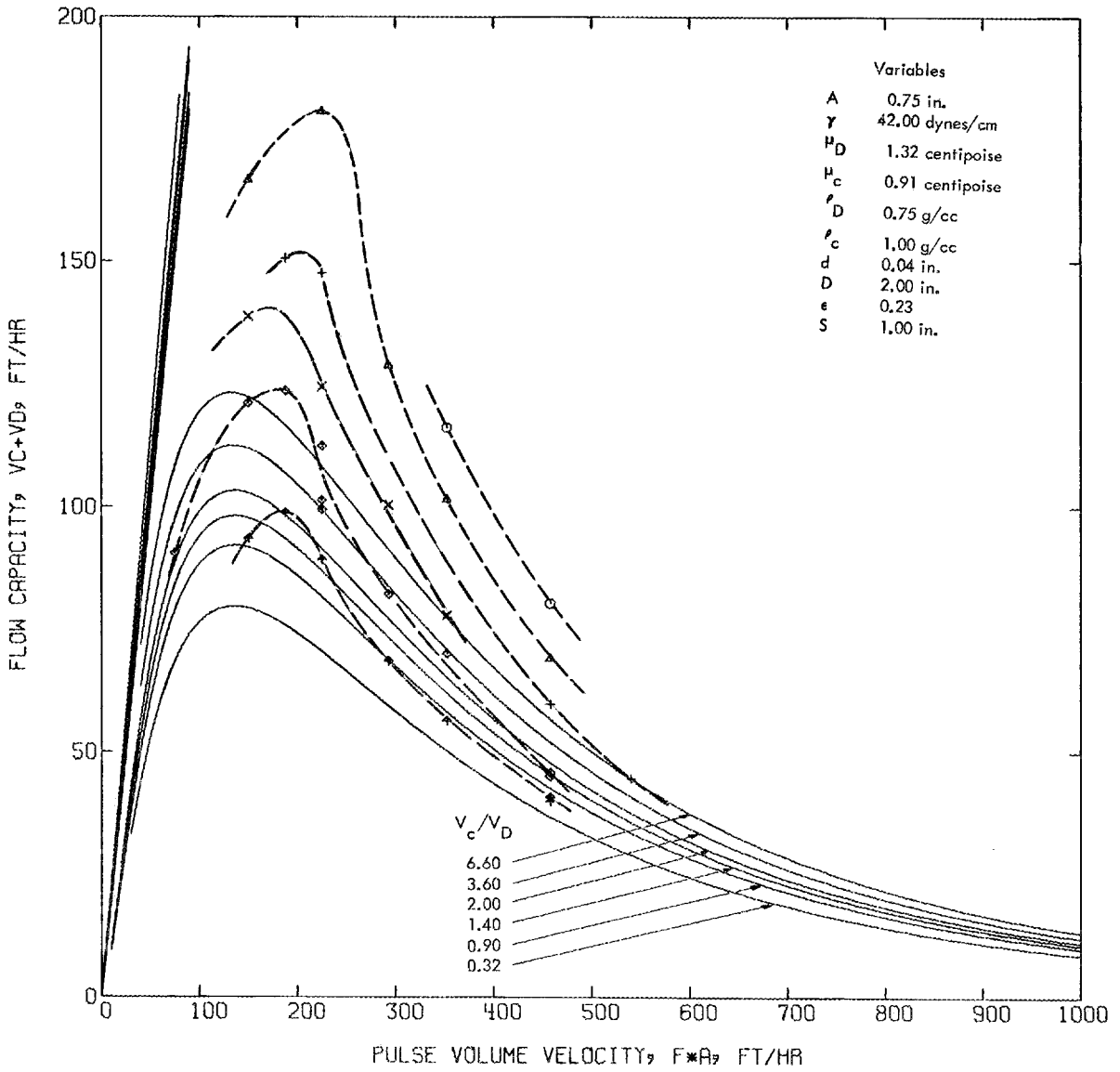

Fig. A-38. Fit of Flood Equation 122 to Data Points 676-707.

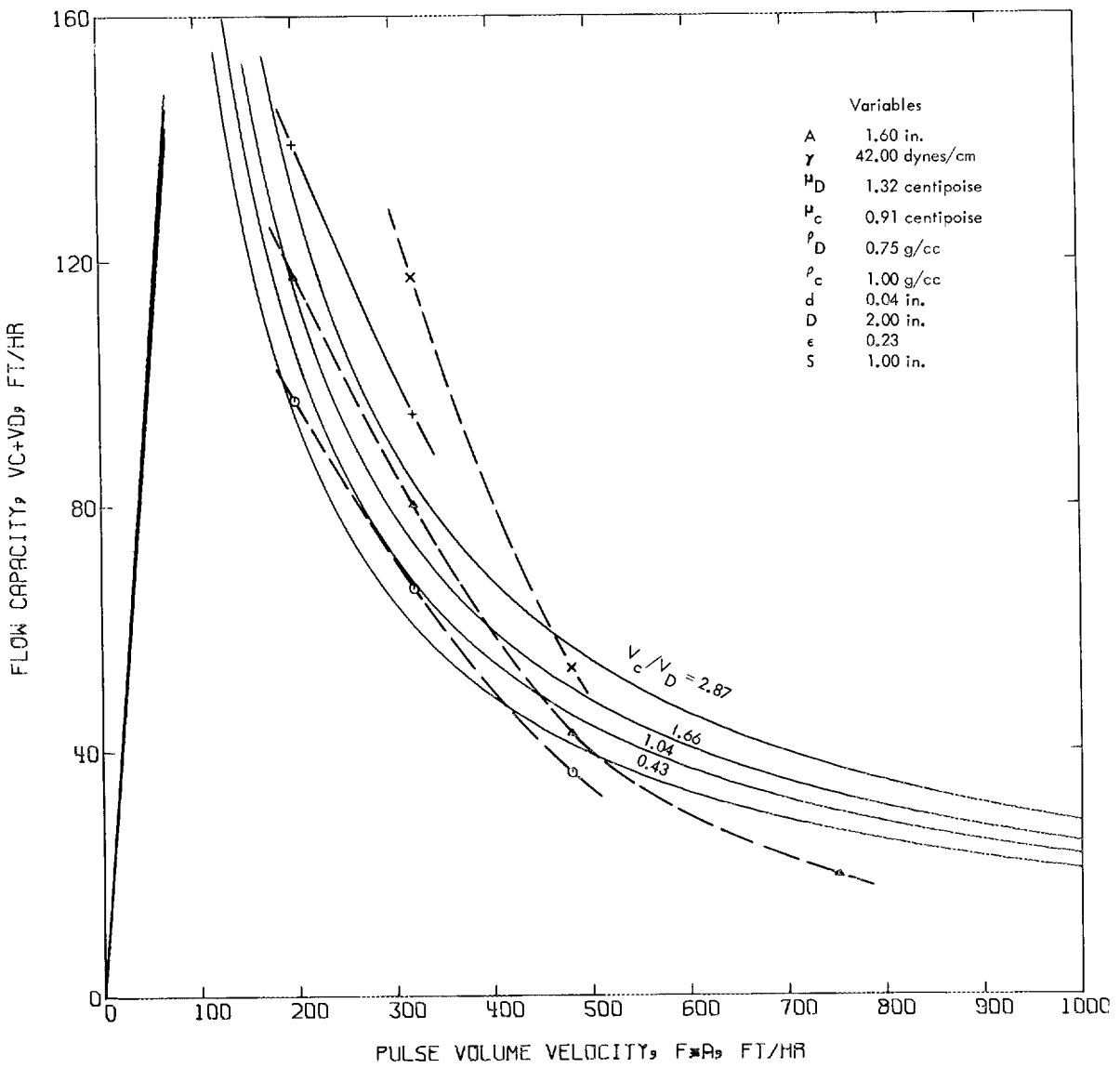

Fig. A-39. Fit of Flood Equation 208 to Data Points 708-720.

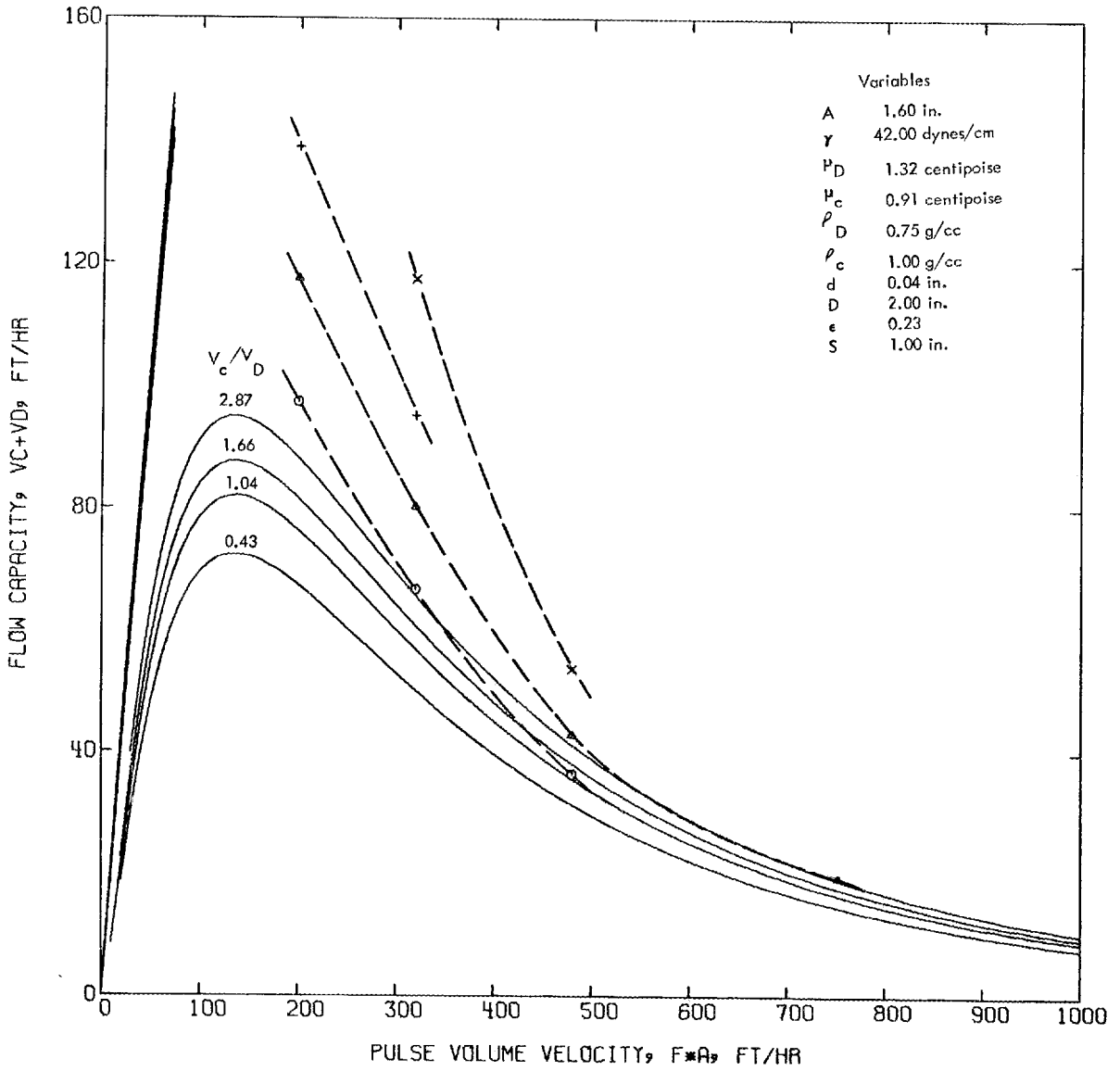

Fig. A-40. Fit of Flood Equation 122 to Data Points 708-720.

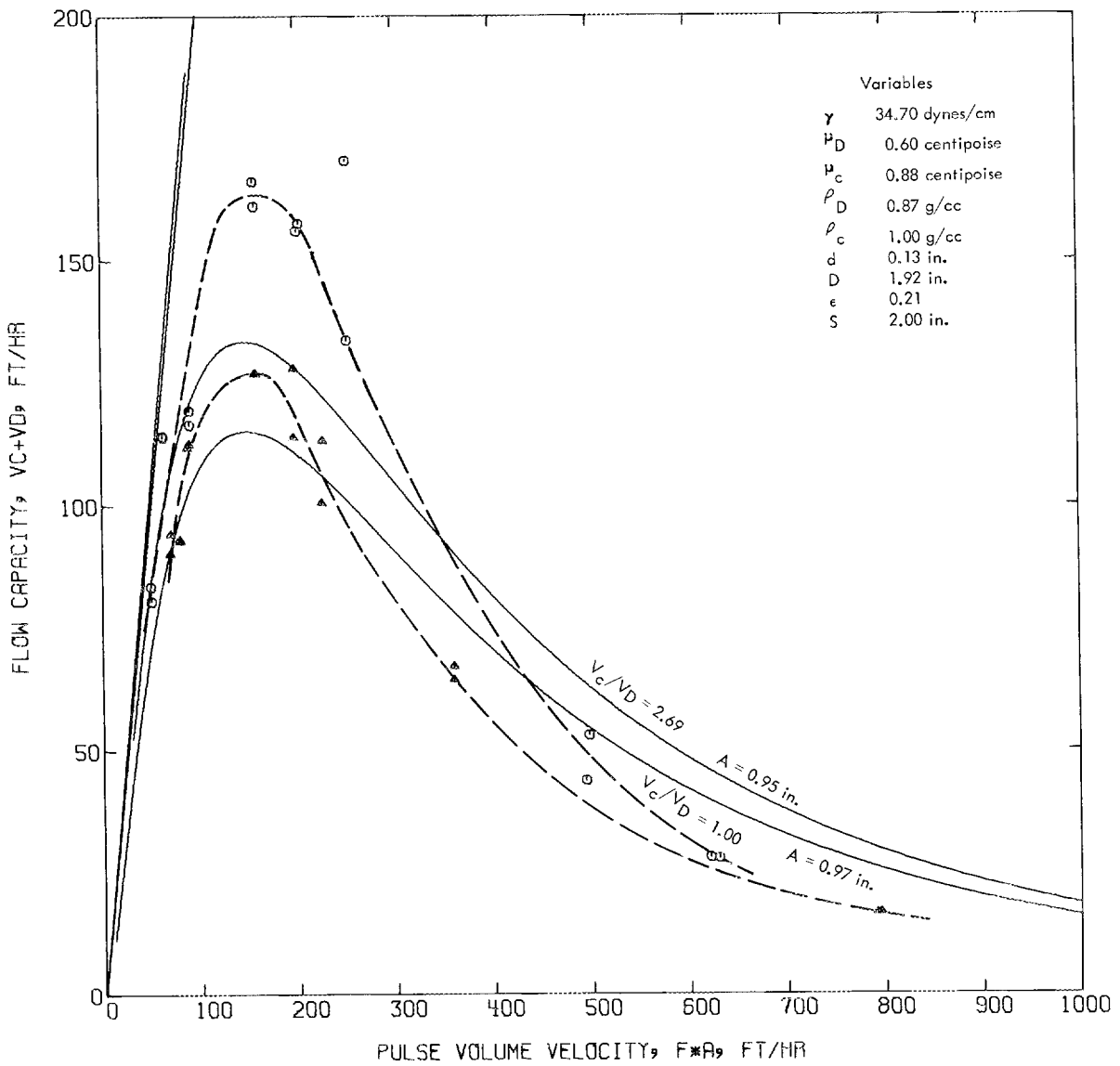

Fig. A-41. Fit of Flood Equation 122 to Data Points 552-605.

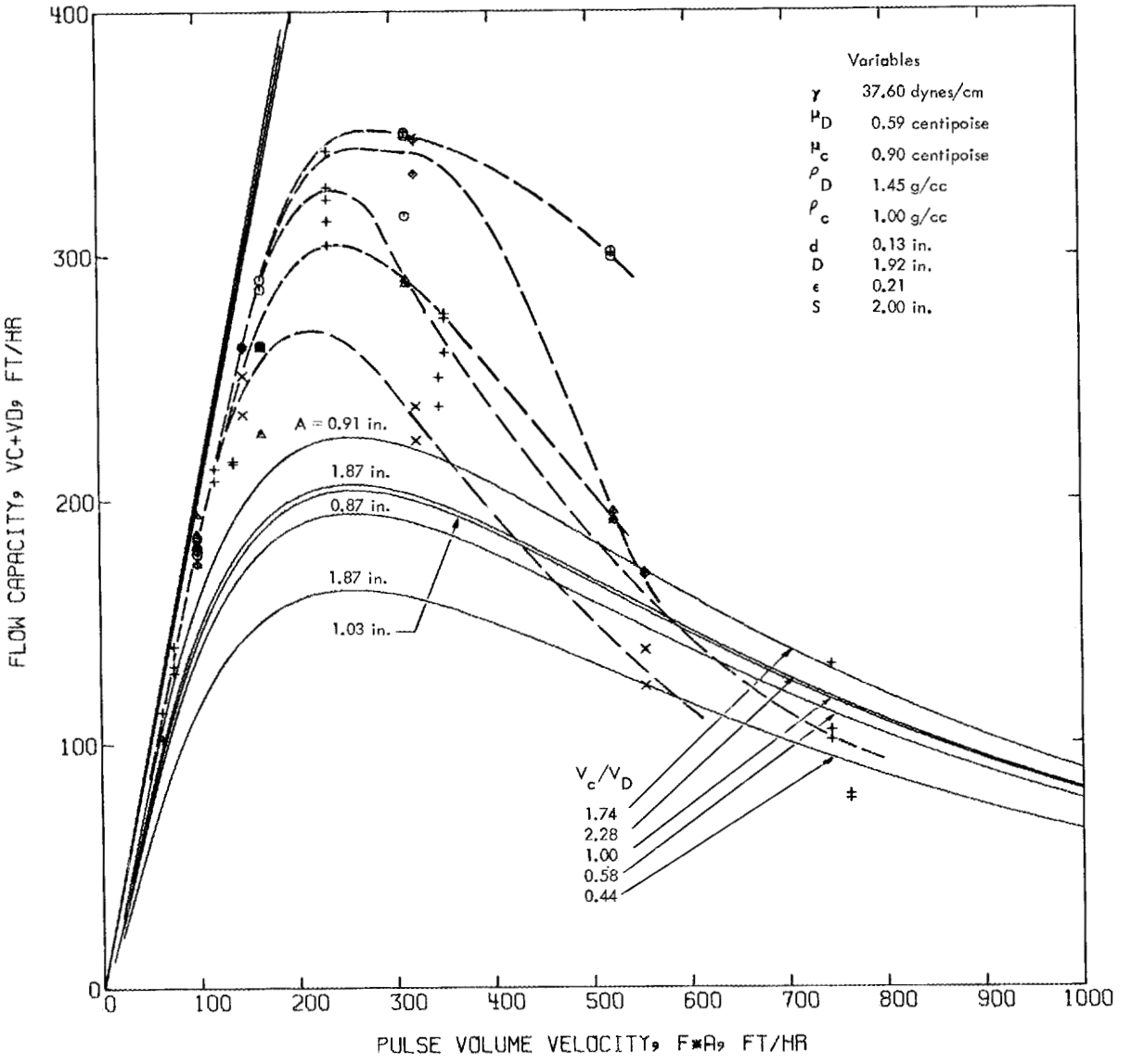

Fig. A-42. Fit of Flood Equation 122 to Data Points 606-675.

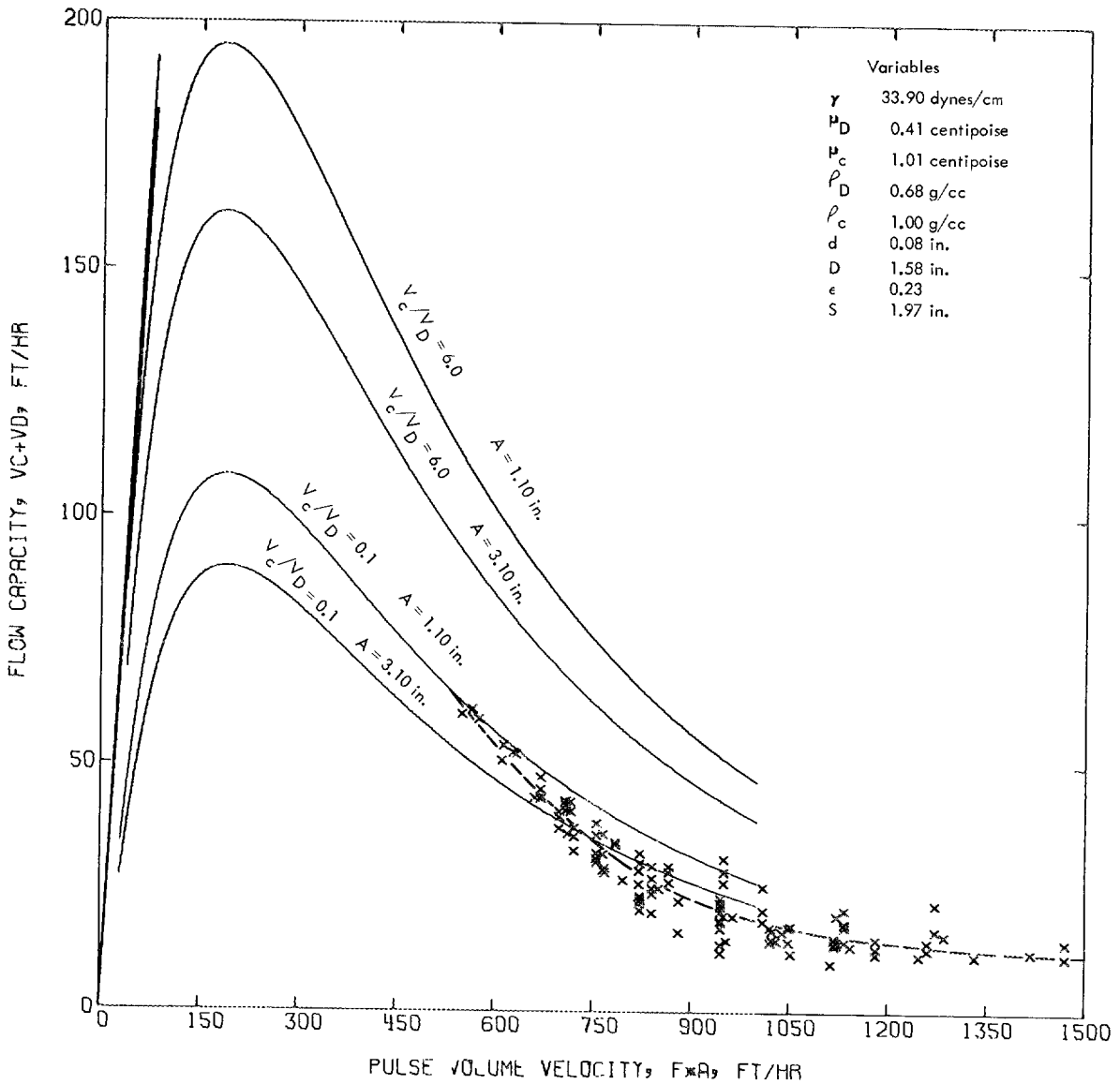

Fig. A-43. Fit of Flood Equation 122 to Data Points 934-1045.

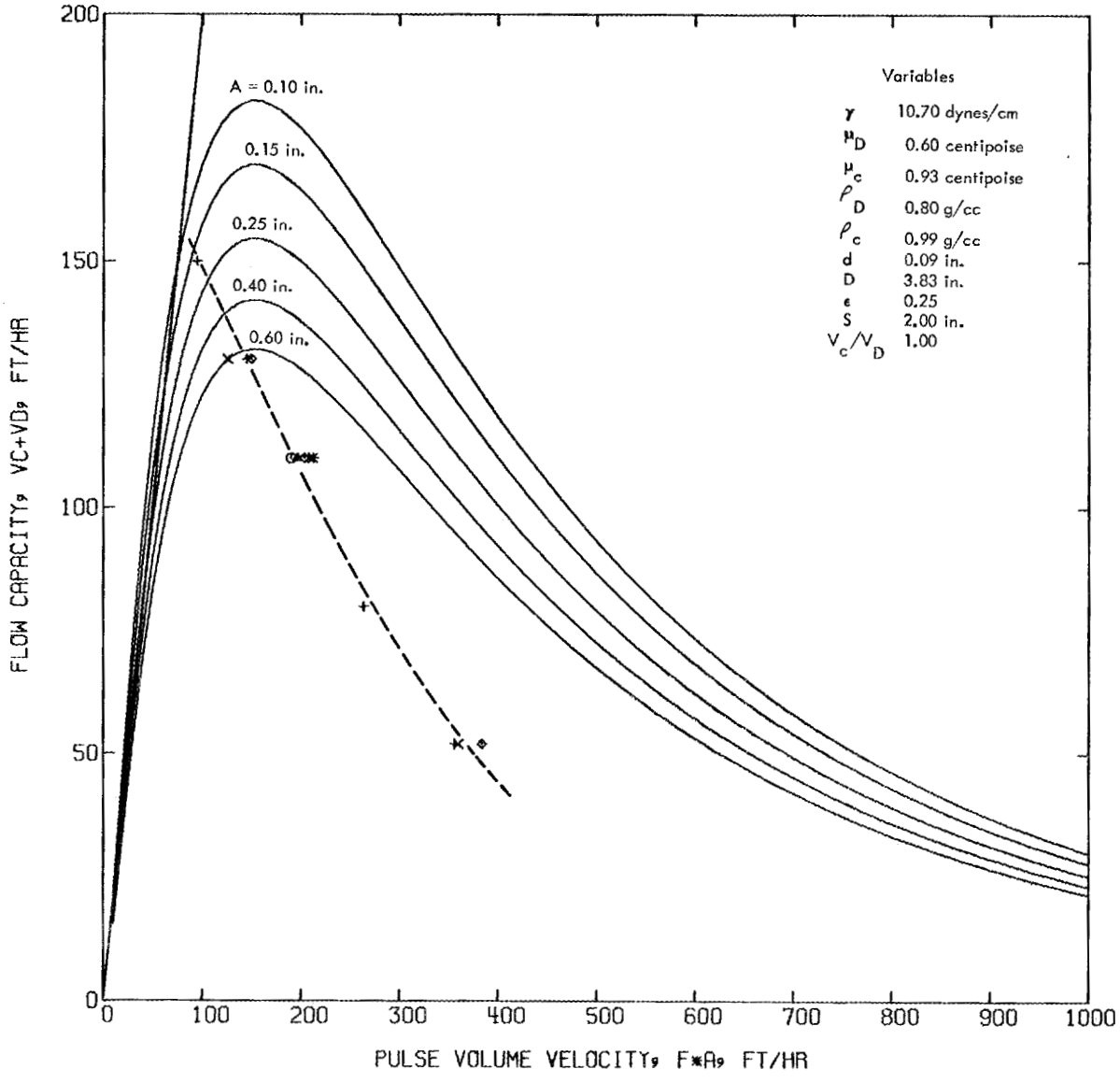

Fig. A-44. Fit of Flood Equation 122 to New Data of Christensen.

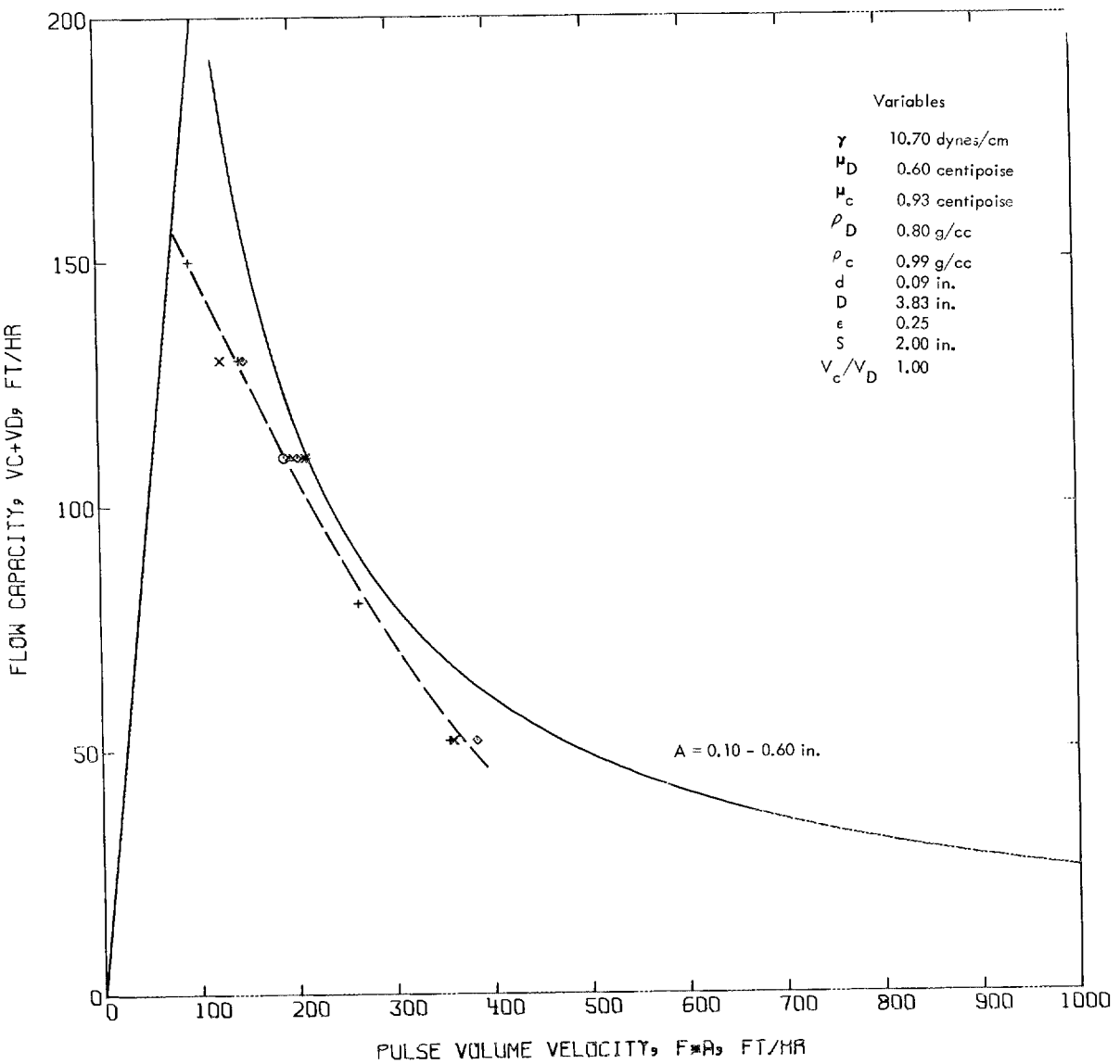

Fig. A-45. Fit of Flood Equation 208 to New Data of Christensen.

PROGRAM GRØEN3

This is a program in FORTRAN-63 that performs a sort of the values of up to 36 variables into 25 equal increments. The initial portion of the program accepts as input the values of the variables to be sorted or the values of other variables which can be used to calculate the variables to be sorted. Instructions for calculating variables for sorting are read in from "Transgeneration Cards". Other input includes the names of the variables. All of these operations are performed in SUBRØUTINE CALCUM. One transgeneration, that of obtaining the flooding capacity due to insufficient pulsation (Δ_G) from the pulse volume velocity (ZZ = 5FA) and the flow ratio (Z = V_c/V_D), is done with the use of a function subprogram, FUNCTIØN DELG(R1,AF), where R1 = Z, AF = ZZ.

The second half of the program, SUBRØUTINE SØRT25, performs the sorting operation, defining the maximum and minimum values of each variable to be sorted, and placing each value within an appropriate level out of a total of 25 equal increments. The boundaries of each level are determined, and all data points within each level are printed out. Finally, the population of each level is given.

ORDER OF CARDS:

Problem Card	
Transgeneration Card(s)	(900 allowed)
Variable Name Card(s)	(3 allowed)
Variable Format Card	
Pick Card	
Input Data Card(s) - if used	(1200 allowed)
Problem Card for the next problem, etc.	

Problem Card:

Columns 1-2	The letters "PR".
3-4	"5" if input data are on cards. "7" if input data are on Tape Unit 7.
5-6	No. of original variables including "n", the data point numbers. Maximum value allowed is 60.

7-10	No. of data points or observations, maximum of 1200.
11-13	No. of Transgeneration Cards, maximum of 900.
14-16	No. of variables to be sorted, maximum of 36.
17-72	Job title.

Transgeneration Card(s):

Columns 1-2	The letters "TR".
3-4	Variable number assigned to transformed variable.
5-6	Transformation Code (see below).
7-8	A-variable No. or Z.
9-14	B-variable No. or ZZ.

Variable Name Card(s):

Columns 1-6	Name of 1st variable to sort.
7-12	Name of 2nd variable to sort.
13-	. . .
67-72	Name of 12th variable to sort.

Variable Format Card:

Columns 1-72 must specify the format of the input data.
For example: (F6.3,2F5.2,F10.4,<u>F4.0</u>)
Note: The last field specified (underlined above) must be the format for data point or observation numbers.

Pick Card:	Columns 1-2	Variable No. of 1st variable to sort.
	3-4	Variable No. of 2nd variable to sort.
	5-	. . .
	71-72	Variable No. of 36th variable to sort.

Note: No variable number may exceed 60. Do not assign any transformed variable to a number greater than 60.

Transformation Codes:

00	No action taken	
01	X = SQRTF(x)	(Square-Root Function)
02	X = SQRTF(x) + SQRTF(x+1)	
03	X = LØGF(x)	(Log Function)
04	X = EXPF(x)	(Exponential Function)
05	X = ASINF(x)	(Arcsine Function)
06	X = ASINF(SQRTF(x/(n+1))) + ASINF(SQRTF((x+1)/(n+1)))	
07	X = 1.0/x	
08	X = X + (constant)	

09 $X = x(\text{constant})$
10 $X = x^{**}(\text{constant})$
11 $X = x_A + x_B$
12 $X = x_A - x_B$
13 $X = x_A x_B$
14 $X = x_A / x_B$
15 $X = \text{DELG}(x_A, x_B)$

A-variables on transgeneration cards correspond to x or x_A.
B-variables on transgeneration cards correspond to x_B or constant.

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```
      PROGRAM GROEN3
      DIMENSION SE(36),NPOINT(1200),SC(1200),VNAME(36),GYPSY(7)
      COMMON NV,NO,NT,VNAME,OON,SE,NPOINT,NR,SC,ITAPE
      TYPE INTEGER PR
    8 READ INPUT TAPE 50,900,PR,ITAPE,NV,NO,NT,NR,(GYPSY(I),I=1,7)
      OON = NO+1
      REWIND 2
      IF(ITAPE-5) 10,11,10
   10 REWIND ITAPE
   11 IF(PR-(+2HPR)) 100,12,100
   12 WRITE OUTPUT TAPE 51,901,(GYPSY(I),I=1,7),NV,NO
      CALL CALCUM
      GO TO 8
  100 WRITE OUTPUT TAPE 51,920
      GO TO 1000
  900 FORMAT (A2,2I2,I4,2I3,7A8)
  901 FORMAT (87H1UNIT OPERATIONS SECTION OF CHEMICAL TECHNOLOGY DIVISIO
     1N, OAK RIDGE NATIONAL LABORATORY/1H0,10X,35HSORT OF A DATA GROUP I
     2NTO 25 LEVELS/9H PROBLEM ,7A8/18HONO. OF VARIABLES ,I4/20H NO. OF
     3OBSERVATIONS,I6)
  920 FORMAT (36H1ERROR ON PROBLEM CARD OR DECK SETUP)
 1000 CALL EXIT
      END GROEN3
```

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```
      SUBROUTINE CALCUM
      DIMENSION R(900,4),AV(12),ST(60),SE(36),NPOINT(1200),NE(60),
     1VNAME(36),SC(1200)
      COMMON NV,NO,NT,VNAME,OON,SE,NPOINT,NR,SC,ITAPE
      TYPE INTEGER PR
      IF(NT) 20,20,10
   10 WRITE OUTPUT TAPE 51,900
      DO 18 I=1,NT
      READ INPUT TAPE 50,901,PR,(R(I,J),J=1,4)
      IF(PR-(+2HTR)) 11,12,11
   11 WRITE OUTPUT TAPE 51,902
      CALL EXIT
   12 N1 = R(I,1)
      N2 = R(I,2)
      N3 = R(I,3)
      N4 = R(I,4)
      IF(N2-8) 13,14,14
   13 WRITE OUTPUT TAPE 51,903,I,N1,N2,N3
      GO TO 18
   14 IF(N2-10) 15,15,16
   15 WRITE OUTPUT TAPE 51,904,I,N1,N2,N3,R(I,4)
      GO TO 18
   16 WRITE OUTPUT TAPE 51,903,I,N1,N2,N3,N4
   18 CONTINUE
   20 READ INPUT TAPE 50,905,(VNAME(I),I=1,NR)
      READ INPUT TAPE 50,905,(AV(I),I=1,12)
      READ INPUT TAPE 50,909,(NE(I),I=1,NR)
      DO 280 I=1,NO
      READ (ITAPE,AV)(ST(J),J=1,NV)
      NPOINT(I) = ST(NV)
      IF(NT) 260,260,90
   90 DO 250 J=1,NT
      N1 = R(J,1)
      N2 = R(J,2)
      N3 = R(J,3)
      N4 = R(J,4)
      GO TO (110,110,110,140,150,160,170,180,190,200,210,220,230,240,243
     1),N2
  110 IF(ST(N3)) 113,111,115
  111 IF(N2-2) 114,112,114
  112 ST(N1) = 1.0
      GO TO 250
  113 WRITE OUTPUT TAPE 51,906,N2,N3,I,ST(N3)
      CALL EXIT
  114 ST(N1) = 0.0
      GO TO 250
  115 GO TO (118,120,130),N2
  118 ST(N1) = SQRTF(ST(N3))
      GO TO 250
  120 ST(N1) = SQRTF(ST(N3)) + SQRTF(ST(N3)+1.0)
      GO TO 250
  130 ST(N1) = LOGF(ST(N3))
      GO TO 250
  140 ST(N1) = EXPF(ST(N3))
      GO TO 250
  150 IF(ST(N3)-1.0) 152,156,113
```

```
152 IF(ST(N3)+1.0) 113,153,155
153 ST(N1) = -1.5708
    GO TO 250
155 ST(N1) = ASINF(ST(N3))
    GO TO 250
156 ST(N1) = 1.5708
    GO TO 250
160 IF(ST(N3)) 113,161,161
161 PP = SQRTF(ST(N3)/00N)
    PE = SQRTF((ST(N3)+1.0)/00N)
    IF(PP-1.0) 162,163,113
162 PP = ASINF(PP)
    GO TO 164
163 PP = 1.5708
164 IF(PE-1.0) 165,166,113
165 PE = ASINF(PE)
    GO TO 167
166 PE = 1.5708
167 ST(N1) = PP + PE
    GO TO 250
170 IF(ST(N3)) 175,113,175
175 ST(N1) = 1.0/ST(N3)
    GO TO 250
180 ST(N1) = ST(N3) + R(J,4)
    GO TO 250
190 ST(N1) = ST(N3)*R(J,4)
    GO TO 250
200 ST(N1) = ST(N3)**R(J,4)
    GO TO 250
210 ST(N1) = ST(N3) + ST(N4)
    GO TO 250
220 ST(N1) = ST(N3) - ST(N4)
    GO TO 250
230 ST(N1) = ST(N3)*ST(N4)
    GO TO 250
240 IF(ST(N4)) 242,241,242
241 WRITE OUTPUT TAPE 51,906,N2,N4,I,ST(N4)
    CALL EXIT
242 ST(N1) = ST(N3)/ST(N4)
    GO TO 250
243 Z = ST(N3)
    ZZ = ST(N4)
    ST(N1) = DELG(Z,ZZ)
250 CONTINUE
260 DO 270 J=1,NR
    NN = NE(J)
    SE(J) = ST(NN)
270 CONTINUE
    WRITE TAPE 2,(SE(J),J=1,NR)
280 CONTINUE
    END FILE 2
    REWIND 2
    DO 300 N=1,NR
    WRITE OUTPUT TAPE 51,907,VNAME(N)
    DO 290 J=1,N0
    READ TAPE 2,(SE(K),K=1,NR)
```

```
      SC(J) = SE(N)
  290 CONTINUE
      WRITE OUTPUT TAPE 51,908,(NPOINT(J),SC(J),J=1,NO)
      REWIND 2
      CALL SORT25
  300 CONTINUE
  900 FORMAT (55H0TRANSFORMATION    VARIABLE NO.      TYPE OF          VA   124
     1,24HRIABLE       2ND VARIABLE/32H    CARD NO.          ASSIGNED    ,   125
     247H  TRANSFORMATION    TRANSFORMED    OR  CONSTANT)                    126
  901 FORMAT (A2,3F2.0,F6.0)                                                  127
  902 FORMAT (29H0ERROR ON TRANSFORMATION CARD)                               128
  903 FORMAT (1H 4X,I4,13X,I4,13X,I3,13X,I3,10X,I6)                           129
  904 FORMAT (1H 4X,I4,13X,I4,13X,I3,13X,I3,10X,F12.5)                        130
  905 FORMAT (12A6)                                                           131
  906 FORMAT (1H0//27H TRANSFORMATION OF THE TYPE,I3,24H  CANNOT BE PERF      132
     1ORMED ON/9H VARIABLE,I3,6H POINT,I5,15H   THE VALUE IS,F12.5)           133
  907 FORMAT (49H1LIST OF VARIABLE TO BE SORTED, VARIABLE NAME IS ,A6//1
     20H POINT NO.,6X,5HVALUE,6X,9HPOINT NO.,6X,5HVALUE,6X,9HPOINT NO.,6
     2X,5HVALUE)
  908 FORMAT (3(I8,4X,E14.4))
  909 FORMAT (36I2)
      RETURN
      END
```

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```
      SUBROUTINE SORT25
      DIMENSION SE(36),SO(26),NPOINT(1200),NX(25),NY(50),SC(1200),VNAME(
     136),NP(1200)
      COMMON NV,NO,NT,VNAME,OON,SE,NPOINT,NR,SC
      DO 5 J=1,NO
      NP(J) = NPOINT(J)
    5 CONTINUE
      K = 1
      NC = NO-1
      DO 10 I=1,NC
      ND = I+1
      DO 10 J=ND,NO
      IF(SC(I)-SC(J)) 10,10, 9
    9 TEMP = SC(I)
      SC(I) = SC(J)
      SC(J) = TEMP
      TEMP = NP(I)
      NP(I) = NP(J)
      NP(J) = TEMP
   10 CONTINUE
      RANGE = SC(NO)-SC(1)
      SO(1) = SC(1)
      SO(26) = SC(NO)
      DO 20 I=2,25
      J = I-1
      SO(I) = ((SO(26)-SO(1))/25.)+SO(J)
   20 CONTINUE
      WRITE OUTPUT TAPE 51,900,RANGE,SC(1),SC(NO)
      DO 26 I=1,25
      NK = (2*I)-1
      NL = 2*I
      NY(NK) = K
      ND = I+1
      NX(I) = 0
      DO 22 J=K,NO
      IF(SC(J)-SO(ND)) 21,23,23
   21 NX(I) = NX(I)+1
   22 CONTINUE
   23 K = J
      NY(NL) = J-1
      IF(I - 25) 25,100,100
  100 NX(I) = NX(I)+1 + NO - J
      NY(NL) = NO
   25 WRITE OUTPUT TAPE 51,901,I,SO(I),NX(I)
   26 CONTINUE
      WRITE OUTPUT TAPE 51,902
      DO 50 I=1,25
      NK = (2*I)-1
      NL = 2*I
      WRITE OUTPUT TAPE 51,903,I
      N1 = NY(NK)
      N2 = NY(NL)
      WRITE OUTPUT TAPE 51,904,(NP(J),J=N1,N2)
   50 CONTINUE
  900 FORMAT (27H1DATA SORT AND DISTRIBUTION///
     110H RANGE IS ,E14.4/14H LOW VALUE IS ,E14.4/15H HIGH VALUE IS ,E14
```

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```
   2.4//14H INCREMENT NO.,10X,9HLOW VALUE,10X,10HPOPULATION)
901 FORMAT (I10,10X,E14.4,12X,I4)
902 FORMAT (45HOLIST OF DATA POINT NUMBERS IN EACH INCREMENT)
903 FORMAT (11HOINCREMENT ,I2)
904 FORMAT (12I6)
    RETURN
    END
```

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```
      FUNCTION DELG(RI,AF)
      AI = 2.*RI*AF/(1.+RI)
      VCI = AI
      BI = 2.*(1.-RI)/(3.1416*(1.+RI))
    6 XI = ASINF(ABSF(VCI*(1.-RI)/(3.1416*RI*AF)))
      VC = AI*COSF(XI)/(1.-ABSF(BI*XI))
      ZI = ABSF(VC-VCI)
      YI = 0.0001*VCI
      IF(ZI-YI) 8,8,7
    7 VCI = 0.5*(VCI+VC)
      GO TO 6
    8 VD = VC/RI
      DELG = VD+VC
      RETURN
      END
```

PROGRAM GRØEN4

This is a program in FORTRAN-63 to compute and compare observed and calculated pulsed-column throughputs at flooding for a given flooding equation. Input data may be values of the dependent and independent variables of the flooding equation, or may be values that can be used to calculate dependent and independent variables. The flooding equation must have the form:

$$Y = A_o + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n \ .$$

The Y variable must be the logarithm of some group that contains V_c, V_D, or other velocity term. The programmer must rearrange the flooding equation to read:

$$\ln (V_c + V_D) = A_o + b_1X_1 + b_2X_2 + \ldots + b_nX_n + X_F \ ,$$

where X_F is a FACTOR VARIABLE that relates $\ln (V_c + V_D)$ to Y as shown.

$$Y = \ln (V_c + V_D) - X_F \ .$$

Input data also includes the values of A_o, and b_1 through b_n. The program allows values of $V_c + V_D$ calculated from the flooding equation to be printed out along with the observed values. The absolute and percentage differences between calculated and observed throughputs are printed. Then, estimates of the variance and standard deviation and mean values of these differences are printed. Finally, the differences are sorted and printed in ascending order.

PRØGRAM GRØEN4 contains five subroutines and one function subprogram. SUBRØUTINE SELEC performs the unique task of selecting specified data points or groups of data points out of a master list. The only requirement is that data point numbers be consecutive in any one grouping. Up to 60 points or groups of points may be selected. A data point used here refers to a

single set of conditions required for the calculation of a throughput at flooding, and may include the observed throughput for these conditions. SUBRØUTINE READUM allows intercept and coefficient values for the flooding equation to be read in, reads the Transgeneration Cards (instructions for the calculation of independent variables, see PRØGRAM GRØEN3), variable format card, and pick card, and prints out many of these information bits. SUBRØUTINE CALCUR performs the required calculations that arrive at the proper calculated value of throughput that satisfies the flooding equation. It uses the first set of Transgeneration Cards to calculate all independent variables that do not involve a velocity term. If no trial-and-error procedure is required, control is immediately transferred back to the main program. If a trial-and-error technique is required, the second set of Transgeneration Cards is used. Control is then transferred to the main program to calculate variances, standard deviations, and mean values of differences. SUBRØUTINE ØRDER sorts the differences into ascending order and prints these values. FUNCTIØN DELG(R1,AF) is used to obtain the throughput at flooding due to insufficient pulsation from the flow ratio (R1) and the pulse volume (AF) through a transformation code. SUBRØUTINE DRAWIT prepares a tape to be used on the CALCØMP PLØTTER which prepares a graph showing a logarithmic plot of observed throughputs versus calculated throughputs.

ORDER OF CARDS:	Problem Card	
	Intercept Card	
	Coefficient Card(s)	(35 allowed)
	Transgeneration Card(s) - I	(99 allowed)
	Transgeneration Card(s) - II	(99 allowed)
	Variable Format Card	
	Pick Card	
	Selec Cards	(2 minimum, 8 maximum)
	Input Data Cards - if used	(2400 allowed)
	Drawit Card	
	Problem Card for the next problem, etc.	

Problem Card: Columns 1-2 The letters "PR". Use "RP" if all cards from the Intercept Card through the Pick Card remain the same as in the preceeding problem. For this special case, delete those cards.

3- The number "5" if input data are on cards. The number "7" if input data are on Tape Unit 7.

4-5 No. of original variables including "n", the data point numbers. Maximum value allowed is 60.

6-9 No. of data points or observations, maximum of 2400.

10-11 No. of Transgeneration Cards in first group, maximum of 99.

12-13 No. of Transgeneration Cards in second group, maximum of 99.

14-15 No. of independent variables in flooding equation, maximum of 35.

16- "0" for direct calculation, "1" for a trial-and-error technique.

17- "1" if a list of every trial in the trial-and-error procedure is desired, otherwise "0".

18-72 Job title.

Intercept Card:

Columns 1-20 used for intercept value (A_o) in FØRMAT (F20.8).

Coefficient Card(s):

Columns 1-20 used for coefficient value (b_n) in FØRMAT (F20.8).

Transgeneration Cards:

(Both Groups, see PRØGRAM GRØEN3).

Variable Format Card:

(See PRØGRAM GRØEN3).

Pick Card: Columns 1-2 Variable No. of 1st independent variable, the variable having the coefficient shown on the 1st coefficient card.

3- . . .

69-70 Variable No. of 35th independent variable.

71-72 Variable No. of the FACTOR VARIABLE.

Note: The variable No. of the FACTOR VARIABLE appears last, but not

necessarily in columns 71-72. If there are only two independent variables, then the number of the FACTOR VARIABLE would appear in columns 5-6.

Selec Cards:

1st Card:	Columns 1-4	used for the number of data points or groups of data points, maximum of 60.
2nd Card:	Columns 1-4	Point No. of 1st point in 1st series.
	5-8	Point No. of last point in 1st series.
	9-12	Point No. of 1st point in 2nd series.
	13-16	Point No. of last point in 2nd series.
	17-	. . .
	69-72	Point No. of last point in 9th series.
3rd through 8th Card:		Similar format as in the 2nd card until all groups up to 60 are defined.
Drawit Card:	Columns 1-2	Blank.
	3-8	The letters "DRAWIT".
	9-24	Name of programmer.

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```
      PROGRAM GROEN4
      DIMENSION GYPSY(7),CO(35),IV(12),NE(36),ST(60),NPOINT(2400),R(200,
     14),EXP(2400),CAL(2400),DIF(2400),PER(2400),IPOINT(2400)
      COMMON NV,NO,NTT,NT,NR,CO,COO,IV,NE,ST,CA,NXX,NRR,NPOINT,R,ITAPE,
     1NY,OON,I,DIF,NUT
    8 READ INPUT TAPE 50,900,IR,ITAPE,NV,NO,NT,NTT,NR,NY,NUT,(GYPSY(I),
     1I=1,7)
      NRR = NR + 1
      NTT = NTT + 100
      NXX = 0
      OON = NO-1
      REWIND 2
      WRITE OUTPUT TAPE 51,901,(GYPSY(I),I=1,7),NR,NO
      IF(ITAPE-5) 10,11,10
   10 REWIND ITAPE
   11 IF(IR-(+2HPR)) 400,12,400
   12 CALL READUM
   13 CALL SELEC(NV,ITAPE,IV)
      SUM1 = 0.0
      SUM1A = 0.0
      SUM1SQ = 0.0
      SUM2 = 0.0
      SUM2A = 0.0
      SUM2SQ = 0.0
      DO 300 I=1,NO
      READ TAPE 2,(ST(J),J=1,NV)
      NPOINT(I) = ST(NV)
      EXP(I) = ST(1) + ST(2)
      CA = EXP(I)
      CALL CALCUR
      CAL(I) = CA
      DIF(I) = EXP(I) - CAL(I)
      PER(I) = 100.*(DIF(I)/EXP(I))

      SUM1A = SUM1A + DIF(I)

      SUM2A = SUM2A + PER(I)
      SUM1SQ = SUM1SQ + DIF(I)*DIF(I)
      SUM2SQ = SUM2SQ + PER(I)*PER(I)
  300 CONTINUE
      SOO = NO - NXX
      AVE1 = SUM1A/SOO
      AVE2 = SUM2A/SOO
      VAR1 = (SUM1SQ - (SUM1A*SUM1A/SOO))/(SOO-1.)
      VAR2 = (SUM2SQ - (SUM2A*SUM2A/SOO))/(SOO-1.)
      IF(VAR1) 310,311,311
  310 VAR1 = 0.0
  311 IF (VAR2) 312,313,313
  312 VAR2 = 0.0
  313 DEV1 = SQRTF(VAR1)
      DEV2 = SQRTF(VAR2)
      WRITE OUTPUT TAPE 51,904
      WRITE OUTPUT TAPE 51,905,(NPOINT(I),EXP(I),CAL(I),DIF(I),PER(I),I=
     11,NO)
      WRITE OUTPUT TAPE 51,906,SOO,AVE1,AVE2,VAR1,VAR2,DEV1,DEV2
      DO 314 I=1,2400
```

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```
      IPOINT(I) = NPOINT(I)
  314 CONTINUE
      CALL ORDER
      DO 315 I=1,2400
      NPOINT(I) = IPOINT(I)
      DIF(I) = PER(I)
  315 CONTINUE
      CALL ORDER
      DO 320 I=1,2400
      NPOINT(I) = IPOINT(I)
  320 CONTINUE
      CALL DRAWIT(EXP,CAL,GYPSY)
      GO TO 8
  400 IF(IR-(+2HRP)) 401,13,401
  401 WRITE OUTPUT TAPE 51,920
      GO TO 1000
  900 FORMAT (A2,I1,I2,I4,3I2,2I1,6A8,A7)
  901 FORMAT (87H1UNIT OPERATIONS SECTION OF CHEMICAL TECHNOLOGY DIVISIO
     1N, OAK RIDGE NATIONAL LABORATORY/1H0,10X,76HCALCULATION OF EXPERIM
     2ENTAL VS PREDICTED PULSE COLUMN THROUGHPUT AT FLOODING/9H PROBLEM
     3,7A8////18HONO. OF VARIABLES ,I4/20H NO. OF OBSERVATIONS,I6)
  904 FORMAT (54H1LIST OF CALCULATED AND EXPERIMENTAL VALUES OF VC + VD/
     110HOPOINT NO.,10X,12HEXPERIMENTAL,10X,10HCALCULATED,10X,10HDIFFERE
     2NCE,10X,10HDIFFERENCE/23X,7HVC + VD,13X,7HVC + VD,13X,8HABSOLUTE,1
     33X,7HPERCENT)
  905 FORMAT (I8,10X,F14.2,6X,F14.2,5X,F14.2,5X,F14.2)
  906 FORMAT (23H0AVERAGE DIFFERENCE FOR,F6.0,10H POINTS IS,F14.2/30H AV
     1ERAGE PERCENT DIFFERENCE IS,F23.2/27H VARIANCE OF DIFFERENCES IS,F
     226.2/35H VARIANCE OF PERCENT DIFFERENCES IS,F18.2/37H STANDARD DE
     3VIATION OF DIFFERENCES IS,F16.2/45H STANDARD DEVIATION OF PERCENT
     4DIFFERENCES IS,F8.2)
  920 FORMAT (36H1ERROR ON PROBLEM CARD OR DECK SETUP)
 1000 CALL EXIT
      END GROEN4
```

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```
      SUBROUTINE READUM
      DIMENSION CO(35),IV(12),NE(36),ST(60),NPOINT(2400),R(200,4)
      COMMON NV,NO,NTT,NT,NR,CO,COO,IV,NE,ST,CA,NXX,NRR,NPOINT,R,ITAPE,
     1NY
      READ INPUT TAPE 50,909,COO
      READ INPUT TAPE 50,909,(CO(I),I=1,NR)
      IF(NT) 20,20,10
   10 WRITE OUTPUT TAPE 51,900
      DO 18 I=1,NT
      READ INPUT TAPE 50,901,IR,(R(I,J),J=1,4)
      IF(IR-(+2HTR)) 11,12,11
   11 WRITE OUTPUT TAPE 51,902
      CALL EXIT
   12 N1 = R(I,1)
      N2 = R(I,2)
      N3 = R(I,3)
      N4 = R(I,4)
      IF(N2-8) 13,14,14
   13 WRITE OUTPUT TAPE 51,903,I,N1,N2,N3
      GO TO 18
   14 IF(N2-10) 15,15,16
   15 WRITE OUTPUT TAPE 51,904,I,N1,N2,N3,R(I,4)
      GO TO 18
   16 WRITE OUTPUT TAPE 51,903,I,N1,N2,N3,N4
   18 CONTINUE
   20 IF (NTT-100) 30,30,21
   21 WRITE OUTPUT TAPE 51,900
      DO 28 I=101,NTT
      READ INPUT TAPE 50,901,IR,(R(I,J),J=1,4)
      IF(IR-(+2HTR)) 22,23,22
   22 WRITE OUTPUT TAPE 51,902
      CALL EXIT
   23 N1 = R(I,1)
      N2 = R(I,2)
      N3 = R(I,3)
      N4 = R(I,4)
      IF (N2-8) 24,25,25
   24 WRITE OUTPUT TAPE 51,903,I,N1,N2,N3
      GO TO 28
   25 IF (N2-10) 26,26,27
   26 WRITE OUTPUT TAPE 51,904,I,N1,N2,N3,R(I,4)
      GO TO 28
   27 WRITE OUTPUT TAPE 51,903,I,N1,N2,N3,N4
   28 CONTINUE
   30 READ INPUT TAPE 50,905,(IV(I),I=1,12)
      READ INPUT TAPE 50,907,(NE(I),I=1,NRR)
      WRITE OUTPUT TAPE 51,908,COO,(NE(I),CO(I),I=1,NR)
  900 FORMAT (55H0TRANSFORMATION     VARIABLE NO.       TYPE OF          VA
     1,24HRIABLE       2ND VARIABLE/32H     CARD NO.          ASSIGNED    ,
     247H  TRANSFORMATION     TRANSFORMED     OR  CONSTANT)
  901 FORMAT (A2,3F2.0,F6.0)
  902 FORMAT (29H0ERROR ON TRANSFORMATION CARD)
  903 FORMAT (1H 4X,I4,13X,I4,13X,I3,13X,I3,10X,I5)
  904 FORMAT (1H 4X,I4,13X,I4,13X,I3,13X,I3,10X,F12.5)
  905 FORMAT (12A6)
  907 FORMAT (36I2)
```

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```
908 FORMAT (14H0INTERCEPT IS ,F14.4/(2H A,I2,3H = ,F14.4))
909 FORMAT (F20.8)
    RETURN
    END
```

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```
      SUBROUTINE SELEC(NV,ITAPE,IV)
      DIMENSION NS(120),IV(12),ST(60)
      READ INPUT TAPE 50,902,NN
      NN = NN*2
      READ INPUT TAPE 50,900,(NS(I),I=1,NN)
      NN = NN - 1
      DO 100 K=1,NN,2
      M1 = NS(K)
      M2 = K+1
      M2 = NS(M2)
      KK = 0
      IF (M1) 9,200,9
    9 DO 100 I=M1,M2
   10 READ (ITAPE,IV)(ST(J),J=1,NV)
      IN = ST(NV)
      IF (I-IN) 40,50,40
   40 KK = KK+1
      IF (KK-2500) 10,45,45
   45 WRITE OUTPUT TAPE 51,901,I
      CALL EXIT
   50 WRITE TAPE 2,(ST(J),J=1,NV)
  100 CONTINUE
  200 END FILE 2
      REWIND 2
  900 FORMAT (18I4)
  901 FORMAT (45H1ERROR ON TAPE X-917, CANNOT LOCATE POINT NO.,I6)
  902 FORMAT (I4)
      RETURN
      END
```

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```
      SUBROUTINE CALCUR
      DIMENSION CO(35),IV(12),NE(36),ST(60),NPOINT(2400),R(200,4),SU(60)
     1,SM(60),DIF(2400)
      COMMON NV,NO,NTT,NT,NR,CO,COO,IV,NE,SU,CA,NXX,NRR,NPOINT,R,ITAPE,
     1NY,OON,I,DIF,NUT
      NOT = 0
      NIT = NUT
   10 DEL = 0.0
      CA = SU(1) * SU(2)
      IJ = 0
      DO 50 J=1,NV
      ST(J) = SU(J)
   50 CONTINUE
   80 IF (NT) 259,259,90
   90 DO 250 J=1,NT
      N1 = R(J,1)
      N2 = R(J,2)
      N3 = R(J,3)
      N4 = R(J,4)
      IF(N1 - 2) 113,113,100
  100 GO TO (110,110,110,140,150,160,170,180,190,200,210,220,230,240,243
     1),N2
  110 IF(ST(N3)) 113,111,115
  111 IF(N2-2) 114,112,114
  112 ST(N1) = 1.0
      GO TO 250
  113 WRITE OUTPUT TAPE 51,906,N2,N3,NPOINT(I),ST(N3)
      CA = SU(1) + SU(2)
      NXX = NXX + 1
      GO TO 263
  114 ST(N1) = 0.0
      GO TO 250
  115 GO TO (118,120,130),N2
  118 ST(N1) = SQRTF(ST(N3))
      GO TO 250
  120 ST(N1) = SQRTF(ST(N3)) * SQRTF(ST(N3)*1.0)
      GO TO 250
  130 ST(N1) = LOGF(ST(N3))
      GO TO 250
  140 ST(N1) = EXPF(ST(N3))
      GO TO 250
  150 IF(ST(N3)-1.0) 152,156,113
  152 IF(ST(N3)+1.0) 113,153,155
  153 ST(N1) = -1.5708
      GO TO 250
  155 ST(N1) = ASINF(ST(N3))
      GO TO 250
  156 ST(N1) = 1.5708
      GO TO 250
  160 IF(ST(N3)) 113,161,161
  161 PP = SQRTF(ST(N3)/OON)
      PE = SQRTF((ST(N3)*1.0)/OON)
      IF(PP-1.0) 162,163,113
  162 PP = ASINF(PP)
      GO TO 164
  163 PP = 1.5708
```

```
164 IF(PE-1.0) 165,166,113
165 PE = ASINF(PE)
    GO TO 167
166 PE = 1.5708
167 ST(N1) = PP * PE
    GO TO 250
170 IF(ST(N3)) 175,113,175
175 ST(N1) = 1.0/ST(N3)
    GO TO 250
180 ST(N1) = ST(N3) * R(J,4)
    GO TO 250
190 ST(N1) = ST(N3)*R(J,4)
    GO TO 250
200 ST(N1) = ST(N3)**R(J,4)
    GO TO 250
210 ST(N1) = ST(N3) * ST(N4)
    GO TO 250
220 ST(N1) = ST(N3) * ST(N4)
    GO TO 250
230 ST(N1) = ST(N3)*ST(N4)
    GO TO 250
240 IF(ST(N4)) 242,241,242
241 WRITE OUTPUT TAPE 51,906,N2,N4,NPOINT(I),ST(N4)
    CA = SU(1) + SU(2)
    NXX = NXX + 1
    GO TO 263
242 ST(N1) = ST(N3)/ST(N4)
    GO TO 250
243 Z = ST(N3)
    ZZ = ST(N4)
    ST(N1) = DELG(Z,ZZ)
250 CONTINUE
259 IF(NY) 260,260,264
260 SE2 = 0.0
    DO 261 J=1,NR
    NN = NE(J)
    ST(NN) = ST(NN)* CO(J)
    SE2 = SE2 + ST(NN)
261 CONTINUE
    SE2 = SE2 + COO
    NN1 = NE(NRR)
    SE1 = SE2 +ST(NN1)
    IF (SE1-709.0) 262,262,911
262 SE2 = EXPF(SE1)
    IF (SE2-1000000.0) 266,266,911
263 RETURN
264 DO 265 J=1,60
    SM(J) = ST(J)
265 CONTINUE
    IF(NTT) 270,270,269
266 CA = SE2
    GO TO 263
269 WRITE OUTPUT TAPE 51,900,NPOINT(I)
270 IF(NTT-100) 501,501,271
271 DO 273 J=3,60
    SM(J) = ST(J)
```

```
273 CONTINUE
274 DO 500 J=101,NTT
    N1 = R(J,1)
    N2 = R(J,2)
    N3 = R(J,3)
    N4 = R(J,4)
    IF(N1-2) 279,279,275
275 GO TO (276,276,276,290,300,310,320,330,340,350,360,370,380,390,400
   1),N2
276 IF(SM(N3)) 279,277,281
277 IF(N2-2) 280,278,280
278 SM(N1) = 1.0
    GO TO 500
279 WRITE OUTPUT TAPE 51,906,N2,N3,NPOINT(I),SM(N3)
    CA = SU(1) * SU(2)
    NXX = NXX + 1
    GO TO 263
280 SM(N1) = 0.0
    GO TO 500
281 GO TO (282,283,284),N2
282 SM(N1) = SQRTF(SM(N3))
    GO TO 500
283 SM(N1) = SQRTF(SM(N3))+SQRTF(SM(N3)+1.0)
    GO TO 500
284 SM(N1) = LOGF(SM(N3))
    GO TO 500
290 SM(N1) = EXPF(SM(N3))
    GO TO 500
300 IF(SM(N3)-1.0) 302,306,278
302 IF(SM(N3)+1.0) 278,303,305
303 SM(N1) = -1.5708
    GO TO 500
305 SM(N1) = ASINF(SM(N3))
    GO TO 500
306 SM(N1) = 1.5708
    GO TO 500
310 IF(SM(N3)) 278,311,311
311 PP = SQRTF(SM(N3)/BON)
    PE = SQRTF((SM(N3)+1.0)/BON)
    IF(PP-1.0) 312,313,278
312 PP = ASINF(PP)
    GO TO 314
313 PP = 1.5708
314 IF(PE-1.0) 315,316,278
315 PE = ASINF(PE)
    GO TO 317
316 PE = 1.5708
317 SM(N1) = PP + PE
    GO TO 500
320 IF(SM(N3)) 325,278,325
325 SM(N1) = 1.0/SM(N3)
    GO TO 500
330 SM(N1) = SM(N3) + R(J,4)
    GO TO 500
340 SM(N1) = SM(N3) * R(J,4)
    GO TO 500
```

```
350 SM(N1) = SM(N3)**R(J,4)
    GO TO 500
360 SM(N1) = SM(N3) + SM(N4)
    GO TO 500
370 SM(N1) = SM(N3) - SM(N4)
    GO TO 500
380 SM(N1) = SM(N3) * SM(N4)
    GO TO 500
390 IF(SM(N4)) 392,391,392
391 WRITE OUTPUT TAPE 51,906,N2,N4,NPOINT(I),SM(N4)
    CA = SU(1) + SU(2)
    NXX = NXX + 1
    GO TO 263
392 SM(N1) = SM(N3)/SM(N4)
    GO TO 500
400 Z = SM(N3)
    ZZ = SM(N4)
    SM(N1) = DELG(Z,ZZ)
500 CONTINUE
501 SE2 = 0.0
    DO 510 J=1,NR
    NN = NE(J)
    SM(NN) = SM(NN)* CO(J)
    SE2 = SE2+SM(NN)
510 CONTINUE
    SE2 = SE2 + COO
    NN1 = NE(NRR)
    SE1 = SE2 + SM(NN1)
    IF (SE1-709.0) 502,502,503
502 SE2 = EXPF(SE1)
    IF (SE2-1000000.0) 517,517,503
503 IJ = IJ + 1
    GO TO 911
517 IF(NOT) 516,516,908
516 YY = ABSF(0.0010*SE2)
    DEL1 = ABSF(CA-SE2)
    IJ = IJ + 1
    IF(DEL1-YY) 263,263,511
511 IF(NIT) 700,700,610
610 WRITE OUTPUT TAPE 51,901,IJ,CA,SE2
700 IF(IJ-100) 513,513,512
512 WRITE OUTPUT TAPE 51,902,NPOINT(I)
    IF(NIT) 850,850,860
850 NIT = 1
    GO TO 10
860 CA = SU(1) + SU(2)
    NXX = NXX +1
    GO TO 263
513 IF(IJ-1) 514,514,520
514 MM = 1
    R1 = SU(1)/SU(2)
515 IF(MM-2) 530,540,550
520 IF(DEL1-DEL) 515,515,521
521 CA = CA1
    MM = MM+1
    IF(MM-8) 515,800,800
```

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```
530 CA1 = CA
    CA = 0.5*(CA+SE2)
    GO TO 600
540 IF(CA-SE2) 541,263,542
541 CA1 = CA
    CA = 0.9*CA
    GO TO 600
542 MM = MM + 1
550 IF(MM-4) 551,552,553
551 CA1 = CA
    CA = 1.1 * CA
    GO TO 600
552 CA1 = CA
    CA = 0.99 * CA
    GO TO 600
553 IF(MM-6) 554,555,556
554 CA1 = CA
    CA = 1.01 * CA
    GO TO 600
555 CA1 = CA
    CA = 0.999 * CA
    GO TO 600
556 CA1 = CA
    CA = 1.001 * CA
600 SM(1) = CA * R1/(1.0+R1)
    SM(2) = CA/(1.0+R1)
    DEL = DEL1
    GO TO 270
800 WRITE OUTPUT TAPE 51,903,NPOINT(I),CA1,SE2
    IF(NIT) 801,801,907
801 NIT = 1
    GO TO 10
900 FORMAT (21H TRIALS FOR POINT NO.,I6/6H TRIAL,5X,5HINPUT,5X,6HOUTPU
   1T)
901 FORMAT (I6,2F10.2)
902 FORMAT (42H0LOOPED MORE THAN 100  TIMES FOR POINT NO.,I6)
903 FORMAT (10H0POINT NO.,I6,38H CALCULATION APPARENTLY WILL NOT CLOSE
   1/9H TRIAL IS,F14.4,10X,9HRESULT IS,F14.4)
906 FORMAT (1H0//27H TRANSFORMATION OF THE TYPE,I3,24H  CANNOT BE PERF
   1ORMED ON/9H VARIABLE,I3,6H POINT,I5,15H   THE VALUE IS,F12.5)
907 CA = 1.0
    NOT = 1
    GO TO 600
908 WRITE OUTPUT TAPE 51,909,CA,SE2
909 FORMAT (6H TRIAL,F8.1,5X,6HRESULT,F14.4)
    CA = CA * 10.0
    IF (CA - 1001.0) 600,600,910
910 NOT = 0
    GO TO 1000
911 WRITE OUTPUT TAPE 51,912,NPOINT(I),IJ,CA,SE1,SE2
912 FORMAT (32H SOMETHING IS TOO BIG, POINT NO.,I6,5X,9HTRIAL NO.,I4,
   15X,5HTRIAL,F10.2,5X,10HLOG RESULT,F10.2,5X,6HRESULT,F10.2)
    IF (NY) 1000,1000,913
913 CA = 0.5*CA
    IF (IJ-100) 600,600,1000
1000 CA = SU(1) + SU(2)
```

```
      NXX = NXX - 1
      RETURN
      END
```

07-09-65

```
      SUBROUTINE ORDER
      DIMENSION CO(35),IV(12),NE(36),ST(60),NPOINT(2400),R(200,4),
     1DIF(2400)
      COMMON NV,NO,NTT,NT,NR,CO,COO,IV,NE,ST,CA,NXX,NRR,NPOINT,R,ITAPE,
     1NY,OON,I,DIF
      NC = NO - 1
      DO 10 J=1,NC
      ND = J + 1
      DO 10 K=ND,NO
      IF(DIF(J)-DIF(K)) 10,10,9
    9 TEMP = DIF(J)
      DIF(J) = DIF(K)
      DIF(K) = TEMP
      TEMP = NPOINT(J)
      NPOINT(J) = NPOINT(K)
      NPOINT(K) = TEMP
   10 CONTINUE
      WRITE OUTPUT TAPE 51,900
      WRITE OUTPUT TAPE 51,901,(NPOINT(J),DIF(J),J=1,NO)
  900 FORMAT (49H1LIST OF ABSOLUTE DIFFERENCES IN INCREASING ORDER/10HOP
     1OINT NO.,5X,10HDIFFERENCE,5X,10H POINT NO.,5X,10HDIFFERENCE,5X,10H
     2 POINT NO.,5X,10HDIFFERENCE,5X,10H POINT NO.,5X,10HDIFFERENCE)
  901 FORMAT (I8,F16.2,6X,I8,F16.2,6X,I8,F16.2,6X,I8,F16.2)
      RETURN
      END
```

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```
      FUNCTION DELG(RI,AF)
      AI = 2.*RI*AF/(1.+RI)
      VCI = AI
      BI = 2.*(1.-RI)/(3.1416*(1.+RI))
    6 XI = ASINF(ABSF(VCI*(1.-RI)/(3.1416*RI*AF)))
      VC = AI*COSF(XI)/(1.-ABSF(BI*XI))
      ZI = ABSF(VC-VCI)
      YI = 0.0001*VCI
      IF(ZI-YI) 8,8,7
    7 VCI = 0.5*(VCI+VC)
      GO TO 6
    8 VD = VC/RI
      DELG = VD+VC
      RETURN
      END
```

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```
      SUBROUTINE DRAWIT(EXP,CAL,GYPSY)
      DIMENSION DWG(2400),EXP(2400),CAL(2400),GYPSY(7),JUNK(10),NAME(2),
     1PK(8)
      COMMON NV,NO
      DATA(JUSTUS=8H  DRAWIT)
      READ 900,JUNK
      IF (JUNK(1)=JUSTUS) 10,20,10
   10 RETURN
   20 DECODE (24,901,JUNK) JUST,NAME(1),NAME(2)
      XMAX = 6.0
      YMAX = 2.69897
      XFAC = 19.0/XMAX
      YFAC = 9.0/YMAX
      CALL PLOTS(DWG,2400,6)
      CALL PLOT(1.0,0.9,3)
      PX = 0.0
      PXP = 1.0
      PK(1) = 0.30103
      PK(2) = 0.47712
      PK(3) = 0.60206
      PK(4) = 0.69897
      PK(5) = 0.77815
      PK(6) = 0.84510
      PK(7) = 0.90309
      PK(8) = 0.95424
      DO 50 J=1,10
      CALL SYMBOL(PXP-0.15,0.70,0.14,2H10,0.0,0.2)
      CALL NUMBER(PXP-0.09,0.80,0.14,PX,0.0,4HF1.0)
      CALL PLOT(PXP,1.0,3)
      DO 40 K=1,8
      PXP = (PX+PK(K))*XFAC + 1.0
      CALL PLOT(PXP,1.0,2)
      CALL PLOT(PXP,1.1,1)
      CALL PLOT(PXP,1.0,1)
   40 CONTINUE
      PX = PX + 1.0
      IF (PX-XMAX) 45,60,60
   45 PXP = PX*XFAC + 1.0
      CALL PLOT(PXP,1.0,1)
      CALL PLOT (PXP,1.1,1)
      CALL PLOT (PXP,1.0,1)
   50 CONTINUE
   60 CALL PLOT(20.0,1.0,1)
      PY = 0.0
      PYP = 1.0
      DO 80 J=1,5
      DO 70 K=1,8
      PYP = (PY+PK(K))*YFAC + 1.0
      IF (PY+PK(K)-YMAX) 61,90,90
   61 CALL PLOT(20.0,PYP,2)
      CALL PLOT(19.9,PYP,1)
      CALL PLOT(20.0,PYP,1)
   70 CONTINUE
      PY = PY + 1.0
      PYP = PY*YFAC + 1.0
      CALL PLOT(20.0,PYP,1)
```

```
      CALL PLOT (19.9,PYP,1)
      CALL PLOT (20.0,PYP,1)
   80 CONTINUE
   90 CALL PLOT(20.0,10.0,1)
      PXP = (2.0+PK(4))*XFAC + 1.0
      CALL PLOT(PXP,10.0,3)
      CALL PLOT(1.0,1.0,2)
      PY = 0.0
      PYP = 1.0
      DO 110 J=1,5
      CALL SYMBOL(0.64,PYP-0.10,0.14,2H10,0.0,2)
      CALL NUMBER(0.88,PYP,0.14,PY,0.0,4HF11.0)
      CALL PLOT(1.0,PYP,3)
      DO 100 K=1,8
      PYP = (PY+PK(K))*YFAC + 1.0
      IF (PY+PK(K)-YMAX) 91,120,120
   91 CALL PLOT(1.0,PYP,2)
      CALL PLOT(1.1,PYP,1)
      CALL PLOT(1.0,PYP,1)
  100 CONTINUE
      PY = PY + 1.0
      PYP = PY*YFAC + 1.0
      CALL PLOT(1.0,PYP,1)
      CALL PLOT (1.1,PYP,1)
      CALL PLOT (1.0,PYP,1)
  110 CONTINUE
  120 CALL PLOT(1.0,10.0,1)
      PX = 0.0
      PXP = 1.0
      DO 140 J=1,10
      DO 130 K=1,8
      PXP = (PX+PK(K))*XFAC + 1.0
      CALL PLOT(PXP,10.0,2)
      CALL PLOT(PXP,9.9,1)
      CALL PLOT(PXP,10.0,1)
  130 CONTINUE
      PX = PX + 1.0
      IF (PX-XMAX) 135,150,150
  135 PXP = PX*XFAC + 1.0
      CALL PLOT(PXP,10.0,1)
      CALL PLOT (PXP,9.9,1)
      CALL PLOT (PXP,10.0,1)
  140 CONTINUE
  150 CALL PLOT(20.0,10.0,1)
      CALL SYMBOL(10.0,9.0,0.21,GYPSY,0.0,55)
      CALL SYMBOL(0.3,4.0,0.14,23HEXPERIMENTAL A+0, FT/HR,90.0,23)
      CALL SYMBOL(9.0,0.4,0.14,21HCALCULATED A+0, FT/HR,0.0,21)
      DO 200 J=1,NO
      PXP = LOGF(CAL(J))/2.302585
      PYP = LOGF(EXP(J))/2.302585
      PXP = PXP*XFAC + 1.0
      PYP = PYP*YFAC + 1.0
      CALL SYMBOL(PXP,PYP,0.02,1,0.0,-1)
  200 CONTINUE
      CALL SYMBOL(19.0,0.1,0.07,NAME,0.0,16)
      CALL PLOT(28.0,0.0,-3)
```

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```
      RETURN
900   FORMAT (10A8)
901   FORMAT (3A8)
      END
```

PROGRAM BIMD29
Modified for Use in Flooding Equations

This is a program in FORTRAN-63 devised by the Division of Biostatistics, Department of Preventive Medicine and Public Health, School of Medicine, University of California, Los Angeles, and suitably modified by Unit Operations Section of the Chemical Technology Division of Oak Ridge National Laboratory to produce the desired output format and allow more flexibility. The program accepts input data and computes values of all dependent and independent variables for an equation of the type: $Y = A_o + b_1X_1 + b_2X_2 + \ldots + b_nX_n$, then performs a multiple stepwise regression analysis leading to a multiple-R statistic and proper coefficients A_o and b_1 through b_n. The program prints out values of sums, sums of squares, cross-product sums, cross products of deviations, and simple correlation coefficients for each variable. Terms in the equation may be deleted or replaced for successive regression analyses, therefore Replacement and Deletion Cards specify the variables to be used in each analysis. Finally, for each regression analysis, printout includes analysis of variance table for regression including means, standard deviations, regression coefficients, standard error of regression coefficient, computed t values and partial correlation coefficients; incremental values of multiple-R, F value, sums of squares, etc., and finally a table of residuals and a table of percentage deviations. The table of residuals gives the Y value, Y estimate, and residual. The table of percentage difference gives the antilog of the Y value, antilog of the Y estimate, and the percentage difference. This table is useful only if Y values are logarithms. At the end of the table of deviations, the largest positive percentage difference is given. Also

printed out are the average of the positive percentage differences, the average percentage difference, the average of the negative percentage differences, and the largest negative percentage difference.

PRØGRAM BIMD-29 contains SUBRØUTINES READØ, SELEC, RANK, INVERT, RESIDU, and FUNCTIØN DELG. READØ, RANK, INVERT, and RESIDU are essentially unchanged from the original program. SELEC allows up to 60 data points or groups of data points to be selected from the entire list for use in the regression analysis. FUNCTIØN DELG(Z,ZZ) is available to produce the throughput at flooding due to insufficient pulsation (Δ_G) from input quantities Z, and ZZ, where Z is the ratio V_c/V_D and ZZ is 5FA.

Computational Procedures

Model assumed:

Y is normally distributed with mean μ and variance σ^2,

where $\mu = A + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p$.

The computation steps performed by the program follow:

<u>Step 1</u>. Preliminary computations.

1. Trans-generation: If desired, data are transformed and/or generated according to the codes specified in the Transgeneration Cards.
2. Sums: ΣX_i $\quad i = 1,2, \ldots , p$, where p is the number of variables.
3. Sums of squares: ΣX_i^2
4. Means: $\bar{X}_i = \frac{\Sigma X_i}{n}$, where n is sample size.
5. Standard deviations: $s_i = \sqrt{\frac{\Sigma(X_i - \bar{X}_i)^2}{n - 1}}$.

6. Cross-product sums:

$$P_{ij} = \Sigma X_i \cdot X_j \qquad i = 1,2,\ldots,p$$
$$j = 1,2,\ldots,p$$

7. Cross product of deviations:

$$D_{ij} = \Sigma(X_i - \bar{X}_i)(X_j - \bar{X}_j) \quad .$$

8. Simple correlation coefficients:

$$r_{ij} = \frac{\Sigma(X_i - \bar{X}_i)(X_j - \bar{X}_j)}{\sqrt{\Sigma(X_i - \bar{X}_i)^2}\sqrt{\Sigma(X_j - \bar{X}_j)^2}} \quad .$$

<u>Step 2</u>. The program reads the Replacement and Deletion Card and performs the following computations:

1. Rearrange the variables in the cross product of deviation matrix and construct a_{ij} in the working storage area.
($i = 1,2,\ldots,k$; $j = 1,2,\ldots,k$, where k is the number of variables after deletion.)

2. Compute: $b_{iy} = \dfrac{a_{iy}}{a_{ii}}$,

$c_{iy} = b_{iy} \cdot a_{iy}$,

$i = 1,2,\ldots,p$, where p is the number of independent variables.

Then, find the maximum c_{iy}, which is the largest sum of squares explained by the ith variable in the first step of the regression. This value is printed out under the heading of Sum of Squares.

Let $b_{1y} = b_{iy}$; $c_{1y} = c_{iy}$; $a_{1j} = a_{ij}$,

where i is the variable entering in the regression.

3. Obtain $P = \dfrac{c_{1y}}{\Sigma\,(Y_i - \bar{Y})^2}$

P is compared with the percentage value specified in Col. 21-25 of the Problem Card. If P is greater than the percentage value specified, the program goes to the section immediately following; otherwise, it jumps to 6, below. P is printed out under the heading of Proportion of Variance.

4. Obtain f value for variable entered.

$$f = \frac{c_{1y}}{\dfrac{\Sigma\,(Y_i - \bar{Y})^2 - c_{1y}}{(n - 1) - 1}} .$$

In general,

$$f = \frac{\text{sum of squares residual}}{\text{D.F. residual}} .$$

5. Compute:

$b_{1j} = \dfrac{a_{1j}}{a_{11}}$ $\quad j = 1,2,\ldots,p$, where p is the number of independent variables.

$a_{ij\cdot 1} = a_{ij} - a_{i1} \cdot b_{1j}$ $\quad i = 2,3,\ldots,k$

$j = 2,3,\ldots,k$, where k is the number of variables including the dependent variable.

The sections 2-5 above are repeated to select and enter the remaining variables in the regression in the order of their contribution to the sum of squares of the dependent variable.

6. Compute cumulative regression:

a. Sums of squares:

$$Z_k = \sum_{j=1}^{k} c_{jy} \quad k = 1,2,\ldots,q,$$ where q is the number of the variables entered in the regression.

b. Proportions of variances:

$$R_k^2 = \frac{Z_k}{\Sigma\ (Y_i - \bar{Y})^2} \ .$$

c. Multiple correlation coefficients:

$$R_k = \sqrt{R_k^2} \ .$$

d. Standard error of estimates:

$$E_{Y \cdot 1-k} = \sqrt{\frac{\Sigma\ (Y_i - \hat{Y}_i)^2}{n - k - 1}} = \sqrt{\frac{\Sigma\ (Y_i - \bar{Y})^2 - Z_k}{n - k - 1}} \ .$$

e. F values:

$$F_k = \frac{\frac{Z_k}{k}}{\frac{\Sigma(Y_i - \hat{Y}_i)^2}{n - k - 1}} = \frac{\frac{Z_k}{k}}{\frac{\Sigma(Y_i - \bar{Y})^2 - Z_k}{n - k - 1}} \ .$$

<u>Step 3</u>. Simple correlation coefficients of those variables entered in the regression are rearranged in the working storage area to perform the following computations:

1. Invert the correlation coefficient matrix and obtain c'_{ij}. ($i = 1,2,\ldots,p$; $j = 1,2,\ldots,p$, where p is the number of independent variables entered.) The inversion is performed by using the SUBROUTINE INVERT, programmed at Rocketdyne, North American Aviation.

2. c_{ij} values:

$$c_{ij} = \frac{c'_{ij}\ r_{ij}}{D_{ij}} .$$

3. Joint regression coefficients:

$$b_j = c_{1j}\ \Sigma\ (X_1 - \bar{X}_1)(Y - \bar{Y}) + c_{2j}\ \Sigma\ (X_2 - \bar{X}_2)(Y - \bar{Y}) + \ldots + c_{pj}\ \Sigma(X_p - \bar{X}_p)(Y - \bar{Y}) .$$

4. Intercept (A value):

$$A = \bar{Y} - \Sigma\ b_j\ \bar{X}_j .$$

5. Standard deviations of the regression coefficients:

$$s_{b_j} = \sqrt{s^2_{Y\cdot 12\ldots p} \cdot c_{jj}} ,$$

$j = 1,2,\ldots,p$, where p is the number of independent variables entered.

6. t values:

$$t_j = \frac{b_j}{s_{b_j}} .$$

7. Partial correlation coefficients:

$$r'_{jY\cdot(jY)'} = \frac{-a_{Yj}}{\sqrt{a_{YY} \cdot a_{jj}}} ,$$

where a_{jj} is the inverse of a simple correlation coefficient r_{jj}.

8. Compare check on final coefficient:

The last b_{iy} computed in the section 2 of Step 2 is also the regression coefficient of the last independent variable. This coefficient is printed out to check the accuracy of the computing procedure explained above.

Step 4. Analysis of extreme residuals: The statistical procedure for detection of outliers explained by Dixon and Massey[130] is used in this program. This procedure assumes that data are normally distributed and that they come from the same population. Residuals are not classified in this group. Therefore, readers are reminded that this statistical procedure is only approximate.

INSUFFICIENT-PULSATION FLOODING

In a pulsed column, flooding can occur when the pulsing energy is too low to force the liquids through the pulse plates as fast as they are fed to the column. This type of flooding behavior is distinctly different from flooding due to emulsification of the phases, where the limiting column throughput is governed by a multitude of factors including column geometry and fluid physical properties. Flooding due to insufficient pulsation is governed only by the amount of pulsing energy and the ratio of phase flow rates.

W. H. Swift analyzed nine cases involving various means of feeding fluids to and removing fluids from pulse columns.[87] Four of these cases are of interest; these are:

Case 1: Constant introduction and withdrawal of both liquid phases.

Case 2: Introduction of the light phase during the pulse downstroke with constant withdrawal of the heavy phase.

Case 5: Constant introduction of the light phase with removal of the heavy phase during the pulse upstroke.

Case 6: Introduction of the light phase during the pulse downstroke and withdrawal of the heavy phase during the pulse upstroke.

The equations for column throughput developed for these cases by Swift are:

$$V_H + V_L = 2\ V_p \qquad \text{(Case 1)} \qquad (1)$$

$$V_H + V_L = 2\ V_p - V_L \qquad \text{(Case 2)} \qquad (2)$$

$$V_H + V_L = 2\ V_p - V_H \qquad \text{(Case 5)} \qquad (3)$$

$$V_H + V_L = V_p \qquad \text{(Case 6)} \qquad (4)$$

and are valid if one defines the pulse upstroke or downstroke as that

portion of the pulsing cycle where the pulsing unit piston or diaphragm is moving in a direction which tends to raise or lower the column contents. However, in actual operation, the pulse upstroke must be inferred as meaning that portion of the pulsing cycle where the net velocity in the column is upward. The two definitions are identical only if there are no flows to or from the column, or if the flow rates of light and heavy phases are equal (flow ratio = 1.0) and steady throughout the pulsing cycle. Edwards and Beyer recognized this difference and developed a more usable equation for case 5.[31]

$$V_H + V_L = V_p \cos \phi' + \frac{V_L \phi'}{\pi} + \frac{V_L}{2} \quad , \tag{5}$$

where $\phi' = \text{arc sin} \frac{V_L}{\pi V_p}$. In a similar manner, B. E. Claybaugh derived a better equation for the conditions of case 1:[19]

$$V_H + V_L = 2\, V_p \cos \phi + 2\, (V_L - V_H) \frac{\phi}{\pi} \quad , \tag{6}$$

where $\phi = \text{arc sin} \frac{V_L - V_H}{\pi V_p}$.

The following derivation of cases 2 and 6 parallels those of cases 1 and 5. For case 2 consider for the moment only those flows which are constant or which vary in a continuous manner. The upward flow in the column due only to the pulse is:

$$Q_1 = \frac{v}{2} \sin (2\pi Ft) \ , \tag{7}$$

where time (t) is measured from the midpoint of the upward stroke of the pulsing unit. Superimposed on the pulse flow is the steady downward flow of heavy phase.

$$Q_2 = -V_H t \quad . \tag{8}$$

The total net upward flow due to the pulse and heavy phase is then:

$$Q = \frac{v}{2} \sin (2\pi Ft) - V_H t \quad . \tag{9}$$

These relationships are shown in Fig. A-46. The net rate of upward flow is:

$$\frac{dQ}{dt} = \pi Fv \cos (2\pi Ft) - V_H \ , \tag{10}$$

and is shown in Fig. A-47. During a typical pulse cycle the total upward and downward flows due to the pulse and heavy phase are represented by q_U and q_D in Fig. A-47, where

$$q_U = \int_{t_2}^{t_3} \frac{dQ}{dt} = \left[\frac{v}{2} \sin (2\pi Ft) - V_H t \right]_{t_2}^{t_3} \quad . \tag{11}$$

$$q_D = -\int_{t_1}^{t_2} \frac{dQ}{dt} = -\left[\frac{v}{2} \sin (2\pi Ft) - V_H t \right]_{t_1}^{t_2} \quad . \tag{12}$$

To evaluate the limits, note that

$$t_1 = \frac{1}{4F} - t' \quad , \tag{13}$$

$$t_2 = \frac{3}{4F} + t' \quad , \tag{14}$$

$$t_3 = \frac{5}{4F} - t' \quad . \tag{15}$$

Also note that when $V_H = 0$, $t' = 0$ and when $V_H = \pi Fv$, $t' = 1/4F$. Therefore,

$$t' = \frac{1}{2\pi F} \text{ arc sin } \frac{V_H}{\pi Fv} \quad . \tag{16}$$

Let $\phi' = \text{arc sin } \frac{V_H}{\pi Fv}$. (17)

Therefore, $t_1 = \frac{1}{4F} - \frac{\phi'}{2\pi F}$ (18)

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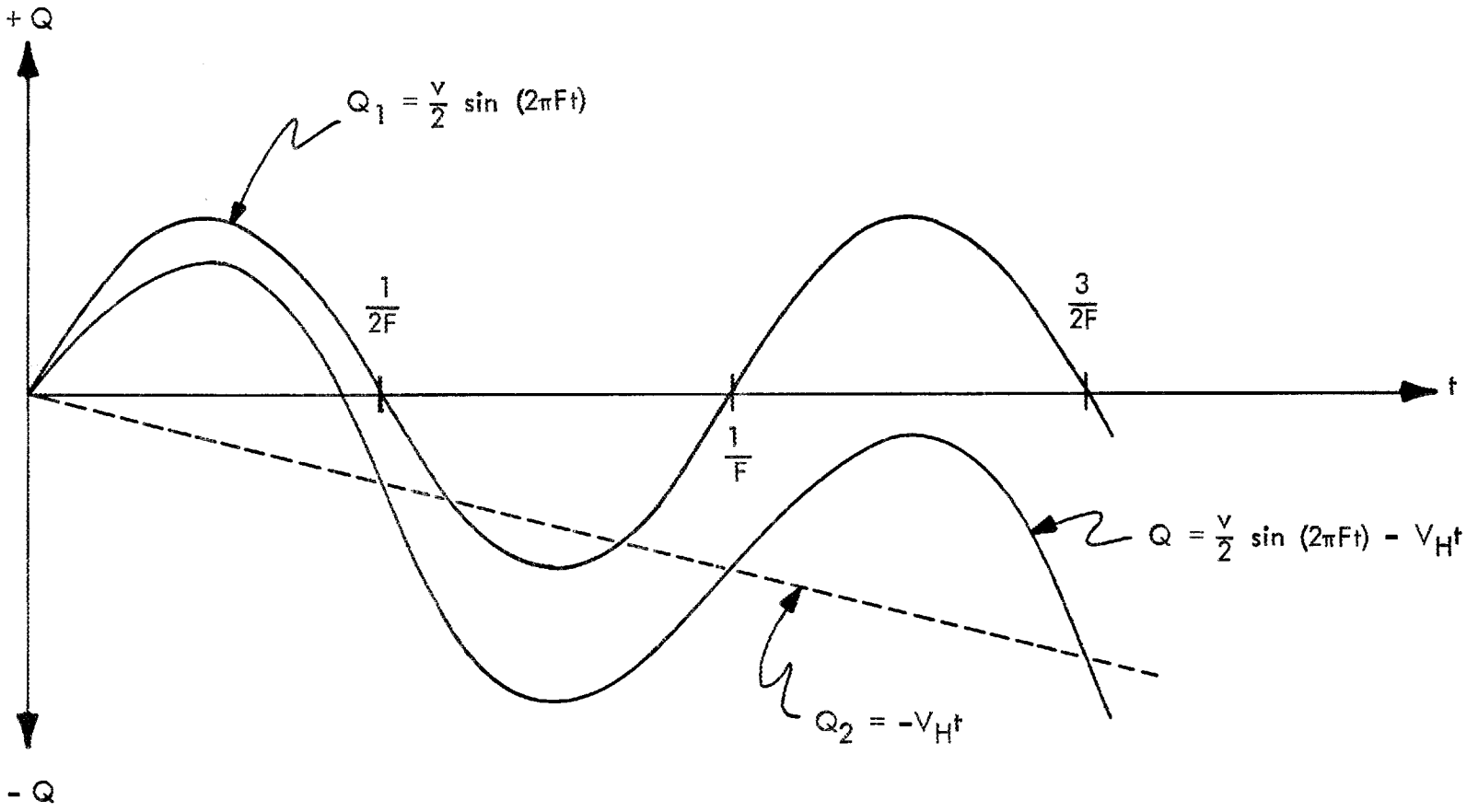

Fig. A-46. Flow Components, Case 2.

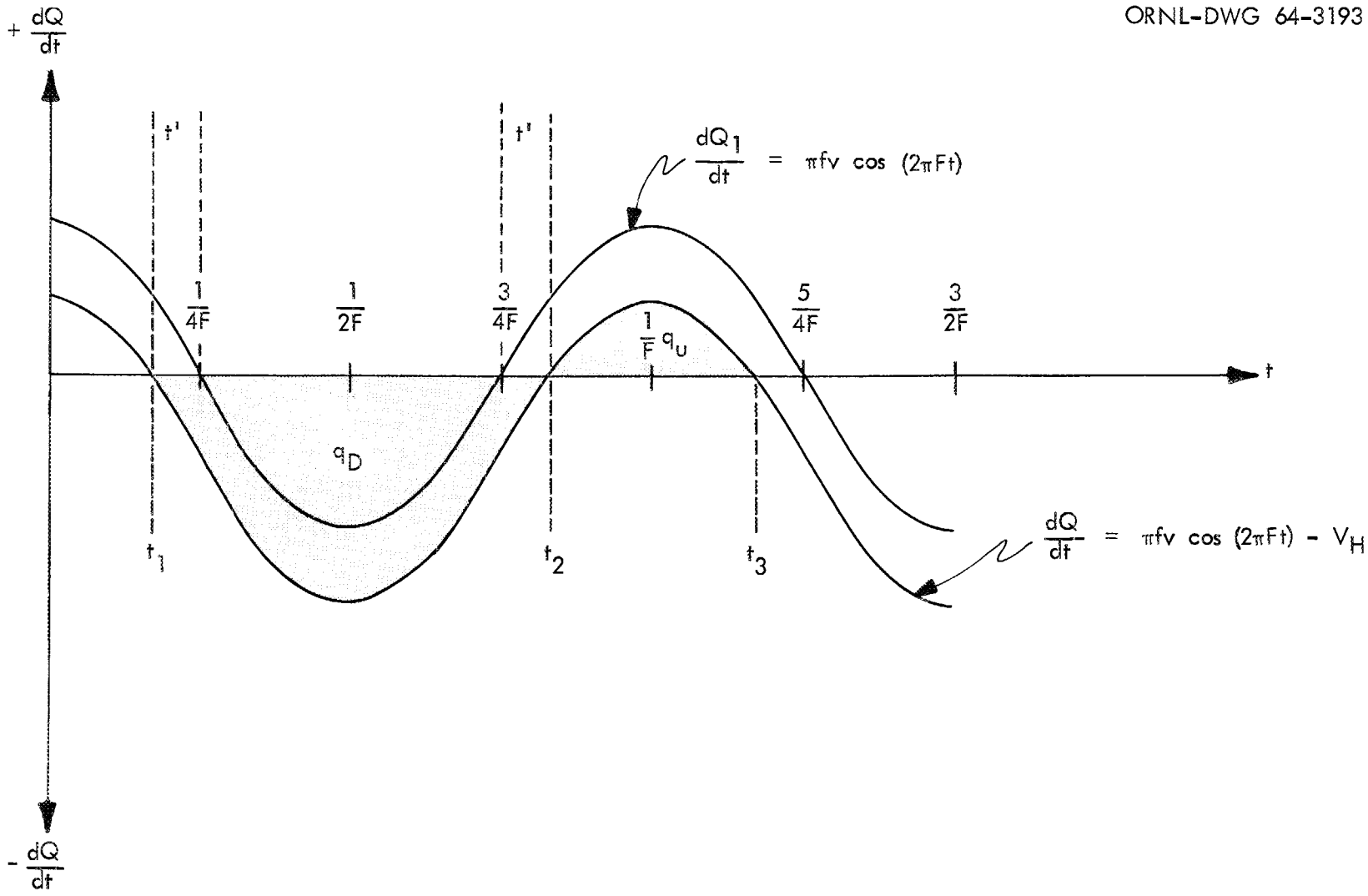

Fig. A-47. Flow Rate Components, Case 2.

$$t_2 = \frac{3}{4F} + \frac{\phi'}{2\pi F} \tag{19}$$

$$t_3 = \frac{5}{4F} - \frac{\phi'}{2\pi F} \tag{20}$$

and $$q_U = \frac{V_H}{2\pi F}(2\phi' - \pi) + v \cos \phi' \tag{21}$$

$$q_D = \frac{V_H}{2\pi F}(2\phi' + \pi) + v \cos \phi' \ . \tag{22}$$

The quantities q_U and q_D must be related to the discontinuous flows of light phase and recycle as follows, no matter how these flows vary with time.

$$q_U F = V_R + V_L \tag{23}$$

$$q_D F = V_R' + V_L + V_H \tag{24}$$

By substituting Eq. (21) in (23) and Eq. (22) in (24), it is immediately seen that

$$V_R = V_R' = V_p \cos \phi' + \frac{V_H \phi'}{\pi} - \frac{V_H}{2} - V_L \ . \tag{25}$$

At flooding, $V_R = 0$, and the column throughput is:

$$V_H + V_L = V_p \cos \phi' + \frac{V_H \phi'}{\pi} + \frac{V_H}{2} \ , \tag{26}$$

where ϕ' is defined by Eq. (17).

For case 6, the only continuously varying flow is the pulse flow represented by Eq. (7), and there are no steady flows. Therefore,

$$\frac{dQ}{dt} = \pi F v \cos (2\pi F t) \ , \tag{27}$$

and $$q_U = q_D = v \ . \tag{28}$$

This quantity is related to the discontinuous flows of light phase, heavy phase, and recycle as follows:

$$q_U F = q_D F = V_p = V_R + V_H + V_L \quad . \tag{29}$$

At flooding, $V_R = 0$, and the column throughput is, for this case, identical to that shown by Swift in Eq. (4). Thus, Eqs. (6), (26), (5), and (4), are the proper ones to use for cases 1, 2, 5, and 6, respectively.

For any of the cases at any flow ratio (V_H/V_L), a plot of column throughput ($V_H + V_L$) versus the pulse-volume velocity (V_p) produces a straight line passing through the origin. This line represents the maximum column throughput, at a given pulse condition that is allowable before flooding due to insufficient pulsation occurs. Of course, at some given pulsing condition, flooding due to emulsification may occur at a column throughput that is much lower than required to flood by insufficient pulsing conditions.

Table A-22 lists the slopes of these insufficient flooding lines for the four cases at flow ratios from 0.01 to 100. These are shown graphically in Fig. A-48. The values for cases 1, 2, and 5 were obtained using the CDC-1604 digital computer to perform the necessary repetitive calculations.

Notation

a = Amplitude of pulse in the column from one extreme position to the other, cm, calculated from the pulse generator output and the column cross-section

A = Cross-sectional area of column cartridge, cm^2

F = Pulse frequency, cycles/min

q_U, q_D = Total upward and downward flows, respectively, in a given pulse cycle considering only those streams whose flow rates are constant or vary in a continuous manner, cm^3

Q = Net upward flow, considering only those streams whose flow rates are constant or vary in a continuous manner, cm^3

t = Time, sec

t' = Time increment defined in Fig. A-47, sec

Table A-22. Insufficient-Pulsation Flooding Ratios

Flow Ratio, $V_H:V_L$	Flooding Ratio, $(V_H + V_L)/V_p$ Case 1 Eq. (6)	Case 2 Eq. (26)	Case 5 Eq. (5)	Case 6 Eq. (4)
1:100	2.894	1.005	2.867	1.000
1:70	2.841	1.007	2.804	1.000
1:50	2.783	1.010	2.733	1.000
1:30	2.680	1.016	2.603	1.000
1:20	2.586	1.025	2.480	1.000
1:10	2.408	1.048	2.231	1.000
1:7	2.313	1.068	2.088	1.000
1:5	2.228	1.093	1.949	1.000
1:3	2.114	1.148	1.740	1.000
1:2	2.047	1.210	1.586	1.000
1:1	2.000	1.365	1.365	1.000
2:1	2.047	1.586	1.210	1.000
3:1	2.114	1.740	1.148	1.000
5:1	2.228	1.949	1.093	1.000
7:1	2.313	2.088	1.068	1.000
10:1	2.408	2.231	1.048	1.000
20:1	2.586	2.480	1.025	1.000
30:1	2.680	2.603	1.016	1.000
50:1	2.783	2.733	1.010	1.000
70:1	2.841	2.804	1.007	1.000
100:1	2.894	2.867	1.005	1.000

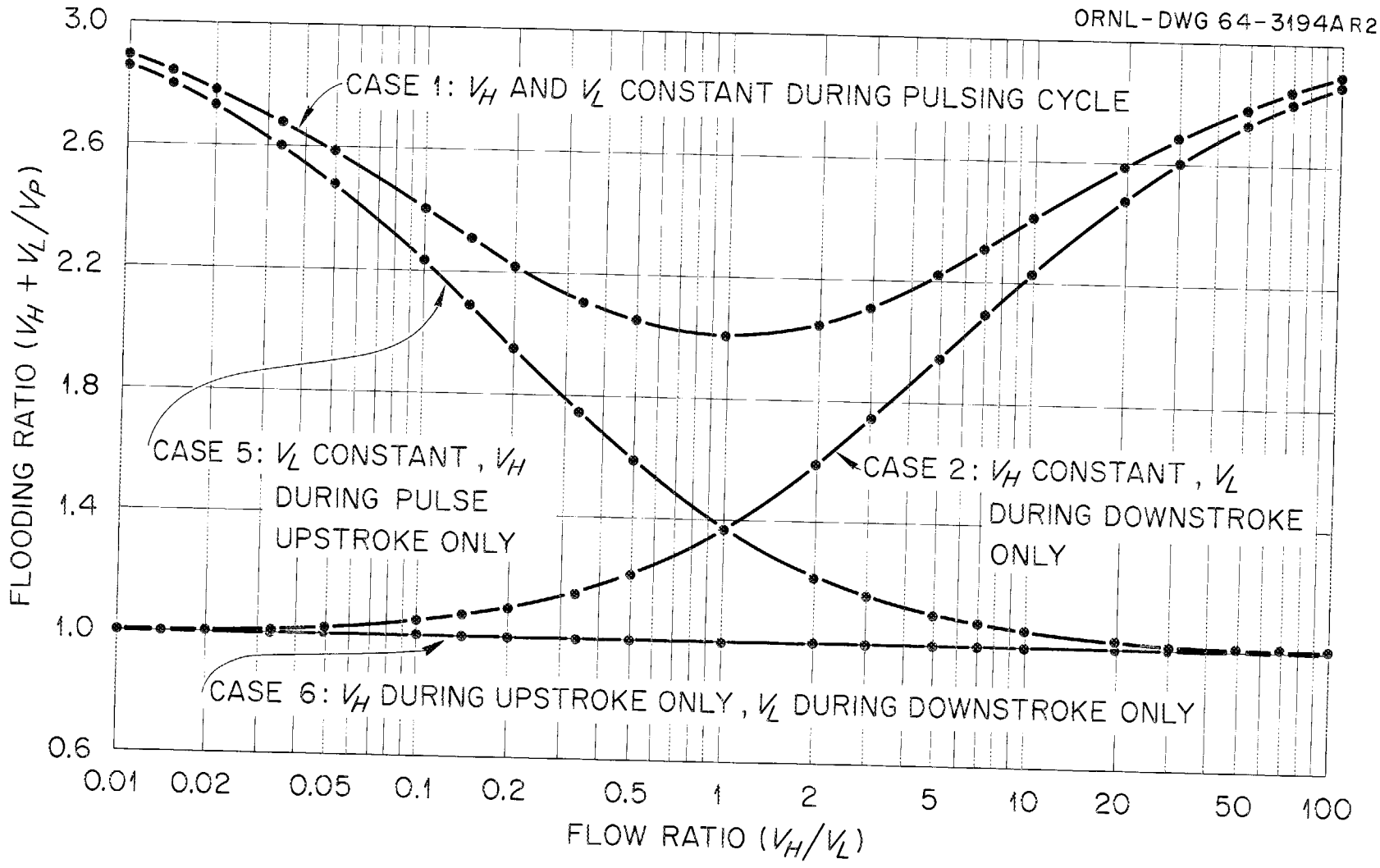

Fig. A-48. Calculated Ratio of the Throughput at Flooding Due to Insufficient Pulsation to the Pulsed-Volume Velocity as a Function of Flow Ratio for Four Different Modes of Flow in a Pulsed Column.

$v = aA$, cm^3

V_H = Heavy-phase flow rate, cm^3/sec

V_L = Light-phase flow rate, cm^3/sec

V_p = Pulse-volume velocity = vF, cm^3/sec

V_R = Recycle rate in upward direction, cm^3/sec

V_R' = Recycle rate in downward direction, cm^3/sec

SAMPLE CALCULATION: F STATISTIC

Note: All data are from the benzene--water system, points 552-605.

Model, case I: $Y = A_o + A_1X_1 + A_2X_2 + A_3X_3 + A_4X_1^2 + A_5X_2^2 + A_6X_3^2 + A_7X_1X_2 + A_8X_1X_3 + A_9X_2X_3 + X_{10}X_3^3$,

where

$Y = \ln (V_D/\Delta_D)$

$X_1 = \ln (V_c/V_D)$

$X_2 = \ln A$

$X_3 = \ln \pi_D$

For the benzene--water data, the number of data points, n = 54; number of treatments, m = 27. The data in the following table result from the regression calculation as made with the BIMD29 computer program on the above model.

Analysis of Variance, Summary Table for Regression

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Due to regression	10	92.7849227	9.27849
Deviation about regression	43	0.3453602	0.00803163
Total	53	93.1302829	

The variation associated with the deviation about regression (43 degrees of freedom) is that analyzed here. It is made up of both the lack of fit of the model and the experimental error. The experimental error is evaluated as follows:

For the independent variable Y:

Sums of squares within treatments: $\sum_{i=1}^{2} \sum_{j=1}^{m} (Y_{ij} - \bar{Y}_j)^2 = 0.1655696$,

where i = number of replications within each treatment, 2 in this case.

Degrees of freedom: j = number of treatments, m = 27 in this case.

$\bar{Y}_j$ = mean Y for each treatment.

Mean square within treatments = 0.1655696/27 = 0.00613221

Sum of squares, deviation about regression: $\sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2$

where $\hat{Y}_i$ is the calculated value of Y_i, or the estimate of Y_i at various values of X_i.

Therefore: $\hat{Y}_i = A_o + A_1X_1 + A_2X_2 + A_3X_3 + A_4X_1^2 + A_5X_2^2 + A_6X_3^2 + A_7X_1X_2 + A_8X_1X_3 + A_9X_2X_3 + A_{10}X_3^3$.

The Deviation about Regression = (Sum of squares within treatments) + (Sum of squares due to lack of fit)

Analysis of Variance, Summary Table for Lack of Fit

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Statistic[a]
Within treatments (experimental error)	27	0.1655696	0.00613221	
Lack of fit	16	0.1797906	0.01123691	1.83
Deviation about regression	43	0.3453602		

[a]The F statistic here is the ratio of (mean-square lack of fit)/(mean square experimental error).

and should be compared with $F_{16,27} = 2.056$ at the 95% level of significance.

The fact that the calculated F is less than the critical value shows no

significant lack of fit, that is, the equation fits the data within the experimental error.

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