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IS-197

Chemistry-General (UC-4)
TID-4500, August 1, 1959

UNITED STATES ATOMIC ENERGY COMMISSION
Research and Development Report

PROGRESS REPORT ON FRICTION LOSS
OF SLURRIES IN STRAIGHT TUBES

by

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September 1960

Ames Laboratory
at
Iowa State University of Science and Technology
F. H. Spedding, Director
Contract W-7405 eng-82

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Printed in USA. Price \$ 2.25 . Available from the

Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

TABLE OF CONTENTS

	Page
Abstract	5
I. INTRODUCTION	6
II. RESULTS OF PREVIOUS WORK	6
III. MATERIALS AND EQUIPMENT	8
A. Materials	8
B. Equipment	9
C. Calibration	11
D. Test Procedure	11
IV. ANALYSIS	12
A. Types of Flow	12
B. Analysis of the Friction Loss	14
V. DISCUSSION	19
VI. APPENDIX	26
A. Graphic Data	26
B. Tabulated Data	63

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PROGRESS REPORT ON FRICTION LOSS OF SLURRIES IN STRAIGHT TUBES

Glenn Murphy, Michael A. McCoy, and

Harold E. Wolfe

ABSTRACT

This progress report summarizes the work to date on the experimental evaluation of the head loss of slurries flowing in horizontal and vertical tubes. The slurries used in the investigation were spherical glass beads and ion exchange resin particles suspended in water. The tube size used was approximately 0.3-in. inside diameter. Concentrations from zero to approximately 50 percent by weight were used.

The results are presented in graphical form as head loss in feet of mixture vs. Froude number and a "Z-factor" vs. Froude number. The Z-factor is evaluated as the ratio of the pressure drop of the pure fluid to the pressure drop of the mixture flowing at the same mean velocity. The relationship between the Z-factor for turbulent flow and concentration is presented in graphical form for the three directions of flow.

I. INTRODUCTION

The object of this report is to present the experimental data obtained from a study of the head loss in a solid-liquid mixture flowing in horizontal and vertical tubes. The tests were conducted in 0.3-in. inside diameter glass tubes with glass beads of 0.0028-in. average diameter, with glass beads of 0.0013-in. average diameter, and with ion-exchange resin beads of 0.0044-in. average diameter suspended in water. Weight concentrations (pounds of solid per pound of mixture) were varied from approximately 4 to 50 per cent by weight and the average temperature was 20°C.

This report follows an earlier report¹ on the investigation of the flow properties of slurries in horizontal tubes. A correlation of data for flow in vertical tubes is now in progress but is not included in this report. The data taken are summarized in the appendix, and plots of head loss vs. Froude number and plots of Z-factor (ratio of pressure drop of fluid to pressure drop of mixture flowing at the same velocity) vs. Froude number are also presented.

II. RESULTS OF PREVIOUS WORK

Earlier data on the horizontal flow of a slurry as reported by Murphy, Young, and Burian² indicated that the following conclusions could be

¹ Glenn Murphy, D. F. Young, and R. J. Burian, "Progress Report on Friction Loss of Slurries in Straight Tubes", U. S. Atomic Energy Commission Report, ISC-474, April 4, 1954.

² Ibid.

stated relative to the general flow characteristics of a slurry.

(1) There are three characteristic regions of flow: (a) a high-velocity region characterized by an approximately uniform distribution of solids throughout the tube; (b) a transition region characterized by a non-uniform distribution of solids, but with no stationary layer of particles; and (c) a low-velocity region characterized by a stationary layer of particles.

(2) The upper transition velocity, or boundary between the high velocity and the transition velocity regions, is a function of the particle size, and apparently there is a critical size for each material.

(3) For particles smaller than the critical size the upper transition velocity increases both as the concentration of solid and as the particle size increases. The following equation gives approximate values for the upper transition velocities:

$$\frac{\rho_f}{\rho_s} \left(\frac{v_{ut}^2}{Dg} \right) = 285 \left[\frac{d}{D} e_s \right]^{0.6}$$

(4) For particles larger than the critical size the upper transition velocity increases as the concentration of solid increases. The following equation gives approximate values for the upper transition velocity:

$$\frac{\rho_f}{\rho_s} \left(\frac{v_{ut}^2}{Dg} \right) = 75 (e_s)^{1.35}$$

(5) The variation in the lower transition velocity is not sufficiently defined to indicate the variation with concentration and particle size.

In addition, the following relationships were developed for the high-

velocity region of flow.

For particles whose size is less than the critical size, the pressure drop can be expressed as

$$\frac{\Delta P_m}{\Delta P_w} = 0.96 \left(\frac{D}{d} \right)^{0.076} (e_s)^{0.113},$$

where ΔP_m is the pressure drop of the mixture and ΔP_w is the pressure drop of the pure fluid flowing at the same mean velocity.

For particles whose size is greater than the critical size, the pressure drop can be expressed as

$$\Delta P_m = 1.07 \Delta P_w.$$

In these conclusions it was noted that the critical size depended upon the specific weight of the material, and the value of the critical size was not precisely determined.

III. MATERIALS AND EQUIPMENT

A. Materials

Glass beads and ion-exchange resin particles were used for the solid phases of the slurries, and tap water was used for the liquid phase in the tests. Both types of solid materials were spherical in shape. The glass particles are "Superbrite" glass beads ordinarily used for pavement marking and were obtained from the Minnesota Mining and Manufacturing Company. The resin particles used in the tests were obtained by dry screening with U. S. Standard screens and taking the fraction between

100 and 200 mesh. Size and specific weight determinations were made using the methods described in a previous report.³

Table I lists the properties of the materials tested.

Table I.		
Properties of the Materials Tested		
Material	Av. Particle Diameter (in.)	Specific Weight (pcf)
Glass	0.0026	174.2
Glass	0.0028	154.4
Glass	0.0013	147.0
Resin	0.0044	84.1

Figure 1 shows the relationship between concentration by weight and specific weight of the mixture for the materials used in the investigation.

B. Equipment

The basic equipment used in the tests included three test sections, a pump and motor unit, a slurry supply tank, a measuring tank and graduated cylinder, platform scales, three differential manometers, and a series of copper and steel nozzles.

The major pieces of equipment used were essentially the same as

³ Ibid.

those used to collect the data presented in a previous report.⁴ Because the particles were small, the slurry could be pumped directly through a centrifugal pump, and it was not necessary to use the solids feed tank. A series of copper and steel nozzles was used to vary the flow since it could not be adjusted satisfactorily with gate or globe valves.

An injection nozzle was installed at the bottom of the measuring tank so that the pump could be used to force the slurry back into the supply tank and thus eliminate manual handling of the material.

A 1/30 hp Industrial Mixer with a 15-in. shaft and 3-in. propeller was used to maintain a uniform suspension in the supply tank. A copper cooling coil was used to keep the slurry temperature constant.

A bromoform manometer was added to the system to improve the accuracy of pressure-drop measurement in the region in which the pressure differential was too great for the range of the carbon tetrachloride manometer but was too small to provide an appreciable difference on the mercury manometer. A calibrated sight glass was installed in the side of the weighing tank to permit volume measurement to be obtained more easily than by using the piezometer tube.

A two-liter graduated cylinder was used to collect the mixture for low rates of flow.

The glass tube used for upward flow tests was 0.314-in. inside diameter, and the tube used for downward flow was 0.322-in. inside

⁴ Ibid.

diameter. Both tubes had a test section 36-in. long, with a 32-in. entrance section. The horizontal test section was a glass tube with an inside diameter of 0.315-in. It was 46-in. long, with a 32-in. entrance section.

The slurry was directed out of a horizontal pipe into the upward flow section, through a tygon connecting tube into the downward flow test section, and then through an inclined tube into the weighing tank as shown in Fig. 2.

C. Calibration

The three test-sections were calibrated with water. The turbulent region was found to follow the Blasius equation for smooth pipes, and the laminar region was found to follow the relationship $f = 64/R$. The transition region occurred within a Reynolds number range of 1500 to 4000. The results of the calibration are shown in Fig. 3.

D. Test Procedure

The test procedure used is summarized by the following outline.

1. The Industrial Mixer was turned on to suspend the particles in the fluid in the supply tank, and the cooling water was turned on.
2. The pump was started, and the slurry was allowed to circulate through the system. The scale was balanced, and the air was bled from the manometer leads. The concentration was adjusted if necessary.
3. When the system had reached an equilibrium condition, the test was started by switching the flow from the supply tank into the measuring

tank (or graduated cylinder). The stop watch was started simultaneously with this action.

4. The following data were taken during the test run: manometer readings, temperature of the mixture, and visual observation of the flow, if significant.

5. If the measuring tank was used, the flow was switched from the measuring tank into the supply tank, and the watch was stopped simultaneously as the beam on the scales passed its balance point. If the graduated cylinder was used, the action took place as the two-liter mark was reached. The weight and volume of the mixture and the time were recorded, the specific weight of the mixture was calculated, and the concentration was found from a plot of specific weight vs. concentration (see Fig. 1).

6. After the data had been recorded, the measuring tank was emptied by pulling the plug in the bottom of the tank and allowing the ejector nozzle to force the mixture back into the supply tank.

7. The pump was then stopped and a different nozzle inserted into the system for a test run at a different velocity.

IV. ANALYSIS

A. Types of Flow

Observation of the horizontal flow of the materials tested indicated that the types of flow are the same as those described in a previous report.⁵

⁵ Ibid.

The three regions are characterized by the particular solids-distribution across the vertical diameter. The high-velocity region has a uniform solids-distribution, the transition region has a non-uniform distribution but no stationary layer of solids, and the low-velocity region has a stationary layer of particles in the bottom of the pipe.

Three distinct regions of flow may also be distinguished in vertical upward flow. The high-velocity region is again characterized by a uniform distribution of solids, but as the velocity is decreased, the flow enters a velocity region in which the particles concentrate in a "core" in the center of the tube leaving a boundary layer of clear fluid between the center core and the inner wall of the tube. As the velocity is decreased further, the solids again appear to be approximately uniform in distribution throughout the tube.

In downward flow the tendency for coring is reversed. That is, in a certain velocity range the solids move toward the outside of the tube, leaving a fluid core. However, it is more difficult to make observations under this condition.

The types of coring described in the foregoing paragraph occur when the density of the solid is greater than the density of the fluid. When the density of the solid is less than the density of the fluid, the coring is reversed. That is, the solids concentrate in a central core with downward flow and in a peripheral annulus when the flow is upward.

B. Analysis of the Friction Loss

The initial steps used in this analysis of the problem are identical to those used in the first study discussed in the previous report. For an initial experimental study it is desirable to reduce to a minimum the number of variables that must be investigated. This reduction of the number of variables may be done with dimensional analysis.

The phenomenon is assumed to involve the following variables:

<u>Symbol</u>	<u>Dimensions</u>	<u>Variable</u>
ΔP	$M L^{-1} T^{-2}$	Pressure drop
L	L	Length of tube
D	L	Inside diameter of tube
d	L	Diameter of particles
r	-	Roughness of tube
ρ_f	$M L^{-3}$	Density of fluid
ρ_s	$M L^{-3}$	Density of solid
μ	$M L^{-1} T^{-1}$	Viscosity of fluid
e_s	-	Concentration of solids
v_m	$L T^{-1}$	Velocity of mixture
g	$L T^{-2}$	Acceleration of gravity
α	-	Distribution factor

These twelve variables may be combined into nine independent, dimensionless groups to form the characteristic equation for the phenomenon.

One form of the equation is

$$\frac{\Delta P}{\rho_f \nu_m^2} = \phi \left[\frac{L}{D}, r, \frac{\rho_f \nu_m D}{\mu}, \frac{\rho_s}{\rho_f}, e_s, \frac{d}{D}, \frac{\nu_m^2}{Dg}, \alpha \right] \quad (1)$$

If the fluid carries no solid particles, the last five terms in Eq. (1) are not involved, and the equation reduces to

$$\frac{\Delta P}{\rho_f \nu_f^2} = \phi_1 \left[\frac{L}{D}, r, \frac{\rho_f \nu_f D}{\mu} \right] \quad (2)$$

It is known that the variable, L/D , is separable when it has a value greater than approximately 20, so that

$$\frac{\Delta P}{\rho_f \nu_f^2} = \frac{L}{D} \phi_2 \left[r, \frac{\rho_f \nu_f D}{\mu} \right] \quad (3)$$

The function ϕ_2 is usually replaced by a coefficient, $f/2$, making it possible to rewrite Eq. (3) as

$$\frac{\Delta P}{\rho_f \nu_f^2} = \frac{f}{2} \frac{L}{D} \quad (4)$$

or

$$\Delta P = f \frac{L}{D} \frac{\rho_f \nu_f^2}{2} \quad (5)$$

Equation (5) may also be written in terms of the head loss, H_f .

Thus,

$$H_f = f \frac{L}{D} \frac{\nu_f^2}{2g} \quad (6)$$

which is the familiar Darcy Equation for head loss in a pipe. Charts have been developed for evaluating f for known values of the Reynolds number,

$\frac{\rho_f \nu_f D}{\mu}$, and the pipe roughness, r .

In extending the results to the flow of slurries it was assumed in this investigation that the quantity L/D in Eq. (1) was still separable, so that

$$\frac{\Delta P}{\rho_f v_m^2} = \frac{L}{D} \phi_3 \left[r, \frac{\rho_f v_m D}{\mu}, \frac{\rho_s}{\rho_f}, e_s, \frac{d}{D}, \frac{v_m^2}{Dg}, \alpha \right] \quad (7)$$

It appeared reasonable to assume that ϕ_3 , in Eq. (7), could be resolved into two component terms--one being the friction factor of the fluid alone (f) and the other being the ratio of the pressure loss for the pure fluid to the pressure loss of the mixture if both are flowing at the same mean velocity (Z). If this assumption is made, Eq. (7) becomes

$$\frac{\Delta P}{\rho_f v_m^2} = \frac{L}{D} \frac{f}{Z} \frac{1}{Z} \quad (8)$$

or

$$H_f = \frac{v_m^2}{2g} \frac{L}{D} \frac{f}{Z} \quad (9)$$

where

$$Z = \frac{\Delta P_f}{\Delta P_m} \quad (10)$$

and where H_f is the head loss of the mixture in an equivalent column of pure fluid.

From a comparison of Eqs.(7) and (8), it appears reasonable to assume that Z is a function of those variables in ϕ_3 , that are not included in f . Then

$$Z = \phi_4 \left[\frac{\rho_s}{\rho_f}, e_s, \frac{d}{D}, \frac{v_m^2}{Dg}, \alpha \right] \quad (11)$$

Experimental tests are now being conducted to determine the function, ϕ_4 . The scope of the tests conducted is indicated in Table II.

The calculation of the Z-factor is made in the following way. The pressure drop of the mixture is measured experimentally, and the mean velocity of the mixture is found from the measured discharge of the mixture. The pressure drop of the pure fluid is calculated using the mean velocity of the mixture and a value of the friction factor (f) found from the calibration curve. The Reynold's number is calculated using the mean mixture velocity and the properties of the pure fluid at the measured temperature. The Z-factor is the ratio of the pressure drop of the pure fluid to the pressure drop of the mixture flowing at the same mean velocity.

Table II.

Scope of the Test Program

18

Direction	Material	Particle Diameter (in.)	Tube Diameter (up/down) (in.)	Tube Length (in.)	Concentration Range (percent by weight)	Velocity Range (fps)
Horizontal	Glass	0.0026	0.314	46	5 - 50	0.5-16.5
	Glass	0.0013	0.315	46	5 - 30	0.6-23.8
	Resin	0.0044	0.315	46	8 - 35	0.4-19.6
Vertical	Glass	0.0028	0.314/0.322	36	5 - 50	0.4-15.0
	Glass	0.0013	0.314/0.322	36	5 - 40	0.6-16.0
	Resin	0.0044	0.314/0.322	36	4 - 46	0.6-13.5

V. DISCUSSION

The experimental data obtained in the tests are tabulated in Appendix B. The variation of the pressure drop with Froude number for different concentrations of solid material is shown in two types of figures. The first is a plot of the friction loss of the slurry vs. the Froude number, based on the mean velocity of the mixture and the inside diameter of the test section. The second type is a plot of the ratio of the pressure drop of the pure fluid to the pressure drop of the mixture flowing at the same mean velocity (Z-factor) vs. the Froude number.

The actual reduced data for a representative concentration are shown for each type of material and for each direction of flow. The results for all concentrations are shown in the form of average curves for each material and each direction of flow. These figures are given in Appendix A and will be discussed in this section.

Figures 7, 8, and 9 are curves of head loss in feet of mixture vs. Froude number, for the three materials tested in horizontal flow and for the concentration ranges investigated. A study of the data showed that the upper-transition velocity (the velocity at which the head loss curve, on logarithmic paper, departs from the straight line portion) is dependent upon the particle size and solid concentration. For the materials and size ranges tested, there was no indication of critical size, and as a result the following expression was developed for the

upper transition velocity:

$$\frac{v_{UT}^2}{Dg} = 3.23 + 195 \left(\frac{d}{D} \right) - 31,400 \left(\frac{d}{D} \right)^2 - \left[18.5 - 5060 \left(\frac{d}{D} \right) + 143,000 \left(\frac{d}{D} \right)^2 \right] e_s.$$

Plots of Froude number (based on the lower transition velocity) vs. e_s for the materials tested indicate that the expression for the lower-transition velocity would have the same general form as that for the upper-transition velocity except that the ratio ρ_s / ρ_f might appear in the function.

At velocities greater than the upper-transition velocity, the head loss vs. Froude number curves generally all lie parallel to, and above, the same curve for water. The distance between the curve for the slurry and that for water increases with an increase in concentration, indicating that for a given Froude number an increase in concentration will cause an increase in head loss.

The curve for $e_s = 35$ percent in Fig. 9 illustrates a condition which does not agree with the pattern just discussed. For values of Froude number greater than approximately 30, a straight line portion exists but has a steeper slope than the same curve for water. For Froude numbers between nine and thirty, the curve dips below the curve for water, and for values of Froude number less than ten, the curve is approximately straight with a slope slightly less than that for the curve for water in laminar flow.

If laminar and turbulent regions of flow are defined on the basis of the characteristic slope of the respective head loss curves, then the

$e_s = 35$ percent curve for the 0.0044-in. resin in horizontal flow can be considered to exhibit evidences of laminar and turbulent flow. For Froude numbers up to approximately ten this curve indicates laminar flow of the slurry, and for Froude numbers greater than thirty turbulent flow can be considered to exist. The region between Froude numbers of ten and thirty represents the transition from one type of flow to the other.

Figures 10 through 18 include the curves of head loss vs. Froude number for upward and downward vertical flow of the materials for the concentrations investigated. In all of these curves, it is to be noted that the same general behavior results as that described for the $e_s = 35$ percent curve for the 0.0044-in. resin in horizontal flow. For all three materials in the turbulent region (where the head loss vs. Froude number curve is parallel to the same curve for water in turbulent flow) the head loss increases slightly with an increase in concentration. At high concentrations (e. g., $e_s = 35$ percent or greater) the slope of the slurry head loss curve in the turbulent region has a tendency to become slightly greater than that for the same curve for water in turbulent flow.

In the laminar region, the head loss curves for the 0.0044-in. resin and the 0.0028-in. glass in downward flow lie above the same curves for upward flow, and the slopes of these curves are generally slightly less steep than the upward flow curves.

The data for the laminar flow of the 0.0013-in. glass indicate that the head loss curve for upward flow lies above that for downward flow, which is the reverse of the condition noted in the 0.0044-in. resin and the 0.0028-in. glass.

It was also noted that the velocity at which transition from laminar to turbulent flow takes place is dependent upon the concentration. The transition velocity increases with increasing concentration. The facts that the laminar region for the slurry extends to much higher Froude numbers than for the pure water and that the transition velocity increases with concentration, suggest that the presence of the particles in the fluid exerts a calming or dampening effect on the turbulence, tending to maintain laminar flow at higher than ordinary velocities.

Representative plots of actual reduced data for the upward and downward flow of the materials investigated are shown in Figs. 16, 17 and 18.

Figures 22 through 27 are plots of calculated Z-factors vs. Froude number for representative concentrations for the materials tested and the different directions of flow. Figures 28 through 36 are average curves for each material at the various concentrations tested.

It was noted that the Z-factors were constant for a certain range of Froude numbers, depending upon the material used and the direction of flow. This was considered to be the region of turbulent flow, or the region in which the particles were uniformly distributed throughout the tube. As the Froude number decreases, the slurry flow enters the

transition region, or the region in which the particles are not uniformly distributed throughout the tube. This region is the curved portion of the Z-factor curves. A further decrease in Froude number results in a corresponding decrease in the Z-factor. This region is the straight-line portion of the Z-factor curves at low Froude numbers. It appears that in this range the slurry has the characteristics of laminar flow. This straight-line portion is also noticed on the head loss vs. Froude number curves, particularly those representing vertical flow of the 0.0044-in. resin particle slurries which were discussed earlier.

It was also noted that the Z-factors in the transition region (curved portion of the curves) sometimes have a value greater than one, which means that the pressure loss due to friction of the slurry is less than that of water flowing at the same velocity. Again, this is particularly noticeable in the data for the resin slurries in vertical flow.

In the turbulent region the Z-factors decrease with increasing concentration. The values of the Z-factor for turbulent flow were found for each direction of flow and were plotted against the concentration. The resulting curves are shown in Figs. 4, 5 and 6.

The following relationships were found from these curves.

	0.0013-in. glass	0.0028-in. glass (all data)
Horizontal	$Z = 0.972 - 0.0078 e_s$	
Upward	$Z = 0.850 - 0.0063 e_s$	$Z = 1.08 e_s^{-0.125}$
Downward	$Z = 0.927 - 0.00715 e_s$	

where e_s = concentration in percent by weight.

The following conclusions are drawn from the study of the head loss curves and observations of the flow.

Horizontal Flow

(1) There are three distinct regions of flow: (a) a high velocity region characterized by an approximately uniform distribution of solids throughout the tube; (b) a transition region characterized by a non-uniform distribution of solids but with no stationary layer of particles; and (c) a low velocity region characterized by a stationary layer of particles in the bottom of the tube.

(2) The upper transition velocity, or velocity at which the head loss curve departs from the straight-line portion on a logarithmic plot, is a function of concentration and particle size and can be expressed by the relationship

$$\frac{v_{UT}^2}{gD} = 3.23 + 195\left(\frac{d}{D}\right) - 31,400\left(\frac{d}{D}\right)^2 - \left[18.5 - 5060\left(\frac{d}{D}\right) + 143,000\left(\frac{d}{D}\right)^2\right]e_s,$$

which holds for the three materials tested.

(3) In the turbulent region for a given Froude number, the head loss increases slightly with increasing concentration.

Vertical Flow

(1) The three materials tested exhibit regions of laminar and turbulent flow which are characterized by the slope of the head loss vs. Froude number curve.

(2) The velocity at which transition from laminar to turbulent flow begins to occur increases with increasing concentration for a given material.

(3) The head loss curves for laminar flow for the 0.0044-in. and the 0.0028-in. glass in a downward direction, lie above the same curves for upward flow, indicating a higher head loss in this region for downward flow than for upward flow.

The following general statements may be made from a study of the Z-factor curves in the turbulent region.

In horizontal flow, the greatest pressure drop occurs with the 0.0028-in. glass, while the pressure drop is about the same for the other two materials.

In upward flow, the greatest loss occurs with the 0.0013-in. glass, while the least pressure drop occurs with the resin particles.

In downward flow, the tendency is the same as that for horizontal flow.

In regard to the specific materials in turbulent flow for a particular concentration and velocity, the following statements may be made.

For the 0.0013-in. glass, the pressure drop for horizontal flow is less than that for vertical flow in either direction. The pressure drop for downward flow is less than that for upward flow.

For the 0.0028-in. glass, the pressure drop is about the same in all directions.

For the 0.0044-in. resin, the greatest pressure drop occurs in downward flow, while the least pressure drop occurs in horizontal flow.

VI. APPENDIX

A. Graphic Data (Figures 1-36)

Fig. 1—Relationship between concentration and specific weight for materials used in the investigation.

Fig. 2—Schematic diagram of flow equipment.

Fig. 3—Calibration curve for experimental equipment.

Fig. 4—Relationship between Z-factor in turbulent flow and concentration for 0.0028-in. dia. glass particles.

Fig. 5—Relationship between Z-factor in turbulent flow and concentration for 0.0013-in. dia. glass particles.

Fig. 6—Relationship between Z-factor in turbulent flow and concentration for 0.0044-in. dia. resin particles.

Fig. 7—Average head loss curves for 0.0026-in. dia. glass in horizontal flow.

Fig. 8—Average head loss for 0.0013-in. dia. glass in horizontal flow.

Fig. 9—Average head loss curves for 0.0044-in. dia. resin in horizontal flow.

Fig. 10— Plct of actual head loss data for horizontal flow of 0.0026-in. dia. glass (30 percent).

Fig. 11—Plot of actual head loss data for horizontal flow of 0.0013-in. dia. glass (20 percent).

Fig. 12—Plot of actual head loss data for horizontal flow of 0.0044-in. dia. resin (35 percent).

Fig. 13—Average head loss curves for 0.0028-in. dia. glass in upward flow.

Fig. 14—Average head loss curves for 0.0013-in. dia. glass in upward flow.

Fig. 15—Average head loss curves for 0.004-in. dia. resin in upward flow.

Fig. 16—Average head loss curves for 0.0028-in. dia. glass in downward flow.

Fig. 17—Average head loss curves for 0.0013-in. dia. glass in downward flow.

Fig. 18—Average head loss curves for 0.0044-in. dia. resin
in downward flow.

Fig. 19—Plot of actual head loss data for vertical flow of 0.0028-in. dia. glass (30 percent).

Fig. 20—Plot of actual head loss data for vertical flow of 0.0013-in. dia. glass (5 percent).

Fig. 21—Plot of actual head loss data for vertical flow of 0.0044-in. dia. resin (35 percent).

Fig. 22—Plot of Z-factors for horizontal flow of 0.0026-in. dia. glass (30 percent).

Fig. 23—Plot of Z-factors for horizontal flow of 0.0013-in. dia. glass (20 percent).

Fig. 24—Plot of Z-factors for horizontal flow of 0.0044-in. dia. resin (35 percent).

Fig. 25—Plot of Z-factors for vertical flow of 0.0028-in. dia. glass (25 percent).

Fig. 26—Plot of Z-factors for vertical flow of 0.0013-in. dia. glass (30 percent).

Fig. 27—Plot of Z-factors for vertical flow of 0.0044-in. dia. resin (23.5 percent).

Fig. 28—Average Z-factor curves for horizontal flow of 0.0026-in. dia. glass (All concentrations).

Fig. 29—Average Z-factor curves for horizontal flow of 0.0013-in. dia. glass (All concentrations).

Fig. 30—Average Z-factor curves for horizontal flow of 0.0044-in. dia. resin (All concentrations).

Fig. 31—Average Z-factor curves for upward flow of 0.0028-in. dia. glass (All concentrations).

Fig. 32—Average Z-factor curves for upward flow of 0.0013-in. dia. glass (All concentrations).

Fig. 33—Average Z-factor curves for upward flow of 0.0044-in. dia. resin (All concentrations).

Fig. 34—Average Z-factor curves for downward flow of 0.0028-in. dia. glass (All concentrations).

Fig. 35—Average Z-factor curves for downward flow of 0.0013-in. dia. glass (All concentrations).

Fig. 36—Average Z-factor curves for downward flow of 0.0044-in. dia. resin (All concentrations).

B. Tabulated Data

	Page
Table I. Properties of Materials Tested.....	9
Table II. Scope of the Test Program.....	18
Table III. 0.0026-in. dia. glass-horizontal flow.....	64
Table IV. 0.0013-in. dia. glass-horizontal flow.....	70
Table V. 0.0044-in. dia. resin-horizontal flow.....	72
Table VI. 0.0028-in. dia. glass-vertical flow.....	75
Table VII. 0.0013-in. dia. glass-vertical flow.....	86
Table VIII. 0.0044-in. dia. resin-vertical flow.....	90

Table III.

0.0026-in. Dia. glass; horizontal flow

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
1	18	6.8	16.55	4.04	326	.877
2	19	6.0	15.77	3.76	296	.864
3	19	6.3	14.22	3.15	240	.859
4	22	6.8	13.18	2.65	206	.870
5	19	5.5	12.44	2.48	184	.866
6	19	5.4	11.75	2.24	164	.865
7	19	5.6	11.04	2.05	145	.843
8	19	5.6	10.32	1.79	126.8	.857
9	19	5.6	9.83	1.645	115	.862
10	19	5.6	9.30	1.50	103	.857
11	19	6.3	8.73	1.34	90.5	.858
12	20	6.0	8.26	1.21	81.3	.861
13	19	6.5	7.88	1.12	73.8	.854
14	18.5	5.1	7.36	0.993	64.4	.868
15	19	5.1	6.82	0.864	55.3	.868
16	19	5.1	6.08	0.711	44.0	.870
17	19	4.8	5.50	0.587	36.0	.880
18	19	4.8	4.53	0.419	24.4	.884
19	19	5.5	3.94	0.329	18.5	.876
20	19	4.8	3.58	0.281	15.24	.878
21	19	6.0	3.22	0.231	12.4	.894
22	18.5	6.3	2.82	0.183	9.45	.897
23	20	4.7	2.55	0.155	7.70	.888
24	20	5.7	1.83	.0878	3.98	.085
25	18.5	4.0	1.545	.0691	2.84	.861
26	20	5.5	1.41	.0710	2.37	.706
27	19.5	5.2	1.31	.0675	2.04	.655
28	19.5	4.7	1.27	.0668	1.905	.626
29	19	4.9	1.15	.0650	1.57	.545
30	19	5.5	1.09	.0649	1.415	.500
31	19.5	4.0	1.031	.0654	1.27	.455
32	19.5	5.2	0.996	.0662	1.18	.419
33	19.5	4.0	0.960	.0667	1.09	.393
34	19.5	4.7	0.883	.0775	0.928	.292
35	19.5	5.6	0.849	.0770	0.855	.272
36	20	4.7	0.792	.0835	0.745	.225
37	20	4.4	0.772	.0850	0.707	.211
38	20	4.0	0.715	.0777	0.607	.202
39	18.5	11.2	15.45	3.69	284	.824
40	18.5	12.0	14.44	3.28	248	.823
41	18.5	11.2	13.81	3.00	227	.829
42	18.5	11.2	13.06	2.75	203	.817

Table III. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
43	18.5	11.2	12.29	2.47	180	.820
44	18	11.2	11.04	2.09	145	.809
45	16	11.8	10.38	1.855	128	.825
46	17	12.2	9.17	1.49	100	.831
47	18	11.3	8.65	1.34	89.2	.824
48	18	11.7	8.21	1.22	80.1	.827
49	18	11.7	7.44	1.023	65.8	.826
50	18	11.2	6.6	0.842	43.6	.822
51	20	10.4	5.8	0.670	40.0	.814
52	18	10.0	3.89	0.327	15.2	.848
53	18	9.7	3.25	0.240	10.55	.845
54	19	10.0	2.50	0.150	7.47	.865
55	19	10.0	1.89	0.0948	4.24	.845
56	19	9.0	1.80	0.0825	3.85	.888
57	20	10.8	1.425	0.0732	2.41	.670
58	20	9.3	1.267	0.0703	1.905	.573
59	19	9.8	1.211	0.0724	1.75	.523
60	20	8.7	1.18	0.0767	1.653	.470
61	19	9.8	1.142	0.0736	1.54	.459
62	20	9.2	1.115	0.0776	1.48	.421
63	18.5	10.8	1.04	0.0765	1.285	.378
64	19.0	9.8	0.975	0.0771	1.130	.337
65	19.5	10.8	0.931	0.0789	1.03	.300
66	19	9.8	0.855	0.0807	0.869	.257
67	19.5	10.0	0.840	0.0855	0.837	.234
68	20	10.0	0.822	0.0853	0.804	.226
69	21	11.2	0.794	0.0987	0.751	.183
70	20.5	9.2	0.825	.0894	0.681	.218
71	19	15.0	15.4	3.74	282	.783
72	19	14.5	14.8	3.46	260	.791
73	19	14.0	14.1	3.18	236	.790
74	18	16.3	13.2	2.78	207	.792
75	19	15.0	12.04	2.41	172.4	.788
76	18.5	17.0	11.2	2.09	148.6	.783
77	19	16.8	10.31	1.80	126.4	.788
78	18.5	17.0	9.83	1.65	115.0	.793
79	18.5	16.8	9.01	1.39	96.5	.810
80	19.5	16.1	8.10	1.15	78.0	.813
81	19	16.5	7.42	1.00	65.5	.801
82	18.5	17.7	6.50	0.814	50.3	.782
83	18.5	17.7	5.82	0.677	40.2	.771
84	18.5	15.8	3.86	0.330	17.7	.792

Table III. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
85	18.5	16.2	3.14	0.230	11.75	.793
86	18.5	15.5	2.44	0.149	7.08	.815
87	18.5	16.0	1.73	0.0827	3.55	.799
88	19.5	14.0	1.58	0.0806	2.96	.705
89	19.5	16.0	1.42	0.0861	2.40	.545
90	17.5	15.1	1.39	0.0798	2.29	.577
91	19.5	15.2	1.38	0.0866	2.26	.520
92	19.5	15.0	1.23	0.0788	1.80	.470
93	19.0	14.8	1.145	0.0825	1.56	.400
94	19.5	15.0	1.09	0.0810	1.41	.371
95	20	14.2	1.01	0.0872	1.21	.304
96	19.5	14.2	0.956	0.0875	1.09	.277
97	20	14.0	0.902	0.0910	0.968	.241
98	20	14.2	0.794	0.111	0.749	.159
99	19	13.2	0.770	0.1158	0.705	.147
100	19	17.0	0.689	0.119	0.562	.087
101	19.5	15.8	0.556	0.133	0.365	.0603
102	19.5	16.0	0.530	0.138	0.335	.0553
103	18	21.3	15.13	3.62	272	.751
104	18	21.0	14.23	3.25	241	.755
105	19	21.0	13.16	2.85	206	.743
106	20	21.0	12.60	2.64	189	.741
107	18	21.8	11.75	2.39	164	.725
108	19	21.0	11.49	2.24	157	.744
109	19	20.8	10.93	2.08	142	.734
110	19	20.8	10.50	1.94	131	.736
111	19	20.8	10.71	1.98	136	.746
112	19	20.0	9.70	1.69	112	.744
113	18	21.6	9.34	1.59	104	.728
114	19	21.6	8.03	1.20	76.7	.742
115	19	20.9	7.47	1.06	66.3	.740
116	19	20.7	6.72	0.874	53.6	.748
117	19	20.4	6.51	0.851	50.4	.729
118	19	20.1	5.85	0.708	40.7	.730
119	19	19.7	3.87	0.329	17.8	.769
120	20	19.2	3.16	0.232	11.9	.772
121	19	22.1	2.45	0.152	7.13	.760
122	20	22.0	1.91	0.0998	4.34	.755
123	19	19.2	1.70	0.0842	3.45	.746
124	20	18.0	1.58	0.0783	2.97	.708
125	20	19.2	1.34	0.0708	2.14	.587
126	19.5	20.8	1.29	0.0806	1.975	.482
127	20	20.5	1.275	0.0895	1.93	.425
128	19.5	19.0	1.26	0.0885	1.89	.478
129	20	20.8	1.18	0.0895	1.655	.372

Table III. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
130	19.5	18.4	1.085	0.1000	1.40	.295
131	20.5	22.5	1.007	0.1125	1.204	.222
132	19.5	19.7	0.784	0.117	0.730	.143
133	20	19.7	0.623	0.123	0.500	.102
134	18	24.3	14.9	3.54	264	.731
135	18	24.5	14.0	3.19	232	.722
136	20	23.5	12.8	2.71	194.5	.727
137	19	24.0	11.62	2.27	160.5	.734
138	20	24.2	11.0	2.05	144	.728
139	19	24.1	10.3	1.89	126	.711
140	21	23.6	9.48	1.59	107	.730
141	19	23.1	8.02	1.20	76.5	.729
142	19	25.3	6.95	0.930	57.4	.716
143	19.5	25.0	5.81	0.665	40.1	.739
144	22	23.5	5.28	0.572	33.1	.718
145	19.5	23.5	3.95	0.350	18.55	.729
146	19.5	25.0	3.09	0.228	11.38	.728
147	26	23.5	2.51	0.137	7.48	.815
148	19	25.0	1.94	0.106	4.47	.717
149	20	22.3	1.65	0.0877	3.23	.655
150	19	25.5	1.515	0.0887	2.73	.553
151	19	26.0	1.41	0.101	2.36	.434
152	19.5	25.0	1.292	0.0955	1.98	.400
153	19.5	24.0	1.265	0.1025	1.90	.359
154	20	25.2	1.135	0.112	1.535	.270
155	19.5	25.5	0.985	0.123	1.150	.193
156	19.5	25.5	0.945	0.1315	1.06	.168
157	19.5	25.5	0.880	0.1335	0.92	.146
158	20	25.5	0.740	0.1443	0.65	.101
159	20	32.2	15.8	3.59	296	.738
160	20	30.2	15.2	3.44	273	.727
161	20	30.2	14.2	3.00	239	.742
162	20	30.5	12.75	2.54	193	.725
163	21	30.8	9.6	1.56	110	.712
164	21	30.0	9.1	1.395	98.5	.733
165	21	31.0	7.6	1.055	68.6	.700
166	21.5	28.0	5.77	0.665	39.6	.702
167	22	28.3	5.41	0.598	34.8	.695
168	18	31.5	3.75	0.328	16.75	.690
169	19	31.7	3.38	0.267	13.6	.702
170	19	31.2	2.47	0.152	7.23	.706
171	19	31.2	2.15	0.130	5.47	.666
172	19	31.5	1.95	0.1085	4.52	.676
173	19.5	30.5	1.49	0.098	2.65	.476

Table III. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
174	19	30.5	1.405	0.1095	2.35	.387
175	19	30.5	1.30	0.1155	2.01	.321
176	19	29.8	1.14	0.130	1.545	.229
177	19	29.8	0.955	0.140	1.082	.157
178	19	29.3	0.882	0.155	0.925	.124
179	18.5	29.8	0.823	0.161	0.807	.1072
180	21	31.0	0.387	0.199	0.179	.0229
181	20.5	31.0	0.423	0.199	0.212	.0268
182	20	34.8	15.85	3.58	298	.735
183	21	36.0	14.5	3.04	250	.727
184	22	35.5	12.85	2.53	196	.706
185	21.5	37.0	11.15	1.96	148	.705
186	21	34.3	9.13	1.405	96.6	.688
187	21	33.0	7.28	0.956	63.0	.708
188	22	35.0	5.3	0.568	33.4	.670
189	18	35.6	3.73	0.323	16.5	.670
190	26	34.0	3.33	0.244	13.3	.693
191	19	35.6	2.60	0.169	8.04	.690
192	19	35.1	2.46	0.156	7.19	.677
193	19.5	35.1	2.07	0.118	5.09	.670
194	19	34.3	1.835	0.1056	3.98	.584
195	19.5	34.8	1.765	0.109	3.71	.553
196	19.5	34.3	1.590	0.1147	2.99	.414
197	20	34.8	1.475	0.113	2.58	.390
198	19.5	33.6	1.408	0.1123	2.34	.346
199	19.5	34.8	1.330	0.120	2.105	.310
200	19.5	33.5	1.22	0.137	1.77	.238
201	20	33.5	1.09	0.133	1.405	.184
202	20	32.9	1.005	0.131	1.195	.160
203	19.5	34.8	0.941	0.155	1.05	.132
204	20	32.5	0.910	0.1545	0.98	.111
205	20	32.0	0.749	0.1600	0.664	.069
206	21	41.3	15.7	3.48	294	.705
207	20	40.6	14.6	3.11	252	.695
208	20.5	37.5	13.35	2.79	212	.680
209	22	38.0	12.9	2.50	196	.701
210	22	41.8	12.05	2.31	173	.655
211	21	38.5	12.00	2.18	171	.717
212	22.5	40.0	10.6	1.805	133	.674
213	23	40.0	9.15	1.422	99.5	.667
214	21.3	40.6	6.42	0.795	48.8	.642
215	23	38.2	5.85	0.652	40.6	.669
216	24	37.5	5.60	0.588	37.2	.687
217	24.5	38.0	5.18	0.522	31.9	.680

Table III. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
218	24	46.5	15.00	3.33	267	.643
219	19	44.2	14.65	3.18	255	.670
220	24	46.1	12.0	2.34	171	.613
221	24	46.0	11.45	2.12	156	.624
222	21.5	43.5	11.31	2.08	152	.647
223	24	45.6	8.9	1.38	94.2	.616
224	25	46.5	5.52	0.558	36.1	.656
225	27	46.2	5.17	0.445	31.8	.674
226	19	47.0	2.23	0.152	5.86	.515
227	19	47.2	1.735	0.150	3.56	.338
228	19	47.4	1.557	0.157	2.86	.266
229	19	46.8	1.400	0.148	2.32	.235
230	19	46.8	1.372	0.154	2.23	.227
231	19	45.3	1.193	0.153	1.68	.171
232	19.5	45.3	1.16	0.154	1.58	.161
233	19.5	45.3	0.985	0.167	1.15	.108
234	19.5	45.5	0.900	0.163	0.958	.093
235	19.5	45.5	0.824	0.167	0.803	.074
236	20	44.4	0.644	0.174	0.490	.043
237	21	46.6	0.490	0.2035	0.284	.027
238	22	45.3	0.452	0.220	0.241	.0216
239	19.0	51.2	2.27	.170	6.09	.460
240	19.5	51.2	2.13	.174	5.34	.399
241	19.5	51.2	1.71	.1625	3.45	.293
242	19.5	50.7	1.535	.1635	2.79	.236
243	19.5	50.3	1.38	.164	2.25	.202
244	19.5	49.6	1.36	.171	2.19	.189
245	20.0	49.6	1.192	.1645	1.681	.155
246	20.0	49.6	1.122	.1755	1.49	.130
247	20.0	49.6	0.952	.178	1.072	.0935
248	20.0	49.0	0.880	.171	0.916	.0825
249	20.0	49.0	0.825	.1745	0.806	.0697
250	20.5	47.6	0.629	.1835	0.468	.0384

Table IV.

0.0013-in. Dia. glass; horizontal flow

Reference No.	Temp. (°C)	Concentration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
1	16.0	5.0	23.6	7.36	660	.911
2	17.0	5.0	21.95	6.25	570	.936
3	17.5	5.0	18.18	4.51	390	.930
4	18.0	5.0	15.45	3.44	283	.912
5	18	5.0	8.59	1.20	87.1	.940
6	18	5.0	7.26	0.91	62.3	.940
7	17.5	5.0	6.13	0.646	44.5	.912
8	17.5	5.0	4.12	.335	20.1	.936
9	18	5.0	3.82	.294	17.2	.928
10	18	5.0	2.55	.142	7.67	.947
11	18	5.0	2.48	.138	7.24	.926
12	18	4.8	2.13	.1032	5.35	.950
13	18	4.8	1.76	.0752	3.64	.930
14	18	4.5	1.46	.0579	2.54	.888
15	18.5	4.8	1.17	.0554	1.61	.615
16	18.5	5.0	1.11	.0503	1.47	.617
17	18.5	3.8	0.821	.0481	0.799	.340
18	17.5	9.4	23.8	7.39	668	.888
19	18.0	10.7	21.0	6.25	519	.833
20	18	10.7	18.4	4.63	401	.897
21	18	9.2	15.4	3.50	280	.874
22	18	10.4	8.58	1.24	87.0	1.028
23	18	10.0	7.19	0.909	61.2	.884
24	10.5	9.4	6.03	.655	43.1	.900
25	17.0	10.0	4.04	.349	19.35	.847
26	17.5	10.0	3.82	.300	17.3	.888
27	18.0	9.7	2.50	.1437	7.35	.875
28	18.0	9.7	2.43	.1375	7.00	.877
29	18.0	10.0	2.12	.1043	5.29	.903
30	18.0	9.4	1.76	.0755	3.66	.905
31	18	9.2	1.44	.0564	2.43	.850
32	18.5	9.4	1.155	.0478	1.58	.681
33	18.5	10.4	1.105	.0571	1.445	.520
34	19.0	9.2	0.816	.0636	0.778	.246
35	18.0	20.1	23.4	7.41	649	.803
36	18.5	20.0	20.6	5.84	503	.815
37	18.5	19.3	15.3	3.53	277	.802
38	18.5	20.0	8.52	1.24	85.7	.818
39	19.0	20.0	7.19	0.925	61.0	.809
40	19	19.5	6.02	.687	42.9	.802
41	19	19.3	4.16	.355	20.5	.813
42	18	19.3	3.80	.299	17.1	.830
43	18.5	19.5	2.57	.152	7.77	.810
44	19	20.0	2.47	.139	7.20	.830

Table IV. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
45	19.4	20.1	2.10	.106	5.19	.815
46	19	20.0	1.74	.078	3.60	.805
47	19	19.7	1.46	.0572	2.52	.806
48	19	20.0	1.174	.0595	1.63	.525
49	19	19.7	1.108	.0585	1.453	.480
50	19.5	19.3	0.842	.0665	0.840	.240
51	19.5	17.7	0.623	.0810	0.459	.110
52	17.5	30.1	23.5	7.49	650	.745
53	18.0	30.1	21.3	6.35	536	.743
54	18.5	29.9	18.7	5.04	413	.743
55	19.0	29.9	8.56	1.292	86.8	.740
56	19	30.3	7.15	0.953	60.5	.728
57	19	30.3	5.97	0.695	42.1	.725
58	19	30.1	4.06	.340	19.5	.755
59	18.5	29.5	2.56	.154	7.71	.746
60	18.5	27.9	2.15	.120	5.45	.718
61	19	29.2	2.45	.1427	7.08	.750
62	19	27.6	1.323	.050	2.07	.737
63	19	30.1	2.10	.1052	5.21	.768
64	19	27.9	0.912	.0677	0.985	.265

Table V.

0.0044-in. Dia. resin; horizontal flow

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
1	17.5	4.0	19.6	5.20	454	.939
2	17.5	5.2	19.35	5.23	443	.891
3	17.5	5.2	18.90	4.98	422	.916
4	18.0	5.8	18.0	4.56	383	.920
5	18	5.2	16.85	4.08	336	.915
6	18	4.0	15.7	3.59	291	.920
7	18.5	4.6	14.38	3.07	244	.920
8	18.5	4.6	13.18	2.66	205	.910
9	18.5	5.2	11.75	2.20	163	.898
10	18.5	5.8	8.30	1.20	81.7	.896
11	17.5	5.8	8.45	1.213	84.5	.922
12	18.0	7.0	7.54	0.997	67.2	.920
13	18	8.2	7.25	0.926	62.1	.912
14	18	8.2	6.13	.680	44.5	.928
15	18	8.2	4.10	.349	19.9	.893
16	18.5	8.2	3.73	.300	16.5	.875
17	19	9.4	2.64	.1625	8.25	.882
18	18.5	8.2	2.54	.1550	7.64	.868
19	18.5	8.8	2.43	.138	7.00	.900
20	18.5	8.8	2.04	.104	4.90	.875
21	18.5	9.4	1.85	.0913	4.06	.847
22	18.5	9.4	1.70	.0775	3.42	.858
23	19.0	8.2	1.44	.0576	2.45	.860
24	19	8.2	1.38	.0564	2.25	.815
25	18.5	9.4	1.26	.0413	1.70	.862
26	18.5	8.2	1.07	.0376	1.355	.772
27	19.0	8.8	0.782	.0325	0.723	.447
28	19	8.2	0.600	.0338	0.427	.281
29	19	9.4	0.549	.0362	0.357	.240
30	19	8.2	0.542	.0351	0.348	.242
31	19	8.2	0.442	.0376	0.2305	.185
32	18.5	12.9	19.0	5.21	427	.865
33	18.5	14.0	18.4	4.95	402	.861
34	18.5	15.1	17.55	4.56	364	.852
35	19.0	14.0	16.5	4.07	322	.863
36	19	12.9	15.2	3.58	272	.845
37	19	12.3	14.05	3.12	234	.850
38	19	14.0	12.9	2.68	196.5	.848
39	19	14.0	8.19	1.24	79.4	.827
40	19	17.0	8.23	1.22	80.0	.841

Table V. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
41	18.5	16.8	7.65	0.94	69.2	.963
42	18.5	16.8	5.95	.690	41.9	.847
43	18.5	16.2	3.76	.308	16.75	.850
44	19.0	16.2	2.51	.160	7.46	.806
45	19	16.2	2.01	.109	4.75	.801
46	19	15.7	1.82	.0897	3.93	.820
47	19	15.7	1.775	.0896	3.72	.785
48	18.5	15.7	1.685	.0848	3.36	.761
49	19.0	16.2	1.420	.0650	2.38	.729
50	19	16.2	1.375	.0625	2.235	.720
51	19	16.2	1.120	.0466	1.495	.666
52	19	16.2	1.05	.0430	1.305	.638
53	19	15.7	.788	.0430	.735	.340
54	19	16.8	.717	.0453	.607	.260
55	17.0	24.0	18.2	5.22	391	.780
56	18.0	22.7	17.1	4.625	345	.785
57	19.0	25.1	15.75	4.02	293	.776
58	19	24.0	14.1	3.32	235	.780
59	19	24.0	12.6	2.735	188	.780
60	19	24.0	8.09	1.26	77.4	.778
61	19	24.0	7.04	0.95	58.5	.803
62	19	24.6	5.90	.695	41.2	.803
63	19	24.6	4.02	.359	19.1	.797
64	19	24.6	3.76	.310	16.75	.824
65	19	24.6	2.51	.1625	7.45	.771
66	19	24.6	2.00	.1145	4.73	.735
67	19	24.6	1.775	.093	3.73	.738
68	19.5	24.0	1.695	.0798	3.39	.790
69	19.5	24.6	1.415	.0695	2.365	.662
70	19.5	24.6	1.380	.0702	2.25	.627
71	20.0	25.1	1.017	.0634	1.22	.395
72	20.0	24.6	1.055	.0635	1.32	.425
73	20.0	24.6	0.769	.0587	0.700	.235
74	20.0	22.3	0.567	.0622	0.381	.136
75	19.0	35.6	18.15	5.10	389.0	.761
76	19	34.0	16.5	4.34	322	.761
77	19	34.6	15.3	3.78	278	.770
78	19	34.6	14.0	3.20	232	.779
79	19.5	34.0	12.5	2.59	185	.788
80	19.5	34.6	11.1	2.115	146.5	.782
81	19.5	33.3	8.03	1.140	76.3	.819
82	19.0	35.1	6.94	0.842	57.0	.862
83	19	34.6	5.72	.555	38.7	.934

Table V. (cont.)

Reference No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
84	19.5	34.6	4.01	.2645	19.05	1.050
85	19.5	34.6	3.73	.2525	16.5	.965
86	19.5	34.6	2.51	.1435	7.45	.848
87	19.5	35.6	1.935	.113	4.44	.683
88	19.0	35.6	1.61	.0994	3.06	.562
89	19.5	35.1	1.35	.0895	2.15	.458
90	19.0	35.1	5.87	.618	40.75	.882
91	19.0	35.1	4.78	.406	27.0	.927
92	19.0	35.1	3.50	.226	14.5	.970
93	19.5	35.1	1.02	.0838	1.232	.293

Table VI.

0.0028-in. Dia. glass; vertical flow

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow		Froude No.	Z-factor	Downward Flow		Froude No.	Z-factor
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)		
1	19	2.0	14.95	3.34	265.0	.903	14.20	2.99	233.5	.900
2	18.5	1.9	11.50	2.153	157.0	.895	10.95	1.89	139.0	.915
3	18.5	1.7	10.10	1.724	121.5	.894	9.60	1.52	106.5	.901
4	19	1.7	7.69	1.066	70.2	.894	7.32	0.941	61.9	.905
5	19	2.0	6.92	.884	57.0	.898	6.58	.782	50.2	.903
6	19	0.9	6.07	.721	43.7	.880	5.78	.619	38.8	.921
7	20	4.25	15.0	3.38	268.0	.879	14.28	3.04	235.0	.871
8	19	4.75	13.3	2.77	211.0	.882	12.70	2.50	186.0	.875
9	19	4.25	12.35	2.44	181.0	.875	11.75	2.20	160.0	.870
10	18	4.75	11.25	2.12	150.5	.860	10.70	1.90	132.5	.863
11	17	6.25	7.94	1.118	74.9	.885	7.55	1.025	66.0	.885
12	17	4.75	7.56	1.09	68.0	.840	7.20	0.949	60.1	.869
13	17	5.5	7.03	0.905	58.7	.885	6.70	.820	52.0	.872
14	19	6.0	6.82	.885	55.5	.835	6.48	.788	48.5	.860
15	17	5.5	6.29	.761	47.1	.870	5.99	.696	41.5	.843
16	17	6.6	4.13	.348	20.2	.898	3.94	.333	17.9	.837
17	17	5.7	4.06	.339	19.6	.905	3.86	.313	17.2	.863
18	17	5.5	3.90	.325	18.1	.879	3.72	.298	16.0	.850
19	17.5	5.0	2.12	.1045	5.34	.938	2.02	.0983	4.72	.885
20	17.5	5.0	2.08	.1045	5.14	.909	1.98	.0967	4.53	.867
21	17.5	4.5	1.67	.06725	3.35	.974	1.59	.0700	2.93	.823
22	17.5	5.0	1.68	.0648	3.32	.995	1.60	.0698	2.95	.829
23	17.5	4.25	1.45	.0529	2.50	.855	1.38	.0521	2.20	.677
24	17.5	4.25	1.34	.0433	2.13	.768	1.275	.0458	1.885	.622
25	17.5	4.5	1.323	.0442	2.08	.723	1.260	.0447	1.840	.613
26	18	4.25	1.13	.0226	1.52	.938	1.075	.0307	1.34	.605
27	18	4.25	1.11	.0234	1.46	.865	1.057	.0283	1.29	.632
28	18	4.25	0.949	.0154	1.07	1.010	.903	.0267	0.943	.523
29	18	4.10	.951	.0192	1.075	.815	.905	.0267	.946	.538

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concentration (%)	Mean Velocity of Mixture (fps)	Upward Flow Head Loss (ft/ft)	Flow Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Downward Flow Head Loss (ft/ft)	Flow Froude No.	Z-factor
30	18	4.25	.838	.0154	0.834	.882	.798	.0259	.736	.474
31	18	4.25	.817	.0170	0.793	.783	.777	.0254	.699	.474
32	20	10.1	14.8	3.36	260.0	.839	14.1	3.02	230.0	.833
33	20	10.1	14.2	3.10	240.0	.843	13.55	2.82	211.5	.828
34	19.5	9.75	13.1	2.74	204.0	.833	12.45	2.44	179.0	.830
35	19	9.75	11.1	2.02	146.0	.843	10.55	1.85	128.5	.826
36	19	10.25	9.1	1.40	98.5	.867	8.66	1.30	86.8	.829
37	19.5	9.5	7.46	1.10	66.0	.775	7.10	0.962	58.3	.790
38	18.5	10.1	6.67	0.873	52.9	.805	6.35	.728	46.7	.867
39	19.0	9.75	5.86	.689	40.9	.815	5.58	.606	36.0	.829
40	17.0	11.0	2.07	.1075	5.11	.865	1.97	.0987	4.49	.816
41	17	9.25	2.10	.1175	5.24	.800	2.00	.0944	4.60	.882
42	17	10.0	1.645	.0675	3.21	.902	1.565	.0632	2.83	.854
43	17	10.0	1.65	.0690	3.21	.882	1.570	.0648	2.85	.839
44	17	11.2	1.43	.0530	2.425	.768	1.360	.0525	2.14	.643
45	17	9.25	1.46	.0558	2.53	.776	1.390	.0490	2.23	.768
46	17	10.3	1.46	.0510	2.50	.840	1.380	.0520	2.20	.692
47	17	10.0	1.328	.0433	2.09	.633	1.262	.0388	1.84	.676
48	17	9.8	1.320	.0452	2.07	.648	1.255	.0418	1.82	.618
49	17	11.3	1.115	.0214	1.47	.907	1.060	.0384	1.30	.448
50	17	11.5	1.083	.0217	1.39	.850	1.030	.0379	1.23	.432
51	17	10.3	1.06	.0310	1.33	.573	1.007	.0321	1.173	.492
52	18.0	11.2	0.935	.0195	1.04	1.000	0.890	.0365	0.916	.358
53	18	10.3	0.918	.0310	1.002	.462	0.873	.0321	.882	.401
54	18	10.3	0.900	.0263	0.963	.535	0.855	.0344	.846	.366
55	18	10.0	0.849	.0254	0.857	.521	0.807	.0303	.753	.394
56	18	10.3	0.835	.0225	0.829	.578	0.785	.0314	.713	.370
57	18	11.3	.883	.0275	.937	.492	.845	.0346	.826	.360
58	19	12.1	.743	.0252	.656	.427	.707	.0312	.579	.322

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concentration (%)	Mean Velocity of Mixture (fps)	Upward Flow Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Downward Flow Head Loss (ft/ft)	Froude No.	Z-factor
59	19	12.3	.706	.0315	.592	.336	.672	.0190	.522	.503
60	18.5	14.25	14.45	3.32	248.0	.798	13.75	3.00	219.0	.788
61	19	14.75	12.80	2.715	194.5	.783	12.15	2.425	171.0	.783
62	19	15.2	10.90	2.08	141.5	.771	10.38	1.857	124.5	.772
63	19	15.2	9.53	1.607	108.0	.787	9.09	1.454	95.4	.780
64	18.5	14.0	7.53	1.07	67.4	.796	7.17	0.952	59.4	.799
65	18.5	15.8	6.72	0.88	53.7	.783	6.38	.784	47.1	.783
66	17	13.7	1.785	.0855	3.79	.822	1.70	.077	3.34	.795
67	19.5	14.5	1.780	.0915	3.76	.730	1.693	.076	3.31	.777
68	18.5	15.4	1.762	.0845	3.69	.780	1.675	.0803	3.245	.725
69	19.5	15.25	1.380	.0490	2.26	.773	1.315	.0510	2.00	.640
70	19.0	15.4	1.385	.0445	2.28	.867	1.320	.0513	2.01	.620
71	17.0	12.5	1.183	.0317	1.66	.694	1.125	.0315	1.46	.610
72	19.5	15.25	1.190	.0272	1.68	.830	1.133	.041	1.482	.478
73	19.5	13.75	1.190	.0355	1.68	.642	1.135	.0334	1.492	.600
74	17.0	13.25	0.905	.0165	0.974	.858	0.861	.0360	0.857	.357
75	20.0	14.9	1.085	.0267	1.400	.680	1.032	.0377	1.230	.422
76	19.5	14.8	1.085	.0270	1.395	.670	1.030	.0428	1.228	.371
77	20.0	14.5	0.890	.0252	.942	.515	.848	.0380	.830	.304
78	20.0	14.3	.893	.0260	.948	.504	.850	.0362	.835	.321
79	20.5	13.75	.752	.0258	.672	.417	.715	.0312	.592	.312
80	20.0	13.50	.755	.0293	.678	.374	.718	.0278	.596	.357
81	20.5	13.50	.660	.0130	.518	.733	.628	.0218	.455	.392
82	19.0	17.0	.692	.0200	.570	.506	.658	.0234	.501	.386
83	19.5	15.75	.559	.0184	.372	.440	.531	.0260	.326	.282
84	19.5	16.0	.532	.0155	.336	.495	.506	.0257	.296	.269
85	19.5	13.9	.387	.0150	.178	.378	.368	.0207	.156	.245

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
86	19	22.6	14.20	3.21	239.5	.753	13.50	2.89	211.0	.745
87	19	22.2	13.25	2.90	205.0	.729	12.60	2.56	184.0	.753
88	19	21.5	11.90	2.46	168.2	.730	11.30	2.15	148.0	.745
89	19	21.75	11.00	2.10	143.9	.745	10.45	1.877	126.3	.740
90	19	21.75	9.16	1.493	99.8	.761	8.72	1.34	87.9	.755
91	18.5	22.2	7.52	1.033	67.2	.775	7.15	.957	59.2	.750
92	18.5	21.6	6.64	0.875	52.4	.741	6.31	.758	46.0	.762
93	17.5	21.25	6.30	.792	47.2	.753	5.99	.728	41.5	.725
94	17.5	21.5	5.80	.662	40.0	.777	5.51	.621	35.2	.728
95	18.0	20.75	3.76	.3175	16.8	.760	3.58	.294	14.82	.728
96	18	21.25	3.52	.284	14.73	.755	3.35	.268	12.98	.705
97	18	20.5	2.52	.158	7.55	.757	2.40	.1503	6.64	.705
98	18	20.5	2.40	.143	6.82	.766	2.275	.1389	5.99	.694
99	18	20.75	2.30	.131	6.29	.777	2.19	.1282	5.55	.705
100	18	20.5	1.845	.086	4.04	.809	1.755	.0895	3.56	.688
101	18	21.0	1.72	.0760	3.52	.800	1.638	.0756	3.10	.715
102	18	21.25	1.965	.0955	4.59	.797	1.865	.0994	4.03	.680
103	18	21.0	1.54	.0610	2.82	.818	1.465	.0657	2.49	.675
104	18	21.0	1.64	.0650	3.19	.846	1.560	.0706	2.81	.701
105	18	21.0	1.62	.0690	3.12	.796	1.540	.0728	2.74	.665
106	18	21.0	1.39	.0390	2.29	.895	1.320	.0571	2.02	.512
107	17.5	20.25	1.43	.0450	2.425	.855	1.360	.0516	2.14	.633
108	17.5	21.0	1.41	.0420	2.37	.860	1.342	.0564	2.09	.547
109	18	21.0	1.26	.0248	1.89	1.004	1.200	.0507	1.67	.425
110	18	19.6	1.305	.0370	2.03	.758	1.24	.0455	1.78	.524
111	18	20.1	1.280	.0320	1.95	.819	1.22	.0456	1.718	.496
112	18	18.75	1.09	.0283	1.415	.630	1.04	.0441	1.25	.492
113	18	20.5	1.646	.0630	3.22	.890	1.565	.0752	2.83	.652
114	18	20.25	1.430	.0465	2.43	.850	1.360	.0566	2.14	.590
115	18	20.25	1.465	.0485	2.56	.878	1.395	.058	2.25	.630
116	18	19.5	1.278	.0315	1.942	.825	1.215	.0458	1.708	.490
117	18	19.0	1.234	.022	1.811	1.07	1.175	.0385	1.600	.537

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
118	18	19.75	1.026	.018	1.252	.875	0.975	.0455	1.100	.309
119	18	19.75	.987	.0185	1.158	.805	.940	.0432	1.023	.309
120	18.5	19.0	.910	.0272	.984	.540	.866	.0364	0.868	.327
121	19.0	26.1	14.10	3.28	236.5	.713	13.42	2.90	208.0	.722
122	19	26.1	12.85	2.79	196.2	.734	12.25	2.465	173.6	.723
123	19	26.1	11.70	2.32	162.7	.726	11.13	2.03	143.5	.740
124	17.5	25.6	10.73	2.04	136.7	.720	10.20	1.795	120.3	.725
125	18.0	26.1	7.43	1.08	65.6	.713	7.06	0.925	57.7	.742
126	18	26.1	6.47	0.844	49.7	.717	6.15	.732	43.7	.735
127	18	26.1	5.78	.699	39.7	.710	5.50	.596	34.9	.740
128	17.5	26.0	6.40	.770	48.8	.770	6.09	.723	42.9	.726
129	17.5	26.1	5.60	.690	37.3	.678	5.325	.611	32.8	.678
130	18.0	24.3	3.67	.321	16.05	.704	3.49	.287	14.10	.695
131	18	25.1	3.46	.285	14.2	.708	3.29	.265	12.52	.673
132	18	26.9	2.50	.151	7.43	.745	2.38	.153	6.55	.657
133	18	26.5	2.345	.138	6.54	.733	2.23	.1404	5.75	.638
134	18	26.5	2.265	.135	6.10	.706	2.155	.129	5.37	.655
135	18.5	26.1	1.83	.085	3.98	.770	1.74	.0945	3.505	.617
136	18.5	26.5	1.62	.061	3.13	.866	1.54	.075	2.74	.610
137	18.5	25.1	1.445	.046	2.48	.865	1.375	.053	2.19	.648
138	18.5	25.0	1.46	.049	2.53	.678	1.39	.0555	2.23	.640
139	19	26.5	1.263	.033	1.90	.764	1.205	.040	1.68	.544
140	19	27.2	1.21	.029	1.735	.750	1.150	.045	1.527	.420
141	19	25.75	1.024	.0295	1.25	.512	0.975	.0415	1.100	.320
142	19	26.1	0.970	.023	1.12	.590	.923	.049	0.986	.248
143	19	26.0	0.898	.017	0.958	.719	.855	.045	0.846	.243
144	20	24.75	0.688	.021	0.562	.440	.655	.031	.496	.269
145	19.0	32.5	13.65	3.085	221.0	.680	13.0	2.800	195.5	.669

Table VI.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
146	19	29.0	12.90	2.685	198.0	.730	12.27	2.405	174.1	.716
147	20	29.0	11.95	2.395	169.4	.713	11.34	2.180	148.7	.701
148	20	28.6	10.8	2.01	138.5	.715	10.30	1.808	122.6	.714
149	20	28.1	8.95	1.50	95.1	.692	8.54	1.322	84.3	.706
150	19	29.0	7.52	1.070	67.2	.720	7.15	0.931	59.1	.737
151	19	29.0	6.60	0.847	51.7	.724	6.29	.745	45.7	.732
152	19	29.0	5.93	.693	41.9	.726	5.64	.615	36.8	.734
153	18.0	29.0	1.635	.043	3.17	1.095	1.555	.0688	2.79	.677
154	18.5	29.0	1.94	.099	4.47	.715	1.840	.0995	3.92	.627
155	18.5	29.0	1.93	.097	4.42	.723	1.835	.1042	3.90	.595
156	18	28.3	1.485	.0455	2.61	.910	1.410	.0655	2.30	.545
157	19	29.0	1.560	.0425	2.89	1.11	1.485	.0774	2.54	.533
158	18.5	28.3	1.580	.0480	2.96	1.015	1.500	.0737	2.67	.577
159	18.5	28.6	1.340	.0285	2.13	1.035	1.275	.0500	1.88	.501
160	17.5	28.0	1.270	.0260	1.91	0.915	1.205	.0505	1.68	.416
161	17.5	28.3	1.208	.0255	1.73	.925	1.150	.0520	1.53	.472
162	18.0	28.6	1.820	.077	3.93	.828	1.730	.0905	3.46	.627
163	18	29.8	1.625	.0615	3.14	.834	1.545	.0745	2.765	.602
164	18	30.75	1.430	.035	2.43	1.050	1.360	.0555	2.14	.560
165	18	30.9	1.435	.0365	2.45	1.010	1.365	.055	2.15	.573
166	18	30.75	1.255	.030	1.873	0.765	1.195	.053	1.65	.375
167	18	30.2	1.215	.034	1.755	.621	1.155	.048	1.543	.382
168	18	29.5	1.015	.031	1.225	.470	0.965	.0415	1.077	.312
169	18.5	30.8	0.950	.0295	1.073	.440	0.904	.0395	0.945	.292
170	19.0	30.9	0.888	.0285	.938	.410	.845	.036	.826	.292
171	19	29.8	0.678	.0155	.547	.581	.645	.032	.481	.253
172	19.5	28.3	0.545	.0145	.353	.500	.519	.027	.311	.243
173	20.0	28.8	0.510	.0145	.309	.460	.485	.028	.272	.215
174	19.0	31.5	1.012	.0285	1.217	.495	.963	.044	1.072	.284
175	19	31.8	0.954	.0245	1.08	.523	.908	.052	.953	.219
176	19	30.9	.891	.0255	0.944	.462	.848	.042	.832	.252
177	19	29.8	.676	.0180	.543	.495	.643	.038	.478	.211

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
178	19.5	28.3	.545	.0130	.353	.559	.519	.0275	.311	.238
179	19.5	28.3	.513	.0110	.311	.619	.488	.0310	.275	.198
180	19.0	28.9	.515	.0165	.311	.413	.490	.0285	.278	.2175
181	19.5	28.2	.545	.021	.353	.351	.519	.031	.311	.214
182	19	29.5	.678	.021	.547	.430	.645	.0315	.481	.260
183	19	30.8	.890	.0355	.942	.331	.847	.044	.830	.241
184	18.5	30.8	1.825	.070	3.96	.908	1.735	.0984	3.48	.571
185	18.5	30.25	1.62	.0515	3.12	.985	1.540	.0821	2.74	.542
186	19	30.0	1.415	.027	2.38	1.360	1.345	.0642	2.09	.490
187	18.5	29.9	1.45	.031	2.50	1.260	1.380	.066	2.20	.510
188	19	28.8	1.25	.026	1.855	0.903	1.19	.049	1.638	.415
189	19	29.0	1.206	.0235	1.730	.900	1.145	.052	1.517	.352
190	18.5	35.3	13.15	2.87	205.5	.746	12.52	2.67	181.0	.712
191	18.5	34.7	12.40	2.56	182.5	.683	11.75	2.32	160.0	.667
192	18.5	35.1	10.42	1.934	129.0	.670	9.90	1.74	113.4	.660
193	19.0	35.1	10.33	1.800	127.0	.708	9.82	1.67	111.6	.673
194	18.5	34.7	7.21	0.960	61.8	.709	6.85	0.868	54.4	.695
195	18.5	34.3	6.47	.774	49.8	.731	6.17	.711	44.0	.703
196	19.0	36.5	5.71	.626	38.8	.712	5.43	.592	34.1	.664
197	19.0	35.8	3.59	.289	15.3	.687	3.42	.273	13.5	.648
198	19.0	35.8	3.81	.331	17.3	.665	3.63	.299	15.2	.653
199	19.0	35.0	2.44	.151	7.04	.668	2.315	.139	6.2	.642
200	19.0	35.1	2.61	.169	8.11	.677	2.49	.157	7.17	.645
201	19.0	35.1	1.63	.060	3.16	.832	1.55	.053	2.78	.834
202	19	34.3	1.845	.079	4.04	.800	1.755	.0928	3.56	.595
203	19.5	34.3	1.600	.059	3.04	.818	1.520	.0815	2.67	.520
204	20	33.8	1.383	.042	2.27	.785	1.315	.0385	2.00	.763
205	20	33.5	1.213	.045	1.75	.475	1.155	.0390	1.54	.470
206	20	33.5	1.095	.038	1.43	.433	1.045	.038	1.261	.512
207	20	33.5	0.930	.038	1.028	.318	0.885	.0325	0.908	.330

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concentration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
208	20	32.5	.915	.021	.0996	.566	0.872	.0265	.879	.401
209	20	32.8	1.075	.033	1.377	.570	1.025	.0395	1.215	.352
210	20	32.4	1.180	.0365	1.653	.543	1.120	.0412	1.450	.408
211	19.5	33.6	1.415	.0435	2.38	.830	1.350	.0505	2.10	.618
212	20.0	32.9	1.010	.0315	1.213	.442	0.960	.0405	1.067	.302
213	19.0	35.1	1.800	.063	3.85	.952	1.715	0.100	3.40	.532
214	19.5	35.25	1.620	.046	3.13	1.072	1.540	.0845	2.74	.510
215	20.0	36.25	1.250	.022	1.861	1.045	1.190	.061	1.64	.323
216	20.0	36.0	1.195	.0275	1.700	.730	1.140	.0585	1.504	.299
217	19.0	34.8	2.355	.177	6.60	.540	2.245	.134	5.83	.633
218	19	36.8	2.275	.124	6.16	.713	2.165	.125	5.44	.628
219	19	36.1	1.78	.079	3.77	.733	1.695	.1005	3.32	.510
220	19	36.25	1.63	.0555	3.16	.890	1.55	.063	2.78	.680
221	19	35.9	1.43	.0415	3.425	.865	1.36	.045	2.13	.685
222	19	35.9	1.24	.0380	1.820	.561	1.175	.0445	1.60	.421
223	19	35.5	1.185	.0365	1.670	.530	1.128	.043	1.47	.390
224	19.5	34.6	0.943	.0350	1.06	.351	0.888	.0385	.922	.280
225	18	46.5	12.40	2.52	183.0	.633	11.80	2.48	160.8	.572
226	18	45.2	11.48	2.26	156.4	.627	10.90	1.965	137.7	.640
227	19	43.9	10.42	1.76	129.0	.681	9.91	1.642	113.7	.650
228	18.5	43.9	7.28	0.94	63.0	.685	6.93	.887	55.5	.641
229	18.5	44.0	6.43	.722	49.1	.715	6.125	.698	43.4	.658
230	18.5	44.5	5.68	.584	38.3	.710	5.41	.574	33.8	.641
231	18.5	43.1	3.50	.265	14.6	.680	3.33	.352	12.84	.453
232	18.5	42.8	3.62	.287	15.6	.667	3.44	.284	13.71	.595
233	19.0	43.1	2.30	.125	6.29	.687	2.19	.1025	5.55	.744
234	19	44.8	2.45	.136	7.16	.698	2.33	.1275	6.28	.657
235	19	44.2	1.505	.050	2.69	.775	1.435	.0490	2.38	.692
236	18.5	44.5	2.11	.088	5.29	.915	2.010	.084	4.66	.773
237	19.5	44.4	1.37	.036	2.23	.842	1.305	.0435	1.967	.585

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
238	20.0	43.9	1.00	.034	1.189	.369	0.950	.045	1.045	.246
239	20.0	43.9	1.86	.060	4.11	.976	1.770	.0695	3.63	.748
240	19.0	45.8	1.79	.049	3.80	1.12	1.700	.0605	3.34	.796
241	19.5	45.8	1.432	.0435	2.44	.783	1.365	.054	2.15	.545
242	19.5	45.3	1.200	.0435	1.71	.428	1.138	.034	1.498	.470
243	19.5	45.3	1.165	.0380	1.61	.450	1.107	.039	1.417	.381
244	20.0	44.8	0.910	.0445	.983	.240	0.865	.056	0.865	.171
245	20	44.8	0.817	.0365	.794	.260	0.778	.0335	.700	.256
246	20.5	44.4	0.643	.041	.492	.180	0.613	.031	.435	.216
247	21.0	45.2	0.512	.020	.311	.288	0.487	.0225	.274	.230
248	19.0	47.0	2.24	.089	5.97	.895	2.13	.081	5.25	.870
249	19	47.2	1.745	.048	3.62	1.070	1.66	.067	3.18	.677
250	19	47.4	1.565	.044	2.91	.962	1.49	.061	2.57	.595
251	19	46.75	1.410	.042	2.37	.760	1.34	.0515	2.08	.530
252	19	46.8	1.380	.039	2.26	.765	1.312	.055	1.99	.456
253	19	45.25	1.200	.036	1.71	.492	1.14	.049	1.55	.320
254	19.5	45.25	1.166	.040	1.62	.423	1.11	.049	1.42	.301
255	19.5	45.25	0.990	.032	1.16	.370	0.941	.0455	1.024	.2215
256	20	43.9	0.530	.0215	0.334	.288	0.505	.021	0.295	.266
257	18.5	46.8	0.912	.036	.988	.300	0.868	.043	0.871	.226
258	18.5	46.8	0.850	.028	.859	.359	0.809	.042	.757	.215
259	18.5	45.8	0.645	.023	.495	.333	0.614	.0295	.436	.222
260	19.0	44.4	0.512	.026	.311	.235	0.487	.027	.274	.203
261	19.5	43.8	0.470	.020	.263	.279	0.447	.024	.231	.209
262	19.5	44.6	0.478	.019	.271	.295	0.455	.021	.239	.242
263	19.5	44.3	3.62	.278	15.58	.672	3.44	.253	13.7	.655
264	19	45.4	3.44	.254	14.09	.672	3.27	.259	12.4	.583
265	19.5	45.3	2.49	.131	7.35	.738	2.37	.155	6.47	.553
266	19.5	45.3	2.32	.116	6.37	.737	2.2	.137	5.60	.550
267	19.5	45.3	2.22	.106	5.86	.749	2.11	.127	5.15	.551
268	19.5	44.9	1.75	.050	3.64	1.046	1.665	.0655	3.20	.705
269	20	45.4	1.61	.041	3.08	1.096	1.53	.0615	2.70	.633

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow			Z-factor	Downward Flow		
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.		Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.
270	19.5	44.8	1.40	.038	2.32	.842	1.332	.0505	2.05
271	20	45.1	1.224	.034	1.784	.592	1.165	.0505	1.57
272	20	45.4	1.18	.031	1.653	.587	1.122	.0490	1.457
273	20	45.3	0.920	.021	1.005	.516	0.876	.0470	0.887
274	18.5	50.0	10.14	1.694	122.2	.651	9.64	1.456	107.5
275	18.0	49.6	7.18	.865	61.2	.700	6.83	0.833	53.9
276	18.0	49.6	6.25	.725	46.5	.654	5.95	.649	41.0
277	18.0	49.3	5.58	.565	37.1	.688	5.32	.575	32.7
278	18.5	49.3	3.65	.265	15.8	.691	3.47	.273	13.94
279	18	49.6	3.47	.235	14.33	.720	3.30	.263	12.59
280	19	49.6	2.40	.075	6.86	1.18	2.29	.1105	6.06
281	19.5	49.3	1.52	.036	2.74	1.06	1.445	.078	2.42
282	19	49.3	2.15	.064	5.47	1.10	2.040	.1015	4.82
283	19.5	49.3	1.39	.0335	2.31	0.911	1.325	.0635	2.03
284	20	47.8	0.990	.035	1.166	.340	0.943	.0835	1.03
285	19.5	49.3	1.712	.0445	3.48	1.100	1.630	.077	3.08
286	19.5	48.8	1.385	.040	2.27	.750	1.315	.069	2.00
287	20.0	46.8	1.205	.033	1.72	.570	1.145	.046	1.51
288	20.0	47.8	1.152	.0545	1.58	.302	1.095	.045	1.388
289	20.0	47.7	0.965	.034	1.108	.337	0.918	.045	0.975
290	20.0	46.9	0.815	.045	0.791	.2065	0.775	.041	.694
291	19.0	50.6	3.52	.244	14.74	.653	3.35	.2055	13.0
292	20.0	51.6	2.43	.081	7.04	1.090	2.32	.1105	6.22
293	19.0	51.2	2.285	.070	6.20	1.135	2.17	.0995	5.45
294	19.5	51.2	2.140	.064	5.44	1.10	2.03	.106	4.78
295	19.5	51.2	1.718	.049	3.51	0.982	1.632	.0835	3.08
296	19.5	50.7	1.540	.0445	2.82	0.876	1.468	.097	2.49
297	19.5	49.8	3.60	.249	15.41	.705	3.42	.285	13.54
298	19.0	49.9	3.47	.243	14.33	.690	3.30	.260	12.60
299	19	49.6	2.345	.076	6.54	1.11	2.23	.097	5.75

Table VI. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
300	19	49.2	2.22	.0645	5.86	1.20	2.11	.0915	5.15	.745
201	19	49.8	1.75	.0495	3.64	1.02	1.665	.075	3.20	.595
302	19.5	51.0	1.63	.031	3.16	1.41	1.55	.077	2.78	.500
303	19.5	50.5	1.395	.0285	2.31	1.06	1.326	.063	2.03	.408

Table VII.

0.0013-in. Dia. glass; vertical flow

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Z-factor	Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.				Head Loss (ft/ft)	Froude No.	Z-factor
1	18.0	3.5	14.75	3.59	258		.820	14.05	2.92	228.0	.905
2	18.0	3.5	13.85	3.22	228		.821	13.20	2.61	201.0	.896
3	18.5	3.0	12.45	2.67	184.0		.821	11.85	2.16	162.5	.902
4	18.5	3.3	7.94	1.20	74.9		.831	7.55	.988	65.9	.893
5	18.5	3.0	7.05	0.985	59.2		.825	6.70	.801	51.9	.895
6	18.5	2.7	6.10	0.749	44.2		.842	5.80	0.613	39.0	.910
7	18.5	2.7	2.16	0.127	5.54		.803	2.055	0.0916	4.87	.987
8	18.5	2.7	1.995	0.116	4.73		.770	1.90	.0836	4.17	.947
9	18.5	3.3	2.46	0.150	7.19		.850	2.34	.123	6.34	.918
10	18.5	3.3	2.08	0.103	5.13		.883	1.98	.0912	4.53	.929
11	18.5	2.5	1.73	0.0805	3.56		.862	1.645	.0650	3.13	.946
12	19.0	2.7	1.448	0.0576	2.49		.880	1.375	.0491	2.19	.912
13	20	6.2	14.1	3.32	236.5		.804	13.4	2.72	208.0	.862
14	19.5	6.9	13.2	2.90	207.0		.817	12.55	2.42	182.0	.863
15	19.5	6.9	12.3	2.57	179.5		.812	11.72	2.09	159.0	.889
16	19.5	6.3	11.0	2.11	144.0		.828	10.48	1.753	127.0	.874
17	19.5	6.0	10.1	1.80	121.0		.825	9.59	1.487	106.2	.880
18	19.5	6.9	9.16	1.54	100.0		.810	8.71	1.271	88.0	.873
19	20	6.3	7.60	1.094	68.5		.821	7.23	.905	60.5	.880
20	21	7.4	6.72	.883	53.7		.809	6.40	.739	47.5	.862
21	19	4.8	6.00	.716	42.8		.843	5.72	.595	37.8	.901
22	18	7.6	5.26	.592	32.9		.795	5.00	.483	28.9	.863
23	20	5.6	4.76	.494	26.9		.808	4.53	.389	23.7	.910
24	18.5	5.1	3.86	.336	17.7		.829	3.67	.284	15.62	.870
25	18.5	5.1	3.70	.297	16.3		.874	3.52	.258	14.35	.890
26	18	4.5	2.45	.1475	7.14		.857	2.335	.123	6.31	.914

Table VII. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
27	19.5	4.2	2.10	.1070	5.22	.895	2.00	.0949	4.62	.898
28	20	4.0	1.753	.0778	3.65	.899	1.668	.0688	3.22	.902
29	20	3.2	1.468	.0600	2.56	.821	1.398	.0464	2.25	.918
30	20	2.7	1.190	.0432	1.685	.577	1.133	.0315	1.485	.683
31	20	2.7	1.128	.0416	1.510	.518	1.073	.0315	1.332	.596
32	18.5	10.0	13.95	3.24	231.0	.794	13.25	2.72	203.0	.833
33	19	10.2	13.15	2.95	205.5	.781	12.50	2.455	180.5	.830
34	19	10.4	11.90	2.50	169.0	.777	11.33	2.06	148.5	.833
35	19.5	10.4	10.85	2.10	139.5	.773	10.33	1.771	123.3	.826
36	19.5	10.0	9.38	1.657	104.5	.765	8.94	1.380	92.2	.819
37	19.5	10.0	8.35	1.362	82.8	.763	7.95	1.088	73.0	.845
38	19.5	10.0	7.56	1.097	67.8	.799	7.19	0.916	59.7	.842
39	19.5	10.0	6.74	0.903	54.0	.795	6.42	.748	47.8	.849
40	17.5	10.4	6.21	.713	45.8	.877	5.92	.603	40.5	.923
41	18.0	10.4	3.99	.351	18.9	.817	3.79	.300	16.6	.843
42	19.0	10.0	3.69	.305	16.2	.815	3.52	.257	14.3	.855
43	19.0	10.0	2.53	.153	7.6	.840	2.41	.1326	6.7	.862
44	19.0	10.0	2.09	.108	5.19	.853	1.985	.0949	4.55	.855
45	19.0	10.0	1.775	.0765	3.74	.905	1.685	.0695	3.28	.882
46	19.5	9.4	1.455	.059	2.51	.775	1.382	.0465	2.21	.854
47	19.5	9.4	1.20	.0445	1.71	.541	1.14	.0272	1.50	1.030
48	19.5	9.1	1.105	.0365	1.45	.538	1.05	.0262	1.28	0.661
49	18	20.2	13.85	3.32	228.0	.720	13.20	2.80	201.0	.755
50	18.5	20.4	12.85	2.92	196.0	.715	12.22	2.42	173.0	.764
51	19.0	21.0	11.83	2.53	166.5	.710	11.25	2.10	146.5	.755
52	19.0	20.6	10.85	2.15	140.5	.720	10.33	1.795	123.0	.760
53	19.5	20.2	9.33	1.688	103.5	.702	8.88	1.387	91.1	.757
54	19.5	20.8	8.48	1.434	85.3	.694	8.07	1.186	75.4	.748
55	19.5	19.5	7.52	1.146	67.0	.710	7.16	0.944	59.3	.767

Table VII. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
56	17.5	19.7	6.48	.914	49.8	.694	6.16	.775	44.0	.728
57	19.5	19.7	5.95	.760	42.1	.714	5.67	.621	37.1	.774
58	18.0	20.0	5.80	.742	39.9	.703	5.52	.622	35.3	.744
59	18.5	19.7	3.95	.354	18.55	.751	3.42	.298	13.5	.668
60	19.0	20.2	3.64	.315	15.75	.725	3.46	.262	13.9	.774
61	19.0	19.7	2.50	.160	7.42	.740	2.38	.130	6.54	.810
62	19.5	19.7	2.07	.117	5.09	.725	1.97	.0926	4.48	.810
63	19.5	19.5	1.75	.0885	3.64	.722	1.66	.0664	3.19	.845
64	20.0	19.3	1.45	.0663	2.50	.655	1.38	.0362	2.20	1.037
65	20.0	20.0	1.162	.0405	1.605	.517	1.102	.0171	1.405	1.054
66	20.0	20.2	1.090	.0380	1.415	.472	1.039	.0198	1.245	0.793
67	20.0	19.5	0.822	.0247	0.802	.470	0.783	.0115	0.707	.907
68	20.0	19.0	0.642	.0225	0.490	.402	0.610	.0095	0.430	.860
69	18	30.4	13.62	3.20	220.5	.678	12.95	2.73	194.0	.700
70	19	29.6	12.73	2.89	192.5	.667	12.12	2.40	170.0	.711
71	19.5	30.3	11.78	2.54	164.5	.652	11.20	2.106	145.2	.700
72	19.5	29.1	10.80	2.18	139.0	.664	10.30	1.810	122.5	.710
73	20.0	29.7	9.30	1.707	102.8	.644	8.85	1.393	90.5	.701
74	20.0	29.7	8.35	1.432	82.8	.638	7.93	1.163	72.6	.692
75	20.0	29.1	7.50	1.170	66.9	.646	7.15	0.962	59.1	.700
76	18.0	30.0	6.62	0.918	52.0	.670	6.30	.771	45.9	.709
77	18.0	29.7	6.22	.752	45.8	.733	5.91	.626	40.4	.781
78	20.0	29.3	5.77	.706	39.5	.670	5.50	.603	34.9	.704
79	18.5	29.6	3.94	.356	18.4	.693	3.75	.3025	16.25	.725
80	19.0	29.7	3.63	.318	15.7	.671	3.46	.268	13.90	.710
81	19	29.3	2.49	.156	7.37	.708	2.36	.135	6.48	.725
82	19	30.0	2.05	.106	5.00	.740	1.95	.093	4.40	.746
83	18.5	30.0	1.74	.074	3.60	.798	1.660	.0505	3.18	1.040
84	19	30.3	1.425	.0645	2.41	.583	1.352	.0285	2.12	1.120
85	19.5	29.6	1.145	.044	1.56	.427	1.090	.0237	1.385	0.700
86	19.5	29.6	1.085	.0465	1.395	.356	1.033	.0170	1.235	.858

Table VII.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
87	20.0	28.2	0.810	.030	0.779	.357	0.770	.0110	0.686	.879
88	18	39.5	13.35	3.21	212.0	.591	12.72	2.71	187.5	.644
89	19	39.5	12.70	2.90	192.0	.619	12.10	2.46	169.0	.640
90	19.5	40.9	11.73	2.55	163.5	.597	11.15	2.13	144.0	.638
91	20.0	39.7	10.65	2.19	134.5	.592	10.15	1.82	119.0	.635
92	20	39.8	9.48	1.794	107.0	.589	9.02	1.471	94.0	.636
93	20	39.5	8.46	1.442	85.1	.602	8.05	1.258	75.0	.611
94	20.5	39.8	7.43	1.144	65.6	.600	7.07	0.965	57.8	.632
95	20	40.2	6.50	0.952	50.2	.573	6.18	.778	44.2	.620
96	20	40.7	5.76	.733	39.4	.595	5.48	.646	34.8	.601
97	18.5	40.7	5.04	.600	30.2	.585	4.79	.487	26.55	.639
98	19	40.4	3.96	.365	18.65	.632	3.77	.315	16.4	.644
99	19.5	41.0	3.68	.319	16.10	.630	3.50	.298	14.15	.594
100	20	40.0	2.51	.157	7.48	.656	2.39	.142	6.60	.644
101	20	40.0	2.025	.095	4.87	.746	1.925	.099	4.28	.632
102	20	39.8	1.715	.090	3.50	.590	1.632	.0615	3.08	.762
103	20	39.2	1.420	.053	2.40	.674	1.352	.0335	2.115	.925
104	20	39.3	1.138	.038	1.535	.456	1.082	.064	1.355	.236

Table VIII.

0.0044-in. Dia. resin; vertical flow

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
1	17.5	4.0	14.55	3.13	252.0	0.940	13.85	2.84	222.0	.914
2	18	4.0	13.75	2.89	224.5	.905	13.10	2.59	198.5	.905
3	18	3.4	12.75	2.59	193.0	.895	12.10	2.33	169.5	.880
4	18	4.0	12.02	2.30	172.0	.911	11.45	2.05	151.5	.908
5	18.5	3.4	11.20	2.00	149.0	.917	10.65	1.81	131.5	.900
6	18.5	4.0	10.05	1.70	120.0	.893	9.56	1.54	106.0	.882
7	18.5	4.6	8.92	1.36	94.6	.905	8.48	1.23	83.0	.885
8	18.5	4.6	7.79	1.08	72.0	.900	7.42	0.980	63.6	.888
9	18.5	4.6	7.00	0.810	58.2	.995	6.66	.813	51.4	.882
10	18.5	4.6	6.30	.747	47.2	.888	6.00	.673	41.6	.875
11	19	5.3	5.34	.571	33.9	.873	5.08	.524	29.8	.840
12	18.5	3.4	3.75	.334	16.7	.810	3.56	.284	14.7	.843
13	18.5	4.6	3.45	.259	14.2	.901	3.28	.243	12.45	.850
14	18.5	4.6	2.57	.142	7.84	.978	2.45	.150	6.94	.823
15	18.5	3.4	2.45	.148	7.13	.870	2.33	.130	6.29	.878
16	18.5	4.0	2.39	.138	6.80	.892	2.28	.130	6.00	.842
17	18	4.0	1.915	.107	4.37	.782	1.825	.096	3.85	.775
18	18.5	4.6	1.485	.077	2.63	.648	1.415	.050	2.31	.868
19	18	9.4	14.30	3.225	204.5	.867	13.61	2.915	185.2	.847
20	19	7.7	14.00	2.97	196.0	.910	13.32	2.685	177.4	.885
21	19	8.2	13.05	2.67	170.3	.921	12.42	2.41	154.2	.877
22	19	8.2	12.30	2.33	151.3	.915	11.70	2.11	136.9	.899
23	19	8.2	11.40	2.06	130.0	.904	10.85	1.872	117.7	.884
24	19	3.2	9.82	1.59	96.4	.905	9.34	1.452	87.2	.878
25	19	8.8	8.65	1.30	74.8	.880	8.23	1.169	67.7	.870
26	19	3.2	7.94	1.10	63.0	.900	7.55	0.992	57.0	.886
27	19	8.8	6.74	0.839	45.4	.888	6.41	.759	41.1	.870
28	19	8.8	6.60	.852	43.6	.844	6.28	.784	39.4	.807

Table VIII(cont.)

Ref. No.	Temp. (°C)	Concentration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
29	19	8.2	6.13	.700	37.6	.901	5.83	.637	34.0	.878
30	19	8.2	3.84	.328	17.52	.848	3.65	.305	15.4	.807
31	19	8.2	3.68	.300	16.10	.858	3.50	.280	14.17	.817
32	19	7.0	2.61	.168	8.10	.843	2.48	.150	7.11	.833
33	19	7.0	2.49	.154	7.37	.854	2.37	.139	6.49	.834
34	19	7.7	2.41	.129	6.91	.957	2.29	.131	6.06	.834
35	19	7.6	2.035	.1019	4.92	.900	1.94	.1093	4.35	.745
36	19	7.0	1.995	.1045	4.73	.848	1.898	.0928	4.17	.848
37	19	7.0	1.790	.082	3.80	.891	1.704	.0822	3.35	.790
38	19	8.8	1.775	.0805	3.745	.895	1.689	.0785	3.30	.813
39	17.5	8.2	1.615	.0658	3.10	.919	1.538	.0507	2.73	1.036
40	19	7.7	1.560	.0665	2.89	.845	1.484	.0608	2.55	.810
41	19	7.7	1.365	.0530	2.22	.735	1.299	.0488	1.95	.655
42	18	8.2	1.345	.0515	2.15	.667	1.280	.0563	1.895	.521
43	19	8.8	1.325	.046	2.087	.740	1.261	.0491	1.84	.594
44	18.5	8.2	1.320	.0363	2.07	.905	1.255	.0611	1.820	.458
45	19.5	7.0	1.065	.0266	1.35	.709	1.013	.0238	1.185	.695
46	19.5	7.0	1.027	.0210	1.252	.830	.976	.0246	1.10	.627
47	19	8.2	1.025	.022	1.249	.796	.975	.026	1.10	.593
48	19.5	7.0	1.023	.0251	1.244	.696	.947	.0238	1.096	.646
49	19.5	7.0	0.988	.022	1.160	.740	.940	.0230	1.023	.634
50	18.5	8.2	.953	.0155	1.079	1.007	.906	.0268	.950	.520
51	19	8.2	.767	.0179	.697	.678	.730	.0348	.615	.315
52	19	8.2	.678	.0107	.546	.998	.645	.0204	.481	.473
53	18	9.4	10.86	1.985	140.3	.870	10.33	2.02	123.5	.757
54	18.5	7.0	1.47	.0716	2.57	.673	1.40	.0551	2.27	.760
55	18	12.9	13.46	2.95	215.0	.841	12.81	2.71	190	.812
56	18	12.9	13.46	2.82	215.0	.880	12.81	2.56	190	.860
57	18	12.9	13.06	2.67	203.0	.886	12.43	2.44	178.8	.855

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow				20
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	
58	18	12.9	12.44	2.53	184.0	.855	11.83	2.31	161.9	.829	
59	18.5	12.3	12.14	2.40	175.3	.863	11.55	2.18	154.3	.842	
60	18	12.9	10.77	1.993	137.9	.843	10.25	1.826	121.6	.818	
61	18	11.2	7.65	1.071	69.5	.868	7.28	0.969	61.3	.847	
62	18	11.2	6.07	.760	43.9	.814	5.78	.642	38.6	.853	
63	17.5	11.7	3.81	.327	17.2	.840	3.625	.303	15.2	.790	
64	17.5	11.7	3.62	.304	15.6	.827	3.445	.283	13.7	.785	
65	17	11.7	2.58	.163	7.88	.848	2.45	.1585	6.94	.709	
66	18	10.0	2.57	.185	7.85	.747	2.445	.1555	6.92	.785	
67	18.5	12.0	2.45	.152	7.15	.830	2.33	.1439	6.28	.775	
68	18.5	11.7	2.40	.136	6.85	.900	2.28	.1455	6.02	.737	
69	18.5	11.7	1.94	.0993	4.47	.842	1.846	.0968	3.94	.767	
70	18.5	11.7	1.765	.0855	3.71	.830	1.68	.084	3.26	.760	
71	18.5	11.2	1.525	.0658	2.77	.804	1.45	.066	2.43	.697	
72	19	10.6	1.35	.0528	2.16	.700	1.285	.0450	1.909	.685	
73	19	11.2	1.327	.0498	2.09	.685	1.263	.0509	1.85	.572	
74	19	11.7	1.27	.0420	1.917	.690	1.210	.0492	1.694	.510	
75	20	12.9	1.172	.0446	1.63	.523	1.115	.0446	1.438	.455	
76	18.5	12.9	1.03	.0214	1.26	.817	0.980	.0272	1.111	.568	
77	20	12.9	1.018	.0257	1.232	.660	0.970	.0288	1.089	.523	
78	19.5	12.3	0.953	.0265	1.08	.578	0.907	.0249	.951	.548	
79	18.5	13.5	0.950	.0218	1.073	.704	0.904	.0284	.945	.485	
80	19	12.3	0.750	.0170	.669	.694	0.714	.0241	.590	.441	
81	19.5	12.9	0.730	.0179	.634	.630	0.695	.0225	.559	.455	
82	19	12.9	0.600	.0139	.428	.680	0.571	.0217	.377	.391	
83	19.5	12.3	0.585	.0163	.407	.557	0.557	.0194	.359	.416	
84	19	12.3	0.540	.0155	.347	.550	0.514	.0209	.305	.366	
85	19	12.9	0.503	.0123	.301	.640	0.479	.0201	.265	.341	

Table VIII. (cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
86	19.5	12.3	0.364	.0107	.158	.525	0.346	.0078	.139	.656
87	17	15.2	13.75	3.14	225.0	.820	13.10	2.89	198.5	.792
88	17	14.6	13.69	3.11	223.0	.823	13.02	2.86	196.0	.793
89	17.5	15.7	13.40	2.97	213.5	.828	12.75	2.715	188.1	.812
90	18	15.7	12.45	2.65	184.3	.811	11.85	2.35	162.4	.823
91	18.5	14.0	11.76	2.28	164.4	.854	11.18	2.07	144.6	.830
92	18	15.7	11.45	2.34	155.9	.795	10.90	1.97	137.5	.836
93	18.5	15.7	10.77	2.07	137.9	.807	10.25	1.87	121.6	.793
94	18.5	15.7	9.56	1.654	108.7	.815	9.10	1.52	95.8	.787
95	18.5	15.7	8.54	1.389	86.7	.798	8.12	1.43	76.2	.685
96	18.5	15.7	7.65	1.099	69.5	.831	7.28	1.016	61.3	.800
97	18.5	14.0	7.08	0.951	59.6	.840	6.73	0.850	52.4	.837
98	17.5	14.6	6.70	0.851	53.4	.860	6.38	.788	47.0	.820
99	18.5	14.0	5.97	.725	42.3	.820	5.68	.657	37.3	.801
100	19	15.7	5.21	.586	32.2	.792	4.96	.529	28.5	.783
101	19	15.7	3.76	.320	16.76	.820	3.58	.307	14.8	.760
102	19.5	15.7	3.64	.300	15.75	.821	3.47	.290	13.9	.754
103	18.5	15.2	2.55	.1625	7.73	.822	2.43	.204	6.83	.583
104	19	15.2	2.37	.1560	6.67	.750	2.26	.151	5.91	.690
105	19	15.2	2.38	.145	6.73	.812	2.265	.139	5.94	.752
106	18.5	15.2	2.01	.105	4.80	.839	1.91	.1024	4.22	.762
107	19	14.6	1.43	.0524	2.43	.863	1.36	.049	2.14	.780
108	20	15.1	1.06	.0225	1.33	.813	1.01	.033	1.18	.485
109	19.5	16.3	0.66	.0295	0.518	.344	0.628	.019	0.456	.481
110	18	20.2	13.85	3.25	228.0	.787	13.18	2.973	201.0	.764
111	18	21.9	12.70	2.83	192	.775	12.08	2.58	169.0	.751
112	18.5	21.3	11.95	2.52	170	.777	11.37	2.28	150.0	.765
113	18.5	21.3	10.80	2.135	138.6	.773	10.28	1.935	122.3	.753
114	18	20.2	9.45	1.71	106.2	.763	8.99	1.528	93.5	.758
115	19	21.9	8.19	1.283	79.6	.784	7.79	1.162	70.0	.768
116	18	20.2	7.55	1.183	67.8	.752	7.18	1.117	59.6	.700
117	18.5	21.3	6.91	0.930	56.8	.808	6.58	0.870	50.1	.769

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
118	18.5	21.3	6.03	.745	43.3	.797	5.74	.673	38.1	.782
119	18.5	20.2	5.26	.583	32.9	.801	5.01	.570	29.0	.728
120	18.5	21.9	3.85	.359	17.62	.750	3.66	.367	15.5	.650
121	18.5	21.9	3.70	.288	16.30	.876	3.52	.337	14.33	.662
122	18	20.2	2.59	.1525	7.98	.892	2.46	.182	7.00	.659
123	19	20.2	2.52	.1472	7.55	.875	2.40	.171	6.66	.670
124	19	20.2	2.385	.1215	6.77	.962	2.27	.175	5.96	.592
125	18	21.9	3.85	.342	17.62	.792	3.67	.330	15.58	.726
126	18.5	21.9	3.66	.306	15.93	.805	3.48	.298	14.01	.732
127	19.5	20.2	2.60	.1645	8.04	.826	2.47	.1677	7.06	.715
128	19	20.8	2.43	.143	7.02	.845	2.31	.1483	6.18	.719
129	19	20.8	1.95	.0935	4.52	.880	1.855	.1027	3.98	.709
130	19	20.8	1.76	.075	3.68	.913	1.675	.0857	3.24	.709
131	19	20.2	1.40	.048	2.33	.855	1.33	.0556	2.05	.629
132	19.5	20.2	1.37	.0327	2.23	1.200	1.305	.0463	1.97	.710
133	19.5	20.8	1.304	.0249	2.02	1.275	1.24	.0440	1.78	.613
134	19.5	20.2	1.07	.0172	1.361	1.065	1.02	.0370	1.203	.438
135	19.5	20.2	0.925	.0250	1.018	.592	0.880	.0355	0.895	.361
136	19.5	20.8	0.970	.0155	1.119	.985	0.923	.0370	0.986	.369
137	19.5	20.2	1.35	.0327	2.160	1.125	1.285	.0425	1.91	.725
138	19.5	21.3	1.29	.0300	1.970	1.020	1.230	.0426	1.75	.613
139	20	19.1	0.972	.0250	1.124	.617	0.925	.0278	0.990	.490
140	20	20.2	0.533	.0172	0.634	.636	0.695	.0285	0.559	.347
141	18	23.5	13.52	3.23	217.0	.750	12.87	2.94	191.0	.732
142	18	23.5	12.95	2.98	199.5	.761	12.35	2.68	176.0	.745
143	18.5	23.5	12.30	2.66	180.0	.775	11.70	2.42	158.2	.748
144	18.5	24.1	11.33	2.36	152.5	.752	10.80	2.12	134.5	.745
145	18.5	24.6	10.71	2.10	136.5	.767	10.20	1.93	120.0	.737
146	19.0	23.5	10.12	1.939	121.8	.750	9.65	1.735	107.5	.745
147	19.0	23.5	9.41	1.664	105.2	.770	8.96	1.510	93.0	.752
148	18.5	22.4	7.65	1.117	69.5	.804	7.27	1.005	61.1	.791
149	19.0	24.1	6.77	0.921	54.5	.782	6.44	0.834	48.0	.766

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concentration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow		
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor
150	19	24.1	6.56	.883	51.2	.773	6.25	.804	45.1	.754
151	19	23.5	5.78	.694	39.8	.787	5.51	.628	35.1	.770
152	19	23.5	5.35	.611	34.0	.779	5.08	.571	29.8	.735
153	19	24.1	3.83	.328	17.4	.805	3.64	.321	15.35	.730
154	19	23.5	3.67	.311	16.0	.791	3.49	.288	14.1	.760
155	19	23.5	2.59	.167	7.96	.797	2.46	.159	7.0	.745
156	18.5	23.5	2.50	.157	7.43	.805	2.38	.149	6.53	.756
157	19	23.5	2.40	.146	6.85	.802	2.29	.139	6.05	.748
158	19	23.5	1.955	.0975	4.53	.839	1.86	.0809	4.00	.898
159	19	23.5	1.780	.0710	3.75	.973	1.69	.0648	3.31	.950
160	19	23.5	1.553	.051	2.86	1.042	1.48	.0526	2.53	.890
161	19	23.5	1.360	.0402	2.20	.915	1.295	.0434	1.935	.713
162	19	23.5	1.320	.0371	2.07	.870	1.255	.0418	1.820	.654
163	19	22.4	1.043	.0243	1.295	.713	0.993	.0296	1.140	.519
164	18.5	26.7	13.35	3.17	212	.742	12.70	2.92	187.0	.713
165	18.5	27.8	12.80	2.81	195	.780	12.18	2.64	172.0	.730
166	18.5	27.3	12.10	2.665	174	.740	11.51	2.42	153	.725
167	18.5	26.7	11.26	2.38	150.8	.733	10.72	2.15	133	.720
168	19	27.3	10.51	2.175	131.4	.708	10.00	1.940	116	.703
169	19	26.7	10.18	1.93	123.2	.755	9.69	1.762	108.6	.734
170	19	26.7	9.31	1.64	103.1	.761	8.86	1.504	90.8	.735
171	19	27.8	8.10	1.278	78.0	.765	7.71	1.195	68.7	.720
172	18.5	26.7	7.73	1.119	71.1	.810	7.36	1.032	62.7	.777
173	18.5	27.3	6.86	0.992	56.0	.795	6.53	0.841	49.3	.775
174	18.5	28.3	6.10	0.713	44.2	.835	5.80	0.662	38.9	.795
175	18	27.8	5.60	0.656	37.3	.783	5.33	.605	32.9	.753
176	18.5	27.8	5.15	.573	31.5	.772	4.90	.492	27.8	.800
177	18.5	27.8	3.89	.341	18.0	.795	3.70	.325	15.9	.742
178	18	27.8	3.64	.307	15.75	.787	3.46	.294	13.85	.730
179	18.5	27.8	2.585	.159	7.94	.832	2.46	.1122	7.00	1.045
180	19	26.2	2.50	.1545	7.43	.822	2.38	.1585	6.55	.710
181	18.5	27.8	2.49	.149	7.37	.835	2.37	.1076	6.49	1.02
182	19	26.7	2.42	.1325	6.97	.891	2.30	.1116	6.12	.935

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concentration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow			96
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor	
184	19	27.3	1.76	.0595	3.69	1.136	1.675	.0660	3.25	.910	
185	19	27.3	1.545	.045	2.84	1.163	1.470	.0545	2.50	.840	
186	19	26.7	0.882	.0268	0.925	0.499	0.839	.0325	0.815	.370	
187	19	27.3	1.313	.0350	2.05	.900	1.249	.0477	1.800	.555	
188	19	26.7	1.040	.0284	1.29	.605	0.990	.0355	1.134	.425	
189	19.5	26.7	0.980	.0276	1.141	.554	0.933	.0340	1.006	.402	
190	19	26.7	2.375	.1325	6.71	0.862	2.26	.0910	5.91	1.107	
191	19	26.2	1.915	.0715	4.36	1.100	1.822	.0756	3.84	0.920	
192	19	26.2	1.765	.0576	3.71	1.185	1.68	.0612	3.26	.985	
193	19	26.2	1.540	.0500	2.82	1.036	1.465	.0543	2.48	.835	
194	19	26.7	1.345	.0428	2.15	0.808	1.28	.0454	1.895	.645	
195	19	26.2	1.325	.0417	2.09	.781	1.261	.0444	1.840	.628	
196	19	26.2	1.050	.0341	1.311	.510	0.999	.0360	1.155	.429	
197	19	26.7	0.980	.0328	1.14	.470	0.933	.0318	1.006	.432	
198	20	26.7	0.764	.0253	0.693	.445	0.727	.0287	0.612	.354	
199	19	32.0	13.43	3.125	214.5	.750	12.78	2.86	189	.720	
200	19	32.0	12.06	2.47	173.0	.782	11.48	2.23	152.5	.770	
201	18.5	31.5	10.87	1.949	140.4	.830	10.34	1.79	124.0	.808	
202	19	32.0	10.55	1.952	132.3	.784	10.04	1.78	116.6	.764	
203	18	31.5	7.70	1.028	70.5	.863	7.33	0.958	62.1	.825	
204	18	32.5	6.62	.816	52.1	.701	6.30	.844	45.9	.715	
205	18	32.0	5.66	.654	38.0	.790	5.39	.608	33.6	.755	
206	18.5	31.0	3.86	.213	17.7	1.24	3.67	.205	15.6	1.145	
207	18.5	32.0	3.64	.181	15.75	1.32	3.47	.1826	14.0	1.156	
208	18	31.5	2.59	.1155	7.98	1.14	2.47	.1265	7.05	0.929	
209	18.5	32.0	2.47	.1085	7.25	1.113	2.35	.1182	6.39	.905	
210	18.5	32.0	2.37	.109	6.68	1.03	2.26	.1145	5.88	.868	
211	19	31.5	1.86	.0835	4.11	0.877	1.77	.092	3.62	.705	
212	19	32.0	1.70	.0760	3.44	.825	1.618	.0928	3.03	.600	
213	19	31.0	1.49	.058	2.64	.816	1.420	.0800	2.33	.515	
214	19	31.0	1.30	.053	2.01	.565	1.237	.0748	1.77	.340	
215	19	32.0	1.25	.0465	1.855	.564	1.190	.0732	1.643	.309	

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
216	19.5	32.0	1.065	.039	1.35	.450	1.015	.0515	1.19	.301
217	19.5	32.5	0.987	.036	1.158	.425	0.939	.0488	1.02	.277
218	19	32.0	0.934	.033	1.037	.426	.889	.0463	0.914	.274
219	19	32.5	0.709	.029	0.598	.362	.674	.0354	.525	.268
220	19.5	32.0	0.565	.0225	0.379	.368	.538	.0290	.334	.259
221	18	33.5	13.05	3.09	202.0	.715	12.40	2.81	178.2	.700
222	18	33.5	12.60	2.81	189.0	.742	12.00	2.54	166.6	.729
223	18.5	33.5	12.08	2.55	173.6	.756	11.50	2.32	153.3	.740
224	19	34.0	11.40	2.23	154.6	.777	10.95	2.06	138.8	.763
225	19	34.0	10.50	2.01	130.8	.746	10.00	1.81	115.7	.739
226	19	34.5	10.20	1.786	123.7	.800	9.70	1.65	108.8	.770
227	19	35.1	9.33	1.564	103.6	.782	8.90	1.416	91.6	.770
228	19	34.0	8.50	1.212	86.0	.861	8.10	1.153	75.8	.799
229	19	34.5	7.39	0.956	64.8	.852	7.03	0.794	57.3	.905
230	19	35.1	7.05	.813	59.1	.920	6.70	.654	51.9	1.01
231	19	34.5	6.50	.733	50.2	.885	6.19	.576	44.3	1.00
232	19	34.0	6.14	.614	44.8	.959	5.84	.399	39.5	1.31
233	19	34.0	5.47	.350	35.6	1.370	5.21	.373	31.4	1.26
234	19	34.5	3.87	.2025	17.8	1.295	3.68	.1973	15.7	1.18
235	19	34.5	3.64	.1905	15.75	1.235	3.47	.1847	13.9	1.135
236	19	35.1	2.55	.1235	7.73	1.020	2.425	.1348	6.8	0.824
237	19	35.1	2.46	.117	7.19	1.015	2.34	.1289	6.34	.815
238	19	34.0	2.36	.115	6.61	0.962	2.245	.1163	5.83	.840
239	19	34.5	1.86	.086	4.11	.845	1.770	.091	3.62	.706
240	19	34.5	1.715	.0785	3.50	.798	1.633	.088	3.09	.636
241	19.5	34.5	1.30	.0535	2.01	.567	1.237	.0627	1.770	.406
242	19	34.5	1.275	.0535	1.93	.517	1.214	.0627	1.700	.378
243	19	34.5	1.12	.0355	1.49	.547	1.066	.0635	1.314	.270
244	19	39.1	13.65	2.93	221.0	.793	13.0	2.67	195.0	.780
245	19	39.6	13.00	2.68	201.0	.794	12.38	2.43	177.0	.790

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Mean Velocity of Mixture (fps)	Upward Flow			Mean Velocity of Mixture (fps)	Downward Flow			∞
				Head Loss (ft/ft)	Froude No.	Z-factor		Head Loss (ft/ft)	Froude No.	Z-factor	
246	19	39.6	12.50	2.49	185.0	.800	11.87	2.21	162.5	.805	
247	20	39.1	11.75	2.31	164.0	.779	11.20	2.11	144.5	.795	
248	19.5	38.6	10.93	2.05	142.6	.775	10.4	1.81	125.0	.777	
249	19.5	39.1	10.75	1.734	137.5	.890	10.25	1.60	121.5	.862	
250	19.5	39.1	9.80	1.184	114.0	1.11	9.30	1.20	100.0	.965	
251	19.5	37.1	8.90	0.799	94.0	1.395	8.45	0.673	82.7	1.47	
252	19	38.1	7.44	.560	65.8	1.440	7.08	.541	57.8	1.33	
253	19	39.6	7.14	.462	60.6	1.62	6.78	.443	53.2	1.50	
254	19	39.1	6.15	.400	45.0	1.44	5.84	.383	39.4	1.34	
255	19.5	39.1	5.40	.328	34.6	1.405	5.13	.323	29.3	1.21	
256	19.5	38.1	3.81	.233	17.2	1.07	3.63	.2315	15.2	0.965	
257	19	38.1	3.61	.217	15.5	1.055	3.44	.212	13.65	.958	
258	19	38.1	2.54	.140	7.66	0.885	2.42	.145	6.77	.760	
259	19.5	37.1	2.465	.1365	7.23	.863	2.35	.144	6.37	.724	
260	19	37.1	2.320	.1285	6.40	.825	2.21	.138	5.65	.680	
261	19.5	37.1	1.84	.093	4.02	.758	1.75	.100	3.54	.621	
262	19.5	37.1	1.715	.087	3.49	.719	1.635	.093	3.08	.593	
263	19.5	37.1	1.440	.0755	2.47	.568	1.37	.0805	2.17	.461	
264	20	37.1	1.275	.063	1.93	.451	1.215	.0701	1.705	.347	
265	20	37.1	1.230	.0645	1.80	.391	1.170	.0687	1.583	.314	
266	20	43.3	14.45	2.21	248.5	1.16	13.78	2.11	219.0	1.075	
267	20	43.3	14.00	1.93	233.0	1.26	13.15	1.69	200.0	1.24	
268	20	42.1	13.38	1.70	212.0	1.315	12.72	1.455	187.2	1.36	
269	20	43.1	11.95	1.44	170.0	1.27	11.35	1.237	149.0	1.305	
270	20	42.1	10.95	1.205	142.8	1.31	10.42	1.065	137.2	1.435	
271	20	43.1	9.97	1.046	118.2	1.275	9.5	0.937	104.2	1.26	
272	20	42.1	8.46	0.843	85.1	1.29	8.05	.772	75.0	1.15	
273	20	43.6	7.35	.694	64.2	1.125	6.81	.629	53.6	1.06	
274	20	42.1	6.55	.597	50.9	1.07	6.24	.545	45.0	1.045	
275	20	42.1	5.50	.477	35.9	0.985	5.23	.445	31.7	.938	

Table VIII.(cont.)

Ref. No.	Temp. (°C)	Concen- tration (%)	Upward Flow				Downward Flow			
			Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor	Mean Velocity of Mixture (fps)	Head Loss (ft/ft)	Froude No.	Z-factor
276	20	42.1	4.72	.402	26.4	.897	4.48	.373	23.25	.855
277	20	42.1	3.35	.257	13.35	.769	3.185	.260	11.75	.672
278	19	42.6	3.45	.267	14.20	.785	3.29	.285	12.50	.652
279	19.5	41.1	2.505	.184	7.45	.649	2.38	.192	6.54	.552
280	20	42.6	2.29	.165	6.24	.615	2.18	.183	5.49	.491
281	20	42.6	2.26	.157	6.06	.628	2.15	.176	5.34	.499
282	20	42.6	1.742	.114	3.60	.550	1.657	.131	3.17	.424
283	19.5	43.3	1.635	.108	3.17	.520	1.555	.126	2.80	.393
284	24	46.0	13.55	2.20	218.0	1.005	12.85	1.92	191.0	1.016
285	24	46.9	12.78	2.02	193.5	0.977	12.15	1.75	170.5	1.010
286	24	46.9	12.15	1.84	175.0	.988	11.55	1.613	154.5	1.000
287	24	46.0	10.93	1.62	142.0	.935	10.40	1.371	125.0	.980
288	24	46.9	9.87	1.445	115.5	.870	9.38	1.233	101.5	.905
289	24	46.9	8.92	1.186	94.5	.898	8.49	1.035	83.3	.905
290	24	46.9	7.31	0.92	63.5	.813	6.95	.862	56.0	.770
291	24	46.0	6.86	.833	56.0	.805	6.54	.747	49.4	.800
292	24.5	46.0	5.65	.654	37.9	.716	5.36	.586	33.3	.716
293	24.5	46.0	4.73	.553	26.6	.632	4.51	.528	23.5	.588
294	24.5	46.0	4.38	.446	22.8	.683	4.17	.462	20.1	.587
295	24.0	46.0	3.50	.358	14.55	.576	3.34	.341	12.9	.540
296	24.5	46.0	3.32	.331	13.05	.563	3.15	.321	11.5	.515
297	24.5	46.0	2.40	.210	6.85	.505	2.28	.223	6.01	.415
298	24.5	46.0	2.33	.208	6.46	.483	2.22	.211	5.71	.425
299	24.5	46.0	2.15	.188	5.49	.466	2.045	.194	4.84	.400
300	24.5	46.0	1.662	.149	3.28	.374	1.580	.146	2.89	.339
301	24.5	46.0	1.555	.1265	2.86	.393	1.475	.139	2.52	.316