UNIVERSITY OF ALBERTA

MEASUREMENT OF LOCAL SOLIDS CONCENTRATION IN A SLURRY MIXING TANK

BY

ROBERT SCOTT MacTAGGART

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF CHEMICAL ENGINEERING

EDMONTON, ALBERTA
FALL 1991

ISBN 0-315-69978-7

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: Robert Scott MacTaggart

TITLE OF THESIS: Measurement of Local Solids Concentration in a Slurry Mixing Tank

DEGREE: Master of Science

YEAR THIS DEGREE GRANTED: 1991

(signed) ....

Permanent Address:
5322-50 Street
Camrose, Alberta, Canada
T4V 1R6

Date: ....

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Measurement of Local Solids Concentration in a Slurry Mixing Tank** submitted by Robert Scott MacTaggart in partial fulfillment of the requirements for the degree of Master of Science.

....

Dr. J.H. Masliyah

....

Dr. H.A. Nasr-El-Din

....

Dr. J.T. Ryan

....

Dr. C.A. Shook

....

Dr. P.M. Steffler

Date: October 1, 1991

To my dear wife Peggy for her patience and devotion during the course of this work.

ABSTRACT

Local solids concentration in a mechanically agitated slurry mixing tank has usually been measured by the withdrawal of a sample from the vessel. The accuracy of this method has been in question for a number of years and has been found to be a function of the sample tube geometry, sampling velocity, position in the vessel and slurry properties. The measurement of the true local solids concentration in slurry mixing tanks suffers from the lack of a reliable measurement technique.

A novel conductivity probe was developed for measuring local solids concentrations in slurries. It was found to be a suitable method for measuring more concentrated slurries where methods such as optical techniques fail.

Comparison of solids concentration measurements obtained by the sample withdrawal technique and from the conductivity probe showed that significant errors can result with the former. Although the flow profile is relatively well defined in some regions of the mixing tank, the local solids concentration cannot be predicted with correlations from the literature.

ACKNOWLEDGEMENTS

I would like to thank Keith, Ron, Bob and John in the Chemical Engineering machine shop and Don and Walter in the electronics shop for their help in assembling and modifying the equipment.

Dr. Jacob Masliyah deserves many thanks for his encouragement and guidance in the completion of this thesis.

I would like to thank Syncrude Canada Ltd. for allowing me the time to complete this work.

Finally, and most of all, I would like to sincerely thank Dr. Hisham Nasr-El-Din for his patience, guidance and many fruitful discussions during the course of this work.

TABLE OF CONTENTS

Page

Page

Page

Page

LIST OF TABLES

Table	Description	Page

LIST OF FIGURES

Figure Caption Page

Figure	Caption	Page

Figure Caption Page

Figure Caption Page

Figure Caption Page

Figure Caption Page

Figure Caption Page

NOMENCLATURE

The most commonly used symbols are described below. Others are defined where they occur in the text.

Symbol	Description	Units
a	constant in Equation 4.3	-
b	exponent in Equation 4.3	-
B	baffle width	m
B_1	constant in Equation 2.3	-
C_B	bulk particle volume concentration	volume fraction
C_0	local particle volume concentration	volume fraction
C_S	sample particle volume concentration	volume fraction
C_1	constant in Equation 2.10	-
d	diameter	μm
D	impeller diameter	m
E	voltage	mV
g	gravitational acceleration	m/s^2
h	impeller height above tank bottom	m
H	total liquid height in mixing tank	m
I	current	mA
I^*	light intensity	cd
k	electrical conductivity	$ohm^{-1}m^{-1}$
k_1	constant in Equations 2.4 and 2.5	-
k_2	constant in Equations 2.8 and 2.9	-
k_3	constant in Equation 2.23	-
K	particle inertia parameter	-
l	impeller blade length	m

Symbol	Description	Units
L	length of measurement section	m
m	exponent in Equation 2.17	-
M	mass	kg
N	mixer speed	rpm
r	radial distance from center of mixing tank	m
R	mixing tank radius	m
R'	electrical resistance	ohm
s	particle density / liquid density	-
S	dimensionless constant accounting for geometry in Equation 1.1	-
t	temperature	°C
T	mixing tank diameter	m
U_B	pipeline bulk velocity	m/s
U_0	local upstream velocity	m/s
U_S	sampling velocity	m/s
V	volume	m^3
w	impeller blade width	m
x	distance	m
X	weight percent solids	-
X_1	width of the annulus containing particles which do not enter the sample tube (Equation 2.7)	mm
Y	position	m
Y_1	width of the annulus containing particles which do enter the sample tube (Equation 2.6)	mm
z	axial height in mixing tank	m
z_1	sample tube insertion length from the mixing tank wall (Equation 2.10)	m

Symbol	Description	Units

Greek Symbols

α	solids conductivity / liquid conductivity	-
α_1	angle of inclination	degree
β	angle of sample tube face	degree
γ	angle of sample tube tip	degree
δ	relative sample tube thickness (Wall Thickness/Sample Tube Radius)	-
ϵ	molar absorption coefficient	-
θ	angular position in mixing tank	degree
μ	viscosity	Pa.s
ν	kinematic viscosity	m^2/s
π	3.1415926 ...	-
ρ	density	kg/m^3
τ	time	s
ϕ	sample tube inside diameter	mm
$\sum$	sum of a series	-

Subscripts

B	ballast	-
C	with solids	-
JS	just suspended	-
L	liquid	-

Symbol	Description	Units
M	mixture	-
0	liquid only	-
P	particle	-
S	sample	-
T	total	-
W	water (liquid)	-
50	mean particle size; 50% cumulative weight percent retained	-

1. INTRODUCTION

1.1 Introductory Comments

Mixing is a common unit operation in the process and mineral industries. The suspension of solids in a liquid within a stirred vessel is used in crystallization, leaching and reactions utilizing a solid catalyst (Baldi et al., 1981). The stirred vessel is the most common reactor for polymerization reactions (Gerstenberg et al., 1983) due to its:

- suitability for batch and continuous operation.
- wide applicability from the laboratory to large scale.
- flexibility of mode of operation.
- standard construction.
- relatively simple conversion to other product types

Mixing vessels are also very common in gassed processes such as hydrogenation and oxidation reactors, fermentation, waste water treatment, evaporative crystallization and froth flotation (Chapman et al., 1983a,b).

Recent reviews have shown that even though mixing has been well studied for many years, there are still many areas that need to be examined. Classical areas for research, such as mixer power consumption, are of lesser importance today for some industries than are areas of mixer design which directly affect the product generated (Carpenter, 1985). Ford et al. (1985) state that "if better mixing will achieve a 1% yield improvement, then the mixer can be over-designed by 10,000% before the extra energy cost negates the chemical saving".

An important slurry mixing process parameter is the degree of solids suspension. This is characterized by on-bottom motion of the solids, off-bottom motion or complete uniformity (Oldshue, 1983). Off-bottom suspension is commonly referred to as the point where all particles are in motion off the vessel bottom with some velocity. It is a good indicator of optimal liquid-solid mass transfer versus power consumption (Oldshue, 1983). The point of off-bottom suspension has been extensively examined for many systems. The Zweitering correlation (Zweitering, 1958) (Equation 1.1) provides the best prediction due to the wide range of variables covered (Nienow, 1985; Nienow et al., 1986).

$$N_{JS} = \frac{S\ \nu_L^{0.1}\ d_P^{0.2} \left[\frac{g\ (\rho_P - \rho_L)}{\rho_L}\right]^{0.45} X^{0.13}}{D^{0.85}} \qquad (1.1)$$

where:

d_P = particle size (m)

D = impeller diameter (m)

g = gravitational acceleration (m/s^2)

N_{JS} = just suspended mixer speed (1/s)

S = dimensionless constant accounting for geometry

X = weight percent solids

ρ_L = liquid density (kg/m^3)

ρ_P = particle density (kg/m^3)

ν_L = kinematic liquid viscosity (m^2/s)

Information on solids distribution in mechanically stirred vessels is relatively scarce, but is very important in processes such as crystallization (Kipke, 1983). Classical sampling is the removal of a small sample from the system. It has been used as a means of measuring suspension uniformity or local solids concentration due to its simplicity. However, representative samples are extremely difficult to withdraw from a mixing tank (Nienow, 1985) because of inertia differences between the fluid and particles of different size or density (Smith, 1990). Despite this serious shortcoming, sample withdrawal continues to be used as a method of determining local solids concentration in mixing tanks. Table 1.1 shows that of the mixing systems reviewed, sampling was used by more than 50% of the investigators to determine the concentration of the dispersed phase.

Other methods are available for measuring local solids concentrations in slurry mixing tanks. Optical methods have been used (Bohnet and Niesmak, 1980; Tojo and Miyanami, 1982; Fajner et al., 1985; Yamazaki et al., 1986; Ayazi Shamlou and Koutsakos, 1989; Magelli et al., 1990) but are generally limited to solids concentrations less than one or two percent. Conductivity methods were used by Machon et al. (1982) and Rieger et al. (1988) and were able to measure a wide range of solids concentrations. The liquid conductivity must generally be known and it varies widely with a number of factors.

1.2 Objectives

The objectives of this study are to:

- Determine the reliability of local solids concentration measurements by sample withdrawal from a slurry mixing tank under a variety of sampling and mixing conditions.

- Develop and test a new conductivity method for measuring local solids concentration.

- Measure and analyze sampling errors from a slurry mixing tank by comparing sampling and conductivity measured solids concentration results.

- Investigate the conditions for which sampling can provide reliable local solids concentration measurements from a slurry mixing tank.

Filename: TAB-A2.WK1

TABLE 1.1
REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
McLaren White et al. (1932)	1.32	0.46		0.48	Radial	Paddle		0.08	0.14	N/A	N/A	Sampling
Zweitering (1958)	0.15 0.19 0.24 0.29 0.45 0.60	1.00	Flat	Various	Radial Radial Axial	2-Paddle Vaned Disc 6-Blade Prop	Various	Various	N/A	4	0.10	N/A
Rushton (1965)	0.31	1.00	N/A	0.33	Radial	Rushton	0.33	N/A	N/A	4	N/A	Sampling
Nienow (1968)	0.14	1.00	Flat	0.26-0.52	Radial	6-Blade	0.14-0.33	0.25	0.20	4	0.10	N/A
Randolph and Iskander (1968)	0.37	1.00	Inverted Dish	0.28	Mixed	6-Blade 45 Degree	0.28	N/A	N/A	4	0.09	Sampling
Rehakova and Novosad (1971b)	0.30	1.00	N/A	0.31	Radial		0.31	N/A	N/A	4	0.08	Sampling
Weinstein and Treybal (1973)	0.31	1.00	N/A	0.50	Radial	6-Blade	N/A	N/A	N/A	4	0.16	N/A
Nienow and Wisdom (1974)	0.29	1.00	N/A	0.24-.72	Radial	Rushton	0.25	N/A	N/A	4	0.10	N/A
Musil (1976)	0.60	1.00	Conical	0.25-0.53	Axial	3-Blade 24 Degree 6-Blade 45 Degree	N/A	N/A	N/A	4	N/A	Optical

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED

REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Baldi et al. (1978)	0.12 0.19 0.23	1.00 1.00 1.00	Flat	0.20–0.33	Radial	8–Blade	0.10–0.66	0.25	0.25	4	0.10	N/A
Musil and Vlk (1978)	0.60		Conical	0.25–0.53	Axial	3–Blade 24 Degree	N/A	N/A	N/A	N/A	N/A	Conductivity
Van der Molen and Van Maanen (1978)	0.12 0.29 0.90	1.00 1.00 1.00	Flat Flat Flat	0.33	Radial	Rushton 6–Blade	0.10–0.50	0.25	0.20	4	0.10	N/A
Bertrand et al. (1980)	0.40	1.00	Flat	0.33	Radial	6–Blade	0.30–0.50	0.25	0.20	4	0.10	N/A
Bohnet and Niesmak (1980)	0.29	1.05	Flat	N/A	Axial	Prop 2–Blade	N/A	N/A	N/A	4	N/A	Optical
Einenkel (1980)	0.79	1.00	N/A	0.32	Axial	Prop	0.23	N/A	N/A	N/A	N/A	N/A
Sharma and Das (1980)	0.31 0.46	1.00 1.00	Flat Flat	0.33	Radial	Rushton 6–Blade	0.33	N/A	N/A	4	N/A	Sampling
Weidmann et al. (1980)	0.20 0.45	1.00 1.00	Dished	0.33	Axial	Prop 3–Blade	0.50	N/A	N/A	4	0.10	N/A
Baldi et al. (1981)	0.18	1.00	Flat	0.27	Radial	8–Blade	0.20	0.25	0.25	4	0.10	Sampling

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED
REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Bourne et al. (1981)	0.15	N/A	N/A	0.34	Radial	Rushton 6–Blade	0.66	N/A	0.20	4	0.10	N/A
Chudacek (1982)	1.00	1.00	N/A	0.33	Axial	Prop 3–Blade	0.25	N/A	N/A	N/A	0.10	N/A
Cliff et al. (1981)	0.91	1.00	Flat Dished	0.34	Axial	Prop 3–Blade	0.25–0.33	N/A	N/A	4	0.08	Optical
Oldshue (1981)	0.76	N/A	Dished	0.30	Axial	4–Blade 45 Degree	0.10	N/A	0.20	N/A	N/A	Sampling
Machon et al. (1982)	0.29	1.00	Conical	0.33–0.40	Axial	6–Blade 45 Degree	N/A	N/A	N/A	4	0.10	Conductivity
Rieger and Ditl (1982)	0.15 0.20 0.30 0.40	1.00 1.00 1.00 1.00	Flat	0.17–0.50	Radial Axial	N/A	0.06–0.75	0.25	0.20	N/A	N/A	N/A
Tojo and Miyanami (1982)	0.10 0.20 0.30	1.00 1.00 1.00	Flat	0.14–0.42 0.50–0.80	Axial Vib. Disc	Prop 4–Blade	N/A	N/A	N/A	N/A	N/A	Optical
Chapman et al. (1983)	0.29 0.56 1.83	N/A	Flat	0.14–0.28 0.07–0.90	Radial	Rushton 6–Blade Various	0.25	0.25	0.20	4	0.10	N/A

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED
REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Hong and Lee (1983)	0.29 0.39	N/A	Flat	N/A	Radial	6–Blade	N/A	N/A	N/A	4	N/A	Optical
Edwards and Ellis (1984)	1.22	0.94	N/A	0.31 0.37	Axial Radial	Prop 6–Blade	N/A	0.25	0.15	Various	0.10	N/A
Nienow and Kuboi (1984)	0.29	1.00	N/A	0.50	Mixed Radial	6–Blade 45 Degree Rushton 6–Blade		0.25	0.17	4	0.10	N/A
Chudecek (1985)	0.50	1.00	Various	0.33	Axial	Prop	0.08–0.50	N/A	N/A	4	0.10	N/A
Fajner et al. (1985)	0.13	4.00	Flat	0.30	Radial	Rushton Multiple	N/A	0.25	0.20	4	0.10	Optical
Laufhutte and Mersmann (1985a,b)	N/A	1.00	N/A	0.33	Radial	Rushton 6–Blade	0.10–0.50	N/A	N/A	N/A	0.10	N/A
Wiedmann et al. (1985)	0.20 0.70 1.50	1.00 1.00 1.00	N/A	0.33	Axial Radial	Prop 6–Blade	N/A	N/A	N/A	N/A	N/A	N/A
Buurman et al. (1986)	0.48 4.26	1.00 1.00	Ellipse	0.40	Axial	4–Blade 45 Degree	0.33	N/A	N/A	4	0.10	Sampling

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED

REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Cloete and Coetzee (1986)	0.14	1.00	Conical									
	0.42	1.00		0.48	Axial	4-Blade 45 Degree	0.25	N/A	N/A	4	0.08	N/A
				0.40		5-Blade						
				0.48		5-Blade						
	0.90	1.00		0.34		4-Blade 45 Degree				4	0.10	
				0.34	Radial	4-Blade Paddle						
Middleton et al. (1986)	0.31	1.35		0.48	Radial	6-Blade	0.45	0.25	0.20	4	0.10	N/A
	0.91	1.00		0.33		6-Blade	0.51	0.25	0.20	4	0.11	
Yamazaki et al. (1986)	0.30	1.00	Flat	0.23	Radial	Rushton 6-Blade	N/A	N/A	N/A	N/A	N/A	N/A
				0.33	Axial	4-Blade Prop	0.3				0.10	Optical
Barresi and Baldi (1987a,b)	0.39	1.19	Torisph.	0.33	Axial	A-310 4-Blade 45 Degree	0.39	N/A	N/A	4	0.10	Sampling
					Mixed	6-Blade 45 Degree						
					Radial	Rushton						
Bourne and Dell'ava (1987)	0.15	1.00	Dished	0.34	Radial	6-Blade	0.33	0.25	0.20	N/A	0.10	N/A
	0.45	1.00	Dished	0.34		Rushton	0.33	0.25	0.20		0.10	

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED
REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Molerus and Latzel (1987)	0.19 0.45 1.50	1.00 1.00 1.00	N/A	0.32	Axial	Prop 3–Blade	0.32	N/A	N/A	4	N/A	Conductivity
Ayazi Shamlou and Zolfagharian (1988)	0.24	1.25	Flat	N/A	Axial	45–Degree	N/A	N/A	N/A	4	0.10	N/A
Costes and Couderc (1988)	0.44 0.63	1.00 1.00	N/A	0.33	Radial	Rushton 6–Blade	0.50	0.25	0.20	N/A	0.10	N/A
Ellis et al. (1988)	0.14	1.00	Flat	N/A	Radial	6–Blade	0.66	N/A	N/A	4	0.10	Optical
Geisler and Mersmann (1988)	N/A	1.00	Dished	0.35	Axial	Prop	0.33	N/A	N/A	4	0.10	N/A
Hemrajani et al. (1988)	0.20 0.30 0.50 0.90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Various	Various	N/A
Komori (1988)	0.29	2.41	Flat	0.50	Radial	4–Blade Paddle	N/A	N/A	0.20	4	0.10	N/A
Mann et al. (1988)	0.30	N/A	N/A	0.33	N/A	N/A	0.50	N/A	N/A	N/A	N/A	Optical
Mao and Yang (1988)	0.12	1.00	N/A	N/A	Radial	6–Blade	0.33	N/A	N/A	4	N/A	Optical

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED
REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Ostendorf and Mewes (1988)	0.10	1.07	N/A	N/A	Radial	Rushton 6–Blade	N/A	N/A	N/A	N/A	N/A	N/A
Raghava Rao et al. (1988)	0.30 0.40 0.57 1.00 1.50	1.00 1.00 1.00 1.00 1.00	Flat Flat Flat Flat Flat	Various Various	Radial Mixed	6–Blade 6–Blade	0.17–0.50	0.25	0.20	4	0.10	N/A
Rieger et al. (1988)	0.20 0.30 0.40	1.00 1.00 1.00	Flat Flat Flat	0.20–0.50	Mixed	6–Blade Pitched	0.50	N/A	N/A	N/A	0.10	Conductivity
Ayazi Shamlou and Koutsakos (1989)	0.23	3.00	Sphere	0.29–0.44	Mixed	6–Blade 45 Degree	N/A	N/A	0.16	4	0.10	Optical
Bakker and Frijlink (1989)	1.2	N/A	N/A	0.40	Radial Axial	6–Blade 6–Blade 45 Degree 60–Degree	0.50–0.65	N/A	N/A	4	0.10	N/A
Chatzi et al. (1989)	0.15	1.00	N/A	0.50	Radial	Rushton 6–Blade	0.33	0.25	0.20	4	0.10	N/A
Pandit et al. (1989)	0.29	1.00	N/A	0.33	Radial Axial	Various Various	0.33	N/A	N/A	4	0.10	N/A

N/A = Not Available; Not Applicable

TABLE 1.1 CONTINUED
REVIEW OF MIXING SYSTEMS AND CONCENTRATION MEASUREMENT TECHNIQUES

	TANK			IMPELLER				RADIAL IMPELLER BLADE DIMENSIONS		BAFFLES		
REFERENCE	DIAMETER (m)	LIQUID HEIGHT	BOTTOM SHAPE	DIAMETER	TYPE	DESCRIP.	HEIGHT ABOVE BOTTOM	LENGTH	WIDTH	NUMBER	WIDTH	CONC. MEASURE TECH.
SYMBOL	T	H/T		D/T			h/T	l/D	w/D		B/T	
Papastefanos and Shamaloudis (1989)	0.284 Rnd & Sqr	1.00	N/A	0.53	Radial	6–Blade Disc	N/A	0.25	0.20	4	0.10	N/A
						6–Blade Paddle			0.20			
					Axial	6–Blade 45 Degree			0.20			
Skelland and Moeti (1989)	0.21	1.00	N/A	0.28–0.47 0.30–0.47	Axial Radial	N/A	N/A	N/A	N/A	4	0.09	Conductivity
Magelli et al. (1990)	0.13	4.00	N/A	0.33–0.60	Radial	Rushton 6–Blade Multiple	N/A	0.25	0.20	4	0.10	Optical
Ranade and Joshi (1990)	0.30 0.50	N/A	N/A	0.33	Radial	Rushton 6–Blade	N/A	0.25	0.20	4	0.10	N/A

N/A = Not Available; Not Applicable

2. LITERATURE REVIEW

Concentration measurement techniques make use of a property that is significantly different for each phase including density, electrical conductivity, dielectric constant or absorption of electromagnetic radiation. The concentration of each phase can be determined with an appropriate calibration curve (Nasr-El-Din et al., 1987). Reviews of these techniques are given by Kakka and Phil (1974), Jones and Delhaye (1976), Debreczeni et al. (1978), Kao and Kazanskij (1979) and Baker and Hemp (1981).

This chapter outlines some of the techniques available for measuring the concentration of solids in a slurry. All the techniques determine the average concentration over a certain area or volume. The size of this area or volume can vary with the technique used. This section begins with a brief outline of the techniques that measure average concentration over a large volume of space and a chord length. Since the objective of this study is to measure the local solids concentration in a slurry mixing tank, a more detailed review of techniques that measure solids concentration over a small volume of space is discussed.

2.1 Solids Concentration Measurement Over a Large Volume of Space

Gravimetric devices in this category include the vertical counterflow meter, inclined pipe concentration meter and the straight pipe concentration meter (Debreczeni et al., 1978; Kao and Kazanskij, 1979) and are depicted in Figure 2.1. The first two methods use the pressure drop across a length of pipe (L) to determine the solids concentration in that volume of pipe. The straight pipe concentration meter directly measures the difference in weight of a given length of pipe due to the presence of solids (assuming the solids density is different than the liquid density).

Capacitance methods have been used to measure the void fraction in gas-liquid and gas-solids flows (Chun and Sung, 1986; Geraets and Borst, 1988; Barnes et al., 1990). These techniques require relatively large solids to air mass flow ratios

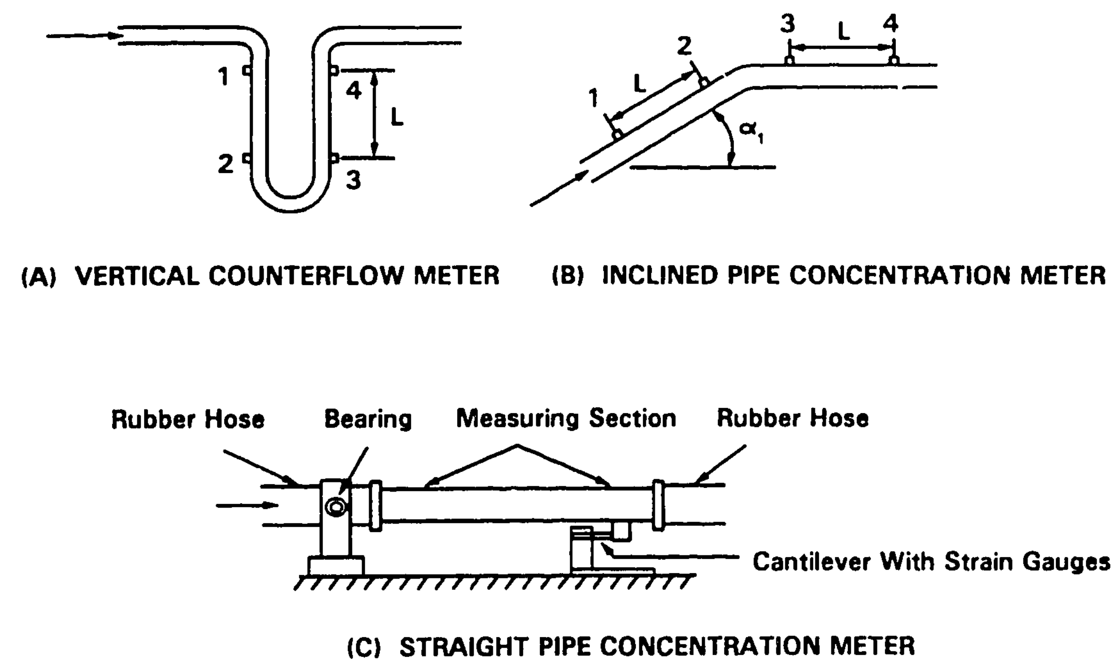


Figure 2.1: Concentration Measurement in a Large Volume of Space: Pressure Drop and Weighing Methods
Adapted From: Debreczeni et al. (1978) and Kao and Kazanskij (1979)

and gas-liquid methods tend to be sensitive to the flow pattern within the pipe.

Tournaire (1986) devised a conductivity probe with six flush mounted electrodes on a pipe driven by a rotating electric field that was relatively insensitive to the void fraction distribution in the gas-liquid flow. Most conductivity devices have electrodes in contact with the solution being measured. Electrodeless conductivity sensors have electrodes that are not in contact with the solution and are especially suited for very conductive or corrosive slurries, highly abrasive slurries or those containing fibrous material. In a typical instrument, shown in Figure 2.2, the sample flows through a pipe that is surrounded by two toroidal coils. One coil acts

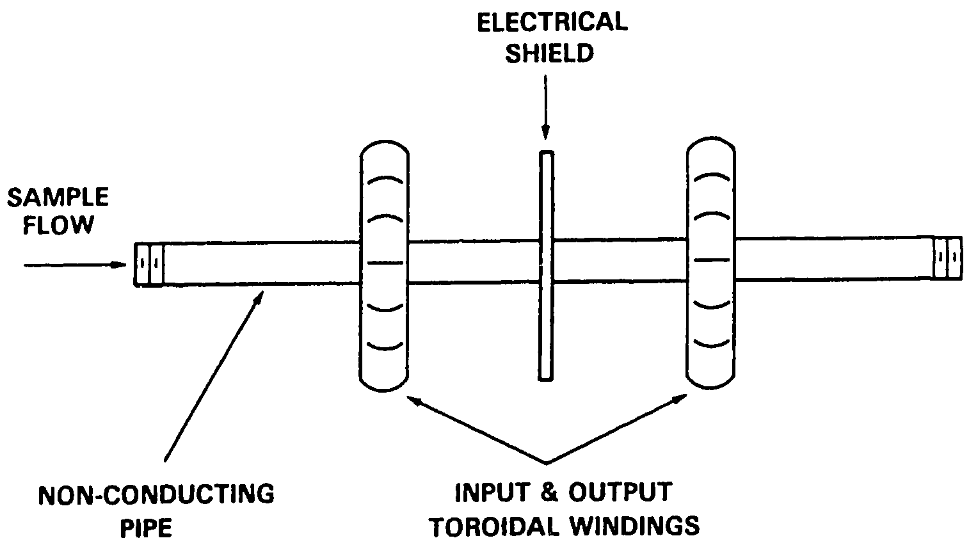


Figure 2.2: Electrodeless Conductivity Cell
Adapted From: Liptak and Venczel (1982)

as the transmitter and the other as the receiver (Perry and Chilton, 1973; Liptak and Venczel, 1982; Considine and Considine, 1985).

2.2 Solids Concentration Measurement Over a Chord Length

A variety of methods measure solids concentration over a chord extending through a pipe or vessel. Ong and Beck (1975) used ultrasonic sensors but found that the calibration curve was a function of flow velocity. Keska (1978) and Green and Cunliffe (1983) used capacitance methods in slurry systems. Peters and Shook (1981) measured the amplitude of voltage fluctuations from a vertically mounted magnetic flowmeter to determine the time averaged slurry solids concentration. They found however that the relationship with solids concentration was nonlinear.

Kao and Kazanskij (1979) discussed a method using a gamma ray gauge, neutron gauge and conductivity sensor for measuring solids concentration of three component slurries containing coal, refuse and water. The solids density and gamma energy attenuation coefficient must be known. There are also particle size limitations and a trade-off between the maximum measurable particle density and maximum chord length.

Optical methods have been used by Musil (1976), Bohnet and Niesmak (1980), Fajner et al. (1985), Ayazi Shamlou and Koutsakos (1989) and Magelli et al. (1990) to measure solids concentration along chords of various lengths in mixing tanks. Stanley-Wood et al. (1981) used the scattered light from two laser beams and the magnitude of the auto-correlogram at zero time shift to determine the chord averaged solids concentration in a slurry pipeline. They found however that the signal was dependent upon particle size. In all these optical concentration techniques, measurements are only possible when the solids concentration is less than one to two percent by volume. This is due to scattering and blocking of the light between the source and the detector. This seriously limits the usefulness of optical detectors for determining solids concentration in most slurry systems. Yianneskis (1987) indicates that this concentration range can be extended by closely matching the refractive indices of the solid and the liquid.

A series of papers (Beck et al., 1971; Lee et al., 1974; Ong and Beck, 1975) outline the details of a novel conductivity sensor useful for solids concentration measurement over a chord length in a slurry pipeline. An important difference between this technique and other conductivity methods was that the liquid conductivity was not measured to determine the solids concentration. The mean value of fluctuations in the instantaneous conductivity due to the movement of solids past the sensor electrodes were measured. A band-pass filter, with a range of 1-1000 Hz, was used to eliminate low frequency fluctuations caused by variations in the fluid conductivity due to temperature or composition changes. Drawbacks of this technique included calibration curves which were dependent upon slurry velocity, electrode type and configuration.

All the techniques mentioned to this point provide an average concentration over a large length, area or volume of space. However, multiphase flows are rarely homogeneous. These methods reviewed do not give information about the local solids concentration. This may not be a concern when only a bulk average concentration is desired, but for many applications, local solids concentration measurements are required.

2.3 Solids Concentration Measurement Over a Small Volume of Space

The three methods of local solids concentration measurement discussed in this section are sample withdrawal, optical and electrical techniques. Sampling from slurry pipelines is first reviewed since the flow direction is known and the flow structure is fully developed. This is followed by a review of sampling from mixing tanks where the flow structure is more complicated. A short discussion of optical methods is presented, followed by an outline of the various electrical (conductivity) concentration probes.

2.3.1 Sample Withdrawal

2.3.1.1 Sampling From Vertical Slurry Pipelines

The objective of sample withdrawal is to obtain a sample that is representative or identical in all properties, to the system being sampled at the point of sampling.

The sampling efficiency, or the separation or aspiration coefficient, is defined as the ratio of the sample solids concentration to the actual local solids concentration (Nasr-El-Din, 1989).

$$\text{Sampling Efficiency} = C_S/C_0 \tag{2.1}$$

where:

C_S = solids concentration obtained by sample withdrawal.

C_0 = local solids concentration.

A sampling efficiency of unity implies that there is no sampling error while a sampling efficiency different than unity indicates a sampling error.

Nasr-El-Din (1989) states that there are three factors that lead to non-representative sampling of slurry systems:

- Particle inertia.
- Flow structure ahead of the sampler.
- Particle bouncing.

Particle inertia refers to the inertia of a particle relative to the inertia of an equal volume of the surrounding fluid. The flow structure ahead of the sampler can be non-uniform due to the lack of a well developed rectilinear flow or disturbance of the flow by the sampler. Particle bouncing will be discussed later.

Sampling errors due to particle inertia are a result of disturbances of the fluid flow ahead of the sampling device by the sampler and how the particles respond to these disturbances. Coarse or heavy particles with high inertia do not respond to rapid changes in the fluid direction and will tend to separate from the fluid flow. Fine or light particles with low inertia will follow the fluid flow more easily.

2.3.1.1.1 Sampling With Thin L-Shaped Probes

Thin L-shaped sampling probes are commonly used to measure solids concentration in slurry pipelines, as shown in Figure 2.3 (Rushton and Hillestad, 1964; Karabelas, 1977; Hayashi et al., 1980; all from Nasr-El-Din, 1989). Particle inertia has a significant effect on the solids concentration obtained from these devices.

Anisokinetic sampling (sampling velocity (U_S) different than the local pipe velocity at the point of sampling (U_0)) will cause the fluid streamlines ahead of the sample nozzle to either converge or diverge as shown in Figure 2.4. The inertia of the particles in the flowing fluid, governs how the particles respond to the deflected

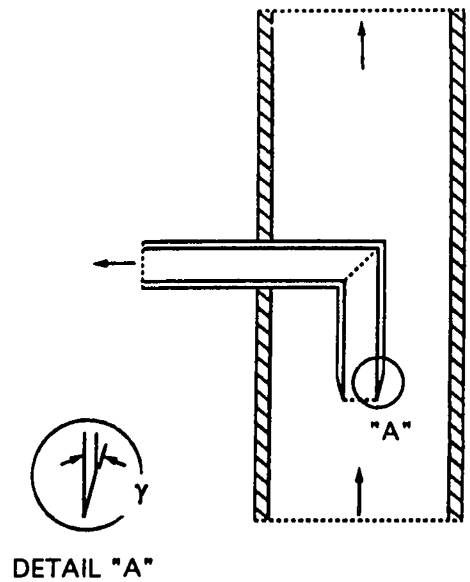


Figure 2.3: L-Shaped Sampling Probe in a Vertical Slurry Pipeline
Adapted From: Nasr-El-Din (1989)

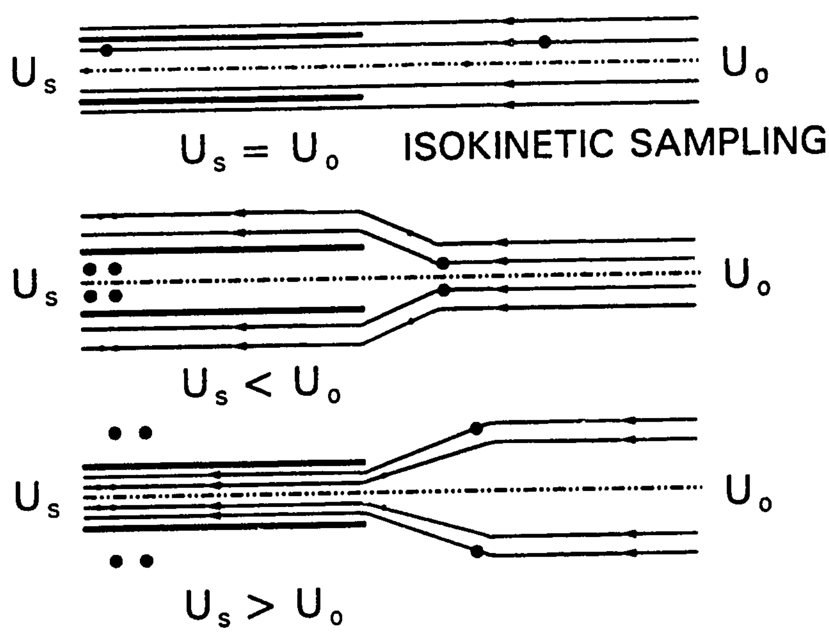


Figure 2.4: Flow Streamlines Ahead of a Sampler
Adapted From: Nasr-El-Din (1989)

fluid streamlines. Two extreme cases exist. Very small particles or those with a density approaching the fluid, have very low inertia relative to an equal volume of fluid. These particles can follow the fluid streamlines, even if deflected due to anisokinetic sampling, and will enter the sampler. Sample solids concentration is not affected by the sampling velocity. Very coarse or dense particles have very high inertia relative to the fluid drag and tend to travel in straight lines "like bullets" (Nasr-El-Din, 1984). At a relative sampling velocity (U_S/U_0) less than unity, more particles are sampled than at the isokinetic velocity ($U_S/U_0 = 1$), resulting in a sample concentration higher than the local pipe concentration. At U_S/U_0 greater than unity, many particles miss the sample tube resulting in a sample solids concentration (C_S) lower than the upstream local solids concentration in the pipe at the point of sampling (C_0).

The response of a particle to deflections in the fluid streamlines is a function of the dimensionless group known variously as the Stokes number, Barth number or particle inertia parameter (K). It is defined as:

$$K = \frac{\rho_P \, d_P^2 \, U_o}{18 \, \mu_L \, (\phi/2)} \tag{2.2}$$

where:

d_P = particle size (m)

U_o = local velocity (m/s)

μ_L = liquid viscosity (Pa.s)

ρ_P = particle density (kg/m^3)

ϕ = sample tube inside diameter (m)

Model predictions and experimental results discussed by Nasr-El-Din (1989) show that as the particle inertia parameter increases, sampling errors increase because increasing particle inertia decreases the importance of the particle drag force. Particle trajectories will then deviate more from the corresponding fluid streamlines and result in greater sampling errors.

Figure 2.5 shows that as the local concentration in the vertical pipeline increases, sampling errors decrease. This is again due to particle inertia. Increasing solids concentration increases the drag force experienced by the particle, causing the particle to deviate less from the fluid streamlines.

The effect of sample probe diameter was reviewed by Nasr-El-Din (1984). Sampling with small diameter probes was required to measure local solids concentrations precisely but these small probes can cause significant sampling errors due to particle deposition in the sample tube. Particle deposition errors can be reduced by using simple, short sampling probes. It was also recommended that the sample tube diameter be at least five to six times the particle size to minimize sampling errors.

2.3.1.1.2 Sampling With Blunt L-Shaped Probes

Thick walled L-shaped sampling tubes with blunt ends are more robust than thin-walled sampling tubes in the presence of abrasive solids flow. The blunt sample tube distorts the local fluid flow however and particle inertia leads to sampling errors. Nasr-El-Din (1989) showed that as the relative sample tube wall thickness (δ, ratio of the sample tube wall thickness to the sample tube radius) increased, distortions of the fluid flow increased and so did the sampling error (Figure 2.6). Particle bouncing was also found to cause the sampling errors with these probes. Particle bouncing results when a particle loses some of its inertia as it strikes the blunt end of the sample tube. The particle can then more easily be withdrawn into the sampling tube. A thicker sample tube wall results in more particle bouncing and larger sampling errors.

Nasr-El-Din (1989) found that when sampling polystyrene particles (ρ_P = 1050 kg/m^3) in water with blunt L-shaped probes, no sampling errors occurred,

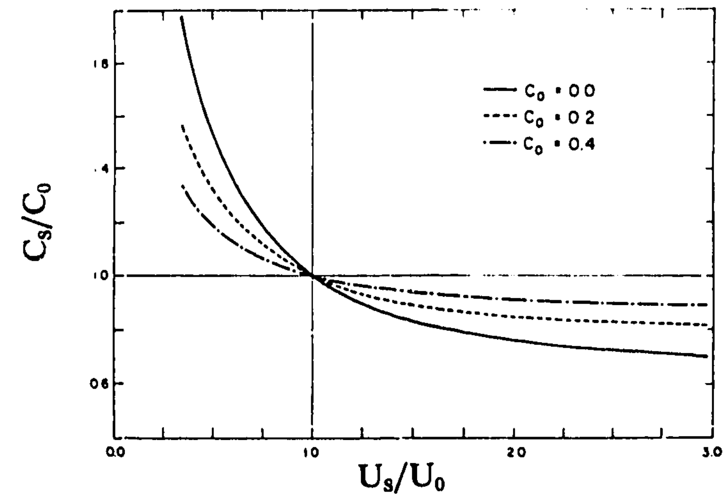


Figure 2.5: Effect of Solids Concentration on L-Shaped Probe Sampling Efficiency
Adapted From: Nasr-El-Din (1989)

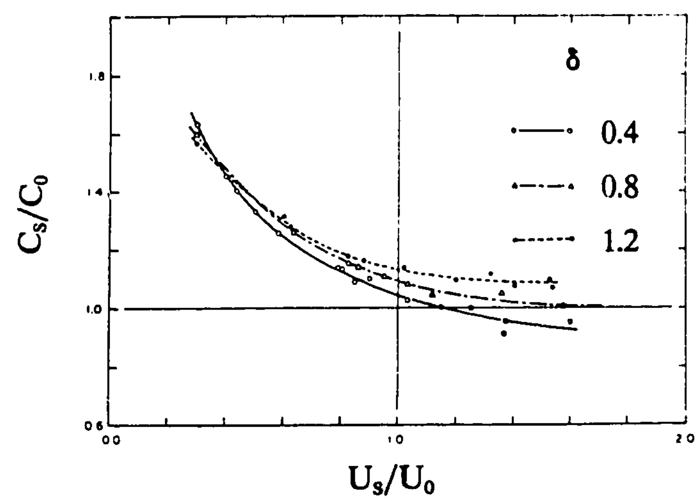


Figure 2.6: Effect of Probe Wall Thickness on Sampling Efficiency
Adapted From: Nasr-El-Din (1989)

regardless of the sampling velocity or the sample probe thickness. The inertia of these particles was so low that they were unaffected by the fluid field distortions caused by the blunt sample tube.

Sampling errors with blunt probes were eliminated by tapering the probe tip to an angle of 18° or less. With the tapered sample tube, distortions of the flow field by the sampling tube were minimized and particle bouncing was not a factor. Sampling results were equal for all thicknesses of sample tube. Sampling at the isokinetic velocity was still required in order to obtain representative samples.

2.3.1.1.3 Side-Wall Sampling

Side wall sampling, shown in Figure 2.7, is a common method of sampling slurries due to its simplicity of operation. Only a small opening is required in the pipe wall and a sample tube does not obstruct the fluid flow. With this type of

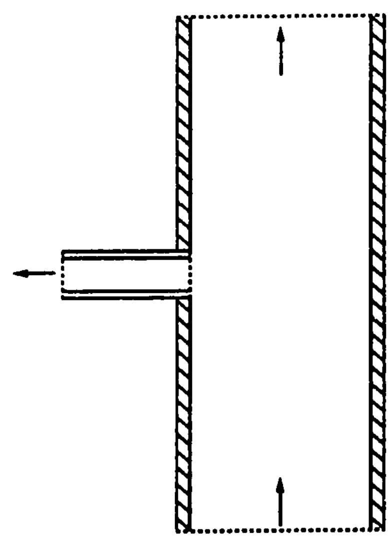


Figure 2.7: Side-Wall Sampling from a Vertical Slurry Pipeline
Adapted From: Nasr-El-Din (1989)

sampling device however, particles must change their direction by 90° to be withdrawn into the sample tube. The sampling efficiency is a strong function of the particle inertia and upstream solids distribution (Nasr-El-Din, 1989).

The solids collection mechanism as well as the performance of the side-wall sampler is quite different than for the L-shaped sampling probe from vertical slurry pipelines. The sample concentration increases with sampling velocity for side-wall samplers as shown in Figure 2.8 whereas the opposite is true for L-shaped probe samplers (Figure 2.5). The sample solids concentration (C_S) is normalized by the bulk solids concentration in the pipe (C_B) in Figure 2.8. The side-wall sampler withdraws slurry from across the pipe cross section and not from a local point. It is therefore unreasonable to normalize the sample solids concentration with the local concentration (C_0) as is done for L-shaped probe samplers. Similarly, the sampling velocity (U_S) is normalized by the bulk velocity (U_B) across the pipe cross section rather than the local upstream velocity (U_0), as is the case with the L-shaped sample probe.

The effect of bulk solids concentration is the same for both side wall and L-shaped probe samplers (Figure 2.8). Increasing particle concentration increases the drag force exerted by the fluid on the particles and subsequently the particle acceleration, thus allowing the particles to follow the fluid flow more easily. The sampling efficiency increases with bulk solids concentration.

The sample tube diameter (ϕ) was found to have a large effect on the sampling efficiency, when sampling from the side wall of a vertical slurry pipeline (Figure 2.9). At a given particle velocity past the sample tube opening, less time is available for the particle to turn 90° and enter the small diameter sampler than to enter the larger sampler. This results in fewer particles entering the small sample tube and lower sample solids concentration at a given sampling velocity (Nasr-El-Din, 1989).

The experimental results of Nasr-El-Din (1989) showed that the sampling efficiency of side-wall samplers is a strong function of particle size (Figure 2.10). As

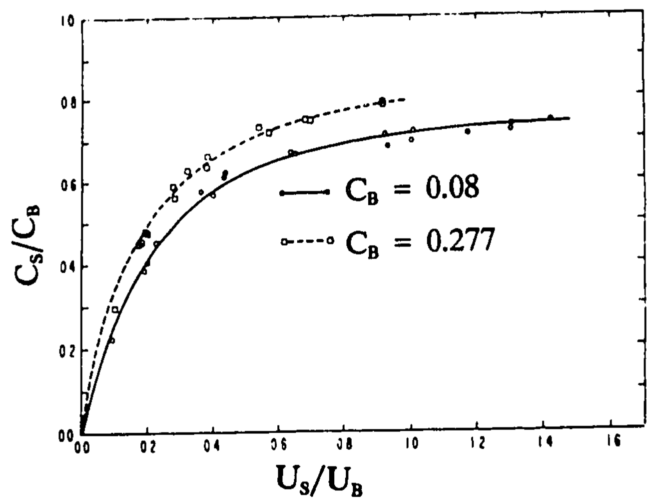


Figure 2.8: Effect of Sampling Velocity and Bulk Solids Concentration on Sampling Efficiency for Side-Wall Samplers
Adapted From: Nasr-El-Din (1989)

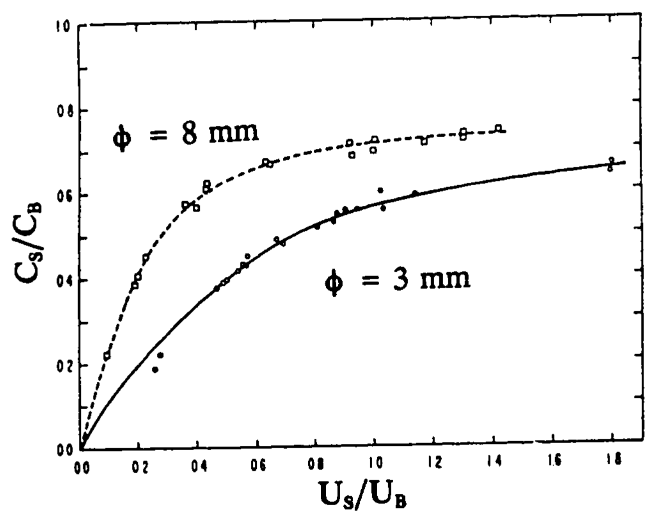


Figure 2.9: Effect of Sample Tube Diameter on Sampling Efficiency for Side Wall Sampling from a Vertical Slurry Pipeline
Adapted From: Nasr-El-Din (1989)

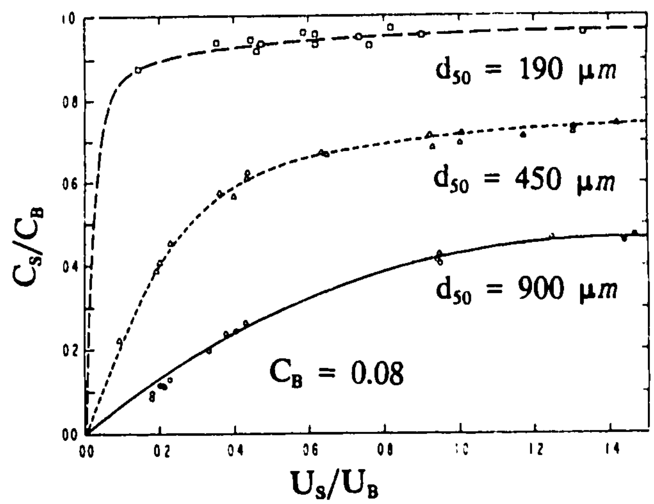


Figure 2.10: Effect of Particle Size on Sampling Efficiency for Wall Sampling from a Vertical Slurry Pipeline
Adapted From: Nasr-El-Din (1989)

shown in Equation 2.2, the particle inertia parameter increases with the square of the particle diameter. Higher particle inertia results in significant deviations of the particle trajectories from the 90° change of direction of the fluid streamlines into the side-wall sampler. Lower sampling efficiency with increasing particle size is the result.

The sample particle size distribution is also significantly effected by sampling velocity into a side-wall sampler. Results show that as the sampling velocity ratio decreases, fewer coarse particles are sampled due to their high inertia. The sample particle size distribution tends to be finer than the bulk solids particle size distribution.

2.3.1.1.4 Side-Wall Sampling With a Projection

One method of increasing the sampling efficiency of a side-wall sampler is to add a projection (Figure 2.11). The projection provides very different sampling results (Figure 2.12) since the flow pattern ahead of the sample tube is altered by the projection. In addition, different sampling results are obtained by different types of projected sampling probes (straight projection, side port probe, 135° angle probe). This is again due to different flow fields ahead of the different sampling tubes.

Particle bouncing is likely a significant factor affecting the sampling efficiency of projecting sample probes. Particles tend to hit the projection, lose inertia and enter the sample tube (Nasr-El-Din, 1989).

2.3.1.1.5 Effect of Flow Structure Ahead of the Sampler

The discussion to this point has focused on situations where the flow structure ahead of the sampler is rectilinear, as would be found in the fully developed flow in a pipeline. Deviations from this type of flow, caused by pipe fittings (e.g. elbows and tees) in a pipeline or from systems with complicated flow patterns (such as mixing tanks), makes it very difficult to align the sample probe with the slurry flow direction. Downstream from a pipe elbow for example, secondary flows cause the bulk flow to be helical. Because of the helical motion, it is very difficult to align the probe with the fluid velocity vector. Consequently, and because of the inertia effect, the sample concentration will always be less than the upstream concentration (Lundgren et al., 1978 from Nasr-El-Din, 1989). In addition, Dunnett (1989) explains that a sample tube not oriented parallel to the main flow direction can be thought of as a blunt body as its physical presence affects the fluid flow.

2.3.1.1.6 Summary of Sample Withdrawal From Slurry Pipelines

It has been shown in this section that obtaining representative samples from a vertical slurry pipeline is not straight forward. Trying to take "short-cuts" by using simple side wall samplers or robust thick L-shaped probe samplers can lead to non-representative samples due to the orientation of the sample tube relative to the

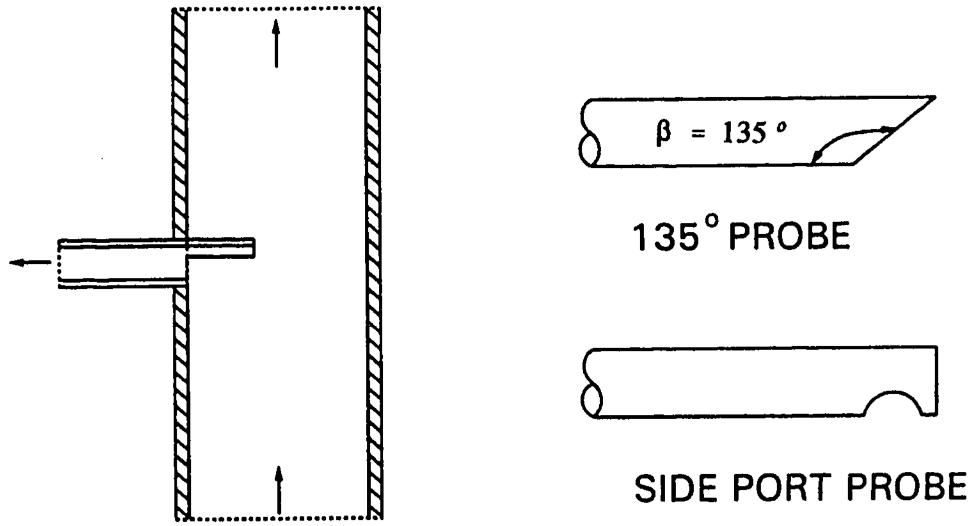


Figure 2.11: Side-Wall Samplers With a Projection
Adapted From: Nasr-El-Din (1989)

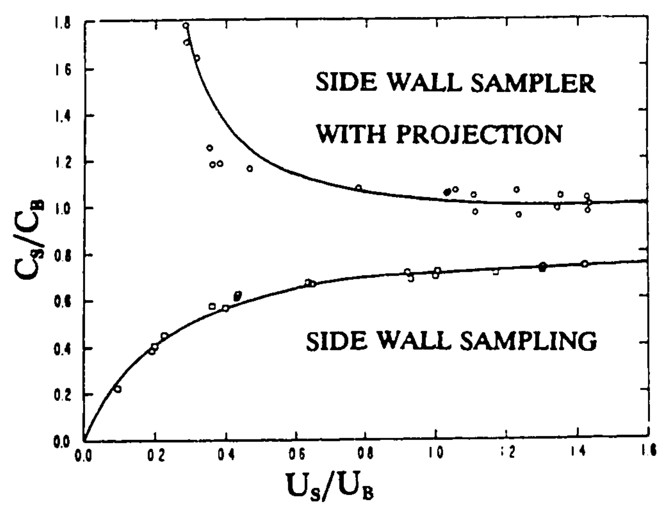


Figure 2.12: Sampling Efficiency of Side-Wall Samplers With and Without a Projection. Adapted From: Nasr-El-Din (1989)

upstream flow field, disturbance of the upstream flow field and particle inertia relative to the fluid. Representative samples can be obtained regularly from vertical slurry pipelines by using thin or properly tapered L-shaped samplers oriented precisely with the upstream flow and sampling at the isokinetic velocity.

2.3.1.2 Sampling From Mixing Tanks

The need to know and control the concentration of the suspended phase in mixed slurry reactors is very common. One of the biggest problems with measuring the concentration of the suspended phase in a mixing tank by sampling is the requirement outlined previously of a well defined flow field ahead of the sampler. This is not an easy condition to meet.

The flow field ahead of a radial flow impeller is relatively well known. Rushton (1965) described the radial velocity of flow on the center line of a radial flow turbine as an expanding jet from the impeller (Figure 2.13). The radial velocity (U_0, m/s) is given by:

$$U_0 = \frac{B_1 N D^2}{r} \tag{2.3}$$

where:

- B_1 = constant dependent upon the number of impeller blades and the ratio of the impeller to tank diameter.
- N = impeller speed (rps).
- D = impeller diameter (m).
- r = distance from the center of the impeller (m).

This equation is applicable only on the plane of a radial flow impeller between the impeller blade tip (r/R = D/2R) and near the tank wall (r/R ≈ 0.95). Radial flow from the impeller impinges on the tank wall and splits into flow upwards and downwards along the tank wall. For this reason, Equation 2.3 is only valid to radial

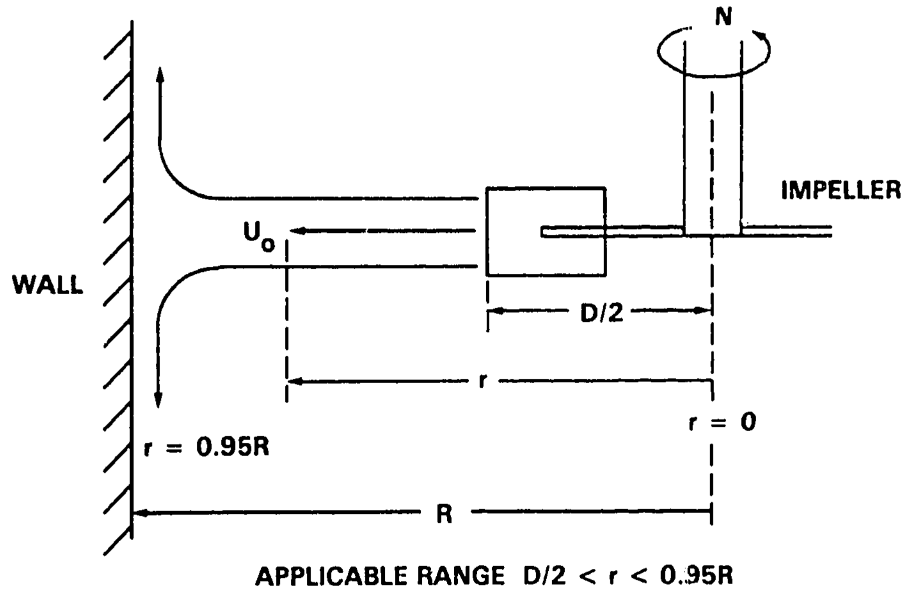


Figure 2.13: Radial Velocity From a Radial Flow Impeller

D/T	B_1	
	4 Blades	6 Blades
0.40	0.967	1.15
0.33	0.952	1.13
0.25	0.928	1.10
0.20	0.910	1.08

Table 2.1: Radial Impeller Flow Constants for Equation 2.3

locations near the tank wall. Values of B_1 for standard flat-blade radial flow turbines of various diameters (D/T = ratio of the impeller to tank diameter) are given in Table 2.1.

Rushton (1965), Rehakova and Novosad (1971a,b) and Sharma and Das

(1980) developed empirical or semi-empirical equations to describe the solids concentration obtained by the withdrawal of a sample from the impeller plane of a radial flow impeller in a mixing tank. The ranges of parameters covered in each study are summarized in Table 2.2. All three relations are valid only for fully suspended solids, sampling at the plane of a radial flow impeller and midway between two baffles ($\theta = 45°$).

	Rushton (1965)	Rehakova and Novosad (1971a,b)	Sharma and Das (1980)
Axial Location	Impeller Plane	Impeller Plane	Impeller Plane
Radial Location	0.95R	0.85R	0.75R - 0.94R
Angular Location	$\theta = 45°$	$\theta = 45°$	$\theta = 45°$
Solids Distribution	Fully Suspended	Fully Suspended	Fully Suspended
Impeller Type	Radial Flow	Radial Flow	Radial Flow
Sample Tube Tip Shape	Sharp	Blunt	Sharp
Bulk Solids Concentration (volume fraction)	0.01 - 0.20	0.0018-0.0025	0.0815 - 0.163
Particle Size (μm)	100 - 250	180 - 900	250
Particle Density (kg/m^3)	2410	1018 - 2665	2600
Liquid Density (kg/m^3)	1000	780 - 1000	1000
Velocity Ratio (U_S/U_0)	Not Available	0.2 - 5.6	0.80 - 1.20

Table 2.2: Parameter Ranges For Mixing Tank Sample Concentration Correlations

Rushton found the following effect of sampling velocity ratio (U_S/U_0) on the sample normalized solids concentration (C_S/C_B):

$$C_S / C_B = k_1 (U_S / U_0)^{-0.14} \qquad U_S / U_0 < 1 \qquad (2.4)$$

$$C_S / C_B = k_1 (U_S / U_0)^{-0.087} \qquad U_S / U_0 > 1 \qquad (2.5)$$

where:

$k_1 = 1$ at $r/R = 0.95$.

$k_1 = 1.25$ at $r/R = 1.0$.

applicable for:

$100 \leq d_P \leq 250 \ \mu m$

$\rho_P = 2410 \ kg/m^3, \ \ \rho_L = 1000 \ kg/m^3$

$0.01 \leq C_B \leq 0.20$ (*volume fraction*)

The exponents in Equations 2.4 and 2.5 were found to be a function of particle size, as shown in Figure 2.14 for 50 μm glass beads in water and 100 - 250 μm glass or sand in water. The curves in Figure 2.14 closely resemble those for sampling with L-shaped probes from slurry pipelines (Figure 2.5). This is reasonable since the flow field in this region of the mixing tank is mainly radial from the impeller to near the wall and the sample tube was aligned with this flow, as is an L-shaped sampling probe in a pipeline. The difference in particle inertia for the two particle sizes results in the deviation shown in Figure 2.14.

At the isokinetic sampling velocity ($U_S/U_0 = 1$), calculated from Equation 2.3, the Rushton equations predict the sample solids concentration (C_S) to be equal to the BULK solids concentration (C_B) in the mixing tank, not the local solids concentration at the point of sampling (C_0). The Rushton equations cannot determine

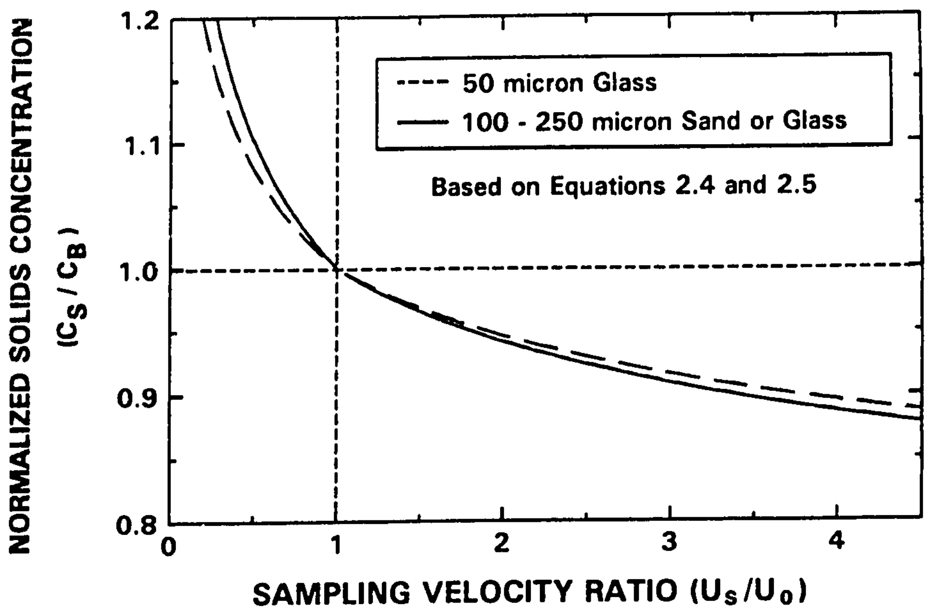


Figure 2.14: Effect of Particle Size on Sample Concentration From the Impeller Plane of a Mixing Tank

sampling efficiency (C_S/C_0) from a mixing tank, but can only show how the sample solids concentration deviate from the BULK solids concentration in the mixing tank. Rushton did not have a method of measuring the local solids concentration (C_0) in the mixing tank and was therefore not able to determine sampling efficiency.

Figure 2.14 indicates that the difference between the sample solids concentration (C_S) and the bulk solids concentration (C_B) in the mixing tank is much more severe at velocity ratios (U_S/U_0) less than unity than for $U_S/U_0 > 1$. For example, at $U_S/U_0 = 3$, the concentration ratio (C_S/C_B) is 8% less than unity, while at $U_S/U_0 = 0.3$, the concentration ratio is 15% larger than unity. This is again similar to sampling from slurry pipelines with L-shaped sampling probes (Figure 2.5). In a situation where no information is known about the solids-liquid system being sampled or the mixer speed, then it is advisable to sample at a high sampling velocity rather than at a low velocity. This will minimize the difference between C_S and C_B.

Sampling errors from an L-shaped sampling probe in a slurry pipeline, decreased with decreasing particle size. A similar trend is seen when sampling from a mixing tank on the plane of a radial flow impeller in Figure 2.14. In this case however, the sampling efficiency (C_S/C_0) and thus the sampling error are not known since C_0 is unknown.

The constant k_1 in Equations 2.4 and 2.5 was found to be a function of the particle and liquid densities. Rushton (1965) says that for alumina-type cracking catalysts (ρ_P = 1.6), k_1 was 0.90 at r/R = 0.95 as opposed to 1.0 for sand or glass (ρ_P = 2.41). This indicates that there was a lower concentration of solids at the sampling point for the lower density alumina versus the higher density sand. The low density solids may have been more evenly suspended throughout the vessel than the higher density solids, thereby making the local solids concentration on the impeller plane at r/R = 0.95 (sampling point) lower.

Rushton found that if the sampling tube was flush with the mixing tank wall (r/R = 1.0), then the sample solids concentration at the same sampling velocity ratio (U_S/U_0) was 25% higher than at the point away from the wall (r/R = 0.95). The center-line flow from a radial impeller reaches stagnation at the mixing tank wall (Rushton, 1965) and the solids travelling in this flow will impinge upon the tank wall and lose inertia. As seen previously when sampling om slurry pipelines, the particle bouncing effect results in increasing sample solids concentrations as the thickness of the sample probe increases (Figure 2.6). When the solids impinge upon the mixing tank wall, it is very similar to a very thick sample tube wall. This appears to result in large particle bouncing effects, with many particles losing enough inertia that they are withdrawn into the sample tube. The sample solids concentration is therefore much higher at the wall than away from the wall.

Rushton briefly examined the sampling errors that result when the sample tube was not oriented in the same direction as the flow. Samples were withdrawn from sample tubes mounted flush with the mixing tank wall, 5.1 cm above the impeller plane and 5.1 cm below, and at the isokinetic sampling velocity calculated from Equation 2.3 for the tank wall. At these positions, the flow is moving axially along the tank wall, at right angles to the sample tube.

The results shown in Table 2.3 indicate large differences in sample solids concentration are obtained by simply moving along the mixing tank wall. Similar results are obtained from a vertical slurry pipeline when the sample is withdrawn from the pipe wall. In this system however, wall sampling gives sample solids concentrations (C_S) consistently LOWER than the bulk solids concentration (C_B) in the pipeline (Figures 2.8, 2.9 and 2.10). This is not the case in the mixing tank as seen in Table 2.3. At positions above and below the impeller plane, the sample solids concentration is consistently HIGHER than the bulk solids concentration in the mixing tank, similar to sampling from the bottom of a horizontal slurry pipeline (Nasr-El-Din et al., 1989a,b). The sample tube mounted flush along the mixing tank wall, actually withdraws slurry from the vicinity of the sample tube opening. It appears that the local solids concentration in the mixing tank in the vicinity of the sample tube opening at these locations is significantly higher than the bulk concentration in the mixing tank. This would account for the high sample solids concentrations obtained at these points. Without a measure of the local solids concentration at these points however, this cannot be determined conclusively.

Rehakova and Novosad (1971a,b) undertook a theoretical analysis of sample withdrawal from the impeller plane of a mixing tank stirred with a radial flow impeller. The assumptions made in their analysis were:

Axial Location of Sample Tube (Flush with Tank Wall)	C_S/C_B at $U_S/U_0 = 1$
Impeller Plane	1.25
5.1 cm ABOVE Impeller Plane	1.55
5.1 cm BELOW Impeller Plane	1.10

Table 2.3: Sample Solids Concentrations From the Mixing Tank Wall
Adapted From: Rushton (1965)

- an isokinetic arrangement of the sample tube to the impeller.
- a homogeneous suspension in the vessel.
- the paths of the liquid and solids were straight lines.
- spherical solids.
- the effect of gravity was neglected.
- the radial liquid velocity was constant.

The correlations developed by Rehakova and Novosad are as follows:

$$\left[\frac{C_S}{C_B}\right] = \left[1 + \frac{2Y_1}{\phi\left(\frac{U_S}{U_0}\right)^{0.5}}\right]^2 \qquad \left(\frac{U_S}{U_0}\right) < 1 \tag{2.6}$$

$$\left[\frac{C_S}{C_B}\right] = \left[1 - \frac{2X_1}{\phi\left(\frac{U_S}{U_0}\right)^{0.5}}\right]^2 \qquad \left(\frac{U_S}{U_0}\right) > 1 \tag{2.7}$$

where:

$$X_1 = \left(\frac{U_S}{U_0}\right)^{0.5}\left(\frac{1}{k_2}\right)\left[(s-1)\phi\right] \ln\left(\left[\frac{k_2}{\phi(s-1)}\right]\left\{\frac{\phi}{2}\left[\left(\frac{U_S}{U_0}\right)^{0.5} - 1\right] + X_1\left[\left(\frac{U_0}{U_S}\right)^{0.5} - 1\right]\right\} + 1\right) \tag{2.8}$$

$$Y_1 = \left(\frac{U_S}{U_0}\right)^{0.5}\left(\frac{1}{k_2}\right)\left[(s-1)\phi\right] \ln\left(\left[\frac{k_2}{\phi(s-1)}\right]\left\{\frac{\phi}{2}\left[1 - \left(\frac{U_S}{U_0}\right)^{0.5}\right] + Y_1\left[\left(\frac{U_0}{U_S}\right)^{0.5} - 1\right]\right\} + 1\right) \tag{2.9}$$

and:

X_1 = width of the annulus containing particles which do not enter the sample tube (mm).

Y_1 = width of the annulus containing particles which do enter the sample tube (mm).

k_2 = constant = 123.5 (best fit of Rehakova and Novosad's data)

s = ρ_P / ρ_L

Similar to Rushton's correlations, Equations 2.6 to 2.9 give no measure of the sampling efficiency (C_S/C_0) since the local concentration (C_0) is unknown. These equations only predict the sample solids concentration, relative to the bulk solids concentration in the mixing tank.

The sample solids concentration (C_S) from these equations is a function of the sample velocity ratio (U_S/U_0), similar to Rushton's correlations. Rehakova and Novosad improved upon Rushton's work by including the effect of the liquid and particle densities (ρ_L , ρ_P) and the sample tube diameter (ϕ). These equations are implicit however, and require a trial and error solution of the annulus widths X_1 and Y_1. The Rushton equations can be solved explicitly.

Rehakova and Novosad found surprisingly that there was no effect of particle size on the sample solids concentration. In contrast, Rushton (1965) found that the deviation of the relative sample solids concentration (C_S/C_B) from unity was less for small particles than for larger particles. The sampling efficiency (C_S/C_0) when sampling from slurry pipelines was also found to be a strong function of particle size (Figure 2.10). This is to be expected since the particle inertia depends upon the square of the particle size (Equation 2.2) and particle inertia can significantly affect sampling efficiency.

The experimental study undertaken by Rehakova and Novosad (1971b) only covered very dilute slurries ($0.0018 \le C_B \le 0.0025$). This limits the applicability of these equations, as the constant k_2 in Equations 2.8 and 2.9 was a best fit of the experimental data.

Rehakova and Novosad found that the relative sample solids concentration (C_S/C_B) was about four percent higher than unity at the isokinetic sampling velocity (U_S/U_0 = 1). This again differs from Rushton's findings, where C_S/C_B = 1 at U_S/U_0 = 1. This may be due to the particle bouncing effect seen when sampling from slurry pipelines with blunt L-shaped sample tubes (Figure 2.6). Rehakova and Novosad used a sample tube with a blunt tip, whereas Rushton used a sample tube with a tapered tip. Impaction of particles on the blunt sample tube tip causes some of the particles to lose inertia and be withdrawn into the sample tube. This results in higher sample solids concentrations than obtained with tapered sample tubes.

In a similar study, Sharma and Das (1980) studied the sampling efficiency from the impeller plane of a mixing tank stirred with a radial flow impeller. Their correlation is as follows:

$$\left(\frac{C_S}{C_B} - 1 \right) = C_1 \left(\frac{\rho_P - \rho_L}{\rho_L} \right) \left(\frac{z_1}{\phi} \right)^{0.5} \left[\left(\frac{U_S}{U_0} \right)^{-1} - 1 \right] \qquad (2.10)$$

where:

C_1 = 0.028 for the 250 μm glass beads - water system used in this study.

z_1 = sample tube insertion length from the mixing tank wall (mm).

The sample solids concentration predicted from Equation 2.10 is only relative to the bulk solids concentration in the mixing tank as was the case with the equations of Rushton (1965) and Rehakova and Novosad (1971a,b). These equations cannot give an indication of the sampling efficiency (C_S/C_0) since the local solids concentration in the mixing tank (C_0) is unknown.

The sample solids concentration from Equation 2.10 is dependent upon the relative sampling velocity (U_S/U_0) as is the Rushton and Rehakova and Novosad correlations. Similar to Rehakova and Novosad's equations, Equation 2.10 is also a function of the particle and fluid densities (ρ_P , ρ_L) and sample tube diameter (ϕ).

Sharma and Das (1980) have also included the sample tube insertion length as a parameter controlling the sample solids concentration. They caution that Equation 2.10 is only valid for z_1 > 0.06R. Values smaller than this approach the mixing tank wall, where a stagnation point in the center-line flow from the impeller exists. It is possible to use Equation 2.10 at radial locations from 0.75R to 0.94R, whereas the Rushton and Rehakova and Novosad equations are valid at only fixed radial locations of 0.95R and 0.85R respectively (Table 2.2).

Sharma and Das found the constant C_1 in Equation 2.10, and thus the sample solids concentration, was a function of particle size. This was similar to the findings of Rushton, but opposite to those of Rehakova and Novosad. The equations of Rehakova and Novosad must be used with caution since the lack of particle size dependence is in disagreement with the findings of the other authors surveyed here.

Sharma and Das conducted several experiments with the sample tube 5 cm above the impeller plane and 5 cm below the impeller. Similar to Rushton's work, Sharma and Das found that $C_S > C_B$ above the impeller plane. They explain that the concept of isokinetic withdrawal of a sample is not applicable in these cases where the sample tube is not in line with the flow direction. The difference between particle inertia and an equal volume of fluid will still play a dominant role in affecting how the solids respond to changes in the fluid flow direction and thus in the sample solids concentration.

The correlations of Rushton (1965), Rehakova and Novosad (1971a,b) and Sharma and Das (1980) predict the sample solids concentration on the impeller plane to equal the bulk solids concentration in the mixing tank at the isokinetic sampling velocity. This sampling situation is similar to sampling from slurry pipelines with L-shaped sampling probes. In this case however, the sample solids concentration equals the local solids concentration at the isokinetic sampling velocity. No independent measure of the local solids concentration was used by Rushton (1965), Rehakova and Novosad (1971a,b) or Sharma and Das (1980) to determine if the local solids concentration on the impeller plane of a mixing tank stirred with a radial flow impeller was the same as the bulk solids concentration in the tank.

Barresi and Baldi (1987a) showed that the shape of a sample tube can significantly affect the sample solids concentration obtained from a mixing tank (Figure 2.15). This was dependent however upon the location in the mixing tank. The mixing tank impeller in this study was a downward pumping axial flow impeller, as described in Figure 2.15. The direction of flow in the mixing tank varies from the bottom to the top of the vessel and thus the orientation of the flow relative to the sample tube varies with position. In the upper regions of the vessel, the flow direction tends to curve into the center of the vessel, away from the sample tube opening. Similar sample solids concentrations are obtained for both sample tubes. In the lower regions of the vessel, the flow past the sample tube is upwards and at right angles to the sample tube face. The angled sample tube, with the tip opening into the flow, consistently gives a higher sample solids concentration than the straight faced sample tube. This is most likely due to particle bouncing on the protruding

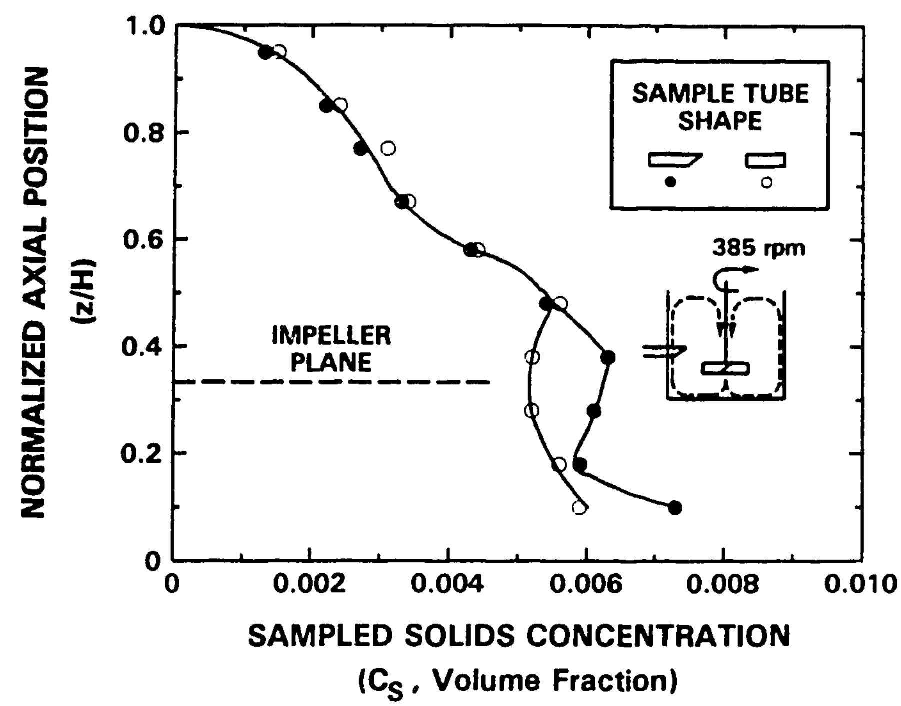


Figure 2.15: Effect of Sampler Shape on Solids Concentration Profiles in a Mixing Tank. Adapted From: Barresi and Baldi (1987a)
d_{50} = 208 - 250 μm, C_B = 0.0058, ϕ = 6.0 mm, r/R = 0.9

angled sample tube tip (Nasr-El-Din, 1989). Particles strike this protruding tip, lose inertia and are withdrawn into the sample tube. This results in a higher sample solids concentration than the straight faced probe, where particle bouncing is not a factor.

In addition to variations of sample solids concentration with sampling method, Beker (1970) from Nasr-El-Din (1984) showed that sample particle size distribution was a function of the sampling velocity.

The rigid requirements outlined in Section 2.3.1.1 for obtaining representative samples and the great difficulty in meeting these requirements in a mixing tank make "sampling of a stirred suspension of solids ... difficult and unreliable" (Perry and Chilton, 1973). Nienow (1985) stated that:

> [illegible] hould be isokinetic, i.e., it should be in a region [illegible] fl [illegible] id and particles are moving at a velocity of [illegible] magnitude and direction, and the withdrawal velocity should itself be at this same magnitude and direction. There are very few regions in a tank where the flow is of sufficiently low turbulence intensity and is sufficiently well defined to be sure that isokinetic sampling is being used"

In addition, Rushton (1965) stated that "every measuring instrument or draw-off tube interferes with the velocity pattern in the stirred liquid and makes accurate sampling virtually impossible". Despite these problems, determination of local solids concentration in mixing tanks by sample withdrawal is attractive due to its simplicity and continues to be used in several recent studies (Baldi et al., 1981; Buurman et al., 1986; Barresi and Baldi, 1987a,b) (Refer to Table 1.1 for a more extensive review). These results must certainly be viewed with caution (Nasr-El-Din, 1987b). Other methods of local solids concentration measurement from mixing tanks must be developed since solids concentration determination by sample withdrawal is unreliable.

2.3.2 Optical Methods

Optical probes, based on light refraction and on light transmission through the medium, have been used to determine local phase concentration. Refractive optical probes have been generally limited to gas-liquid flows and produce a binary signal that can be processed to give phase concentration (Hewitt, 1978; Moujaes, 1990).

Light transmittance optical probes, have been used by several workers for the measurement of solids concentration (Cliff et al., 1981; Tojo and Miyanami, 1982; Yamazaki et al., 1986) and liquid concentration (Schmidt et al., 1989). Two designs are shown in Figures 2.16 and 2.17. Conversion of the transmitted signal to a phase concentration follows the Lambert-Beer law (Schmidt et al., 1989) given by:

$$I^* = I_o^* \exp(-\epsilon\ C\ x) \qquad (2.11)$$

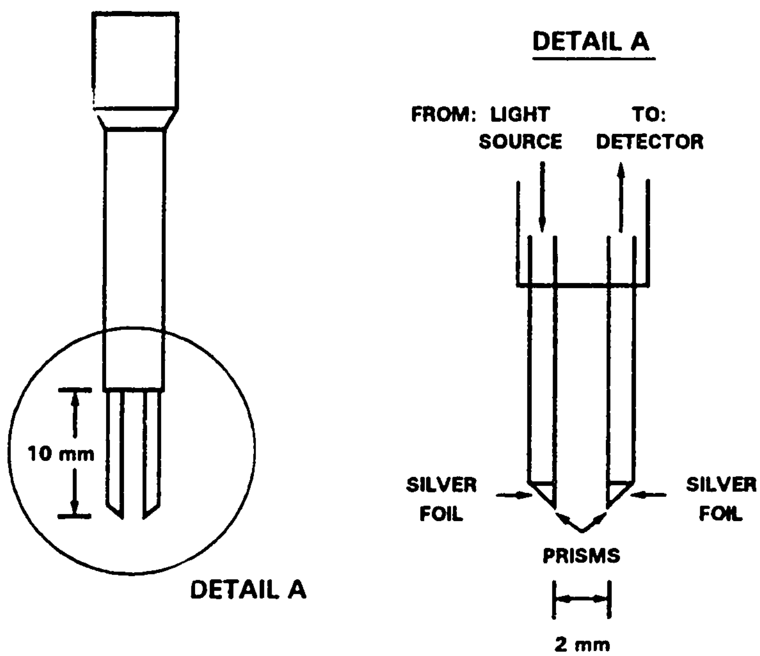


Figure 2.16: Light Transmission Probe
Adapted From: Schmidt et al. (1989)

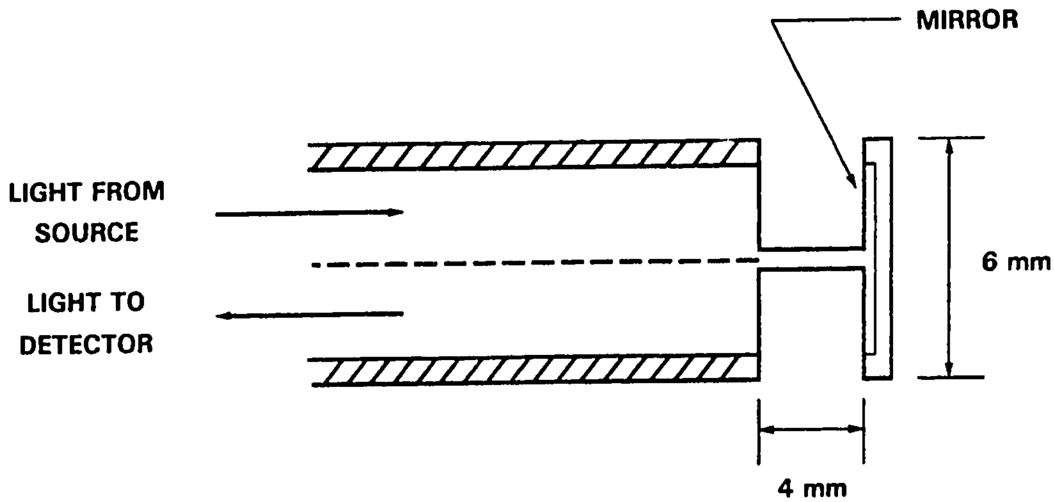


Figure 2.17: Light Transmission Probe
Adapted From: Tojo and Miyanami (1982)

where:

I^* = light intensity at the measured concentration.

I_o^* = light intensity at zero concentration.

C = phase concentration.

x = travelling distance through the medium.

ε = molar absorption coefficient (characteristic for each species).

This technique appears to be limited to slurries with relatively low solids concentration. Tojo and Miyanami (1982) found that since "a considerable part of the light scattered by the particles was superimposed on the returning light in the higher concentration slurries" the above relation was non-linear and was limited to slurries with less than ten weight percent solids.

A novel optical probe developed by Nelson and Oblad (1989) used for the control of a coal flotation cell, measures the amount of ash versus coal in the flotation tailings stream. More ash in the tailings stream increases the reflectance of the stream, thus altering the detector signal.

2.3.3 Electrical Methods

2.3.3.1 Types of Sensors

Electrical techniques available to measure phase concentration make use of the fact that the capacitance or conductivity of the two phases are different. The capacitance methods reviewed, all dealt with measurement over a relatively large volume and were covered in Sections 2.1 and 2.2. Several electrical conductivity techniques are available for measuring local solids concentrations (Lee et al., 1974; Jones and Delhaye, 1976; Musil and Vlk, 1978; Machon et al., 1982; Nasr-El-Din et al., 1987; Rieger et al., 1988).

Figure 2.18 shows a conductivity probe for measuring solids concentration in a slurry mixing tank (Musil and Vlk, 1978; Machon et al., 1982; Rieger et al., 1988). It uses two electrodes to measure the slurry conductivity within the volume of the outer ring electrode. Mixing tank solids concentration profiles measured with this conductivity probe are shown in Figure 2.19. The profiles show a similar trend to those of Barresi and Baldi (1987a) (Figure 2.15) even though the measurement techniques differ. Lee et al. (1974) developed a similar conductivity probe (Figure 2.20) for measuring the conductivity of an immiscible non-conducting liquid dispersed in a conducting liquid between two sensor electrode points.

Four electrode conductivity sensors have been developed by Nasr-El-Din et al. (1987) and Considine and Considine (1985), shown in Figures 2.21 and 2.22, respectively. In the conductivity probe of Nasr-El-Din et al. (1987), the current across the two field electrodes is maintained at a constant value and the slurry

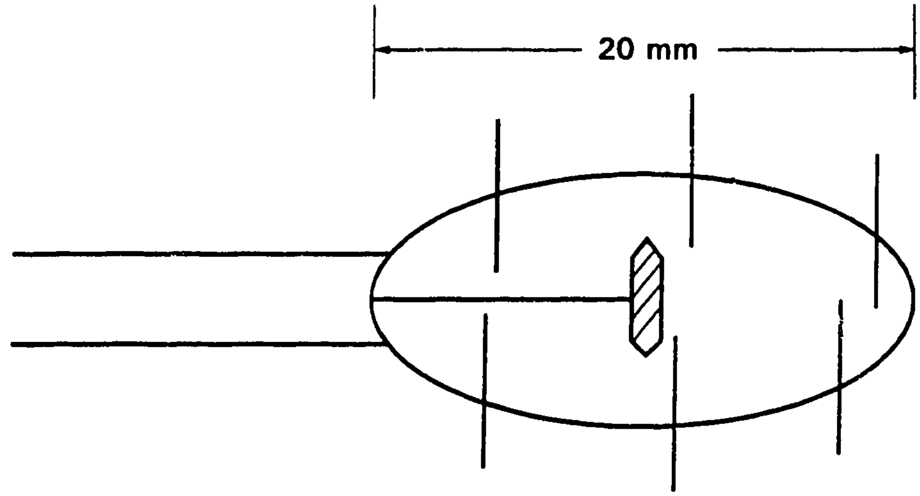


Figure 2.18: Conductivity Probe for Measuring Local Solids Concentration Adapted From: Musil and Vlk (1978), Machon et al. (1982), Rieger et al. (1988)

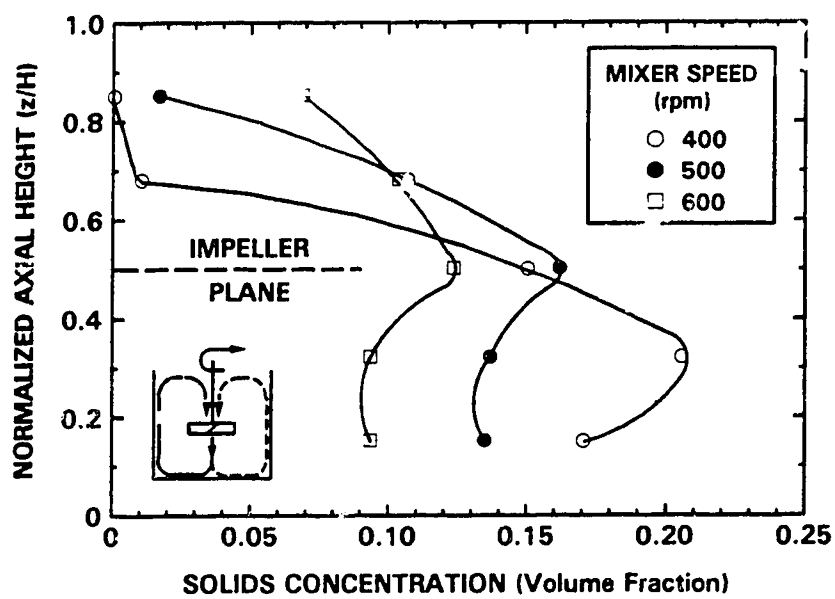


Figure 2.19: Mixing Tank Solids Concentration Profiles Adapted From: Rieger et al. (1988)
d_{50} = 185 μm, ρ_P = 2700 kg/m^3, C_B = 0.10

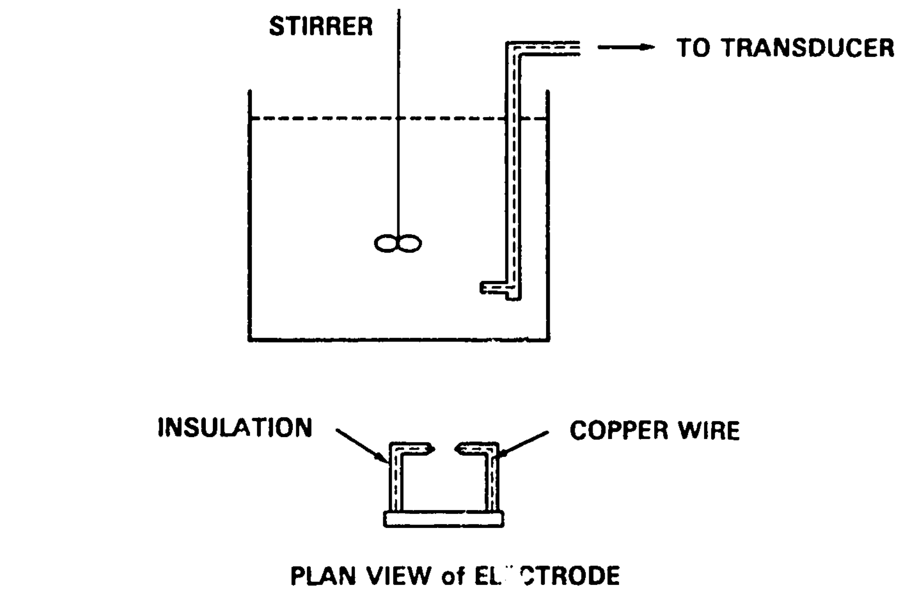


Figure 2.20: Conductivity Probe for a Mixing Tank
Adapted From: Lee et al. (1974)

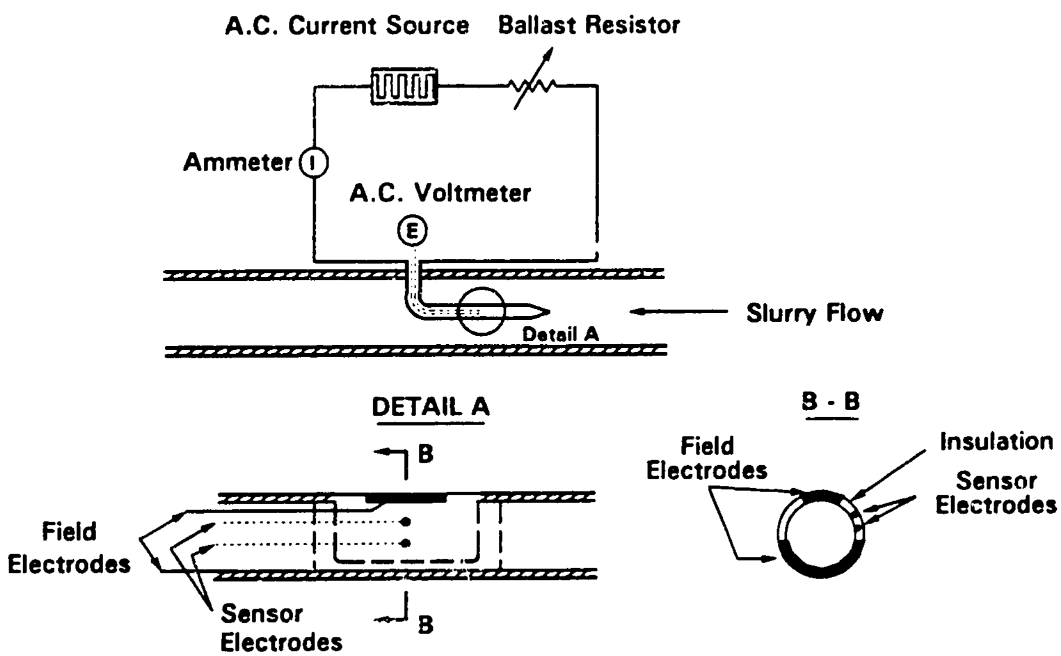


Figure 2.21: Four Electrode Conductivity Probe for a Slurry Pipeline
Adapted From: Nasr-El-Din et al. (1987)

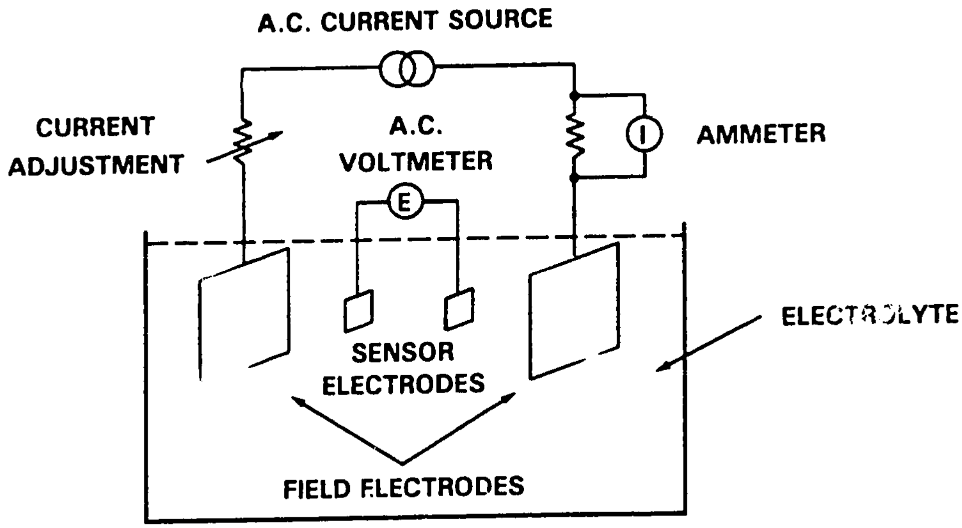


Figure 2.22: Four-Electrode Conductivity Circuit Used by Considine and Considine (1985)

conductivity is determined by measuring the potential difference across the sensor electrodes. The probe of Considine and Considine (1985) operates in the opposite manner. "The alternating current through the entire cell is varied to maintain a constant potential between the measuring electrodes. When this is done, the conductivity of the electrolyte between the measuring electrodes is proportional to the cell current".

2.3.3.2 Limitations of Conductivity Probes

Conductivity sensors that are used to determine solids concentration in a slurry must give reproducible measurements of the solution and slurry conductivity. Measurement errors can be due to physical or chemical changes of the measuring sensors or the solution being measured.

Changes in the conductivity sensor elements can be due to an electrochemical or polarization reaction on the electrodes. Devices employing a direct current are sometimes used (Beck et al., 1971; Jones and Delhaye, 1976; Barnea et al., 1980) but a "direct current will cause polarization of the electrodes and formation of a resistance that will then alter conductivity measurement" (Hordeski, 1987). To minimize this problem, low voltages can be used in conjunction with high speed flows that tend to clean the electrodes (Jones and Delhaye, 1976; Goldstein, 1983). Another alternative is to determine solids concentration from the high frequency conductivity fluctuations due to the solids motion (Beck et al., 1971). A low frequency filter was used to eliminate the relatively slow changes in conductivity due to the polarization phenomenon.

The majority of authors recommend the use of an alternating current to minimize the effect of the polarization resistance (Kidder and Rosenthal, 1965; Mansfield, 1973; Neale and Nader, 1973; Perry and Chilton, 1973; Lee et al., 1974; Ong and Beck, 1975; Jones and Delhaye, 1976; Turner, 1976; Kao and Kazanskij, 1979; Liptak and Venczel, 1982; Goldstein, 1983; Considine and Considine, 1985; Yianatos et al., 1985; Tournaire, 1986; Hordenski, 1987; Nasr-El-Din, et al., 1987). Table 2.4 outlines the frequency and waveform utilized by several authors. As can be seen, the source frequency is generally on the order of 1000 Hz.

Some conductivity probes give signals that are dependent upon the velocity past the sensor. This can be a severe limitation in situations where the local velocity is not known, as is generally the case in mixing tanks. Lee et al. (1974), using the probe shown in Figure 2.20 in a stirred tank filled with a liquid-liquid dispersion, found that as the stirrer speed was increased, the probe field voltage signal increased. They related this to increasing turbulence in the vessel at higher stirrer speeds. Similar results were seen in sand-water slurries in a pipeline (Beck et al., 1974, from Nasr-El-Din et al., 1987). This phenomenon limits the use of these probes to areas where the flow velocity is known or where a calibration curve can be developed.

Nasr-El-Din et al. (1987) developed the four electrode conductivity probe shown in Figure 2.21 to minimize the polarization and velocity dependence of the

Author	Source Frequency	Source Waveform
Neale and Nader (1973)	1000	
Ong and Beck (1975)	60,000	Square
Turner (1976)	1600	
Considine and Considine (1985)	60 - 1000	
Yianatos et al. (1985)	1000	
Tournaire (1986)	10,000	
Nasr-El-Din et al. (1987)	1000	Square

Table 2.4: Alternating Current Frequencies and Waveforms for Conductivity Probes

conductivity signal experienced with some two electrode instruments. The impedance of the sensor circuit is so high that practically no current flows, minimizing any polarization or velocity effects. In fact, "accurate potentials can be measured only under conditions approaching zero current which minimizes errors resulting from resistive potential drop and polarization effects" (Perry and Chilton, 1973). The similar device of Considine and Considine (1985) shown in Figure 2.22 uses the same four electrode concept. Fouling or polarization problems were not a factor with this device either.

To be able to determine solids concentration from conductivity measurements, the solution conductivity must generally be measured. As will be shown, this value is sensitive to changes in the local environment. For reliable measurements, either calibration curves must be developed to compensate for these changes or the solution conductivity must be measured frequently.

It is well known that the ionic strength of a solution or slurry has a very strong effect on its electrical conductivity (Considine and Considine, 1985; Nasr-El-Din et al., 1987). Nasr-El-Din showed that the addition of only 14.3 x 10^{-3} weight percent of an anionic surfactant to tap water decreased the measured conductivity probe sensor voltage by nearly 20%.

Solution conductivity is also a strong function of temperature. Kidder and Rosenthal (1965) state that the effect of temperature is to increase conductivity by between 0.5 and 5% per degree Celsius for most common electrolytes, depending upon the nature and concentration of both the electrolyte and the non-ionic materials in solution. Turner (1976) found a 1.8% per degree Celsius increase for aqueous NaCl solutions. Considine and Considine (1985) state that an increase of 2.5% per degree Celsius is common for most solutions and Nasr-El-Din et al. (1987) found a 2% per degree Celsius increase for tap water. For reliable results, the system temperature must be controlled or the results must be compensated for temperature variations. Another method is to use a bandpass filter to eliminate the relatively slow (low frequency) changes in the solution conductivity due to temperature while measuring solids concentration from the high frequency portion of the signal (Beck et al., 1971; Lee et al., 1974; Ong and Beck, 1975).

The performance of a conductivity sensor can be a function of its physical design and location. Nasr-El-Din et al. (1987) showed that conductivity measurements from the four-electrode design shown in Figure 2.21 were sensitive to the position of the probe relative to a boundary (in this case the wall of the slurry pipeline). Significant deviations in the conductivity measurements occurred when the probe was closer than about one to two centimeters from the pipe wall. These deviations were largest if the field electrode with the smallest area was closest to the wall. It was also found that the conductivity probe responded differently when mounted in a pipeline built of an insulating material (acrylic) versus a conducting material (steel).

The position effects for the insulating material were attributed to obstruction of the field current flow by confining the conducting region by the boundary (Nasr-El-Din et al., 1987). At a constant total field current (standard operation of this conductivity probe), the current near the sensor electrodes was increased and the measured sensor voltage increased when near a boundary. This increase in the field current resistance and sensor voltage due to the insulating boundary was offset somewhat by approaching the boundary with the field electrode with the larger area. The use of a conducting boundary reduced the field current confining phenomenon but caused short circuiting if the small field electrode touched the pipe due to the grounding method used.

Since the solution conductivity measurements can vary with ionic strength, temperature and position, it would be difficult to entirely compensate for these effects with the use of a calibration curve. It is most reliable to regularly measure the solution conductivity to track any changes due to chemical, temperature or position changes. Nasr-El-Din et al. (1987) used the following function to correct for solution composition, temperature at a given position:

$$\frac{E(C, r, z, \theta) - E(0, r, z, \theta)}{E(0, r, z, \theta)} \tag{2.12}$$

where:

$E(C, r, z, \theta)$ = slurry sensor voltage (conductivity) at position z, r, θ.

$E(0, r, z, \theta)$ = liquid sensor voltage (conductivity) at the same position.

2.3.3.3 Two-Phase Electrical Conductivity Expressions

To convert conductivity measurements into solids concentration, it is necessary to have a calibration curve. A number of correlations are available. Maxwell (1881) was one of the first to investigate suspension conductivity and derived the following expression:

$$\frac{k_M - k_L}{k_M + 2k_L} = C \frac{k_P - k_L}{k_P + 2k_L} \tag{2.13}$$

where:

C = dispersed phase volume fraction.

k_M = mixture conductivity.

k_P = dispersed phase conductivity.

k_L = continuous phase conductivity.

Maxwell assumed that the suspension was dilute and that the solids were spheres, such that "their effects in disturbing the course of the current could be taken as independent of each other".

Despite these limitations, Turner (1976), when studying the conductivity of liquid-solid fluidized beds of conducting and non-conducting solids, found the Maxwell equation to be quite adequate to even packed bed concentrations if the ratio of the solids to liquid conductivity (α) was less than about 10. Even for $\alpha > 100$, the Maxwell expression was adequate to solids concentrations of about 20%. Neale and Nader (1973) found that Maxwell's relation was very good for suspensions of containing 55% non-conducting spheres. Equation 2.13 adequately predicted bubble concentrations to 30% in the bubbling zone of a gas-liquid bubble column (Yianatos et al., 1985). Bashir and Goddard (1990) found that the Maxwell equation was good for monodispersed suspensions of ion exchange beads for concentrations up to 50% and $0.044 \leq \alpha \leq 1.48$.

For non-conducting solids ($k_P = 0$), the Maxwell equation reduces to:

$$k_M = k_L \frac{2(1-C)}{(2+C)} \tag{2.14}$$

The same expression was developed by Wagner (1914) in Pal and Rhodes (1985) and by Hashin (1968) from Neale and Nader (1973).

Rayleigh (1892) (from Turner, 1976) developed an expression for the conductivity of regular cubic arrays of non-conducting, mono-sized spheres under conditions when their interactions cannot be neglected.

$$k_M = k_L \left[1 + \frac{3C}{0.394\, C^{10/3} - C - 2} \right] \tag{2.15}$$

Turner (1976) found that this relation diverged from experimental data at concentrations greater than about 40% and had little useful advantage over the simpler Maxwell equation.

Bruggeman (1935) (from Nasr-El-Din et al., 1987) extended Maxwell's relationship to cover mixtures of non-conducting solids in a conducting liquid and obtained:

$$k_M = k_L \, (1-C)^{1.5} \tag{2.16}$$

An identical expression was derived by Hanai (1960, 1961a,b) in Pal and Rhodes (1985) who developed a theory for concentrated dispersions based on Wagner's (1914) work. Pal and Rhodes found this expression to work very well for oil-in-water emulsions to oil volume fractions up to 70% by volume.

De la Rue and Tobias (1959) (from Nasr-El-Din et al., 1987) measured the conductivity of random suspensions of spheres, cylinders and sand particles in aqueous solutions of zinc bromide and used a relation similar to Bruggeman:

$$k_M = k_L \, (1-C)^m \tag{2.17}$$

where:

m = 1.5 for $0.45 \le C \le 0.75$

Prager (1963) (from Neale and Nader. 1973) developed a generalized diffusion model for a suspension of arbitrary shaped particles in terms of statistical parameters based on a random geometry (Yianatos et al., 1985). He gave:

$$k_M = k_L \frac{(1-C)(3-C)}{3} \tag{2.18}$$

Weissberg (1963) (from Yianatos et al., 1985) simplified Prager's calculations by considering an idealized bed in which the centers were randomly situated without restricting the spheres to non-overlapping locations. Weissberg's expression is given by:

$$k_M = k_L \frac{2(1-C)}{2 - \ln(1-C)} \tag{2.19}$$

Considering a cellular bubble shape, that may be found in the froth zone of a gas-liquid bubble column, Fanlo and Lemlich (1965), Steiner et al. (1977) and Desai and Kumar (1983) (all from Yianatos et al., 1985) used the relationship:

$$k_M = k_L \frac{(1-C)}{2.315\ C} \tag{2.20}$$

Yianatos et al. found Equation 2.20 was quite adequate for bubble concentrations in the range of 60 - 95%.

Jeffrey (1973) (from Turner, 1976), developed an equation that accounted for the "chance that a given central sphere may be approached closely by another sphere, which will not occur in a regular, or in a well-spaced, array of the same concentration". The expression for mixture conductivity is given by:

$$k_M = \frac{k_L}{2} \left[2 - 3C - 3C^2 \left(\Sigma - \frac{1}{2} \right) \right] \tag{2.21}$$

where: Σ = sum of a slowly converging series requiring over 100 terms before being correct to three significant figures.

Turner found however that this relation diverged significantly from the Maxwell equation for $\alpha = 10$ at concentrations above about 40%.

Begovich and Watson (1978) used the following empirical expression to determine the mixture conductivity for a liquid-solid fluidized bed:

$$k_M = k_L \, (1 - C) \tag{2.22}$$

Nasr-El-Din et al. (1987) found that this relation under-predicts the slurry resistance for all concentrations when compared to either Maxwell's or Bruggeman's relations.

Machon et al. (1982) used another empirical expression:

$$k_M = k_L \, (1 - k_3 C) \tag{2.23}$$

where:

k_3 = a constant to be determined experimentally.

Nasr-El-Din et al. (1987) advised caution when using the above relation since it has no theoretical justification and is unrealistic at the limit $C = 1$, unless $k_3 = 1$.

An expression similar to Maxwell's was derived geometrically for spherical shaped bubbles in a homogeneous regime by Yianatos et al. (1985):

$$k_M = k_L \, \frac{(1 - C)}{(1 + 0.55C)} \tag{2.24}$$

The four relations that appear most realistic for this study (non-conducting solids in a conducting liquid) are the Maxwell, Bruggeman, Prager and Weissberg relations (Equations 2.14, 2.16, 2.18 and 2.19 respectively). They are compared in Figure 2.23 by plotting the mixture and fluid resistances (proportional to the conductivity probe sensor voltage) (R_M' , R_L') versus the solids concentration. There is little difference between these equations for solids concentrations less than about

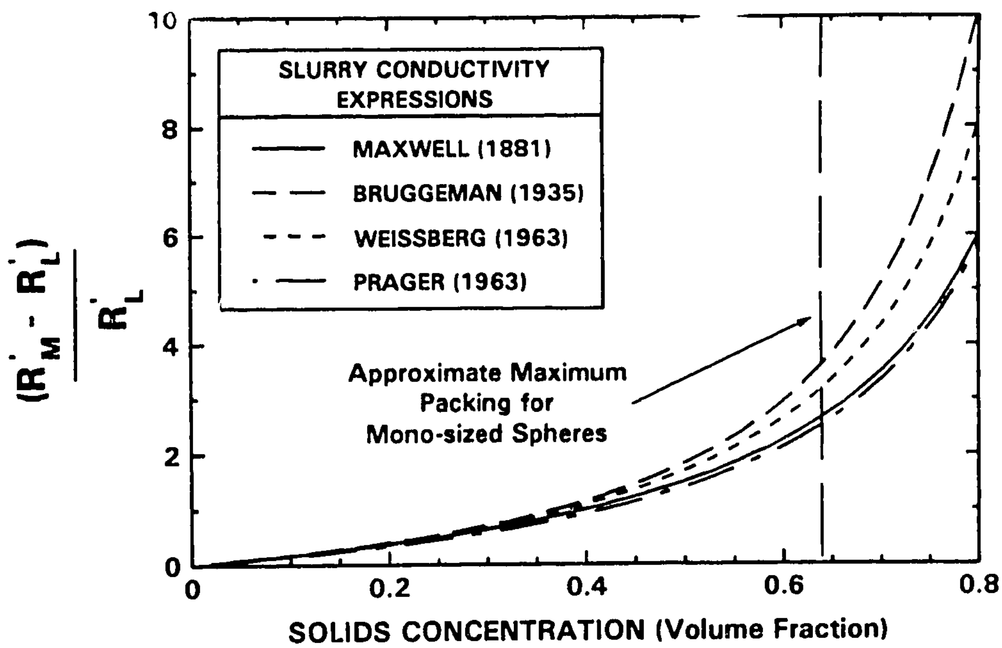


Figure 2.23: Slurry Electrical Conductivity Expressions

40%. At higher solids concentrations, there are significant differences between the four relations. Solids concentrations at or above the maximum packing for monosized solids are difficult to obtain unless the particle size distribution is large. In these situations, it would be advisable to use an equation such as Bruggeman's, that was developed for distributions of particles.

2.3.4 Summary

Several techniques have been shown to successfully measure local solids concentration in slurry systems. Optical methods are limited to relatively low solids concentrations. Capacitance methods have generally been limited to solids concentration measurements over a large volume or chord length. Electrical conductivity techniques appear to be the most promising for measuring local solids concentrations of relatively concentrated slurries.

Many two-electrode conductivity probes suffer from a velocity dependence.

This is very undesirable for application in a mixing tank where the local velocities are not well known. The four electrode designs utilizing an alternating field current (Considine and Considine, 1985; Nasr-El-Din, 1987) do not appear to have this limitation. The design of Nasr-El-Din (1987) has shown success at measuring local solids concentrations in a slurry pipeline. The L-shaped design is best suited for a pipeline flow but not for a mixing tank. A straight conductivity probe of a similar design would be better suited for a mixing tank.

Many expressions have been developed to convert the electrical conductivity of a suspension to solids concentration since the early expression by Maxwell (1881). None however show a significant improvement over the Maxwell equation for non-conducting solids to solids concentrations to about 40% by volume.

A four-electrode conductivity sensor utilizing an alternating field current is the most attractive for measuring local slurry conductivity in a slurry mixing tank. The Maxwell (1881) correlation is a suitable equation for converting electrical conductivity measurements to solids concentration, for non-conducting solids.

3. EXPERIMENTAL STUDIES

This chapter outlines the equipment and liquid-particle system used in this study. In addition, the sampling and conductivity experimental techniques, the experimental limitations and estimation of errors are discussed.

3.1 Equipment

3.1.1 Vessel and Impellers

A review of the mixing tanks and impeller systems used by several investigators was done so that the tank and impeller chosen for this study would be similar to those from the literature. Table 3.1 summarizes the parameters reviewed and the dimensions chosen for the equipment in this study. Table 1.1 provides a more detailed review.

A schematic diagram of the mixing tank is shown in Figure 3.1. The vessel was constructed of plexiglas to enable viewing of the mixing process. The impeller was driven by a 1/4 H.P. variable speed D.C. motor, with the mixer speed measured with a Cole-Parmer model 8211 optical tachometer.

Samples of the slurry in the mixing tank were withdrawn using sampling tubes mounted axially along the vessel wall, midway between two baffles ($\theta = 45^{o}$) as shown in Figures 3.1 and 3.2. The sampling tubes were located at axial positions from near the bottom of the tank ($z/H = 0.1$) to near the top free liquid surface ($z/H = 0.9$). The tubes could be inserted from the wall ($r/R = 1.0$) to the impeller shaft ($r/R = 0.04$) of the tank, except on the impeller plane, where the range was $0.33 \leq r/R \leq 1.0$. Sampling tubes up to 12.7 mm outside diameter could be accommodated.

The top of the vessel was fitted with a conductivity probe mounting system to allow positioning of the probe at any axial position in the tank and radial positions

PARAMETER	SYMBOL	UNIT	TYPICAL VALUE FROM REVIEW[1]	PRESENT STUDY
Tank Diameter	T	m	various	0.29
Liquid Height	H/T	-	1.0	1.0
Impeller Diameter	D/T	-	0.08 - 0.61	0.33
Impeller Type			Radial and Axial	Radial
Impeller Height Above Tank Bottom	h/T	-	various	0.3
Radial Impeller Blade Length	l/D	-	0.25	0.25
Radial Impeller Blade Width	w/D	-	0.20	0.20
Number of Baffles			4	[illegible]
Baffle Width	B/T	-	0.10	0.10

Table 3.1: Mixing Tank and Impeller Specifications

from r/R = 1.0 (wall) to r/R = 0.22. The limit of r/R = 0.22 was due to the design of the probe holder. Positions closer to the impeller could not be accommodated. The angular position could be varied but was generally fixed at $\theta = 45^0$, mid-way between two baffles, as shown in Figure 3.1.

The mixing experiments were carried out using a six-bladed radial flow, disc-type Rushton impeller shown in Figure 3.3. The flow profiles in a mixing tank for a radial flow impeller of this type are shown in Figure 3.4.

[1] See Table 1.1 for full review and references.

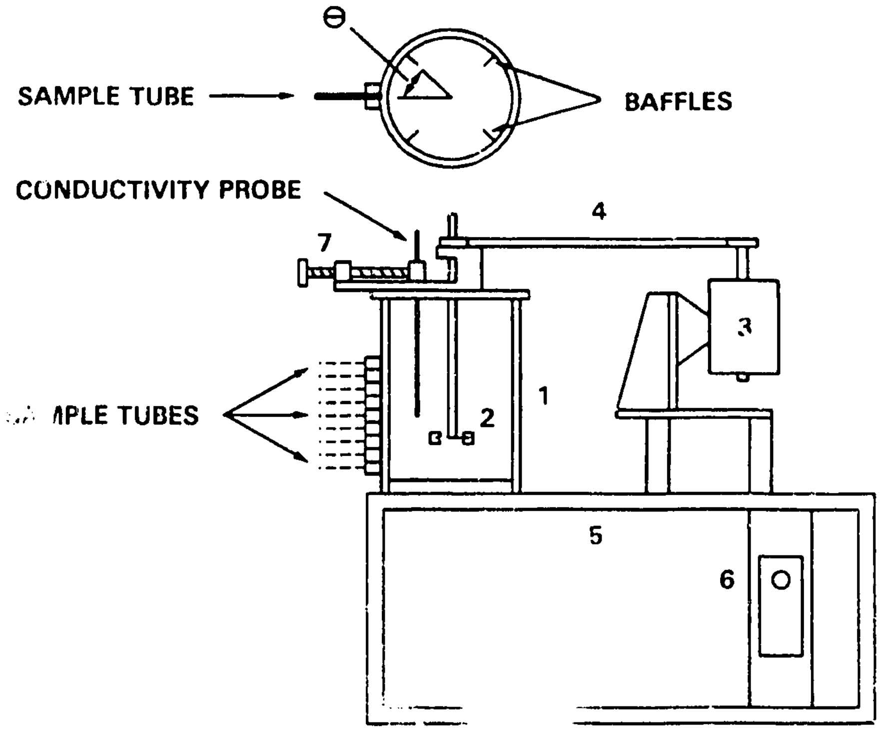


Figure 3.1: Mixing Tank Schematic

1 - Mixing Tank	5 - Stand
2 - Impeller	6 - Motor Control
3 - D.C. Motor	7 - Conductivity Probe Holder
4 - Drive Belt	

3.1.2 Sample Withdrawal

Slurry samples were withdrawn from the mixing vessel using a Cole-Parmer Masterflex peristaltic pump equipped with 6.4 mm flexible tubing and a variable speed drive. Samples were collected in a Kohlrausch flask, a wide mouth volumetric flask, and the sampling time was measured with a stopwatch. This method, outlined

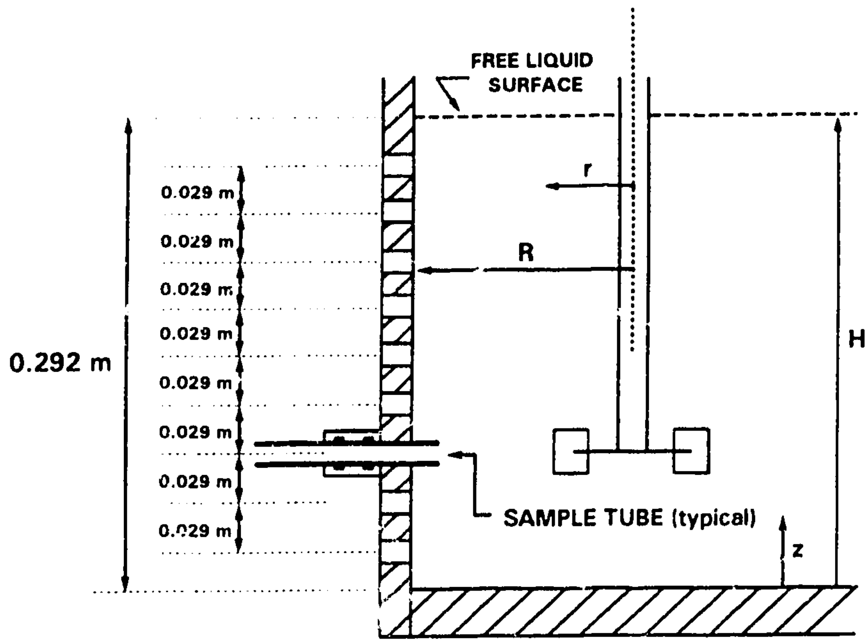


Figure 3.2: Sample Tube Mounting System

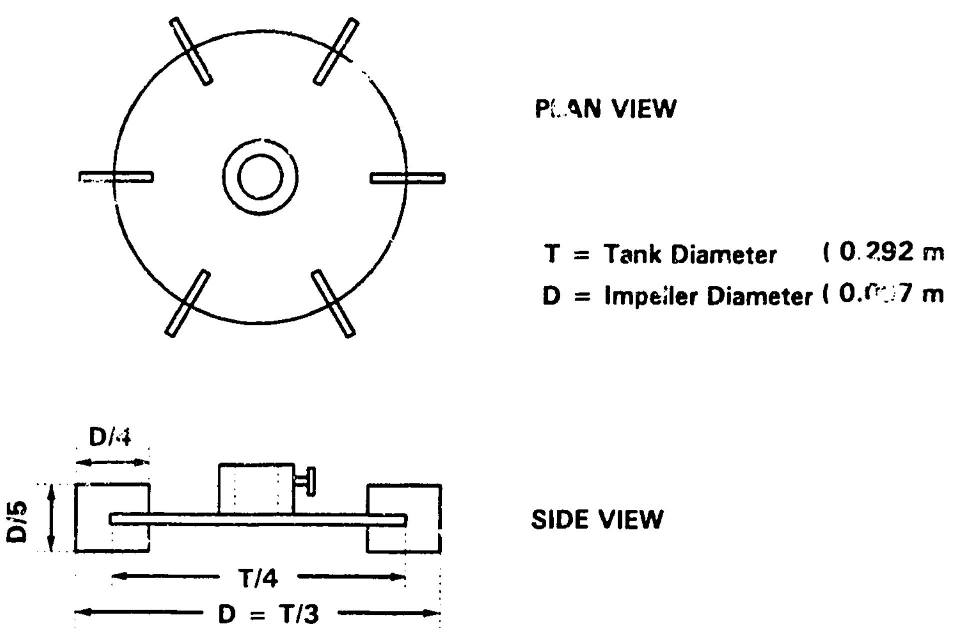


Figure 3.3: Radial Flow Impeller

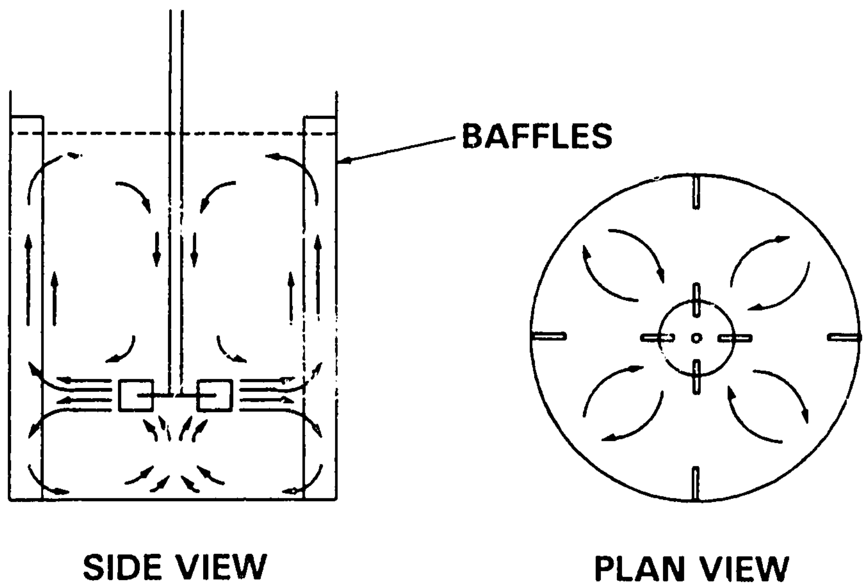


Figure 3.4: Typical Flow Patterns in a Mixing Tank Stirred with a Radial Flow Impeller

in Section 3.3.1, gave both the sample slurry solids concentration as well as the volumetric flow rate.

Figure 3.5 shows the sizes and shapes of the stainless steel sampling tubes used in this study. The inside diameters (ϕ) of each tube were measured with a micrometer. The radial positions of the angled tubes were standardized as shown in Figure 3.6. When positioned at the wall ($r/R = 1.0$), the angled tip of the sampling tube just projected into the tank.

A limited number of samples were obtained with a tapered sample tube as shown in Figure 3.7. This sample tube had a tip angle of $\gamma = 18°$ as compared with a tip angle of $\gamma = 90°$ for all the other sample tubes.

A summary of the ranges of mixing and sampling parameters covered in this study are shown in Table 3.2.

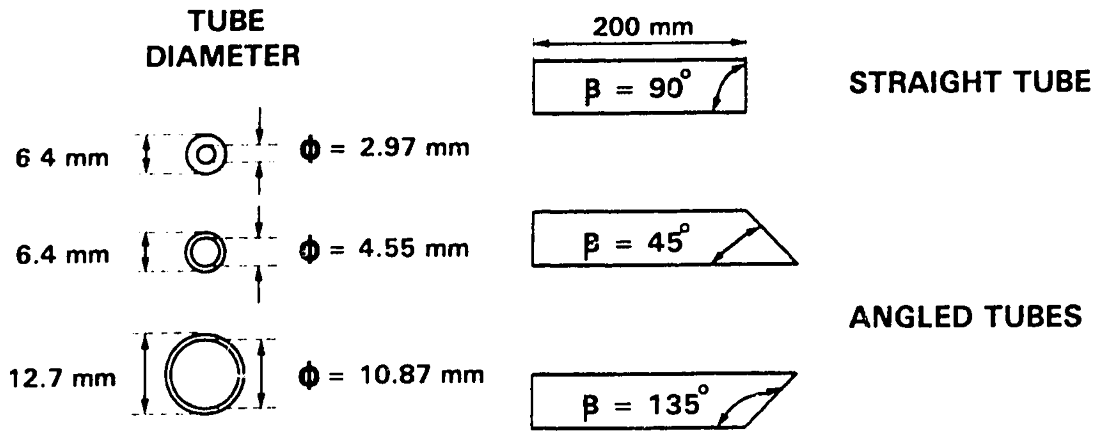


Figure 3.5: Sample Tube Dimensions

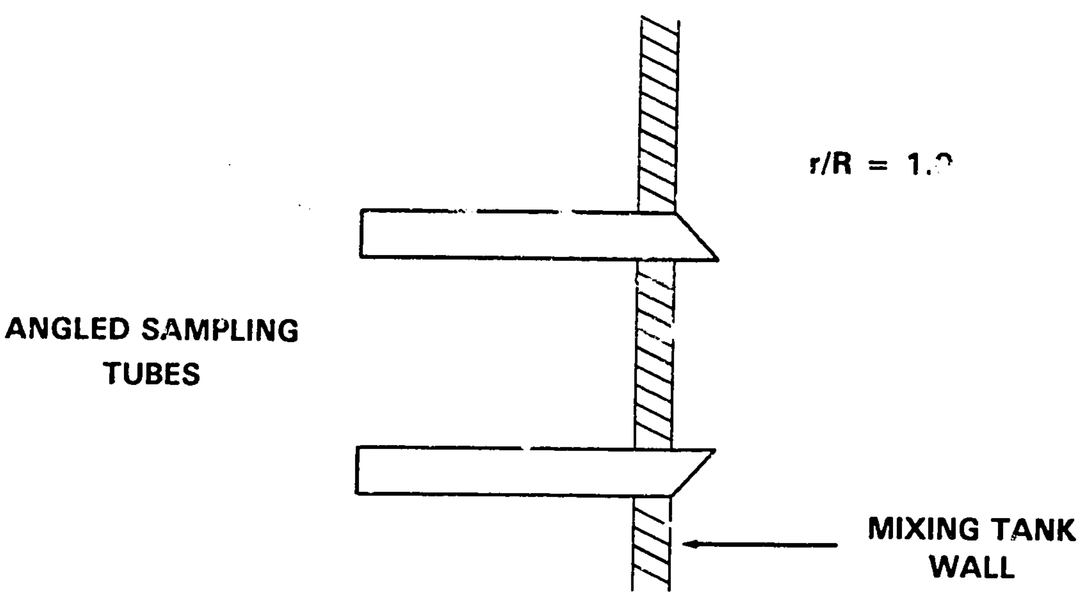
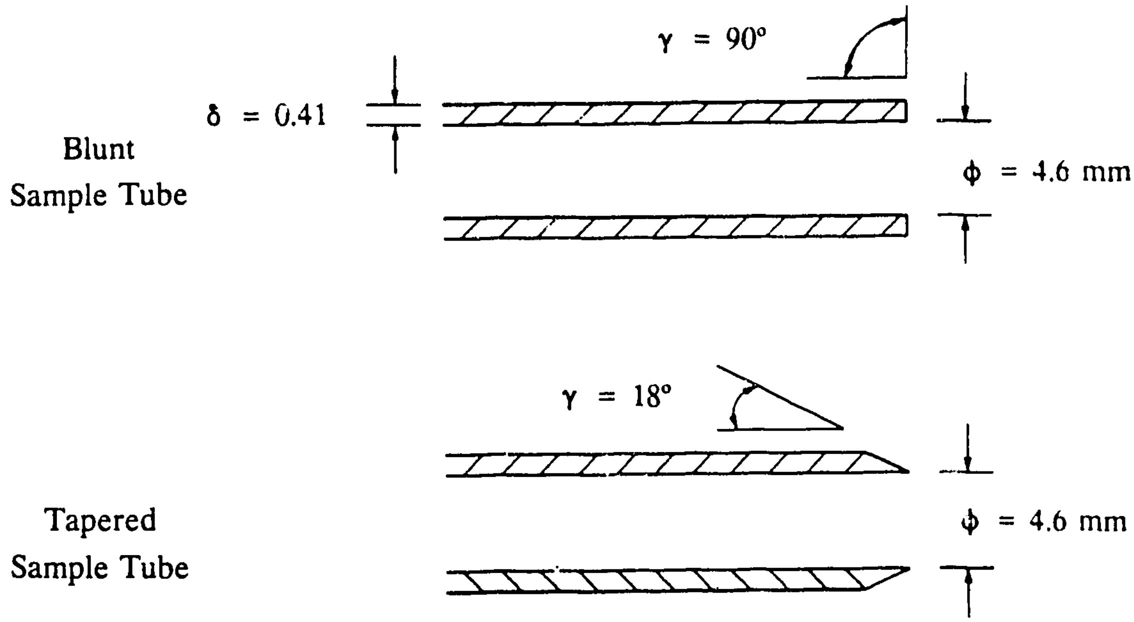


Figure 3.6: Angled Sample Tube Radial Position



δ = Wall Thickness / Sample Tube Radius

Figure 3.7: Sample Tube Tip Angle

Variable	Symbol	Units	Range
Sampling Velocity	U_s	m/s	0.3 - 3.0
Mixer Speed	N	rpm	440 - 750
Position in Vessel - Axial[2] - Radial[3]	 z/H r/R		 0.1 - 0.9 0.1 - 1.0

Table 3.2: System Parameters Studied

[2] z/H = 0.0 = Bottom; z/H = 1.0 = Top Liquid Surface.

[3] r/R = 0.0 = Impeller Axis; r/R = 1.0 = Tank Wall.

3.1.3 Conductivity Probe

The conductivity probe used for measuring local solids concentration in these tests was a modification of the design used by Nasr-El-Din et al. (1987). The probe, shown in Figure 3.8, was constructed of straight stainless steel tubing, 4.8 mm in diameter and 610 mm long. Two field and two sensor electrodes were located on the sensing end of the conductivity probe (Details A and B). The sensor electrodes consisted of two small gauge stainless steel wires set approximately 1 mm apart and mounted flush with the flat end of the conductivity probe. The large field electrode was the body of the conductivity probe while the small field electrode was a small, half-round piece of the 4.8 mm tubing. All of the electrodes were set in place and electrically insulated from each other with Caulk Orthodontic Resin from the L.D. Caulk Company. The opposite end of the conductivity probe, outside the mixing

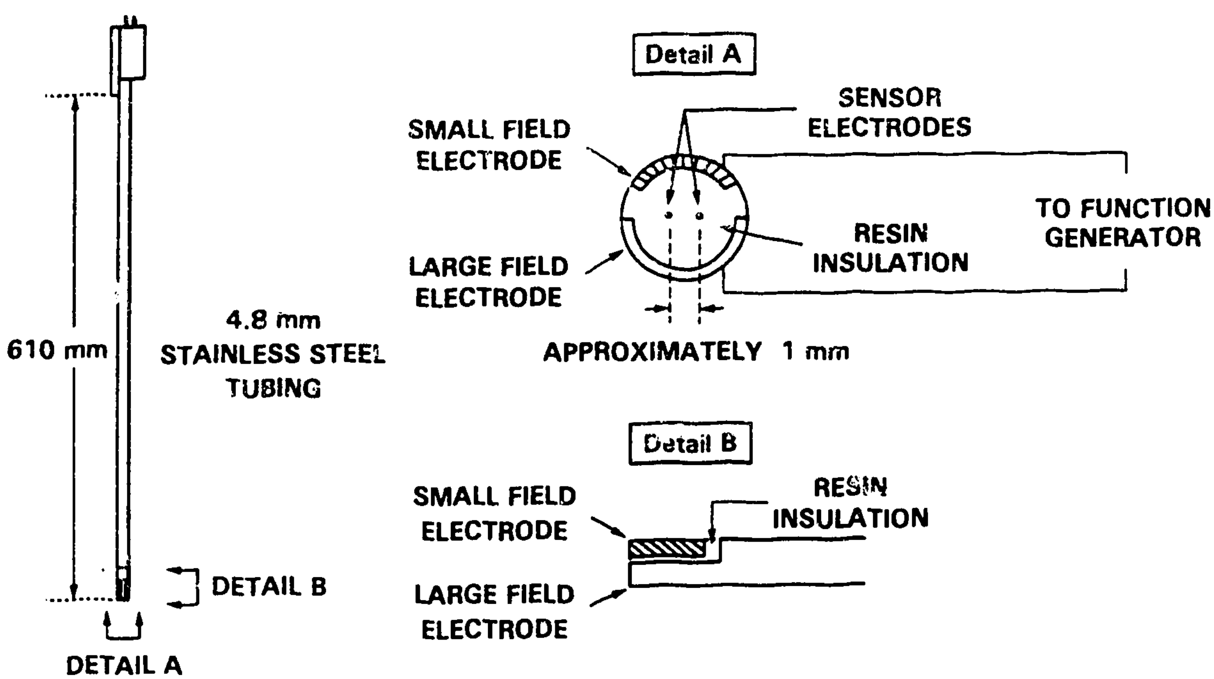


Figure 3.8: Conductivity Probe Schematic

vessel, was a nine pin computer plug into which the four electrode wires were connected.

The conductivity probe circuits are shown in Figure 3.9. The field current was generated by an Interstate Electronics Corporation F51 function generator and monitored by a Beckman 3010 multimeter with a ±0.001 mA A.C resolution. An alternating square wave of 1000 Hz frequency and approximately 11 volts amplitude, giving a 1.0 mA field current, was used to avoid fluid electrolysis. A 5000 ohm variable ballast resistor was used to maintain the field current as constant as possible. The sensor voltage was measured with a Fluke 77 multimeter with a resolution of ± 1 mV. The sensor circuit had such a high impedance that there was essentially no current flowing. This minimized polarization of the sensor electrodes and the associated problems outlined in Section 2.3.3.2.

Conductivity probe calibration tests were conducted in a suspension of slowly

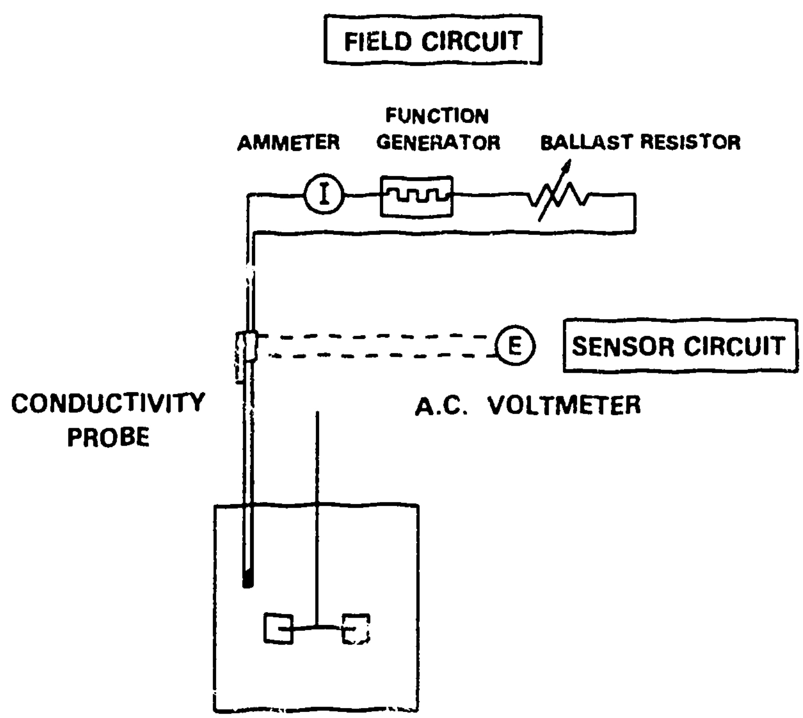


Figure 3.9: Conductivity Probe Circuit

settling polystyrene particles in water. The particles were dry sieved several times to produce a closely sized cut (300 - 355 μm). Several drops of a nonionic surfactant (Triton X-100, $C_8H_{17}(C_6H_4)(OCH_2CH_2)_xOH$) were added to eliminate particle flocculation and an aluminum stir-rod was used to homogenize the solution. Measurements were made in a graduated cylinder at several solids concentrations by adding water or polystyrene particles.

3.2 Liquid-Particle System

A summary of the liquid and particle parameters covered in this study are given in Tables 3.3 and 3.4. The fluid in all cases was tap water and the particles were sand. The temperature of the system was not controlled but varied from 20 - 30°C. with a mean of 24.9°C and a standard deviation of 2.4°C. This mean temperature was used to determine the fluid density, required to calculate the sample solids concentration.

Particle densities were determined by displacement of water in a 500 ml volumetric flask. Care was taken to remove trapped air from the sand. Reproducibility of these measurements was excellent with the ratio of the population

	Density	Mean Particle Size	Bulk Volume Concentration
Symbol	ρ_P (kg/m^3)	d_{50} (μm)	C_B (Volume Fraction)
Sand Fraction 1	2635	82	0.30
Sand Fraction 2	2635	255	0.10, 0.30
Sand Fraction 3	2631	410	0.01 - 0.30
Sand Fraction 4	2630	500	0.10, 0.30
Sand Fraction 5	2625	1000	0.10

Table 3.3: Particle Properties

Variable	Symbol	Units	Value
Fluid Density	ρ_L	kg/m³	997
Fluid Viscosity	μ_L	mPa.s	0.95

Table 3.4: Water Properties at 24.9°C
From: Perry and Chilton (1973)

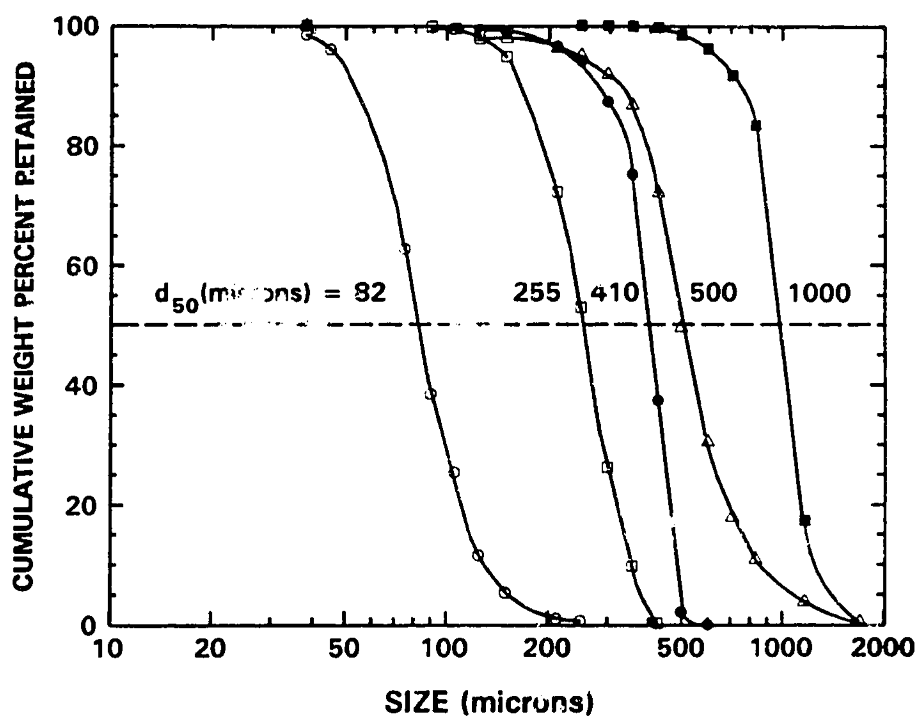


Figure 3.10: Sand Particle Size Distributions

standard deviation to the mean averaging ±0.12%. A complete summary of these experiments is given in Appendix A.

Particle size distributions were measured by sieving 150 gram samples for 25 minutes. The results are shown in Figure 3.10 with a complete tabulation of results in Appendix A.

3.3 Experimental Technique

All experiments were run in batch mode using sand-water slurries. Dry sand was weighed and added to the tank. Tap water was then added until the liquid level in the mixing tank equalled the tank diameter (H/T = 1.0).

3.3.1 Sample Withdrawal

Prior to withdrawal of a sample from the mixing tank, the proper sample tube was inserted to the desired axial and radial position in the tank. The mixer was then started, set to the required speed and operated for five minutes before the sample was taken. This was an adequate period for the mixing vessel to come to steady-state, as described in Section 3.5.

To withdraw a slurry sample from the mixing tank, the peristaltic pump was started and allowed to run for several seconds until the flow was steady. A 300 to 400 ml sample was then collected in the 500 ml Kohlrausch flask and the sampling interval was measured with a stopwatch. This sample size was approximately 2% of the tank volume. Larger samples were not removed as they may have significantly altered the bulk concentration in the mixing tank. The pump was then reversed, the line flushed out with water and the pump and mixer stopped.

The sample was weighed, the Kohlrausch flask topped up with tap water to the 500 ml line and the flask re-weighed. The mixture or sample concentration (C_M) and the sampling velocity (U_S) were calculated following the technique of Kao and

Kazinskij (1979):

$$V_M = V_T - \left[\frac{M_T - M_M}{\rho_L}\right] \tag{3.1}$$

$$\rho_M = \frac{M_M}{V_M} \tag{3.2}$$

$$C_S = C_M = \frac{\rho_M - \rho_L}{\rho_P - \rho_L} \tag{3.3}$$

$$U_S = \frac{4\ V_M}{\pi\ \phi^2\ \tau} \tag{3.4}$$

where:

V_M	=	Sample (mixture) volume.
M_M	=	Sample (mixture) mass.
C_S , C_M	=	Sample (mixture) solids concentration.
ρ_M	=	Sample (mixture) density.
V_T	=	Total volume.
M_T	=	Total mass at total volume.
ρ_L	=	Liquid density.
ρ_P	=	Particle density.
τ	=	Sample interval.
ϕ	=	Sample tube inside diameter.

The sampled sand and water were returned to the tank, the liquid level was adjusted to H/T = 1.0 and the mixer was re-started.

Several tests were made to determine the particle size distribution of the sampled sand. This was done by collecting the sample as described above, filtering off the water and drying the sand completely. The sand was sieved for 25 minutes with sufficient sieves to cover the size distribution. The sand was then returned to the mixing tank for further experiments. A summary of these experiments is given in Appendix B.

3.3.2 Conductivity Measurements

Measurement of solids concentration with the conductivity probe required the measurement of the slurry conductivity as well as the liquid conductivity.

Prior to taking measurements, the mixing tank was loaded with sand and water and the mixer started and allowed to run for five minutes before conductivity measurements were taken. The conductivity probe was checked periodically for any physical damage and for shorting of the field or sensor circuits.

To measure slurry conductivity, the probe was moved to the appropriate location in the mixing tank and the circuit wiring connected to the probe. The field current was set at 1.0 mA with a square wave at a frequency of 1000 Hz. The field current fluctuated somewhat due to variations in the solids concentration. This was most noticeable near the slurry-liquid interface near the top of the mixing tank or slurry-sediment interface at the bottom of the tank. The field current was set as close to 1.0 mA as possible with the ballast resistor. The sensor voltage (E_C) was then measured. This reading also fluctuated somewhat. The average high and low values were recorded, ignoring 'spikes' of high and low voltage that occurred periodically.

As will be discussed in Section 4.2, the slurry conductivity measurements varied as the probe was rotated to discrete positions about its axis. This was due to the position of the probe electrodes relative to the direction of flow. Calibration tests indicated that the highest measured value was the correct one. Therefore, four measurements were taken at a given spot in the mixing tank, corresponding to four rotated positions of the conductivity probe, 90° apart. This technique allowed the measurement of the highest and correct slurry conductivity without knowledge of the direction of flow at the point of measurement.

The fluid conductivity was measured with the mixer off and the sand totally settled. The probe was repositioned to the point where the slurry conductivity was measured, unless in the sand sediment. The field current was adjusted to 1.0 mA and the sensor voltage (E_0) was measured. These measurements did not fluctuate. Measurements of E_0 were frequently required to account for changes in the fluid conductivity due to heating of the system from the mixing action.

Calculation of solids concentration from the conductivity data was done using a calibration curve outlined in Section 4.2.

3.4 Experimental Limitations

A number of factors limited the range of experimental parameters that could be covered in this study.

- There was an upper limit of the mixer speed due to air entrainment into the slurry by the vortex generated. Air can give rise to errors when measuring slurry conductivity since it is an insulator like sand, and cannot be distinguished from the sand by the conductivity probe. Unrealistically high solids concentration values may result.
- The lower limit of sampling velocity was due to plugging of the sample lines. This depended upon the sand size and concentration and the diameter of the sample tube used. The lowest sampling velocity used was a pump speed of 50 rpm corresponding to a sampling velocity (U_S) of 0.3 m/s with a sample tube diameter (ϕ) of 4.6 mm.
- The upper limit of the sampling velocity of U_S = 3 m/s, corresponded to a pump speed of approximately 1500 rpm.
- The sample size was limited to 300 - 400 ml in order to minimize changes in the

bulk concentration in the mixing tank.

3.5 Error Estimation

Errors in the solids concentration measurement by sample withdrawal can occur in a number of areas:

- Sample volume determination due to variation in fluid temperature and density and thermal expansion of the volumetric flask.
- Inadequate drying of the volumetric flask.
- Change in the fluid volume in the mixing tank due to withdrawal of the sample.
- The mixing tank not at steady-state.

The temperature of the mixing experiments varied from 20 - 30°C, while the Kohlrausch volumetric flask used for sample volume determination was calibrated at 20°C. Some error in sample volume measurement could be due to thermal expansion of the flask. This error was estimated by adding water of various temperatures to the flask and weighing. The density of water was obtained from Perry and Chilton (1973). Volumetric variations are shown in Table 3.5. As can be seen, errors due to thermal expansion of the volumetric flask are negligible.

Variation in water density with temperature will cause an error in the determination of sample volume and thus concentration, since the mean temperature of 24.9°C was used in all calculations. A simple calculation was done for a typical sample of 638 g total weight (M_T), 415 g sample weight (M_M) and a solids density of 2.65 g/ml. Using Equations 3.1 to 3.3, Table 3.6 was generated. Error in solids concentration due to variations in fluid density is less than one percent for the temperatures experienced in the experiments.

Prior to taking a sample, the Kohlrausch flask was not dried completely, but shaken until the majority of the water was removed. A small amount of water remained in the flask and would introduce some error in the sample volume

Temperature (°C)	Water Density (kg/m³)	Measured Volume (ml)	Relative Error[4] (%)
37	993.4	499.9	0.02
32	995.1	499.7	0.06
27	996.5	499.8	0.04
24	997.3	499.5	0.10
20	998.2	499.5	0.10
17	998.8	499.5	0.10

Table 3.5: Errors Due to Thermal Expansion of the Volumetric Flask

Temperature (°C)	Water Density (kg/m³)	Mixture Volume (ml)	Mixture Conc. (C_M)	Relative Error[5] (%)
37	993.4	275.5	0.310	1.41
30	995.7	276.0	0.307	0.52
24.9	997.1	276.4	0.305	0
20	998.2	276.6	0.304	0.43
17	998.8	276.7	0.303	0.65

Table 3.6: Sample Volume Errors Due to Water Density Variation

[4] Relative Error = 100 * (Calibrated Volume (500 ml) - Measured Volume) / Calibrated Volume

[5] Relative Error = 100 * (C_M at temperature (t) - C_M at 24.9°C) / (C_M at 24.9°C)

determination. Fourteen experiments were performed to determine the amount of water that remained in the flask and are summarized as follows:

Mass of Water Remaining in Shaken 'Dry' Flask

Average	1.08 g
Standard Deviation	0.18 g

This error is relatively small as compared to the 500 ml volume of the Kohlrausch flask.

Withdrawal of a sample from the batch mixing tank reduced the total volume of slurry in the tank. As the sample concentration (C_S) is rarely the same as the bulk concentration (C_B) in the mixing tank, sample removal will change the bulk concentration somewhat. An estimate of this change is shown in Table 3.7 for various sample concentrations. The assumption is that the total volume of slurry removed from the tank prior to and during sampling is 800 ml. This includes running the sample flow before sampling to ensure steady flow. The majority of samples taken from the tank were in the range of $0.5 \le C_S / C_B \le 1.5$, where the change in bulk concentration due to sampling is less than about two percent.

The equilibration time (time to establish steady-state in the mixing tank after start-up) was determined by measuring the concentration at a single point in the tank by sampling and the conductivity probe at different periods after the mixer was started. The 255 μm sand at C_B = 0.10 and 0.30 and N = 545 rpm were used. Measurements were taken at z/H = 0.4 and r/R = 0.6. The sample tube was 4.55 mm in diameter with $\beta = 90°$. Results for the sampling tests are in Appendix C and the conductivity tests in Appendix D.

The concentrations measured by sampling and the conductivity probe became invariant in less than one minute. Allowing five minutes for the mixing tank to come to steady state after starting the mixer appears more than adequate.

Sample Concentration (C_S/C_B)	Relative Change in C_B Due to Sampling[6] (%)
0.5	-2.13
1.0	0
1.5	2.13
2.0	4.27

Table 3.7: Variation in Bulk Concentration Due to Sample Removal

The total possible error was calculated as a summation of the cumulative errors outlined above. The first three sources of error are volumetric errors of 0.5 ml for thermal expansion of the flask, 0.6 ml for water density variations with temperature and 1.08 ml for the small amount of water remaining in the shaken dry flask. Using the example shown previously, the cumulative error in the solids concentration measurement due to these three sources is 2.4%. When added to a 2% variation in concentration due to withdrawal of the sample, a maximum possible relative error of 4 - 5% in the sample concentration measurements results. As will be shown in the following chapter, sample solids concentration differences due to sampling technique are generally much higher than these experimental errors.

[6] Relative C_B Change = 100* [(C_B before sample withdrawal) - (C_B after sample withdrawal)] / [C_B before sample withdrawal]

4. RESULTS AND DISCUSSION

The discussion of results is divided into four sections. The first section will show how sampling results from a slurry mixing tank can vary widely as a function of sampling method, mixing conditions and particle properties. The next section will outline the development. testing and calibration of a new conductivity technique for measuring local solids concentrations. Following that, the conductivity method will be used as a reference for measuring local solids concentrations in the slurry mixing tank. The results will be compared with sampling measurements and an analysis of sampling errors in the slurry mixing tank will be conducted. Finally, several sample solids concentration correlations will be compared with the experimental data from this study.

4.1 Sample Withdrawal From the Slurry Mixing Tank.

The two characteristics of a solid-liquid sample that may vary are the sample solids concentration and the sample particle size distribution. The variation of sample solids concentration with the location in the mixing tank, method of sampling, mixing conditions and particle properties will be first explored. Following this, the variation of sample particle size distribution with the method of sampling and sample location will be shown.

4.1.1 Effect of Sampling Velocity and Location on Sample Solids Concentration

An ideal sampler should provide a sample whose concentration is equal to the local concentration of the system being sampled, regardless of how the sample is obtained. If this were the case, no differences in the sample solids concentration (C_S) with sampling velocity (U_s) would be seen A typical trend of sample solids concentration versus sampling velocity is shown in Figure 4.1. Data in this figure are for the 410 μm sand, at a bulk solids concentration of 0.30, sampled with the 4.6 mm diameter, straight faced sampling tube at a normalized axial location of 0.4 and a normalized radial location of 0.1. The trend indicates that samples obtained from a slurry mixing tank are generally a function of sampling velocity.

The direction of the solid-liquid flow in a mixing tank agitated with a radial flow impeller varies with location in the mixing tank as shown previously in Figure 3.4. The position of a sample tube inserted from the tank wall, as in this study, will at times be parallel to the flow, perpendicular to the flow or at a position where the flow has both parallel and perpendicular components. These variations will affect the approach of the solids to the sampler and thus the sample solids concentration.

The variation of sample solids concentration with radial position is illustrated in Figure 4.2 for an angled sample tube located just above the impeller plane. The

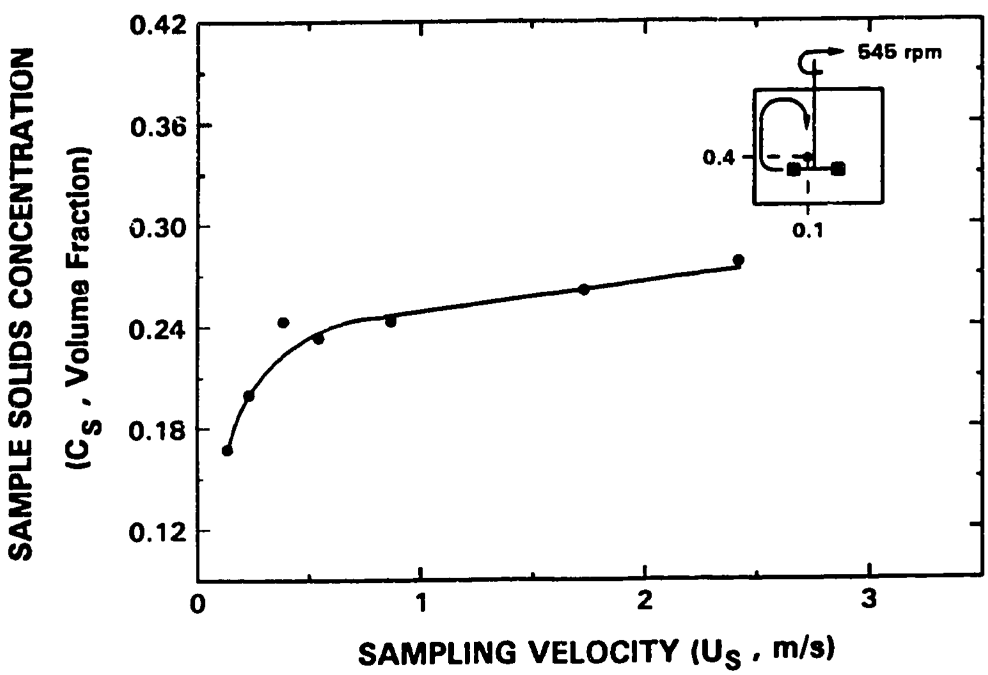


Figure 4.1: Sample Solids Concentration versus Sampling Velocity
d_{50} = 410 μm, C_B = 0.30, ϕ = 4.6 mm,
β = 90°, z/H = 0.4, r/R = 0.1

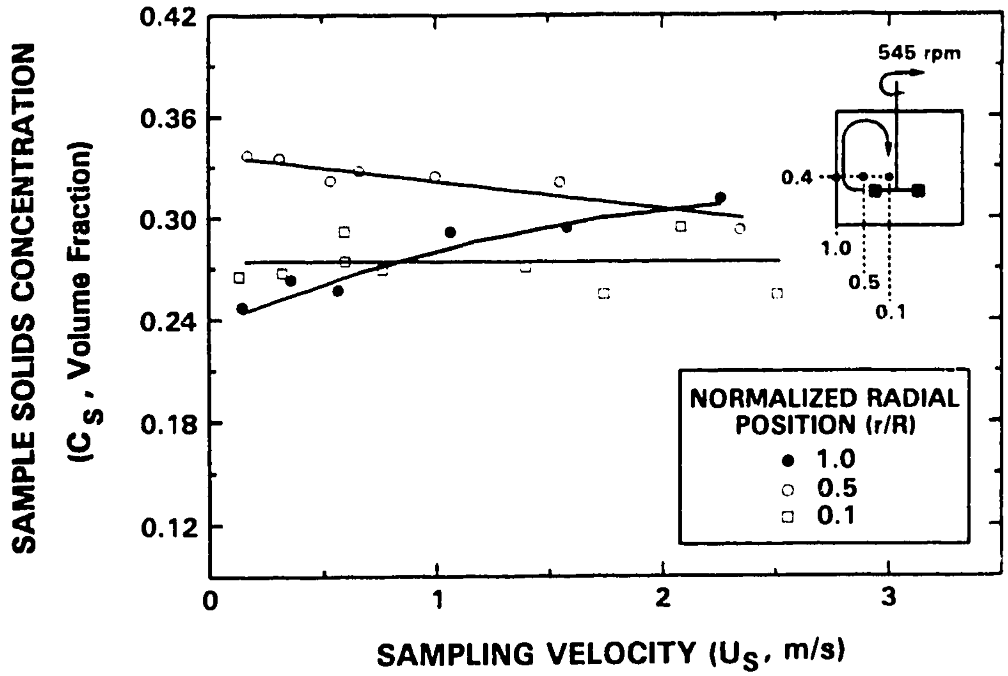


Figure 4.2: Effect of Radial Position on Sample Concentration
d_{50} = 410 μm, C_B = 0.30, ϕ = 4.6 mm, β = 45°
z/H = 0.4

response of sample concentration to sample velocity is flat at a radial position near the impeller shaft (r/R = 0.1). At an intermediate position (r/R = 0.5), the sample concentration decreases with increasing sampling velocity while at the wall (r/R = 1.0), the sample concentration increases with sampling velocity. Figure 4.2 suggests that there are radial variations in solids concentration. The variations may however be due to sample withdrawal errors. This cannot be determined without an independent measure of the local solids concentration at the point of sampling in the mixing tank.

Sample solids concentration varies even more widely at different axial locations in the mixing tank (Figure 4.3). At the impeller plane (z/H = 0.3), the sample concentration decreases with increasing sampling velocity. At this position,

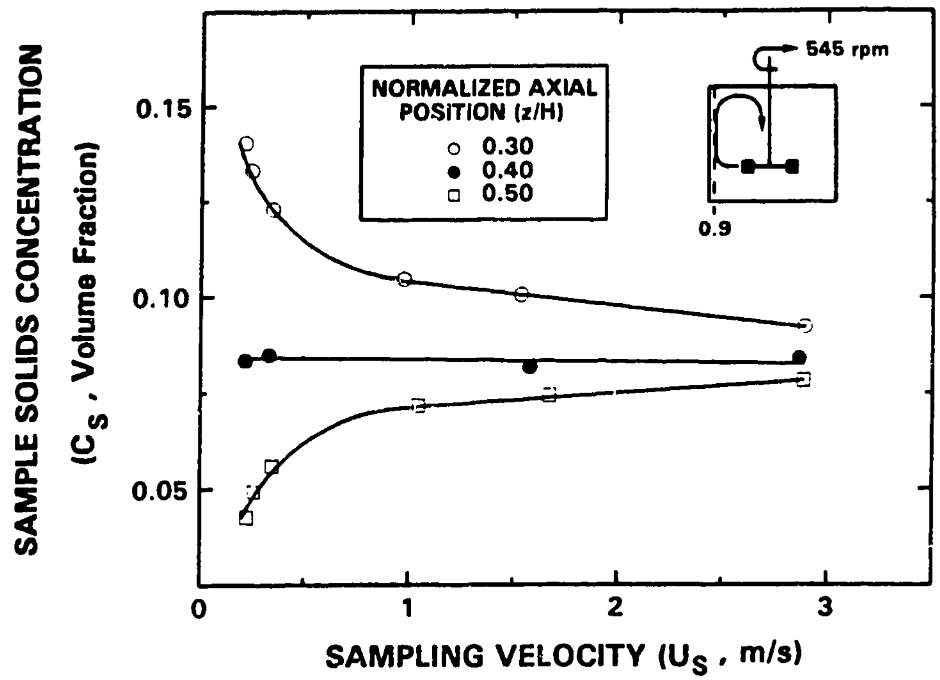


Figure 4.3: Effect of Axial Location on Sample Concentration
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, β = 90°,
r/R = 0.9

the flow is mainly radial outwards from the impeller and generally parallel to the sample tube (Figure 3.4). Above this plane (z/H = 0.5), the flow is essentially vertical and perpendicular to the sample tube. An opposite trend results with the sample concentration increasing with increasing sampling velocity. At a position between these two (z/H = 0.4), the sample concentration is insensitive to sampling velocity.

These results are different than those of Rushton (1965) and Sharma and Das (1980) for sampling along the mixing tank wall, above and below the impeller plane. These researchers found that the sample solids concentration (C_S) was higher than the bulk solids concentration (C_B) in the mixing tank at a location above the impeller plane. The results in Figure 4.3 show that the sample solids concentrations, at the positions above the impeller plane (z/H = 0.4 and 0.5), are less than the bulk solids concentration (C_B = 0.10) for all sampling velocities. The samples obtained by Rushton and Sharma and Das were taken with a sample tube mounted flush with the tank wall (r/R = 1.0), whereas the data in Figure 4.3 were obtained with a sample tube located away from the tank wall (r/R = 0.9). There are most likely differences in the local solids concentration (C_0) in the mixing tank at these two radial locations, giving rise to the differences in sample solids concentration.

At low sampling velocities, the large differences in the sample solids concentration at the three axial locations in Figure 4.3 is partially due to particle inertia and the flow relative to the sample tube opening. The flow direction relative to the sample tube opening varies with axial location and the inertia of the particles results in very different sample solids concentrations at low sampling velocities. At high sampling velocities, the sample withdrawal rate overcomes the particle inertia to some extent, and the sample concentrations for the three locations are similar.

Clearly, different sampling mechanisms are dominant at different locations in the mixing vessel, for a sample tube entering from the mixing tank wall. The response of sample solids concentration with sampling velocity on the impeller plane resembles sampling from a slurry pipeline with an L-shaped probe sampler (Figure 2.5). Above the impeller plane (z/H = 0.5), the response resembles wall sampling from a slurry pipeline (Figure 2.8). This makes it very difficult a-priori to determine what sampling velocity is required in order to obtain a representative measure of the local solids concentration by sample withdrawal.

4.1.2 Effect of Sample Tube Geometry on Sample Solids Concentration

Three areas of sample tube geometry will be explored in this section for their effect on sample concentration; sampler shape, diameter and tip angle. As discussed in Chapter 2, these have been shown to affect the solids concentration obtained by sampling from solid-liquid systems (Nasr-El-Din, 1984, 1989; Barresi and Baldi, 1987a).

Three sample tube shapes were studied as shown in Figure 3.5. A typical response of sample concentration to sampling velocity for each of these samplers is shown in Figure 4.4. At a single location in the mixing tank near the impeller shaft and just above the impeller blades (r/R = 0.1, z/H = 0.4), differences in sample concentrations of more than 100% can result depending upon sample tube shape and sampling velocity. This occurs even though the local solids concentration in the mixing tank is unchanged. Similar variations in sample solids concentration with sample tube shape have been measured in a mixing tank by Barresi and Baldi (1987a) as shown in Figure 2.13. They found the largest differences in sample solids concentration due to sampler shape occur near the impeller plane in the mixing tank.

It is quite evident that withdrawal of a sample from the same location in a

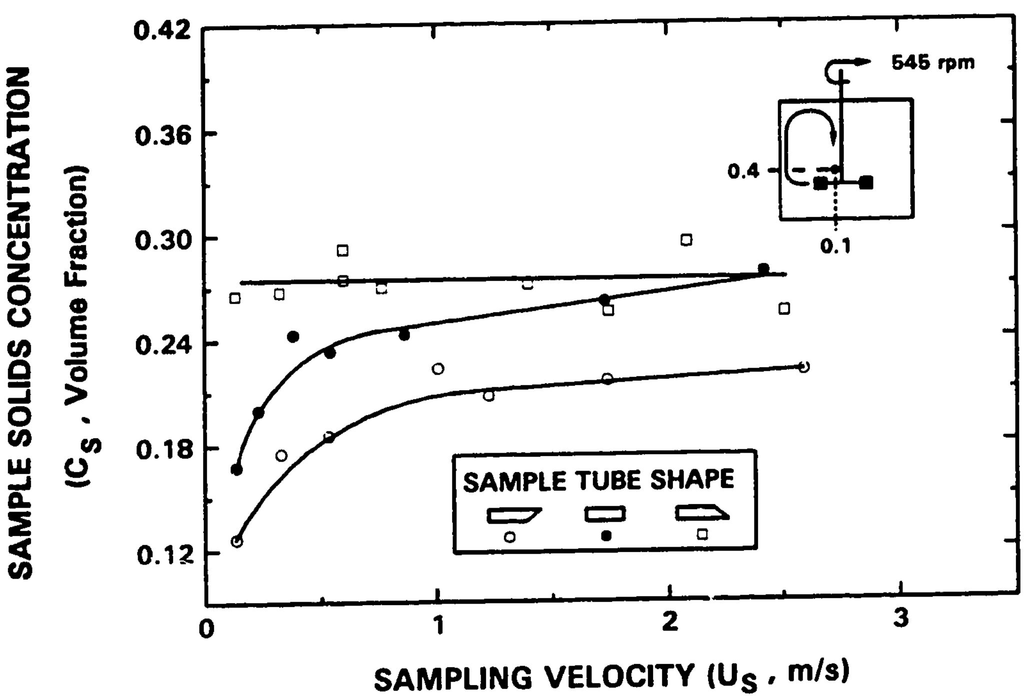


Figure 4.4: Effect of Sampler Shape on Sample Concentration
d_{50} = 410 μm, C_B = 0.30, ϕ = 4.6 mm,
z/H = 0.4, r/R = 0.1

mixing tank with differently shaped sample tubes can result in large differences in sample solids concentration. The sample tube shape that gives the most representative sample will vary with position in the mixing tank due to the variation of flow direction with position. It is extremely difficult to know which design to use in order to obtain a representative sample.

The effect of sample tube diameter on sample solids concentration is shown in Figure 4.5. At this position in the mixing tank, differences in sample concentration of over 20% are obtained with different diameters of sample tube, even though the local solids concentration remains the same. Similar variations were observed by Nasr-El-Din (1989) when sampling from the wall of a slurry pipeline with different port diameters (Figure 2.11). As discussed in Section 2.3.1.1.3, these differences were attributed to less time available for a particle to change direction and to enter the

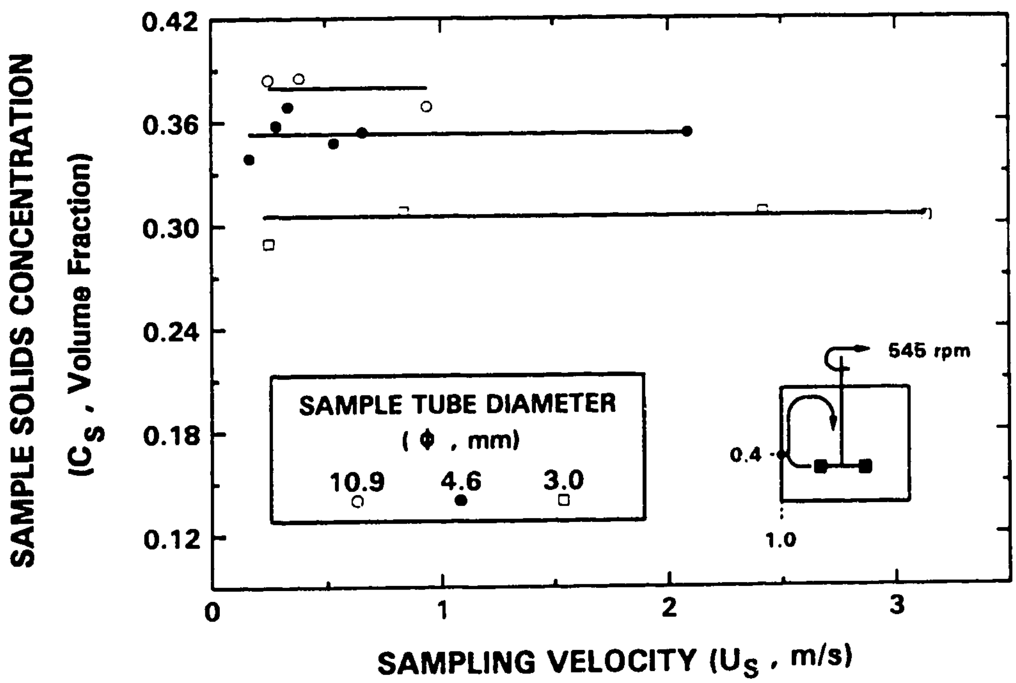


Figure 4.5: Effect of Sampler Diameter on Sample Concentration d_{50} = 410 μm, C_B = 0.30, β = 90°, z/H = 0.4, r/R = 1.0

sample tube with a smaller opening resulting in lower sample solids concentration than the tube with the larger opening.

The thickness of the sample tube tip has been shown to be important in determining the quality of sample obtained when withdrawing the sample parallel to the solid-liquid flow in a slurry pipeline (Nasr-El-Din, 1984, 1989). It was found that a tapered sampler tip with an angle $\leq$ 18°, eliminated any errors due to sample tube wall thickness.

Sample concentrations obtained from the impeller plane of the mixing tank with an untapered (γ = 90°) and a tapered sample tube with a tip angle of γ = 18° (Figure 3.7) were compared. Sampling results for these two samplers are shown in Figure 4.6. The tapered sample tube gives a consistently lower sample solids

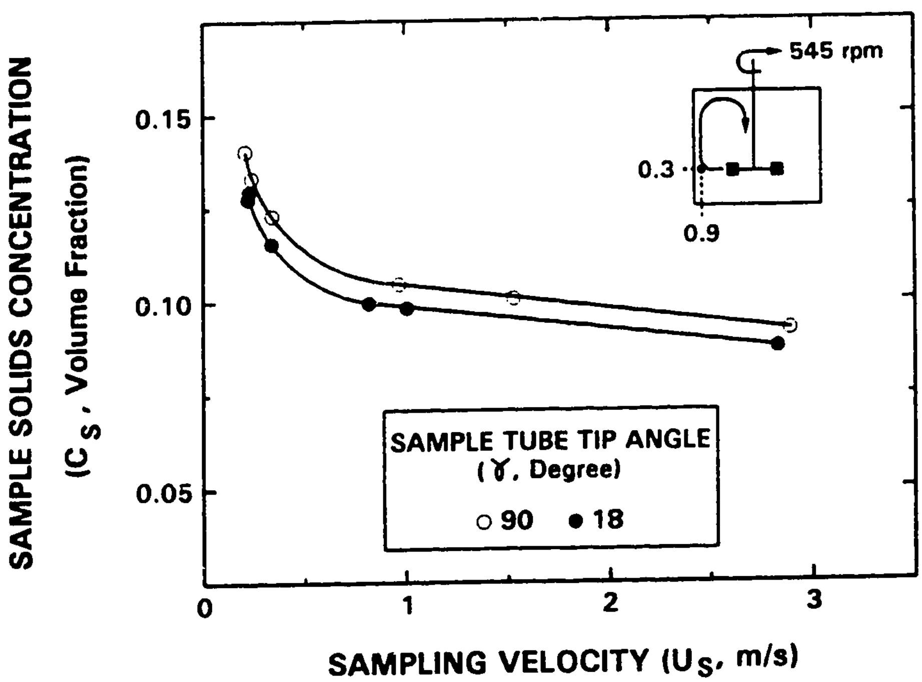


Figure 4.6: Effect of Sampler Tip Angle on Sample Concentration
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, β = 90°,
z/H = 0.3, r/R = 0.9

concentration than the untapered sample tube. Nasr-El-Din (1989) found that when sampling from slurry pipelines with L-shaped sampling tubes, the difference in sample concentration between blunt samplers ($\gamma = 90^o$) and tapered samplers ($\gamma = 18^o$) increases with the relative thickness of the sampler (δ). These differences were attributed to a loss of particle inertia due to particle bouncing on the blunt sample tube tip. Flow into the sample tube at this location in the mixing tank (impeller plane) is similar to flow into a sample tube aligned with the flow in a pipeline (Figure 3.4). The increase in sample solids concentration by using the blunt sample tube ($\gamma = 90^o$) can also be attributed to particle bouncing on the sample tube tip.

4.1.3 Effect of Mixer Speed on Sample Solids Concentration

Varying the mixer speed will change the velocity of the liquid and solids in the mixing tank. In addition, the distribution of the solids and therefore the local solids concentration will change with the mixer speed. Both factors will affect the sampling results obtained.

Figure 4.7 shows the effect of mixer speed on the sample solids concentration. The just suspended mixer speed (N_{JS}), calculated from the Zweitering correlation (Zweitering, 1958) (Equation 1.1), is 492 rpm for this suspension and mixer. The lowest mixer speed (440 rpm) is below the just suspended speed while the higher mixer speeds (545 and 680 rpm) are higher than N_{JS}. Thus the difference in sample solids concentration between the 440 rpm case and the 545 and 680 rpm cases is most likely due to a difference in the degree of the solids suspension and thus the local solids concentration. Without a true measure of the local solids concentration however, it is not possible to determine whether this is the only reason or whether the difference is also due to sampling errors.

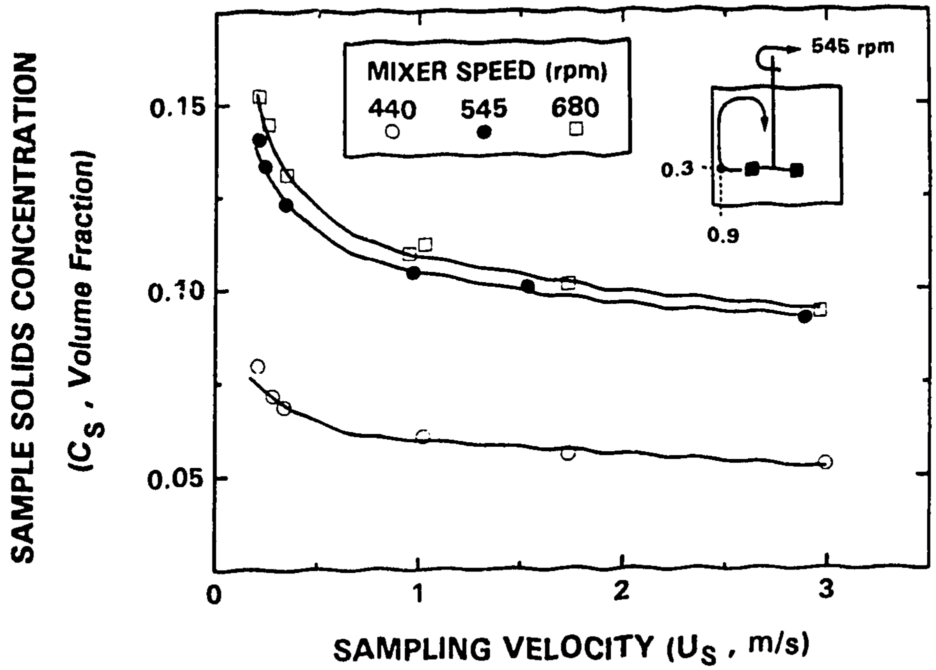


Figure 4.7: Effect of Mixer Speed on Sample Concentration
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, β = 90°,
z/H = 0.3, r/R = 0.9

4.1.4 Effect of Particle Diameter and Bulk Concentration on Sample Solids Concentration

As discussed in Section 2.3.1, particle inertia, particle bouncing and the flow structure ahead of the sample tube will affect the quality of sample withdrawn from a slurry system. The particle inertia parameter (Equation 2.2) determines how the particle will respond to deflections in the fluid streamlines caused by anisokinetic and anisoaxial sampling and thus the sample concentration obtained.

The effect of particle size on sample solids concentration is shown in Figure 4.8 for a single location in the mixing tank. As found by Nasr-El-Din (1989), the sample concentration appears to be more sensitive to sampling velocity as the

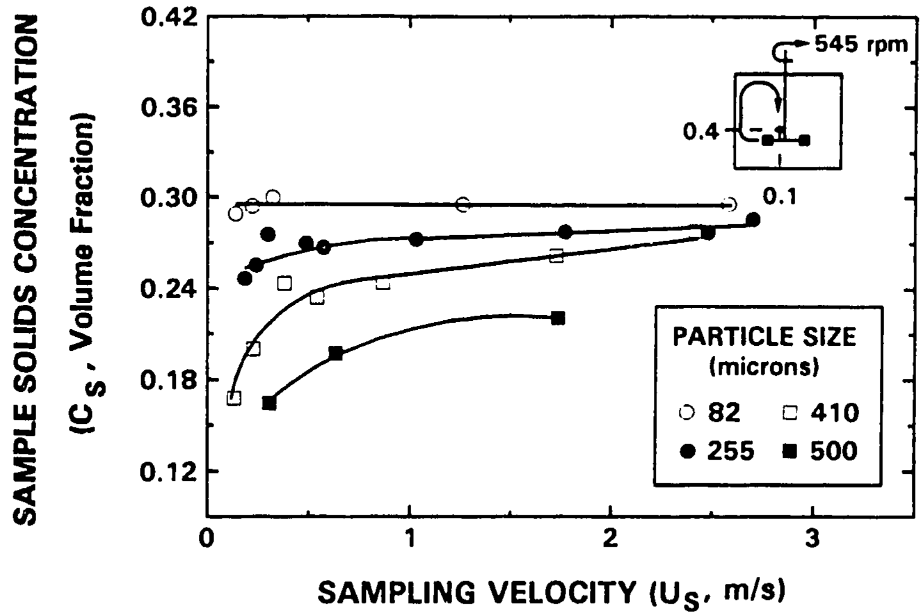


Figure 4.8: Effect of Particle Size on Sample Concentration
C_B = 0.30, ϕ = 4.6 mm, β = 90°,
z/H = 0.4, r/R = 0.1

particle size increases. This indicates that the sampling error increases with particle size. Fine particles are diverted into the sample tube easily, even at low velocities, while large particles with high inertia are not, and require large sampling velocities to be diverted into the sample tube. Confounding this effect though is the fact that larger particles are less easily suspended by the mixer than smaller particles. It is difficult to determine the magnitude of the sampling error due to particle size without a true measure of the local solids concentration.

The effect of bulk solids concentration on the sample concentration is shown in Figure 4.9. In this figure, the sample solids concentration (C_S) is normalized by the bulk solids concentration in the mixing tank (C_B) so that the data can be more easily compared. Nasr-El-Din (1989) found that sampling errors decrease with

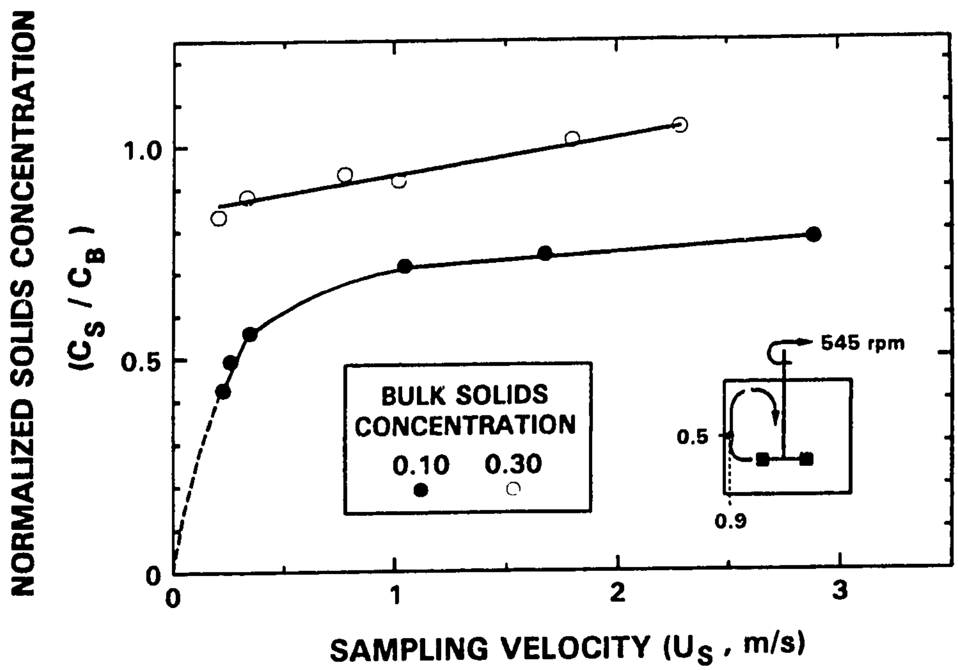


Figure 4.9: Effect of Bulk Solids Concentration on Sample Concentration
d_{50} = 410 μm, ϕ = 4.6 *mm*, β = 90°,
z/H = 0.5, r/R = 0.9

increasing solids concentration in a slurry pipeline (Figure 2.8) due to an increase in the particle drag force with solids concentration, thus increasing the tendency for particles to follow the fluid streamlines. It is unclear from Figure 4.9 whether the same trend is seen in the slurry mixing tank. Without a true measure of the local solids concentration, it cannot be determined if increasing the solids concentration in the mixing tank decreases sampling error, as seen in a slurry pipeline.

The sample solids concentration (C_S) is generally quite different from the bulk solids concentration in the mixing tank (C_B). These differences may be due to sampling errors or changes in the local solids concentration (C_0) in the mixing tank with location, or both. An independent measure of local solids concentration is required before sampling errors can be evaluated.

4.1.5 Effect of Sampling Technique and Location on Sample Particle Size Distribution

Nasr-El-Din (1989) showed that the sample particle size distribution (PSD) can vary with sampling velocity and sample tube size for wall sampling from slurry pipelines. Beker (1970) from Nasr-El-Din (1984) also found the sample PSD to be a function of sampling velocity when sampling from dilute suspensions in a mixing tank.

Results described to this point have been obtained from closely sized sand slurries. To determine the effect of sampling velocity, sample tube shape and position on the PSD of the sand sample, a number of samples were obtained from a mixture of 10 volume percent fine 82 μm sand and 10 volume percent coarse 500 μm sand. The results of these tests are shown in Table 4.1. Repeatability of the data appears good for both the sample concentration and for the mean particle size (d_{50}) (runs 800 and 803). A complete summary of these tests can be found in Appendix B.

The effect of sampling velocity on sample PSD is illustrated in Figure 4.10 for runs 814 and 816. In agreement with Nasr-El-Din (1989) and Beker (1970), the mean sample particle size (d_{50}) increases by over 50% when the sampling velocity is decreased from 2.76 m/s to 0.30 m/s.

Sampling velocity appears to affect the sample particle size distribution only if the sample solids concentration is affected by velocity. Runs 807 and 808 are sampled at very different sampling velocities, however the sample solids concentrations and the mean sample particle sizes (d_{50}) are similar. Runs 810 and 811 shown the same trend. Samples in runs 813 and 815 were again taken at very different sampling velocities but there is some variation in sample concentration and a comparable difference in sample particle size.

The effect of sample tube shape on sample PSD is shown in Figure 4.11 for runs 813 and 814. In this figure, the samples were obtained at the same location and

Run	Position		β	U_s (m/s)	Sample	
	z/H	r/R			C_s (vol. frac.)	d_{50} (μm)
800	0.1	1.0	90°	1.61	0.222	280
801	0.7	1.0	90°	1.58	0.200	160
802	0.3	1.0	90°	1.63	0.229	355
803	0.1	1.0	90°	1.62	0.222	290
804	0.9	1.0	90°	1.59	0.137	90
805	0.5	1.0	90°	1.60	0.218	220
806	0.8	1.0	90°	1.58	0.169	110
807	0.4	1.0	90°	0.66	0.231	330
808	0.4	1.0	90°	2.79	0.217	330
810	0.4	0.1	90°	0.32	0.149	100
811	0.4	0.1	90°	2.52	0.157	110
813	0.4	0.5	135°	0.29	0.138	95
814	0.4	0.5	45°	0.30	0.204	210
815	0.4	0.5	135°	2.85	0.178	125
816	0.4	0.5	45°	2.76	0.184	135

Table 4.1: Effect of Sampling Technique and Location on Sample Particle Size Distribution

at the same sampling velocity, but using different sampler shapes (β = 45° and 135°). The mean sample particle size (d_{50}) more than doubles (95 μm versus 210 μm) by using the 45° sampler instead of the 135° sampler.

This trend is not general as shown in Table 4.1 for runs 815 and 816. The different sampler shape only results in a relatively small change in sample particle size. It appears once again that the sample particle size is only effected by sampler shape when the sample solids concentration is effected. These experiments show that

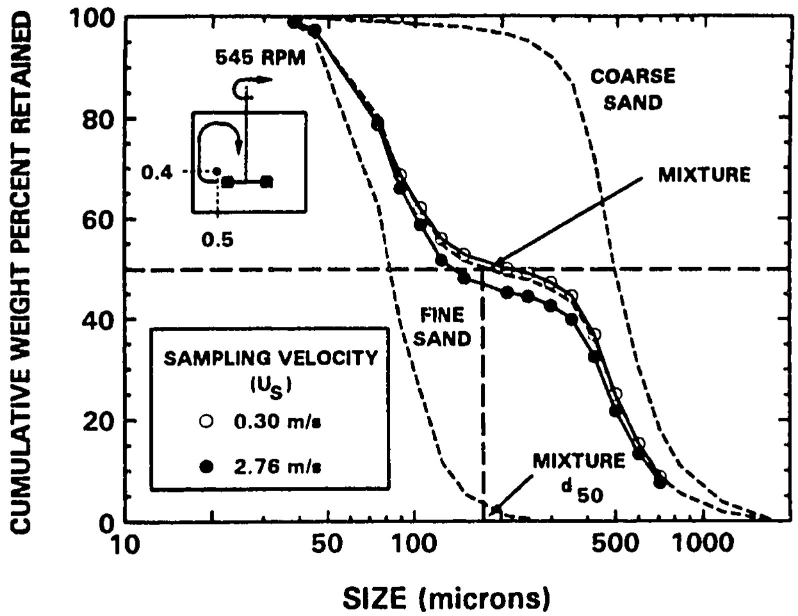


Figure 4.10: Effect of Sampling Velocity on Sample Particle Size Distribution (Runs 814 and 816)

C_B = 0.20, ϕ = 4.6 *mm*, β = 45°, z/H = 0.4, r/R = 0.5

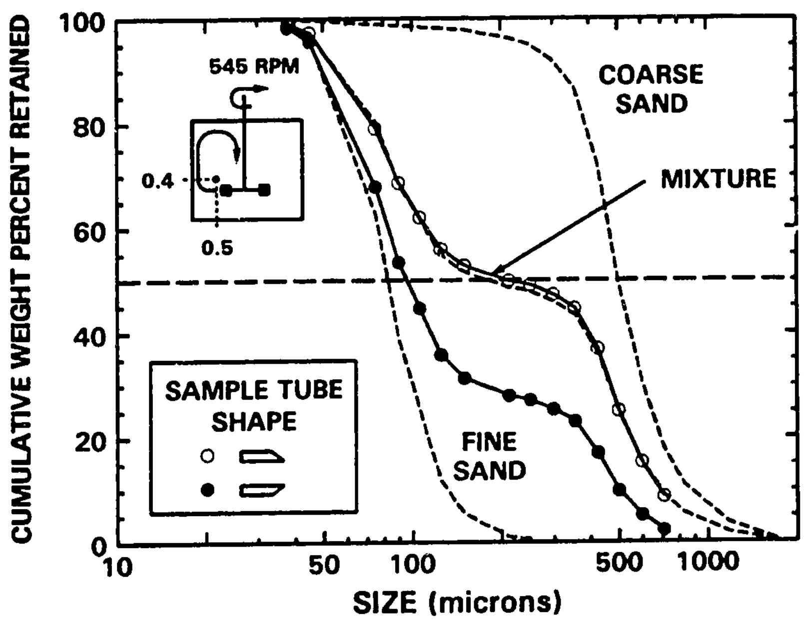


Figure 4.11: Effect of Sampler Shape on Sample Particle Size Distribution (Runs 813 and 814)

C_B = 0.20, ϕ = 4.6 *mm*, U_S = 0.3 *m/s*, z/H = 0.4, r/R = 0.5

sampling technique can not only significantly affect sample solids concentration but also sample particle size.

The distribution of fine and coarse solids in a mixing tank is likely uneven due to the difference in settling velocity of the sands. Sampling is one of the few methods that has the capability of determining this distribution. The solids size distribution with position in the mixing tank can however only be determined approximately by sampling due to the variations in sample PSD due to sampling technique just shown.

The variation of the mean sample particle size with radial position in the mixing vessel is shown in Figure 4.12 for runs 808 and 811. It appears that the coarse solids are less abundant near the center of the mixing tank ($r/R = 0.1$) than at the wall of the tank ($r/R = 1.0$). Similar results are shown by runs 807 and 810 for a much lower sampling velocity. This appears reasonable as the centrifugal force generated by the impeller will tend to accelerate all the sand fractions to the mixing tank wall. The coarse sands will tend to settle relatively quickly while only the finer sands will remain suspended and travel to the center of the mixing tank. Thus the suspended sand mixture will tend to be finer at the center of the tank than at the mixing tank wall.

Fine particles are more easily suspended (axial distribution) than coarse particles in a mixing tank (McLaren White et al., 1932; Oldshue, 1981a). The suspension in the upper portions of the mixing vessel will be finer and thus the sample will tend to be relatively finer. This is illustrated in Figure 4.13 where an axial scan along the wall of the mixing tank was made. It is interesting to note that the coarsest sample was obtained at the plane of the impeller ($z/H = 0.3$). A slightly finer sample was obtained below this point and progressively finer samples obtained above this point. The impeller plane is also the location of the highest sample concentration.

When all the data in Table 4.1 was plotted together (Figure 4.14), the mean sample particle size appears to be a function of the sample solids concentration. As stated previously, the bulk sand in the mixing tank was a mixture of 10 volume

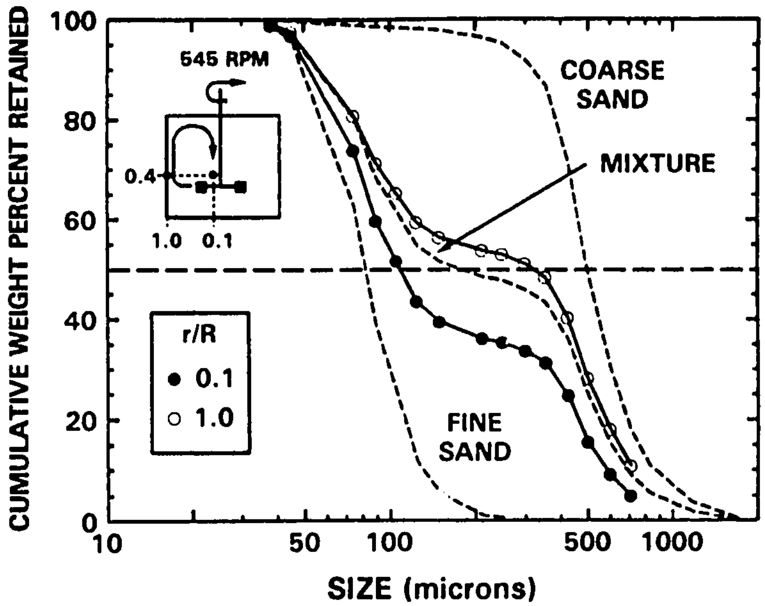


Figure 4.12: Variation of Particle Size Distribution with Radial Position (Runs 808 and 811)

C_E = 0.20, ϕ = 4.6 *mm*, β = 90°, U_S ≈ 2.6 *m/s*, *z/H* = 0.4

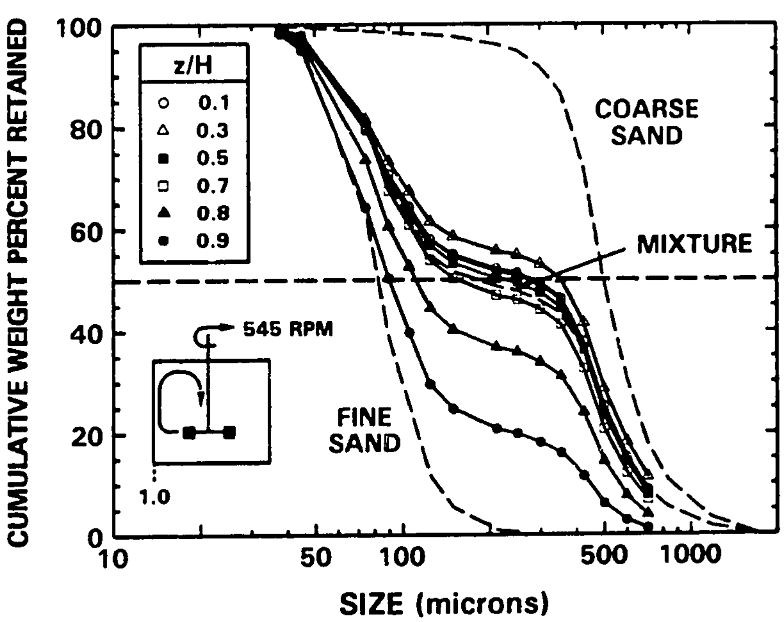


Figure 4.13: Variation of Particle Size Distribution with Axial Position

C_B = 0.20, ϕ = 4.6 *mm*, β = 90°, U_S ≈ 1.6 *m/s*, *r/R* = 1.0

percent fine (82 μm) sand and 10 volume percent coarse (500 μm) sand. The breakpoint in Figure 4.14 occurs at a solids concentration of 0.20, the total bulk solids concentration of the mixture, and a mean particle size of d_{50} = 150 μm, the approximate mean particle size of the bulk mixture (Figure 4.10). It appears that when the sampling method or the position in the mixing tank are such that low concentration samples are obtained, these samples also tend to be relatively fine. Conversely, if the sample solids concentration is high, then the mean sample particle size is relatively coarse.

This trend is analyzed in a different manner in Figure 4.15 where the mass fraction of fine sand in a sample is plotted against sample solids concentration. The fraction of fines is defined as the weight of all sand fractions in the sample smaller than 150 μm plus one-half of the 150 μm fraction divided by the total sample weight. As can be seen, a good trend appears between the sample solids concentration and the mass of fine sand in the sample. Within the conditions tested here, it appears that when sampling conditions favor a low concentration sample, the solids in the sample will also tend to be fine. Conversely, high concentration samples will tend to consist of coarse solids.

4.1.6 Summary

It has been shown that it is possible to obtain very different sampling results, both in terms of sample solids concentration and sample particle size distribution, depending upon the method of sample withdrawal from a slurry mixing tank. For a given condition and at a single location in the mixing tank, the average local solids concentration does not change, however the sample solids concentration can vary significantly. It is very difficult to know a-priori what sampling technique to use in a mixing tank to obtain a representative sample.

Particle size and bulk concentration also affect the sample concentration obtained. Sample solids concentration from a fine sand slurry is not affected by

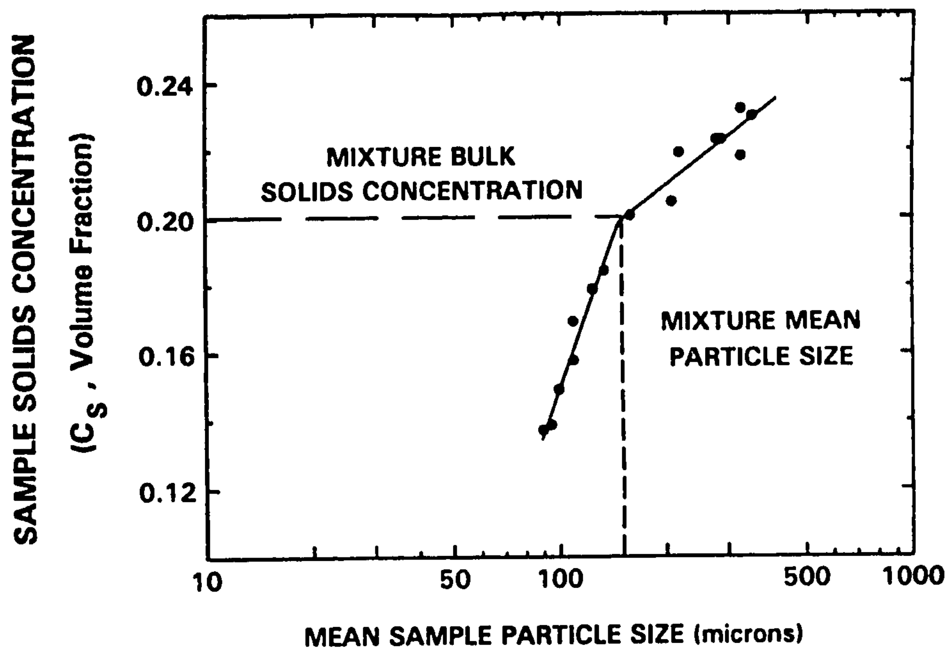


Figure 4.14: Sample Mean Particle Size versus Sample Solids Concentration

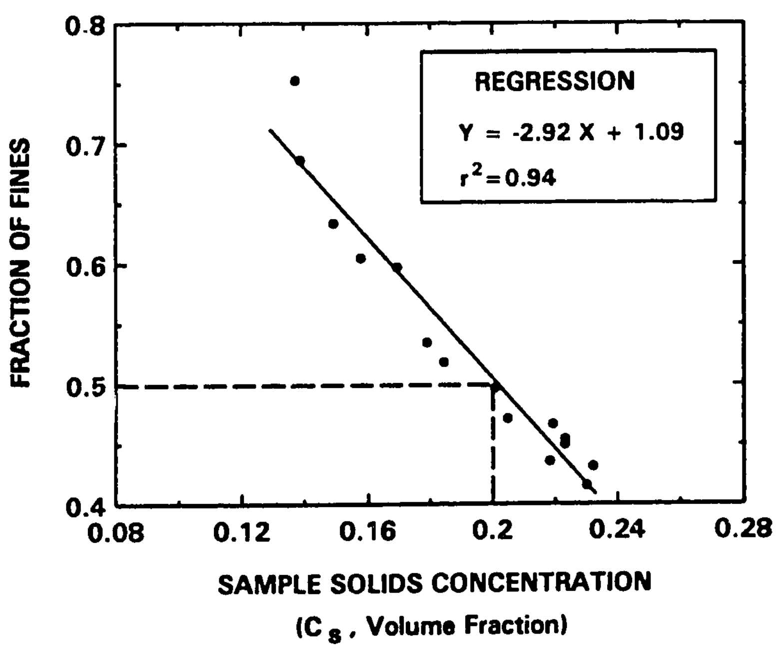


Figure 4.15: Sample Fines Fraction versus Sample Solids Concentration

sampling velocity, however the sample solids concentration from a coarse sand slurry varies significantly with sampling velocity.

The local solids concentration in a slurry mixing tank will vary with location in the tank and the mixing conditions. It is not possible however to distinguish between differences in local concentration and errors due to the sampling technique.

A new method for accurately measuring local solids concentration in a slurry mixing tank is needed to assess the sampling errors at various locations and sampling conditions. Only then can it be determined if and how sampling can be used to obtain a representative measurement of local solids concentration in a slurry mixing tank. The next section will show that the conductivity probe is a practical method for measuring local solids concentration in a mixing tank.

4.2 Conductivity Probe Development, Testing and Calibration

The conductivity probe used in this study (Figures 3.8 and 3.9) was a modification of the four-electrode design used by Nasr-El-Din et al. (1987). It was also very similar to the device discussed in Considine and Considine (1985) and shown in Figure 2.20. Considerable effort was required to manufacture the conductivity probes so that leaks and shorting of the measuring circuit did not occur.

As discussed in Section 2.3.3.2, conductivity measurements can be affected by the ionic strength and temperature of the solution being measured as well as the proximity to a boundary. In addition, some conductivity probe designs are affected by the flow velocity past the probe. These issues were investigated to understand how to operate the conductivity probe to obtain reliable measurements of solids concentration. In addition, the solids concentration measurements by the conductivity probe were compared with a known solids concentration in two systems; a slurry pipeline and a slowly settling suspension. Some limited mixing tank concentration profiles are provided as a comparison with data from other investigators.

4.2.1 Effect of NaCl Concentration and Temperature on Sensor Output

The effect of dissolved ion concentration on the solution conductivity was determined by conducting experiments in the mixing tank filled with clean tap water. Small discrete amounts of sodium chloride were added, the system homogenized and the solution resistivity (inverse of the conductivity), as indicated by the conductivity probe sensor voltage was measured.

As can be seen in Figure 4.16, a large drop in fluid resistivity (with the corresponding increase in fluid conductivity) occurs with the addition of very small amounts of NaCl. This trend continues until the system is saturated. Obviously, any electrolyte addition will drastically alter the fluid conductivity and will complicate the solids concentration measurements.

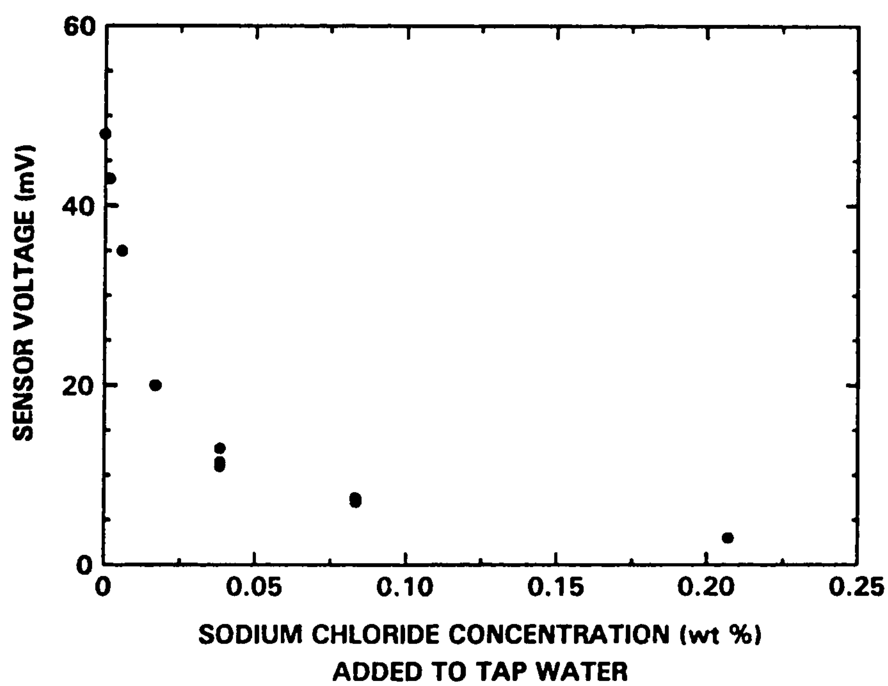


Figure 4.16: Effect of NaCl Concentration on the Conductivity Probe Sensor Voltage

To determine the sensitivity of this conductivity probe design to temperature, experiments were performed in the mixing tank filled with clean hot tap water. Conductivity measurements were taken while the water was cooled with the heat exchanger system, shown in Figure 4.17.

Figure 4.18 shows the decrease in solution resistivity (sensor voltage) with increasing solution temperature. The data were fitted with the following quadratic equation:

$$E(mV) = 68.8 - 1.50\, t(^{o}C) + 0.0128\, (t(^{o}C))^2 \qquad (4.1)$$

The sensitivity of the sensor voltage to temperature was calculated as per cent per degree Celsius:

$$\begin{matrix} \textit{Sensor Voltage} \\ \textit{Temperature Effect} \end{matrix} (\%\ per\ ^{o}C) = 100 * \frac{\frac{dE}{dt}}{E} \qquad (4.2)$$

and is shown in Figure 4.19. The sensor voltage varies by between 2.1 and 2.3% per °C between 20 and 30 °C; the temperature range in this study. This is quite comparable to values found in the literature as discussed in Section 2.3.3.2. To be able to take reliable measurements of solids concentration with the conductivity probe, the solution temperature must either be closely controlled, the solution conductivity measured frequently or the conductivity compensated for temperature variations.

4.2.2 Effect of Approaching Conducting and Non-Conducting Boundaries on Sensor Output

As discussed in Section 2.3.3.2, approaching a boundary can significantly affect

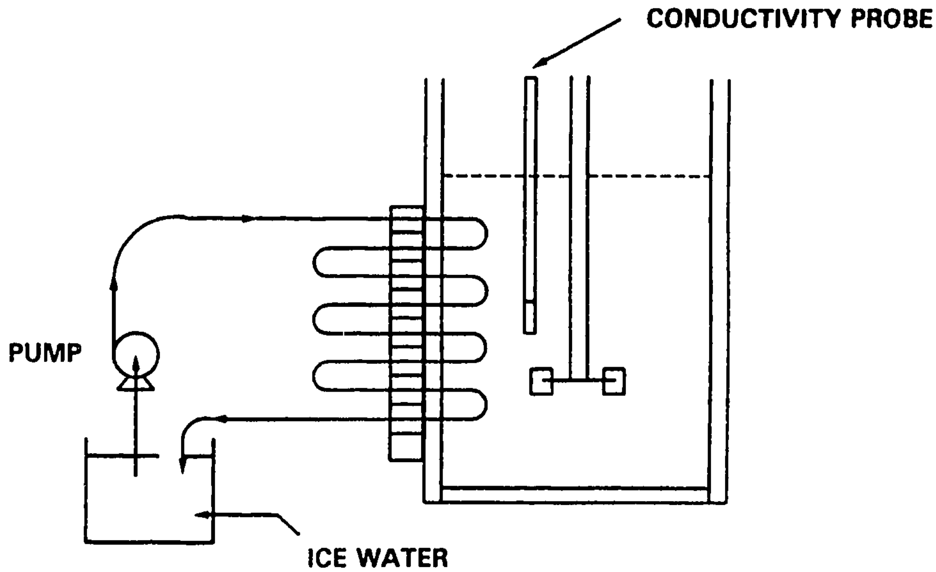


Figure 4.17: Mixing Tank Heat Exchanger System

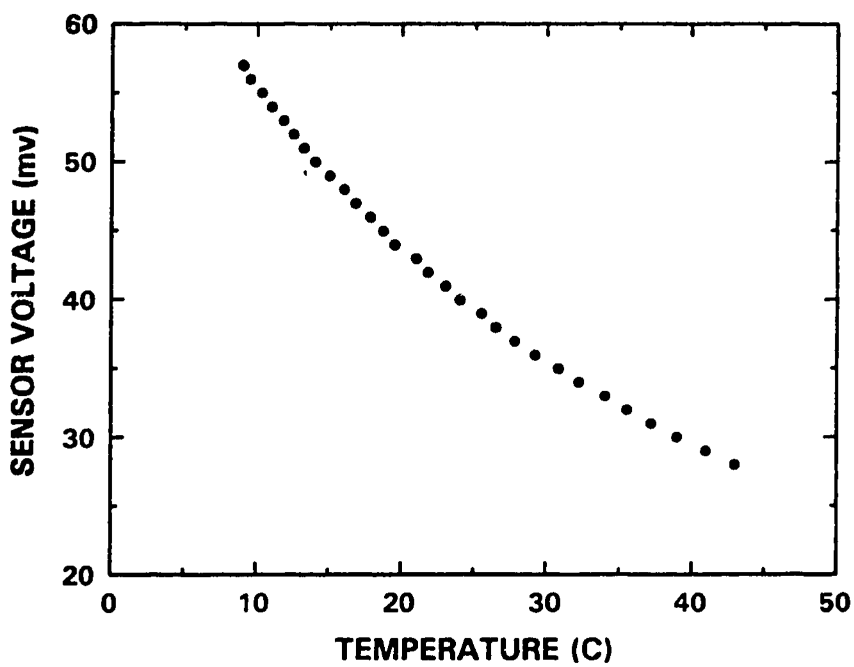


Figure 4.18: Effect of Temperature on the Conductivity Probe Sensor Voltage

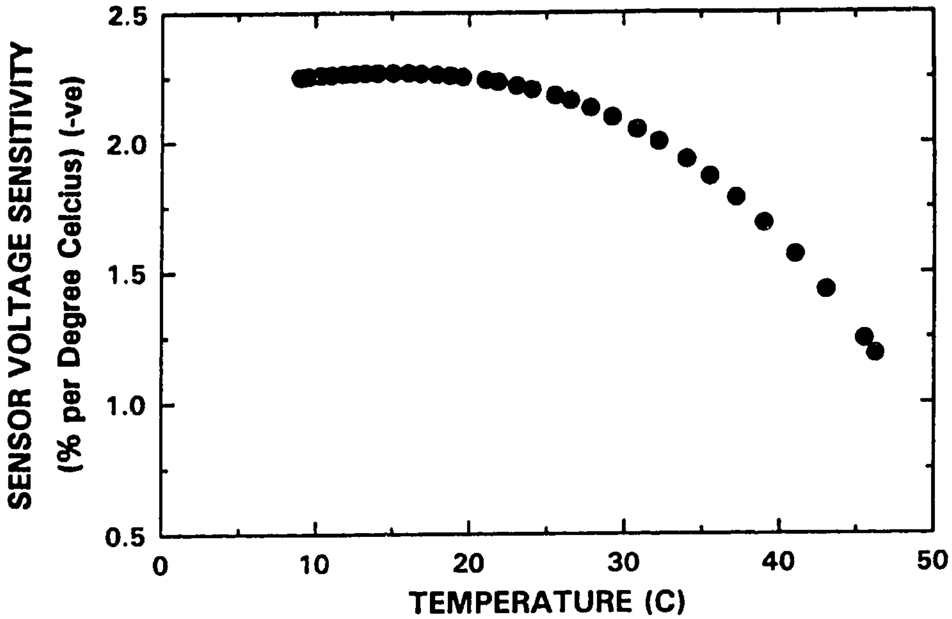


Figure 4.19: Sensitivity of Conductivity Probe Sensor Voltage to Temperature

the conductivity probe sensor voltage. There are a number of boundaries in the mixing vessel that may be approached quite closely with the conductivity probe (Figure 4.20). These boundaries are the:

(1)	Plexiglas bottom of the tank	(Insulating Boundary)
(2)	Radial impeller plate	(Conducting Boundary)
(3)	Radial impeller blade edge	(Conducting Boundary)
(4)	Baffle edge	(Conducting Boundary)
(5)	Plexiglas tank wall	(Insulating Boundary)
(6)	Free liquid surface	(Insulating Boundary)

Figure 4.21 shows the effect on the conductivity probe sensor voltage when

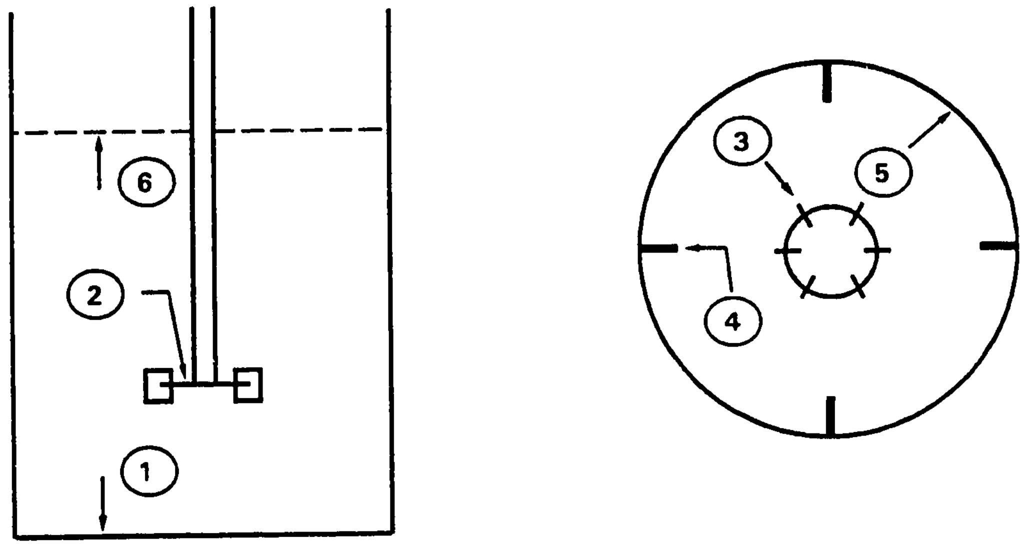


Figure 4.20: Mixing Tank Boundaries Approached by the Conductivity Probe

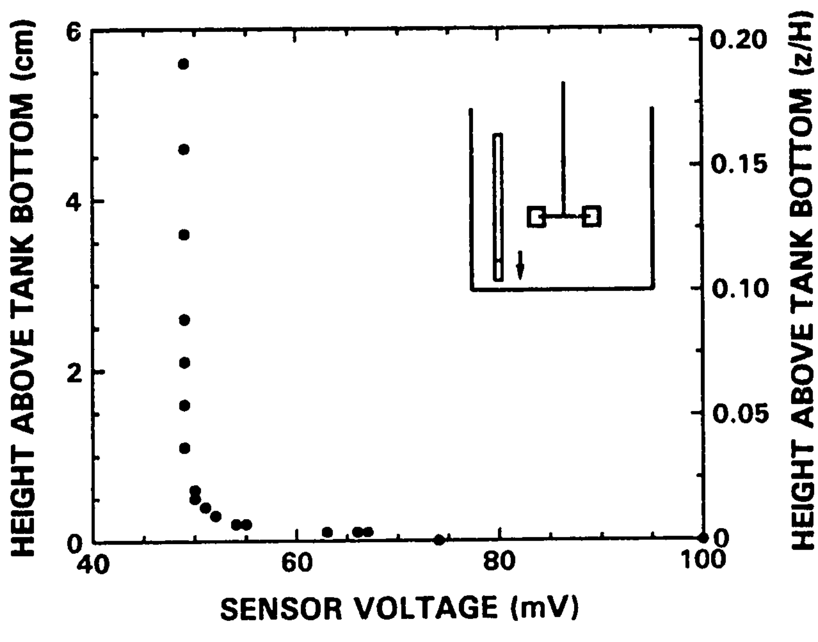


Figure 4.21: Effect of Approaching the Plexiglas Bottom on the Conductivity Probe Sensor Voltage

approaching the bottom of the plexiglas tank filled with clean tap water. Only when the probe is within one centimeter (z/H = 0.034) of the tank bottom does the sensor voltage vary significantly.

Approaching the conducting impeller plate with the conductivity probe is shown in Figure 4.22. Deviations in the sensor voltage are again only observed when the probe is less than one centimeter from the plate. In this case however, the sensor voltage decreases as the two field electrodes are shorted out on the stainless steel impeller plate.

It is possible to approach several boundaries in the tank from a lateral direction. One of these is the edge of the impeller blade as shown in Figure 4.23. Moving laterally it is possible to approach the impeller blade with either the large

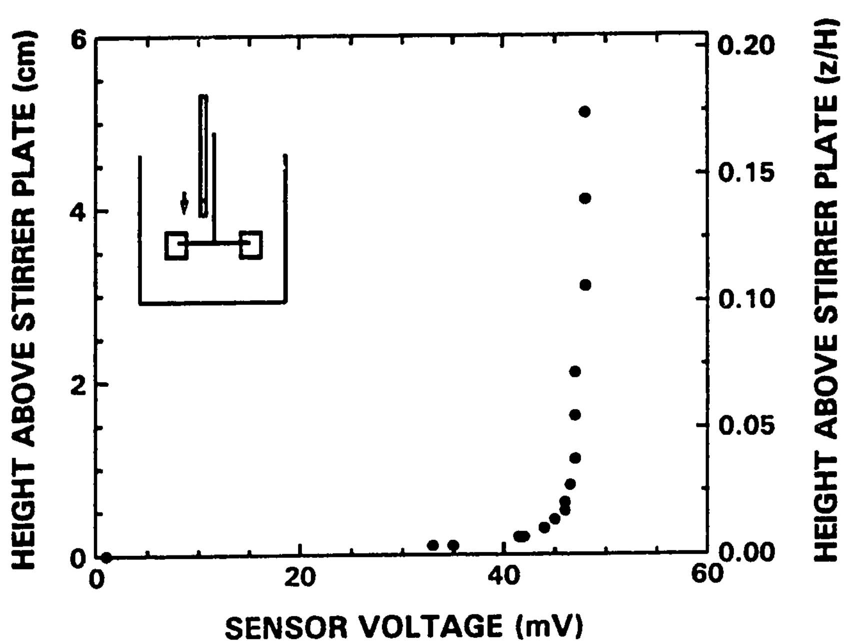


Figure 4.22: Effect of Approaching the Impeller Plate on the Conductivity Probe Sensor Voltage

or small field electrode facing the blade. Nasr-El-Din et al. (1987) showed with their conductivity probe that large deviations in the sensor voltage were observed when approaching the edge of the slurry pipeline with the small field electrode. Much lower deviations were seen when approaching with the large field electrode. Very similar results are seen in Figure 4.23. No deviation in sensor voltage is apparent when approaching the edge of the impeller blade with the large field electrode, while a significant reduction is seen when approaching closer than one centimeter with the small field electrode.

When approaching a stainless steel baffle, shown in Figure 4.24, very similar results are observed. There is no deviation in sensor voltage when approaching with the large field electrode but a significant decrease in sensor voltage when

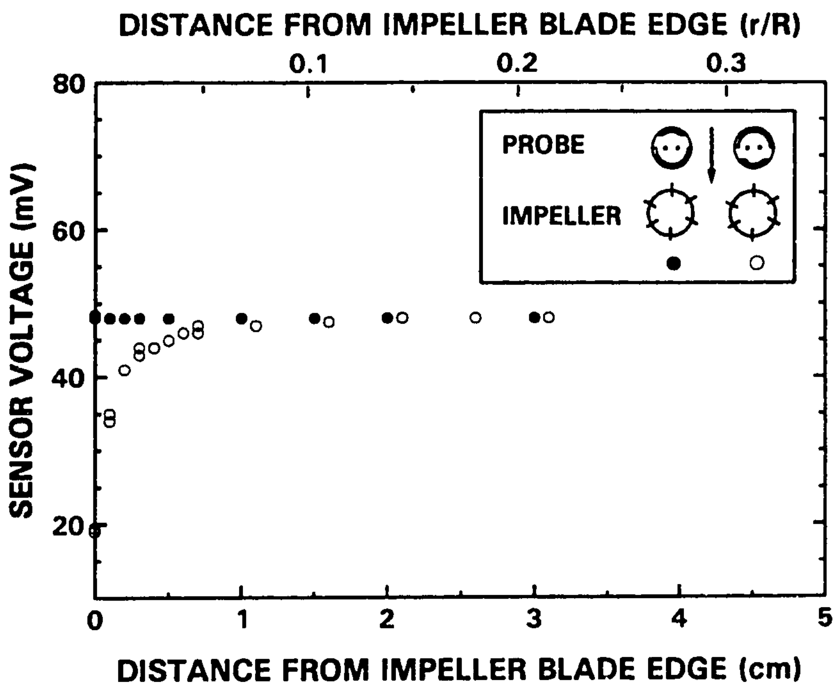


Figure 4.23: Effect of Approaching the Impeller Blade on the Conductivity Probe Sensor Voltage

approaching closer than one centimeter with the small field electrode.

When approaching the insulating plexiglas wall of the mixing tank, shown in Figure 4.25, similar results are again seen. Significant deviation in sensor voltage is only observed when approaching closer than one centimeter with the small field electrode. In this case however, the sensor voltage increases when the probe is close to the plexiglas wall.

It was noticed during preliminary experiments that the fluid conductivity increased somewhat when approaching the top liquid surface in the tank. This trend, shown in Figure 4.26, is nearly a mirror image of the trend shown in Figure 4.21 In both cases, the conductivity probe is approaching an insulating boundary (mixing tank plexiglas bottom in Figure 4.21 and air in Figure 4.26). Approaching the air-liquid boundary by raising the probe (Figure 4.26) shows a significant deviation in sensor voltage only when closer than two centimeters from the top liquid surface. The

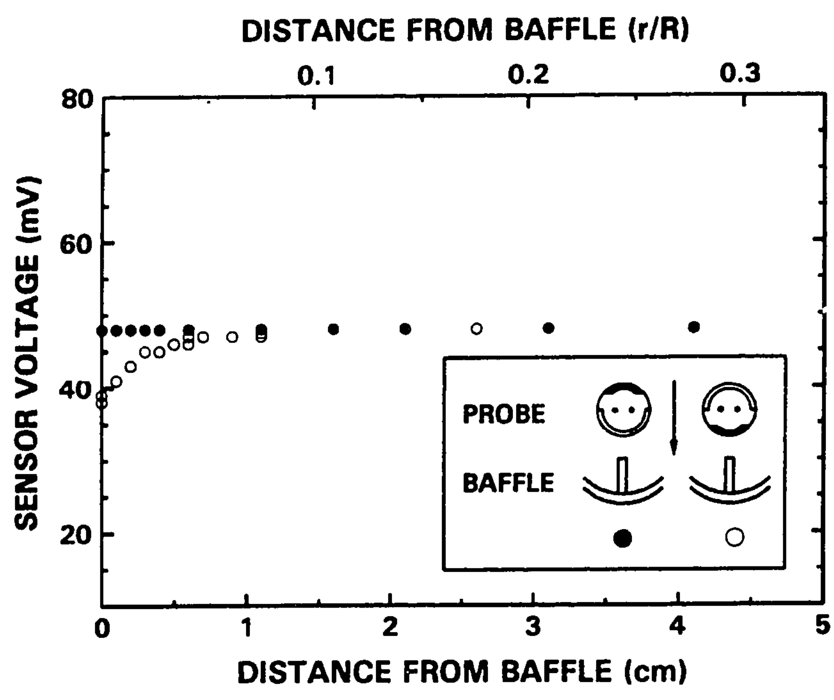


Figure 4.24: Effect of Approaching a Baffle on the Conductivity Probe Sensor Voltage

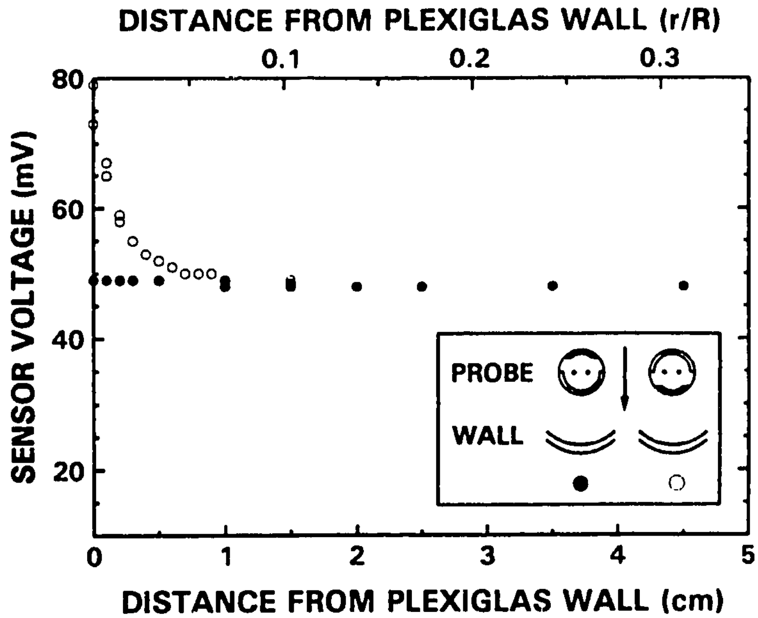


Figure 4.25: Effect of Approaching the Plexiglas Wall on the Conductivity Probe Sensor Voltage

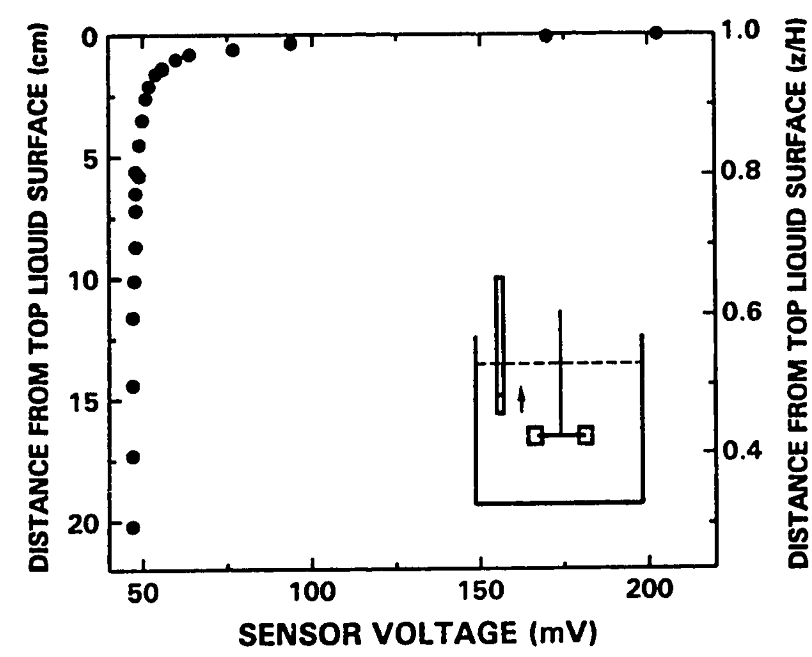


Figure 4.26: Effect of Approaching the Top Liquid Surface on the Conductivity Probe Sensor Voltage

conductivity probe is more sensitive when approaching the air-liquid boundary than when approaching the tank bottom due to the geometry of the probe.

With this design of conductivity probe, measurements taken more than one to two centimeters from a boundary will minimize the effect of the boundary on the measured sensor voltage. If it is necessary to approach a boundary to within one centimeter, approaching with the large field electrode will minimize any sensor voltage deviation due to the boundary. When approaching within two centimeters of the top liquid surface, it was necessary to measure the liquid conductivity at the same point as the slurry conductivity was measured in order to eliminate the effect of position on the measured solids concentration.

4.2.3 Effect of Field Circuit Operation on Sensor Output

Three field circuit parameters were set when operating the conductivity probe:

- field current.
- type of alternating wave form.
- alternating current frequency.

Figure 4.27 shows that increasing the field current, increases the sensor voltage linearly. The slope is proportional to the fluid resistance, which varies with the ionic strength of the solution. To obtain a measurable difference between the slurry resistance and the liquid resistance, it was preferable to operate at a reasonably large sensor voltage, with a correspondingly large field current. At a large field current however, electrolysis of the water may occur. When operating at a 1.0 mA field current, adequate resolution was obtained and no electrolysis was observed.

An alternating field current was used to minimize electrolysis. Changing the waveform as shown in Figure 4.28 does have a small effect on the sensor voltage. This may be due to the ability of the voltmeter (Fluke 77) to measure each waveform. Because of this, all conductivity probe measurements were made with a

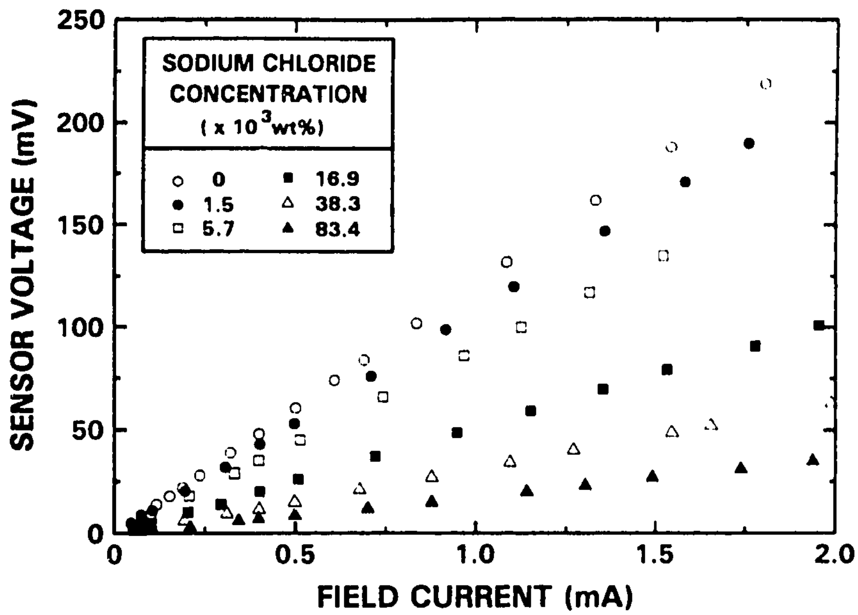


Figure 4.27: Effect of Field Current on the Conductivity Probe Sensor Voltage

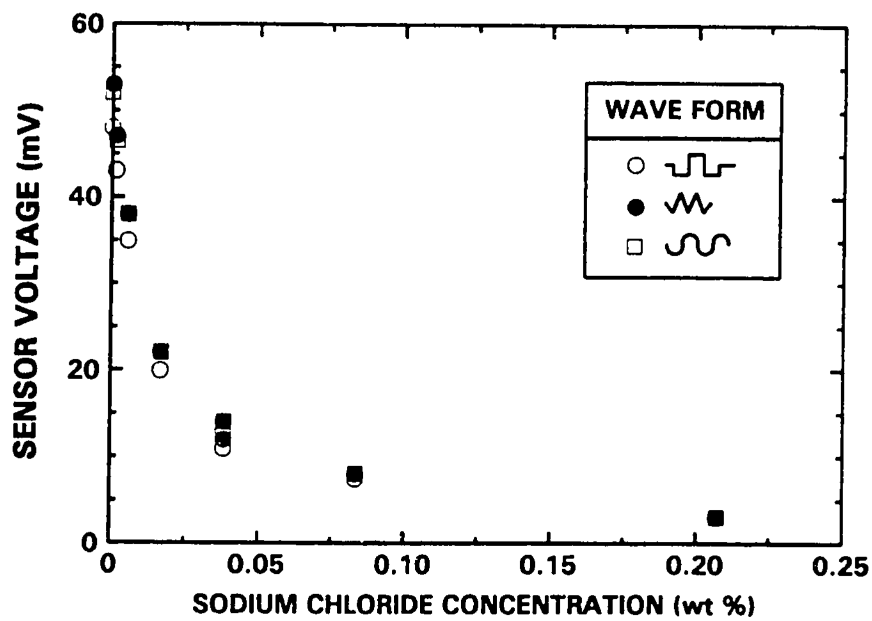


Figure 4.28: Effect of Field Waveform on the Conductivity Probe Sensor Voltage

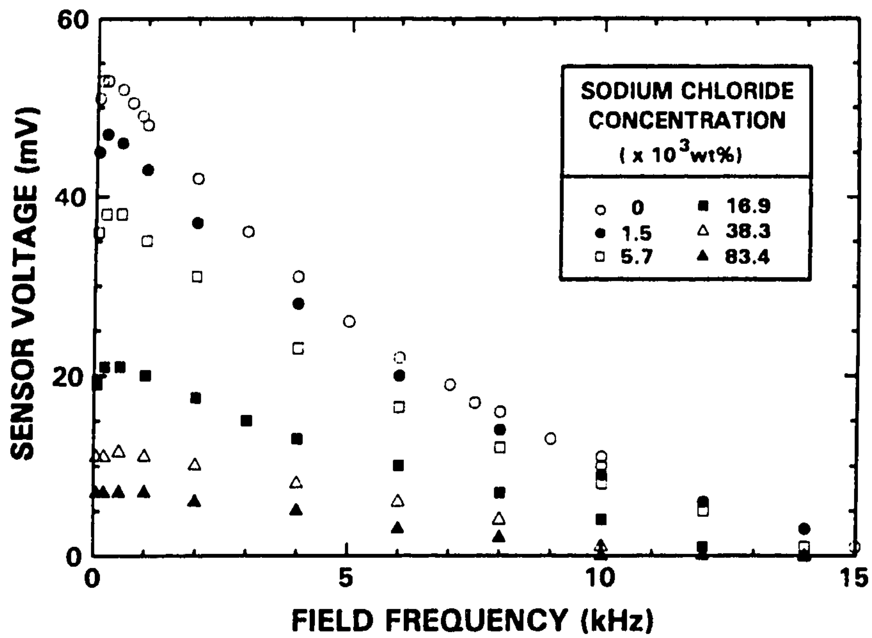


Figure 4.29: Effect of Field Frequency on the Conductivity Probe Sensor Voltage

square wave form as used by Nasr-El-Din et al. (1987).

Increasing the alternating field frequency significantly reduced the sensor voltage measured, as shown in Figure 4.29. This may again be due to the ability of the ammeter and voltmeter to respond to these frequencies. For good resolution between the slurry and fluid resistivity, a field frequency of 1000 Hz was used.

4.2.4 Effect of Velocity on Sensor Voltage

As discussed in Section 2.3.3.2, the output from some conductivity probes is a function of velocity. This is generally attributed to polarization of the electrode surfaces. This is undesirable for use in a mixing tank since the flow velocity is not well known and varies with position in the tank. The four-electrode conductivity probe design used here, with the high impedance sensor circuit, was an attempt to

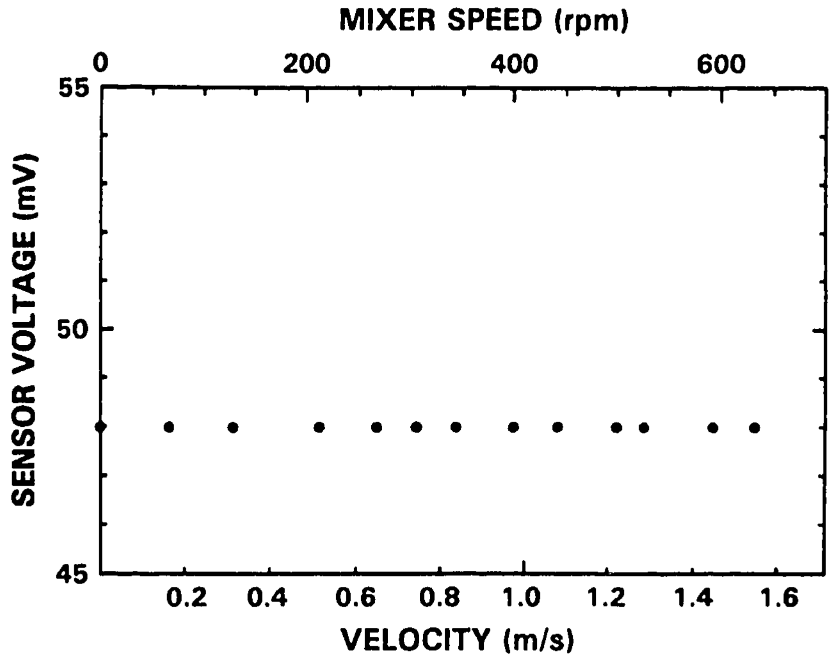


Figure 4.30: Effect of Velocity (Water Only) on the Conductivity Probe Sensor Voltage (z/H = 0.3, r/R = 0.5)

eliminate electrode polarization and the velocity effect.

Figure 4.30 shows the effect of velocity (mixer speed) on sensor voltage in the mixing tank filled with tap water. The flow velocity was calculated from Equation 2.3 with B_l = 1.13, D = 0.097m and r = 0.73m. Similar to the results of Nasr-El-Din et al. (1987), no variation of sensor voltage with velocity was observed, indicating that this conductivity probe was not affected by electrode polarization.

4.2.5 Effect of Probe Orientation on Sensor Voltage

During preliminary slurry conductivity measurements in the mixing tank, it was found that the conductivity output changed as the probe was rotated about its axis. These conductivity readings, converted to solids concentration using the Maxwell correlation (Equation 2.14), are shown in Figure 4.31 for the 255 μm sand, at a bulk

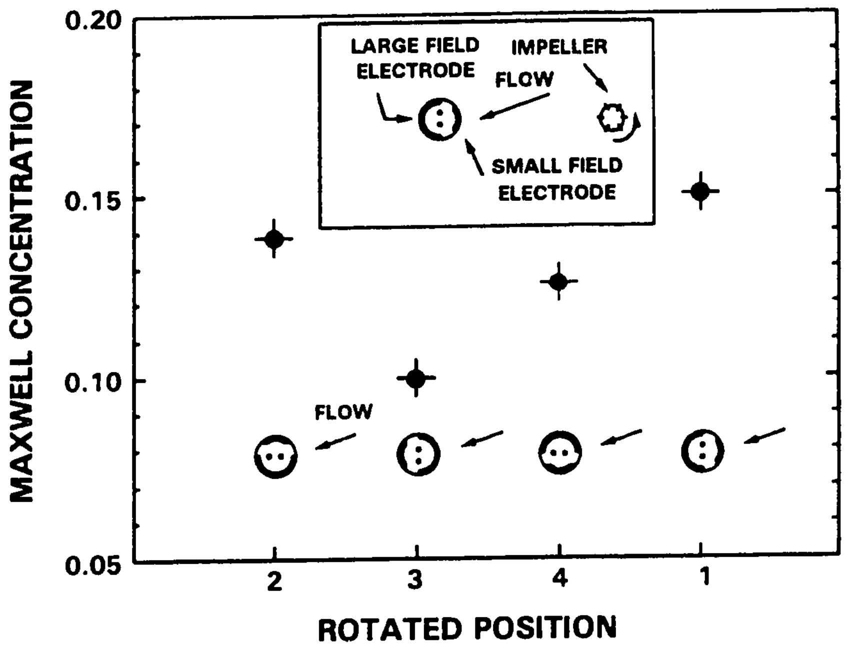


Figure 4.31: Effect of Probe Rotation on Measured Solids Concentration in the Mixing Tank (With Slurry)
d_{50} = 255 μm, C_B = 0.10, N = 545 rpm, z/H = 0.3, r/R = 0.6

concentration of 0.10 and located on the impeller plane.

The variation in measured solids concentration with probe orientation is a function of the slurry flow relative to the conductivity probe electrode position. The highest measured "solids concentration" was obtained when the small field electrode faced into the slurry flow, while the lowest measured "solids concentration" was obtained when the large field electrode faced into the slurry flow. This is very similar to the effect of approaching the insulating tank wall with the small and large field electrodes facing the wall (Figure 4.25). There was a large increase in the conductivity probe sensor voltage (which would correspond to an increase in measured "solids concentration") when approaching the insulating wall with the small field electrode facing the wall. There was no change in the sensor voltage however, when approaching the wall with the large field electrode. The slurry solids in the mixing tank act like the insulating wall in Figure 4.25. When the small field electrode faces the insulating solids flow, a larger measured "solids concentration" results than when the large field electrode faces the solids flow. There is increased sensitivity to the slurry solids by facing the small field electrode into the slurry flow.

Figure 4.31 shows that there is a cyclic response as the conductivity probe is rotated about its axis, however the cycles are not sinusoidal, but are asymmetric. Positions two and four are mirror images of each other and give similar, but slightly different responses. This is most likely due to the presence of angular flow on the plane of the impeller ($z/H = 0.3$), as will be discussed in more detail in Section 4.3.2. The actual flow at the conductivity probe is from the top right hand corner in Figure 4.31. More of the small field electrode is facing into this flow in position two than in position four, resulting in a higher measured "solids concentration" in position two. This difference should become even larger closer to the impeller, where the angular flow is stronger.

This orientation effect is due to the system (slurry), the local flow direction and the geometry of the conductivity probe. It is not a result of polarization of the conductivity probe electrodes.

The variation of measured solids concentration with conductivity probe orientation is significant and was a concern since it was not known which measured solids concentration value was correct. The effect was not due to a change in the solids concentration in the tank since the only action was to rotate the probe about its axis at a fixed position.

To better analyze and quantify the effect of probe orientation on the measured solids concentration, the conductivity probe was tested in a slurry pipeline where the direction of flow is well known and the solids concentrations more easily measured than in the mixing tank. A 5.1 cm slurry pipeline, shown in Figure 4.32, was used.

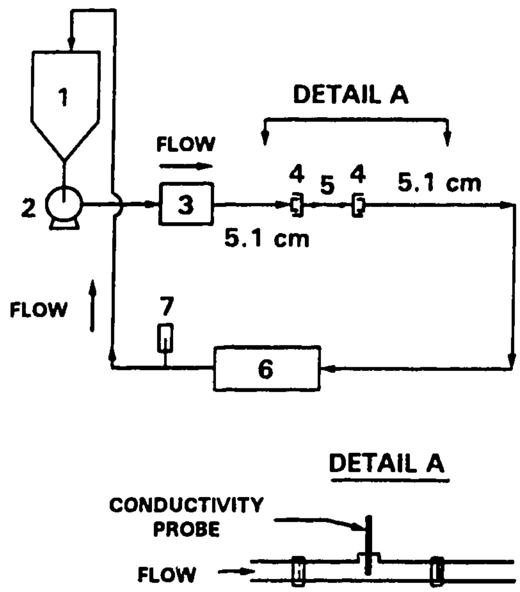


Figure 4.32: Slurry Pipeline Loop

1 - Holding Tank
2 - Pump
3 - Flow Meter
4 - Rotatable Joint
5 - Conductivity Probe Location
6 - Heat Exchanger
7 - Thermometer

As can be seen in Figure 4.33, for a slurry containing 300 μm sand, at a bulk solids concentration of 0.126 and a bulk pipe velocity of 2.3 m/s, the measured solids concentration shows the same trend as seen in the mixing tank. The highest concentration measured by the conductivity probe was observed when the small field electrode was facing into the slurry flow and the lowest concentration was seen when the small field electrode was facing away from the flow.

These differences in conductivity readings with probe orientation were not observed in water with the absence of solids. When tested in the mixing tank, no

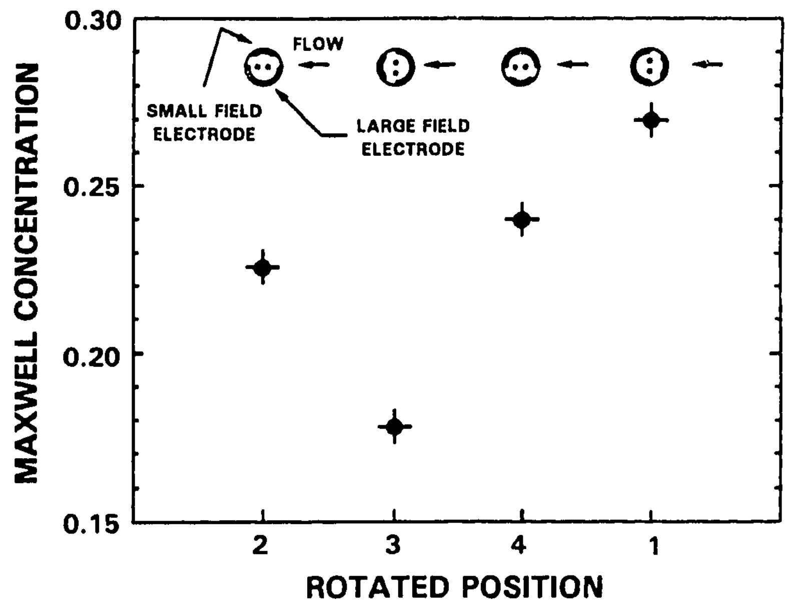


Figure 4.33: Effect of Probe Rotation on Measured Concentration in the Slurry Pipeline
d_{50} = 300 μm, C_B = 0.126, U_B = 2.3 m/s

significant effect of probe orientation on sensor voltage was observed for a variety of mixer speeds (Figure 4.34). The small increase in sensor voltage at the very high mixer speeds was due to entrainment of air into the mixing tank by the impeller. Air is an insulator, giving rise to an increase in the local resistance near the conductivity probe and an increase in the sensor voltage. Clearly, an insulator such as a wall or slurry solids, are required for the conductivity probe output to vary with probe orientation. With no insulator, as in pure water, there is no orientation effect.

To quantify this orientation effect, calibration experiments were carried out in the slurry pipeline. Results from the straight conductivity probe used in these studies and an L-shaped conductivity probe of the same design used by Nasr-El-Din et al. (1987) were compared. These authors have shown this L-shaped conductivity probe (Figure 2.21) to give reliable measurements of solids concentration in a slurry pipeline.

Discrete amounts of 300 μm sand were added to the slurry pipeline to cover

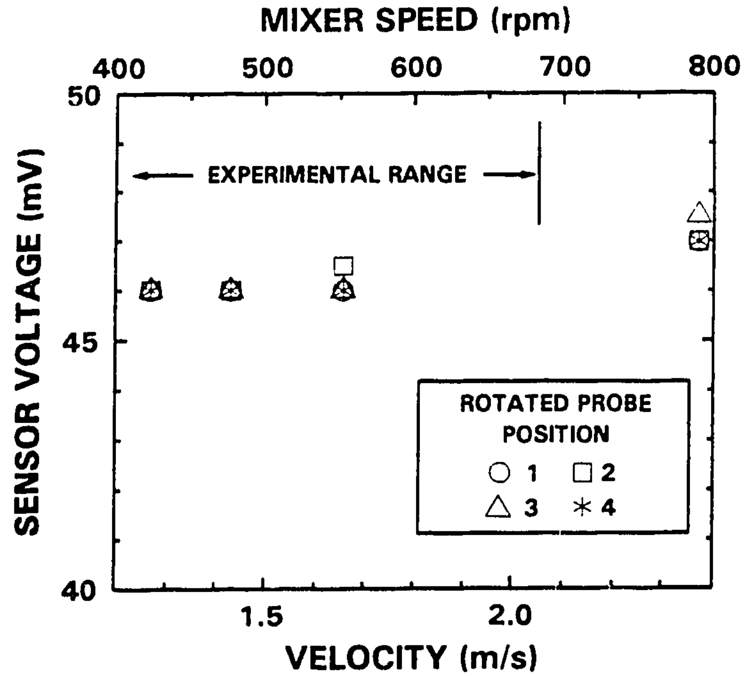


Figure 4.34: Effect of Probe Rotation on the Conductivity Probe Sensor Voltage in the Mixing Tank (Water Only) (z/H = 0.3, r/R = 0.4)

a range of bulk concentrations from about 11 to 27 percent by volume. Conductivity readings were taken at 2.5, 3.2 and 3.8 centimeters from the top of the horizontal pipeline with the L-shaped conductivity probe. Readings at the same positions were repeated with the straight conductivity probe, and the probe rotated about its axis to the four positions shown in Figure 4.33. With this method, sensor voltages corresponding to solids concentrations from 10 to 45 percent by volume were measured. The data are summarized in Table 4.2 and in Appendix D.

Table 4.2 shows that only the "solids concentration" measured at position 1, with the small field electrode facing into the flow, agrees closely with the value of C_0 measured with the L-shaped conductivity probe. Measurements at all other positions are lower, with the lowest occurring at position 3. The data for position 1 are

C_0	Concentration at Probe Position				Error 1[7]	Error 2[8]
	1	2	3	4		
0.102	0.102	0.082	0.068	0.107	0.00	
0.172	0.183	0.153	0.119	0.179	-6.40	10.2
0.276	0.269	0.225	0.177	0.240	2.54	15.7
0.096	0.080	0.056	0.031	0.071	16.67	
0.167	0.169	0.130	0.100	0.161	-1.20	16.2
0.276	0.266	0.222	0.161	0.240	3.62	15.2
0.150	0.134	0.106	0.073	0.130	10.67	13.6
0.208	0.201	0.155	0.121	0.182	3.37	19.3
0.295	0.270	0.230	0.166	0.257	8.47	10.9
0.261	0.257	0.201	0.145	0.222	1.53	21.5
0.330	0.307	0.263	0.188	0.273	6.97	14.6
0.369	0.360	0.300	0.236	0.313	2.44	17.5
0.339	0.320	0.253	0.178	0.279	5.60	20.3
0.399	0.368	0.300	0.228	0.314	7.77	19.9
0.444	0.437	0.354	0.291	0.373	1.58	20.2
				Average	3.35	16.5

Table 4.2: Conductivity Probe Solids Concentration Measurements from the Slurry Pipeline

compared with the L-shaped conductivity probe in Figure 4.35. The average error at position 1 is 3.35%.

If the direction of flow is known, then the actual solids concentration can be measured by the conductivity probe by rotating the probe so that the small field

[7] Error 1 = $100 * (C_0 - C_{Position\ 1}) / C_0$

[8] Error 2 = $100 * (C_{Position\ 1} - \text{Average } C_{(Positions\ 2\ and\ 4)}) / \text{Average } C_{(Positions\ 2\ and\ 4)}$

electrode faces into the flow. In the mixing tank, this can be done on the plane of the radial flow impeller since the radial flow from this impeller closely resembles flow in a pipeline.

In other regions in the mixing tank, the flow direction is not well known. To determine the actual solids concentration from the conductivity probe, the probe should be rotated about its axis until the highest signal is obtained. This would correspond to the small field electrode facing into the flow, and would give the actual solids concentration. A simplified method was used whereby conductivity measurements were taken at four positions, rotated 90° from each other.

The simplified method of rotating the conductivity probe to four discrete positions may not provide the maximum signal (small field electrode facing directly into the flow) and therefore would not give the best solids concentration estimate. This would occur if none of the four discrete positions, at which the probe was rotated to, corresponded to the small field electrode facing into the flow. The result would be that the signals obtained at these four positions would be shifted somewhere along the cyclic curve shown in Figure 4.31.

To account for this, the two solids concentration measurements at positions 90° from the maximum value, corresponding to the values at positions two and four in Figure 4.31, mid-way between the highest and lowest values, were averaged. As shown in Table 4.2, the difference between this average and the maximum value in the pipeline is, on average, 16.5%. For all conductivity measurements in the mixing tank, this average was multiplied by 1.165 to obtain the maximum value and then further multiplied by 1.0335 to account for the error between the maximum and true solids concentration (Error 1 in Table 4.2).

4.2.6 Conductivity Probe Calibration in a Slowly Settling Suspension

Solids concentration measurements from the straight conductivity probe compared well with the L-shaped conductivity probe when the small field electrode faced into the flow in a slurry pipeline. This calibration was confirmed by measuring

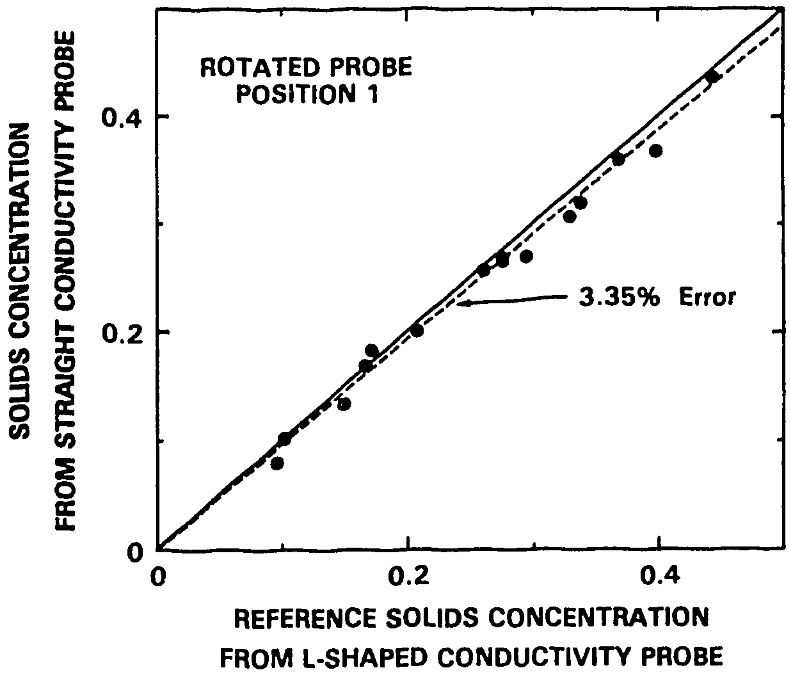


Figure 4.35: Conductivity Probe Calibration Curve from the Slurry Pipeline

the concentration of a slowly settling suspension with the straight conductivity probe. The results are shown in Figure 4.36. The conductivity probe normalized sensor voltage, as described in Equation 2.12, is plotted on the Y-axis versus the actual suspension particle concentration on the X-axis. The Maxwell correlation (Equation 2.14) is shown for comparison. The close fit of the experimental data to the Maxwell correlation confirms its usefulness to convert conductivity measurements to solids concentration.

When the conductivity probe was rotated about its axis in the slowly settling suspension, there was no difference in the measurements. The slow axial flow past the probe is symmetric and does not result in an orientation effect. To obtain differences in the conductivity probe sensor voltage with probe orientation, there must be solids (insulator) and lateral flow past the vertically mounted conductivity

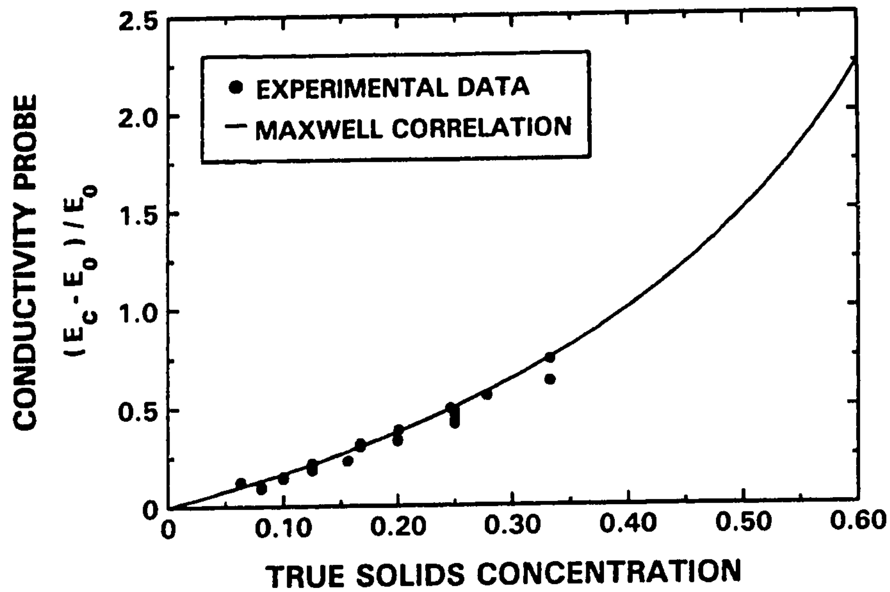


Figure 4.36: Conductivity Probe Calibration Curve from Sedimentation Experiments

probe. In the mixing tank, the position with the worst orientation effect is on the impeller plane. The flow at this location is similar to pipeline flow, and therefore the orientation effect can be corrected for as discussed in the last section.

4.2.7 Comparison of Conductivity Measured Concentration Profiles With Those From the Literature

Solids concentration profiles measured with the conductivity probe were compared qualitatively with several from the literature in order to test the suitability of the probe for measuring local solids concentration in a mixing tank.

Figure 4.37 shows axial solids concentration profiles for the 255 μm and

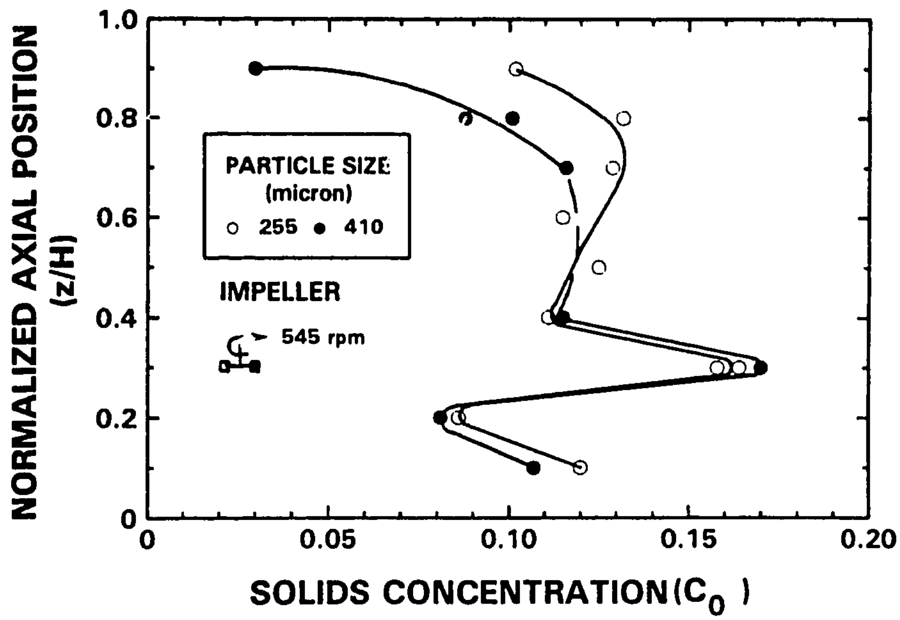


Figure 4.37: Mixing Tank Solids Concentration Profiles Measured with the Conductivity Probe (r/R = 0.6, C_B = 0.10)

410 μm sands at a radial position of r/R = 0.6 as measured with the straight conductivity probe. These profiles are quite similar to those described by several authors (Einenkel, 1980; Machon et al., 1982; Yamazaki et al., 1986; Barresi and Baldi, 1987a; Rieger et al., 1988; Ayazi Shamlou and Koutsakos, 1989). Sample solids concentration profiles from Barresi and Baldi (1987a) were shown in Figure 2.15. These profiles were determined by sample withdrawal from a very dilute suspension (C_B = 0.0058). Profiles from Rieger et al. (1988) were shown in Figure 2.19. These profiles were measured with a conductivity technique and are from a slurry with a similar particle size and bulk solids concentration as that shown in Figure 4.37 from this study.

Even though the suspensions and the solids concentration measurement techniques are different for the profiles of Barresi and Baldi (1987a) and Rieger et al. (1988), they are quite similar in shape to the profiles measured in this study (Figure 4.37). The straight conductivity probe used in this study appears to be suitable for measuring the local solids concentration in a slurry mixing tank.

4.2.8 Summary

It has been confirmed that the conductivity probe sensor output is a strong function of solution ionic strength, temperature and probe position relative to a boundary. As well, it has been shown that the sensor output is sensitive to the probe orientation relative to the direction of the slurry flow. To eliminate the effect of solution composition, temperature and position, with this design of conductivity probe, the liquid conductivity was measured frequently at the same positions in the vessel that the slurry conductivity measurements were taken. The conductivity sensor readings were normalized using the relation of Nasr-El-Din et al. (1987) (Equation 2.12). The effect of probe orientation was minimized by using the highest conductivity sensor reading from four positions rotated 90° from each other.

4.3 Analysis of Sample Withdrawal Errors in a Slurry Mixing Tank

In Section 4.2 it was shown that the conductivity probe developed for this study is a practical device for measuring local solids concentration in a slurry mixing tank. To obtain reliable results however, the conductivity probe must be used carefully. In some industrial situations, sampling may be the only concentration measurement technique available for use. It would therefore be desirable to know the differences between the actual local solids concentration and that measured by sampling. It would then be possible to correct for sampling errors and to determine under what situations sampling can provide acceptable results.

The objective of this section is to quantify the sampling errors from a slurry mixing tank and to show under what conditions a representative sample may be obtained.

4.3.1 Sampling Efficiency

Sampling efficiency is defined as the ratio of the solids concentration measured by sample withdrawal and the local solids concentration, measured in this study by the conductivity probe (Equation 2.1). A ratio of unity implies no sampling error.

As discussed in Section 2.3.1, sampling error is due to the flow structure ahead of the sampler, particle inertia relative to the fluid and particle bouncing. The following sections will go into some detail on how the different parameters affecting particle inertia, particle bouncing and the flow structure ahead of the sample tube can affect the sampling efficiency from a slurry mixing tank.

4.3.2 Effect of Flow Structure Ahead of the Sampler on Sampling Efficiency

Prior to examining sampling errors, it would be desirable to understand the mechanism of sampling from a mixing tank in order to better interpret the results obtained.

The flow structure in a mixing tank stirred with a radial flow impeller is rather complicated as shown in Figure 3.4. On the axial plane of the impeller, the flow is generally radial towards the tank wall. This is true except for the region near the tank wall where a stagnation point exists and the flow splits into axial flow upwards and downwards (Rushton, 1965; Laufhutte and Mersmann, 1985a,b). Above the impeller plane, near the tank wall, the flow is generally axial.

Slurry samples in this study were withdrawn from tubes inserted into the mixing tank wall (Figure 3.2). Thus, the orientation of the sample tube to the flow in the vessel was at times parallel with the flow (impeller plane), nearly perpendicular to the flow (above the impeller plane) or some combination of the two. These different orientations resulted in the different mechanisms of sample withdrawal shown in Figure 4.3.

These sampling mechanisms are very similar to those observed when sampling from a slurry pipeline by different methods. When sampling parallel to the slurry flow on the impeller plane ($z/H = 0.3$) the trend closely approaches that for L-shaped probes, sampling parallel to flow in a slurry pipeline (Figure 2.5). Sampling perpendicular to the slurry flow above the impeller plane ($z/H = 0.5$) gives trends similar to wall sampling from slurry pipelines (Figure 2.8). A third trend is seen for the mixing tank position of $z/H = 0.4$, $r/R = 0.9$ where the sample solids concentration is relatively insensitive to sampling velocity. It is quite probable that the flow is not fully parallel nor perpendicular to the sample tube but a combination of these. The two competing mechanisms appear to "cancel out" the effect of sampling velocity, resulting in a flat curve.

As was discussed, the direction of solid-liquid flow in a mixing tank, agitated with a radial flow impeller, is quite complicated. On the plane of the impeller however, it was expected that the flow is similar to that of an expanding jet (Rushton, 1965), with entirely radial flow components parallel to the sample tube. If this were the case, the sample solids concentration (C_S), sampled at the isokinetic sampling velocity ($U_S/U_0 = 1$)[9], would equal the local solids concentration ($C_S/C_0 = 1$). Figure 4.38 shows that this is not the case. At the isokinetic sampling velocity, the sampling efficiency (C_S/C_0) is significantly less than unity.

Rehakova and Novosad (1971b) found that the relative solids concentation (C_S/C_B) differed from unity at the isokinetic sampling velocity ($U_S/U_0 = 1$) for dilute solids suspensions in a mixing tank. They attributed this to the possibility that the local concentration varied throughout the vessel and was not equal to the bulk solids concentration (C_B), even at the impeller plane. Figure 4.37 shows this is indeed the

[9] The local velocity in the mixing tank (U_0) can only be predicted on the plane of a radial flow impeller (Equation 2.3). In all other locations in the mixing tank, U_0 cannot be determined easily and data is plotted versus the sampling velocity (U_S) only.

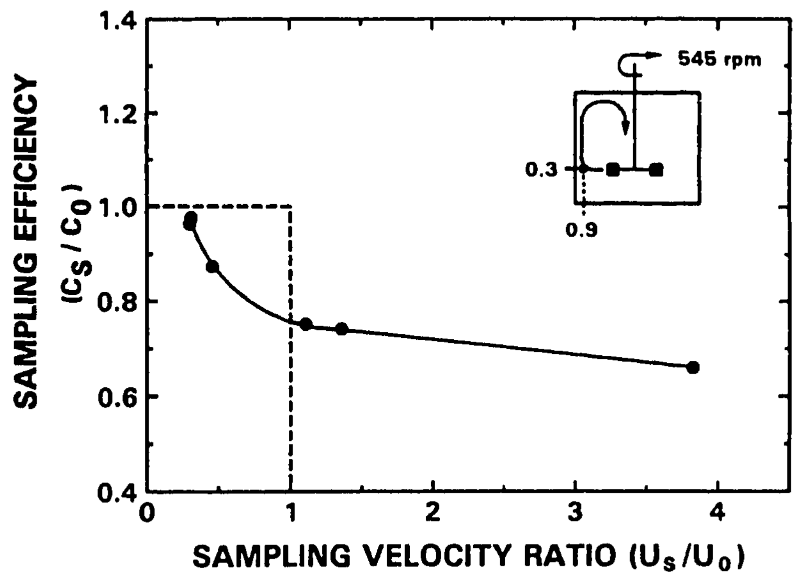


Figure 4.38: Sampling Efficiency on the Impeller Plane (Tapered Sample Tube) d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, β = 90°, γ = 18°, z/H = 0.3, r/R = 0.9

case for the more concentrated suspensions used in this study.

It is also possible that the flow on the impeller plane was not purely radial, but consisted of axial and angular flow components. Laufhutte and Mersmann (1985b) have shown that this is true in a mixing tank filled with liquid only and stirred with the same Rushton-type impeller used in this study. Figure 4.39 shows the radial-angular vector field of the mean velocity measured by laser doppler velocimetry for planes 40 mm and 10 mm below the impeller. In the immediate vicinity of the impeller, large angular velocity components exist. These angular flows are lower at greater distances from the impeller but still exist. It is reasonable to expect similar profiles at the impeller plane.

This was tested in the mixing tank by sampling at the impeller plane (z/H = 0.3) at a normalized radial position of r/R = 0.9 with the angled sample tube ($\beta \neq 90°$). This tube was rotated about its axis to four different positions, 90° from

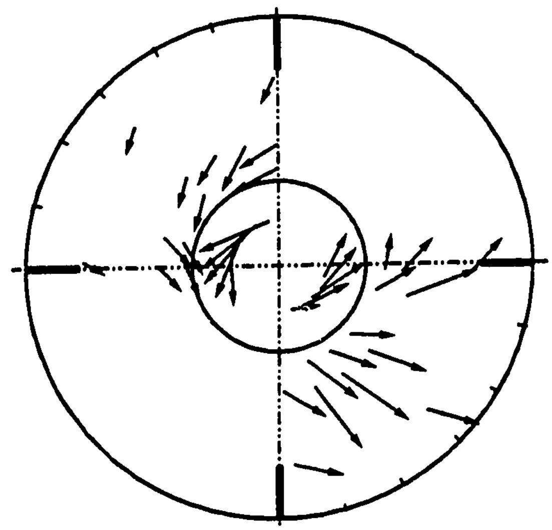


Figure 4.39: Radial-Angular Velocity Field in a Mixing Tank
Adapted From: Laufhutte and Mersmann (1985b)

each other, such that the angled face was facing upwards ($\beta = 45°$), downwards ($\beta = 135°$) or to the front or back of the mixing tank. The results are shown in Figures 4.40 and 4.41.

Figure 4.40 shows the sampling efficiency for the cases where the angled sampling tube was rotated towards the front and back of the mixing tank. As can be seen, large differences in the sampling efficiency occur for these two situations. The highest sample solids concentration occurs when the angled face of the sample tube opens towards the flow (indicated by the impeller rotation). The lowest concentration occurs when the angled sample tube face opens away from the flow. The fluid streamlines into the tube are diverted more severely in the second case as compared to the first. This results in greater separation of the particle trajectories from the fluid flow and lower sample solids concentrations. This phenomenon will be discussed in further detail in the next section.

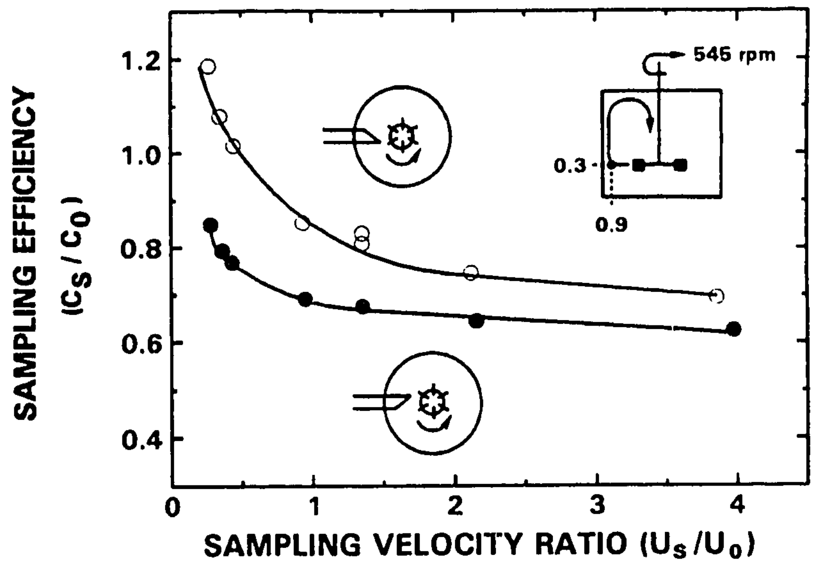


Figure 4.40: Effect of Lateral Sampler Orientation on the Sample Quality on the Impeller Plane.
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, z/H = 0.3, r/R = 0.9

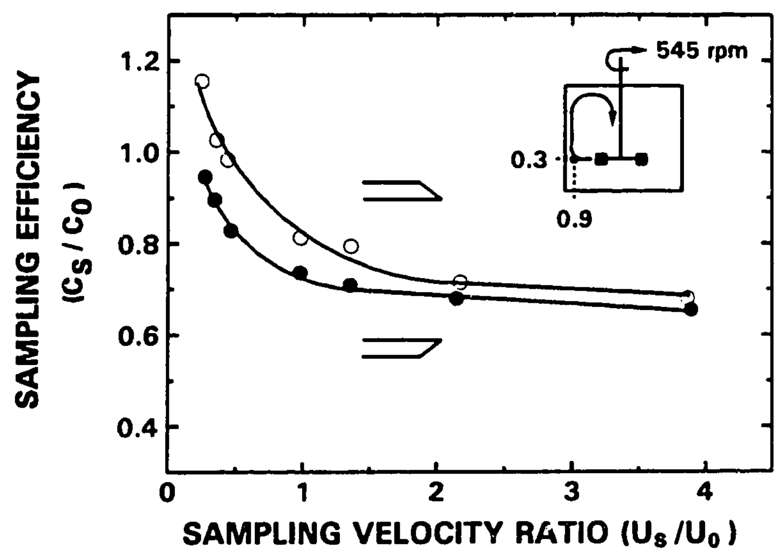


Figure 4.41: Effect of Vertical Sampler Orientation on the Sample Quality on the Impeller Plane
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, z/H = 0.3, r/R = 0.9

Figure 4.40 confirms the existence of angular flow at this position in the vessel. If the flow were purely radial, the sample solids concentration should not differ for the two positions shown in this figure. The frontal face of the sample tube presented to the radial flow is the same.

Similar results are shown in Figure 4.41 for the angled sample tube facing upwards and downwards. Differences in sampling efficiency again exist indicating in this case the presence of axial flow components at this point in the vessel. Axial flow is expected near the wall of the vessel on the impeller plane where the flow splits into axial flow upwards and downwards (Figure 3.4). Rushton (1965) recommended a radial position of at least 1/40 the tank diameter ($r/R = 0.95$) inside the tank wall to eliminate the flow stagnation effect at the tank wall that results in the axial flow. The experiments shown in Figure 4.41 were carried out at a radial position of $r/R = 0.90$, further from the tank wall than recommended by Rushton. Even at this point, it appears that some axial flow exists.

Figures 4.40 and 4.41 show that even on the radial impeller plane the flow structure is such that solids approach the sample tube obliquely and not parallel to the sample tube. This violates the requirement stated by Nienow (1985) that the sample withdrawal velocity be in the same direction as the fluid-particle flow. The sampling mechanism thus differs from that seen when sampling parallel to the flow in slurry pipelines with L-shaped samplers. It is therefore reasonable to expect the sampling efficiency (C_S/C_0) to differ from unity at the isokinetic sampling velocity predicted by Equation 2.3 and shown in Figure 4.38.

4.3.3 Effect of Particle Inertia on Sampling Efficiency

Several parameters were shown in Equation 2.2 to affect the particle inertia. In this section, particle size and bulk concentration will be examined for their effect on sampling efficiency.

The particle inertia parameter is dependent upon the square of the particle size as shown in Table 4.3 for the sands used in this study[10]. As such, sampling

d_{50} (μm)	K
82	0.331
255	3.20
410	8.25
500	12.3
1000	49.0

Table 4.3 Particle Inertia Parameters

results should be a strong function of particle size.

Figure 4.42 shows the sampling efficiency as a function of particle size for sampling parallel to the flow on the impeller plane. The trend for the smallest ($82\,\mu m$) is somewhat different than for the larger 410 and $1000\,\mu m$ sands. The sensitivity of sample solids concentration to sampling velocity is lower for the $82\,\mu m$ sand than for the 410 and $1000\,\mu m$ sands. A similar decreasing sensitivity of sample concentration to sampling velocity for smaller particle inertia parameters (K) is seen when sampling from a slurry pipeline (Nasr-El-Din, 1989).

A greater effect of particle size on sampling efficiency is expected for flow perpendicular to the sample tube as shown in Figure 2.10 for wall sampling from a slurry pipeline. This is due to the perpendicular approach of the sand particles to the sampling tube. In order to be withdrawn into the sampling tube, the solid particles must change direction by 90°. Large separations between the fluid

[10] The Particle Inertia Parameter was calculated using Equation 2.2 with U_0 from Equation 2.3, for the plane of the radial impeller at r/R = 0.9, 545 rpm and with the 4.55 mm diameter sampling tube.

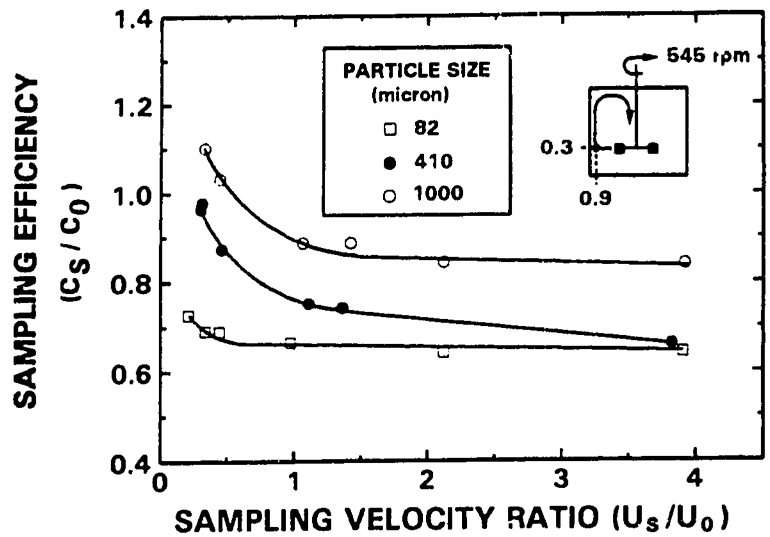


Figure 4.42: Effect of Particle Size on Sampling Efficiency on the Impeller Plane (Tapered Sample Tube)
C_B = 0.10, ϕ = 4.6 mm, β = 90°, γ = 18°, z/H = 0.3, r/R = 0.9

streamlines and the particle trajectories occur, especially with increasing particle size (increasing inertia parameter K).

This effect is seen in the mixing tank at a position of z/H = 0.5 and r/R = 0.9, shown in Figure 4.43. At this position, it is not possible to determine the particle inertia parameter (K) as the upstream local velocity (U_0) is not known. In addition, the sampling efficiency is plotted against the sampling velocity (U_S) only and not against the sampling velocity ratio (U_S/U_0), since the local velocity (U_0) is not known. As can be seen however, sampling error increases dramatically as particle size and thus particle inertia, increases. The trends in Figure 4.43 are very similar to those seen when sampling from the wall of a slurry pipeline (Figure 2.10).

At high sampling velocities, there is a much larger difference in sampling efficiency with particle size in Figure 4.43 than in Figure 4.42. This is due to the perpendicular approach of the solids to the sample tube opening in Figure 4.44 as

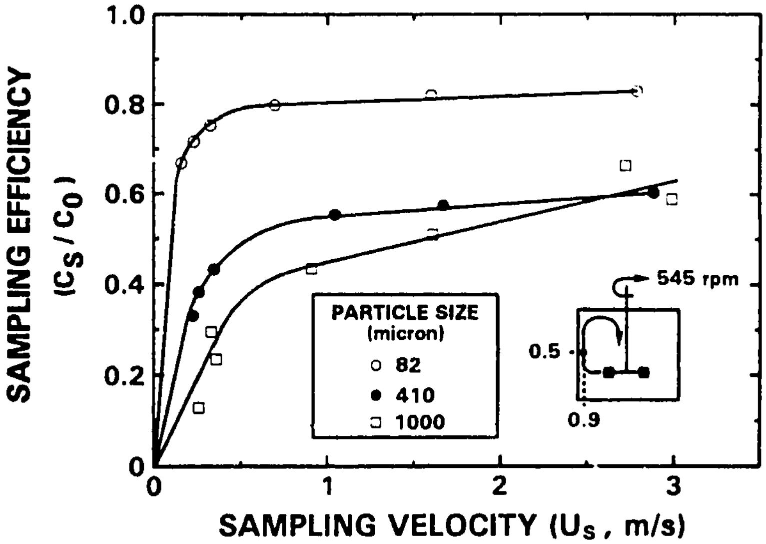


Figure 4.43: Effect of Particle Size on Sampling Efficiency with Flow Perpendicular to the Sample Tube in the Mixing Tank
C_B = 0.10, ϕ = 4.6 mm, β = 90°, z/H = 0.5, r/R = 0.9

opposed to the parallel approach in Figure 4.42.

At some positions in the mixing tank, the fluid flow is neither entirely parallel nor perpendicular to the sample tube but a combination of each (mixed flow). Figure 4.44 shows the effect of particle size from a position where the flow is likely mixed. There is some effect of particle size on sampling efficiency, however the trend is not as strong as seen in Figure 4.43 where the flow was more clearly perpendicular to the sample tube.

The effect of particle size on sampling efficiency is evident at several positions in the mixing tank where the solid-liquid flow relative to the sample tube is quite different. The particle size effect is most severe when the solid-liquid flow is perpendicular to the sampling tube resulting in a 90° deflection of the fluid flow into the sampling tube. The separation between the solids trajectories and the fluid streamlines increases with particle size, resulting in a significant decrease in sampling

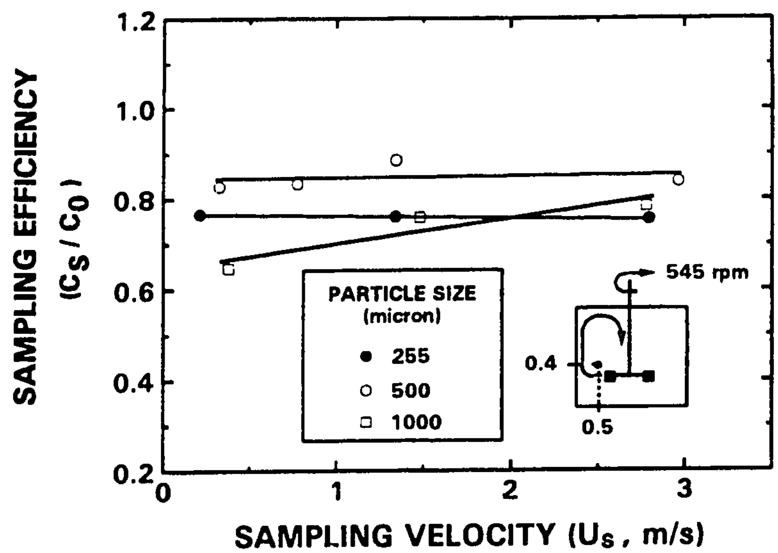


Figure 4.44 Effect of Particle Size on Sampling Efficiency for Mixed Flow in the Mixing Tank
C_B = 0.10, ϕ = 4.6 mm, β = 90°, z/H = 0.4, r/R = 0.5

efficiency with increasing particle size. At positions where the fluid streamlines are deflected less than 90° (parallel or mixed flow relative to the sampling tube), the decrease in sampling efficiency with increasing particle size is less.

Nasr-El-Din (1989) showed that increasing the bulk solids concentration (C_B) in a slurry pipeline, decreases the sampling errors for both L-shaped probe and side wall sampling (Figure 2.8). This phenomenon was attributed to the increased drag force on the particle which decreases the deviation of the particle trajectories from the fluid streamlines. This results in the solid particles more closely following the fluid streamlines and improved sampling efficiency.

Figure 4.45 shows a very similar trend for the case of sampling perpendicular

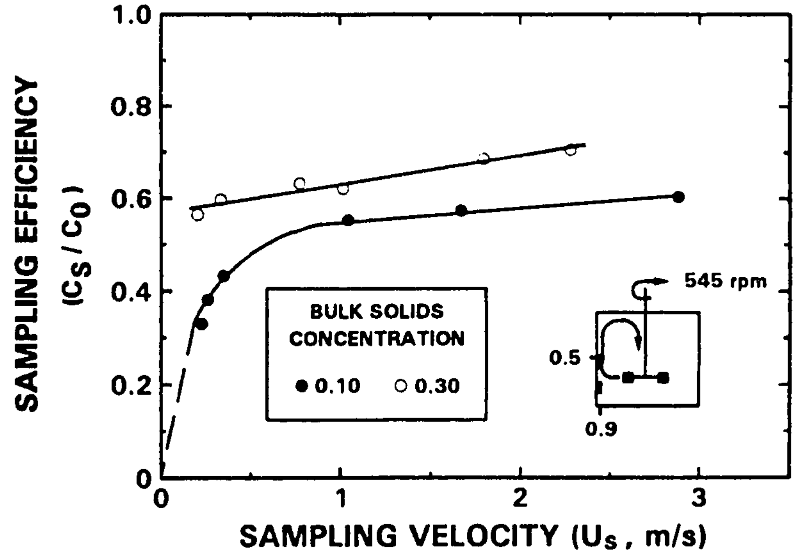


Figure 4.45 Effect of Bulk Solids Concentration on Sampling Efficiency for Sampling Perpendicular to the Flow in the Mixing Tank
d_{50} = 410μm, ϕ = 4.6 mm, β = 90°, z/H = 0.5, r/R = 0.9

to the flow in the mixing tank (comparable to side wall sampling in a pipeline). As the bulk solids concentration increases from 0.10 to 0.30, the sampling error decreases. Sampling from mixing tank slurries with high bulk concentrations can improve the sampling efficiency. However, when sampling perpendicular to the flow when the particle inertia is large (such as with the 410μm sand slurry used in Figure 4.45), the sampling error is not eliminated.

4.3.4 Effect of Sample Tube Design on Sampling Efficiency

There are several aspects of sample tube design that can affect the sampling performance of the device; tip angle, tube diameter and the shape of the sample tube. These parameters will be explored in the following.

Nasr-El-Din (1989) showed that sampling with blunt L-shaped probes from a slurry pipeline resulted in sampling errors that increased with the relative thickness of the sample tube (δ) (Figure 2.6). This was due to distortion of the fluid streamlines by the blunt tip and the particle bouncing effect. Solids particles tend to strike the blunt face of the sampler and lose some of their inertia. This causes them to be more easily withdrawn into the sampler resulting in higher sample concentrations. Sampling errors were eliminated when the tip angle of the sampler was about 18° or less.

The same trend is seen in the mixing tank when sampling on the plane of the impeller with the 410 μm sand (Figure 4.46). Reducing the sample tube tip angle reduces particle bouncing and the sample solids concentration. The effect is more pronounced for the 1000 μm sand shown in Figure 4.47. Particle inertia is again responsible. The fluid streamlines are deflected by the blunt sample tube face. The 410 μm sand particles will follow these deflected streamlines to some extent whereas the larger 1000 μm sand particles will not. The majority of the large particles travelling in-line with the thick sample tube edge will strike this edge, lose inertia and be withdrawn into the sample tube (particle bouncing effect). Some of the smaller 410 μm solids will deflect around the thick sample tube edge and will not strike it. Therefore a lesser proportion of these small solids will strike the face, lose inertia and be withdrawn into the sample tube. The sample solids concentration for a sample tube with a blunt (untapered) tip and the tapered tip is therefore smaller for the small sand than for the larger sand.

Reducing the sample tube tip angle to 18° minimizes the deflection of the fluid streamlines and particle bouncing on the sample tube face. As a result, similar sampling efficiencies for both the 410 μm and the 1000 μm sands are evident.

Sample tube diameter can have a large impact on sampling efficiency when sampling perpendicular to the flow in the mixing tank (Figure 4.48). As shown previously, the sampling mechanism at this location closely resembles that of wall

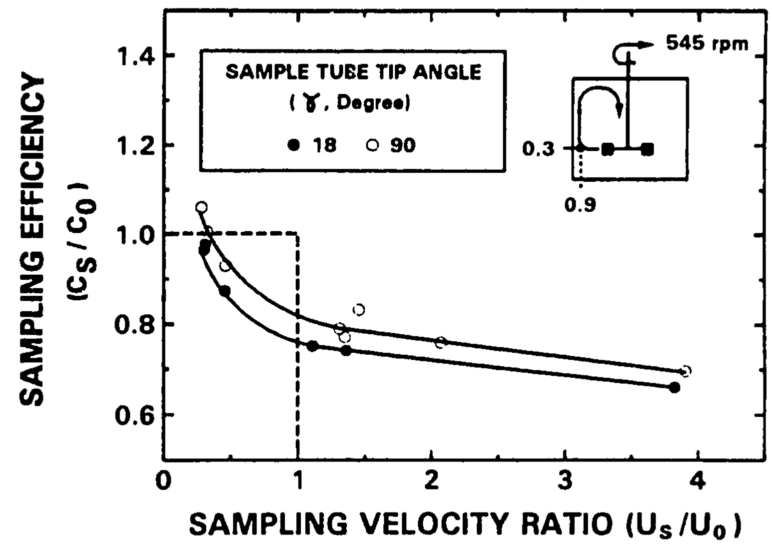


Figure 4.46 Effect of Sampler Tip Angle when Sampling Parallel to the Flow in the Mixing Tank d_{50} = 410 μm, C_B = 0.10, φ = 4.6 mm, β = 90°, δ = 0.4, z/H = 0.3, r/R = 0.9

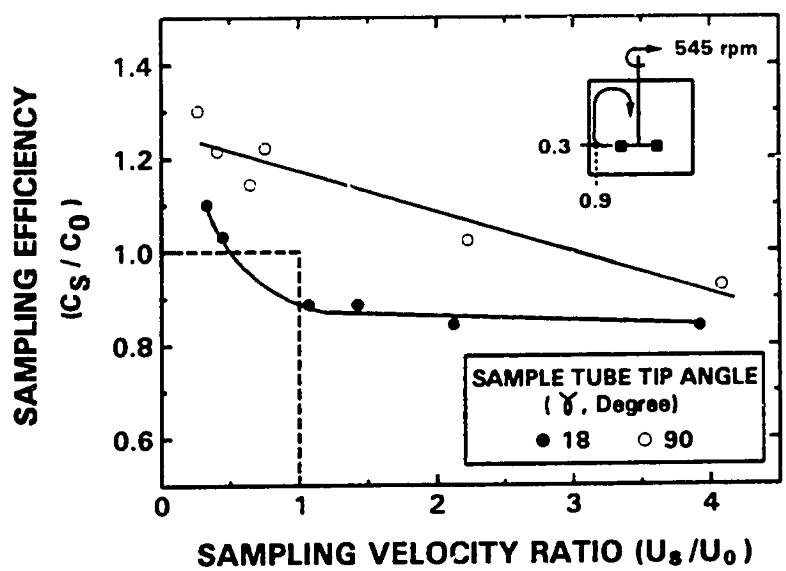


Figure 4.47 Effect of Sampler Tip Angle when Sampling Parallel to the Flow in the Mixing Tank d_{50} = 1000 μm, C_B = 0.10, φ = 4.6 mm, β = 90°, δ = 0.4, z/H = 0.3, r/R = 0.9

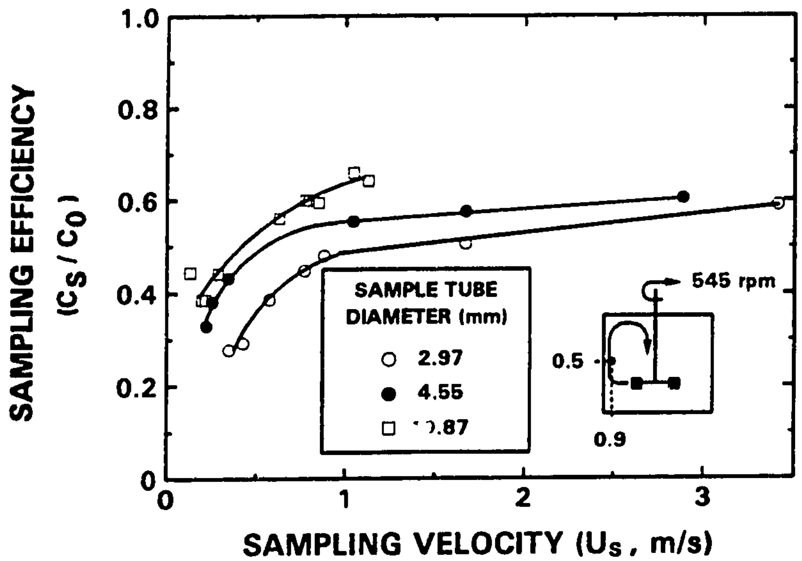


Figure 4.48 Effect of Sample Tube Diameter on Sampling Efficiency in the Mixing Tank
d_{50} = 410 μm, C_B = 0.10, β = 90°, z/H = 0.5, r/R = 0.9

sampling from a slurry pipeline (Figure 2.9). As is the case in a slurry pipeline, the sampling efficiency increases as the sample tube opening increases, for a given sampling velocity. As discussed in Section 2.3.1.1.3, this is due to an increased amount of time available for a particle to change its direction 90° to be withdrawn into the sample tube. Clearly when sampling perpendicular to a flow, it is desirable to sample with as large a sample tube as reasonable. This however does not ensure that a representative sample will be obtained.

The effect of sample tube shape is shown for the 255 μm sand in Figure 4.49. Large differences in sample solids concentration can be obtained at a given sampling velocity, simply by using different sample tube shapes. The mechanism for sampling is completely different as well. Results for the 135° sample tube resemble wall sampling from a slurry pipeline with the sampling efficiency increasing with sampling velocity. On the other hand, the 45° sample tube performance resembles sampling with an L-shaped probe sampler in a slurry pipeline, with the sample concentration generally decreasing with increasing sampling velocity. The straight faced (90°) sampler gives sample solids concentrations between the 45° and 135° samplers, and is insensitive to sampling velocity.

Figure 4.49 shows that the sample solids concentration is highest for the 45° sampling tube at all sampling velocities. This is due to the sample tube shape and the downwards direction of solid-liquid flow at this position in the mixing tank (z/H = 0.4, r/R = 0.5). Particle bouncing on the protruding tip of the 45° sample tube results in a loss of particle inertia and an increase in sample solids concentration.

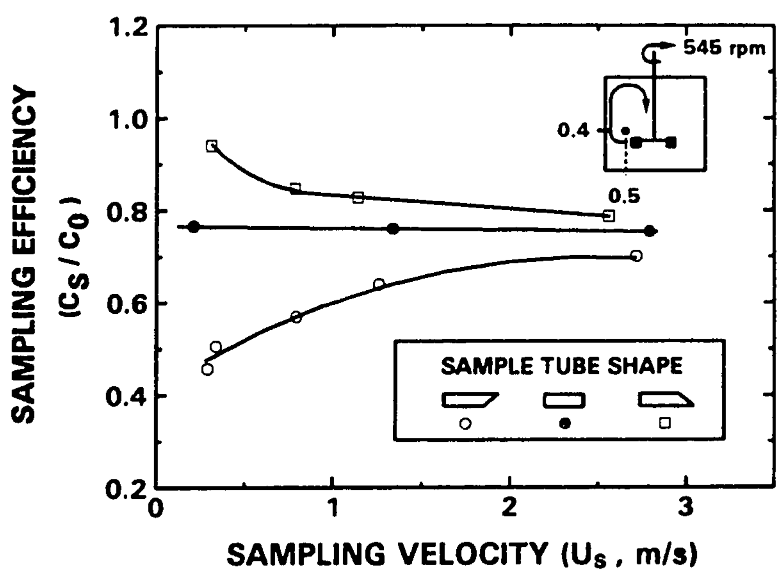


Figure 4.49 Effect of Sampler Shape on Sampling Efficiency in the Mixing Tank
d_{50} = 255 μm, C_B = 0.10, ϕ = 4.6 mm, z/H = 0.4, r/R = 0.5

The same effect was described by Nasr-El-Din (1989) when sampling from the wall of a slurry pipeline with a angled sample tube. Barresi and Baldi (1987a) observed the same effect when sampling from a mixing tank, stirred by an axial flow impeller (Figure 2.13). Just above and below the impeller, the angled sample tube, opening into the flow, gave consistently higher sample solids concentrations than a straight faced sampling tube.

The sample solids concentrations are consistently lower for the 135° sampling tube than for the 45° sampling tube, especially at low sampling velocities (Figure 4.49). This is due to the orientation of this sample tube relative to the flow. To enter the sample tube, the fluid streamlines must bend at least 90°. The same is true for the solids, but due to particle inertia, separation between the particle trajectories and the fluid flow occurs and the sample solids concentration is reduced.

The deflection of the fluid streamlines and particle trajectories into the 90° sampling tube at this position in the mixing tank is between the 45° and 135° sampling tubes. As a result, the sample solids concentration is between the 45° and 135° sampling tubes.

Figure 4.50 shows comparable results for the 1000 μm sand at the same position in the vessel. The 45° sample tube (opening into the flow) again gives the highest sample solids concentration, the 135° sample tube (facing away from the flow) the lowest concentration and the 90° straight faced sampler gives solids concentrations in between the other two. The differences between the sample solids concentrations obtained by the different sampling tubes is much wider for the 1000 μm sand than for the 255 μm sand, at a given sampling velocity. This is due to particle inertia. The inertia parameter (K) of the 1000 μm sand is more than 15 times larger than that of the 255 μm sand (Table 4.2). As a result, the separation between the solids trajectories and the fluid streamlines is much larger for the 1000 μm sand than for the 255 μm sand. This is especially evident for the 135° sampler where the solids must deflect by a large angle to enter the sampler. This is more difficult for the 1000 μm sand than for the 255 μm sand, resulting in much

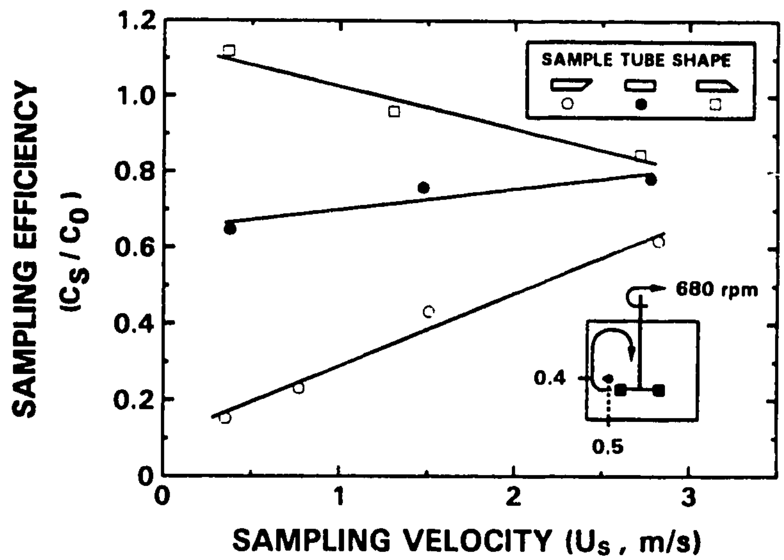


Figure 4.50 Effect of Sampler Shape on Sampling Efficiency in the Mixing Tank
d_{50} = 1000 μm, C_B = 0.10, ϕ = 4.6 mm, z/H = 0.4, r/R = 0.5

lower sampling efficiency at a given sampling velocity.

Obviously, sampler design can have a large impact on sampling efficiency and the effect increases with particle diameter. The different sampling mechanism for the different sample tube designs makes it extremely difficult in a mixing tank to determine the sampling velocity required to obtain a representative sample without prior knowledge of the solids and fluid properties and the flow velocity and direction past the sample tube.

4.4 Sample Concentration Correlations

In the previous sections, it has been shown that the solids concentration obtained by sample withdrawal from a slurry mixing tank is rarely equivalent to the local solids concentration. Since sampling is often the simplest or only method available for determining solids concentration, it would be very useful to be able to compensate for sampling error with a correlation.

4.4.1 Sampling on the Plane of the Impeller

Rushton (1965) developed correlations to predict the solids concentration measured by sampling with a tapered sample tube on the plane of a radial flow impeller in a mixing tank (Equations 2.4 and 2.5). These correlations predict the sample solids concentration (C_S) to equal the bulk solids concentration (C_B) at the isokinetic sampling velocity ($U_S = U_0$ - determined from Equation 2.3). This is indee[illegible] case for the 410 μm sand used in this study (Figure 4.51). The Rushton cor[illegible] vn for comparison, predicts the sample solids concentration very well, with [illegible] deviations being at low sampling velocities.

[illegible] e case where the solids are not fully suspended, as shown in Figure 4.52 for the 1000 μm sand, the Rushton prediction fails. In this case, the sample solids concentration is far less than the bulk solids concentration at the isokinetic velocity ($U_S/U_0 = 1$). Obviously the Rushton correlation is valid for situations where the solids are fully suspended.

The Rushton correlation predicts the sample solids concentration (C_S) to equal the <u>BULK</u> solids concentration (C_B) at the isokinetic sampling velocity ($U_S/U_0 = 1$). The bulk solids concentration is not necessarily the local solids concentration on the impeller plane as shown in Table 4.4 for various impeller speeds for the 410 μm sand.

A correlation for the local solids concentration (C_0) can be developed by fitting a Rushton-type correlation, shown in Equation 4.3, to the experimental data.

$$C_S / C_0 = a \, (U_S / U_0)^b \tag{4.3}$$

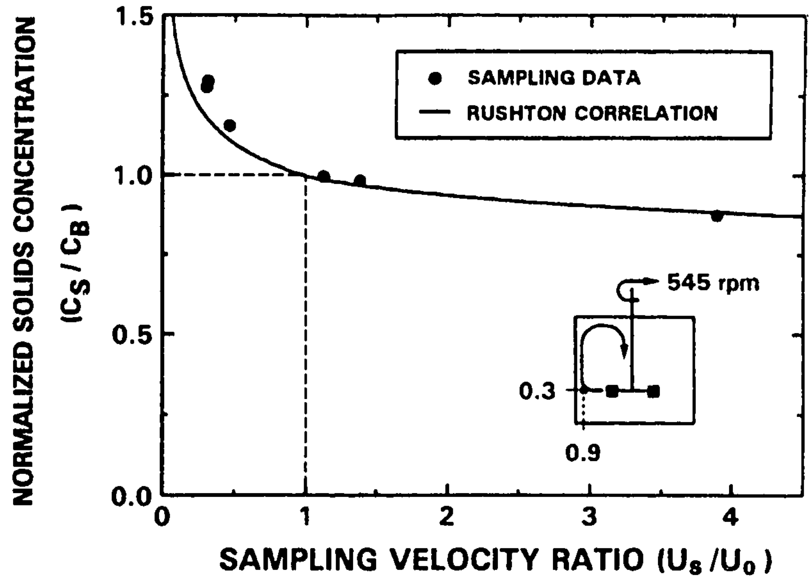


Figure 4.51 Comparison of the Rushton Correlation with Sampling Data
d_{50} = 410μm, C_B = 0.10, ϕ = 4.6 mm, β = 90°, γ = 18°, z/H = 0.3, r/R = 0.9

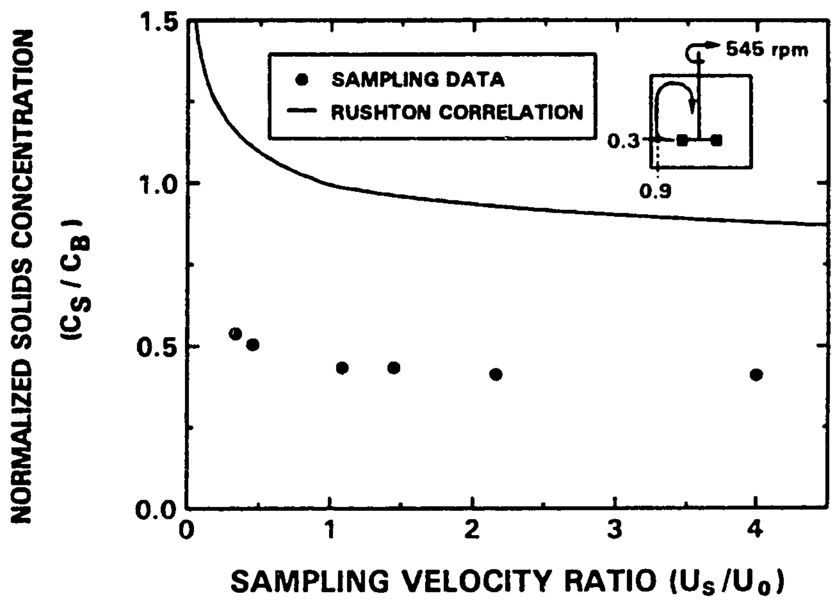


Figure 4.52 Comparison of the Rushton Correlation with Sampling Data
d_{50} = 1000μm, C_B = 0.10, ϕ = 4.6 mm, β = 90°, γ = 18°, z/H = 0.3, r/R = 0.9

This was done for the 82, 410 and 1000 μm sands at a bulk concentration of 0.10 and for the tapered (γ = 18°), 4.6 mm diameter sampling tube, sampling on the radial impeller plane (z/H = 0.3). The results are shown in Table 4.5 and the data and fitted line for the 410 μm sand shown in Figure 4.53.

N (rpm)	C_B	C_0
440	0.100	0.079
545	0.100	0.124
680	0.100	0.132

Table 4.4 Comparison of Bulk and Local Solids Concentrations
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, γ = 18°, z/H = 0.3, r/R = 0.9

Rushton (1965) pointed out that the exponent (b) becomes larger (more negative) as the particle size increases. This is true for the 82 and 410 μm sands but is not true for the 1000 μm sand. The exponent of the 1000 μm sand is smaller (less negative) than for the 410 μm sand. This could be due to the incomplete suspension of the 1000 μm sand, a situation that Rushton did not study. In addition, the sampling tube used for these tests was only 4.6 times the diameter of the 1000 μm

d_{50} (μm)	a	b	r^2
82	0.723	-0.041	0.92
410	0.847	-0.156	0.97
1000	0.885	-0.115	0.90

Table 4.5: Fitted Parameters for Equation 4.3
z/H = 0.3, C_B = 0.10, ϕ = 4.6 mm, γ = 18°

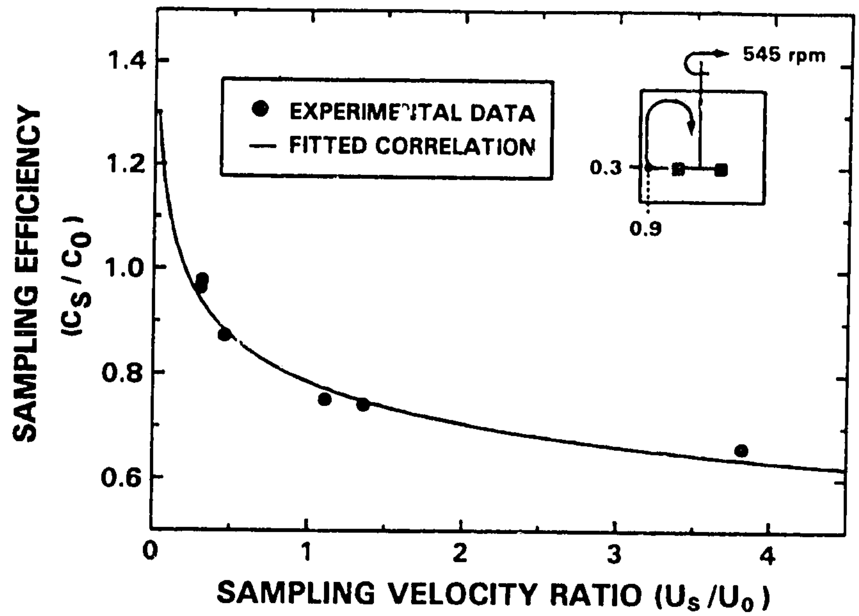


Figure 4.53: Curve Fitted To Sampling Efficiency Data From the Mixing Tank
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, γ = 18°, z/H = 0.3, r/R = 0.9

sand. This small aspect ratio is less than that recommended by Nasr-El-Din (1984) for sampling from slurry pipelines and as a result, may cause sampling behaviour that was not accounted for by Rushton (1965).

It appears that a correlation of the type used by Rushton (Equation 4.3) may be used to predict the local solids concentration in a mixing tank on the plane of a radial flow impeller. More work needs to be done to be able to predict the coefficient 'a' and the exponent 'b'.

Rehakova and Novosad (1971a,b) and Sharma and Das (1980) analyzed the same problem of sampling on the radial impeller plane of a mixing tank. Each group developed different correlations to predict the relative solids concentration (C_S/C_B) at this location (Equations 2.6 to 2.10).

The Rushton and Sharma and Das correlations are shown in Figure 4.54 along

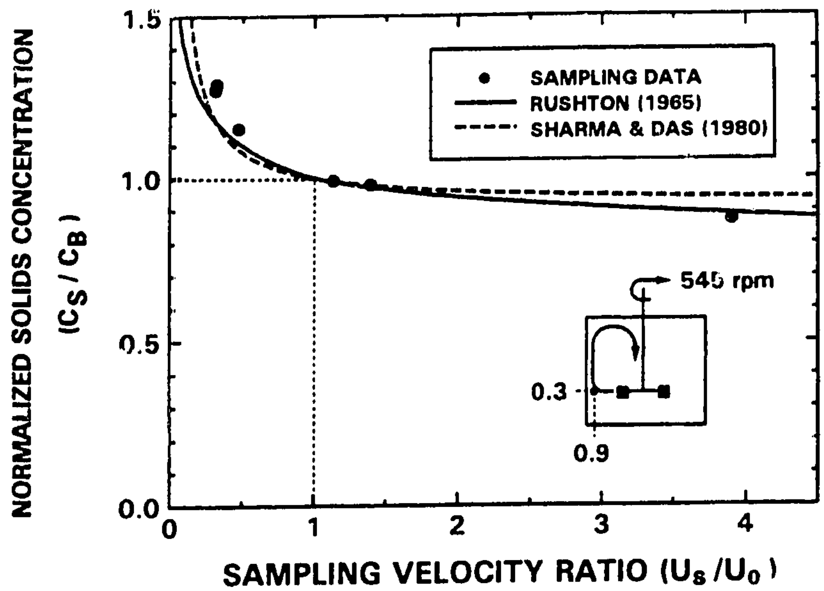


Figure 4.54: Comparison of the Rushton and Sharma and Das Correlations with Experimental Data
d_{50} = 410 μm, C_B = 0.10, ϕ = 4.6 mm, γ = 18°, z/H = 0.3, r/R = 0.9

with sampling data from this study. The correlations of Rehakova and Novosad are not compared due to the very low solids concentrations covered in their study and the lack of a particle size dependence.

The correlation by Sharma and Das is very similar to that of Rushton, however it predicts a slightly higher solids concentration ratio (C_S/C_B). The Rushton correlation appears to give the best fit of the data over the entire range of sampling velocities.

5. CONCLUSIONS

The following conclusions can be drawn from this study:

- The solids concentration measured by sampling from slurry mixing tanks can vary widely and is a function of sampling velocity, particle size, bulk solids concentration, position of the sampler relative to the flow, sample tube shape, diameter and tip angle.

- The sample particle size distribution can vary widely with the sampling velocity and sample tube shape. For a mixture containing equal amounts of coarse and fine sands, the fraction of fine particles in the sample is a linear function of the sample solids concentration, within the range of parameters covered in this study.

- The conductivity probe developed in this study can accurately measure local solids concentration in a slurry mixing tank. The conductivity probe must be used with care as the measurement accuracy is a function of solution ion concentration, temperature, position relative to a boundary in the vessel, field circuit operation and the rotated position of the probe relative to the slurry flow.

- The sampling mechanism in a slurry mixing tank can resemble L-shaped probe sampling in a slurry pipeline (sampling parallel to the flow), side wall sampling from a slurry pipeline (sampling perpendicular to the flow) or a combination of the two.

- The flow on the impeller plane of a mixing tank stirred with a radial flow impeller is not purely radial in nature but also consists of axial and angular velocity components. This results in sample solids concentrations lower than the local solids concentration at the isokinetic sampling velocity.

- For fully suspended solids, sampled with a sampling tube with a tip angle of 18°, on the plane of the impeller, the sample solids concentration equals the bulk solids concentration at the isokinetic sampling velocity.

- Sampling error increases with increasing particle size when sampling perpendicular to the flow in a mixing tank.

- Sampling error is reduced, with increasing bulk solids concentration when sampling perpendicular to the flow in the mixing tank. The sampling error is still significant however for the 410 μm sand even at a bulk solids concentration of 0.30.

- Reducing the tip angle of a blunt sample tube when sampling on the plane of a radial flow impeller reduces the sample solids concentration due to a reduction in particle bouncing and disturbance of the fluid flow field.

- Increasing the sample tube diameter when sampling perpendicular to the flow will increase the sample solids concentration at a given sampling velocity. More time is available for the particles to deflect 90° and be withdrawn into the larger sample tube.

- Differently shaped samplers can greatly change the sample solids concentration at a given sampling velocity and location in the mixing tank. These differences increase with increasing particle size.

- The sampling mechanism is completely different for 45°, 90° and 135° shaped sample tubes at the same location in the mixing tank. This is due to the shape of the sample tube opening relative to the solid-liquid flow and to particle bouncing.

- The Rushton and Sharma and Das correlations adequately predict the sample solids concentration on the plane of a radial flow impeller when using a sample tube with a tip angle of 18°, in a fully suspended suspension and when the bulk solids concentration in the vessel is known.

6. RECOMMENDATIONS

It is recommended that:

- A correlation, predicting the local solids concentration in a slurry mixing tank on the plane of a radial flow impeller, be developed. This can be accomplished by further investigating the effect of particle properties, mixing and sampling conditions on the constants in Equation 4.3.

- The conductivity probe instrumentation be better developed to obtain more accurate average conductivity and solids concentration values from the fluctuating signal.

- The effect of conductivity probe rotation on the measured solids concentration be further investigated. This phenomenon may be useful for determining the direction of flow in a mixing tank.

- The conductivity probe be redesigned to eliminate the unsymmetric electrode placement and the effect of rotation on conductivity measurement. Pipeline calibration of the new design is essential.

BIBLIOGRAPHY

AYAZI SHAMLOU, P. KOUTSAKOS, E. Solids suspension and distribution in liquids under turbulent agitation. Chem. Eng. Sci. 44 3: 529-542, 1989

AYAZI SHAMLOU, P. ZOLFAGHARIAN, A. Incipent solid motion in liquids in mechanically agitated vessels. Fluid Mixing III, Instn. Chem. Engrs: 195-208 1988

BAKER, R.C. HEMP, J. Slurry concentration meters state of the art review and bibliography. (BHRA) Fluid Engineering Series 8: 3-25, 1981

BAKKER, A. FRIJLINK, J.J. The drawdown and dispersion of floating solids in aerated and unaerated stirred vessels. Chem. Eng. Res. Des. 67 2: 208-210 1989

BALDI, G. CONTI, R. and ALARIA, E. Complete suspension of particles in mechanically agitated vessels. Chem. Eng. Sci. 33: 21-25 1978

BALDI, G. CONTI, R. and GIANETTO, A. Concentration profiles for solids suspended in a continuous agitated reactor. AIChE J. 27 6: 1017-1020 1981

BARNEA, D. SHOHAM, O. and TAITEL, Y. Flow pattern characterization in two phase flow by electrical conductance probe. Int. J. Multiphase Flow 6: 387-397, 1980

BARNES, R.N. GOODWILL, D.J., REED, A.R. and WOODHEAD, S.R. Measuring bulk solids quantities-part 3: Pneumatic conveying systems. Eng. Digest. 36 1: 20-23, 1990

BARRESI, A. BALDI, G. Solid dispersion in an agitated vessel. Chem. Eng. Sci. 42 12: 2949-2956 1987a

BARRESI, A. BALDI, G. Solid dispersion in an agitated vessel: effect of particle shape and density. Chem. Eng. Sci. 42 12: 2969-2972 1987b

BASHIR. Y.M.	GODDARD, J.D. Experiments on the conductivity of suspensions of ionically-conductive spheres. AIChE J. 36 3: 387-396 1990
BECK, M.S.	CALVERT, G., HOBSON, J.H., LEE, K.T. and MENDIES, P.J. Total volume and component flow measurement in industrial slurries and suspensions using correlation techniques. Trans. Inst. Measurement and Control. 4 8: 133-138, 1971
BECK, M.S.	MENDIES, P.J., WALECKI, T. and GATLAND, H.B. Measurement and control in hydraulic transport systems using cross-correlation measurement systems and fluidic diverters. Hydrotransport 3, Proc. 3rd Int. Conf. on the Hydraulic Transport of Solids in Pipes. Paper F5: BHRA, 69-80, 1974
BEGOVICH, J.M.	WATSON, J.S. An electroconductivity technique for the measurement of axial variation of holdups in three-phase fluidized beds. AIChE J. 24 2: 351-354 1978
BEKER, G.W.	Intrinsic classified withdrawal in continuous well mixed crystallization. Ph.D. Thesis, Iowa State University, 1970
BERTRAND, J.	COUDERC, J.P. and ANGELINO, H. Power consumption, pumping capacity and turbulence intensity in baffled stirred tanks: Comparison between several turbines. Chem. Eng. Sci. 35: 2157-2163 1980
BOHNET, M.	NIESMAK, G. Distribution of solids in stirred suspensions. Ger. Chem. Eng. 3: 57-65 1980
BOURNE, J.R.	DELL'AVA, P. Micro- and macro-mixing in stirred tank reactors of different sizes. Chem. Eng. Res. Des. 65: 180-186 1987
BOURNE, J.R.	KOZICKI, F., MOERGELI, U. and RYS, P. Mixing and fast chemical reaction III, Model-experiment comparisons. Chem. Eng. Sci. 36 10: 1655-1663 1981
BRUGGEMAN, D.A.G.	Berechnung verschiedener physicalischer konstanten von heterogenen substanzen. Annln. Phys. 24: 636, 1935
BUURMAN, C.	RESOORT, G. and PLASCHKES, A. Scaling-up rules

for solids suspension in stirred vessels. Chem. Eng. Sci. 41 11: 2865-2871 1986

CARPENTER, K.J. A fine chemicals view of the mixing world. 5th European Conf. on Mixing, BHRA: 233-241 1985

CHAPMAN, C.M. NIENOW, A.W., COOKE, M. and MIDDLETON, J.C. Particle-gas-liquid mixing in stirred vessels. Part I: Particle-liquid mixing. Chem. Eng. Res. Des. 61: 71-81, 1983a

CHAPMAN, C.M. NIENOW, A.W., COOKE, M. and MIDDLETON, J.C. Particle-gas-liquid mixing in stirred vessels. Part II: Gas-liquid mixing. Chem. Eng. Res. Des. 61: 82-95 1983b

CHATZI, E.G. GAVRIELIDES, A.D. and KIPARISSIDES, C. Generalized model for prediction of the steady-state drop size distributions in batch stirred vessels. Ind. Eng. Chem. Res. 28: 1704-1711 1989

CHUDACEK, M.W. Formation of unsuspended solids profile in a slurry mixing vessel. 4th European Conf. on Mixing, BHRA: 275-287, 1982

CHUDACEK, M.W. Solids suspension behavior in profiled bottom and flat bottom mixing tanks. Chem. Eng. Sci. 40 3: 385-392 1985

CHUN, M-H. SUNG, C-K. Parametric effects on the void fraction measurement by capacitance transducers. Int. J. Multiphase Flow 12 4: 627-640, 1986

CLIFF, M.J. EDWARDS, M.F. and OHIAERI, I.N. The suspension of settling solids in agitated vessels. Fluid Mixing, The Institution of Chemical Engineers: 1981

CLOETE, F.L.D. COETZEE, M.C. Calculating the minimum power required for complete suspension of solids in a mixer. Powder Tech. 46: 239-243 1986

CONSIDINE, D.M. CONSIDINE, G.D., Ed's. Process instruments and controls handbook. 3rd ed. McGraw-Hill Book Company, New York, 1985

COSTES, J. COUDERC, J.P. Study by laser doppler anemometry of the turbulent flow induced by a Rushton turbine in a stirred tank: Influence of the size of the units - I. Mean flow and turbulence. Chem. Eng. Sci. 43 10: 2751-2764, 1988a

COSTES, J. COUDERC, J.P. Study by laser doppler anemometry of the turbulent flow induced by a Rushton turbine in a stirred tank: Influence of the size of the units - II. Spectral analysis and scales of turbulence. Chem. Eng. Sci. 43 10: 2765-2772 1988b

COX, M.C. RHODES, E. A strategy for the continuous in-pipeline metering of oil/water emulsions. 37th Canadian Chem. Eng. Conf., Montreal: May 19-22 1987

DEBRECZENI, E. MEGGYES, T. and TARJAN, I. Measurement methods in an experimental rig for hydraulic transport. Hydrotransport 5, Proc. 5th Int. Conf. on the Hydraulic Transport of Solids in Pipes, Paper G1, BHRA Fluid Engineering: 1-19 1978

DE LA RUE, R.E. TOBIAS, C.W. On the conductivity of dispersions. J. Electrochem. Soc. 106: 827, 1959

DESAI, D. KUMAR, R. Liquid holdup in semi-batch cellular foams. Chem. Engng. Sci. 38: 1525-1534, 1983

DUNNETT, S.J. A mathematical study of thin-walled sampling probes orientated to the flow. J. Aerosol Sci., 20 8: 1557-1560 1989

EDWARDS, M.F. ELLIS, D.I. The drawdown of floating solids into mechanically agitated vessels. Fluid Mixing II, Instn. Chem. Engrs.: 1-13 1984

EINENKEL, W.-D. Influence of physical properties and equipment design on the homogeneity of suspensions in agitated vessels. Ger. Chem. Eng. 3: 118-124 1980

ELLIS, D.I. GODREY, J.C. and MAJIDIAN, N. A study of the influence of impeller speed on the mixing of floating solids in a liquid. Fluid Mixing III, The Instn. Chem. Engrs.: 181-194 1988

FAJNER, D. MAGELLI, F., NOCENTINI, M. and PASQUALI, G. Solids concentration profiles in a mechanically stirred and staged column slurry reactor. Chem. Eng. Res. Des. 63: 235-240 1985

FANLO, S. LEMLICH, R. Predicting the performance of foam fractionation columns. AIChE I. Chem. E. Symp. Ser., 9: 75-78 1965

FORD, W.N. ETCHELLS III, A.W. and SHORT, D.G.R. An industrial mixing laboratory. 5th European Conf. on Mixing, Paper 4, BHRA: 1985

GEISLER, R.K. MERSMANN, A.B. Local velocity distribution and power dissipation rate of suspensions in stirred vessels. 6th European Conf. on Mixing, BHRA: 267-272 1988

GERAETS, J.J.M. BORST, J.C. A capacitance sensor for two-phase void fraction measurement and flow pattern identification. Int. J. Multiphase Flow 14 3: 305-320, 1988

GERSTENBERG, H. SCKUHR, P. and STEINER, R. Stirred tank reactors for polymerization. Ger. Chem. Eng. 6: 129-141 1983

GOLDSTEIN, R.J. Ed. Fluid mechanics measurements. Hemisphere Publishing Corp., Washington 1983

HANAI, T. Kolloidzeitschrift, 171: 23, 1960

HANAI, T. Kolloidzeitschrift, 175: 61, 1961a

HANAI, T. Bull. Inst. Chem. Res. Kyoto Univ., 39: 341, 1961b

HARDY, J.E. HYLTON. J.O. Electrical impedence string probes for two-phase void and velocity measurements. Int. J. Multiphase Flow 10 5: 541-556, 1984

HASHIN, Z. Assessment of the self consistent scheme approximation: conductivity of particulate composites. J. Comp. Mat., 2: 284, 1968

HAYASHI, H., SAMPEI, T., ODA, S. and OHTOMO, S. Some experimental studies on iron concentrate slurry transport in pilot plant. Proc. Seventh Int. Conf. Hydraulic

Transport of Solids in Pipes, Paper D2., 149, 1980

HEMRAJANI, R.R. — SMITH, D.L., KOROS, R.M. and TARMY, B.L. Suspending floating solids in stirred tanks - mixer design, scale-up and optimization. 6th European Conf. on Mixing, BHRA: 259-265 1988

HEWITT, G.F. — Measurement of two phase flow parameters. Academic Press, London: 1978

HONG, P.O. — LEE, J.M. Unsteady-state liquid-liquid dispersions in agitated vessels. Ind. Eng. Chem. Proc. Des. Dev. 22: 130-135, 1983

HORDESKI, M.F. — Transducers for automation. Van Nostrand Reinhold Co., New York: 1987

JEFFREY, D.J. — Proc. R. Soc. Lond. A335: 335, 1973

JONES, O.C. — DELHAYE, J-M. Transient and statistical measurement techniques for two-phase flows: A critical review. Int. J. Multiphase Flow 3: 89-116, 1976

KAKKA, R.S. — PHIL, M. Review of instruments for measuring flow rate and solids concentrations in steel works slurry pipelines. Hydrotransport 3. Proc. 3rd Int. Conf. on the Hydraulic Transport of Solids in Pipes, Paper F6, BHRA Fluid Engineering, 81-92, 1974

KAO, D.T. — KAZANSKIJ, I. On slurry flow velocity and solid concentration measuring techniques. Proc. 4th Int. Tech. Conf. on Slurry Transportation, Slurry Transportation Assoc.: 102-120, 1979

KARABELAS, A.J. — Vertical distribution of dilute suspensions in turbulent pipe flow. AIChE J. 23: 426, 1977

KESKA, J. — Measurement of the distribution and overall spatial solid body content of mixtures in pipelines. Hydrotransport 5, Proc. 5th Int. Conf. on the Hydraulic Transport of Solids in Pipes, Paper G5, BHRA Fluid Engineering, 59-72, 1978

KIDDER, R.J. — ROSENTHAL, R. Recent advances in conductivity measurement. Instruments and Control Systems 38: 118-121, 1965

KIPKE, K. Problems in mixing technology. Ger. Chem. Eng. 6: 119-128 1983a

KOMORI, S. MURAKAMI, Y. Turbulent mixing in baffled stirred tanks with vertical-blade impellers. AIChE J. 34 6: 932-937 1988

LAUFHUTTE, H.D. MERSMANN, A.B. Dissipation of power in stirred vessels. 5th European Conf. on Mixing, BHRA: 331-340 1985a

LAUFHUTTE, H.D. MERSMANN, A. Laser-doppler velocimetry as a suitable measuring technique for the determination of flow behaviour in stirred fluids. Ger. Chem. Eng. 8: 371-379, 1985b

LEE, K.T. BECK, M.S. and MCKEOWN, K.J. An on-line instrument for measuring small quantities of dispersed non-conducting liquid in a conducting liquid. Measurement and Control 7: 341-345, 1974

LIPTAK, B.G. VENCZEL, K. Instrument Engineers' Handbook. Chilton Book Company, Radner Pennsylvania: 1982

LUNDGREN, D.A. DURHAM, M.D. and MASON, K.W. Sampling from tangential flow streams. Amer. Ind. Hyg. Assoc., 39: 640, 1978

MACHON, V. FORT, I. and SKRIVANEK, J. Local solids distribution in the space of a stirred vessel. 4th European Conf. on Mixing, BHRA: 289-302 1982

MAGELLI, R. FAJNER, D., NOCENTINI, M. and PASQUALI, G. Solid distribution in vessels stirred with multiple impellers. Chem, Eng. Sci. 45 3: 615-625, 1990

MANN, R. KNYSH, P., RASEKOALA, E.A. and DIDARI, M. Mixing in a closed stirred vessel: Use of networks-of-zones to interpret mixing curves acquired by fibre-optic photometry. Fluid Mixing III, Instn. of Chem. Engrs: 49-62 1988

MANSFIELD, P.H. Electrical transducers for industrial measurement. Butterworths, London 1973

MAO, H YANG, S. Residence time distribution of solid particles in a liquid solid stirred tank. 6th European Conf. on Mixing, BHRA: 281-286 1988

MAXWELL, J.C. A treatise on electricity and magnetism. Calender Press, Oxford, 1881

MCLAREN WHITE, A. SUMERFORD, S.D., BRYANT, E.O. and LUKENS, B.E. Studies in agitation. Suspension of sand in water. Ind. Eng. Chem. 24 10: 1160-1162 1932

MIDDLETON, J.C. PIERCE, F. and LYNCH, P.M. Computations of flow fields and complex reaction yield in turbulent stirred reactors, and comparison with experimental data. Chem. Eng. Res. Des. 64: 18-22 1986

MOLERUS, O. LATZEL, W. Suspension of solid particles in agitated vessels - I. Archimedes numbers ≤ 40. Chem. Eng. Sci. 42 6: 1423-1430 1987a

MOUJAES, S.F. Testing of a spherical dual-tipped optical fiber probe for local measurements of void fraction and gas velocity in two-phase flows. Can. J. Chem. Eng. 68 3: 504-510 1990

MUSIL, L. The hydrodynamics of mixed crystallizers. Colln. Czech. Chem. Commun. 41: 839-852 1976

MUSIL, L. VLK, J. Suspending solid particles in an agitated conical-bottom tank. Chem. Eng. Sci. 33: 1123-1131 1978

NASR-EL-DIN, H. Sampling from slurry pipelines. Ph.D. Thesis, University of Saskatchewan, Saskatoon 1984

NASR-EL-DIN, H.A. Sampling from slurry pipelines. Chapter 14 in Wastewater Treatment Technology, Gulf Publishing Company, Vol. 3, Cheremisinoff, P.N. Ed. Houston 1989

NASR-EL-DIN, H. AFACAN, A. and MASLIYAH, J.H. Wall sampling from horizontal slurry pipelines. Chem. Eng. Comm. 82: 203-221, 1989a

NASR-EL-DIN, H. AFACAN, A. and MASLIYAH, J.H. Solids segregation in slurry flow through tee junctions with a horizontal approach. Int. J. Multiphase Flow 15: 659-671, 1989b

NASR-EL-DIN, H. SHOOK, C.A. and COLWELL, J. A conductivity probe for measuring local concentrations in slurry systems. Int. J. Multiphase Flow 13: 365-378, 1987

NEALE, G.H. NADER, W.K. Prediction of transport processes within porous media: Diffusive flow processes within an homogeneous swarm of spherical particles. AIChE J. 19 1: 112-119, 1973

NELSON, M.G. OBLAD, H.B. Fiber optic detector for flotation cell processing. United States Patent No. 4,797,550: Jan. 10, 1989

NIENOW, A.W. Suspension of solid particles in turbine agitated baffled vessels. Chem. Eng. Sci. 23: 1453-1459 1968

NIENOW, A.W. The suspension of solid particles. Mixing in the Process Industries, N. Harnby, M.F. Edwards and A.W. Nienow Eds., Butterworths, London 1985

NIENOW, A.W. KONNO, M. and BUJALSKI, W. Studies on three-phase mixing: A review and recent results. Chem. Eng. Res. Des. 64: 35-42 1986

NIENOW, A.W. KUBOI, R. A technique for studying intervortex mixing rates in a dual impeller agitated vessel in high viscosity fluids. Fluid Mixing II, M.F. Edwards, N. Harnby and J.C. Middleton Eds., The Institution of Chemical Engineers 1984

NIENOW, A.W. WISDOM, D.J. Flow over disc turbine blades. Chem. Eng. Sci. 29: 1994-1997 1974

OLDSHUE, J.Y. Suspension characteristics of mixtures of particle sizes in solid-liquid slurries. World Cong. Chem. Eng. 4: 408-410, 1981a

OLDSHUE, J.Y. Fluid mixing technology and practice. Chem. Eng. 90 12: 82-108 1983

ONG, K.H. BECK, M.S. Slurry flow velocity, concentration and particle size measurement using flow noise and correlation techniques. Measurement and Control 8: 453-463 1975

OSTENDORF, W. MEWES, D. Measurement of temperature fields in mixing vessels using optical tomography. Chem. Eng. Technol. 11: 148-155 1988

PAL, R. RHODES, E. Metering of two phase liquid-liquid flow. Proc. 3rd Multi-Phase Flow and Heat Transfer Symposium, Part B, Miami Beach: Apr. 18-20 1983

PAL, R. RHODES, E. Methods of metering oil and water production of wells 2nd Int. Conf. on Multiphase Flow, Paper H2: 397-411, June 19-21 1985

PANDIT, A.B. RIELLY, C.D., NIRANJAN, K. and DAVIDSON, J.F. The convex bladed mixed flow impeller: A multipurpose agitator. Chem. Eng. Sci. 44 11: 24[illegible]-2474 1989

PAPASTEFANOS, N. STAMATOUDIS, M. Effect of vessel and impeller geometry on impeller power number in closed vessels for Reynold's numbers between 40 and 65000. Chem. Eng. Res. Des. 67 [illegible] 169-174 1989

PERRY, R.H. CHILTON, C.H. Chemical engineers' handbook. 5th Ed. McGraw-Hill Book Company, New York: 1973

PETERS, J, SHOOK, C.A. Electromagnetic sensing of slurry concentration. Can. J. Chem. Eng. 59: 430-437, 1981

PRAGER, S. Diffusion and viscous flow in concentrated suspensions. Physica, 29: 129, 1963

RADER, D.J. MARPLE, V.A. A study of the effects of anisokinetic sampling. Aerosol Sci. Tech. 8: 283-299 1988

RAGHAVA RAO, K.S.M.S. REWATKAR, V.B. and JOSHI, J.B. Critical impeller speed for solid suspension in mechanically agitated contactors. AIChE J. 34 8: 1332-1340 1988

RANADE, V.V. JOSHI, J.B. Flow generated by a disc turbine. Part I experimental. Trans. I. Chem. E. 68 A: 19-33 1990

RANDOLPH, A.D. ISKANDER, M.R. Experimental study of concentration profiles and withdrawal rates of solids in a well-stirred vessel. AIChE Symp. on Mixing, Preprint 1968

RAYLEIGH, LORD On the influence of obstacles arranged in rectangular order upon the properties of a medium. Phil. Mag., 34: 481, 1892

REHAKOVA, M. NOVOSAD, Z. The separation effect at the outlet of a vessel with a mechanically agitated suspension. Coll. Czech. Chem. Commun. 36: 3004-3007 1971a

REHAKOVA, M. NOVOSAD, Z. Determination of the separation effect in a stirred vessel with a suspension by a dynamic method. Coll. Czech. Chem. Commun. 36: 3008-3012 1971b

RIEGER, F. DITL . Suspension of solid particles in agitated vessels. 4th European Conf. on Mixing, BHRA: 263-273 1982

RIEGER, F. DITL, P. and HAVELKOVA, O. Suspension of solid particles-concentration profiles and particle layer on the vessel bottom. 6th European Conf. On Mixing, BHRA: 251-258 1988

RUSHTON, J.H. The continuous removal of mixed phases from a mixing tank. AIChE I. Chem. E. Symp. Series, 10 10:3-10:7 1965

RUSHTON, J.H. HILLESTAD, J.G. Sampling of nonhomogeneous flow in pipes. Div. of Refining, 44: 517, 1964

SCHMIDT, H. TSOURIS, C., EGGERT, E. and TAVLARIDES L.L. Laser photometric probe for concentration measurements in liquid dispersions. AIChE J. 35 3: 507-510, 1989

SHARMA, R.N. DAS, H.C.L. Effect of withdrawal flow velocity on the composition of a two phase system in a mixing tank. Coll. Czech. Chem. Commun. 45: 3293-3301 1980

SKELLAND, A.H.P. MOETI, L.T. Effects of surface active agents on minimum impeller speeds for liquid-liquid dispersions in baffled vessels. Ind. Eng. Chem. Res. 28: 122-127, 1989

SMITH, J.M. Industrial needs for mixing research. Trans. I. Chem. E. 68 A: 3-6 1990

STANLEY-WOOD, N.G. LLEWELLYN, G.J. and TAYLOR, A. On-stream particle size, concentration and velocity measurements by auto-correlation of scattered laser light. Powder Tech. 29: 217-223 1981

STEINER, L. HUNKELER, R. and HARTLAND, S. Behaviour of dynamic cellular foams. Trans. I. Chem. Engng., 55: 153-163, 1977

TOJO, K. MIYANAMI, K. Solids suspension in mixing tanks. Ind. Eng. Chem. Fund. 21: 214-220 1982

TOURNAIRE, A. Dependence of the instantaneous response of impedence probes on the local distribution of the void fraction in a pipe. Int. J. Multiphase Flow 12 6: 1019-1024, 1986

TURNER, J.C.R. Two phase conductivity. The electrical conductance of liquid-fluidized beds of spheres. Chem. Eng. Sci. 31: 487-492, 1976

VAN DER MOLEN, K. VAN MAANEN, H.R.E. Laser-doppler measurements of the turbulent flow in stirred vessels to establish scaling rules. Chem. Eng. Sci. 33: 1161-1168 1978

WAGNER, K.W. Arch. Elekrotech., 2: 371, 1914

WATSON, H.H. Errors due to anisokinetic sampling of aerosols. Am. Ind. Hyg. Assoc. Q. 15: 20-24 1954

WEINSTEIN, B. TREYBAL, R.E. Dispersed phase holdup in baffled mixing vessels. AIChE J. 19 4: 851-852 1973

WEISSBERG, H.L. Effective diffusion coefficient in porous media. J. Appl. Phys., 34: 2636-2639, 1963

WIEDMANN, J.-A. STEIFF, A. and WEINSPACH, P.-M. Investigation of power consumption, suspension and flooding characteristics of stirred, aerated slurry reactors. Ger. Chem. Eng. 3: 303-312 1980

WIEDMANN, J.-A. STEIFF, A. and WEINSPACH, P.-M. Suspension behaviour of two- and three-phase stirred reactors. Ger. Chem. Eng. 8: 321-335, 1985

YAMAZAKI, H. TOJO, K. and MIYANAMI, K. Concentration profiles of solids suspended in a stirred tank. Powder Tech. 48: 20 -216 1986

YIANATOS, J.B. LAPLANTE, A.R. and FINCH, J.A. Estimation of local holdup in the bubbling and froth zones of a gas-liquid column. Chem. Eng. Sci. 40 10: 1965-1968, 1985

YIANNESKIS, M. Velocity, particle sizing and concentration measurement techniques for multiphase flow. Powder Tech. 49: 261-269 1987

ZWIETERING, Th. N. Suspending of solids particles in liquid by agitators. Chem. Eng. Sci. 8: 244-253 1958

APPENDIX A

PARTICLE PROPERTIES

Filename PARTSIZb WK1

LAST UPDATE SEPT 8, 1991

SAND FRACTION #1 PARTICLE SIZE DISTRIBUTION (d50 = 82 microns)

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
9	Particle Size	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	Pan	Total
10	(micron)																	
11																		
12	Wt. in Sieve (g)							0.77	0.52	[illegible]	8.15	20.71	18.90	32.42	55.07	4.81	2.55	150.23
13	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.86	5.07	10.50	24.28	36.86	58.44	95.10	98.30	100.00	
14																		
15	Wt. in Sieve (g)							0.79	0.55	6.43	7.96	20.52	20.41	27.84	58.63	5.82	3.24	152.22
16	Cum. Wt % Retained	0.00	0.00	0.00	0.00	[illegible]	0.00	0.52	0.88	5.10	10.35	23.83	37.24	55.53	94.05	97.87	100.00	
17																		
18	Wt. in Sieve (g)							0.98	0.64	6.66	9.57	19.08	18.35	38.72	42.53	2.73	1.78	141.04
19	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.69	1.15	5.87	12.66	26.18	39.19	66.65	96.80	98.74	100.00	
20																		
21	Wt. in Sieve (g)							1.08	0.65	6.80	10.66	20.76	19.36	41.89	43.55	2.80	1.72	149.27
22	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.72	1.16	5.71	12.86	26.76	39.73	67.80	96.97	98.85	100.00	
23																		
24	Wt. in Sieve (g)							1.11	0.64	6.73	10.25	22.13	21.13	39.85	48.88	2.73	1.75	155.20
25	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.72	1.13	5.46	12.07	[illegible]	39.94	65.62	97.11	98.87	100.00	
26																		
27	Wt. in Sieve (g)							0.82	0.58	6.68	10.37	20.97	20.18	41.54	46.29	3.11	1.91	152.45
28	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.92	5.30	12.10	25.86	39.09	66.34	96.71	98.75	100.00	
29																		
30	Wt. in Sieve (g)							0.96	0.56	6.35	9.40	20.63	19.26	[illegible]	50.98	3.91	2.11	148.32
31	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.65	1.02	5.31	11.64	25.55	38.54	[illegible]	95.94	98.58	100.00	
32																		
33	Wt. in Sieve (g)							0.96	0.57	6.37	8.53	21.33	19.88	34.31	54.31	4.08	2.42	152.76
34	Cum. Wt % Retained	0.00	0.00	0.00	0.00	0.00	0.00	0.63	1.00	5.17	10.76	24.72	37.73	60.19	95.74	98.42	100.00	
35																		
36	Ave. Cum Wt % Ret.	0.00	0.00	0.00	0.00	0.00	0.00	0.62	1.01	5.36	11.62	25.44	[illegible]	62.77	96.05	[illegible]	100.00	
37																		

SAND FRACTION #2 PARTICLE SIZE DISTRIBUTION (d50 = 255 microns)

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
43	Particle Size	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	Pan	Total
44	(micron)																	
45																		
46	Wt. in Sieve (g)				0.46	12.95	26.30	40.24	30.16	34.86	4.38	3.02	0.53	0.20			0.03	153.13
47	Cum. Wt % Retained	0.00	0.00	0.00	0.30	8.76	25.93	52.21	71.91	94.67	97.53	99.50	99.55	99.98	99.98	99.98	100.00	
48																		
49	Wt. in Sieve (g)				0.34	14.91	23.31	39.14	27.09	33.11	4.84	2.37	0.45	0.16			0.03	145.75
50	Cum. Wt % Retained	0.00	0.00	0.00	0.23	10.46	26.46	53.31	71.90	94.61	97.93	99.56	99.87	99.98	99.98	99.98	100.00	
51																		
52	Wt. in Sieve (g)				0.33	15.29	25.84	42.62	30.94	36.08	4.81	2.72	0.46	0.15			0.03	159.27
53	Cum. Wt % Retained	0.00	0.00	0.00	0.21	9.81	26.03	52.79	72.22	94.87	97.89	99.60	99.89	99.98	99.98	99.98	100.00	
54																		
55	Wt. in Sieve (g)				0.33	14.81	24.54	40.57	28.91	32.99	4.64	2.10	0.42	0.13			0.03	149.47
56	Cum. Wt % Retained	0.00	0.00	0.00	0.22	10.13	26.55	53.69	73.03	95.10	98.21	99.61	99.89	99.98	99.98	99.98	100.00	
57																		
58	Ave. Cum Wt % Ret.	0.00	0.00	0.00	0.24	9.79	26.24	53.00	72.26	94.81	97.89	99.57	99.87	99.98	99.98	99.98	100.00	
59																		
60																		

SAND FRACTION #3 PARTICLE SIZE DISTRIBUTION (d50 = 410 microns)

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
61																		
62																		
63	Particle Size	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	Pan	Total
64	(micron)																	
65																		
66	Wt. in Sieve (g)		0.10	2.77	59.66	56.05	18.01	11.36	3.77	4.15	0.80						1.04	157.71
67	Cum. Wt % Retained	0.00	0.06	1.82	39.65	75.19	86.61	93.81	96.20	98.83	99.34	99.34	99.34	99.34	99.34	99.34	100.00	
68																		
69	Wt. in Sieve (g)		0.04	2.06	48.39	57.83	18.24	9.57	3.51	3.90	0.72						1.29	145.45
70	Cum. Wt % Retained	0.00	0.03	1.44	34.71	74.47	87.01	93.59	96.01	98.62	99.11	99.11	99.11	99.11	99.11	99.11	100.00	
71																		
72	Wt. in Sieve (g)		0.09	4.52	54.50	53.96	17.80	10.50	3.58	3.09	0.52						0.52	148.86
73	Cum. Wt % Retained	0.00	0.06	3.10	39.71	75.96	87.78	94.83	97.[illegible]	99.20	99.65	99.65	99.65	99.65	99.65	99.65	100.00	
74																		
75	Wt. in Sieve (g)		0.10	3.08	53.45	62.42	19.97	10.13	3.68	3.55	0.57						0.78	157.73
76	Cum. Wt % Retained	0.00	0.06	2.02	35.90	75.48	88.14	94.56	96.89	99.14	99.51	99.51	99.51	99.51	99.51	99.51	100.00	
77																		
78	Ave. Cum Wt % Ret.	0.00	0.05	2.09	37.49	75.27	87.38	94.20	96.58	98.97	99.40	99.40	99.40	99.40	99.40	99.40	100.00	

SAND FRACTION #4 PARTICLE SIZE DISTRIBUTION (d50 = 500 microns)

84	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
85																				
86																				
87	Particle Size	1700	1168	833	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	Pan
88	(micron)																			
89																				
90	Wt. in Sieve (g)					43.07	27.12	31.64	21.54	7.97	4.82	1.87	2.19	0.39						2.51
91	Cum. Wt % Retained				0.00	30.09	49.04	71.15	86.20	91.77	95.14	96.44	97.97	98.25	98.25	98.25	98.25	98.25	98.25	100.00
92																				
93	Wt. in Sieve (g)				41.47	29.45	42.14	50.38	34.85	11.89	7.31	2.76	3.41							4.90
94	Cum. Wt % Retained				18.14	31.03	49.47	71.51	86.76	91.96	95.16	96.36	97.86	97.86	97.86	97.86	97.86	97.86	97.86	100.00
95																				
96	Wt. in Sieve (g)				25.36	19.34	27.39	36.49	23.26	8.12	5.19	2.05	2.69							3.38
97	Cum. Wt % Retained				16.55	29.16	47.03	70.84	86.02	91.32	94.70	96.04	97.79	97.79	97.79	97.79	97.79	97.79	97.79	100.00
98																				
99	Wt. in Sieve (g)				31.31	20.76	29.51	37.47	22.48	7.68	4.63	1.82	2.32	0.41						1.84
100	Cum. Wt % Retained				19.54	32.50	50.91	74.30	88.33	93.12	96.01	97.15	98.60	98.85	98.85	98.85	98.85	98.85	98.85	100.00
101																				
102	Wt. in Sieve (g)				27.17	19.65	28.45	32.57	20.36	6.93	4.58	1.66	2.25	0.52						3.49
103	Cum. Wt % Retained				18.40	31.71	50.99	73.05	86.84	91.53	94.64	95.76	97.28	97.64	97.64	97.64	97.64	97.64	97.64	100.00
104																				
105	Wt. in Sieve (g)				27.01	19.20	27.54	34.31	21.55	7.40	4.87	1.83	2.44	0.51						3.29
106	Cum. Wt % Retained				18.01	30.82	49.18	72.06	86.44	91.37	94.62	95.84	97.47	97.81	97.81	97.81	97.81	97.81	97.81	100.00
107																				
108	Wt. in Sieve (g)	0.9	5.9	12.8	11.70	21.80	35.40													88.60
109	Cum. Wt % Retained	0.51	3.84	11.07	17.67	29.98	49.97	49.97	49.97	49.97	49.97	49.97	49.97	49.97	49.97	49.97	49.97	49.97	49.97	100.00
110																				
111	Wt. in Sieve (g)	0.7	5.6	12.4	10.20	19.60	31.70													78.50
112	Cum. Wt % Retained	0.44	3.97	11.78	18.21	30.56	50.54	50.54	50.54	50.54	50.54	50.54	50.54	50.54	50.54	50.54	50.54	50.54	50.54	100.00
113																				
114	Wt. in Sieve (g)	0.5	5.1	10.5	11.20	20.10	33.80													83.30
115	Cum. Wt % Retained	0.30	3.40	9.79	16.60	28.81	49.36	49.36	49.36	49.36	49.36	49.36	49.36	49.36	49.36	49.36	49.36	49.36	49.36	100.00
116																				
117	Ave. Cum Wt % Ret.	0.42	3.74	10.88	17.89	30.52	49.61	72.15	86.76	91.84	95.04	96.27	97.83	98.13	98.13	98.13	98.13	98.13	98.13	100.00
118																				

SAND FRACTION #5 PARTICLE SIZE DISTRIBUTION (d50 = 1000 microns)

	C	D	E	F	G	H	I	J	K	L	M	N	O
125	Particle Size	1700	1168	833	710	600	500	425	355	300	250	Pan	Total
126	(micron)												
127													
128	Wt. in Sieve (g)		24.90	96.85	12.81	6.95	3.61	[illegible]	0.44	0.06	0.02	0.01	147.72
129	Cum. Wt % Retained	0.00	16.86	82.42	91.09	95.80	98.24	99.64	99.94	99.98	99.99	0.01	
130													
131	Wt. in Sieve (g)		28.74	107.40	13.08	6.80	3.28	1.71	0.32	0.03		0.03	161.39
132	Cum. Wt % Retained	0.00	17.81	84.35	92.46	96.67	98.71	99.76	99.96	99.98	99.98	0.02	
133													
134	Ave. Cum Wt % Ret.	0.00	17.33	83.39	91.78	96.23	98.47	99.70	99.95	99.98	99.99	0.01	
135													

Filename: PSDM-1a.WK1
LAST UPDATE: SEPT 8, 1991 (Checked With Raw Data October 8, 1990)

PARTICLE SIZE DISTRIBUTION of
MIXTURE of 50% – 82 micron SAND, 50% – 500 micron SAND

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
14	Particle Size	1700	1168	833	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	Pan	Total
15	(micron)																				
16																					
17																					
18	82 MICRON SAND																				
19																					
20	Cum. Wt % Retained										0.62	1.01	5.38	11.62	25.44	38.54	62.77	96.05	98.55	100.00	
21	Discrete Fraction										0.62	0.39	4.37	6.24	13.82	13.1	24.23	33.28	2.5	1.45	100
22																					
23	500 MICRON SAND																				
24																					
25	Cum. Wt % Retained	0.42	3.74	10.88	17.89	30.52	49.61	72.15	86.76	91.84	95.04	96.27	97.83	98.14						100.00	
26	Discrete Fraction	0.42	3.32	7.14	7.01	12.63	19.09	22.54	14.61	5.08	3.2	1.23	1.56	0.31						1.86	100
27																					
28	MIXTURE																				
29																					
30	Discr Wt % Retained	0.21	1.66	3.57	3.51	6.31	9.55	11.27	7.31	2.54	1.91	0.81	2.97	3.28	6.91	6.55	12.12	16.64	1.25	1.66	100
31	Cum. Wt % Retained	0.21	1.87	5.44	8.95	15.26	24.81	36.06	43.38	45.92	47.83	48.64	51.61	54.88	61.79	68.34	80.46	97.10	98.35	100.00	

Filename PARTDEN.WK1

PARTICLE DENSITIES FROM DISPLACEMENT TESTS

Note: Particle Densities Adjusted For Water Density Where Possible
Water Densities From: Perry and Chilton (1973)

82 micron SAND

DATE	WATER TEMP C	WATER DENSITY g/ml	SAND WT g	WT TO TOT VOL g	VOL H2O ADDED ml	TOTAL VOL ml	SAND VOL ml	SAND DENSITY g/ml
60889	20.0	0.99823	254.78	657.25	403.18	500.00	96.82	2.632
190889	20.0	0.99823	328.17	702.87	375.36	500.00	124.64	2.633
190889	20.0	0.99823	217.90	634.31	417.15	500.00	82.85	2.630
190889	20.0	0.99823	267.27	665.09	398.52	500.00	101.48	2.634
190889	20.0	0.99823	446.84	776.95	330.69	500.00	169.31	2.639
190889	20.0	0.99823	324.17	700.70	377.20	500.00	122.80	2.640
190889	20.0	0.99823	362.83	724.73	362.54	500.00	137.46	2.640
						Average		2.635
						Pop. Std. Dev.		0.0038
						100*(Std. Dev/Avg)		0.146

255 micron SAND

DATE	WATER TEMP C	WATER DENSITY g/ml	SAND WT g	WT TO TOT VOL g	VOL H2O ADDED ml	TOTAL VOL ml	SAND VOL ml	SAND DENSITY g/ml
130589	23.0	0.997801	438.32	771.33	333.74	500.00	166.26	2.636
130589	21.0	0.998023	382.32	736.18	354.56	500.00	145.44	2.629
130589	23.0	0.997801	374.78	731.79	357.80	500.00	142.20	2.636
200689	20.0	0.99823	437.85	771.16	333.90	500.00	166.10	2.636
200689	20.0	0.99823	552.59	842.54	290.46	500.00	209.54	2.637
200689	21.0	0.99802	399.67	747.44	348.46	500.00	151.54	2.637
						Average		2.635
						Pop. Std. Dev.		0.0030
						100*(Std. Dev/Avg)		0.113

410 micron SAND

DATE	WATER TEMP C	WATER DENSITY g/ml	SAND WT g	WT TO TOT VOL g	VOL H2O ADDED ml	TOTAL VOL ml	SAND VOL ml	SAND DENSITY g/ml
80189	24.0	0.99733	713.19	939.78	227.20	500.00	272.80	2.614
80189	24.0	0.99733	551.45	840.88	290.21	500.00	209.79	2.629
80189	24.0	0.99733	556.82	844.32	288.27	500.00	211.73	2.630
80189	24.0	0.99733	709.43	938.36	229.54	500.00	270.46	2.623
80189	24.0	0.99733	588.29	864.34	276.79	500.00	223.21	2.636
80189	24.0	0.99733	669.82	914.51	245.35	500.00	254.65	2.630
270589	23.0	0.997570	348.49	715.01	367.41	500.00	132.59	2.628
270589	24.0	0.997328	407.90	752.08	345.10	500.00	154.90	2.633
270589	23.5	0.997450	400.77	747.67	347.79	500.00	152.21	[illegible]
270589	23.0	0.997570	494.58	805.95	312.13	500.00	187.87	[illegible]
220789	22.5	0.997687	353.42	718.21	365.64	500.00	134.36	2.630
220789	21.0	0.998023	466.32	788.80	323.12	500.00	176.88	2.636
220789	21.0	0.998023	499.75	809.68	310.54	500.00	189.46	2.638
220789	20.0	0.998234	529.42	828.00	299.11	500.00	200.89	2.635
220789	20.0	0.998234	351.22	716.66	366.09	500.00	133.91	2.623
230689	21.0	0.998023	332.62	705.44	373.56	500.00	126.44	2.631
230689	20.5	0.998130	569.60	853.05	283.98	500.00	216.02	2.637
230689	21.0	0.998023	382.16	736.68	355.22	500.00	144.78	2.640
230689	21.0	0.998023	305.54	688.30	383.52	500.00	116.48	2.623

Average	2.631
Pop. Std. Dev.	0.0062
100*(Std. Dev/Avg)	0.23[illegible]

500 micron SAND

DATE	WATER TEMP C	WATER DENSITY g/ml	SAND WT g	WT TO TOT VOL g	VOL H2O ADDED ml	TOTAL VOL ml	SAND VOL ml	SAND DENSITY g/ml
100590	20.3	0.99817	328.80	703.03	374.92	500.00	125.08	2.629
100590	20.0	0.998234	444.37	774.84	331.05	500.00	168.95	2.630
100590	20.1	0.998213	300.21	685.41	385.89	500.00	114.11	2.631
100590	20.1	0.998213	322.30	699.03	377.40	500.00	122.60	2.629

Average	2.630
Pop. Std. Dev.	0.0009
100*(Std. Dev/Avg)	0.035

1000 micron SAND

DATE	WATER TEMP C	WATER DENSITY g/ml	SAND WT g	WT TO TOT VOL g	VOL H2O ADDED ml	TOTAL VOL ml	SAND VOL ml	SAND DENSITY g/ml
230690	19.8	0.99828	496.50	806.70	310.74	500.00	189.26	2.623
230690	20.0	0.99823	322.20	698.90	377.37	500.00	122.63	2.627
60790	19.9	0.99825	355.00	719.20	364.84	500.00	135.16	2.626
60790	19.8	0.99828	477.80	795.00	317.75	500.00	182.25	2.622
						Average		2.625
						Pop. Std. Dev.		0.0023
						100*(Std. Dev/Avg)		0.088

APPENDIX B

PARTICLE SIZE DISTRIBUTION TESTS

Filename: PSDRUN-1a.WK1
LAST UPDATE: SEPT 8, 1991 (Checked With Raw Data October 8, 1990)

PARTICLE SIZE DISTRIBUTION TESTS

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
10	Particle Size	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	< 38	Total	% FINES
11	(micron)																		
12																			
13	Run	800																	
14	Wt. in Sieve (g)	17.72	13.31	20.35	25.76	16.61	5.87	3.92	1.69	5.94	6.95	12.97	12.87	19.83	35.21	3.08	1.68	203.76	45.44
15	Cum. Wt % Retained	8.70	15.23	25.22	37.86	46.01	48.89	50.81	51.64	54.56	57.97	64.34	70.65	80.38	97.66	99.18	100.00		
16																			
17	Run	801																	
18	Wt. in Sieve (g)	13.00	9.70	16.23	22.38	16.22	5.48	3.65	1.65	6.24	6.81	13.05	12.60	24.65	32.65	2.36	1.39	188.06	49.72
19	Cum. Wt % Retained	6.91	12.07	20.70	32.60	41.23	44.14	46.08	46.96	50.28	53.90	60.84	67.54	80.64	98.01	99.26	100.00		
20																			
21	Run	802																	
22	Wt. in Sieve (g)	21.64	13.31	19.81	24.65	16.29	5.69	3.46	1.56	5.34	5.75	11.30	11.38	15.62	30.89	3.10	1.55	191.34	41.60
23	Cum. Wt % Retained	11.31	18.27	28.62	41.50	50.02	52.99	54.80	55.61	58.40	61.41	67.31	73.26	81.43	97.57	99.19	100.00		
24																			
25	Run	803																	
26	Wt. in Sieve (g)	17.22	12.15	19.45	24.65	16.61	5.88	3.74	1.60	5.60	5.73	12.02	12.79	16.59	34.53	3.75	2.02	194.33	44.99
27	Cum. Wt % Retained	8.86	15.11	25.12	37.81	46.35	49.38	51.30	52.13	55.01	57.96	64.14	70.73	79.26	97.03	98.96	100.00		
28																			
29	Run	804																	
30	Wt. in Sieve (g)	1.50	1.83	3.92	6.34	5.31	2.41	2.07	1.07	4.63	5.69	11.95	12.55	16.24	36.24	3.76	2.14	117.65	75.28
31	Cum. Wt % Retained	1.27	2.83	6.16	11.55	16.06	18.11	19.87	20.78	24.72	29.55	39.[illegible]	50.38	64.18	94.99	98.18	100.00		
32																			
33	Run	805																	
34	Wt. in Sieve (g)	14.41	11.77	16.92	23.37	14.95	5.51	3.68	1.53	5.61	6.45	11.82	11.82	17.94	33.20	2.86	1.50	183.34	46.68
35	Cum. Wt % Retained	7.86	14.28	23.51	36.26	44.41	47.41	49.42	50.26	53.32	56.83	63.28	69.73	79.51	97.62	99.18	100.00		
36																			
37	Run	806																	
38	Wt. in Sieve (g)	5.95	5.45	10.31	14.37	10.71	4.09	3.04	1.38	5.24	6.42	12.26	11.86	19.55	34.50	3.23	2.10	150.46	59.76
39	Cum. Wt % Retained	3.95	7.58	14.43	23.98	31.10	33.82	35.84	36.75	40.24	44.50	52.65	60.53	73.53	96.46	98.60	100.00		

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
40																			
41	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
42																			
43	Particle Size	710	600	500	425	355	300	250	212	150	125	106	90	75	45	38	< 38	Total	%
44	(micron)																		FINES
45																			
46	Run	807																	
47	Wt. in Sieve (g)	18.85	13.40	20.84	14.76	15.08	5.54	3.77	1.68	5.31	6.02	11.48	11.53	18.42	31.42	2.65	1.47	192.22	43.17
48	Cum. Wt % Retained	9.81	16.78	27.62	40.50	48.35	51.23	53.19	54.06	56.83	59.96	65.93	71.93	81.51	97.86	99.24	100.00		
49																			
50	Run	808																	
51	Wt. in Sieve (g)	19.21	12.88	18.10	21.67	14.47	4.94	3.35	1.44	4.56	5.43	10.40	10.67	16.95	29.84	2.80	1.65	178.36	43.59
52	Cum. Wt % Retained	10.77	17.99	28.14	40.29	48.40	51.17	53.05	53.86	56.41	59.46	65.29	71.27	80.77	97.51	99.07	100.00		
53																			
54	Run	810																	
55	Wt. in Sieve (g)	5.21	5.22	8.70	12.18	9.00	3.51	2.51	1.21	4.88	5.85	11.13	11.63	18.22	37.82	3.93	2.29	143.29	63.42
56	Cum. Wt % Retained	3.64	7.28	13.35	21.85	28.13	30.58	32.33	33.18	36.58	40.67	48.43	56.55	69.27	95.66	98.40	100.00		
57																			
58	Run	811																	
59	Wt. in Sieve (g)	8.61	7.47	11.25	16.33	11.44	4.29	3.00	1.42	5.87	7.22	14.32	14.16	24.98	40.45	3.64	2.06	176.51	60.52
60	Cum. Wt % Retained	4.88	9.11	15.48	24.74	31.22	33.65	35.35	36.15	39.48	43.57	51.68	59.70	73.85	96.77	98.83	100.00		
61																			
62	Run	813																	
63	Wt. in Sieve (g)	2.69	3.51	5.73	8.74	7.33	2.83	2.19	1.04	4.04	5.50	10.80	10.71	17.53	33.71	3.25	2.01	121.61	68.67
64	Cum. Wt % Retained	2.21	5.10	9.81	17.00	23.02	25.35	27.15	28.01	31.33	35.85	44.73	53.54	67.95	95.67	98.35	100.00		
65																			
66	Run	814																	
67	Wt. in Sieve (g)	15.80	11.90	17.83	21.62	13.93	4.79	3.36	1.58	5.21	5.75	11.10	11.99	13.88	33.22	2.88	1.87	181.71	47.16
68	Cum. Wt % Retained	8.70	15.24	25.06	36.95	44.62	47.26	49.11	49.98	52.84	56.01	62.12	68.71	10	97.39	98.97	100.00		
69																			
70	Run	815																	
71	Wt. in Sieve (g)	12.80	10.40	16.10	21.00	13.90	4.70	3.30	1.80	6.10	6.80	14.40	14.30	21.10	41.10	3.90	2.10	193.80	53.51
72	Cum. Wt % Retained	6.60	11.97	20.28	31.11	38.29	40.71	42.41	43.34	46.49	50.00	57.43	64.81	75.70	96.90	98.92	100.00		
73																			
74	Run	816																	
75	Wt. in Sieve (g)	13.80	10.30	15.40	19.50	13.40	4.90	3.40	1.30	5.20	6.50	12.80	13.20	22.90	33.90	2.90	1.70	181.10	51.85
76	Cum. Wt % Retained	7.62	13.31	21.81	32.58	39.98	42.68	44.56	45.28	48.15	51.74	58.81	66.10	78.74	97.46	99.06	100.00		

APPENDIX C

SAMPLED DATA

Runs	Mean Particle Size (d_{50}) (micron)	Bulk Solids Concentration (C_B)	Mixer Speed (rpm)	Page
1 - 39	410	0.10	545	173
40 - 143	410	0.10	545	175
144 - 196	410	0.10	545	179
197 - 257	410	0.10	680	181
258 - 319	410	0.10	440	184
320 - 344	410	0.10	440,545,680	187
345 - 389	410	0.30	680	188
400 - 503	255	0.30	545	190
504 - 552	410	0.10	440,545,680	194
553 - 600	410	0.30	545	196
601 - 685	410	0.30	545,680	198
686 - 739	82	0.30	545	202
740 - 761	410	0.01/0.05	545	205
800 - 816	82/500	0.20	545	207
850 - 863	82	0.30	545	208
864 - 907	255	0.30	545	209
908 - 967	500	0.30	680,750	211
970 - 976	410	0.10	440	214
980 - 1002	255	0.10	545	215
1010 - 1014	255	0.30	545	216
1020 - 1039	500	0.10	545	217
1050 - 1062	1000	0.10	680	218
1063 - 1068	1000	0.10	545	219
1069 - 1122	410	0.10	545	220
1123 - 1139	410	0.30	545	223
1140 - 1152	1000	0.10	545	224
1153 - 1164	82	0.10	545	225
1165 - 1210	410	0.10	545	226

Filename: 1-39B.WK1 LAST UPDATE SEPT 8, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB=0.0988, 545 RPM, H20 DENSITY = 0.997 (24.9 C)

A	B C		D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date	(D M Yr)	250788	250788	250788	250788	250788	250788	250788	250788	250788	250788	250788	250788	250788
6	Run		1	2	3	4	5	6	7	8	9	10	11	12	13
7	Temperature (C)														
8	Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
9	Sample Tube Inside Diameter (mm)		4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	1.55	4.55	4.55
10	Mixer Speed (RPM)		546	546	546	550	546	546	548	545	545	545	547	546	545
11	Tank Position (z/H)		0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.80	0.80	0.80	0.80
12	Tank Position (r/R)		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13															
14	Sample Time (seconds)		6.11	6.29	6.45	8.09	7.33	7.61	19.64	9.58	18.25	7.63	7.95	12.78	24.85
15	Volumetric Flask Weight (gram)		92.28	92.61	92.41	92.41	92.40	92.49	92.53	92.47	92.42	92.43	92.38	92.38	92.42
16	Sample + Flask Weight (gram)		255.69	255.00	253.37	263.37	238.77	222.49	229.00	263.18	300.43	241.33	239.23	303.27	256.18
17	Sample + Added Water + Flask Weight (gram)		320.81	321.37	320.92	322.15	318.41	315.55	316.39	322.98	329.97	298.22	298.64	302.75	298.40
18	Total Volume With Added Water (ml)		200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
19															
20	Sample Velocity (m/s)		1.3557	1.3046	1.2610	1.0722	1.0079	0.8620	0.3518	0.8989	0.5741	1.1522	1.0862	0.9650	0.3902
21	Sample Concentration (fraction)		0.1324	0.1347	0.1347	0.1316	0.1356	0.1358	0.1332	0.1360	0.1370	0.0274	0.0299	0.0335	0.0255
22	C/CB		1.3397	1.3630	1.3635	1.3325	1.3722	1.3741	1.3486	1.3763	1.3870	0.2769	0.3026	0.3389	0.2585
23															
24	Date	(D M Yr)	260788	260788	260788	260788	20888	20888	20888	20888	20888	20888	20888	70888	70888
25	Run		14	15	16	17	18	19	20	21	22	23	24	25	26
26	Temperature	(C)													
27	Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
28	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29	Mixer Speed	(RPM)	545	545	545	547	545	545	545	545	545	545	545	546	549
30	Tank Position	(z/H)	0.10	0.10	0.10	0.10	0.60	0.60	0.60	0.60	0.60	0.30	0.30	0.30	0.30
31	Tank Position	(r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32															
33	Sample Time	(seconds)	5.59	8.43	6.86	7.67	11.33	9.81	14.69	12.79	7.24	6.74	7.28	7.77	10.01
34	Volumetric Flask Weight	(gram)	92.38				92.33	92.46	92.37	92.40	92.30	92.40	92.46	92.58	92.50
35	Sample + Flask Weight	(gram)	252.26	163.52	132.34	146.20	264.59	268.56	241.66	264.94	248.86	284.40	279.49	257.98	229.59
36	Sample + Added Water + Flask Weight (gram)		317.49	225.26	220.62	223.01	321.76	319.60	317.11	320.53	318.33	327.23	325.73	322.87	318.10
37	Total Volume With Added Water (ml)		200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
38															
39	Sample Velocity	(m/s)	1.4806	1.0073	0.9992	0.9859	0.7744	0.9329	0.5205	0.6936	1.1070	1.4330	1.2978	1.0679	0.6834
40	Sample Concentration	(fraction)	0.1170	0.1146	0.1165	0.1175	0.1288	0.1141	0.1247	0.1219	0.1251	0.1381	0.1349	0.1401	0.1442
41	C/CB		1.1843	1.1601	1.1793	1.1894	1.3039	1.1547	1.2625	1.2338	1.2657	1.3975	1.3657	1.4182	1.4591

Q		R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date	(D M Yr)	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888
Run		27	28	29	30	31	32	33	34	35	36	37	38	39
Temperature	(C)													
Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed	(RPM)	548	543	551	551	547	547	548	549	548	548	549	549	549
Tank Position	(z/H)	0.30	0.30	0.30	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.90	0.90
Tank Position	(r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sample Time	(seconds)	5.31	7.10	9.15	5.84	6.84	19.35	9.66	13.61	16.55	12.87	7.39	9.83	14.70
Volumetric Flask Weight	(gram)	92.60	92.35	92.38	92.62	92.40	92.36	92.37	92.39	92.47	92.38	92.39	92.49	92.33
Sample + Flask Weight	(gram)	253.11	256.43	271.00	217.70	227.66	232.17	238.89	299.40	241.07	277.80	256.34	264.73	248.63
Sample + Added Water + Flask Weight (gram)		321.22	322.67	326.18	303.64	306.06	305.54	309.60	314.52	305.66	312.45	306.96	294.85	293.71
Total Volume With Added Water (ml)		200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Sample Velocity	(m/s)	1.5252	1.1569	0.9723	1.1985	1.0912	0.4018	0.8218	0.8352	0.5025	0.7897	1.2419	1.0623	0.6476
Sample Concentration	(fraction)	0.1358	0.1417	0.1455	0.0625	0.0719	0.0667	0.0845	0.0753	0.0624	0.0766	0.0622	0.0107	0.0078
C/CB		1.3745	1.4340	1.4731	0.6325	0.7278	0.6752	0.8556	0.7617	0.6317	0.7748	0.6297	0.1080	0.0792

Filename: 40-143B.WK1 LAST UPDATE: SEPT 6, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.0988, 545 RPM, H20 DENSITY = 0.997 (24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888	70888
6		Run	40	41	42	43	44	45	46	47	48	49	50	51	52
7		Temperature (C)													
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	549	549	549	548	549	549	549	549	550	550	550	549	549
11		Tank Position (z/H)	0.90	0.90	0.90	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.10	0.10	0.10
12		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13															
14		Sample Time (seconds)	23.15	9.28	9.13	5.79	6.59	7.48	12.54	8.77	10.00	18.31	6.81	7.99	8.13
15		Volumetric Flask Weight (gram)	92.38	92.42	92.47	92.51	92.38	92.38	92.44	92.36	92.38	92.38	92.44	92.36	92.38
16		Sample + Flask Weight (gram)	238.54	221.19	244.05	254.71	254.63	257.77	259.46	254.26	253.01	236.81	248.85	237.35	246.86
17		Sample + Added Water + Flask Weight (gram)	293.84	293.31	294.37	320.20	320.13	321.51	322.61	321.48	320.59	317.97	316.95	315.45	317.35
18		Total Volume With Added Water (ml)	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200 00	200.00	200.00	200.00	200.00	200.00
19															
20		Sample Velocity (m/s)	0.3840	0.8461	1.0073	1.4267	1.2534	1.1188	0.6702	0.9297	0.8132	0.3984	1.1894	0.9365	0.9781
21		Sample Concentration (fraction)	0.0087	0.0071	0.0102	0.1289	0.1292	0.1337	0.1378	0.1372	0.1334	0.1351	0.1167	0.1192	0.1210
22		C/CB	0.0883	0.0723	0.1036	1.3047	1.3076	1.3534	1.3947	1.3886	1.3497	1.3679	1.1810	1.2061	1.2250
23															
24		Date (D M Yr)	70888	70828	70888	70888	70888	80888	80888	80888	80888	80888	120888	120888	120888
25		Run	53	54	55	56	57	58	59	60	61	62	63	64	65
26		Temperature (C)													
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	550	549	550	550	549	548	551	552	552	552	551	552	551
30		Tank Position (z/H)	0.10	0.10	0.10	0.10	0.10	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
31		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32															
33		Sample Time (seconds)	12.36	10.16	7.34	8.11	17.40	20.93	11.00	11.51	18.50	17.95	11.02	15.41	19.64
34		Volumetric Flask Weight (gram)	92.36	92.47	92.52	92.61	92.38	92.48	92.45	92.44	92.44	92.44	92.53	92.69	92.65
35		Sample + Flask Weight (gram)	182.85	164.18	237.41	239.25	236.00	226.36	236.02	236.10	253.90	249.61	237.04	228.22	242.48
36		Sample + Added Water + Flask Weight (gram)	305.05	302.29	315.36	315.11	313.87	298.46	298.78	298.41	300.08	299.02	298.61	297.74	299.41
37		Total Volume With Added Water (ml)	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
38															
39		Sample Velocity (m/s)	0.3853	0.3721	1.0207	0.9397	0.4309	0.3752	0.7663	0.7[illegible]47	0.5109	0.5146	0.7715	0.5199	0.4475
40		Sample Concentration (fraction)	0.1050	0.1037	0.1178	0.1141	0.1109	0.0315	0.0309	0.0292	0.0328	0.0292	0.0296	0.0265	0.0315
41		C/CB	1.0631	1.0499	1.1919	1.1548	1.1225	0.3192	0.3132	0.2960	0.3321	0.2956	0.2993	0.2687	0.3190

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	120888	120888	120888	120888	120888	120888	120888	120888	120888	120888	120888	120888	120888
Run	66	67	68	69	70	71	72	73	74	75	76	77	78
Temperature (C)													
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	553	551	552	553	550	550	551	551	551	551	551	552	552
Tank Position (z/H)	0.80	0.80	0.80	0.80	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Tank Position (r/H)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sample Time (seconds)	13.29	14.75	15.25	13.74	12.61	11.60	10.95	10.39	12.02	9.76	8.97	24.14	24.04
Volumetric Flask Weight (gram)	92.61	92.61	92.66	92.50	92.47	92.77	92.38	92.51	92.37	92.47	92.66	357.77	357.77
Sample + Flask Weight (gram)	263.39	279.63	250.28	267.95	271.46	268.94	268.81	267.58	312.83	270.98	259.30	766.02	768.62
Sample + Added Water + Flask Weight (gram)	301.03	300.83	299.38	299.60	309.90	311.45	308.98	307.73	315.81	308.65	311.34	802.85	799.30
Total Volume With Added Water (ml)	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	400.00	400.00
Sample Velocity (m/s)	0.7508	0.7453	0.6080	0.7531	0.7874	0.8343	0.8970	0.9455	1.0080	1.0222	1.0134	0.9250	0.9446
Sample Concentration (fraction)	0.0340	0.0302	0.0297	0.0280	0.0683	0.0750	0.0659	0.0606	0.0747	0.0633	0.0798	0.0780	0.0708
C/CB	0.3444	0.3057	0.3008	0.2835	0.6918	0.7589	0.6671	0.6135	0.7558	0.6407	0.8080	0.7896	0.7169

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	120888	120888	120888	120888	120888	120888	210888	210888	210888	210888	210888	210888	210888
Run	79	80	81	82	83	84	85	86	87	88	89	90	91
Temperature (C)													
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	553	554	550	552	551	550	550	550	549	549	548	549	548
Tank Position (z/H)	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sample Time (seconds)	24.24	24.61	24.55	25.16	24.41	24.07	24.27	10.48	11.41	10.63	10.98	11.31	11.40
Volumetric Flask Weight (gram)	357.73	357.90	357.82	357.94	357.97	357.78	357.94	92.35	92.74	92.63	92.63	92.61	92.54
Sample + Flask Weight (gram)	768.25	779.45	773.84	781.83	774.70	773.46	775.73	272.56	289.99	277.40	272.44	275.66	280.65
Sample + Added Water + Flask Weight (gram)	797.01	801.91	800.17	801.25	799.41	799.40	800.50	308.02	309.73	313.46	308.14	309.97	313.23
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	200.00	200.00	200.00	200.00	200.00	200.00
Sample Velocity (m/s)	0.9417	0.9433	0.9359	0.9302	0.9454	0.9556	0.9507	0.9650	0.9713	0.9479	0.9197	0.9004	0.9027
Sample Concentration (fraction)	0.0667	0.0733	0.0713	0.0716	0.0695	0.0701	0.0714	0.0606	0.0597	0.0801	0.0600	0.0664	0.0779
C/CB	0.6756	0.7419	0.7221	0.7246	0.7039	0.7092	0.7225	0.6129	0.6046	0.8102	0.6078	0.6718	0.7882

AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
Date (D M Yr)	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888
Run	92	93	94	95	96	97	98	99	100	101	102	103	104
Temperature (C)													
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	546	548	546	546	547	547	549	548	547	548	548	548	549
Tank Position (z/H)	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sample Time (seconds)	26.62	26.11	24.26	24.27	22.85	24.16	31.26	23.96	25.09	25.14	25.39	26.91	25.17
Volumetric Flask Weight (gram)	357.74	358.08	358.09	357.85	358.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	770.70	790.02	767.92	775.33	773.25	411.90	405.26	414.99	414.70	418.53	411.14	421.82	418.00
Sample + Added Water + Flask Weight (gram)	795.00	798.90	796.16	800.31	794.03	438.73	438.48	440.40	440.57	440.28	433.79	441.71	442.95
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.8678	0.9212	0.9422	0.9501	1.0205	0.9497	0.7214	0.9613	0.9169	0.9252	0.9139	0.8686	0.9162
Sample Concentration (fraction)	0.0627	0.0658	0.0647	0.0713	0.0601	0.0655	0.0662	0.0680	0.0683	0.0671	0.0568	0.0691	0.0721
C/CB	0.6342	0.6655	0.6545	0.7213	0.6082	0.6629	0.6703	0.6880	0.6917	0.6794	0.5745	0.6994	0.7293
Date (D M Yr)	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888	210888
Run	105	106	107	108	109	110	111	112	113	114	115	116	117
Temperature (C)													
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	549	548	550	550	548	550	550	549	550	548	551	549	550
Tank Position (z/H)	0.70	0.70	0.70	0.70	0.70	0.60	0.60	0.60	0.60	0.20	0.20	0.20	0.20
Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50
Sample Time (seconds)	23.67	23.84	22.62	20.87	19.43	22.19	21.52	25.12	31.68	18.17	25.28	26.34	25.06
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	420.79	421.33	430.48	428.54	427.06	454.54	452.77	463.75	451.65	467.20	457.12	425.65	427.88
Sample + Added Water + Flask Weight (gram)	438.98	442.38	437.86	445.03	444.76	472.22	474.90	476.04	471.94	479.65	480.37	441.00	444.40
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9919	0.9774	1.0674	1.1300	1.2099	1.0595	1.0797	0.9491	0.7370	1.3117	0.9164	0.8980	0.9410
Sample Concentration (fraction)	0.0644	0.0704	0.0609	0.0738	0.0736	0.1175	0.1233	0.1219	0.1179	0.1277	0.1325	0.0672	0.0728
C/CB	0.6520	0.7125	0.6163	0.7468	0.7448	1.1897	1.2477	1.2341	1.1933	1.2924	1.3414	0.6797	0.7367

AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
Date (D M Yr)	210888	210888	210888	210888	210888	220888	220888	220888	220888	220888	220888	220888	230888
Run	118	119	120	121	122	123	124	125	126	127	128	129	130
Temperature (C)													
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	551	551	552	549	551	553	555	553	552	551	550	550	551
Tank Position (z/H)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.40
Tank Position (r/R)	0.50	0.20	0.20	0.75	0.90	1.00	0.95	0.95	0.80	0.10	0.10	0.15	1.00
Sample Time (seconds)	24.94	27.92	24.05	22.89	22.64	26.69	29.90	23.89	21.51	24.54	25.53	22.91	25.57
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	426.78	427.26	410.85	400.91	432.98	450.86	421.73	446.61	409.32	563.63	596.93	558.18	471.02
Sample + Added Water + Flask Weight (gram)	440.28	456.98	457.01	428.07	446.16	478.14	446.49	474.93	431.32	601.49	609.93	575.84	485.15
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	425.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9530	0.8154	0.9045	1.0069	1.0507	0.8587	0.7717	1.0210	1.0806	0.9073	0.9322	1.0262	0.9280
Sample Concentration (fraction)	0.0657	0.0962	0.1007	0.0445	0.0749	0.1303	0.0778	0.0790	0.0527	0.3426	0.3339	0.2834	0.1370
C/CB	0.6649	0.9735	1.0194	0.4507	0.7585	1.3189	0.7874	0.7998	0.5330	3.4680	3.3797	2.8686	1.3863

Date (D M Yr)	230888	230888	230888	230888	230888	40988	40988	40988	40988	40988	40988	40988	40988
Run	131	132	133	134	135	136	137	138	139	140	141	142	143
Temperature (C)			23										
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	551	551	551	551	550	548	550	549	548	547	547	548	548
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Tank Position (r/R)	0.90	0.50	0.30	0.20	0.10	0.10	1.00	0.90	0.70	0.50	0.30	0.10	0.20
Sample Time (seconds)	23.00	23.27	22.71	22.67	21.87	25.47	25.44	23.62	23.49	22.89	22.11	21.39	25.54
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	416.07	424.82	400.72	409.16	398.59	425.04	446.98	432.31	406.52	409.72	402.64	379.05	406.5
Sample + Added Water + Flask Weight (gram)	450.54	446.16	440.44	436.95	427.91	428.61	473.42	456.34	442.26	442.44	436.56	414.55	430.22
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9771	1.0006	0.9754	1.0095	1.0422	0.9572	0.9029	0.9788	0.9534	0.9866	1.0180	1.0477	0.9059
Sample Concentration (fraction)	0.0867	0.0766	0.0708	0.0627	0.0481	0.0460	0.1223	0.0937	0.0730	0.0727	0.0631	0.0265	0.0511
C/CB	0.8770	0.7749	0.7162	0.6350	0.4866	0.4658	1.2376	0.9482	0.7393	0.7362	0.6391	0.2677	0.5173

Filename: 144-196B.WK1 LAST UPDATE: SEPT 6, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.0986, 545 RPM, H20 DENSITY = 0.997 (24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988
6		Run	144	145	146	147	148	149	150	151	152	153	154	155	156
7		Temperature (C)		24		24.8		25				26			26.5
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	548	548	548	548	549	549	547	548	548	550	549	548	547
11		Tank Position (z/H)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.30	0.30	0.30
12		Tank Position (r/R)	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	1.00	0.90	0.80
13															
14		Sample Time (seconds)	22.60	21.68	24.13	24.35	25.10	22.36	22.80	22.53	24.04	24.55	22.04	21.81	24.23
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	452.07	426.89	407.31	410.57	429.27	497.84	561.30	586.90	594.75	589.79	454.80	450.32	432.16
17		Sample + Added Water + Flask Weight (gram)	470.11	447.17	429.39	427.12	434.58	523.75	597.48	605.47	613.33	611.30	480.80	467.76	466.50
18		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
19															
20		Sample Velocity (m/s)	1.0393	1.0770	0.9631	0.9684	0.9671	1.0287	0.9811	1.0411	0.9756	0.9480	1.0434	1.0786	0.9279
21		Sample Concentration (fraction)	0.1143	0.0780	0.0495	0.0452	0.0555	0.2045	0.3343	0.3316	0.3443	0.3437	0.1342	0.1103	0.1133
22		C/CB	1.1566	0.7892	0.5015	0.4575	0.5616	2.0694	3.3837	3.3567	3.4845	3.4783	1.3584	1.1167	1.1472
23															
24		Date (D M Yr)	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988	40988
25		Run	157	158	159	160	161	162	163	164	165	166	167	168	169
26		Temperature (C)			26.5					26.5			27		
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	547	548	551	548	548	549	544	546	545	545	546	547	545
30		Tank Position (z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.80	0.80	0.80	0.80	0.80	0.80	0.90
31		Tank Position (r/R)	0.70	0.60	0.50	0.40	0.40	0.40	1.00	0.90	0.70	0.50	0.30	0.10	1.00
32															
33		Sample Time (seconds)	19.82	21.80	20.80	18.99	6.02	5.85	24.09	21.42	22.71	22.30	22.77	22.45	25.02
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	340.72	472.28	464.68	460.56	115.92	127.24	397.31	380.12	390.67	391.31	395.53	371.74	369.92
36		Sample + Added Water + Flask Weight (gram)	454.44	482.25	481.72	474.76	170.03	173.65	418.16	418.28	414.14	417.50	405.44	398.98	400.90
37		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	150.00	150.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
38															
39		Sample Velocity (m/s)	0.8873	1.1003	1.1322	1.2493	0.9780	1.0876	0.9678	1.0386	1.0195	1.0307	1.0536	1.0210	0.9069
40		Sample Concentration (fraction)	0.1191	0.1310	0.1325	0.1205	0.1309	0.1426	0.0313	0.0330	0.0249	0.0306	0.0104	0.0000	0.0035
41		C/CB	1.2053	1.3254	1.3414	1.2197	1.3252	1.4430	0.3163	0.3336	0.2524	0.3099	0.1054	0.0000	0.0353

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988
Run	171	172	173	174	175	176	177	178	179	180	181	182	183
Temperature (C)		23.5					25		25			26	
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	545	551	551	549	550	551	550	550	550	550	552	552	549
Tank Position (z/H)	0.90	0.90	0.90	0.90	0.90	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Tank Position (r/R)	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.80	0.70	0.50	0.30	0.10	0.60
Sample Time (seconds)	23.92	24.27	25.22	22.83	24.61	24.01	23.05	21.91	22.53	22.61	23.07	22.22	23.65
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	365.85	368.64	387.37	352.61	386.19	459.36	409.74	399.24	408.37	419.28	426.25	401.87	402.73
Sample + Added Water + Flask Weight (gram)	401.79	401.23	402.31	397.64	398.95	476.45	435.37	431.43	431.16	440.57	440.90	424.34	431.53
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9358	0.9308	0.9389	0.9559	0.9676	0.9807	0.9987	1.0322	1.0295	1.0300	1.0272	1.0448	0.9651
Sample Concentration (fraction)	0.0050	0.0040	0.0056	−0.0020	0.0000	0.1241	0.0598	0.0543	0.0525	0.0575	0.0669	0.0414	0.0540
C/CB	0.0509	0.0410	0.0565	−0.0202	0.0000	1.2563	0.6052	0.5497	0.5315	0.6833	0.6768	0.4191	0.5463
Date (D M Yr)	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988
Run	184	185	186	187	188	189	190	191	192	193	194	195	196
Temperature (C)										27			
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	550	551	552	553	553	553	551	551	553	551	552	553	552
Tank Position (z/H)	0.40	0.40	0.20	0.20	0.20	0.20	0.20	0.70	0.70	0.70	0.70	0.70	0.70
Tank Position (r/R)	0.70	0.70	0.60	0.40	0.40	0.30	0.20	1.00	0.90	0.70	0.50	0.30	0.10
Sample Time (seconds)	19.00	22.39	23.47	19.80	23.61	19.11	21.18	25.61	24.11	24.85	24.14	24.47	22.91
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	427.97	414.51	424.60	475.68	397.25	432.58	480.71	414.82	423.20	414.32	411.39	410.19	387.01
Sample + Added Water + Flask Weight (gram)	442.18	441.84	441.46	492.23	481.48	459.21	506.59	437.53	443.74	438.61	433.38	425.49	404.30
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	1.2486	1.0234	1.0039	1.1909	0.8219	1.2014	1.0861	0.9059	0.9678	0.9297	0.9629	0.9668	0.9734
Sample Concentration (fraction)	0.0688	0.0707	0.0682	0.1491	0.1604	0.0990	0.1764	0.0628	0.0725	0.0649	0.0560	0.0425	0.0093
C/CB	0.6966	0.7155	0.6898	1.5095	1.6232	1.0024	1.7850	0.6360	0.7337	0.6565	0.5667	0.4298	0.0940

Filename: 197-257B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.0988, 680 RPM, H20 DENSITY = 0.997 (24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5		Date (D M Yr)	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988	50988
6		Run	197	198	199	200	201	202	203	204	205	206	207	208
7		Temperature (C)				29			31		31		32	
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	690	686	682	679	678	681	683	682	683	682	679	679
11		Tank Position (z/H)	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.20	0.20	0.20	0.20	0.20
12		Tank Position (r/R)	1.00	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50	0.30
13														
14		Sample Time (seconds)	24.51	23.68	23.28	24.60	24.14	23.03	24.10	22.35	22.70	22.65	22.04	22.37
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	452.31	435.19	415.51	409.99	417.05	413.13	396.51	462.23	436.49	425.72	438.77	471.81
17		Sample + Added Water + Flask Weight (gram)	462.54	461.52	444.15	438.60	440.74	435.63	427.94	477.60	446.68	436.95	460.33	480.99
18		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
19														
20		Sample Velocity (m/s)	0.9780	0.9703	0.9808	0.9283	0.9585	1.0079	0.9403	1.0583	1.0560	1.0555	1.0558	1.0744
21		Sample Concentration (fraction)	0.1001	0.1027	0.0748	0.0656	0.0682	0.0597	0.0484	0.1254	0.0752	0.0601	0.0995	0.1287
22		C/CB	1.0130	1.0399	0.7566	0.6640	0.6905	0.6044	0.4899	1.2692	0.7609	0.6079	1.0073	1.3028
23														
24		Date (D M Yr)	11088	11088	11088	11088	11088	11088	11088	11088	11088	11088	11088	11088
25		Run	210	211	212	213	214	215	216	217	218	219	220	221
26		Temperature (C)	23				25				27			
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	688	679	677	684	682	681	678	678	684	683	682	680
30		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.90	0.90	0.90	0.90	0.90
31		Tank Position (r/R)	1.00	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50	0.30
32														
33		Sample Time (seconds)	24.43	24.01	24.60	25.77	25.52	24.22	23.21	26.11	27.16	27.88	26.01	25.75
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	459.40	457.48	436.29	430.38	421.65	425.56	413.13	394.62	408.44	406.92	410.61	395.29
36		Sample + Added Water + Flask Weight (gram)	479.35	479.60	452.90	446.10	443.13	439.77	432.77	421.53	428.52	430.58	429.44	421.81
37		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
38														
39		Sample Velocity (m/s)	0.9566	0.9678	0.9584	0.9170	0.9121	0.9795	1.0077	0.8786	0.8602	0.8300	0.9012	0.8918
40		Sample Concentration (fraction)	0.1297	0.1309	0.0864	0.0753	0.0717	0.0650	0.0547	0.0373	0.0479	0.0517	0.0492	0.0377
41		C/CB	1.3131	1.3247	0.8742	0.7625	0.7256	0.6579	0.5533	0.3775	0.4846	0.5232	0.4980	0.3817

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	11088	11088	11088	11088	21088	21088	21088	21088	21088	21088	21088	21088	21088
Run	223	224	225	226	227	228	229	230	231	232	233	234	235
Temperature (C)			31			24.5						28	
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	683	684	683	682	682	681	685	686	683	681	683	680	683
Tank Position (z/H)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Tank Position (r/R)	1.00	0.90	0.70	0.50	0.30	0.10	1.00	1.00	0.90	0.70	0.50	0.30	0.10
Sample Time (seconds)	25.24	24.38	23.75	23.37	23.89	24.76	28.87	26.41	26.31	27.99	23.41	23.79	23.87
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	416.76	417.89	409.46	416.13	409.54	412.34	456.15	449.44	423.42	425.64	438.54	432.43	419.54
Sample + Added Water + Flask Weight (gram)	439.28	438.35	434.74	436.40	430.90	426.47	476.60	474.69	443.95	438.95	444.41	440.45	430.61
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9196	0.9573	0.9702	0.9992	0.9746	0.9584	0.8084	0.8725	0.8869	0.8496	1.0301	1.0133	1.0020
Sample Concentration (fraction)	0.0656	0.0638	0.0587	0.0606	0.0519	0.0439	0.1255	0.1240	0.0728	0.0635	0.0712	0.0650	0.0501
C/CB	0.6644	0.6456	0.5942	0.6134	0.5252	0.4442	1.2699	1.2546	0.7371	0.6432	0.7205	0.6582	0.5067

Date (D M Yr)	21088	21088	21088	21088	21088	21088	21088	21088	21088	21088	21088	21088	21088
Run	236	237	238	239	240	241	242	243	244	245	246	247	248
Temperature (C)				30					31				
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	680	688	688	685	685	683	683	684	684	683	685	682	685
Tank Position (z/H)	0.60	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.30	0.30	0.30
Tank Position (r/R)	0.90	1.00	0.90	0.70	0.50	0.30	0.10	1.00	1.00	1.00	0.90	0.70	0.50
Sample Time (seconds)	24.24	25.94	25.46	22.08	22.38	24.62	25.02	24.42	16.27	23.20	20.20	20.80	10.10
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	430.72	440.79	412.12	417.84	420.49	427.08	418.07	455.43	268.17	464.23	448.77	452.40	151.87
Sample + Added Water + Flask Weight (gram)	445.55	466.62	431.73	432.10	439.04	438.51	430.87	469.06	346.70	483.36	464.84	473.82	228.95
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	300.00	400.00	400.00	400.00	200.00
Sample Velocity (m/s)	0.9771	0.8869	0.9187	1.0743	1.0481	0.9706	0.9517	0.9730	0.8363	1.0095	1.1688	1.1192	0.7471
Sample Concentration (fraction)	0.0743	0.1109	0.0530	0.0528	0.0646	0.0625	0.0507	0.1113	0.1317	0.1359	0.1053	0.1213	0.1474
C/CB	0.7519	1.1230	0.5363	0.5348	0.6535	0.6331	0.5131	1.1265	1.3327	1.3755	1.0656	1.2277	1.4919

AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
Date (D M Yr)	21088	21088	21088	21088	21088	21088	21088	21088	21088
Run	249	250	251	252	253	254	255	256	257
Temperature (C)		33					34.5		
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	682	685	684	686	684	683	682	684	682
Tank Position (z/H)	0.30	0.30	0.30	0.10	0.10	0.10	0.10	0.10	0.10
Tank Position (r/R)	0.50	0.40	0.40	1.00	0.90	0.70	0.50	0.30	0.10
Sample Time (seconds)	25.01	16.75	22.10	21.98	25.89	21.86	22.15	21.11	23.49
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	476.65	468.62	441.91	464.32	426.93	396.65	439.54	468.87	466.95
Sample + Added Water + Flask Weight (gram)	488.32	479.18	480.58	469.59	436.21	418.11	451.28	485.53	487.87
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9549	1.4298	1.0052	1.1044	0.9281	1.0648	1.0779	1.1167	0.9923
Sample Concentration (fraction)	0.1411	0.1263	0.1386	0.1098	0.0586	0.0312	0.0827	0.1385	0.1438
C/CB	1.4281	1.2786	1.4024	1.1109	0.5931	0.3160	0.8373	1.4016	1.4557

Filename: 258-319B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.0988, 440 RPM, H20 DENSITY = 0.997 (VALUE AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	151088	151088	151088	151088	161088	161088	161088	161088	161088	161088	161088	161088	161088
6		Run	258	259	260	261	262	263	264	265	266	267	268	269	270
7		Temperature (C)					22								
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	440	440	440	439	444	443	443	443	442	443	443	442	443
11		Tank Position (z/H)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.20	0.20	0.20
12		Tank Position (r/R)	1.00	1.00	0.90	0.70	0.50	0.40	0.30	0.20	0.10	0.60	1.00	0.90	0.90
13															
14		Sample Time (seconds)	20.08	39.49	23.13	32.47	28.27	27.28	26.26	25.23	25.01	20.09	21.75	32.13	22.19
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	432.36	390.28	412.78	417.84	577.41	597.88	584.95	601.60	597.87	569.62	434.18	415.07	409.88
17		Sample + Added Water + Flask Weight (gram)	443.67	438.84	431.27	452.03	605.24	611.43	607.99	614.55	612.62	578.77	445.56	429.93	430.11
18		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
19															
20		Sample Velocity (m/s)	1.1904	0.5471	1.0143	0.6927	0.8095	0.8718	0.8827	0.9434	0.9473	1.2026	1.0988	0.7371	1.0524
21		Sample Concentration (fraction)	0.0707	0.0698	0.0521	0.0891	0.3395	0.3368	0.3397	0.3412	0.3397	0.2773	0.0736	0.0495	0.0505
22		C/CB	0.7151	0.7060	0.5273	0.9016	3.4367	3.4085	3.4381	3.4532	3.4383	2.8063	0.7454	0.5007	0.5108
23															
24		Date (D M Yr)	161088	161088	161088	161088	161088	161088	161088	161088	291088	291088	291088	291088	291088
25		Run	271	272	273	274	275	276	277	278	279	280	281	282	283
26		Temperature (C)				23.5								23	
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	442	443	442	443	443	444	442	443	445	445	445	444	444
30		Tank Position (z/H)	0.20	0.20	0.20	0.20	0.20	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40
31		Tank Position (r/R)	0.70	0.50	0.30	0.10	1.00	1.00	0.90	0.70	0.70	0.50	0.40	0.40	1.00
32															
33		Sample Time (seconds)	21.65	25.30	24.45	27.37	26.59	23.75	25.49	24.72	26.62	25.03	20.16	25.40	21.75
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	414.14	451.89	560.60	610.94	438.92	439.07	402.76	427.51	431.60	429.17	442.09	424.09	432.20
36		Sample + Added Water + Flask Weight (gram)	424.89	463.21	588.54	619.63	445.32	445.19	435.96	439.37	441.77	445.77	443.31	444.07	440.84
37		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
38															
39		Sample Velocity (m/s)	1.1057	0.9448	0.9357	0.8792	0.9057	1.0199	0.8848	0.9656	0.9006	0.9419	1.2165	0.9200	1.1066
40		Sample Concentration (fraction)	0.0410	0.1014	0.3122	0.3454	0.0727	0.0721	0.0620	0.0640	0.0675	0.0750	0.0683	0.0729	0.0657
41		C/CB	0.4152	1.0266	3.1596	3.4959	0.7359	0.7296	0.6277	0.6475	0.6828	0.7590	0.6914	0.7380	0.6654

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
Date (D M Yr)	291088	291088	291088	291088	291088	291088	291088	291088	291088	291088	291088	291088	291088	291088
Run	284	285	286	287	288	289	290	291	292	293	294	295	296	297
Temperature (C)														
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	444	442	444	444	444	444	444	445	444	444	442	445	444	443
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.50	0.50	0.50	0.50	0.50	0.50	0.60	0.60
Tank Position (r/R)	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90
Sample Time (seconds)	21.69	25.71	26.70	22.44	19.95	21.69	23.05	21.23	22.61	21.42	22.58	23.68	24.25	24.26
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	429.29	402.14	418.96	411.01	408.65	391.59	421.72	406.34	401.16	398.78	407.37	403.37	421.29	408.75
Sample + Added Water + Flask Weight (gram)	440.91	425.24	423.61	422.91	421.01	408.00	436.65	422.05	419.18	420.50	415.66	406.69	435.57	425.81
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	1.1011	0.9014	0.9106	1.0636	1.1949	1.0875	1.0273	1.1131	1.0389	1.0859	1.0668	1.0302	0.9781	0.9707
Sample Concentration (fraction)	0.0664	0.0429	0.0384	0.0380	0.0351	0.0147	0.0602	0.0370	0.0327	0.0351	0.0263	0.0122	0.0583	0.0432
C/CB	0.6717	0.4346	0.3887	0.3848	0.3549	0.1486	0.6089	0.3748	0.3305	0.3554	0.2666	0.1232	0.5906	0.4370

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
Date (D M Yr)	291088	291088	291088	291088	301088	301088	301088	301088	301088	301088	301088	301088	301088	301088
Run	298	299	300	301	302	303	304	305	306	307	308	309	310	311
Temperature (C)	24				22.5						23			
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	444	445	443	444	444	442	441	443	442	442	443	443	443	443
Tank Position (z/H)	0.60	0.60	0.60	0.60	0.70	0.70	0.70	0.70	0.70	0.70	0.80	0.80	0.80	0.80
Tank Position (r/R)	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50
Sample Time (seconds)	24.34	23.92	23.96	23.77	24.74	24.59	26.12	23.38	23.90	23.52	22.28	22.84	24.24	23.65
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	410.25	404.60	402.81	396.91	405.51	400.71	398.54	403.08	404.93	393.27	394.62	400.34	390.88	398.34
Sample + Added Water + Flask Weight (gram)	419.97	418.94	414.29	405.00	418.72	418.22	416.51	417.19	411.11	402.91	408.01	408.61	406.64	408.01
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	0.9861	0.9915	0.9972	1.0140	0.9614	0.9565	0.8994	1.0150	1.0134	1.0207	1.0671	1.0548	0.9748	1.0150
Sample Concentration (fraction)	0.0332	0.0320	0.0244	0.0097	0.0315	0.0311	0.0284	0.0292	0.0191	0.0064	0.0146	0.0153	0.0125	0.0144
C/CB	0.3360	0.3235	0.2470	0.0980	0.3190	0.3145	0.2872	0.2952	0.1936	0.0652	0.1476	0.1551	0.1264	0.1462

AF	AG	AH	AI	AJ	AK	AL	AM	AN
Date (D M Yr)	301088	301088	301088	301088	301088	301088	301088	301088
Run	312	313	314	315	316	317	318	319
Temperature (C)			24					
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	442	444	443	443	442	443	444	441
Tank Position (z/H)	0.80	0.80	0.90	0.90	0.90	0.90	0.90	0.90
Tank Position (r/R)	0.30	0.10	1.00	0.90	0.70	0.50	0.30	0.10
Sample Time (seconds)	24.31	24.86	25.38	24.25	26.18	24.49	24.04	23.82
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	409.31	392.52	381.31	379.85	389.99	392.23	387.99	378.26
Sample + Added Water + Flask Weight (gram)	408.88	401.90	401.14	401.09	400.70	402.04	402.68	400.13
Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
Sample Velocity (m/s)	1.0130	0.9663	0.9211	0.9604	0.9144	0.9798	0.9856	0.9761
Sample Concentration (fraction)	0.0154	0.0049	0.0038	0.0037	0.0030	0.0051	0.0062	0.0022
C/CB	0.1559	0.0492	0.0381	0.0375	0.0302	0.0514	0.0624	0.0218

Filename: 320-344B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.0988, 440, 545, 680 RPM, NJS AND PSD TESTS, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	81188	81188	81188	81188	81188	81188	81188	81188	111188	111188	111188	111188	111188
6		Run	320	321	322	323	324	325	326	327	328	329	330	331	332
7		Temperature (C)						24					23		
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	442	442	548	548	682	676	446	547	550	551	551	677	675
11		Tank Position (z/H)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.80	0.80	0.80	0.80	0.80
12		Tank Position (r/R)	0.50	0.50	0.50	0.50	0.50	0.10	0.10	0.10	1.00	1.00	1.00	1.00	1.00
13															
14		Sample Time (seconds)	30.86	25.21	37.79	22.43	21.39	21.88	26.03	24.59	23.11	23.29	24.78	25.30	25.56
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	439.35	457.22	461.92	488.99	452.29	469.08	601.82	607.30	407.93	407.36	411.60	430.30	435.43
17		Sample + Added Water + Flask Weight (gram)	456.30	466.03	484.87	489.68	459.36	481.82	616.14	617.07	422.26	422.83	420.10	445.19	444.77
18		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
19															
20		Sample Velocity (m/s)	0.7633	0.9543	0.6135	1.0949	1.1297	1.0884	0.9112	0.9759	1.0263	1.0153	0.9716	0.9361	0.9399
21		Sample Concentration (fraction)	0.0919	0.1052	0.1397	0.1393	0.0943	0.1312	0.3449	0.3423	0.0372	0.0382	0.0333	0.0737	0.0720
22		C/CB	0.9300	1.0646	1.4142	1.4098	0.9547	1.3280	3.4910	3.4650	0.3768	0.3871	0.3370	0.7462	0.7290
23															
24		Date (D M Yr)	111188	111188	111188	111188	111188	111188	111188	111188	111188	111188	111188	111188	
25		Run	333	334	335	336	337	338	339	340	341	342	343	344	
26		Temperature (C)						24.5							
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	
29		Mixer Speed (RPM)	445	446	445	445	443	451	451	451	450	505	599	785	
30		Tank Position (z/H)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.20	0.20	0.20	0.20	0.20	
31		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	1.00	1.00	1.00	
32															
33		Sample Time (seconds)	24.22	24.18	24.31	23.73	24.25	24.19	23.68	17.62	25.14	29.19	25.16	22.14	
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
35		Sample + Flask Weight (gram)	398.28	395.84	397.86	388.34	399.24	396.14	391.23	470.82	464.87	463.63	464.75	470.82	
36		Sample + Added Water + Flask Weight (gram)	410.36	410.70	410.19	406.99	409.27	408.05	408.83	478.05	476.90	474.53	477.21	476.51	
37		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	
38															
39		Sample Velocity (m/s)	0.9850	0.9795	0.9807	0.9882	0.9889	0.9866	0.9930	1.3709	0.9490	0.8197	0.9472	1.0953	
40		Sample Concentration (fraction)	0.0182	0.0189	0.0180	0.0131	0.0164	0.0146	0.0161	0.1235	0.1232	0.1191	0.1238	0.1206	
41		C/CB	0.1846	0.1914	0.1820	0.1331	0.1663	0.1477	0.1625	1.2499	1.2471	1.2057	1.2534	1.2208	

Filename: 345-389B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 19, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.3022, 680 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	121188	121188	121188	121188	121188	121188	121188	121188	121188	121188	121188	121188	121188
6		Run	345	346	347	348	349	350	351	352	353	354	355	356	357
7		Temperature (C)		28							30.5				
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	685	683	679	677	687	683	683	687	685	681	683	681	681
11		Tank Position (z/H)	0.20	0.70	0.20	0.20	0.20	0.20	0.90	0.20	0.20	0.20	0.20	0.20	0.20
12		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.70	0.50	0.30	0.10	0.10
13															
14		Sample Time (seconds)	23.32	28.61	23.44	24.94	26.09	26.10	28.00	21.73	24.87	26.84	26.94	31.37	26.84
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	619.94	549.53	611.63	609.42	527.81	607.71	406.75	545.65	577.43	588.78	597.58	625.97	612.59
17		Sample + Added Water + Flask Weight (gram)	623.66	560.69	618.79	618.38	588.61	617.91	419.55	562.78	573.68	609.26	613.23	626.63	621.73
18		Total Volume With Added Water (ml)	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00	400.00
19															
20		Sample Velocity (m/s)	1.0451	0.8358	1.0307	0.9642	0.7992	0.9184	0.8504	1.0835	0.9985	0.8695	0.8773	0.7829	0.8956
21		Sample Concentration (fraction)	0.3473	0.2548	0.3427	0.3437	0.3426	0.3440	0.0328	0.2621	0.2651	0.3394	0.3415	0.3492	0.3491
22		C/CB	1.1491	0.8432	1.1341	1.1372	1.1338	1.1384	0.1085	0.8675	0.8771	1.1232	1.1300	1.1554	1.1551
23															
24		Date (D M Yr)	121188	121188	101288	101288	101288	101288	101288	111288	111288	111288	111288	111288	111288
25		Run	358	359	360	361	362	363	364	365	366	367	368	369	370
26		Temperature (C)	32			24							25		
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	680	681	681	683	679	687	684	677	687	684	683	682	680
30		Tank Position (z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.40	0.40	0.40	0.40	0.40	0.40
31		Tank Position (r/R)	1.00	1.00	1.00	0.90	0.70	0.50	0.50	1.00	0.90	0.70	0.50	0.30	0.10
32															
33		Sample Time (seconds)	21.93	23.41	27.12	25.87	27.87	23.64	24.77	27.87	26.73	24.12	27.33	25.81	26.70
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	588.01	601.45	679.60	663.53	684.51	735.86	758.67	693.47	675.00	601.49	654.69	605.88	633.67
36		Sample + Added Water + Flask Weight (gram)	609.20	612.17	745.98	730.16	751.96	776.17	781.86	752.64	702.08	654.73	691.62	674.36	680.80
37		Total Volume With Added Water (ml)	400.00	400.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39		Sample Velocity (m/s)	1.0622	1.0226	0.9829	1.0298	0.9541	1.1956	1.1837	0.9724	1.0879	1.1388	1.0418	1.0278	1.0890
40		Sample Concentration (fraction)	0.3400	0.3355	0.3494	0.3273	0.3588	0.3698	0.3638	0.3530	0.2635	0.2141	0.2553	0.2495	0.2101
41		C/CB	1.1250	1.1101	1.1563	1.0830	1.1872	1.2236	1.2037	1.1680	0.8719	0.7084	0.8448	0.8257	0.6952

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	111288	111288	111288	111288	111288	111288	111288	111288	111288	111288	111288	111288	111288
Run	371	372	373	374	375	376	377	378	379	380	381	382	383
Temperature (C)			28					30.5			29		
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	676	691	683	684	683	681	678	682	681	677	680	684	683
Tank Position (z/H)	0.40	0.50	0.50	0.50	0.50	0.50	0.50	0.60	0.60	0.60	0.60	0.60	0.60
Tank Position (r/R)	0.70	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50	0.30	0.10
Sample Time (seconds)	26.64	29.33	27.60	25.19	28.35	26.90	28.52	28.13	28.35	26.97	30.09	25.42	27.71
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	618.94	651.47	616.43	573.21	603.45	580.63	608.31	653.19	624.81	610.17	671.65	573.73	619.18
Sample + Added Water + Flask Weight (gram)	657.72	732.62	666.59	632.39	662.16	661.82	640.95	716.70	702.69	681.94	703.01	665.86	639.78
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.0C
Sample Velocity (m/s)	1.0645	0.8778	1.0021	1.0758	0.9569	0.9570	1.0076	0.9539	0.9152	0.9760	0.9577	0.9861	1.0639
Sample Concentration (fraction)	0.2113	0.3423	0.2288	0.1860	0.2271	0.2388	0.1866	0.3061	0.2962	0.2623	0.2671	0.2513	0.1804
C/CB	0.6993	1.1326	0.7570	0.6153	0.7514	0.7902	0.6174	1.0128	0.9802	0.8679	0.8839	0.8315	0.5969

Date (D M Yr)	111288	111288	111288	111288	111288	111288
Run	384	385	386	387	388	389
Temperature (C)				32		
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	682	682	681	680	678	686
Tank Position (z/H)	0.70	0.70	0.70	0.70	0.70	0.70
Tank Position (r/R)	1.00	0.90	0.70	0.50	0.30	0.10
Sample Time (seconds)	29.93	29.31	31.91	29.40	27.59	26.95
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	607.10	611.15	642.11	623.76	581.03	552.80
Sample + Added Water + Flask Weight (gram)	669.38	671.17	693.56	683.67	651.39	580.73
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.8991	0.9228	0.8642	0.9202	0.9573	1.0771
Sample Concentration (fraction)	0.2390	0.2403	0.2662	0.2576	0.2179	0.1066
C/CB	0.7909	0.7951	0.8810	0.8524	0.7210	0.3528

Filename: 400-503B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 255 micron SAND, CB = 0.299, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	230689	230689	230689	230689	230689	230689	230689	230689	230689	230689	230689	230689	230689
6		Run	400	401	402	403	404	405	406	407	408	409	410	411	412
7		Temperature (C)		23				24				25			
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	45	135	135	135	135	135	135	45	45
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	550	554	545	541	550	550	551	550	550	549	547	547	548
11		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Position (r/R)	1.00	0.90	0.50	0.10	1.00	1.00	1.00	1.00	0.90	0.50	0.10	0.10	0.90
13															
14		Sample Time (seconds)	20.13	20.17	20.18	20.20	20.16	20.06	20.27	20.01	19.99	20.09	20.08	20.02	20.09
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	513.71	525.70	528.29	487.65	457.63	403.61	423.76	459.42	470.28	516.22	490.23	479.24	518.41
17		Sample + Added Water + Flask Weight (gram)	691.61	679.00	679.21	649.31	649.03	651.22	659.48	672.73	667.65	666.49	644.15	651.90	670.20
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	0.9825	1.0557	1.0625	1.0286	0.9397	0.7715	0.7997	0.8792	0.9293	1.0692	1.0586	1.0040	1.0646
21		Sample Concentration (fraction)	0.3666	0.3183	0.3165	0.2725	0.2983	0.3705	0.3729	0.3719	0.3419	0.2936	0.2573	0.2866	0.3014
22		C/CB	1.2262	1.0644	1.0584	0.9114	0.9978	1.2391	1.2471	1.2437	1.1435	0.9820	0.8605	0.9584	1.0081
23															
24		Date (D M Yr)	230689	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689
25		Run	413	414	415	416	417	418	419	420	421	422	423	424	425
26		Temperature (C)				25						25.5			
27		Sample Tube Type (45, 90, 135 Degree)	45	90	90	90	90	90	90	45	45	45	45	45	45
28		Sample Tube Inside Diameter (mm)	4.55	10.87	10.87	10.87	10.87	10.87	10.87	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	548	549	550	549	550	548	549	549	552	551	550	551	550
30		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
31		Tank Position (r/R)	0.50	1.00	0.90	0.50	0.10	0.10	0.10	1.00	0.90	0.50	0.10	0.10	0.10
32															
33		Sample Time (seconds)	19.93	3.66	3.75	3.82	3.80	15.51	7.00	34.87	35.41	35.11	31.33	19.57	20.11
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	474.78	596.00	645.88	619.68	571.85	2454.40	1114.34	297.70	273.51	479.59	485.83	474.73	417.62
36		Sample + Added Water + Flask Weight (gram)	668.05	723.22	728.28	715.28	687.41	2767.27	2352.74	592.45	587.02	672.00	658.04	651.68	633.18
37		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	2000.00	2000.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39		Sample Velocity (m/s)	0.9447	1.0964	1.1993	1.1400	1.0892	1.1715	1.1667	0.3604	0.3223	0.5378	0.6424	1.0136	0.8679
40		Sample Concentration (fraction)	0.3381	0.3684	0.3361	0.3275	0.3003	0.2800	0.2890	0.2807	0.2913	0.3450	0.2976	0.2900	0.2897
41		C/CB	1.1308	1.2321	1.1242	1.0953	1.0042	0.9364	0.9665	0.9387	0.9741	1.1539	0.9954	0.9698	0.9690

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689	240689
Run	426	427	428	429	430	431	432	433	434	435	436	437	438
Temperature (C)					27							27	
Sample Tube Type (45, 90, 135 Degree)	135	135	135	135	135	135	135	135	135	135	45	45	45
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	550	551	551	550	550	553	552	553	552	551	549	548	551
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.10	0.10	0.90	0.50	1.00	1.00	0.50	0.90	0.90	0.90	0.90	0.90	0.90
Sample Time (seconds)	20.09	21.92	20.44	20.07	20.10	20.19	22.10	20.02	20.41	20.29	20.16	20.13	35.38
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	296.83	457.29	414.65	347.48	463.18	433.13	473.39	476.14	373.52	466.89	468.52	414.45	270.71
Sample + Added Water + Flask Weight (gram)	578.69	630.83	647.50	607.54	675.40	662.90	650.27	667.01	632.53	664.20	654.71	635.07	585.09
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.6652	0.9145	0.8017	0.7329	0.8786	0.8211	0.8977	0.9479	0.7238	0.9157	0.9556	0.8515	0.3210
Sample Concentration (fraction)	0.2253	0.2479	0.3414	0.2783	0.3761	0.3724	0.2872	0.3334	0.3406	0.3349	0.3044	0.2991	0.2863
C/CB	0.7535	0.8290	1.1418	0.9309	1.2579	1.2454	0.9606	1.1151	1.1393	1.1199	1.0182	1.0005	0.9574
Date (D M Yr)	240689	240689	240689	80789	80789	80789	80789	80789	80789	80789	80789	80789	80789
Run	439	440	441	442	443	444	445	446	447	448	449	450	451
Temperature (C)												25	
Sample Tube Type (45, 90, 135 Degree)	45	45	45	45	45	45	45	45	135	135	135	135	135
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	549	550	551	547	546	548	547	545	550	550	548	549	547
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50
Sample Time (seconds)	20.26	20.19	20.09	11.49	16.95	87.91	26.31	39.80	16.31	27.45	11.88	45.51	15.68
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	361.71	393.09	540.42	591.94	644.31	660.14	574.36	554.60	635.68	593.89	640.01	631.87	608.61
Sample + Added Water + Flask Weight (gram)	619.16	626.69	682.22	707.37	722.37	720.15	689.16	678.82	733.56	722.51	734.74	740.93	704.46
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.7339	0.8094	1.0953	2.0566	1.5301	0.3077	0.8996	0.5801	1.5152	0.8312	2.0966	0.5279	1.5861
Sample Concentration (fraction)	0.3047	0.2945	0.3135	0.3319	0.3241	0.3077	0.3024	0.2932	0.3571	0.3686	0.3561	0.3789	0.3113
C/CB	1.0190	0.9851	1.0485	1.1100	1.0839	1.0290	1.0115	0.9807	1.1944	1.2329	1.1910	1.2672	1.0413

AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
Date (D M Yr)	80789	80789	80789	80789	80789	80789	80789	150789	180789	180789	200789	200789	200789
Run	452	453	454	455	456	457	458	459	460	461	462	463	464
Temperature (C)													23
Sample Tube Type (45, 90, 135 Degree)	135	135	135	45	45	45	45	45	45	135	135	135	135
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	545	546	547	547	546	544	548	547	553	554	551	552	554
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.10	0.10	0.10	0.10	0.10	0.10
Sample Time (seconds)	11.05	22.37	46.85	14.83	11.29	23.25	51.48	8.72	13.24	13.21	20.99	35.19	19.29
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	618.37	576.91	596.81	564.60	636.61	613.55	544.64	574.60	519.44	514.25	535.47	481.43	418.94
Sample + Added Water + Flask Weight (gram)	708.07	688.30	681.24	696.75	722.13	716.8[illegible]	697.36	676.25	661.29	653.90	658.55	634.03	621.98
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	2.2821	1.0675	0.5452	1.5239	2.2585	1.0485	0.4143	2.8074	1.6617	1.6757	1.1033	0.6064	0.9448
Sample Concentration (fraction)	0.3120	0.2984	0.2686	0.3294	0.3296	0.3363	0.3500	0.2726	0.2778	0.2636	0.2595	0.2385	0.2544
C/CB	1.0436	0.9981	0.8984	1.1016	1.1023	1.1248	1.1707	0.9118	0.9292	0.8816	0.8679	0.7976	0.8508

Date (D M Yr)	200789	200789	200789	200789	200789	200789	200789	200789	200789	200789	200789	210789	210789
Run	465	466	467	468	469	470	471	472	473	474	475	476	477
Temperature (C)								26					
Sample Tube Type (45, 90, 135 Degree)	135	135	45	45	45	45	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	552	553	553	552	553	552	555	549	552	552	551	549	551
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.10	0.10	0.10	0.10	0.10	0.10	1.00	1.00	1.00	0.50	0.50	0.50	0.10
Sample Time (seconds)	8.39	10.39	33.14	10.97	18.19	8.51	14.77	34.23	10.63	42.04	14.18	8.71	36.43
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	533.32	555.79	507.80	584.20	503.78	511.67	599.26	564.79	653.60	550.84	568.86	566.28	487.20
Sample + Added Water + Flask Weight (gram)	665.95	671.85	662.27	685.87	660.41	659.93	722.31	711.84	742.77	687.88	693.54	693.64	646.94
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	2.6900	2.2706	0.6404	2.2315	1.1594	2.5388	1.5681	0.6334	2.3754	0.5304	1.6262	2.6285	0.5736
Sample Concentration (fraction)	0.2786	0.2759	0.2897	0.2874	0.2883	0.2805	0.3628	0.3695	0.3632	0.3189	0.3176	0.3200	0.2667
C/CB	0.9317	0.9227	0.9691	0.9612	0.9641	0.9383	1.2135	1.2357	1.2148	1.0666	1.0621	1.0703	0.8920

AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF
Date (D M Yr)	210789	210789	210789	210789	210789	210789	210789	210789	210789	210789	210789	210789	210789
Run	478	479	480	481	482	483	484	485	486	487	488	489	490
Temperature (C)	24								26				
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	10.87	10.87	10.87	10.87	10.87	10.87	10.87	10.87	10.87	10.87
Mixer Speed (RPM)	550	549	549	548	551	545	545	544	545	544	544	543	542
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.10	0.10	0.10	1.00	1.00	1.00	0.50	0.50	0.10	0.10	0.10	0.10	0.10
Sample Time (seconds)	12.35	8.63	10.03	8.03	24.63	10.38	27.12	9.95	24.74	8.98	14.38	10.30	4.08
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	515.71	554.47	586.57	681.95	624.58	600.51	545.41	576.50	507.78	604.75	542.53	590.32	596.97
Sample + Added Water + Flask Weight (gram)	659.99	675.59	681.98	755.85	742.93	727.14	694.20	701.95	661.42	696.56	669.67	688.55	694.85
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.7693	2.6975	2.4791	0.5715	0.1668	0.3872	0.1394	0.4052	0.1507	0.4895	0.2791	0.4200	1.0613
Sample Concentration (fraction)	0.2775	0.2856	0.2771	0.3689	0.3914	0.3742	0.3406	0.3319	0.2875	0.2964	0.2806	0.2890	0.2983
C/CB	0.9281	0.9553	0.9266	1.2338	1.3089	1.2516	1.1392	1.1102	0.9617	0.9914	0.9383	0.9666	0.9977
Date (D M Yr)	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789
Run	491	492	493	494	495	496	497	498	499	500	501	502	503
Temperature (C)							25				26		
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	544	544	544	548	543	544	545	544	544	544	544	544	545
Tank Position (z/H)	0.60	0.60	0.60	0.60	0.30	0.30	0.20	0.20	0.80	0.80	0.80	0.40	0.40
Tank Position (r/R)	0.90	0.90	0.60	0.30	0.90	0.60	0.90	0.60	0.90	0.60	0.30	0.90	0.30
Sample Time (seconds)	17.53	22.41	19.26	19.05	19.32	19.18	19.33	18.96	19.38	19.51	19.31	19.42	19.52
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	508.31	483.64	482.82	482.88	512.45	521.35	496.56	489.95	436.02	459.39	395.33	484.33	488.49
Sample + Added Water + Flask Weight (gram)	681.46	671.39	665.47	660.82	683.80	695.58	667.69	669.95	610.32	630.24	572.37	667.91	682.75
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.1449	0.8554	1.0116	1.0380	1.0446	1.0429	1.0447	1.0362	1.0319	1.0360	1.0269	1.0003	1.0247
Sample Concentration (fraction)	0.3423	0.3386	0.3218	0.3082	0.3448	0.3699	0.3146	0.3276	0.2099	0.2447	0.1399	0.3274	0.3083
C/CB	1.1448	1.1326	1.0761	1.0308	1.1530	1.2372	1.0521	1.0958	0.7021	0.8185	0.4678	1.0951	1.0312

Filename: 504-552B.WK1 LAST UPDATE: SEPT 6, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.0997, 440, 545, 680 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789	220789
6		Run	504	505	506	507	508	509	510	511	512	513	514	515	516
7		Temperature (C)		23						24					
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	553	552	554	553	553	544	544	544	543	544	545	544	546
11		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Position (r/R)	1.00	1.00	1.00	1.00	0.90	0.50	0.50	0.50	0.50	0.30	0.10	0.10	0.10
13															
14		Sample Time (seconds)	12.89	35.74	7.45	18.59	19.53	12.55	40.38	9.04	20.02	19.59	21.20	51.78	8.78
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	395.30	369.14	427.88	357.32	357.60	376.02	397.06	463.02	385.28	372.34	367.76	431.51	435.69
17		Sample + Added Water + Flask Weight (gram)	564.45	566.30	564.24	559.56	543.25	538.06	545.39	546.89	540.17	536.04	523.27	532.90	527.56
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	1.5761	0.5201	2.9986	0.9831	0.9882	1.6538	0.5349	2.8293	1.0588	1.0542	0.9980	0.4731	2.8569
21		Sample Concentration (fraction)	0.1222	0.1373	0.1108	0.1258	0.0873	0.0717	0.0817	0.0712	0.0740	0.0684	0.0441	0.0529	0.0436
22		C/CB	1.2255	1.3770	1.1110	1.2613	0.8754	0.7196	0.8195	0.7142	0.7422	0.6862	0.4420	0.5301	0.4374
23															
24		Date (D M Yr)	220789	220789	220789	220789	220789	230789	230789	230789	230789	230789	230789	230789	230789
25		Run	517	518	519	520	521	522	523	524	525	526	527	528	529
26		Temperature (C)	26								24				25
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	544	547	548	542	544	544	545	544	544	545	543	545	542
30		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.20	0.20	0.60	0.60	0.60	0.60	0.80	0.80
31		Tank Position (r/R)	0.10	0.10	0.10	1.00	1.00	0.90	0.60	0.90	0.60	0.30	0.90	0.90	0.60
32															
33		Sample Time (seconds)	15.00	29.90	34.81	30.97	29.86	19.42	19.35	19.64	19.47	20.14	19.50	19.46	19.53
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	408.35	380.13	345.69	414.36	420.10	360.41	360.72	367.75	359.03	366.44	378.42	344.76	350.13
36		Sample + Added Water + Flask Weight (gram)	526.27	524.16	524.80	567.09	568.54	536.53	536.47	539.38	535.76	534.70	541.99	525.94	528.12
37		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39		Sample Velocity (m/s)	1.5651	0.7313	0.5660	0.6887	0.7232	1.0240	1.0289	1.0267	1.0195	1.0115	1.0595	1.0059	1.0124
40		Sample Concentration (fraction)	0.0445	0.0442	0.0502	0.1210	0.1221	0.0720	0.0718	0.0763	0.0707	0.0669	0.0792	0.0528	0.0564
41		C/CB	0.4466	0.4430	0.5039	1.2140	1.2245	0.7219	0.7200	0.7654	0.7087	0.6709	0.7947	0.5292	0.5656

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	230789	230789	230789	230789	230789	230789	230789	230789	230789	230789	230789	230789	230789
Run	530	531	532	533	534	535	536	537	538	539	540	541	542
Temperature (C)							25.5					25.5	
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	543	543	542	444	446	445	445	445	445	446	447	447	447
Tank Position (z/H)	0.80	0.30	0.30	0.30	0.30	0.20	0.20	0.60	0.60	0.60	0.80	0.80	0.80
Tank Position (r/R)	0.30	0.90	0.60	0.60	0.90	0.90	0.60	0.90	0.60	0.30	0.90	0.60	0.30
Sample Time (seconds)	19.50	19.49	19.34	20.15	19.32	20.05	19.27	19.42	19.42	19.87	19.67	19.46	20.18
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	344.76	368.72	379.50	371.46	348.41	350.62	359.12	341.29	332.92	358.59	354.19	349.09	356.19
Sample + Added Water + Flask Weight (gram)	517.82	551.42	558.74	535.80	530.94	526.12	534.94	523.03	516.20	514.77	510.32	507.97	504.39
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.0295	0.9995	1.0183	1.0230	1.0089	0.9938	1.0330	1.0062	1.0013	1.0627	1.0737	1.0766	1.0708
Sample Concentration (fraction)	0.0362	0.1022	0.1151	0.0681	0.0626	0.0522	0.0689	0.0473	0.0343	0.0290	0.0211	0.0170	0.0103
C/CB	0.3633	1.0255	1.1548	0.6831	0.6283	0.5233	0.6911	0.4739	0.3436	0.2909	0.2113	0.1706	0.1029

Date (D M Yr)	230789	230789	230789	230789	230789	230789	230789	230789	230789	230789
Run	543	544	545	546	547	548	549	550	551	552
Temperature (C)	26		27						29	
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	682	679	680	677	672	682	682	683	683	682
Tank Position (z/H)	0.80	0.80	0.80	0.60	0.60	0.60	0.30	0.30	0.20	0.20
Tank Position (r/R)	0.90	0.60	0.30	0.90	0.60	0.30	0.90	0.60	0.90	0.60
Sample Time (seconds)	19.23	19.80	19.92	19.52	19.36	19.91	19.70	19.55	19.78	19.42
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	375.34	383.12	376.94	384.34	368.51	385.29	398.30	409.80	376.06	384.93
Sample + Added Water + Flask Weight (gram)	546.27	541.10	535.86	537.32	537.01	538.77	557.38	567.69	535.72	528.58
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.0508	1.0609	1.0516	1.0287	1.0515	1.0690	1.0628	1.0747	1.0567	1.0636
Sample Concentration (fraction)	0.0890	0.0763	0.0671	0.0728	0.0712	0.0712	0.1058	0.1239	0.0670	0.0548
C/CB	0.8925	0.7656	0.6733	0.7298	0.7142	0.7143	1.0616	1.2432	0.6722	0.5498

Filename: 553-600B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.299, 545 RPM H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	240789	240789	240789	240789	240789	240789	240789	240789	240789	240789	240789	240789	240789
6		Run	553	554	555	556	557	558	559	560	561	562	563	564	565
7		Temperature (C)					24				25.5				
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	554	552	554	546	545	547	546	544	543	544	546	544	543
11		Tank Position (z/H)	0.20	0.20	0.30	0.30	0.30	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Positio (r/R)	0.90	0.60	0.90	0.90	0.60	1.00	1.00	1.00	0.90	0.60	0.50	0.50	0.50
13															
14		Sample Time (seconds)	19.32	19.28	19.87	19.84	19.48	19.98	44.13	10.47	19.63	19.81	19.52	40.52	9.89
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	491.88	515.19	511.99	518.08	507.38	535.49	602.19	559.50	464.66	494.68	497.15	581.24	569.20
17		Sample + Added Water + Flask Weight (gram)	660.57	687.38	672.52	677.76	673.74	693.61	717.08	703.63	651.16	653.40	661.69	680.28	686.92
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	1.0530	1.0441	1.0492	1.0535	1.0517	1.0509	0.5362	2.0879	0.9805	1.0580	1.0554	0.6081	2.3750
21		Sample Concentration (fraction)	0.2998	0.3531	0.3142	0.3228	0.3219	0.3498	0.3477	0.3532	0.2985	0.2782	0.2982	0.2777	0.3019
22		C/CB	1.0028	1.1810	1.0507	1.0797	1.0767	1.1697	1.1628	1.1813	0.9985	0.9303	0.9972	0.9286	1.0098
23															
24		Date (D M Yr)	240789	240789	240789	240789	240789	240789	240789	260789	260789	260789	260789	260789	260789
25		Run	566	567	568	569	570	571	572	573	574	575	576	577	578
26		Temperature (C)		27											
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	135	45	45	45	45	135	135
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	543	542	544	539	542	543	544	546	543	542	542	544	542
30		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
31		Tank Positio (r/R)	0.50	0.30	0.10	0.10	0.10	0.10	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32															
33		Sample Time (seconds)	11.19	19.59	19.38	35.07	8.78	12.07	38.27	29.55	11.86	8.75	18.50	20.60	10.47
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	508.82	463.12	379.57	424.49	500.58	482.63	536.09	387.75	452.12	484.92	473.79	555.64	555.20
36		Sample + Added Water + Flask Weight (gram)	662.67	645.61	606.77	616.04	655.07	643.21	701.98	613.65	645.81	662.42	651.87	704.26	698.65
37		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39		Sample Velocity (m/s)	1.8999	0.9951	0.8636	0.5399	2.4170	1.7270	0.5361	0.5691	1.5854	2.2630	1.0684	1.0477	2.0919
40		Sample Concentration (fraction)	0.2906	0.2840	0.2435	0.2336	0.2777	0.2613	0.3733	0.2577	0.2949	0.3116	0.2921	0.3588	0.3440
41		C/CB	0.9720	0.9500	0.8144	0.7814	0.9288	0.8739	1.2484	0.8620	0.9862	1.0421	0.9768	1.2001	1.1504

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	260789	260789	260789	260789	260789	260789	260789	260789	260789	260789	260789	260789	260789
Run	579	580	581	582	583	584	585	586	587	588	589	590	591
Temperature (C)	24.5						26						
Sample Tube Type (45, 90, 135 Degree)	135	135	135	135	135	45	45	45	45	45	45	45	45
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	543	541	543	542	542	541	542	541	543	541	540	540	540
Tank Position (z/H)	0.40	0.40	0.40	0.40	[illegible]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Positio (r/R)	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.10	0.10	0.10
Sample Time (seconds)	12.90	10.42	31.77	8.24	16.96	19.00	32.70	9.47	13.53	25.54	29.83	11.64	8.80
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	549.61	408.43	408.26	473.18	404.11	474.21	436.46	534.29	521.49	423.40	425.93	466.50	506.95
Sample + Added Water + Flask Weight (gram)	701.05	627.98	610.19	651.93	619.69	663.70	649.75	672.29	678.84	646.90	636.39	636.11	647.80
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.6596	1.6514	0.5758	2.3937	1.0290	1.0033	0.5380	2.3483	1.5554	0.6642	0.5957	1.7430	2.5071
Sample Concentration (fraction)	0.3561	0.2832	0.2298	0.2928	0.2614	0.3262	0.3236	0.2941	0.3225	0.3293	0.2921	0.2553	0.2547
C/CB	1.1910	0.9472	0 7685	0.9792	0.8741	1.0910	1.0822	0.9838	1.0787	1.1012	0.9769	0.8538	0.8519

	R	S	T	U	V	W	X	Y	Z
Date (D M Yr)	260789	260789	260789	270789	270789	270789	270789	270789	270789
Run	592	593	594	595	596	597	598	599	600
Temperature (C)	27			23 5				25	
Sample Tube Type (45, 90, 135 Degree)	45	45	135	135	135	135	135	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	548	548	545	551	551	552	551	551	549
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60
Tank Positio (r/R)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.90	0.90
Sample Time (seconds)	17.96	9.96	18.88	35.13	12.54	7.97	15.35	20.79	18.20
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	432.67	498.73	421.40	396.03	478.16	455.84	409.26	479.89	477.37
Sample + Added Water + Flask Weight (gram)	623.20	660.90	611.53	590.85	623.62	619.86	602.47	666.04	667.48
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.0578	2.0830	1.0075	0.5332	1.7367	2.5888	1.2269	0.9268	1.0453
Sample Concentration (fraction)	0.2471	0.2946	0.2236	0.1856	0.2162	0.2214	0.2078	0.3273	0.3343
C/CB	0.8263	0.9854	0.7480	0.6206	0.7232	0.7404	0.6950	1.0946	1.1182

Filename: 601-685B.WK1 LAST UPDATE: SEPT 6, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 410 micron SAND, CB = 0.299, 545, 680 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date (D M Yr)	270789	270789	270789	270789	270789	270789	270789	270789	270789	270789	270789	270789	270789
6	Run	601	602	603	604	605	606	607	608	609	610	611	612	613
7	Temperature (C)						28						27	
8	Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9	Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	10.87	10.87	10.87	10.87	10.87	10.87	10.87	10.87
10	Mixer Speed (RPM)	547	546	546	548	550	547	550	552	551	549	549	548	550
11	Tank Position (z/H)	0.60	0.60	0.80	0.80	0.80	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12	Tank Position (r/R)	0.60	0.30	0.90	0.60	0.30	1.00	0.50	0.50	0.10	0.10	0.10	0.50	0.50
13														
14	Sample Time (seconds)	17.52	18.22	15.08	17.01	16.45	2.92	1.40	5.11	2.87	19.34	8.68	17.28	8.90
15	Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Sample + Flask Weight (gram)	437.44	443.36	264.87	304.43	282.23	408.34	205.95	476.92	316.71	478.45	534.64	439.48	517.96
17	Sample + Added Water + Flask Weight (gram)	638.05	630.01	504.50	510.99	499.58	652.42	566.81	656.27	590.99	638.15	650.35	636.01	673.03
18	Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	5[illegible].00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19														
20	Sample Velocity (m/s)	1.0489	1.0558	1.0589	1.0587	1.0543	0.9417	1.0626	0.6750	0.8444	0.1893	0.4766	0.1889	0.4171
21	Sample Concentration (fraction)	0.2858	0.2573	0.0141	0.0261	0.0023	0.3691	0.3028	0.3016	0.2517	0.2515	0.2420	0.2779	0.3101
22	C/CB	0.9560	0.8606	0.0473	0.0873	0.0078	1.2346	1.0128	1.0088	0.8418	0.8411	0.8095	0.9293	1.0371
23														
24	Date (D M Yr)	270789	270789	270789	270789	270789	270789	270789	270789	270789	280789	280789	280789	280789
25	Run	614	615	616	617	618	619	620	621	622	623	624	625	626
26	Temperature (C)				27.5		28			30	24.5			
27	Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28	Sample Tube Inside Diameter (mm)	10.87	10.87	10.87	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29	Mixer Speed (RPM)	550	548	550	682	682	681	683	683	685	681	674	675	683
30	Tank Position (z/H)	0.40	0.40	0.40	0.20	0.20	0.30	0.30	0.60	0.60	0.60	0.80	0.80	0.80
31	Tank Position (r/R)	0.50	1.00	1.00	0.90	0.60	0.90	0.60	0.90	0.60	0.30	1.00	0.90	0.70
32														
33	Sample Time (seconds)	15.09	13.92	10.69	19.96	19.50	18.63	18.11	16.92	17.59	19.03	19.43	18.53	18.65
34	Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	Sample + Flask Weight (gram)	533.24	529.37	622.43	486.76	499.59	486.48	486.46	429.43	418.62	463.13	424.41	396.06	427.78
36	Sample + Added Water + Flask Weight (gram)	673.95	703.04	739.27	637.61	679.17	667.17	677.35	637.96	628.24	638.81	592.94	579.56	608.01
37	Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38														
39	Sample Velocity (m/s)	0.2563	0.2522	0.3859	1.0126	1.0089	1.0523	1.0478	1.0572	1.0131	1.0464	1.0476	1.0486	1.0527
40	Sample Concentration (fraction)	0.2992	0.3842	0.3849	0.2591	0.3457	0.3238	0.3548	0.2935	0.2740	0.2652	0.1746	0.1570	0.2099
41	C/CB	1.0007	1.2850	1.2874	0.8664	1.1560	1.0830	1.1865	0.9815	0.9165	0.8870	0.5841	0.5251	0.7022

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	280789	280789	280789	280789	280789	280789	280789	280789	280789	280789	60889	60889	60889
Run	627	628	629	630	631	632	633	634	635	636	637	638	639
Temperature (C)			28.5		29				30.5				
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	682	682	683	682	681	679	680	680	677	676	682	682	678
Tank Position (z/H)	0.80	0.80	0.80	0.90	0.90	0.90	0.90	0.90	0.90	0.10	0.10	0.10	0.10
Tank Position (r/R)	0.50	0.30	0.10	1.00	0.90	0.70	0.50	0.30	0.10	1.00	0.90	0.70	0.50
Sample Time (seconds)	19.37	19.30	19.11	15.30	15.79	16.69	16.32	15.87	16.19	17.20	19.08	19.49	18.70
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	437.41	391.21	345.56	276.91	280.35	292.76	277.32	252.97	303.67	468.36	483.79	523.25	507.98
Sample + Added Water + Flask Weight (gram)	606.55	564.87	513.00	513.33	507.23	508.05	505.88	499.54	496.98	669.52	660.14	689.03	687.86
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.0489	1.0383	1.0687	1.0567	1.0611	1.0468	1.0203	0.9793	1.1628	1.0664	1.0415	1.0531	1.0511
Sample Concentration (fraction)	0.2002	0.1247	0.0267	0.0345	0.0196	0.0206	0.0167	0.0025	0.0000	0.3509	0.3061	0.3494	0.3626
C/CB	0.6695	0.4169	0.0894	0.1155	0.0656	0.0688	0.0558	0.0084	0.0000	1.1737	1.0239	1.1686	1.2128

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	60889	60889	150889	150889	150889	150889	150889	150889	150889	150889	150889	150889	150889
Run	640	641	642	643	644	645	646	647	648	649	650	651	652
Temperature (C)		26		22.5						25		24.5	
Sample Tube Type (45, 90, 135 Degree)	90	90	45	45	135	135	135	135	135	135	45	45	45
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	682	681	552	553	552	553	554	554	554	554	552	552	552
Tank Position (z/H)	0.10	0.10	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.30	0.10	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.10
Sample Time (seconds)	19.81	19.55	54.82	116.13	34.72	47.92	46.53	77.71	51.99	135.72	45.28	120.31	47.74
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	532.50	529.17	459.89	391.56	442.08	413.71	324.20	426.33	337.33	394.40	358.12	524.40	358.14
Sample + Added Water + Flask Weight (gram)	696.29	697.05	637.24	611.67	663.88	656.55	622.79	663.52	582.05	573.33	625.93	685.52	607.76
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.0423	1.0432	0.3614	0.1479	0.4916	0.3291	0.2650	0.2074	0.3011	0.1452	0.3143	0.1730	0.3216
Sample Concentration (fraction)	0.3606	0.3664	0.2636	0.2480	0.3647	0.3772	0.3794	0.3853	0.2009	0.1429	0.3370	0.3382	0.2679
C/CB	1.2059	1.2255	0.8816	0.8296	1.2197	1.2615	1.2687	1.2887	0.6718	0.4778	1.1272	1.1312	0.8959

AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR
Date (D M Yr)	150889	150889	150889	150889	150889	150889	150889	150889	150889	150889	150889	150889	150889
Run	653	654	655	656	657	658	659	660	661	662	663	664	665
Temperature (C)		26		26.5			27		27			27.5	
Sample Tube Type (45, 90, 135 Degree)	45	45	135	135	45	45	45	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	2.97	2.97	2.97	2.97	2.97	2.97
Mixer Speed (RPM)	551	552	551	548	552	553	550	549	550	551	551	551	553
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1.00	1.00	1.00	1.00	0.50	0.50
Sample Time (seconds)	120.52	27.15	45.90	120.75	16.66	13.51	21.30	18.14	42.21	120.41	12.34	45.38	120.49
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	368.29	381.42	314.15	316.50	417.16	442.37	381.41	455.09	367.33	310.11	400.53	330.08	302.32
Sample + Added Water + Flask Weight (gram)	610.30	616.90	568.79	553.12	612.31	634.63	615.56	650.89	621.78	598.45	631.77	600.13	582.65
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.1313	0.5976	0.3277	0.1338	1.1232	1.3983	0.7656	2.4159	0.8371	0.2527	3.1356	0.7288	0.2621
Sample Concentration (fraction)	0.2660	0.2747	0.1759	0.1273	0.2289	0.2712	0.2702	0.3072	0.3082	0.2902	0.3043	0.2714	0.2353
C/CB	0.8895	0.9186	0.5882	0.4256	0.7656	0.9071	0.9037	1.0273	1.0308	0.9705	1.0176	0.9078	0.7871
Date (D M Yr)	150889	150889	150889	150889	150889	150889	150889	160889	160889	160889	160889	160889	160889
Run	666	667	668	669	670	671	672	673	674	675	676	677	678
Temperature (C)		28					28.5	23.5			24.5		
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	552	547	549	551	547	547	552	548	553	551	550	550	548
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.50	0.50	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1.00	1.00	1.00	1.00
Sample Time (seconds)	22.16	16.89	40.09	23.19	120.41	71.06	33.43	14.35	42.97	40.01	22.55	102.67	60.92
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	419.75	532.48	290.67	422.62	286.36	328.61	377.43	454.56	295.33	350.20	380.78	435.50	447.13
Sample + Added Water + Flask Weight (gram)	631.29	660.00	582.52	612.57	561.83	578.88	598.18	616.07	572.18	630.59	638.37	654.08	663.80
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.8748	3.1800	0.7463	1.9263	0.2682	0.5057	1.2029	3.3999	0.7468	0.3363	0.6590	0.1682	0.2854
Sample Concentration (fraction)	0.2823	0.2656	0.2481	0.2256	0.1733	0.1976	0.2190	0.2129	0.2028	0.3695	0.3543	0.3391	0.3579
C/CB	0.9443	0.8884	0.8297	0.7544	0.5795	0.6608	0.7324	0.7120	0.6783	1.2359	1.1848	1.1342	1.1969

AS	AT	AU	AV	AW	AX	AY	AZ
Date (D M Yr)	160889	160889	160889	160889	160889	160889	160889
Run	679	680	681	682	683	684	685
Temperature (C)		26					
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	547	548	550	548	549	550	548
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.50	0.50	0.50	0.50	0.10	0.10	0.10
Sample Time (seconds)	54.08	120.41	41.16	83.36	120.42	70.27	43.40
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	434.02	397.24	435.97	411.52	334.50	347.58	375.74
Sample + Added Water + Flask Weight (gram)	640.86	611.52	640.25	622.24	570.83	584.46	605.65
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.3327	0.1456	0.4409	0.2130	0.1343	0.2297	0.3818
Sample Concentration (fraction)	0.2978	0.2426	0.2940	0.2624	0.1683	0.2005	0.2434
C/CB	0.9961	0.8115	0.9832	0.8774	0.5630	0.6705	0.8141

Filename: 686-739B.WK1 LAST UPDATE: SEPT 6, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 82 micron SAND, CB = 0.298, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	200889	200889	200889	200889	200889	200889	200889	200889	200889	200889	200889	200889	200889
6		Run	686	687	688	689	690	691	692	693	694	695	696	697	698
7		Temperature (C)		23				25				26			
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	549	548	547	545	545	547	545	545	544	548	544	545	544
11		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Position (r/R)	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.10	0.10	0.10	0.10	0.10
13															
14		Sample Time (seconds)	120.76	46.05	13.77	6.88	120.58	45.75	13.04	7.73	120.38	43.45	80.41	13.95	7.83
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	415.02	374.32	454.53	418.80	399.38	379.32	426.50	480.01	403.65	340.34	431.34	424.43	486.36
17		Sample + Added Water + Flask Weight (gram)	638.27	624.14	649.90	637.08	628.27	624.32	638.61	655.86	628.23	610.75	638.74	636.97	657.30
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	0.1406	0.3331	1.3580	2.5125	0.1379	0.3418	1.3548	2.5748	0.1404	0.3238	0.2233	1.2645	2.5806
21		Sample Concentration (fraction)	0.3091	0.3075	0.3040	0.3010	0.2930	0.3021	0.2978	0.2969	0.2883	0.2995	0.2932	0.2947	0.2951
22		C/CB	1.0372	1.0319	1.0201	1.0101	0.9831	1.0138	0.9993	0.9962	0.9673	1.0052	0.9840	0.9890	0.9902
23															
24		Date (D M Yr)	200889	200889	200889	200889	200889	200889	200889	200889	200889	200889	90989	90989	90989
25		Run	699	700	701	702	703	704	705	706	707	708	709	710	711
26		Temperature (C)				26				27					
27		Sample Tube Type (45, 90, 135 Degree)	45	45	45	45	135	135	135	135	135	45	45	45	45
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	547	545	544	543	543	543	543	542	541	544	550	548	546
30		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
31		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.50
32															
33		Sample Time (seconds)	120.46	46.90	14.13	7.61	120.67	45.40	12.11	8.24	120.67	120.68	54.40	14.74	8.16
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	353.23	356.94	459.81	458.24	362.36	378.32	444.80	482.62	352.82	373.19	431.60	481.65	464.97
36		Sample + Added Water + Flask Weight (gram)	609.99	612.04	647.35	648.66	621.75	625.91	645.98	658.38	608.36	622.58	641.07	657.05	651.49
37		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39		Sample Velocity (m/s)	0.1238	0.3201	1.3575	2.4973	0.1222	0.3409	1.5145	2.4161	0.1242	0.1273	0.3277	1.3522	2.3585
40		Sample Concentration (fraction)	0.2807	0.2839	0.2914	0.2967	0.3137	0.3091	0.3019	0.3015	0.2752	0.3032	0.3002	0.2987	0.2985
41		C/CB	0.9420	0.9528	0.9777	0.9955	1.0528	1.0372	1.0132	1.0118	0.9236	1.0174	1.0075	1.0023	1.0016

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	90989	90989	90989	90989	90989	90989	90989	100989	100989	100989	100989	100989	100989
Run	712	713	714	715	716	717	718	719	720	721	722	723	724
Temperature (C)	24				25				23			24.5	
Sample Tube Type (45, 90, 135 Degree)	135	135	135	135	135	135	135	45	45	45	45	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	2.97	2.97
Mixer Speed (RPM)	548	545	543	543	543	543	542	553	550	547	548	546	545
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.50	0.50	0.50	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sample Time (seconds)	8.53	13.68	50.38	120.61	46.01	15.92	8.28	8.32	16.68	52.77	120.54	120.51	48.77
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	490.86	505.97	421.00	330.55	368.53	516.40	477.69	458.75	525.17	407.54	403.31	332.83	384.64
Sample + Added Water + Flask Weight (gram)	659.66	663.83	635.50	601.68	617.18	665.30	653.94	648.35	670.25	633.35	631.48	604.32	623.54
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	2.3843	1.5360	0.3477	0.1163	0.3350	1.3546	2.4008	2.2903	1.3070	0.3188	0.1383	0.2727	0.7706
Sample Concentration (fraction)	0.2975	0.2954	0.2936	0.2762	0.2891	0.2904	0.2936	0.2953	0.2958	0.3010	0.2994	0.2837	0.2932
C/CB	0.9984	0.9913	0.9853	0.9269	0.9702	0.9745	0.9852	0.9908	0.9926	1.0101	1.0047	0.9521	0.9838

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	100989	100989	100989	100989	100989	261189	261189	261189	261189	261189	261189	261189	261189
Run	725	726	727	728	729	730	731	732	733	734	735	736	737
Temperature (C)						23				25			
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	2.97	2.97	10.87	10.87	10.87	10.87	10.87	10.87	10.87	2.97	2.97	2.97	2.97
Mixer Speed (RPM)	548	546	546	545	543	549	548	545	547	544	543	543	543
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.10	0.10	1.00	0.10	0.10	1.00	1.00	0.50	0.50	1.00	1.00	1.00	0.50
Sample Time (seconds)	13.63	11.45	50.39	57.36	14.22	14.54	9.20	9.46	51.98	130.55	18.06	35.73	17.36
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	432.74	495.58	419.29	427.31	534.35	589.48	547.77	597.35	512.65	404.51	497.55	433.44	528.56
Sample + Added Water + Flask Weight (gram)	639.46	659.45	639.66	638.64	671.95	696.33	681.30	694.76	666.85	632.22	663.28	641.85	671.11
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	3.0993	4.2312	0.0597	0.0541	0.2743	0.2911	0.4288	0.4583	0.0716	0.3003	2.6676	1.1754	2.9685
Sample Concentration (fraction)	0.2941	0.2928	0.3089	0.2970	0.2925	0.3075	0.3049	0.2978	0.2976	0.3006	0.3014	0.3008	0.2952
C/CB	0.9867	0.9824	1.0366	0.9968	0.9816	1.0317	1.0230	0.9994	0.9987	1.0086	1.0114	1.0093	0.9905

AE	AF	AG
Date (D M Yr)	261189	261189
Run	738	739
Temperature (C)		26.5
Sample Tube Type (45, 90, 135 Degree)	90	90
Sample Tube Inside Diameter (mm)	2.97	2.97
Mixer Speed (RPM)	542	542
Tank Position (z/H)	0.40	0.40
Tank Position (r/R)	0.50	0.50
Sample Time (seconds)	38.47	130.44
Volumetric Flask Weight (gram)	0.00	0.00
Sample + Flask Weight (gram)	500.49	423.36
Sample + Added Water + Flask Weight (gram)	661.48	635.25
Total Volume With Added Water (ml)	500.00	500.00
Sample Velocity (m/s)	1.2702	0.3181
Sample Concentration (fraction)	0.2939	0.2904
C/CB	0.9863	0.9745

Filename: 740-761B.WK1

LAST UPDATE: SEPT 8, 1991 (CHECKED WITH RAW DATA JULY 18, 1990)

DATA FROM STIRRED TANK SAMPLING (Radial Mixer / 410 Micron Sand / CB = 0.01 & 0.05 / 545 RPM) ASSUMPTIONS: WATER DENSITY = 0.997 (Value at 24.9 C)

1% Data Completed by Drying Sampled Sand. Sampled Sand Not Returned to Tank. Cb Altered Accordingly.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
9		Date (D M Yr)	271189	271189	271189	271189	271189	271189	271189	271189	271189	271189	271189	271189	271189
10		Run	740	741	742	743	744	745	746	747	748	749	750	751	752
11		Temperature (C)				24	24	24	24.5		25	25		25	
12															
13		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
14		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
15															
16		Dry Bulk Sand Weight (gram)	513.08	513.08	513.08	508.27	503.61	499.25	494.04	484.95	479.61	465.91	456.99	452.05	2500.84
17		Bulk Concentration (CB)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.009	0.009	0.009	0.009	0.009	0.049
18															
19		Mixer Speed (RPM)	553	553	553	552	553	553	553	553	555	553	552	553	552
20		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.20	0.20	0.20	0.60	0.60	0.60	0.60
21		Tank Position (r/R)	0.50	0.50	0.50	0.50	0.50	0.50	1.00	0.50	0.10	1.00	0.50	0.10	0.10
22															
23		Sample Time (seconds)	11.70	22.21	46.94	12.67	5.37	19.13	17.36	16.02	17.11	18.33	17.14	16.21	20.55
24		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25		Sample + Flask Weight (gram)	342.65	338.78	265.12	297.67	282.32	325.53	354.04	322.04	348.10	367.54	342.05	322.57	426.11
26		Dried Sand Weight (gram)			4.81	4.66	4.36	5.21	9.09	5.34	13.7	8.92	4.94	3.41	
27		Sample + Added Water + Flask Weight (gram)	500.11	501.69											512.52
28		Total Volume With Added Water (ml)	500.00	500.00											500.00
29															
30		Sample Velocity (m/s)	1.7981	0.9321	0.3445	1.4352	3.2120	1.0393	1.2380	1.2273	1.2243	1.2183	1.2200	1.2195	1.2370
31		Sample Concentration (fraction)	0.0029	0.0058	0.0070	0.0060	0.0059	0.0061	0.0099	0.0063	0.0153	0.0093	0.0055	0.0040	0.0208
32		C/CB	0.2891	0.5822	0.6979	0.6070	0.6042	0.6319	1.0306	0.6742	1.6415	1.0321	0.6223	0.4594	0.4275

Q	R	S	T	U	V	W	X	Y	Z
Date (D M Yr)	271189	271189	281189	281189	281189	281189	281189	281189	281189
Run	753	754	755	756	757	758	759	760	761
Temperature (C)				22.5					24
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Dry Bulk Sand Weight (gram)	2500.84	2500.84	2500.84	2500.84	2500.84	2500.84	2500.84	2500.84	2500.84
Bulk Concentration (CB)	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049	0.049
Mixer Speed (RPM)	552	552	552	550	552	550	551	551	550
Tank Position (z/H)	0.60	0.60	0.20	0.20	0.20	0.40	0.40	0.40	0.40
Tank Position (r/R)	1.00	0.50	1.00	0.50	0.10	0.50	0.50	0.50	0.50
Sample Time (seconds)	18.78	17.93	16.41	16.17	17.64	17.70	8.78	60.37	37.14
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	403.83	376.31	355.91	343.95	405.97	375.95	406.67	328.03	346.62
Dried Sand Weight (gram)		4.81	4.81	4.81	4.81	4.81	4.81	4.81	4.81
Sample + Added Water + Flask Weight (gram)	529.20	515.73	526.05	515.64	551.72	516.22	517.57	513.07	515.18
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.2256	1.2354	1.2343	1.2467	1.2336	1.2485	2.7232	0.3203	0.5480
Sample Concentration (fraction)	0.0502	0.0293	0.0512	0.0320	0.0921	0.0302	0.0300	0.0284	0.0308
C/CB	1.0338	0.6029	1.0542	0.6590	1.8957	0.6215	0.6182	0.5840	0.6352

Filename: 800-816B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA OCT 8, 1990) RADIAL MIXER, MIXTURE 10% 80 micron, 10% 500 micron SAND, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	110590	110590	180590	190590	220590	260590	270590	290590	80690	110790	110790	140790	170790
6		Run	800	801	802	803	804	805	806	807	808	809	810	811	812
7		Temperature (C)	23		22.5	23	22.5	22.5	23	23		22.5			20
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	45
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	545	544	550	550	552	550	552	552	550	544	541	550	547
11		Tank Position (z/H)	0.10	0.70	0.30	0.10	0.90	0.50	0.80	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.10	0.10	1.00
13															
14		Sample Time (seconds)	13.31	13.86	12.14	12.65	12.68	12.22	13.11	29.45	6.77		70.16	10.45	60.15
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
16		Sample + Flask Weight (gram)	473.64	472.44	440.46	452.66	401.34	431.23	429.80	434.90	416.04		454.30	536.40	355.60
17		Sample + Added Water + Flask Weight (gram)	625.34	615.48	619.13	619.71	572.41	612.56	592.01	618.41	608.18		587.90	608.80	569.90
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00		500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	1.6073	1.5820	1.6251	1.6163	1.5929	1.6011	1.5824	0.6598	2.7915		0.3208	2.5153	0.2915
21		Sample Concentration (fraction)	0.2229	0.2006	0.2299	0.2229	0.1376	0.2192	0.1695	0.2320	0.2182		0.1493	0.1578	0.1531
22		C/CB	1.1200	1.0078	1.1550	1.1199	0.6913	1.1013	0.8515	1.1658	1.0964		0.7503	0.7927	0.7694
23															
24		Date (D M Yr)	170790		150890	180890									
25		Run	813	814	815	816									
26		Temperature (C)	21	22	22.5										
27		Sample Tube Type (45, 90, 135 Degree)	135	45	135	45									
28		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55									
29		Mixer Speed (RPM)	549	552	552	551									
30		Tank Position (z/H)	0.40	0.40	0.40	0.40									
31		Tank Position (r/R)	0.50	0.50	0.50	0.50									
32															
33		Sample Time (seconds)	70.52	70.45	8.95	8.37									
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00									
35		Sample + Flask Weight (gram)	409.10	450.30	535.50	488.00									
36		Sample + Added Water + Flask Weight (gram)	574.50	611.70	619.90	611.80									
37		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00									
38															
39		Sample Velocity (m/s)	0.2914	0.2952	2.8541	2.7615									
40		Sample Concentration (fraction)	0.1390	0.2046	0.1787	0.1843									
41		C/CB	0.6987	1.0284	0.8978	0.9260									

Filename: 850-863B.WK1 LAST UPDATE: SEPT 8, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 82 micron SAND, CB = 0.300, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	90790	90790	90790	90790	90790	90790	90790	90790	90790	90790	90790	90790	90790
6		Run	850	851	852	853	854	855	856	857	858	859	860	861	362
7		Temperature (C)	25.8	21.8		23.2	24.3	24.3		25	25.2		25		
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed (RPM)	546	550	548	545	543	541	540	545	544	544	555	551	551
11		Tank Position (z/H)	0.40	0.40	0.40	0.80	0.80	0.80	0.80	0.20	0.20	0.30	0.30	0.60	0.60
12		Tank Position (r/R)	0.60	0.90	0.30	0.90	0.60	0.30	0.60	0.90	0.60	0.90	0.60	0.90	0.60
13															
14		Sample Time (seconds)	20.50	18.70	18.24	17.55	17.29	17.78	18.49	17.47	16.91	17.59	18.38	17.28	19.66
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	533.90	523.50	545.90	533.10	530.50	543.00	563.80	532.50	520.90	538.40	568.40	519.50	598.20
17		Sample + Added Water + Flask Weight (gram)	673.80	669.20	677.40	674.50	673.50	676.20	683.90	673.60	670.40	677.50	688.60	668.20	694.00
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	1.0791	1.1638	1.2412	1.2552	1.2683	1.2674	1.2624	1.2620	1.2731	1.2604	1.2629	1.2487	1.2635
21		Sample Concentration (fraction)	0.2975	0.2945	0.2967	0.3000	0.2996	0.2961	0.2982	0.2982	0.2998	0.3031	0.3075	0.2953	0.2955
22		C/CB	0.9918	0.9817	0.9890	1.0000	0.9988	0.9870	0.9941	0.9940	0.9993	1.0105	1.0250	0.9843	0.9850
23															
24		Date (D M Yr)	90790												
25		Run	863												
26		Temperature (C)	25.7												
27		Sample Tube Type (St, 45Dwn, 45Up)	90												
28		Sample Tube Inside Diameter (mm)	4.55												
29		Mixer Speed (RPM)	552												
30		Tank Position (z/H)	0.60												
31		Tank Position (r/R)	0.30												
32															
33		Sample Time (seconds)	17.76												
34		Volumetric Flask Weight (gram)	0.00												
35		Sample + Flask Weight (gram)	529.80												
36		Sample + Added Water + Flask Weight (gram)	671.80												
37		Total Volume With Added Water (ml)	500.00												
38															
39		Sample Velocity (m/s)	1.2383												
40		Sample Concentration (fraction)	0.2959												
41		C/CB	0.9863												

Filename: 864-907B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 255 micron SAND, CB = 0.300, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date (D M Yr)	100790	100790	100790	100790	100790	100790	100790	100790	100790	100790	100790	100790	100790
6		Run	864	865	866	867	868	869	870	871	872	873	874	875	876
7		Temperature (C)			22.5		23		23.5			24		27	
8		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter (mm)	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97	2.97
10		Mixer Speed (RPM)	545	545	543	543	539	541	541	549	549	549	547	550	552
11		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Position (r/R)	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10	0.10	0.10	0.10	1.00	0.50
13															
14		Sample Time (seconds)	14.71	16.06	60.22	24.31	120.06	41.26	15.85	19.59	92.88	180.24	120.31	120.24	30.45
15		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight (gram)	578.40	587.40	515.10	586.40	605.50	498.50	597.00	575.50	546.50	468.50	502.40	428.40	510.00
17		Sample + Added Water + Flask Weight (gram)	711.70	713.80	689.50	714.90	722.40	649.30	685.90	679.00	661.60	620.70	642.60	656.90	670.50
18		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20		Sample Velocity (m/s)	3.5943	3.3544	0.7792	2.2035	0.4602	1.2200	3.7414	2.9192	0.5976	0.2782	0.4312	0.3251	1.6071
21		Sample Concentration (fraction)	0.3553	0.3522	0.3587	0.3560	0.3571	0.2640	0.2785	0.2781	0.2589	0.2148	0.2448	0.3571	0.3097
22		C/CB	1.1844	1.1739	1.1957	1.1866	1.1904	0.8799	0.9283	0.9271	0.8631	0.7159	0.8160	1.1903	1.0325
23															
24		Date (D M Yr)	100790	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790
25		Run	877	878	879	880	881	882	883	884	885	886	887	888	889
26		Temperature (C)		23		25.5		26		26		26.5		26.5	
27		Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Inside Diameter (mm)	2.97	2.97	2.97	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29		Mixer Speed (RPM)	548	549	550	546	547	549	548	546	546	547	547	547	548
30		Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
31		Tank Position (r/R)	0.50	0.50	0.50	1.00	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.10	0.10
32															
33		Sample Time (seconds)	18.43	151.92	60.37	120.22	33.86	150.13	60.24	100.13	70.07	30.24	120.26	120.20	60.11
34		Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight (gram)	620.20	516.40	504.40	534.30	618.00	495.40	514.20	631.00	587.30	547.10	556.30	510.60	423.90
36		Sample + Added Water + Flask Weight (gram)	709.80	669.10	669.90	701.10	731.30	659.20	680.90	717.60	707.70	686.30	688.70	645.90	630.80
37		Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39		Sample Velocity (m/s)	3.2121	0.3295	0.7986	0.1702	0.7018	0.1375	0.3398	0.2538	0.3329	0.7329	0.1878	0.1864	0.2992
40		Sample Concentration (fraction)	0.3145	0.3003	0.3133	0.3718	0.3679	0.2922	0.3346	0.3238	0.3368	0.3181	0.3162	0.2470	0.2762
41		C/CB	1.0484	1.0010	1.0443	1.2392	1.2262	0.9741	1.1153	1.0792	1.1226	1.0605	1.0541	0.8234	0.9205

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790	110790
Run	890	891	892	893	894	895	896	897	898	899	900	901	902
Temperature (C)	27		27			27					27		
Sample Tube Type (45, 90, 135 Degree)	90	90	45	45	45	135	135	135	135	45	45	135	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	10.87
Mixer Speed (RPM)	547	547	547	548	547	547	548	546	548	546	549	548	547
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.10	0.10	1.00	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.10	0.10	1.00
Sample Time (seconds)	44.95	90.16	90.05	80.12	55.31	60.08	13.93	70.23	50.10	64.12	77.92	70.31	14.27
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	511.90	499.20	497.80	578.30	550.70	524.20	675.80	535.60	547.40	487.80	576.50	445.70	621.40
Sample + Added Water + Flask Weight (gram)	655.80	646.10	658.30	689.40	685.60	701.30	749.30	665.70	671.10	679.70	695.00	615.10	738.80
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.4866	0.2406	0.2315	0.2983	0.4055	0.3300	1.8820	0.3236	0.4615	0.2950	0.3008	0.2887	0.2886
Sample Concentration (fraction)	0.2700	0.2555	0.2878	0.2999	0.3132	0.3841	0.3592	0.2762	0.2803	0.3597	0.3147	0.2157	0.3838
C/CB	0.9000	0.8517	0.9592	0.9998	1.0440	1.2802	1.1973	0.9208	0.9343	1.1991	1.0492	0.7188	1.2793

Date (D M Yr)	110790	110790	110790	110790	110790
Run	903	904	905	906	907
Temperature (C)		27			
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90
Sample Tube Inside Diameter (mm)	10.87	10.87	10.87	10.87	10.87
Mixer Speed (RPM)	547	548	547	548	547
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	0.50	0.50	0.50	0.10	0.10
Sample Time (seconds)	22.26	13.88	31.06	16.28	24.14
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	563.10	599.70	555.10	645.90	599.20
Sample + Added Water + Flask Weight (gram)	696.00	708.60	696.00	703.20	686.90
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.1775	0.3034	0.1244	0.2929	0.1839
Sample Concentration (fraction)	0.3288	0.3282	0.3362	0.2824	0.2791
C/CB	1.0960	1.0941	1.1205	0.9413	0.9305

Filename: 908-967B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA JULY 18, 1990) RADIAL MIXER, 500 micron SAND, CB = 0.300, 680, 750 RPM H20 DENSITY = 0.997 (AT 24.9 C)

A	B C	D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date (D M Yr)	150790	150790	150790	150790	160790	160790	160790	160790	160790	160790	160790	160790	160790
6	Run	908	909	910	911	912	913	914	915	916	917	918	919	920
7	Temperature (C)	23		24.5	25.2	23	24	24.5	25	26.5	27	28	28.5	29
8	Sample Tube Type (45, 90, 135 Degree)	45	45	135	135	135	135	135	135	135	135	135	135	135
9	Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10	Mixer Speed (RPM)	679	681	686	680	377	680	682	684	748	751	753	750	751
11	Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12	Tank Position (r/R)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
13														
14	Sample Time (seconds)	60.05	10.57	60.40	9.61	60.22	30.43	16.73	10.14	15.47	24.89	80.21	60.32	8.14
15	Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Sample + Flask Weight (gram)	468.00	599.90	387.40	558.70	401.60	432.90	470.70	589.00	538.30	517.90	489.10	380.80	489.20
17	Sample + Added Water + Flask Weight (gram)	651.00	685.60	573.40	658.40	579.50	590.00	615.10	669.60	654.90	612.50	578.00	582.10	633.30
18	Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19														
20	Sample Velocity (m/s)	0.3241	2.4091	0.3192	2.5599	0.3284	0.6921	1.3056	2.5423	1.6026	1.0010	0.3150	0.3244	2.6857
21	Sample Concentration (fraction)	0.2951	0.2767	0.1463	0.2448	0.1543	0.1636	0.2010	0.2500	0.2072	0.1723	0.1185	0.1224	0.2322
22	C/CB	0.9837	0.9224	0.4878	0.8160	0.5142	0.5454	0.6701	0.8332	0.6907	0.5744	0.3950	0.4080	0.7741
23														
24	Date (D M Yr)	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790
25	Run	921	922	923	924	925	926	927	928	929	930	931	932	933
26	Temperature (C)	25	26	27	27.5	24	25	26	27	28	29	24.5	25.5	26.5
27	Sample Tube Type (45, 90, 135 Degree)	45	45	45	45	45	45	45	45	45	45	135	135	135
28	Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
29	Mixer Speed (RPM)	745	744	746	748	754	747	748	746	743	753	754	754	752
30	Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
31	Tank Position (r/R)	0.50	0.50	0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
32														
33	Sample Time (seconds)	13.41	60.29	21.21	8.33	15.81	60.21	20.01	60.39	8.03	20.41	13.13	70.33	20.91
34	Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	Sample + Flask Weight (gram)	523.90	470.30	503.00	462.10	573.10	430.40	457.30	431.20	453.80	477.30	513.30	581.20	549.20
36	Sample + Added Water + Flask Weight (gram)	652.70	648.10	649.10	632.00	660.70	608.50	614.60	611.70	628.00	619.70	673.90	715.20	692.40
37	Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38														
39	Sample Velocity (m/s)	1.7006	0.3302	1.0249	2.4334	1.6032	0.3283	1.0519	0.3248	2.4913	1.0763	1.5875	0.3197	1.0482
40	Sample Concentration (fraction)	0.2547	0.2793	0.2609	0.2480	0.2410	0.2096	0.2077	0.2173	0.2438	0.2078	0.3169	0.3630	0.3332
41	C/CB	0.8488	0.9308	0.8697	0.8268	0.8033	0.6987	0.6925	0.7244	0.8127	0.6927	1.0564	1.2099	1.1106

Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date (D M Yr)	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790	160790
Run	934	935	936	937	938	939	940	941	942	943	944	945	946
Temperature (C)	27	26.5	27.5	28.5	29	30	30.5	31.5	27	27.5	28.5	25	26
Sample Tube Type (45, 90, 135 Degree)	135	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	753	746	751	755	749	750	744	752	752	757	754	752	747
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Tank Position (r/R)	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.90	0.60	0.30	0.10	0.10
Sample Time (seconds)	11.17	12.41	60.37	29.21	13.68	80.30	40.81	8.09	18.74	18.44	19.81	14.24	70.27
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	575.20	509.90	469.70	517.70	518.20	469.40	486.80	486.10	499.90	477.00	575.80	545.20	443.10
Sample + Added Water + Flask Weight (gram)	696.30	671.20	654.20	670.70	635.10	610.50	630.80	622.10	636.20	607.50	658.90	643.40	592.70
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	2.0842	1.6761	0.3208	0.7296	1.7207	0.2746	0.5358	2.7641	1.1923	1.2311	1.2935	1.7341	0.3063
Sample Concentration (fraction)	0.3200	0.3127	0.3027	0.3043	0.2186	0.1913	0.2279	0.2082	0.2321	0.1808	0.2357	0.2210	0.1648
C/CB	1.0666	1.0423	1.0091	1.0143	0.7285	0.6378	0.7595	0.6939	0.7737	0.6028	0.7858	0.7367	0.5495

Date (D M Yr)	160790	160790	160790	160790	160790	160790	160790	160790	170790	170790	170790	170790	170790
Run	947	948	949	950	951	952	953	954	955	956	957	958	959
Temperature (C)	27	24	25	26	27	27.5	28.5	29	21.5	22.5	23.5	24.5	26
Sample Tube Type (45, 90, 135 Degree)	90	45	45	45	135	135	135	135	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	751	758	753	749	751	754	749	753	751	751	752	746	750
Tank Position (z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.80	0.80
Tank Position (r/R)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.90	0.60	0.30	0.90	0.60
Sample Time (seconds)	33.16	12.87	70.40	20.13	10.38	70.11	35.51	16.95	15.95	16.85	16.81	17.06	17.62
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	450.40	497.10	463.30	484.10	446.10	388.20	386.80	449.60	470.90	499.00	506.50	442.50	495.00
Sample + Added Water + Flask Weight (gram)	608.70	643.10	632.10	638.00	611.80	557.50	585.10	598.60	642.20	647.70	639.00	579.60	619.20
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	0.6329	1.6896	0.2889	1.0560	1.9778	0.2896	0.5215	1.2719	1.2654	1.2806	1.3431	1.3068	1.3104
Sample Concentration (fraction)	0.1978	0.2504	0.2474	0.2472	0.2079	0.1094	0.1761	0.1749	0.2681	0.2604	0.2344	0.1370	0.1969
C/CB	0.6592	0.8348	0.8247	0.8238	0.6928	0.3647	0.5871	0.5829	0.8938	0.8680	0.7812	0.4567	0.6563

AE	AF	AG	AH	AI	AJ	AK	AL	AM
Date (D M Yr)	170790	170790	170790	170790	170790	170790	170790	170790
Run	960	961	962	963	964	965	966	967
Temperature (C)	26.5	27.5	28	23.5	24.5	25.5	26.5	28
Sample Tube Type (45, 90, 135 Degree)	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter (mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed (RPM)	748	751	750	750	754	748	755	748
Tank Position (z/H)	0.80	0.80	0.80	0.30	0.30	0.30	0.20	0.20
Tank Position (r/R)	0.30	0.60	0.90	0.90	0.90	0.60	0.90	0.60
Sample Time (seconds)	18.21	17.53	17.02	17.38	16.95	17.62	16.35	17.88
Volumetric Flask Weight (gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight (gram)	454.90	481.30	446.90	561.70	545.70	571.10	498.20	573.80
Sample + Added Water + Flask Weight (gram)	566.10	605.90	584.50	683.40	679.50	690.30	642.20	688.90
Total Volume With Added Water (ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity (m/s)	1.3120	1.3157	1.3080	1.3374	1.3273	1.3279	1.3375	1.3227
Sample Concentration (fraction)	0.1066	0.1754	0.1455	0.2996	0.3030	0.3087	0.2475	0.3032
C/CB	0.3552	0.5846	0.4850	0.9987	1.0100	1.0291	0.8250	1.0107

Filename: 970-976B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA OCT 8, 1990) A310 AXIAL MIXER, 410 micron SAND, CB = 0.10, 440 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C		D	E	F	G	H	I	J
5		Date	(D M Yr)	10990	10990	10990	150990	150990	150990	150990
6		Run		970	971	972	973	974	975	976
7		Temperature	(C)	20.2	20.5	20.8			22.5	22.8
8		Sample Tube Type	(45, 90, 135 Degree)	90	90	90	90	90	90	90
9		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed	(RPM)	442	443	443	446		447	448
11		Tank Position	(z/H)	0.30	0.40	0.60	0.50	0.80	0.40	0.20
12		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13										
14		Sample Time	(seconds)	18.64	15.28	19.24	18.85			21.56
15		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight	(gram)	455.60	383.00	402.10	446.60		491.60	501.50
17		Sample + Added Water + Flask Weight	(gram)	577.80	569.80	511.80	569.80		590.70	577.90
18		Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19										
20		Sample Velocity	(m/s)	1.2453	1.2584	1.2466	1.2282			1.2077
21		Sample Concentration	(fraction)	0.1286	0.1396	0.0209	0.1159	0.0000	0.1409	0.1148
22		C/CB		1.2858	1.3957	0.2087	1.1592	0.0000	1.4085	1.1478

Filename: 980-1002B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA OCT 8, 1990) RADIAL MIXER, 255 micron SAND, CB = 0.100, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date	(D M Yr)	160990	160990	160990	160990	160990	160990	160990	160990	160990	160990	160990	160990	160990
6	Run		980	981	982	983	984	985	986	987	988	989	990	991	992
7	Temperature	(C)	18	18.5	18.8	19.5	20	20.2	20.8	21	21.2	21.5	22	22.2	22.5
8	Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	45	45	45	45
9	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10	Mixer Speed	(RPM)	551	551	552	552	553	553	553	551	551	552	552	550	549
11	Tank Position	(z/H)	0.20	0.30	0.40	0.60	0.80	0.30	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12	Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.50	0.50	0.50	0.50	0.50	0.50	0.50
13															
14	Sample Time	(seconds)	20.20	18.91	18.50	19.95	17.90	19.27	18.66	120.32	9.31	20.97	90.39	29.53	9.55
15	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Sample + Flask Weight	(gram)	414.40	467.70	445.10	473.10	413.30	462.60	460.40	469.70	479.40	445.80	532.30	434.00	453.30
17	Sample + Added Water + Flask Weight	(gram)	542.30	572.40	553.00	553.90	547.10	570.20	554.50	556.00	556.40	556.90	576.30	556.50	555.30
18	Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20	Sample Velocity	(m/s)	1.1317	1.2846	1.3024	1.2916	1.2568	1.2513	1.3369	0.2113	2.7928	1.1396	0.3102	0.7854	2.5611
21	Sample Concentration	(fraction)	0.0719	0.1142	0.0849	0.0807	0.0811	0.1116	0.0843	0.0849	0.0836	0.0918	0.1042	0.0939	0.0872
22	C/CB		0.7194	1.1422	0.8493	0.8073	0.8111	1.1164	0.8429	0.8491	0.8361	0.9176	1.0419	0.9389	0.8719
23															
24	Date	(D M Yr)	170990	170990	170990	170990	170990	190990	190990	190990	190990	190990			
25	Run		993	994	995	996	997	998	999	1000	1001	1002			
26	Temperature	(C)	22.5	22.8	23	23.2	23.5	22			22.5				
27	Sample Tube Type (45, 90, 135 Degree)		135	135	135	135	135	90	90	90	90	90			
28	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55			
29	Mixer Speed	(RPM)	552	550	550	551	551	548	548	553	554	554			
30	Tank Position	(z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40			
31	Tank Position	(r/R)	0.50	0.50	0.50	0.50	0.50	0.60	0.60	0.60	0.60	0.60			
32															
33	Sample Time	(seconds)	19.18	30.36	90.33	9.53	80.35	20.30	20.26	20.31	20.49	20.38			
34	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
35	Sample + Flask Weight	(gram)	437.30	430.40	463.30	473.50	482.20	428.70	432.70	434.90	436.90	437.10			
36	Sample + Added Water + Flask Weight	(gram)	544.20	539.00	534.10	552.10	539.20	549.30	551.70	552.40	551.10	551.40			
37	Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00			
38															
39	Sample Velocity	(m/s)	1.2595	0.7922	0.2921	2.7180	0.3390	1.1483	1.1555	1.1572	1.1570	1.1629			
40	Sample Concentration	(fraction)	0.0710	0.0632	0.0507	0.0777	0.0561	0.0818	0.0853	0.0861	0.0833	0.0838			
41	C/CB		0.7103	0.6322	0.5066	0.7770	0.5611	0.8182	0.8533	0.8611	0.8331	0.8381			

Filename: 1010-1014B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA OCT 8, 1990) RADIAL MIXER, 255 micron SAND, CB = 0.300, 545 RPM, EQUILIBRATION TIME TESTS, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H
5	Date	(D M Yr)	190990	190990	190990	190990	190990
6	Run		1010	1011	1012	1013	1014
7	Temperature	(C)					23
8	Sample Tube Type	(45, 90, 135 Degree)	90	90	90	90	90
9	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55
10	Mixer Speed	(RPM)	545	545	545	545	548
11	Tank Position	(z/H)	0.40	0.40	0.40	0.40	0.40
12	Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60
13							
14	Sample Time	(seconds)	22.94	22.32	20.92	20.99	21.71
15	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00
16	Sample + Flask Weight	(gram)	630.40	612.50	573.80	578.20	597.10
17	Sample + Added Water + Flask Weight	(gram)	713.70	705.80	691.90	696.10	700.40
18	Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00
19							
20	Sample Velocity	(m/s)	1.1165	1.1199	1.1217	1.1185	1.1229
21	Sample Concentration	(fraction)	0.3155	0.3114	0.3095	0.3160	0.3110
22	C/CB		1.0516	1.0380	1.0315	1.0534	1.0365
23							
24	Equilibration Time (second)		15–35	60–80	150–170	340–360	600–620

Filename: 1020-1039B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA OCT 8, 1990) RADIAL MIXER, 500 micron SAND, CB = 0.100, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A B	C		D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date	(D M Yr)	190990	190990	190990	190990	190990	190990	190990	190990	190990	190990	190990	190990	190990
6	Run		1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032
7	Temperature	(C)	20.5	20.5	21	21	21.2	21 5		22	22.2		22.5	23	
8	Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	135	135	135	135	45	45	45	45	45
9	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10	Mixer Speed	(RPM)	548	548	549	549	549	548	549	549	548	548	547	546	547
11	Tank Position	(z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12	Tank Position	(r/R)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
13															
14	Sample Time	(seconds)	18.68	26.63	80.49	9.02	17.70	33.98	80.41	9.52	17.84	30.12	73.77	48.37	8.99
15	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Sample + Flask Weight	(gram)	444.00	364.00	460.70	471.90	424.80	433.50	443.10	476.80	458.10	394.40	401.90	438.60	460.20
17	Sample + Added Water + Flask Weight (gram)		536.80	528.20	535.80	537.20	525.80	521.80	514.30	534.60	544.10	537.90	543.70	544.30	537.60
18	Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20	Sample Velocity	(m/s)	1.3397	0.7744	0.3245	2.9626	1.3853	0.7447	0.3278	2.8556	1.4263	0.7271	0.2983	0.5009	2.8895
21	Sample Concentration	(fraction)	0.0576	0.0542	0.0538	0.0545	0.0419	0.0347	0.0226	0.0500	0.0675	0.0678	0.0774	0.0712	0.0567
22	C/CB		0.5764	0.5424	0.5379	0.5454	0.4193	0.3468	0.2258	0.5001	0.6749	0.6776	0.7736	0.7119	0.5669
23															
24	Date	(D M Yr)	210990	210990	210990	210990	210990	210990	210990						
25	Run		1033	1034	1035	1036	1037	1038	1039						
26	Temperature	(C)	22.5	22.5	23	23	23	23.2	23.5						
27	Sample Tube Type (45, 90, 135 Degree)		45	90	90	90	90	90	90						
28	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55						
29	Mixer Speed	(RPM)	555	552	552	552	551	553	551						
30	Tank Position	(z/H)	0.40	0.30	0.40	0.20	0.60	0.60	0.80						
31	Tank Position	(r/R)	0.50	0.60	0.60	0.60	0.60	0.60	0.60						
32															
33	Sample Time	(seconds)	12.75	17.49	17.53	17.67	19.29	20.50	20.29						
34	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
35	Sample + Flask Weight	(gram)	454.80	445.60	418.20	440.40	383.40	396.60	427.10						
36	Sample + Added Water + Flask Weight (gram)		541.60	561.30	532.20	553.60	530.00	530.40	522.70						
37	Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00						
38															
39	Sample Velocity	(m/s)	1.9919	1.3501	1.3530	1.3451	1.1253	1.0974	1.2249						
40	Sample Concentration	(fraction)	0.0639	0.1002	0.0535	0.0873	0.0547	0.0534	0.0367						
41	C/CB		0.6392	1.0016	0.5351	0.8731	0.5465	0.5340	0.3667						

Filename: 1050-1062B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA OCT 8, 1990) RADIAL MIXER, 1000 micron SAND, CB = 0.100, 680 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date	(D M Yr)	210990	210990	210990	210990	210990	210990	210990	210990	210990	210990	210990	210990	210990
6		Run		1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062
7		Temperature	(C)	18		18.5	19	19.5		21		21.5		22	22.5	
8		Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	45	45	45	135	135	135	135
9		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed	(RPM)	551	550	548	681	677	677	677	677	675	677	676	673	681
11		Tank Position	(z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
12		Tank Position	(r/R)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
13																
14		Sample Time	(seconds)	17.45	9.94	80.61	16.94	9.61	60.19	60.28	18.38	9.02	9.10	15.68	60.35	29.31
15		Volumetric Flask Weight	(gram)	167.00	0.00	0.00	0.00	0.00	167.00	166.90	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight	(gram)	591.40	484.70	432.00	436.90	466.90	559.50	566.10	427.30	431.10	442.10	400.50	352.90	375.20
17		Sample + Added Water + Flask Weight (gram)		681.80	517.80	510.80	529.40	532.50	689.40	705.60	536.00	532.20	524.30	515.10	503.80	507.00
18		Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19																
20		Sample Velocity	(m/s)	1.4427	2.8882	0.3212	1.4784	2.7788	0.3778	0.3674	1.3082	2.7178	2.8220	1.5103	0.3553	0.7718
21		Sample Concentration	(fraction)	0.0245	0.0254	0.0179	0.0466	0.0481	0.0397	0.0686	0.0589	0.0519	0.0380	0.0265	0.0093	0.0142
22		C/CB		0.2446	0.2540	0.1795	0.4661	0.4810	0.3971	0.6858	0.5892	0.5193	0.3795	0.2648	0.0934	0.1420

Filename: 1063-1068B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA FEB 18, 1991) RADIAL MIXER, 1000 micron SAND, CB = 0.100, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C		D	E	F	G	H	I
5		Date	(D M Yr)	130191	130191	130191	130191	130191	130191
6		Run		1063	1064	1065	1066	1067	1068
7		Temperature	(C)						
8		Sample Tube Type	(45, 90, 135 Degree)	90	90	90	90	90	90
9		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55
10		Mixer Speed	(RPM)	553	552	553	551	553	553
11		Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30
12		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90
13									
14		Sample Time	(seconds)	30.68	13.09	8.13	90.35	41.86	60.66
15		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight	(gram)	305.70	378.20	427.80	318.60	354.50	327.30
17		Sample + Added Water + Flask Weight	(gram)	525.70	527.10	528.00	528.50	528.20	527.50
18		Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00
19									
20		Sample Velocity	(m/s)	0.5600	1.6475	3.0221	0.1970	0.4786	0.3033
21		Sample Concentration	(fraction)	0.0598	0.0501	0.0454	0.0637	0.0560	0.0595
22		C/CB		0.5981	0.5010	0.4536	0.6366	0.5600	0.5954

Filename: 1069-1122B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA FEB 18, 1991) RADIAL MIXER, 410 micron SAND, CB = 0.100, VARIOUS RPM'S, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date	(D M Yr)	130191	130191	130191	130191	130191	130191	130191	130191	130191	130191	130191	130191	130191
6		Run		1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081
7		Temperature	(C)	13.5			14					16				
8		Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Taper (Degree)		90	90	90	90	90	90	18	18	18	18	18	18	90
10		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
11		Mixer Speed	(RPM)	544	544	544	545	546	546	546	546	546	546	545	545	543
12		Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.50
13		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
14		Sample Time	(seconds)	12.86	60.29	8.61	21.95	94.38	90.55	63.41	20.28	8.41	90.42	23.49	90.32	60.24
15		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight	(gram)	372.60	403.10	464.40	404.90	396.50	433.30	416.50	384.80	441.10	397.50	364.10	410.40	369.00
17		Sample + Added Water + Flask Weight (gram)		551.30	566.20	559.50	557.80	572.70	576.20	564.90	551.90	553.80	567.30	549.60	570.40	529.50
18		Total Volume .ith Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19																
20		Sample Velocity	(m/s)	1.5340	0.3432	2.8902	0.9713	0.2107	0.2423	0.3406	1.0080	2.8298	0.2242	0.8220	0.2312	0.3461
21		Sample Concentration	(fraction)	0.1007	0.1232	0.0923	0.1047	0.1405	0.1333	0.1157	0.0983	0.0875	0.1277	0.0996	0.1296	0.0560
22		C/CB		1.0074	1.2316	0.9227	1.0469	1.4047	1.3332	1.1572	0.9832	0.8746	1.2771	0.9961	1.2960	0.5596
23																
24		Date	(D M Yr)	130191	130191	130191	130191	130191	140191	140191	140191	140191	140191	140191	140191	140191
25		Run		1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094
26		Temperature	(C)		18								21.5			22.5
27		Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
28		Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
29		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
30		Mixer Speed	(RPM)	545	544	546	546	546	310	441	443	443	443	443	443	680
31		Tank Position	(z/H)	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
32		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
33		Sample Time	(seconds)	22.27	9.27	90.39	13.20	90.34	60.55	60.44	21.83	14.11	90.35	8.08	75.48	19.13
34		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35		Sample + Flask Weight	(gram)	421.40	488.80	353.00	401.20	409.60	348.10	368.50	398.30	433.70	346.50	426.00	386.70	377.10
36		Sample + Added Water + Flask Weight (gram)		542.80	554.00	521.60	542.10	529.20	509.90	535.80	534.50	534.70	538.40	532.50	539.10	557.00
37		Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38																
39		Sample Velocity	(m/s)	1.0445	2.8834	0.2251	1.6712	0.2587	0.3430	0.3380	1.0238	1.7378	0.2093	2.9927	0.2829	1.0274
40		Sample Concentration	(fraction)	0.0717	0.0782	0.0427	0.0744	0.0494	0.0207	0.0687	0.0606	0.0556	0.0794	0.0529	0.0716	0.1120
41		C/CB		0.7168	0.7815	0.4272	0.7439	0.4944	0.2066	0.6872	0.6063	0.5557	0.7940	0.5292	0.7158	1.1203

Q		R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date	(D M Yr)	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191
Run		1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107
Temperature	(C)		23		23.5					24.5				23.5
Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed	(RPM)	680	676	676	684	684	684	544	546	547	547	549	553	552
Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.20	0.20	0.20	0.20	0.20	0.10	0.10
Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Sample Time	(seconds)	13.37	60.30	90.83	8.20	22.95	90.45	60.26	21.03	120.30	8.96	90.31	60.28	8.41
Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight	(gram)	437.50	411.40	387.10	454.30	417.50	463.20	392.60	386.60	437.30	463.40	421.90	370.40	448.50
Sample + Added Water + Flask Weight (gram)		560.70	571.30	575.80	558.90	562.10	587.30	539.70	539.20	540.30	547.40	542.00	531.40	548.00
Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity	(m/s)	1.7316	0.3464	0.2104	2.9632	0.9512	0.2553	0.3597	1.0146	0.2028	2.8537	0.2585	0.3454	2.9266
Sample Concentration	(fraction)	0.1011	0.1312	0.1522	0.0936	0.1097	0.1447	0.0715	0.0718	0.0645	0.0720	0.0701	0.0595	0.0757
C/CB		1.0112	1.3119	1.5224	0.9356	1.0965	1.4472	0.7154	0.7179	0.6449	0.7198	0.7014	0.5948	0.7570

Date	(D M Yr)	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191	140191
Run		1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120
Temperature	(C)							24				24.5		24.5
Sample Tube Type (45, 90, 135 Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
Mixer Speed	(RPM)	551	551	551	552	550	551	552	550	549	551	548	549	552
Tank Position	(z/H)	0.10	0.10	0.10	0.10	0.40	0.40	0.40	0.40	0.60	0.60	0.60	0.60	0.60
Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Sample Time	(seconds)	90.32	31.15	14.94	90.45	60.20	14.34	8.04	110.26	60.11	12.21	21.49	120.20	9.54
Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight	(gram)	319.80	410.40	428.40	432.40	366.30	416.00	424.70	439.50	359.10	410.50	392.30	430.20	472.00
Sample + Added Water + Flask Weight (gram)		524.00	541.00	546.20	534.80	543.30	547.70	549.90	551.40	530.50	547.40	540.40	530.30	555.10
Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity	(m/s)	0.2010	0.7286	1.5719	0.2701	0.3294	1.5779	2.8641	0.2163	0.3357	1.8269	1.0058	0.2045	2.6860
Sample Concentration	(fraction)	0.0529	0.0705	0.0765	0.0559	0.0850	0.0818	0.0840	0.0835	0.0597	0.0825	0.0730	0.0487	0.0831
C/CB		0.5287	0.7049	0.7645	0.5592	0.8502	0.8184	0.8401	0.8349	0.5969	0.8251	0.7296	0.4870	0.8314

AE		AF	AG
Date	(D M Yr)	140191	140191
Run		1121	1122
Temperature	(C)		
Sample Tube Type	(45, 90, 135 Degree)	90	90
Sample Tube Taper	(Degree)	90	90
Sample Tube Inside Diameter	(mm)	4.55	4.55
Mixer Speed	(RPM)	549	548
Tank Position	(z/H)	0.60	0.60
Tank Position	(r/R)	0.90	0.90
Sample Time	(seconds)	23.92	90.18
Volumetric Flask Weight	(gram)	0.00	0.00
Sample + Flask Weight	(gram)	398.90	414.80
Sample + Added Water + Flask Weight	(gram)	540.30	533.50
Total Volume With Added Water	(ml)	500.00	500.00
Sample Velocity	(m/s)	0.9209	0.2598
Sample Concentration	(fraction)	0.0714	0.0562
C/CB		0.7142	0.5623

Filename: 1123-B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA MAR 9, 1991) RADIAL MIXER, 410 micron SAND, CB = 0.300, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O	P
5		Date	(D M Yr)	260291	260291	260291	260291	260291	260291	260291	260291	260291	260291	260291	260291	260291
6		Run		1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135
7		Temperature	(C)		23.5		23.5				24.0					
8		Sample Tube Type	(45, 90, 135)	90	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	18
10		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
11		Mixer Speed	(RPM)	557	547	548	544	547	547	545	544	544	545	545	546	551
12		Tank Position	(z/H)	0.50	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.30	0.30	0.30	0.30	0.30
13		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
14		Sample Time	(seconds)	22.54	14.34	11.24	70.31	120.32	30.13	21.58	14.84	11.49	73.60	120.18	28.29	21.21
15		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16		Sample + Flask Weight	(gram)	539.50	625.70	629.20	541.90	560.50	551.00	503.80	621.60	626.90	599.30	656.00	505.00	481.80
17		Sample + Added Water + Flask Weight (gram)		666.50	706.70	711.90	662.40	661.50	672.00	676.90	714.20	716.20	724.10	751.30	681.00	664.20
18		Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19																
20		Sample Velocity	(m/s)	1.0167	1.7960	2.2820	0.3316	0.2038	0.7729	0.9302	1.6872	2.1969	0.3132	0.2070	0.7032	0.9193
21		Sample Concentration	(fraction)	0.2760	0.3044	0.3132	0.2646	0.2503	0.2805	0.3346	0.3243	0.3247	0.3684	0.3827	0.3454	0.3199
22		C/CB		0.9200	1.0145	1.0441	0.8821	0.8342	0.9350	1.1153	1.0811	1.0823	1.2281	1.2755	1.1512	1.0664
23																
24		Date	(D M Yr)	260291	260291	260291	260291									
25		Run		1136	1137	1138	1139									
26		Temperature	(C)													
27		*Sample Tube Type*	*(45, 90, 135)*	90	90	90	90									
28		Sample Tube Taper (Degree)		18	18	18	18									
29		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55									
30		Mixer Speed	(RPM)	551	550	549	548									
31		Tank Position	(z/H)	0.30	0.30	0.30	0.30									
32		Tank Position	(r/R)	0.90	0.90	0.90	0.90									
33		Sample Time	(seconds)	60.40	11.44	110.31	90.25									
34		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00									
35		Sample + Flask Weight	(gram)	540.70	613.50	647.80	582.40									
36		Sample + Added Water + Flask Weight (gram)		696.00	704.10	744.50	717.70									
37		Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00									
38																
39		Sample Velocity	(m/s)	0.3505	2.1995	0.2247	0.2483									
40		Sample Concentration	(fraction)	0.3512	0.3076	0.3737	0.3683									
41		C/CB		1.1707	1.0254	1.2455	1.2278									

Filename: 1140-B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA MAR 9, 1991) RADIAL MIXER, 1000 micron SAND, CB = 0.100, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date	(D M Yr)	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391
6	Run		1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152
7	Temperature	(C)				22.0			22.5			23.0			23.5
8	Sample Tube Type	(45, 90, 135)	90	90	90	90	90	90	90	90	90	90	90	90	90
9	Sample Tube Taper	(Degree)	90	90	90	90	90	90	90	18	18	18	18	18	18
10	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
11	Mixer Speed	(RPM)	545	545	544	550	553	554	554	554	553	553	551	549	550
12	Tank Position	(z/H)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.30	0.30	0.30	0.30
13	Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
14															
15	Sample Time	(seconds)	24.63	9.68	70.31	15.33	8.92	60.58	90.36	21.97	60.28	8.81	91.10	30.14	15.86
16	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Sample + Flask Weight	(gram)	373.90	448.60	381.80	416.20	451.90	358.60	381.80	401.80	350.30	442.40	394.70	412.60	431.00
18	Sample + Added Water + Flask Weight	(gram)	510.50	520.20	506.90	514.10	518.00	504.80	502.20	525.10	525.20	526.30	530.40	525.80	525.70
19	Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
20															
21	Sample Velocity	(m/s)	0.9064	2.7205	0.3276	1.6120	2.9903	0.3587	0.2581	1.0535	0.3312	2.9030	0.2457	0.7886	1.5706
22	Sample Concentration	(fraction)	0.0203	0.0311	0.0138	0.0239	0.0276	0.0110	0.0060	0.0434	0.0505	0.0411	0.0539	0.0434	0.0413
23	C/CB		0.2031	0.3114	0.1378	0.2385	0.2762	0.1095	0.0599	0.4342	0.5054	0.4107	0.5386	0.4340	0.4126

Filename: 1153-B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA MAR 9, 1991) RADIAL MIXER, 82 micron SAND, CB = 0.100, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A	B	C		D	E	F	G	H	I	J	K	L	M	N	O
5		Date	(D M Yr)	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391	80391
6		Run		1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164
7		Temperature	(C)		15.5			16.5						18.5	
8		Sample Tube Type	(45, 90, 135)	90	90	90	90	90	90	90	90	90	90	90	90
9		Sample Tube Taper	(Degree)	90	90	90	90	90	90	18	18	18	18	18	18
10		Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
11		Mixer Speed	(RPM)	544	545	548	545	545	545	542	547	545	546	545	543
12		Tank Position	(z/H)	0.50	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.30	0.30	0.30	0.30
13		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
14															
15		Sample Time	(seconds)	15.77	140.16	90.33	70.75	31.50	9.46	70.47	187.34	14.67	8.86	33.52	90.24
16		Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17		Sample + Flask Weight	(gram)	473.30	409.60	385.20	426.80	408.50	494.40	438.80	564.00	432.30	481.10	456.20	425.90
18		Sample + Added Water + Flask Weight	(gram)	562.00	544.40	544.40	551.60	552.00	565.50	562.30	584.30	557.60	564.30	562.70	560.50
19		Total Volume With Added Water	(ml)	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
20															
21		Sample Velocity	(m/s)	1.6030	0.1601	0.2317	0.3258	0.6952	2.7870	0.3283	0.1575	1.5693	2.8915	0.7214	0.2488
22		Sample Concentration	(fraction)	0.0943	0.0768	0.0823	0.0865	0.0917	0.0954	0.1035	0.1092	0.0964	0.0964	0.0997	0.1037
23		C/CB		0.9430	0.7680	0.8232	0.8647	0.9171	0.9540	1.0354	1.0919	0.9637	0.9642	0.9967	1.0368

Filename: 1165-B.WK1 LAST UPDATE: SEPT 9, 1991 (RAW DATA MAR 9, 1991) RADIAL MIXER, 410 micron SAND, CB = 0.100, 545 RPM, H20 DENSITY = 0.997 (AT 24.9 C)

A B	C		D	E	F	G	H	I	J	K	L	M	N	O	P
5	Date	(D M Yr)	80391	80391	80391	80391	80391	80391	80391	90391	90391	90391	90391	90391	90391
6	Run		1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177
7	Temperature	(C)		12.5			13.5								21.0
8	Sample Tube Type (45,90,135,45 FRNT,45 BA		90	90	90	90	90	90	90	45	45FRNT	45BACK	135	45BACK	45BACK
9	Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
10	Sample Tube Inside Diameter	(mm)	2.97	2.97	2.97	2.97	2.97	2.97	2.97	4.55	4.55	4.55	4.55	4.55	4.55
11	Mixer Speed	(RPM)	550	554	553	553	552	553	552	557	557	557	557	548	552
12	Tank Position	(z/H)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.30	0.30	0.30	0.30	0.30	0.30
13	Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
14	Sample Time	(seconds)	70.47	16.99	150.56	100.21	33.08	60.19	120.10	22.85	22.35	22.33	22.38	22.83	70.27
15	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	Sample + Flask Weight	(gram)	412.30	450.30	387.90	433.40	422.80	405.20	379.70	437.00	417.00	432.40	419.40	435.80	456.50
17	Sample + Added Water + Flask Weight (gram)		534.30	548.60	520.10	531.30	539.50	538.00	520.70	562.80	551.90	564.60	554.50	563.60	581.00
18	Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
19															
20	Sample Velocity	(m/s)	0.7735	3.4102	0.3522	0.5788	1.6710	0.8844	0.4310	1.0062	1.0035	1.0119	1.0017	1.0016	0.3281
21	Sample Concentration	(fraction)	0.0580	0.0764	0.0360	0.0500	0.0655	0.0622	0.0379	0.1053	0.0896	0.1101	0.0940	0.1072	0.1347
22	C/CB		0.5803	0.7640	0.3599	0.4997	0.6554	0.6224	0.3790	1.0529	0.8963	1.1013	0.9405	1.0718	1.3470
23															
24	Date	(D M Yr)	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391
25	Run		1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190
26	Temperature	(C)					21.5				22.0		22.0		
27	Sample Tube Type (45,90,135,45 FRNT,45 BA		45BACK	45BACK	45BACK	45BACK	45BACK	45FRNT	45FRNT	45FRNT	45FRNT	45FRNT	45FRNT	135	135
28	Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
29	Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55
30	Mixer Speed	(RPM)	551	550	550	551	551	551	549	550	548	550	549	549	550
31	Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
32	Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
33	Sample Time	(seconds)	14.85	8.56	120.25	90.38	32.74	70.22	14.49	8.16	120.26	90.44	33.26	60.37	15.34
34	Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	Sample + Flask Weight	(gram)	439.90	456.20	487.10	466.10	434.00	422.60	428.20	442.30	478.00	456.70	434.90	396.10	453.10
36	Sample + Added Water + Flask Weight (gram)		559.90	558.40	598.20	587.00	566.30	558.90	551.10	551.40	572.90	565.60	555.30	558.90	556.80
37	Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
38															
39	Sample Velocity	(m/s)	1.5723	2.8559	0.1987	0.2577	0.6900	0.3182	1.5990	2.9437	0.2070	0.2657	0.7013	0.3430	1.5876
40	Sample Concentration	(fraction)	0.0990	0.0922	0.1571	0.1430	0.1130	0.1018	0.0855	0.0829	0.1125	0.1051	0.0917	0.1098	0.0901
41	C/CB		0.9900	0.9225	1.5707	1.4304	1.1300	1.0177	0.8547	0.8291	1.1250	1.0511	0.9168	1.0981	0.9012

Q		R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Date	(D M Yr)	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391	90391
Run		1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203
Temperature	(C)			22.5				23.0						
Sample Tube Type (45,90,135,45 FRNT,45 BA		135	135	135	135	45	45	45	45	45	45	90	90	90
Sample Tube Taper (Degree)		90	90	90	90	90	90	90	90	90	90	90	90	90
Sample Tube Inside Diameter	(mm)	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	4.55	10.87	10.87	10.87
Mixer Speed	(RPM)	550	549	548	548	550	549	549	548	548	547	548	549	549
Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.50	0.50	0.50
Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Sample Time	(seconds)	8.85	123.61	90.11	32.56	78.81	120.20	90.18	8.92	15.15	31.64	6.86	14.52	30.21
Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight	(gram)	471.80	482.40	441.70	443.20	504.80	442.70	471.10	474.80	456.80	438.70	450.50	427.00	406.40
Sample + Added Water + Flask Weight (gram)		557.30	580.70	570.40	559.60	587.30	587.30	584.40	559.70	559.90	564.30	546.40	535.10	533.50
Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity	(m/s)	2.8787	0.1997	0.2532	0.7239	0.3256	0.1816	0.2635	2.8603	1.6100	0.7270	0.6343	0.2906	0.1329
Sample Concentration	(fraction)	0.0869	0.1254	0.1187	0.0976	0.1303	0.1531	0.1361	0.0903	0.0948	0.1077	0.0726	0.0572	0.0575
C/CB		0.8689	1.2536	1.1866	0.9759	1.3028	1.5314	1.3610	0.9031	0.9477	1.0769	0.7261	0.5722	0.5751

Date	(D M Yr)	90391	90391	90391	90391	90391	90391	90391
Run		1204	1205	1206	1207	1208	1209	1210
Temperature	(C)		23.5				23.5	
Sample Tube Type (45,90,135,45 FRNT,45 BA		90	90	90	90	90	90	90
Sample Tube Taper (Degree)		90	90	90	90	90	90	90
Sample Tube Inside Diameter	(mm)	10.87	10.87	10.87	10.87	10.87	10.87	10.87
Mixer Speed	(RPM)	549	548	548	547	548	548	547
Tank Position	(z/H)	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Sample Time	(seconds)	5.85	20.83	6.09	22.07	5.98	4.96	4.03
Volumetric Flask Weight	(gram)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sample + Flask Weight	(gram)	476.20	456.60	505.90	439.00	531.90	547.20	477.20
Sample + Added Water + Flask Weight (gram)		552.20	533.10	555.50	531.70	558.00	565.60	555.60
Total Volume With Added Water (ml)		500.00	500.00	500.00	500.00	500.00	500.00	500.00
Sample Velocity	(m/s)	0.7806	0.2190	0.7967	0.1987	0.8538	1.0462	1.1267
Sample Concentration	(fraction)	0.0776	0.0500	0.0775	0.0499	0.0769	0.0853	0.0830
C/CB		0.7757	0.5004	0.7750	0.4993	0.7687	0.8530	0.8295

APPENDIX D

CONDUCTIVITY DATA

CONDUCTIVITY DATA

Particle Size (micron)	Bulk Solids Concentration (C_B)	Mixer Speed (rpm)	Page
410	0.10	545	241
410	0.10	440	243
410	0.30	545	245
410	0.30	680	247
410	0.30 Rotated to Plane of Baffle	680	249
82	0.30	545	250
500	0.30	750	252
255	0.30	545	254
410	0.10 Axial Flow Impeller	Various	256
410	0.10 Axial Flow Impeller	Various	257
410	0.10	Various	259
255	0.10	545	260
255	0.10	Various	261
255	0.10	545	262
255	0.30	545	263
255	0.30	Various	264
500	0.10	545	266
500	0.10	Various	267
1000	0.10	Various	268
410	0.10	Various	269
410	0.30	545	270
1000	0.10	545	271
82	0.10	545	272

Filename: PIPE-5a.WK1

LAST UPDATE: FEB 28, 1991 (CHECKED WITH RAW DATA AUG 22, 1990)
CONDUCTIVITY PROBE MEASUREMENTS IN PIPELINE

A	B C	D	E	F	G	H	I	J	K	L	M
8	Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
9	Time of Day (hr:min)	1156	1156	1236	1236	1236	1236	1156	1156	1236	1236
10	Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
12	Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
13	Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300
14	Bulk Concentration (Volume Fraction)	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
15	Temperature (C)	23.5	23.5	24.8	24.8	24.8	24.8	23.5	23.5	24.8	24.8
16	Velocity (m/s)	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
17											
18	Probe Type (St, L) (1)	L	L	St	St	St	St	L	L	St	St
19											
20	Height From Top of Pipe (inch)	1.00	1.00	1.00	1.00	1.00	1.00	1.25	1.25	1.25	1.25
21											
22	Rotated Position			1	2	3	4			1	2
23	L - Probe - Front/Back Sensor Electrodes (F/B)	F	B					F	B		
24											
25	Eo (mvAC)	210	130	59	59.5	59.5	58.5	208.5	130	58	59
26	Ec - LOW (mvAC)	242	152	68	67	65	68	272	168	76	74
27	Ec - HIGH (mvAC)	245	155	70	68	67	70	277	172	79	76
28											
29	(Ec-Eo)/Eo - LOW	0.152	0.169	0.153	0.126	0.092	0.162	0.305	0.292	0.310	0.254
30	(Ec-Eo)/Eo - HIGH	0.167	0.192	0.186	0.143	0.126	0.197	0.329	0.323	0.362	0.288
31											
32	(Ec-Eo)/Eo - AVERAGE	0.160	0.181	0.169	0.134	0.109	0.179	0.317	0.308	0.336	0.271
33	Maxwell Conc - AVERAGE	0.096	0.108	0.102	0.082	0.068	0.107	0.174	0.170	0.183	0.153
34											
35	Maxwell Conc - AVERAGE - L PROBE (F & B)	0.102						0.172			

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

N	O	P	Q	R	S	T	U	V	W	X	Y
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1236	1236	1156	1156	1236	1236	1236	1236	1349	1349	1317
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
Temperature (C)	24.8	24.8	23.5	23.5	24.8	24.8	24.8	24.8	25.5	25.5	25.2
Velocity (m/s)	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2
Probe Type (St, L) (1)	St	St	L	L	St	St	St	St	L	L	St
Height From Top of Pipe (inch)	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.00
Rotated Position	3	4			1	2	3	4			1
L – Probe – Front/Back Sensor Electrodes (F/B)			F	B					F	B	
Eo (mvAC)	59	58	208.5	130	58	58.5	59	58	204	128	61
Ec – LOW (mvAC)	70	76	319	203	88	83	77	84	234	147	68
Ec – HIGH (mvAC)	72	78	330	210	92	85	79	87	239	150	70
(Ec–Eo)/Eo – LOW	0.186	0.310	0.530	0.562	0.517	0.419	0.305	0.448	0.147	0.148	0.115
(Ec–Eo)/Eo – HIGH	0.220	0.345	0.583	0.615	0.586	0.453	0.339	0.500	0.172	0.172	0.148
(Ec–Eo)/Eo – AVERAGE	0.203	0.328	0.556	0.588	0.552	0.436	0.322	0.474	0.159	0.160	0.131
Maxwell Conc – AVERAGE	0.119	0.179	0.271	0.282	0.269	0.225	0.177	0.240	0.096	0.096	0.080
Maxwell Conc – AVERAGE – L PROBE (F & B)			0.276						0.096		

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1317	1317	1317	1349	1349	1317	1317	1317	1317	1349	1349
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
Temperature (C)	25.2	25.2	25.2	25.5	25.5	25.2	25.2	25.2	25.2	25.5	25.5
Velocity (m/s)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Probe Type (St, L) (1)	St	St	St	L	L	St	St	St	St	L	L
Height From Top of Pipe (inch)	1.00	1.00	1.00	1.25	1.25	1.25	1.25	1.25	1.25	1.50	1.50
Rotated Position	2	3	4			1	2	3	4		
L – Probe – Front/Back Sensor Electrodes (F/B)				F	B					F	B
Eo (mvAC)	62	62	61	203	128	59	60	60	59	204	127
Ec – LOW (mvAC)	67	64	67	263	164	76	72	69	75	315	198
Ec – HIGH (mvAC)	68	66	69	267	168	78	75	71	77	322	204
(Ec–Eo)/Eo – LOW	0.081	0.032	0.098	0.296	0.281	0.288	0.200	0.150	0.271	0.544	0.559
(Ec–Eo)/Eo – HIGH	0.097	0.065	0.131	0.315	0.313	0.322	0.250	0.183	0.305	0.578	0.606
(Ec–Eo)/Eo – AVERAGE	0.089	0.048	0.115	0.305	0.297	0.305	0.225	0.167	0.288	0.561	0.583
Maxwell Conc – AVERAGE	0.056	0.031	0.071	0.169	0.165	0.169	0.130	0.100	0.161	0.272	0.280
Maxwell Conc – AVERAGE – L PROBE (F & B)				0.167						0.276	

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

AL	AM	[illegible]		AP	AQ	AR	AS	AT	AU	AV	AW
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1317	1317	1317	1317	1417	1417	1448	1448	1448	1448	1417
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.126	0.126	0.126	0.126	0.168	0.168	0.168	0.168	0.168	0.168	0.168
Temperature (C)	25.2	25.2	25.2	25.2	26	26	26.3	26.3	26.3	26.3	26
Velocity (m/s)	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Probe Type (St, L) (1)	St	St	St	St	L	L	St	St	St	St	L
Height From Top of Pipe (inch)	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.25
Rotated Position	1	2	3	4			1	2	3	4	
L – Probe – Front/Back Sensor Electrodes (F/B)					F	B					F
Eo (mvAC)	58	58.5	59	58	204	128	58	59	59	58	203.5
Ec – LOW (mvAC)	88	82	75	84	256	159	70	68	65	70	280
Ec – HIGH (mvAC)	91	85	77	87	262	163	73	71	67	72	284
(Ec–Eo)/Eo – LOW	0.517	0.402	0.271	0.448	0.255	0.242	0.207	0.153	0.102	0.207	0.376
(Ec–Eo)/Eo – HIGH	0.569	0.453	0.305	0.500	0.284	0.273	0.259	0.203	0.136	0.241	0.396
(Ec–Eo)/Eo – AVERAGE	0.543	0.427	0.288	0.474	0.270	0.258	0.233	0.178	0.119	0.224	0.386
Maxwell Conc – AVERAGE	0.266	0.222	0.161	0.240	0.152	0.147	0.134	0.106	0.073	0.130	0.205
Maxwell Conc – AVERAGE – L PROBE (F & B)					0.150						0.208

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1417	1448	1448	1448	1448	1417	1417	1448	1448	1448
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168
Temperature (C)	26	26.3	26.3	26.3	26.3	26	26	26.3	26.3	26.3
Velocity (m/s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Probe Type (St, L) (1)	L	St	St	St	St	L	L	St	St	St
Height From Top of Pipe (inch)	1.25	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50
Rotated Position		1	2	3	4			1	2	3
L – Probe – Front/Back Sensor Electrodes (F/B)	B					F	B			
Eo (mvAC)	127	57	58	58	57	203	126	56	57	57
Ec – LOW (mvAC)	176	77	73	69	75	325	202	85	81	73
Ec – HIGH (mvAC)	180	80	75	71	77	335	208	89	84	75
(Ec–Eo)/Eo – LOW	0.386	0.351	0.259	0.190	0.316	0.601	0.603	0.518	0.421	0.281
(Ec–Eo)/Eo – HIGH	0.417	0.404	0.293	0.224	0.351	0.650	0.651	0.589	0.474	0.316
(Ec–Eo)/Eo – AVERAGE	0.402	0.377	0.276	0.207	0.333	0.626	0.627	0.554	0.447	0.298
Maxwell Conc – AVERAGE	0.211	0.201	0.155	0.121	0.182	0.294	0.295	0.270	0.230	0.166
Maxwell Conc – AVERAGE – L PROBE (F & B)						0.295				

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L–Shaped Conductivity Probe Used in Pipeline Only

BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1448	1550	1550	1523	1523	1523	1523	1550	1550	1523	1523
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.168	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236	0.236
Temperature (C)	26.3	27	27	26.5	26.5	26.5	26.5	27	27	26.5	26.5
Velocity (m/s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Probe Type (St, L) (1)	St	L	L	St	St	St	St	L	L	St	St
Height From Top of Pipe (inch)	1.50	1.00	1.00	1.00	1.00	1.00	1.00	1.25	1.25	1.25	1.25
Rotated Position	4			1	2	3	4			1	2
L – Probe – Front/Back Sensor Electrodes (F/B)		F	B					F	B		
Eo (mvAC)	56	202.5	130	56	57	57	56	201.5	129.5	55	56
Ec – LOW (mvAC)	84	305	195	83	77	70	78	350	218	89	84
Ec – HIGH (mvAC)	86	315	203	87	80	73	82	360	227	94	88
(Ec–Eo)/Eo – LOW	0.500	0.506	0.500	0.482	0.351	0.228	0.393	0.737	0.683	0.618	0.500
(Ec–Eo)/Eo – HIGH	0.536	0.556	0.562	0.554	0.404	0.281	0.464	0.787	0.753	0.709	0.571
(Ec–Eo)/Eo – AVERAGE	0.518	0.531	0.531	0.518	0.377	0.254	0.429	0.762	0.718	0.664	0.536
Maxwell Conc – AVERAGE	0.257	0.261	0.261	0.257	0.201	0.145	0.222	0.337	0.324	0.307	0.263
Maxwell Conc – AVERAGE – L PROBE (F & B)		0.261						0.330			

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1523	1523	1550	1550	1523	1523	1523	1523	1619	1619	1648
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.264	0.264	0.264
Temperature (C)	26.5	26.5	27	27	26.5	26.5	26.5	26.5	27.2	27.2	27.7
Velocity (m/s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8
Probe Type (St, L) (1)	St	St	L	L	St	St	St	St	L	L	St
Height From Top of Pipe (inch)	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.50	1.00	1.00	1.00
Rotated Position	3	4			1	2	3	4			1
L – Probe – Front/Back Sensor Electrodes (F/B)			F	B					F	B	
Eo (mvAC)	56	55	204	129.5	55	56	56	55	203	131	56
Ec – LOW (mvAC)	74	84	370	240	98	89	80	90	355	225	93
Ec – HIGH (mvAC)	77	88	390	250	105	95	84	95	370	235	98
(Ec–Eo)/Eo – LOW	0.321	0.527	0.814	0.853	0.782	0.589	0.429	0.636	0.749	0.718	0.661
(Ec–Eo)/Eo – HIGH	0.375	0.600	0.912	0.931	0.909	0.696	0.500	0.727	0.823	0.794	0.750
(Ec–Eo)/Eo – AVERAGE	0.348	0.564	0.863	0.892	0.845	0.643	0.464	0.682	0.786	0.756	0.705
Maxwell Conc – AVERAGE	0.188	0.273	0.365	0.373	0.3[illegible]	0.300	0.236	0.313	0.344	0.335	0.320
Maxwell Conc – AVERAGE – L PROBE (F & B)			0.369						0.339		

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

CF	CG	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR
Run Date (D M Yr)	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890	220890
Time of Day (hr:min)	1648	1648	1648	1619	1619	1648	1648	1648	1648	1619	1619
Field Frequency (Hz)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300	300	300	300	300	300	300	300
Bulk Concentration (Volume Fraction)	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264	0.264
Temperature (C)	27.7	27.7	27.7	27.2	27.2	27.7	27.7	27.7	27.7	27.2	27.2
Velocity (m/s)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Probe Type (St, L) (1)	St	St	St	L	L	St	St	St	St	L	L
Height From Top of Pipe (inch)	1.00	1.00	1.00	1.25	1.25	1.25	1.25	1.25	1.25	1.50	1.50
Rotated Position	2	3	4			1	2	3	4		
L – Probe – Front/Back Sensor Electrodes (F/B)				F	B					F	B
Eo (mvAC)	57	57	56	202.5	129	55.5	56	56.5	56	203	130
Ec – LOW (mvAC)	84	74	86	400	250	100	89	79	92	440	280
Ec – HIGH (mvAC)	88	77	91	415	260	108	95	84	97	455	290
(Ec–Eo)/Eo – LOW	0.474	0.208	0.536	0.975	0.938	0.802	0.589	0.398	0.643	1.167	1.154
(Ec–Eo)/Eo – HIGH	0.544	0.351	0.625	1.049	1.016	0.946	0.696	0.487	0.732	1.241	1.231
(Ec–Eo)/Eo – AVERAGE	0.509	0.325	0.580	1.012	0.977	0.874	0.643	0.442	0.688	1.204	1.192
Maxwell Conc – AVERAGE	0.253	0.178	0.279	0.40[illegible]	0.394	0.368	0.300	0.228	0.314	0.445	0.443
Maxwell Conc – AVERAGE – L PROBE (F & B)				0.399						0.444	

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

CS	CT	CU	CV	CW
Run Date (D M Yr)	220890	220890	220890	220890
Time of Day (hr:min)	1648	1648	1648	1648
Field Frequency (Hz)	1000	1000	1000	1000
Field Wave Type	Square	Square	Square	Square
Field Current (mA)	1.0	1.0	1.0	1.0
Particle Diameter (Micron)	300	300	300	300
Bulk Concentration (Volume Fraction)	0.264	0.264	.264	0.264
Temperature (C)	27.7	27.7	27.7	27.7
Velocity (m/s)	1.8	1.8	1.8	1.8
Probe Type (St, L) (1)	St	St	St	St
Height From Top of Pipe (inch)	1.50	1.50	1.50	1.50
Rotated Position	1	2	3	4
L – Probe – Front/Back Sensor Electrodes (F/B)				
Eo (mvAC)	55	56	56	55
Ec – LOW (mvAC)	115	99	88	102
Ec – HIGH (mvAC)	123	105	93	106
(Ec–Eo)/Eo – LOW	1.09.	0.768	0.571	0.855
(Ec–Eo)/Eo – HIGH	1.236	0.875	0.661	0.927
(Ec–Eo)/Eo – AVERAGE	1.164	0.821	0.616	0.891
Maxwell Conc – AVERAGE	0.437	0.354	0.291	0.373
Maxwell Conc – AVERAGE – L PROBE (F & B)				

(1) St = Straight Conductivity Probe Also Used in Mixing Tank
L = L-Shaped Conductivity Probe Used in Pipeline Only

Filename: PIP-CB-2a WK1

LAST UPDATE: AUGUST 22, 1990 (CHECKED WITH RAW DATA AUGUST 22, 1990)

A	B	C	D	E	F	G	H	I	J	K	L	M
9		Date (D M Yr)	220890	220890	220890	220890	220890	220890	[illegible]0890	220890	220890	220890
10		Time of Day	1156	1236	1317	1349	1417	1448	1523	1550	1619	1648
11												
12		Temperature (C)	23.5	24.8	25.2	25.5	26	26.3	26.5	27	27.2	27.7
13												
14		Particle Diameter (micron)	300	300	300	300	300	300	300	300	300	300
15		Solids Density (gram/ml)	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63	2.63
16		Water Density (gram/ml)	0.9975	0.9971	0.9970	0.9969	0.9968	0.9967	0.9967	0.9965	0.9965	0.9964
17												
18		Bucket Weight (gram)	674.00	674.00	674.00	674.00	674.00	674.00	674.00	674.00	674.00	674.00
19		Sample + Bucket (lbs)	23.6250	24.6250	24.0000	26.375	22.4063	26.5938	26.6563	24.2813	24.0313	27.0938
20		Sample + Added Water + Bucket (lbs)	27.5000	27.0625	27.1250	27.9063	27.6875	29.1250	30.2188	30.0000	30.3125	31.0625
21		Total Volume With Added Water (ml)	9995.00	9995.00	9995.00	9995.00	9995.00	9995.00	9995.00	9995.00	9995.00	9995.00
22												
23		Sample Weight (gram)	10051.75	10505.75	10222.00	11300.25	9498.46	11399.59	11[illegible]7.96	10349.71	10236.21	11626.59
24		Weight With Added Water (gram)	11811.00	11612.38	11640.75	11995.46	11896.13	12548.75	13045.34	12946.00	13087.88	13428.38
25		Volume of Added Water (ml)	1763.75	1109.81	1422.98	697.34	2405.32	1152.93	1622.76	2605.29	2861.71	1808.39
26		Sample Volume (ml)	8231.25	8885.19	8572.02	9297.66	7589.68	8842.07	8372.24	7389.71	7133.29	8186.61
27		Sample Density (gram/ml)	1.2212	1.1824	1.1925	1.2154	1.2515	1.2892	1.3650	1.4006	1.4350	1.4202
28		Sample Concentration (Volume Fraction)	0.1370	0.1135	0.1197	0.1338	0.1559	0.1791	0.2255	0.2473	0.2684	0.2594

Filename: COND-21B.WK1   LAST UPDATE: FEB 20, 1991 (CHECKED WITH RAW DATA AUG 23, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.100, 545 RPM, 1000 HZ, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

Position 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTODE)

A	B / C		D	E	F	G	H	I	J
10	Run Date	(D M Yr)	180890	180890	180890	180890	180890	180890	180890
11	Mixer Speed	(RPM)	549	549	550	549	550	549	550
12	Temperature	(C)	24	24	23.5	23	22.5	23	22.5
13	Tank Position	(z/H)	0.90	0.80	0.70	0.60	0.50	0.40	0.30
14	Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90
15									
16	Position 1 - Eo	(mvAC)	46	44	44	43	45	44	45
17	- Ec - LOW	(mvAC)	46	48	51	50	51	51	53
18	- Ec - HIGH	(mvAC)	49	51	54	52	54	54	55
20	Position 2 - Eo	(mvAC)	46	44	44	43	44.5	44	45
21	- Ec - LOW	(mvAC)	46	48	52	50	52	52	54
22	- Ec - HIGH	(mvAC)	48	52	55	53	53	54	56
24	Position 3 - Eo	(mvAC)	46	44	44	43	45	44	45
25	- Ec - LOW	(mvAC)	47	48	53	49	52	51	52
26	- Ec - HIGH	(mvAC)	49	51	55	52	53	53	54
28	Position 4 - Eo	(mvAC)	46	44	44	43.5	45	43.5	45
29	- Ec - LOW	(mvAC)	46	48	51	49	49	50	53
30	- Ec - HIGH	(mvAC)	48	51	53	51	52	52	55
31									
32	AVERAGE CONCENTRATION - Position 1		0.021	0.077	0.114	0.110	0.100	0.114	0.117
33	- Position 2		0.014	0.083	0.125	0.116	0.107	0.120	0.129
34	- Position 3		0.028	0.077	0.131	0.104	0.100	0.106	0.108
35	- Position 4		0.014	0.077	0.108	0.090	0.075	0.103	0.117
37	SCATTER (1) - Position 1	(%)	200.0	50.6	31.4	22.3	36.1	31.4	19.6
38	- Position 2	(%)	200.0	61.7	[illegible]	31.3	11.2	19.6	17.4
39	- Position 3	(%)	97.9	50.6	17.4	36.0	12.0	22.3	22.4
40	- Position 4	(%)	200.0	50.6	22.3	28.0	50.7	24.0	19.6
41									
42	Run Date	(D M Yr)	180890	180890		180890	180890	180890	180890
43	Mixer Speed	(RPM)	550	550		548	548	550	548
44	Temperature	(C)	23.5	23.5		25.5	25.5	24.8	25.5
45	Tank Position	(z/H)	0.20	0.10		0.90	0.80	0.80	0.70
46	Tank Position	(r/R)	0.90	0.90		0.60	0.60	0.60	0.60
47									
48	Position 1 - Eo	(mvAC)	[illegible]	43		44	42	42	41
49	- Ec - LOW	(mvAC)	49	47		45	46	47	46
50	- Ec - HIGH	(mvAC)	50	48		47	48	48	48
52	Position 2 - Eo	(mvAC)	43	43		44	42	42	41
53	- Ec - LOW	(mvAC)	49	49		45	47	47	47
54	- Ec - HIGH	(mvAC)	51	50		47	49	49	48
56	Position 3 - Eo	(mvAC)	44	44		44	42	42	41
57	- Ec - LOW	(mvAC)	49	50		45	46	47	47
58	- Ec - HIGH	(mvAC)	50	51		47	48	49	49
60	Position 4 - Eo	(mvAC)	43	43		44	42	42	41
61	- Ec - LOW	(mvAC)	48	47		45	46	46	47
62	- Ec - HIGH	(mvAC)	49	49		47	48	49	48
63									
64	AVERAGE CONCENTRATION - Position		0.092	0.065		0.029	0.073	0.080	0.089
65	- Position 2		0.098	0.092		0.029	0.087	0.087	0.096
66	- Position 3		0.077	0.090		0.029	0.073	0.087	0.102
67	- Position 4		0.079	0.072		0.029	0.073	0.080	0.096
69	SCATTER (1) - Position 1	(%)	14.0	20.8		97.8	37.2	16.7	30.4
70	- Position 2	(%)	25.8	14.0		97.8	30.5	30.5	13.9
71	- Position 3	(%)	16.8	14.0		97.8	37.2	30.5	25.7
72	- Position 4	(%)	16.8	37.2		97.8	37.2	50.5	13.9

K		L	M	N	O	P	Q	R	S
Run Date	(D M Yr)	180890	180890	180890	180890	180890	180890	180890	180890
Mixer Speed	(RPM)	550	550	550	550	547	547	547	548
Temperature	(C)	24.8	24.5	25	25	26.5	26.5	26.5	26
Tank Position	(z/H)	0.40	0.30	0.20	0.10	0.90	0.80	0.70	0.60
Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.30	0.30	0.30	0.30
Position 1 – Eo	(mvAC)	41	41	41	41	43	41	40	40
– Ec – LOW	(mvAC)	47	52	45	45	43	42	44	45
– Ec – HIGH	(mvAC)	49	54	48	48	45	45	46	46
Position 2 – Eo	(mvAC)	41	41	41	41	43	41	40	40
– Ec – LOW	(mvAC)	47	52	44	46	44	43	45	46
– Ec – HIGH	(mvAC)	49	54	48	48	45	46	46	47
Position 3 – Eo	(mvAC)	41	41.5	41	41	43	41	40	40
– Ec – LOW	(mvAC)	46	47	43	46	44	43	44	45
– Ec – HIGH	(mvAC)	48	49	46	49	46	46	47	46
Position 4 – Eo	(mvAC)	41	41.5	41	41	43	41	40	40
– Ec – LOW	(mvAC)	46	49	43	46	43	42	43	43
– Ec – HIGH	(mvAC)	48	51	45	48	44	44	45	45
AVERAGE CONCENTRATION – Position 1		0.102	0.163	0.082	0.082	0.015	0.039	0.077	0.084
– Position 2		0.102	0.163	0.074	0.089	0.023	0.053	0.084	0.098
– Position 3		0.089	0.094	0.053	0.095	0.030	0.053	0.083	0.084
– Position 4		0.089	0.120	0.046	0.089	0.008	0.031	0.062	0.062
SCATTER (1) – Position 1	(%)	25.7	14.0	50.4	50.4	200.0	117.0	37.0	16.7
– Position 2	(%)	25.7	14.0	74.9	30.4	65.3	81.9	16.7	13.9
– Position 3	(%)	30.4	27.9	81.9	42.0	97.7	81.9	50.3	16.7
– Position 4	(%)	30.4	20.7	63.9	30.4	200.0	97.6	47.1	47.1

Run Date	(D M Yr)	180890	180890
Mixer Speed	(RPM)	548	548
Temperature	(C)	26	26
Tank Position	(z/H)	0.50	0.40
Tank Position	(r/R)	0.30	0.30
Position 1 – Eo	(mvAC)	40	40
– Ec – LOW	(mvAC)	45	44
– Ec – HIGH	(mvAC)	46	45
Position 2 – Eo	(mvAC)	40	40
– Ec – LOW	(mvAC)	45	45
– Ec – HIGH	(mvAC)	46	46
Position 3 – Eo	(mvAC)	40	40
– Ec – LOW	(mvAC)	44	45
– Ec – HIGH	(mvAC)	46	46
Position 4 – Eo	(mvAC)	40	40
– Ec – LOW	(mvAC)	44	43
– Ec – HIGH	(mvAC)	44	45
AVERAGE CONCENTRATION – Position		0.084	0.070
– Position 2		0.084	0.084
– Position 3		0.077	0.084
– Position 4		0.063	0.062
SCATTER (1) – Position 1	(%)	16.7	20.7
– Position 2	(%)	16.7	16.7
– Position 3	(%)	37.0	16.7
– Position 4	(%)	0.0	47.1

Filename: COND-22B.WK1 LAST UPDATE: FEB 20, 1991 (CHECKED WITH RAW DATA AUG 23, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.100, 440 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration – Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B C		D	E	F	G	H	I	J	K
8	Run Date	(D M Yr)	180890	180890	180890	180890	180890	180890	180890	180890
9	Mixer Speed	(RPM)	442	442	442	442	442	442	443	443
10	Temperature	(C)	27	27	27	27	27	27	27	27
11	Tank Position	(z/H)	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20
12	Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
13										
14	Position 1 – Eo	(mvAC)	42	40	40	39	39	39	39	39
15	– Ec – LOW	(mvAC)	42	41	42	41	41	42	43	42
16	– Ec – HIGH	(mvAC)	43	43	44	43	43	43	44	43
17	Position 2 – Eo	(mvAC)	42	41	40	39	39	40	39	39
18	– Ec – LOW	(mvAC)	42	41	43	41	42	42	43	42
19	– Ec – HIGH	(mvAC)	44	43	45	43	43	44	45	44
20	Position 3 – Eo	(mvAC)	42	41	40	39	39	40	39	39
21	– Ec – LOW	(mvAC)	42	41	42	41	41	42	42	42
22	– Ec – HIGH	(mvAC)	44	44	45	43	43	44	44	43
23	Position 4 – Eo	(mvAC)	42	40	40	39	39	39	39	39
24	– Ec – LOW	(mvAC)	42	41	41	40	40	41	42	41
25	– Ec – HIGH	(mvAC)	43	43	44	43	42	43	44	42
26										
27	AVERAGE CONCENTRATION – Position		0.008	0.032	0.047	0.049	0.049	0.056	0.071	0.056
28	– Position 2		0.015	0.016	0.062	0.049	0.056	0.047	0.079	0.064
29	– Position 3		0.015	0.023	0.055	0.049	0.049	0.047	0.064	0.056
30	– Position 4		0.009	0.032	0.039	0.040	0.033	0.049	0.064	0.041
31	SCATTER (1) – Position 1	(%)	200.0	97.6	63.8	63.8	63.8	27.0	20.7	27.0
32	– Position 2	(%)	200.0	200.0	47.1	63.8	27.0	63.8	37.0	47.0
33	– Position 3	(%)	200.0	200.0	81.8	63.8	63.8	63.8	47.0	27.0
34	– Position 4	(%)	200.0	97.6	116.9	116.8	97.5	63.8	47.0	38.4
35										
36	Run Date	(D M Yr)	180890		180890	180890	180890	180890	180890	180890
37	Mixer Speed	(RPM)	443		441	441	441	441	441	441
38	Temperature	(C)	27		26.8	26.5	26.5	26.2	26.8	26.2
39	Tank Position	(z/H)	0.10		0.90	0.80	0.70	0.60	0.60	0.50
40	Tank Position	(r/R)	0.90		0.60	0.60	0.60	0.60	0.60	0.60
41										
42	Position 1 – Eo	(mvAC)	39		42	41	40	40	39	39
43	– Ec – LOW	(mvAC)	42		42	41	41	41	41	42
44	– Ec – HIGH	(mvAC)	43		43	43	43	42	41	42
45	Position 2 – Eo	(mvAC)	39		42	41	40	40	39	39
46	– Ec – LOW	(mvAC)	43		42	42	42	42	41	42
47	– Ec – HIGH	(mvAC)	44		43	43	43	42	42	42
48	Position 3 – Eo	(mvAC)	39		42	41	40	40	39	39
49	– Ec – LOW	(mvAC)	44		42	41	41	41	41	41
50	– Ec – HIGH	(mvAC)	45		43	43	43	43	42	42
51	Position 4 – Eo	(mvAC)	39		42	41	40	40	39	39
52	– Ec – LOW	(mvAC)	42		42	41	41	41	41	41
53	– Ec – HIGH	(mvAC)	43		43	43	43	42	41	42
54										
55	AVERAGE CONCENTRATION – Position		0.056		0.008	0.016	0.032	0.024	0.033	0.049
56	– Position 2		0.071		0.008	0.024	0.040	0.032	0.041	0.049
57	– Position 3		0.086		0.008	0.016	0.032	0.032	0.041	0.041
58	– Position 4		0.056		0.008	0.016	0.032	0.024	0.033	0.041
59	SCATTER (1) – Position 1	(%)	27.0		200.0	200.0	97.6	65.2	0.0	0.0
60	– Position 2	(%)	20.7		200.0	65.3	38.5	0.0	38.4	0.0
61	– Position 3	(%)	16.6		200.0	200.0	97.6	97.[illegible]	38.4	38.4
62	– Position 4	(%)	27.0		200.0	200.0	97.6	6[illegible]	0.0	38.4

L		M	N	O	P	Q	R	S	T	U
Run Date	(D M Yr)	180890	180890		180890	180890	180890	180890	180890	180890
Mixer Speed	(RPM)	441	441		441	441	440	441	440	441
Temperature	(C)	26.2	26.8		26.2	26.2	26.2	26.2	26.2	26.2
Tank Position	(z/H)	0.30	0.20		0.90	0.80	0.80	0.70	0.70	0.60
Tank Position	(r/R)	0.60	0.60		0.30	0.30	0.30	0.30	0.30	0.30
Position 1 – Eo	(mvAC)	39	39		42	40	40	39	39	39
– Ec – LOW	(mvAC)	43	43		42	40	40	41	40	40
– Ec – HIGH	(mvAC)	45	46		43	41	42	42	42	[illegible]
Position 2 – Eo	(mvAC)	39	39		42	40	40	39	39	39
– Ec – LOW	(mvAC)	44	44		42	40	40	41	41	41
– Ec – HIGH	(mvAC)	45	47		43	42	42	42	42	42
Position 3 – Eo	(mvAC)	39	39		42	40	40	39	39	39
– Ec – LOW	(mvAC)	42	43		42	40	40	40	40	41
– Ec – HIGH	(mvAC)	43	46		43	42	42	42	42	42
Position 4 – Eo	(mvAC)	39	39		42	40	40	39	39	39
– Ec – LOW	(mvAC)	43	42		42	40	40	40	40	40
– Ec – HIGH	(mvAC)	44	45		43	41	41	41	41	41
AVERAGE CONCENTRATION – Position		0.079	0.085		0.008	0.008	0.016	0.041	0.033	0.033
– Position 2		0.086	0.100		0.008	0.016	0.016	0.041	0.041	0.041
– Position 3		0.056	0.085		0.008	0.016	0.016	0.033	0.033	0.041
– Position 4		0.071	0.071		0.008	0.008	0.008	0.025	0.025	0.025
SCATTER (1) – Position 1	(%)	37.0	50.2		200.0	200.0	200.0	38.4	97.5	97.5
– Position 2	(%)	16.6	41.8		200.0	200.0	200.0	38.4	38.4	38.4
– Position 3	(%)	27.0	50.2		200.0	200.0	200.0	97.5	97.5	38.4
– Position 4	(%)	20.7	62.4		200.0	200.0	200.0	65.2	65.2	65.2

Run Date	(D M Yr)	180890	180890
Mixer Speed	(RPM)	441	441
Temperature	(C)	26.2	26.2
Tank Position	(z/H)	0.50	0.40
Tank Position	(r/R)	0.30	0.30
Position 1 – Eo	(mvAC)	39	38.5
– Ec – LOW	(mvAC)	40	40
– Ec – HIGH	(mvAC)	42	41
Position 2 – Eo	(mvAC)	39	39
– Ec – LOW	(mvAC)	41	40
– Ec – HIGH	(mvAC)	42	42
Position 3 – Eo	(mvAC)	39	38.5
– Ec – LOW	(mvAC)	41	40
– Ec – HIGH	(mvAC)	42	41
Position 4 – Eo	(mvAC)	39	39
– Ec – LOW	(mvAC)	40	40
– Ec – HIGH	(mvAC)	41	41
AVERAGE CONCENTRATION – Position		0.033	0.033
– Position 2		0.041	0.033
– Position 3		0.041	0.033
– Position 4		0.025	0.025
SCATTER (1) – Position 1	(%)	97.5	48.4
– Position 2	(%)	38.4	97.5
– Position 3	(%)	38.4	48.4
– Position 4	(%)	65.2	65.2

Filename: COND-23B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA AUG 23, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.300, 546 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELEC

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	190890		190890	190890	190890	190890	190890
9		Mixer Speed	(RPM)	548		550	550	550	552	552
10		Temperature	(C)	24.5		24.5	24	24	23	23
11		Tank Position	(z/H)	0.40		0.90	0.80	0.70	0.60	0.50
12		Tank Position	(r/R)	0.50		0.90	0.90	0.90	0.90	0.90
13										
14		Position 1 - Eo	(mvAC)	39		44	42	42	42	42
15		- Ec - LOW	(mvAC)	68		44	43	63	72	73
16		- Ec - HIGH	(mvAC)	74		45	46	71	85	80
17		Position 2 - Eo	(mvAC)	39		44	43	42	42	42
18		- Ec - LOW	(mvAC)	66		44	43	59	76	78
19		- Ec - HIGH	(mvAC)	71		44	46	71	85	85
20		Position 3 - Eo	(mvAC)	39		44	43	42	42	42
21		- Ec - LOW	(mvAC)	66		44	43	58	79	76
22		- Ec - HIGH	(mvAC)	72		45	47	70	91	82
23		Position 4 - Eo	(mvAC)	38.5		44	42	41.5	42	42
24		- Ec - LOW	(mvAC)	64		44	43	59	77	72
25		- Ec - HIGH	(mvAC)	69		44	47	70	85	78
26										
27		AVERAGE CONCENTRATION - Position 1		0.353		0.007	0.038	0.283	0.364	0.353
28		- Position 2		0.335		0.000	0.022	0.264	0.378	0.385
29		- Position 3		0.338		0.007	0.029	0.255	0.404	0.369
30		- Position 4		0.326		0.000	0.045	0.267	0.381	0.343
31		SCATTER (1) - Position 1	(%)	12.2		200.0	117.0	23.1	22.8	13.2
32		- Position 2	(%)	11.3		ERR	200.0	38.9	14.6	10.9
33		- Position 3	(%)	13.3		200.0	200.0	41.2	16.7	10.2
34		- Position 4	(%)	12.1		ERR	129.9	35.5	12.7	12.0
35										
36		Run Date	(D M Yr)	190890	190890	190890	190890		190890	190890
37		Mixer Speed	(RPM)	552	552	550	550		548	548
38		Temperature	(C)	22.5	22.5	24.5	25		27	27
39		Tank Position	(z/H)	0.40	0.30	0.30	0.20		0.90	0.80
40		Tank Position	(r/R)	0.90	0.90	0.90	0.90		0.60	0.60
41										
42		Position 1 - Eo	(mvAC)	43	43	40	40		41	39
43		- Ec - LOW	(mvAC)	75	84	81	68		41	39
44		- Ec - HIGH	(mvAC)	81	91	87	74		41	42
45		Position 2 - Eo	(mvAC)	43	43	40	40		41	39
46		- Ec - LOW	(mvAC)	77	85	82	74		41	39
47		- Ec - HIGH	(mvAC)	83	92	87	82		41	41
48		Position 3 - Eo	(mvAC)	43	43	40	40		41	39
49		- Ec - LOW	(mvAC)	73	76	73	74		41	39
50		- Ec - HIGH	(mvAC)	80	82	77	81		41	41
51		Position 4 - Eo	(mvAC)	43	43	40.5	40		41	39
52		- Ec - LOW	(mvAC)	68	[illegible]	74	65		41	39
53		- Ec - HIGH	(mvAC)	74	84	81	70		41	42
54										
55		AVERAGE CONCENTRATION - Position 1		0.351	0.408	0.423	0.340		0.000	0.024
56		- Position 2		0.364	0.413	0.426	0.387		0.000	0.017
57		- Position 3		0.341	0.358	0.368	0.384		0.000	0.017
58		- Position 4		0.302	0.370	0.378	0.314		0.000	0.024
59		SCATTER (1) - Position 1	(%)	11.1	9.3	7.9	12.8			200.0
60		- Position 2	(%)	10.3	9.0	6.5	12.9			200.0
61		- Position 3	(%)	13.8	10.7	7.2	11.5			200.0
62		- Position 4	(%)	15.0	10.0	11.8	12.5			200.0

TRODE)

	K	L	M	N	O	P	Q	R	S	T
Run Date	(D M Yr)	190890	190890	190890	190890		190890	190890	190890	190890
Mixer Speed	(RPM)	550	554	554	548		552	552	552	548
Temperature	(C)	26	25.5	25.5	27.2		27.2	27.2	27.2	24
Tank Position	(z/H)	0.50	0.40	0.30	0.20		0.90	0.80	0.70	0.60
Tank Position	(r/R)	0.60	0.60	0.60	0.60		0.30	0.30	0.30	0.30
Position 1 – Eo	(mvAC)	39	39	39	37.5		40	38	37	39
– Ec – LOW	(mvAC)	62	67	73	70		40	38	42	62
– Ec – HIGH	(mvAC)	68	72	81	90		40	39	45	68
Position 2 – Eo	(mvAC)	38.5	39	39	37.5		40	38	37	39
– Ec – LOW	(mvAC)	62	66	83	70		40	38	46	63
– Ec – HIGH	(mvAC)	68	72	88	90		40	39	52	70
Position 3 – Eo	(mvAC)	38.5	39	39	37.5		40	38	37	39
– Ec – LOW	(mvAC)	62	60	66	80		40	38	45	[illegible]
– Ec – HIGH	(mvAC)	68	66	71	100		40	40	51	71
Position 4 – Eo	(mvAC)	39	39	39	37.5		40	38	37	39
– Ec – LOW	(mvAC)	62	63	73	70		40	38	43	57
– Ec – HIGH	(mvAC)	71	70	78	90		40	39	48	63
AVERAGE CONCENTRATION – Position 1		0.307	0.342	0.393	0.424		0.000	0.009	0.104	0.307
– Position 2		0.314	0.338	0.443	0.424		0.000	0.009	0.176	0.319
– Position 3		0.314	0.290	0.335	0.478		0.000	0.017	0.164	0.322
– Position 4		0.318	0.319	0.384	0.424		0.000	0.009	0.131	0.263
SCATTER (1) – Position 1	(%)	16.0	10.8	12.8	27.5			200.0	41.5	16.0
– Position 2	(%)	15.6	13.3	6.0	27.5			200.0	41.6	17.4
– Position 3	(%)	15.6	17.8	11.3	20.1			200.0	46.1	19.5
– Position 4	(%)	22.5	17.4	8.5	27.5			200.0	51.6	21.1

Run Date	(D M Yr)	190890	190890
Mixer Speed	(RPM)	548	548
Temperature	(C)	24	24.5
Tank Position	(z/H)	0.50	0.40
Tank Position	(r/R)	0.30	0.30
Position 1 – Eo	(mvAC)	39	39
– Ec – LOW	(mvAC)	64	64
– Ec – HIGH	(mvAC)	71	69
Position 2 – Eo	(mvAC)	39	39
– Ec – LOW	(mvAC)	66	64
– Ec – HIGH	(mvAC)	72	71
Position 3 – Eo	(mvAC)	39	39
– Ec – LOW	(mvAC)	66	65
– Ec – HIGH	(mvAC)	72	71
Position 4 – Eo	(mvAC)	39	39
– Ec – LOW	(mvAC)	64	62
– Ec – HIGH	(mvAC)	70	68
AVERAGE CONCENTRATION – Position 1		0.326	0.319
– Position 2		0.338	0.326
– Position 3		0.338	0.331
– Position 4		0.323	0.307
SCATTER (1) – Position 1	(%)	16.6	12.4
– Position 2	(%)	13.3	16.6
– Position 3	(%)	13.3	13.9
– Position 4	(%)	14.5	16.0

Filename: COND-24B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA AUG 23, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.300, 680 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J	K
8		Run Date	(D M Yr)	200890		200890	200890	200890	200890	·00890	200890
9		Mixer Speed	(RPM)	685		679	679	681	681	682	682
10		Temperature	(C)	22.2		26	26	25	25	23.5	23.5
11		Tank Position	(z/H)	0.40		0.90	0.80	0.70	0.60	0.50	0 40
12		Tank Position	(r/R)	0.50		0.90	0.90	0.90	0.90	0 90	0 90
13											
14		Position 1 - Eo	(mvAC)	46		47	45	45 5	45	47	47
15		- Ec - LOW	(mvAC)	78		43	59	72	78	74	81
16		- Ec - HIGH	(mvAC)	83		52	64	77	84	79	86
17		Position 2 - Eo	(mvAC)	46.5		47	45	46	45	46	46
18		- Ec - LOW	(mvAC)	77		49	59	68	86	83	81
19		- Ec - HIGH	(mvAC)	82		53	64	74	91	88	86
20		Position 3 - Eo	(mvAC)	46		47.5	45	46	45	46	46
21		- Ec - LOW	(mvAC)	76		48	58	71	86	82	78
22		- Ec - HIGH	(mvAC)	80		51	63	76	93	87	84
23		Position 4 - Eo	(mvAC)	46.5		47	45	45.5	45	47	47
24		- Ec - LOW	(mvAC)	74		48	59	68	82	75	76
25		- Ec - HIGH	(mvAC)	79		52	64	74	88	79	81
26											
27		AVERAGE CONCENTRATION - Position 1		0.333		0.040	0.196	0.298	0.347	0.295	0.341
28		- Position 2		0.321		0.053	0.196	0.265	0.392	0.364	0.352
29		- Position 3		0.317		0.027	0.186	0.284	0.397	0.358	0.336
30		- Position 4		0.300		0.040	0.196	0.271	0.372	0.298	0.308
31		SCATTER (1) - Position 1	(%)	9.7		130.3	24.5	12.1	10.9	12.0	9.0
32		- Position 2	(%)	10.3		95.9	24.5	17.7	7.0	8.1	8.7
33		- Position 3	(%)	8.6		148.2	26.4	13.0	9.5	8.3	11.4
34		- Position 4	(%)	11.7		130.3	24.5	17.2	9.4	9.4	11.0
35											
36		Run Date	(D M Yr)	200890	200890	200890		200890	200890	200890	200890
37		Mixer Speed	(RPM)	678	680	678		679	679	679	679
38		Temperature	(C)	27.8	27	27.8		25.5	25.5	24.2	24.2
39		Tank Position	(z/H)	0.30	0.20	0.10		0.90	0.80	0.70	0 60
40		Tank Position	(r/R)	0.90	0.90	0.90		0.60	0.60	0.60	0.60
41											
42		Position 1 - Eo	(mvAC)	41	42	41		46	44	44	44
43		- Ec - LOW	(mvAC)	77	68	75		47	67	77	75
44		- Ec - HIGH	(mvAC)	83	71	82		50	72	82	80
45		Position 2 - Eo	(mvAC)	40	41	40		46	44	44	44
46		- Ec - LOW	(mvAC)	78	67	80		47	67	76	79
47		- Ec - HIGH	(mvAC)	83	72	90		51	73	83	84
48		Position 3 - Eo	(mvAC)	40	41	40		46	44	44	44
49		- Ec - LOW	(mvAC)	70	69	97		47	65	75	81
50		- Ec - HIGH	(mvAC)	75	74	106		51	70	81	85
51		Position 4 - Eo	(mvAC)	41	42	41		46	44	44	44
52		- Ec - LOW	(mvAC)	77	67	80		46	63	76	77
53		- Ec - HIGH	(mvAC)	82	71	90		49	69	82	82
54											
55		AVERAGE CONCENTRATION - Position 1		0.388	0.304	0.378		0.035	0.278	0.349	0.336
56		- Position 2		0.403	0.316	0.427		0.041	0.282	0.349	0.362
57		- Position 3		0.351	0.331	0.505		0.041	0.262	0.339	0.371
58		- Position 4		0.385	0.300	0.416		0.021	0.249	0.346	0.349
59		SCATTER (1) - Position 1	(%)	9.4	7.6	11.6		117.3	14.2	9.2	9.9
60		- Position 2	(%)	7.4	12.0	12.8		130.2	16.6	12.9	8.5
61		- Position 3	(%)	10.0	11.0	7.2		130.2	15.7	11.7	6.5
62		- Position 4	(%)	8.0	10.4	13.3		200.0	20.6	11.2	9.2

L		M	N	O	P	Q	R	S	T	U
Run Date	(D M Yr)	[illegible]00890	200890	200890		200890	200890	200890	200890	200890
Mixer Speed	(RPM)	[illegible]	684	680		678	678	682	684	684
Temperature	(C)	22.2	23.2	27		26	26	28.2	27	27
Tank Position	(z/H)	0.40	0.30	0.20		0.90	0.80	0.80	0.70	0.60
Tank Position	(r/R)	0.60	0.60	0.60		0.30	0.30	0.30	0.30	0.30
Position 1 – Eo	(mvAC)	46	45	42		40	38	36	36	36
– Ec – LOW	(mvAC)	73	93	90		41	48	43	59	61
– Ec – HIGH	(mvAC)	78	97	101		42	53	48	64	65
Position 2 – Eo	(mvAC)	46	45	42		40	38	36	36	36
– Ec – LOW	(mvAC)	73	93	95		41	47	43	61	61
– Ec – HIGH	(mvAC)	77	97	104		42	52	48	66	67
Position 3 – Eo	(mvAC)	46	45	42		40	38	36	36	36
– Ec – LOW	(mvAC)	65	74	85		41	48	44	59	62
– Ec – HIGH	(mvAC)	70	78	94		42	54	50	65	67
Position 4 – Eo	(mvAC)	46	45.5	42		40	38	36	36	36
– Ec – LOW	(mvAC)	71	86	86		41	46	42	57	57
– Ec – HIGH	(mvAC)	76	90	92		43	52	47	61	62
AVERAGE CONCENTRATION – Position 1		0.299	0.425	0.458		0.024	0.179	0.148	0.320	0.333
– Position 2		0.296	0.425	0.476		0.024	0.167	0.148	0.337	0.341
– Position 3		0.237	0.314	0.429		0.024	0.184	0.167	0.324	0.345
– Position 4		0.284	0.384	0.427		0.032	0.160	0.135	0.298	0.303
SCATTER (1) – Position 1	(%)	11.9	4.6	11.2		65.2	33.0	45.2	13.4	9.9
– Position 2	(%)	9.7	4.6	8.2		65.2	36.5	45.2	12.1	14.2
– Position 3	(%)	17.8	8.9	10.8		65.2	38.0	45.9	15.6	11.5
– Position 4	(%)	13.0	5.8	7.3		97.6	46.3	51.4	12.2	14.9

Run Date	(D M Yr)	200890	200890
Mixer Speed	(RPM)	680	680
Temperature	(C)	27.7	27.7
Tank Position	(z/H)	0.50	0.40
Tank Position	(r/R)	0.30	0.30
Position 1 – Eo	(mvAC)	35.5	35.5
– Ec – LOW	(mvAC)	58	58
– Ec – HIGH	(mvAC)	64	62
Position 2 – Eo	(mvAC)	35.5	35.5
– Ec – LOW	(mvAC)	58	56
– Ec – HIGH	(mvAC)	62	61
Position 3 – Eo	(mvAC)	35.5	35.5
– Ec – LOW	(mvAC)	58	57
– Ec – HIGH	(mvAC)	63	62
Position 4 – Eo	(mvAC)	35.5	35.5
– Ec – LOW	(mvAC)	56	55
– Ec – HIGH	(mvAC)	61	60
AVERAGE CONCENTRATION – Position 1		0.323	0.315
– Position 2		0.315	0.301
– Position 3		0.319	0.310
– Position 4		0.301	0.292
SCATTER (1) – Position 1	(%)	16.0	11.2
– Position 2	(%)	11.2	15.2
– Position 3	(%)	13.7	14.4
– Position 4	(%)	15.2	16.1

Filename: COND-25B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATE AUG 23, 1990)

CONDUCTIVITY PROBE DATA *** BAFFLE PLANE ***, RADIAL MIXER, 410 micron SAND, CB = 0.300, 680 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration – Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	g	H	I	J	K
8		Run Date	(D M Yr)	200890	200890	200890	200890	200890	200890	200890	200890
9		Mixer Speed	(RPM)	682	[illegible]2	681	682	681	675	675	675
10		Temperature	(C)	29.5	29.5	27	29.5	27	27.8	27.8	27.8
11		Tank Position	(z/H)	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20
12		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13											
14		Position 1 – Eo	(mvAC)	43	41	43	40	43	41	42	41
15		– Ec – LOW	(mvAC)	45	60	71	65	68	64	79	64
16		– Ec – HIGH	(mvAC)	51	65	75	70	73	69	84	69
17		Position 2 – Eo	(mvAC)	43	41	43	40	43	41	42	41
18		– Ec – LOW	(mvAC)	48	65	78	73	69	63	79	69
19		– Ec – HIGH	(mvAC)	54	71	82	78	73	67	83	74
20		Position 3 – Eo	(mvAC)	43	41	43	40	43	41	42	41
21		– Ec – LOW	(mvAC)	47	62	72	69	73	60	64	68
22		– Ec – HIGH	(mvAC)	53	67	77	74	76	64	68	73
23		Position 4 – Eo	(mvAC)	43	41	43	40	43	41	42	41
24		– Ec – LOW	(mvAC)	45	58	67	63	66	63	75	68
25		– Ec – HIGH	(mvAC)	50	64	71	67	71	68	79	72
26											
27		AVERAGE CONCENTRATION – Position 1		0.070	0.258	0.317	0.314	0.298	0.293	0.385	0.293
28		– Position 2		0.109	0.304	0.364	0.371	0.302	0.280	0.382	0.331
29		– Position 3		0.096	0.276	0.328	0.344	0.328	0.254	0.275	0.324
30		– Position 4		0.064	0.244	0.287	0.294	0.283	0.284	0.357	0.320
31		SCATTER (1) – Position 1	(%)	114.3	17.3	9.1	12.5	12.8	13.9	7.8	13.9
32		– Position 2	(%)	67.8	15.5	6.9	8.9	10.0	12.0	6.3	11.0
33		– Position 3	(%)	78.7	15.4	10.7	10.4	6.4	14.2	12.1	11.5
34		– Position 4	(%)	106.0	22.8	11.0	11.3	14.1	14.6	7.4	9.4
35											
36		Run Date	(D M Yr)	200890							
37		Mixer Speed	(RPM)	682							
38		Temperature	(C)	29.5							
39		Tank Position	(z/H)	0.20							
40		Tank Position	(r/R)	0.60							
41											
42		Position 1 – Eo	(mvAC)	40							
43		– Ec – LOW	(mvAC)	63							
44		– Ec – HIGH	(mvAC)	67							
45		Position 2 – Eo	(mvAC)								
46		– Ec – LOW	(mvAC)								
47		– Ec – HIGH	(mvAC)								
48		Position 3 – Eo	(mvAC)	40							
49		– Ec – LOW	(mvAC)	67							
50		– Ec – HIGH	(mvAC)	72							
51		Position 4 – Eo	(mvAC)								
52		– Ec – LOW	(mvAC)								
53		– Ec – HIGH	(mvAC)								
54											
55		AVERAGE CONCENTRATION – Position 1		0.294							
56		– Position 2									
57		– Position 3		0.329							
58		– Position 4									
59		SCATTER (1) – Position 1	(%)	11.3							
60		– Position 2	(%)								
61		– Position 3	(%)	11.4							
62		– Position 4	(%)								

Filename: COND-26B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATE AUG 23, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 82 micron SAND, CB = 0.300, 545 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration – Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J	K
8		Run Date	(D M Yr)	200890		200890	200890	200890	200890	200890	200890
9		Mixer Speed	(RPM)	544		544	544	540	540	543	543
10		Temperature	(C)	23.5		22	22	22.5	22.5	22	22
11		Tank Position	(z/H)	0.40		0.90	0.80	0.70	0.60	0.50	0.40
12		Tank Position	(r/R)	0.50		0.90	0.90	0.90	0.90	0.90	0.90
13											
14		Position 1 – Eo	(mvAC)	48		57	54	49	49	50	50
15		– Ec – LOW	(mvAC)	82		90	88	84	82	83	85
16		– Ec – HIGH	(mvAC)	85		93	91	[illegible]	84	85	87
17		Position 2 – Eo	(mvAC)	48		57	54	49	49	50	50
18		– Ec – LOW	(mvAC)	82		86	87	85	82	84	86
19		– Ec – HIGH	(mvAC)	84		90	90	86	84	85	87
20		Position 3 – Eo	(mvAC)	48		57	54	49	49	50	50
21		– Ec – LOW	(mvAC)	79		91	88	84	81	82	84
22		– Ec – HIGH	(mvAC)	81		94	90	86	83	84	86
23		Position 4 – Eo	(mvAC)	48		57	54	49	49	50	50
24		– Ec – LOW	(mvAC)	83		88	87	83	80	81	83
25		– Ec – HIGH	(mvAC)	86		92	91	84	81	82	85
26											
27		AVERAGE CONCENTRATION – Position 1		0.330		0.287	0.305	0.326	0.316	0.312	0.324
28		– Position 2		0.327		0.266	0.299	0.332	0.316	0.315	0.327
29		– Position 3		0.308		0.293	0.302	0.329	0.310	0.305	0.318
30		– Position 4		0.336		0.278	0.302	0.319	0.300	0.296	0.312
31		SCATTER (1) – Position 1	(%)	5.7		6.2	5.9	1.9	4.0	4.0	3.8
32		– Position 2	(%)	3.8		9.5	6.1	1.8	4.0	2.0	1.8
33		– Position 3	(%)	4.3		6.0	4.0	3.7	4.2	4.2	3.9
34		– Position 4	(%)	5.5		8.8	8.0	2.0	2.2	2.2	4.0
35											
36		Run Date	(D M Yr)	200890	200890	200890	200890		200890	200890	200890
37		Mixer Speed	(RPM)	543	544	542	542		546	544	546
38		Temperature	(C)	22	22	21	21		22	23.5	22
39		Tank Position	(z/H)	0.30	0.30	0.20	0.10		0.90	0.90	0.80
40		Tank Position	(r/R)	0.90	0.90	0.90	0.90		0.60	0.60	0.60
41											
42		Position 1 – Eo	(mvAC)	50	54	53	53		53	50	51
43		– Ec – LOW	(mvAC)	84	86	83	86		90	89	85
44		– Ec – HIGH	(mvAC)	87	89	85	88		92	91	88
45		Position 2 – Eo	(mvAC)	50	54	53	53		53	50	51
46		– Ec – LOW	(mvAC)	88	90	87	84		91	90	87
47		– Ec – HIGH	(mvAC)	91	93	90	87		93	93	90
48		Position 3 – Eo	(mvAC)	50	54	53	53		53	50	51
49		– Ec – LOW	(mvAC)	84	85	85	92		90	89	85
50		– Ec – HIGH	(mvAC)	87	88	87	94		92	91	88
51		Position 4 – Eo	(mvAC)	50	54	53	53		53	50	51
52		– Ec – LOW	(mvAC)	89	89	84	85		90	87	87
53		– Ec – HIGH	(mvAC)	92	92	86	87		92	90	89
54											
55		AVERAGE CONCENTRATION – Position 1		0.321	0.292	0.280	0.300		0.323	0.348	0.317
56		– Position 2		0.345	0.316	0.309	0.290		0.329	0.350	0.329
57		– Position 3		0.321	0.286	0.293	0.335		0.323	0.348	0.317
58		– Position 4		0.351	0.311	0.287	0.293		0.323	0.339	0.326
59		SCATTER (1) – Position 1	(%)	5.7	6.3	4.6	4.1		3.6	3.3	[illegible]
60		– Position 2	(%)	5.0	5.5	5.8	6.6		3.4	4.7	
61		– Position 3	(%)	5.7	6.6	4.3	3.3		3.6	3.3	[illegible]
62		– Position 4	(%)	4.8	5.7	4.5	4.3		3.6	5.2	3.6

L		M	N	O	P	Q	R	S	T	U
Run Date	(D M Yr)	200890	200890	200890	200890	200890	200890	200890		200890
Mixer Speed	(RPM)	550	550	549	549	543	543	543		551
Temperature	(C)	22.8	22.8	22	22	22.8	22.8	22.8		22.2
Tank Position	(z/H)	0.70	0.60	0.40	0.30	0.30	0.20	0.10		0.90
Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60		0.30
Position 1 – Eo	(mvAC)	52	52	50	50	51	51	51		52
– Ec – LOW	(mvAC)	84	85	84	89	87	82	81		88
– Ec – HIGH	(mvAC)	87	88	87	92	89	84	82		92
Position 2 – Eo	(mvAC)	52	52	50	50	51	51	51		52
– Ec – LOW	(mvAC)	85	85	87	89	88	81	83		90
– Ec – HIGH	(mvAC)	88	89	90	92	90	82	85		93
Position 3 – Eo	(mvAC)	52	52	50	50	51	51	51		52
– Ec – LOW	(mvAC)	84	84	81	84	82	80	85		87
– Ec – HIGH	(mvAC)	87	87	84	86	84	82	87		92
Position 4 – Eo	(mvAC)	52	52	50	50	51	51	51		52
– Ec – LOW	(mvAC)	83	83	86	85	85	81	84		87
– Ec – HIGH	(mvAC)	87	87	88	87	87	83	86		90
AVERAGE CONCENTRATION – Position 1		0.300	0.307	0.321	0.351	0.32[illegible]	0.295	0.285		0.327
– Position 2		0.307	0.310	0.339	0.351	0.332	0.285	0.301		0.336
– Position 3		0.300	0.300	0.302	0.318	0.295	0.282	0.314		0.324
– Position 4		0.297	0.297	0.330	0.324	0.314	0.288	0.308		0.319
SCATTER (1) – Position 1	(%)	6.3	6.0	5.7	4.8	3.6	4.4	2.3		7.1
– Position 2	(%)	6.0	7.9	5.2	4.8	3.5	2.3	4.2		5.0
– Position 3	(%)	6.3	6.3	6.4	3.9	4.4	4.8	3.9		9.0
– Position 4	(%)	8.5	8.5	3.6	3.8	3.9	4.6	4.1		5.6

Run Date	(D M Yr)	200890
Mixer Speed	(RPM)	551
Temperature	(C)	22.2
Tank Position	(z/H)	0.80
Tank Position	(r/R)	0.30
Position 1 – Eo	(mvAC)	49
– Ec – LOW	(mvAC)	85
– Ec – HIGH	(mvAC)	87
Position 2 – Eo	(mvAC)	49
– Ec – LOW	(mvAC)	86
– Ec – HIGH	(mvAC)	89
Position 3 – Eo	(mvAC)	49
– Ec – LOW	(mvAC)	85
– Ec – HIGH	(mvAC)	88
Position 4 – Eo	(mvAC)	49
– Ec – LOW	(mvAC)	83
– Ec – HIGH	(mvAC)	86
AVERAGE CONCENTRATION – Position 1		0.336
– Position 2		0.344
– Position 3		0.338
– Position 4		0.326
SCATTER (1) – Position 1	(%)	3.6
– Position 2	(%)	5.1
– Position 3	(%)	5.3
– Position 4	(%)	5.7

Filename: COND-27B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATE AUG 23, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 500 micron SAND, CB = 0.300, 750 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration – Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B / C		D	E	F	G	H	I	J	K
8	Run Date	(D M Yr)	210890	210890		210890	210890	210890	210890	210890
9	Mixer Speed	(RPM)	752	748		748	748	748	748	748
10	Temperature	(C)		28		25.2	25.2	25.2	25.5	25.5
11	Tank Position	(z/H)	0.40	0.40		0.90	0.80	0.70	0.60	0.50
12	Tank Position	(r/R)	0.50	0.50		0.90	0.90	0.90	0.90	0.90
13										
14	Position 1 – Eo	(mvAC)	43	38		45	43	42	41	41
15	– Ec – LOW	(mvAC)	63	57		46	55	62	72	67
16	– Ec – HIGH	(mvAC)	67	60		48	59	66	78	71
17	Position 2 – Eo	(mvAC)	43	38		45	43	42	41	41
18	– Ec – LOW	(mvAC)	62	57		46	54	61	76	76
19	– Ec – HIGH	(mvAC)	[illegible]	60		48	60	65	81	81
20	Position 3 – Eo	(mvAC)	4[illegible]	38		45	43	42	41	41
21	– Ec – LOW	(mvAC)	[illegible]1	54		46	53	61	76	77
22	– Ec – HIGH	(mvAC)	64	58		48	57	65	80	82
23	Position 4 – Eo	(mvAC)	43	38		45	43	42	41	41
24	– Ec – LOW	(mvAC)	61	55		46	53	62	78	68
25	– Ec – HIGH	(mvAC)	65	58		4[illegible]	[illegible]7	66	82	73
26										
27	AVERAGE CONCENTRATION – Position 1		0.254	0.264		0.02[illegible]	[illegible].178	0.258	0.355	0.313
28	– Position 2		0.245	0.264		0.029	0.177	0.250	0.378	0.378
29	– Position 3		0.232	0.239		0.029	0.156	0.250	0.375	0.385
30	– Position 4		0.236	0.245		0.029	0.156	0.258	0.388	0.324
31	SCATTER (1) – Position 1	(%)	13.[illegible]	10.8		97.8	23.6	13.[illegible]	11.[illegible]	9.8
32	– Position 2	(%)	14[illegible]	10.8		97.8	35.5	14.[illegible]	8.3	8.3
33	– Position 3	(%)	11.8	16.9		97.8	28.2	1[illegible]	6.8	8.0
34	– Position 4	(%)	[illegible]3	12.3		97.8	28.2		[illegible]3	11.5
35										
36	Run Date	(D M Yr)	210890	21[illegible]90	210890	210890		210890	210890	210890
37	Mixer Speed	(RPM)	755	[illegible]5	748	748		750	750	75[illegible]
38	Temperature	(C)	24	[illegible]4	22.5	22.5		27	27	2[illegible]
39	Tank Position	(z/H)	0.40	[illegible]	0.20	0.10		0.90	0.80	0.70
40	Tank Position	(r/R)	0.90	0.90	0.90	0.90		0.60	0.60	0.60
41										
42	Position 1 – Eo	(mvAC)	44	44	46	46		43	41	44
43	– Ec – LOW	(mvAC)	68	85	72	82		48	57	73
44	– Ec – HIGH	(mvAC)	75	91	77	90		48	64	78
45	Position 2 – Eo	(mvAC)	44	44	46	46		43	41	44
46	– Ec – LOW	(mvAC)	68	85	75	88		46	60	74
47	– Ec – HIGH	(mvAC)	74	91	80	95		49	64	78
48	Position 3 – Eo	(mvAC)	44	44	46	46		43	41	44
49	– Ec – LOW	(mvAC)	68	73	74	100		45	55	73
50	– Ec – HIGH	(mvAC)	74	78	79	110		48	60	77
51	Position 4 – Eo	(mvAC)	44	44	46	46		43	41	44
52	– Ec – LOW	(mvAC)	66	79	72	80		46	58	74
53	– Ec – HIGH	(mvAC)	72	84	77	90		48	63	77
54										
55	AVERAGE CONCENTRATION – Position 1		0.293	0.400	0.292	0.366		0.058	0.239	0.323
56	– Position 2		0.290	0.400	0.313	0.397		0.065	0.254	0.326
57	– Position 3		0.290	0.323	0.306	0.460		0.051	0.211	0.319
58	– Position 4		0.274	0.362	0.292	0.360		0.058	0.240	0.323
59	SCATTER (1) – Position 1	(%)	18.1	8.2	12.4	12.7		47.3	27.5	10.8
60	– Position 2	(%)	15.8	8.2	10.9	9.3		62.8	14.2	8.4
61	– Position 3	(%)	15.8	10.8	11.4	9.2		82.1	24.0	8.8
62	– Position 4	(%)	17.5	8.5	12.4	10.5		47.3	19.5	6.5

L		M	N	O	P	Q	H	S	[illegible]	V
Run Date	(D M Yr)	210890	210890	210890	210890		210890	210890	210890	210890
Mixer Speed	(RPM)	750	750	752	752		752	748	748	748
Temperature	(C)	25.5	25.5	27	27			25.2	25 2	27
Tank Position	(z/H)	0.50	0.40	0.30	0.20		0 90	0 80	0.70	0 60
Tank Position	(r/R)	0.60	0.60	0.60	0.60		0 30	0 30	0 30	0 30
Position 1 – Eo	(mvAC)	42	42	40	40		46	42	41	39
– Ec – LOW	(mvAC)	59	58	72	85		47	48	63	65
– Ec – HIGH	(mvAC)	63	02	76	92		49	52	66	69
Position 2 – Eo	(mvAC)	42	42	40	40		46	42	41	39
– Ec – LOW	(mvAC)	62	57	72	89		47	49	65	67
– Ec – HIGH	(mvAC)	66	60	75	98		50	54	69	70
Position 3 – Eo	(mvAC)	42	42	40	40		46	42	41	39
– Ec – LOW	(mvAC)	63	53	61	85		48	48	66	67
– Ec – HIGH	(mvAC)	67	56	63	92		50	53	70	71
Position 4 – Eo	(mvAC)	42	42	40	40		46	42	41	39
– Ec – LOW	(mvAC)	59	56	71	85		47	49	60	59
– Ec – HIGH	(mvAC)	64	59	74	92		49	52	63	63
AVERAGE CONCENTRATION	Position 1	0.231	0.222	0.361	0.446		0.028	0.112	0 276	0.323
– Position 2		0.258	0.207	0.358	0.471		0.035	0.130	0 297	0.335
– Position 3		0.267	0 165	0.268	0.446		0.041	0.116	0 305	0.339
– Position 4		0.238	0 197	0.351	0.446		0.028	0.118	0 250	0 273
SCATTER (1) – Position 1	(%)	10.2	17.3	7.5	8.0		97.9	44.7	9.2	9.7
– Position 2	(%)	13.5	14.4	5 8	8.9		117.3	46.2	10.8	6.8
– Position 3	(%)	12.3	20.1	6.7	8.0		64.2	52.4	10.3	8.8
– Position 4	(%)	19.7	15.6	6.0	8.0		97.9	31.2	11 0	13.2

Run Date	(D M Yr)	210890	210890
Mixer Speed	(RPM)	748	748
Temperature	(C)	27	28
Tank Position	(z/H)	0.50	0.40
Tank Position	(r/R)	0.30	0.30
Position 1 – Eo	(mvAC)	39	38
– Ec – LOW	(mvAC)	63	59
– Ec – HIGH	(mvAC)	66	63
Position 2 – Eo	(mvAC)	39	38
– Ec – LOW	(mvAC)	64	60
– Ec – HIGH	(mvAC)	67	63
Position 3 – Eo	(mvAC)	39	38
– Ec – LOW	(mvAC)	64	60
– Ec – HIGH	(mvAC)	68	62
Position 4 – Eo	(mvAC)	39	38
– Ec – LOW	(mvAC)	58	57
– Ec – HIGH	(mvAC)	62	60
AVERAGE CONCENTRATION – Position 1		0.303	0.287
– Position 2		0.312	0.292
– Position 3		0.315	0.287
– Position 4		0.264	0.264
SCATTER (1) – Position 1	(%)	8.2	12.4
– Position 2	(%)	7.8	9.1
– Position 3	(%)	10.2	6.2
– Position 4	(%)	14.0	10.8

Filename. COND-28B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA AUG 23, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 255 micron SAND, CB = 0.300, 545 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J	K
8		Run Date	(D M Yr)	210890	210890		210890	210890	210890	210890	210890
9		Mixer Speed	(RPM)	547	547		550	550	550	554	554
10		Temperature	(C)	23.2	24.5		25.2	25.2	25.2	24.5	24.5
11		Tank Position	(z/H)	0.40	0.40		0.90	0.80	0.70	0.60	0.50
12		Tank Position	(r/R)	0.50	0.50		0.90	0.90	0.90	0.90	0.90
13											
14		Position 1 – Eo	(mvAC)	43.5	42		37	35	35	35	35
15		– Ec – LOW	(mvAC)	79	75		37	52	62	64	60
16		– Ec – HIGH	(mvAC)	82	80		39	56	65	67	62
17		Position 2 – Eo	(mvAC)	43	42		37	36	35	35	35
18		– Ec – LOW	(mvAC)	77	77		37	53	59	66	66
19		– Ec – HIGH	(mvAC)	82	82		40	57	63	69	68
20		Position 3 – Eo	(mvAC)	43	42		37	36	35	35	35
21		– Ec – LOW	(mvAC)	75	73		38	53	62	68	63
22		– Ec – HIGH	(mvAC)	79	77		40	55	65	71	66
23		Position 4 – Eo	(mvAC)	43.5	42		37	35	35	35	35
24		– Ec – LOW	(mvAC)	78	75		38	54	62	64	59
25		– Ec – HIGH	(mvAC)	81	79		40	57	65	68	62
26											
27		AVERAGE CONCENTRATION – Position 1		0.362	0.360		0.017	0.265	0.352	0.367	0.331
28		– Position 2		0.361	0.373		0.026	0.260	0.331	0.382	0.379
29		[illegible]		0.345	0.343		0.034	0.250	0.352	0.396	0.360
30		– Position 4		0.355	0.357		0.034	0.281	0.352	0.371	0.327
31		SCATTER (1) – Position 1	(%)	5.2	9.0		200.0	15.5	6.8	6.2	5.1
32		– Position 2	(%)	8.8	[illegible]		200.0	15.6	10.3	5.7	3.9
33		– Position 3	(%)	7.7	8.0		97.4	8.3	6.8	5.3	6.5
34		– Position 4	(%)	5.4	7.4		97.4	10.5	6.8	8.1	7.9

A	B	C		D	E	F	G	H	I	J	K
35											
36		Run Date	(D M Yr)	210890	210890	210890	210890		210890	210890	210890
37		Mixer Speed	(RPM)	554	552	552	552		552	552	552
38		Temperature	(C)	24.5	24	24	24		26	26	26
39		Tank Position	(z/H)	0.40	0.30	0.20	0.10		0.90	0.80	0.70
40		Tank Position	(r/R)	0.90	0.90	0.90	0.90		0.60	0.60	0.60
41											
42		Position 1 – Eo	(mvAC)	35	36	36	36		36.5	35	34
43		– Ec – LOW	(mvAC)	66	68	63	61		37	57	61
44		– Ec – HIGH	(mvAC)	69	72	66	64		38	61	64
45		Position 2 – Eo	(mvAC)	35	35.5	35.5	35.5		36.5	34.5	34
46		– Ec – LOW	(mvAC)	66	74	67	64		37	56	62
47		– Ec [illegible]	(mvAC)	69	77	70	68		39	60	65
48		Position 3 – Eo	(mvAC)	35	35.5	35.5	35.5		36.5	34.5	34
49		– Ec – LOW	(mvAC)	64	66	64	71		37	53	64
50		– Ec – HIGH	(mvAC)	67	69	68	75		39	57	68
51		Position 4 – Eo	(mvAC)	35	36	36	36		36.5	34.5	34
52		– Ec – LOW	(mvAC)	62	73	64	64		37	54	62
53		– Ec – HIGH	(mvAC)	64	75	68	68		38	57	65
54											
55		AVERAGE CONCENTRATION – Position 1		0.382	0.386	0.345	0.329		0.018	0.313	0.358
56		– Position 2		0.382	0.429	0.382	0.364		0.026	0.312	0.366
57		– Position 3		0.367	0.375	0.364	0.413		0.026	0.283	0.385
58		– Position 4		0.348	0.413	0.357	0.357		0.018	0.288	0.366
59		SCATTER (1) – Position 1	(%)	5.7	7.2	6.9	7.6		98.6	11.5	6.8
60		– Position 2	(%)	5.7	4.3	5.6	8.4		131.3	11.7	6.4
61		– Position 3	(%)	6.2	5.9	8.4	6.3		131.3	14.0	7.7
62		– Position 4	(%)	4.7	3.1	8.6	8.6		98.6	10.2	6.4

L		M	N	O	P	Q	R	S	T	U
Run Date	(D M Yr)	210890	210890	210890	210890	210890		210890	210890	210890
Mixer Speed	(RPM)	553	553	549	549	549		547	547	547
Temperature	(C)	26.5	26.5	22.5	22.5	22.5		23.2	23.2	24
Tank Position	(z/H)	0.50	0.40	0.30	0.20	0.10		0.90	0.80	0.70
Tank Position	(r/R)	0.80	0.60	0.60	0.60	0.60		0.30	0.30	0.30
Position 1 – Eo	(mvAC)	33	33	44.5	44.5	44.5		47	44	43
– Ec – LOW	(mvAC)	59	59	91	77	77		47	62	73
– Ec – HIGH	(mvAC)	62	62	94	82	80		48	65	76
Position 2 – Eo	(mvAC)	33	33	44.5	44.5	44.5		47	44	43
– Ec – LOW	(mvAC)	58	60	93	76	85		47	64	76
– Ec – HIGH	(mvAC)	61	64	97	80	90		48	68	79
Position 3 – Eo	(mvAC)	33	33	44.5	44.5	44.5		47	44	43
– Ec – LOW	(mvAC)	58	55	78	74	89		47	64	74
– Ec – HIGH	(mvAC)	62	58	82	77	93		48	68	77
Position 4 – Eo	(mvAC)	33	33	44.5	44.5	44.5		47	44	43
– Ec – LOW	(mvAC)	56	59	84	73	82		47	58	68
– Ec – HIGH	(mvAC)	60	63	88	76	85		48	61	72
AVERAGE CONCENTRATION – Position 1		0.357	0.357	0.418	0.344	0.337		0.007	0.228	0.328
– Position 2		0.348	0.369	0.431	0.334	0.391		0.007	0.250	0.348
– Position 3		0.352	0.322	0.347	0.317	0.410		0.007	0.250	0.335
– Position 4		0.335	0.381	0.378	0.310	0.369		0.007	0.190	0.295
SCATTER (1) – Position 1	(%)	7.0	7.0	3.3	9.4	5.8		200.0	11.9	6.4
– Position 2	(%)	7.4	8.7	4.5	8.0	7.1		200.0	13.7	5.7
– Position 3	(%)	9.6	8.7	7.4	6.6	5.1		20[illegible]	13.7	6.1
– Position 4	(%)	10.7	9.1	3.1	6.9	4.9		200.0	15.7	10.5

Run Date	(D M Yr)	210890	210890	210890
Mixer Speed	(RPM)	547	547	547
Temperature	(C)	24	24	24.5
Tank Position	(z/H)	0.60	0.50	0.40
Tank Position	(r/R)	0.30	0.30	0.30
Position 1 – Eo	(mvAC)	43	43	42
– Ec – LOW	(mvAC)	78	78	76
– Ec – HIGH	(mvAC)	81	82	80
Position 2 – Eo	(mvAC)	43	43	42
– Ec – LOW	(mvAC)	77	73	74
– Ec – HIGH	(mvAC)	80	77	77
Position 3 – Eo	(mvAC)	43	43	42
– Ec – LOW	(mvAC)	75	75	77
– Ec – HIGH	(mvAC)	80	78	81
Position 4 – Eo	(mvAC)	43	43	42
– Ec – LOW	(mvAC)	74	77	72
– Ec – HIGH	(mvAC)	78	81	75
AVERAGE CONCENTRATION – Position 1		0.361	0.364	0.363
– Position 2		0.355	0.331	0.347
– Position 3		0.348	0.342	0.370
– Position 4		0.338	0.358	0.333
SCATTER (1) – Position 1	(%)	5.3	6.9	7.1
– Position 2	(%)	5.5	8.4	5.9
– Position 3	(%)	9.5	3.9	6.8
– Position 4	(%)	8.0	7.1	6.4

Filename: COND-29B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)

CONDUCTIVITY PROBE DATA, AXIAL MIXER, 410 micron SAND, CB = 0.100, NJS TEST, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (F E = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J
8	Run Date		(D M Yr)	10990	10990	10990	10990	10990	10990	10990
9	Mixer Speed		(RPM)	550	631	394	331	465	327	347
10	Temperature		(C)							
11	Tank Position		(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12	Tank Position		(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13										
14	Position 1 – Eo		(mvAC)	43	43	42	42	42	42	42
15	– Ec – LOW		(mvAC)	49	47	53	50	51	51	52
16	– Ec – HIGH		(mvAC)	51	49	56	53	53	53	54
17	Position 2 – Eo		(mvAC)							
18	– Ec – LOW		(mvAC)							
19	– Ec – HIGH		(mvAC)							
20	Position 3 – Eo		(mvAC)							
21	– Ec – LOW		(mvAC)							
22	– Ec – HIGH		(mvAC)							
23	Position 4 – Eo		(mvAC)							
24	– Ec – LOW		(mvAC)							
25	– Ec – HIGH		(mvAC)							
26										
27	AVERAGE CONCENTRATION	– Position 1		0.098	0.072	0.165	0.131	0.137	0.137	0.148
28		– Position 2								
29		– Position 3								
30		– Position 4								
31	SCATTER (1)	– Position 1	(%)	25.8	37.2	20.1	27.5	17.3	17.3	15.5
32		– Position 2	(%)							
33		– Position 3	(%)							
34		– Position 4	(%)							
35										
36	Run Date		(D M Yr)	10990	10990					
37	Mixer Speed		(RPM)	269	201					
38	Temperature		(C)							
39	Tank Position		(z/H)	0.30	0.30					
40	Tank Position		(r/R)	0.60	0.60					
41										
42	Position 1 – Eo		(mvAC)	42	42					
43	– Ec – LOW		(mvAC)	47	43					
44	– Ec – HIGH		(mvAC)	48	44					
45	Position 2 – Eo		(mvAC)							
46	– Ec – LOW		(mvAC)							
47	– Ec – HIGH		(mvAC)							
48	Position 3 – Eo		(mvAC)							
49	– Ec – LOW		(mvAC)							
50	– Ec – HIGH		(mvAC)							
51	Position 4 – Eo		(mvAC)							
52	– Ec – LOW		(mvAC)							
53	– Ec – HIGH		(mvAC)							
54										
55	AVERAGE CONCENTRATION	– Position 1		0.080	0.023					
56		– Position 2								
57		– Position 3								
58		– Position 4								
59	SCATTER (1)	– Position 1	(%)	16.7	65.3					
60		– Position 2	(%)							
61		– Position 3	(%)							
62		– Position 4	(%)							

Filename: COND-30B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCT 8, 1990)

CONDUCTIVITY PROBE DATA, AXIAL MIXER, 410 micron SAND, CB = 0.100, 440 rpm, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELEC

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	150990	150990	150990	150990	150990	150990	150990
9		Mixer Speed	(RPM)	444	444	444	445	445	445	
10		Temperature	(C)	23.2	23.2	23.2	23.2	23.2	23.2	VISUAL
11		Tank Position	(z/H)	0.10	0.20	0.30	0.40	0.50	0.60	0.70
12		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90
13										
14		Position 1 - Eo	(mvAC)	40	40	40	40	40	40	
15		- Ec - LOW	(mvAC)	51	49	52	54	42	40	
16		- Ec - HIGH	(mvAC)	55	53	55	59	46	42	
17		Position 2 - Eo	(mvAC)	40	40	40	40	39	40	
18		- Ec - LOW	(mvAC)	52	51	54	56	41	40	
19		- Ec - HIGH	(mvAC)	55	54	61	60	45	4[illegible]	
20		Position 3 - Eo	(mvAC)	40.5	40.5	40.5	40	39.5	40	
21		- Ec - LOW	(mvAC)	53	54	58	58	40	40	
22		- Ec - HIGH	(mvAC)	56	58	6[illegible]	63	45	41	
23		Position 4 - Eo	(mvAC)	40	40	40	39.5	40	40	
24		- Ec - LOW	(mvAC)	54	52	53	57	43	40	
25		- Ec - HIGH	(mvAC)	57	55	59	61	47	41	
26										
27		AVERAGE CONCENTRATION - Position 1		0.177	0.154	0.183	0.215	0.062	0.0[illegible]	0.000
28		- Position 2		0.183	0.172	0.224	0.230	0.063	0.008	0.000
29		- Position 3		0.187	0.203	0.247	0.254	0.047	0.008	0.000
30		- Position 4		0.205	0.183	0.209	0.247	0.076	0.[illegible]08	0.000
31		SCATTER (1) - Position 1	(%)	25.4	30.9	18.2	23.9	95.2	200.0	
32		- Position 2	(%)	18.2	19.9	31.3	17.1	95.1	200.0	
33		- Position 3	(%)	17.5	20.6	18.9	18.2	164.1	200.0	
34		- Position 4	(%)	15.4	18.2	29.8	15.5	74.8	200.0	
35										
36		Run Date	(D M Yr)	150990	150990		150990	150990	150990	150990
37		Mixer Speed	(RPM)				449	449	44[illegible]	442
38		Temperature	(C)				22.8	22.8	22.8	23
39		Tank Position	(z/H)	0.80	0.90		0.10	0.20	0.30	0.40
40		Tank Position	(r/R)	0.90	0.90		0.60	0.60	0.60	0.60
41										
42		Position 1 - Eo	(mvAC)				40	40	40	40
43		- Ec - LOW	(mvAC)				52	48	49	51
44		- Ec - HIGH	(mvAC)				55	50	52	54
45		Position 2 - Eo	(mvAC)				40	40	40	40
46		- Ec - LOW	(mvAC)				49	47	50	53
47		- Ec - HIGH	(mvAC)				51	50	53	55
48		Position 3 - Eo	(mvAC)				40	40	40	40
49		- Ec - LOW	(mvAC)				49	48	51	54
50		- Ec - HIGH	(mvAC)				51	50	53	57
51		Position 4 - Eo	(mvAC)				40	40	40	40
52		- Ec - LOW	(mvAC)				51	48	50	55
53		- Ec - HIGH	(mvAC)				53	50	52	57
54										
55		AVERAGE CONCENTRATION - Position 1		0.000	0.000		0.183	0.130	0.149	0.172
56		- Position 2		0.000	0.000		0.143	0.124	0.160	0.189
57		- Position 3		0.000	0.000		0.143	0.130	0.167	0.205
58		- Position 4		0.000	0.000		0.167	0.130	0.155	0.210
59		SCATTER (1) - Position 1	(%)				18.2	19.4	24.4	19.9
60		- Position 2	(%)				17.2	31.0	22.0	11.6
61		- Position 3	(%)				17.2	19.4	13.9	15.4
62		- Position 4	(%)				13.9	19.4	15.4	9.9

K		L	M	N	O	P	Q	R
Run Date	(D M Yr)	150990	150990	150990	150990	150990		150990
Mixer Speed	(RPM)	442	442					443
Temperature	(C)	23	23		— VISUAL —			23
Tank Position	(z/H)	0.50	0.60	0.70	0.80	0.90		0.40
Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60		0.30
Position 1 – Eo	(mvAC)	40	40					40
– Ec – LOW	(mvAC)	45	40					45
– Ec – HIGH	(mvAC)	50	41					47
Position 2 – Eo	(mvAC)	40	40					40
– Ec – LOW	(mvAC)	42	40					49
– Ec – HIGH	(mvAC)	47	41					51
Position 3 – Eo	(mvAC)	40	40					40
– Ec – LOW	(mvAC)	44	40					51
– Ec – HIGH	(mvAC)	50	42					54
Position 4 – Eo	(mvAC)	40	40					40
– Ec – LOW	(mvAC)	44	40					51
– Ec – HIGH	(mvAC)	50	42					53
AVERAGE CONCENTRATION – Position 1		0.110	0.008	0.000	0.000	0.000		0.091
– Position 2		0.068	0.008	0.000	0.000	0.000		0.143
– Position 3		0.103	0.016	0.000	0.000	0.000		0.172
– Position 4		0.103	0.016	0.000	0.000	0.000		0.167
SCATTER (1) – Position 1	(%)	60.0	200.0					30.4
– Position 2	(%)	105.6	200.0					17.2
– Position 3	(%)	78.3	200.0					19.9
– Position 4	(%)	78.3	200.0					13.9

Run Date	(D M Yr)	150990	150990	150990	150990	150990
Mixer Speed	(RPM)	443	443			
Temperature	(C)	23	23		— VISUAL —	
Tank Position	(z/H)	0.50	0.60	0.70	0.80	0.90
Tank Position	(r/R)	0.30	0.30	0.30	0.30	0.30
Position 1 – Eo	(mvAC)	40	40			
– Ec – LOW	(mvAC)	41	40			
– Ec – HIGH	(mvAC)	44	40			
Position 2 – Eo	(mvAC)	40	40			
– Ec – LOW	(mvAC)	42	40			
– Ec – HIGH	(mvAC)	44	41			
Position 3 – Eo	(mvAC)	40	40			
– Ec – LOW	(mvAC)	42	40			
– Ec – HIGH	(mvAC)	45	41			
Position 4 – Eo	(mvAC)	40	40			
– Ec – LOW	(mvAC)	43	40			
– Ec – HIGH	(mvAC)	45	41			
AVERAGE CONCENTRATION – Position 1		0.039	0.000			
– Position 2		0.047	0.008			
– Position 3		0.055	0.008			
– Position 4		0.062	0.008			
SCATTER (1) – Position 1	(%)	116.9				
– Position 2	(%)	63.8	200.0			
– Position 3	(%)	81.8	200.0			
– Position 4	(%)	47.1	200.0			

Filename: COND-31B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.100, NJS TESTS, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	150990	150990	150990	150990	150990	150990	150990
9		Mixer Speed	(RPM)	638	520	354	710	633	555	457
10		Temperature	(C)							
11		Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13										
14		Position 1 - Eo	(mvAC)	42.5	42.5	42	42	42	42	42
15		- Ec - LOW	(mvAC)	54	52	45	54	54	53	48
16		- Ec - HIGH	(mvAC)	56	53	47	56	56	54	49
17		Position 2 - Eo	(mvAC)							
18		- Ec - LOW	(mvAC)							
19		- Ec - HIGH	(mvAC)							
20		Position 3 - Eo	(mvAC)							
21		- Ec - LOW	(mvAC)							
22		- Ec - HIGH	(mvAC)							
23		Position 4 - Eo	(mvAC)							
24		- Ec - LOW	(mvAC)							
25		- Ec - HIGH	(mvAC)							
26										
27		AVERAGE CONCENTRATION - Position 1		0.164	0.136	0.052	0.171	0.171	0.154	0.093
28		- Position 2								
29		- Position 3								
30		- Position 4								
31		SCATTER (1) - Position 1	(%)	13.4	8.6	54.4	12.8	12.8	7.4	
32		- Position 2	(%)							
33		- Position 3	(%)							
34		- Position 4	(%)							
35										
36		Run Date	(D M Yr)	150990	150990	150990	150990	150990	150990	
37		Mixer Speed	(RPM)	140	260	344	429	574	690	
38		Temperature	(C)							
39		Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	
40		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	
41										
42		Position 1 - Eo	(mvAC)	42	42	42	42	42	42	
43		- Ec - LOW	(mvAC)	42	43	44	46	52	54	
44		- Ec - HIGH	(mvAC)	42	43	46	47	54	56	
45		Position 2 - Eo	(mvAC)							
46		- Ec - LOW	(mvAC)							
47		- Ec - HIGH	(mvAC)							
48		Position 3 - Eo	(mvAC)							
49		- Ec - LOW	(mvAC)							
50		- Ec - HIGH	(mvAC)							
51		Position 4 - Eo	(mvAC)							
52		- Ec - LOW	(mvAC)							
53		- Ec - HIGH	(mvAC)							
54										
55		AVERAGE CONCENTRATION - Position 1		0.000	0.016	0.045	0.067	0.148	0.171	
56		- Position 2								
57		- Position 3								
58		- Position 4								
59		SCATTER (1) - Position 1	(%)			64.0	20.8	15.5	12.8	
60		- Position 2	(%)							
61		- Position 3	(%)							
62		- Position 4	(%)							

Filename: COND-32B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 255 micron SAND, CB = 0.100, 545 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	160990		160990	160990	160990	160990	160990
9		Mixer Speed	(RPM)	551		548	548	551	548	551
10		Temperature	(C)	22.8		23.2	23.2	22.8	23.5	22.8
11		Tank Position	(z/H)	0.40		0.10	0.20	0.30	0.30	0.40
12		Tank Position	(r/R)	0.50		0.60	0.60	0.60	0.60	0.60
13										
14		Position 1 - Eo	(mvAC)	39.5		39	39	39.5	39	39.5
15		- Ec - LOW	(mvAC)	45		44	43	49	48	45
16		- Ec - HIGH	(mvAC)	46		46	45	51	50	46
17		Position 2 - Eo	(mvAC)	39.5		39	39	39.5	39	39.5
18		- Ec - LOW	(mvAC)	45		45	43	48	48	45
19		- Ec - HIGH	(mvAC)	47		47	45	50	50	47
20		Position 3 - Eo	(mvAC)	39.5		39	39	39.5	39	39.5
21		- Ec - LOW	(mvAC)	45		45	42	45	45	45
22		- Ec - HIGH	(mvAC)	46		47	44	47	46	46
23		Position 4 - Eo	(mvAC)	39.5		39	39	39.5	39	[illegible]
24		- Ec - LOW	(mvAC)	45		44	43	47	47	[illegible]
25		- Ec - HIGH	(mvAC)	46		46	45	49	48	[illegible]
26										
27		AVERAGE CONCENTRATION - Position 1		0.092		0.093	0.079	0.150	0.146	[illegible]
28		- Position 2		0.099		0.107	0.079	0.138	0.146	0.096
29		- Position 3		0.092		0.107	0.084	0.099	0.100	0.092
30		- Position 4		0.092		0.093	0.079	0.125	0 127	0.099
31		SCATTER (1) - Position 1	(%)	15.1		30.3	[illegible]	16.2	17.1	15.1
32		- Position 2	(%)	27.8		25.6	37.0	18.2	17.1	27.8
33		- Position 3	(%)	15.1		25.6	47.0	27.8	13.9	15.1
34		- Position 4	(%)	15.1		30.3	37.0	20.6	10.3	27.8

A	B	C		D	E	F	G	H
35								
36		Run Date	(D M Yr)	160990	160990	160990	160990	160990
37		Mixer Speed	(RPM)	548	548	548	548	548
38		Temperature	(C)	23.2	23.2	23.5	23.5	23.5
39		Tank Position	(z/H)	0.50	0.60	0.70	0.80	0.90
40		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60
41								
42		Position 1 - Eo	(mvAC)	39	39.5	40	40.5	43
43		- Ec - LOW	(mvAC)	45	45	46	47	48
44		- Ec - HIGH	(mvAC)	47	47	48	49	50
45		Position 2 - Eo	(mvAC)	39	39.5	40	40.5	43
46		- Ec - LOW	(mvAC)	46	45	47	48	48
47		- Ec - HIGH	(mvAC)	47	47	48	50	50
48		Position 3 - Eo	(mvAC)	39	39.5	40	40.5	43
49		- Ec - LOW	(mvAC)	45	45	47	47	49
50		- Ec - HIGH	(mvAC)	46	46	48	49	50
51		Position 4 - Eo	(mvAC)	39	39.5	40	40.5	43
52		- Ec - LOW	(mvAC)	45	45	46	47	48
53		- Ec - HIGH	(mvAC)	46	46	48	49	50
54								
55		AVERAGE CONCENTRATION - Position 1		0.107	0.099	0.104	0.110	0.085
56		- Position 2		0.114	0.099	0.111	0.123	0.085
57		- Position 3		0.100	0.092	0.111	0.110	0.092
58		- Position 4		0.100	0.092	0 104	0.110	0.085
59		SCATTER (1) - Position 1	(%)	25.6	27.8	25.6	23.8	30.6
60		- Position 2	(%)	11.8	27.8	11.9	20.7	30.6
61		- Position 3	(%)	13.9	15.1	11.9	23.8	14.0
62		- Position 4	(%)	13.9	15.1	25.6	23.8	30.6

Filename: COND-33B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 256 micron SAND, CB = 0.100, NJS TESTS, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C	D	E	F	G	H	I	J
8	Run Date	(D M Yr)	160990	160990	160990	160990	160990	160990	160990
9	Mixer Speed	(RPM)	548	465	391	428	348	234	302
10	Temperature	(C)	24	24	24	24	24	24	24
11	Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12	Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13									
14	Position 1 - Eo	(mvAC)	39	39	39	39	39	39	39
15	- Ec - LOW	(mvAC)	49	48	44	46	41	40	40
16	- Ec - HIGH	(mvAC)	50	49	45	47	42	40	42
17	Position 2 - Eo	(mvAC)							
18	- Ec - LOW	(mvAC)							
19	- Ec - HIGH	(mvAC)							
20	Position 3 - Eo	(mvAC)							
21	- Ec - LOW	(mvAC)							
22	- Ec - HIGH	(mvAC)							
23	Position 4 - Eo	(mvAC)							
24	- Ec - LOW	(mvAC)							
25	- Ec - HIGH	(mvAC)							
26									
27	AVERAGE CONCENTRATION - Position 1		0.152	0.140	0.086	0.114	0.041	0.017	0.033
28	- Position 2								
29	- Position 3								
30	- Position 4								
31	SCATTER (1) - Position 1	(%)	8.1	9.1	16.6	11.8	38.4	0.0	97.5
32	- Position 2	(%)							
33	- Position 3	(%)							
34	- Position 4	(%)							

A	B	C	D	E	F
35					
36	Run Date	(D M Yr)	160990	160990	160990
37	Mixer Speed	(RPM)	509	649	580
38	Temperature	(C)	24	24	24
39	Tank Position	(z/H)	0.30	0.30	0.30
40	Tank Position	(r/R)	0.60	0.60	0.60
41					
42	Position 1 - Eo	(mvAC)	39	39	39
43	- Ec - LOW	(mvAC)	48	49	48
44	- Ec - HIGH	(mvAC)	49	50	50
45	Position 2 - Eo	(mvAC)			
46	- Ec - LOW	(mvAC)			
47	- Ec - HIGH	(mvAC)			
48	Position 3 - Eo	(mvAC)			
49	- Ec - LOW	(mvAC)			
50	- Ec - HIGH	(mvAC)			
51	Position 4 - Eo	(mvAC)			
52	- Ec - LOW	(mvAC)			
53	- Ec - HIGH	(mvAC)			
54					
55	AVERAGE CONCENTRATION - Position 1		0.140	0.152	0.146
56	- Position 2				
57	- Position 3				
58	- Position 4				
59	SCATTER (1) - Position 1	(%)	9.1	8.1	17.1
60	- Position 2	(%)			
61	- Position 3	(%)			
62	- Position 4	(%)			

Filename: COND-34B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)
CONDUCTIVITY PROBE DATA, ** EQUILIBRATION TIME **, RADIAL MIXER, 255 micron SAND, CB = 0.100, 545 RPM, 1000 Hz, SQUARE WAVE, 1.0
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	160990	160990	160990	160990	160990	160990	160990
9		Mixer Speed	(RPM)	546	546	546	546	546	546	546
10		Temperature	(C)	24.2	24.2	24.2	24.2	24.2	24.2	24.2
11		Time From Start	(minutes)	0.3	0.83	1.5	2.67	5	7	8.5
12		Tank Position	(z/H)	0.40	0.40	0.40	0.40	0.40	0.40	0.40
13		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
14										
15		Position 1 - Eo	(mvAC)							
16		- Ec - LOW	(mvAC)							
17		- Ec - HIGH	(mvAC)							
18		Position 2 - Eo	(mvAC)	39	39	39	39	39	39	39
19		- Ec - LOW	(mvAC)	45	45	45	45	45	45	45
20		- Ec - HIGH	(mvAC)	46	47	47	47	47	47	47
21		Position 3 - Eo	(mvAC)							
22		- Ec - LOW	(mvAC)							
23		- Ec - HIGH	(mvAC)							
24		Position 4 - Eo	(mvAC)							
25		- Ec - LOW	(mvAC)							
26		- Ec - HIGH	(mvAC)							
27		AVERAGE CONCENTRATION - Position 1								
28		- Position 2		0.100	0.107	0.107	0.107	0.107	0.107	0.107
29		- Position 3								
30		- Position 4								
31		SCATTER (1) - Position 1	(%)							
32		- Position 2	(%)	13.9	25.6	25.6	25.6	25.6	25.6	25.6
33		- Position 3	(%)							
34		- Position 4	(%)							
35										
36		Run Date	(D M Yr)	160990						
37		Mixer Speed	(RPM)	546						
38		Temperature	(C)	24.2						
39		Time From Start	(minutes)	10						
40		Tank Position	(z/H)	0.40						
41		Tank Position	(r/R)	0.60						
42										
43		Position 1 - Eo	(mvAC)							
44		- Ec - LOW	(mvAC)							
45		- Ec - HIGH	(mvAC)							
46		Position 2 - Eo	(mvAC)	39						
47		- Ec - LOW	(mvAC)	45						
48		- Ec - HIGH	(mvAC)	47						
49		Position 3 - Eo	(mvAC)							
50		- Ec - LOW	(mvAC)							
51		- Ec - HIGH	(mvAC)							
52		Position 4 - Eo	(mvAC)							
53		- Ec - LOW	(mvAC)							
54		- Ec - HIGH	(mvAC)							
55		AVERAGE CONCENTRATION - Position 1								
56		- Position 2		0.107						
57		- Position 3								
58		- Position 4								
59		SCATTER (1) - Position 1	(%)							
60		- Position 2	(%)	25.6						
61		- Position 3	(%)							
62		- Position 4	(%)							

Filename: COND-35B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)

CONDUCTIVITY PROBE DATA,** EQUILIBRATION TIME **, RADIAL MIXER, 256 micron SAND, CB = 0.300, 545 RPM, 1000 Hz, SQUARE WAVE, 1 0

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FR[illegible] , 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	[illegible]	190890	190990	190890	190990	190990	190990
9		Mixer Speed	(RPM)	50	550	550	550	550	550	550
10		Temperature	(C)	[illegible]	23.5	23.5	[illegible] 5	23.5	23.5	23 5
11		Time From Start	(minutes)	33	0.833	1.5	[illegible] 5	4.167	6	8
12		Tank Position	(z/H)	0.40	0.40	0.40	[illegible]	0.40	0 40	0.40
13		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
14										
15		Position 1 - Eo	(mvAC)							
16		- Ec - LOW	(mvAC)							
17		- Ec - HIGH	(mvAC)							
18		Position 2 - Eo	(mvAC)	35	35	35	35	35	35	35
19		- Ec - LOW	(mvAC)	65	66	66	65	67	67	67
20		- Ec - HIGH	(mvAC)	72	71	70	70	71	71	72
21		Position 3 - Eo	(mvAC)							
22		- Ec - LOW	(mvAC)							
23		- Ec - HIGH	(mvAC)							
24		Position 4 - Eo	(mvAC)							
25		- Ec - LOW	(mvAC)							
26		- Ec - HIGH	(mvAC)							
27		AVERAGE CONCENTRATION - Position 1								
28		- Position 2		0.389	0.389	0.386	0.382	0.393	0.393	0.396
29		- Position 3								
30		- Position 4								
31		SCATTER (1) - Position 1	(%)							
32		- Position 2	(%)	12.8	9.1	7.5	9.5	7.2	7.2	8.8
33		- Position 3	(%)							
34		- Position 4	(%)							
35										
36		Run Date	(D M Yr)	190990						
37		Mixer Speed	(RPM)	550						
38		Temperature	(C)	23.5						
39		Time From Start	(minutes)	10						
40		Tank Position	(z/H)	0.40						
41		Tank Position	(r/R)	0.60						
42										
43		Position 1 - Eo	(mvAC)							
44		- Ec - LOW	(mvAC)							
45		- Ec - HIGH	(mvAC)							
46		Position 2 - Eo	(mvAC)	35						
47		- Ec - LOW	(mvAC)	66						
48		- Ec - HIGH	(mvAC)	72						
49		Position 3 - Eo	(mvAC)							
50		- Ec - LOW	(mvAC)							
51		- Ec - HIGH	(mvAC)							
52		Position 4 - Eo	(mvAC)							
53		- Ec - LOW	(mvAC)							
54		- Ec - HIGH	(mvAC)							
55		AVERAGE CONCENTRATION - Position 1								
56		- Position 2		0.392						
57		- Position 3								
58		- Position 4								
59		SCATTER (1) - Position 1	(%)							
60		- Position 2	(%)	10.7						
61		- Position 3	(%)							
62		- Position 4	(%)							

Filename: COND-36B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 255 micron SAND, CB = [illegible], NJS TESTS, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELEC

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	190990	190990	190990	190990	190990	190990	190990
9		Mixer Speed	(RPM)	542	614	690	764	857	603	535
10		Temperature	(C)							
11		Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13										
14		Position 1 - Eo	(mvAC)	36	36	36	36	36	36	36
15		- Ec - LOW	(mvAC)	75	75	73	72	71	74	74
16		- Ec - HIGH	(mvAC)	79	78	76	74	73	76	77
17		Position 2 - Eo	(mvAC)							
18		- Ec - LOW	(mvAC)							
19		- Ec - HIGH	(mvAC)							
20		Position 3 - Eo	(mvAC)							
21		- Ec - LOW	(mvAC)							
22		- Ec - HIGH	(mvAC)							
23		Position 4 - Eo	(mvAC)							
24		- Ec - LOW	(mvAC)							
25		- Ec - HIGH	(mvAC)							
26										
27		AVERAGE CONCENTRATION - Position 1		0.431	0.428	0.416	0.407	0.400	0.419	0.422
28		- Position 2								
29		- Position 3								
30		- Position 4								
31		SCATTER (1) - Position 1	(%)	5.6	4.2	4.6	3.2	3.3	3.0	4.4
32		- Position 2	(%)							
33		- Position 3	(%)							
34		- Position 4	(%)							
35										
36		Run Date	(D M Yr)	190990		190990	190990	190990	190990	190990
37		Mixer Speed	(RPM)	387		641	746	825	631	558
38		Temperature	(C)							
39		Tank Position	(z/H)	0.30		0.60	0.60	0.60	0.60	0.60
40		Tank Position	(r/R)	0.60		0.60	0.60	0.60	0.60	0.60
41										
42		Position 1 - Eo	(mvAC)	36		36	36	36	36	36
43		- Ec - LOW	(mvAC)	69		63	61	60	63	62
44		- Ec - HIGH	(mvAC)	72		67	65	63	67	67
45		Position 2 - Eo	(mvAC)							
46		- Ec - LOW	(mvAC)							
47		- Ec - HIGH	(mvAC)							
48		Position 3 - Eo	(mvAC)							
49		- Ec - LOW	(mvAC)							
50		- Ec - HIGH	(mvAC)							
51		Position 4 - Eo	(mvAC)							
52		- Ec - LOW	(mvAC)							
53		- Ec - HIGH	(mvAC)							
54										
55		AVERAGE CONCENTRATION - Position 1		0.390		0.349	0.333	0.321	0.349	0.345
56		- Position 2								
57		- Position 3								
58		- Position 4								
59		SCATTER (1) - Position 1	(%)	5.3		9.0	9.9	8.0	9.0	11.5
60		- Position 2	(%)							
61		- Position 3	(%)							
62		- Position 4	(%)							

TRODE)

		K	L	M	N	O	P	Q	R
Run Date	(D M Yr)		190990	190990		190990	190990	190990	190990
Mixer Speed	(RPM)		483	367		751	618	570	517
Temperature	(C)								
Tank Position	(z/H)		0.60	0.60		0.20	0.20	0.20	0.20
Tank Position	(r/R)		0.60	0.60		0.60	0.60	0.60	0.60
Position 1 – Eo	(mvAC)		36	36		36	36	36	36
– Ec – LOW	(mvAC)		63	64		58	62	62	66
– Ec – HIGH	(mvAC)		67	68		62	65	65	71
Position 2 – Eo	(mvAC)								
– Ec – LOW	(mvAC)								
– Ec – HIGH	(mvAC)								
Position 3 – Eo	(mvAC)								
– Ec – LOW	(mvAC)								
– Ec – HIGH	(mvAC)								
Position 4 – Eo	(mvAC)								
– Ec – LOW	(mvAC)								
– Ec – HIGH	(mvAC)								
AVERAGE CONCENTRATION – Position 1			0.349	0.357	0.000	0.307	0.337	0.337	0.375
– Position 2									
– Position 3									
– Position 4									
SCATTER (1) – Position 1	(%)		9.0	8.6		11.6	7.2	7.2	9.6
– Position 2	(%)								
– Position 3	(%)								
– Position 4	(%)								

Run Date	(D M Yr)	190990
Mixer Speed	(RPM)	448
Temperature	(C)	
Tank Position	(z/H)	0.20
Tank Position	(r/R)	0.60
Position 1 – Eo	(mvAC)	36
– Ec – LOW	(mvAC)	69
– Ec – HIGH	(mvAC)	73
Position 2 – Eo	(mvAC)	
– Ec – LOW	(mvAC)	
– Ec – HIGH	(mvAC)	
Position 3 – Eo	(mvAC)	
– Ec – LOW	(mvAC)	
– Ec – HIGH	(mvAC)	
Position 4 – Eo	(mvAC)	
– Ec – LOW	(mvAC)	
– Ec – HIGH	(mvAC)	
AVERAGE CONCENTRATION – Position 1		0.393
– Position 2		
– Position 3		
– Position 4		
SCATTER (1) – Position 1	(%)	6.9
– Position 2	(%)	
– Position 3	(%)	
– Position 4	(%)	

Filename: COND-37B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 500 micron SAND, CB = 0.100, 545 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELEC

A	B	C	D	E	F	G	H	I	J
8	Run Date	(D M Yr)	190990	190990		190990	190990	190990	190990
9	Mixer Speed	(RPM)	552	552		551	551	551	552
10	Temperature	(C)	24.5	24.5		24	24	24	24.5
11	Tank Position	(z/H)	0.40	0.40		0.10	0.20	0.30	0.40
12	Tank Position	(r/R)	0.50	0.50		0.60	0.60	0.60	0.60
13									
14	Position 1 - Eo	(mvAC)	38	38		38.5	38.5	38.5	38
15	- Ec - LOW	(mvAC)	41	41		45	46	45	41
16	- Ec - HIGH	(mvAC)	43	42		48	48	47	42
17	Position 2 - Eo	(mvAC)	38	38		38.5	38.5	38.5	38
18	- Ec - LOW	(mvAC)	41	41		46	44	45	42
19	- Ec - HIGH	(mvAC)	42	42		48	46	47	43
20	Position 3 - Eo	(mvAC)	38	38		38.5	38.5	38.5	38
21	- Ec - LOW	(mvAC)	41	40		43	43	43	41
22	- Ec - HIGH	(mvAC)	42	42		45	45	44	42
23	Position 4 - Eo	(mvAC)	38	38		38.5	38.5	38.5	38
24	- Ec - LOW	(mvAC)	40	40		45	45	44	41
25	- Ec - HIGH	(mvAC)	42	41		48	47	46	42
26									
27	AVERAGE CONCENTRATION - Position 1		0.065	0.058		0.121	0.128	0.115	0.058
28	- Position 2		0.058	0.058		0.128	0.101	0.115	0.073
29	- Position 3		0.058	0.050		0.087	0.087	0.080	0.058
30	- Position 4		0.050	0.042		0.121	0.115	0.101	0.058
31	SCATTER (1) - Position 1 (%)		46.9	27.0		33.1	20.5	23.6	27.0
32	- Position 2 (%)		27.0	27.0		20.5	27.7	23.6	20.6
33	- Position 3 (%)		27.0	63.7		33.3	33.3	18.4	27.0
34	- Position 4 (%)		63.7	38.4		33.1	23.6	27.7	27.0
35									
36	Run Date	(D M Yr)	190990	190990	190990	190990	190990		
37	Mixer Speed	(RPM)	551	551	551	551	551		
38	Temperature	(C)	24	24	24	24	24		
39	Tank Position	(z/H)	0.50	0.60	0.70	0.80	0.90		
40	Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60		
41									
42	Position 1 - Eo	(mvAC)	39	39.5	40	41	43		
43	- Ec - LOW	(mvAC)	41	42	42	42	43		
44	- Ec - HIGH	(mvAC)	43	43	44	43	44		
45	Position 2 - Eo	(mvAC)	39	39.5	40	41	43		
46	- Ec - LOW	(mvAC)	41	42	43	42	43		
47	- Ec - HIGH	(mvAC)	43	44	44	44	44		
48	Position 3 - Eo	(mvAC)	39	39.5	40	41	43		
49	- Ec - LOW	(mvAC)	41	43	42	41	43		
50	- Ec - HIGH	(mvAC)	42	45	44	43	44		
51	Position 4 - Eo	(mvAC)	39	39.5	40	41	43		
52	- Ec - LOW	(mvAC)	41	42	42	41	43		
53	- Ec - HIGH	(mvAC)	42	44	44	43	44		
54									
55	AVERAGE CONCENTRATION - Position 1		0.049	0.048	0.047	0.024	0.008		
56	- Position 2		0.049	0.056	0.055	0.031	0.008		
57	- Position 3		0.041	0.070	0.047	0.016	0.008		
58	- Position 4		0.041	0.056	0.047	0.016	0.008		
59	SCATTER (1) - Position 1 (%)		63.8	31.8	63.8	65.3	200.0		
60	- Position 2 (%)		63.8	54.2	27.0	97.6	200.0		
61	- Position 3 (%)		38.4	41.5	63.8	200.0	200.0		
62	- Position 4 (%)		38.4	54.2	63.8	200.0	200.0		

Filename: COND-38B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 8, 1990)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 500 micron SAND, CB = 0.100, NJS TESTS, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H	I	J
8		Run Date	(D M Yr)	190990	190990	190990	190990	190990	190990	190990
9		Mixer Speed	(RPM)	551	735	647	595	479	514	390
10		Temperature	(C)							
11		Tank Position	(z/H)	0.30	0.30	0.30	0.30	0.30	0.30	0.30
12		Tank Position	(r/R)	0.60	0.60	0.60	0.60	0.60	0.60	0.60
13										
14		Position 1 - Eo	(mvAC)	38	38	38	38	38	38	38
15		- Ec - LOW	(mvAC)	44	48	48	46	41	42	39
16		- Ec - HIGH	(mvAC)	46	50	50	48	43	44	41
17		Position 2 - Eo	(mvAC)							
18		- Ec - LOW	(mvAC)							
19		- Ec - HIGH	(mvAC)							
20		Position 3 - Eo	(mvAC)							
21		- Ec - LOW	(mvAC)							
22		- Ec - HIGH	(mvAC)							
23		Position 4 - Eo	(mvAC)							
24		- Ec - LOW	(mvAC)							
25		- Ec - HIGH	(mvAC)							
26										
27		AVERAGE CONCENTRATION - Position 1		0.109	0.162	0.162	0.136	0.065	0.080	0.034
28		- Position 2								
29		- Position 3								
30		- Position 4								
31		SCATTER (1) - Position 1	(%)	25.5	15.3	15.3	19.2	46.9	36.9	97.4
32		- Position 2	(%)							
33		- Position 3	(%)							
34		- Position 4	(%)							

Filename: COND-39B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA OCTOBER 13, 1990)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 1000 micron SAND, CB = 0.100, 680 RPM, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C	D	E	F
8	Run Date	(D M Yr)	190990	130191	130191
9	Mixer Speed	(RPM)	680	545	545
10	Temperature	(C)			
11	Tank Position	(z/H)	0.40	0.30	0.30
12	Tank Position	(r/R)	0.50	0.90	0.90
13					
14	Position 1 - Eo	(mvAC)	43.5	43.25	43.5
15	- Ec - LOW	(mvAC)	47	47	47
16	- Ec - HIGH	(mvAC)	48	48	48
17	Position 2 - Eo	(mvAC)	43.5	44	44
18	- Ec - LOW	(mvAC)	47	46	47
19	- Ec - HIGH	(mvAC)	48	48	48
20	Position 3 - Eo	(mvAC)	43.5	44	44
21	- Ec - LOW	(mvAC)	46	46	46
22	- Ec - HIGH	(mvAC)	47	48	47
23	Position 4 - Eo	(mvAC)	43.5	43	43.5
24	- Ec - LOW	(mvAC)	46	46	46
25	- Ec - HIGH	(mvAC)	47	47	47
26					
27	AVERAGE CONCENTRATION - Position 1		0.058	0.061	0.058
28	- Position 2		0.058	0.043	0.050
29	- Position 3		0.044	0.043	0.036
30	- Position 4		0.044	0.051	0.044
31	SCATTER (1) - Position 1 (%)		23.6	22.1	23.6
32	- Position 2 (%)		23.6	64.1	27.2
33	- Position 3 (%)		31.9	64.1	38.6
34	- Position 4 (%)		31.9	27.1	31.9
35					

Filename: COND-40B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA FEB 28, 1991)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.100, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration – Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C	D	E	F	G	H	I	J
8	Run Date	(D M Yr)	260291	260291	260291	260291	260291	260291	260291
9	Mixer Speed	(RPM)	545	545	550	550	550	550	550
10	Temperature	(C)		22		22			
11	Tank Position	(z/H)	0.30	0.40	0.50	0.60	0.70	0.80	0.90
12	Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90	0.90	0.90
13									
14	Position 1 – Eo	(mvAC)	36.5	37	36	36	36.5	37	39
15	– Ec – LOW	(mvAC)	43	43	42	41	43	42	39
16	– Ec – HIGH	(mvAC)	45	45	44	43	45	45	42
17	Position 2 – Eo	(mvAC)	37	37	36	36	36.5	37.5	39
18	– Ec – LOW	(mvAC)	44	43	42	43	44	42	39
19	– Ec – HIGH	(mvAC)	46	45	44	45	46	45	42
20	Position 3 – Eo	(mvAC)	37	37	36	36	36.5	37.5	39
21	– Ec – LOW	(mvAC)	42	42	42	42	44	41	39
22	– Ec – HIGH	(mvAC)	44	44	44	44	47	43	42
23	Position 4 – Eo	(mvAC)	36.5	37	36	36	36.5	37	39
24	– Ec – LOW	(mvAC)	43	42	40	41	43	41	39
25	– Ec – HIGH	(mvAC)	44	44	42	43	45	43	41
26									
27	AVERAGE CONCENTRATION – Position 1		0.120	0.112	0.115	0.100	0.120	0.104	0.024
28	– Position 2		0.128	0.112	0.115	0.129	0.134	0.096	0.024
29	– Position 3		0.097	0.097	0.115	0.115	0.141	0.074	0.024
30	– Position 4		0.113	0.097	0.084	0.100	0.120	0.082	0.017
31	SCATTER (1) – Position 1	(%)	23.5	25.4	25.4	30.1	23.5	41.5	200.0
32	– Position 2	(%)	21.9	25.4	25.4	21.8	20.4	45.5	200.0
33	– Position 3	(%)	30.2	30.2	25.4	25.4	28.7	41.3	200.0
34	– Position 4	(%)	12.7	30.2	36.7	30.1	23.5	36.8	200.0
35									
36	Run Date	(D M Yr)	260291	260291	260291		260291	260291	260291
37	Mixer Speed	(RPM)	550	550	546		686	440	440
38	Temperature	(C)			23		23	23	
39	Tank Position	(z/H)	0.20	0.10	0.30		0.30	0.30	0.30
40	Tank Position	(r/R)	0.90	0.90	0.90		0.90	0.90	0.90
41									
42	Position 1 – Eo	(mvAC)	36	36	36		35	35	35
43	– Ec – LOW	(mvAC)	40	39	42		42	39	39
44	– Ec – HIGH	(mvAC)	41	40	44		44	40	40
45	Position 2 – Eo	(mvAC)	36	36	36		36	35.5	35.5
46	– Ec – LOW	(mvAC)	41	40	43		43	39	39
47	– Ec – HIGH	(mvAC)	42	41	44		45	41	40
48	Position 3 – Eo	(mvAC)	36	36	36		36	36	36
49	– Ec – LOW	(mvAC)	40	41	41		41	38	38
50	– Ec – HIGH	(mvAC)	41	42	42		42	40	39
51	Position 4 – Eo	(mvAC)	36	36	36		35	35	35
52	– Ec – LOW	(mvAC)	40	39	42		42	38	38
53	– Ec – HIGH	(mvAC)	41	40	43		44	39	39
54									
55	AVERAGE CONCENTRATION – Position 1		0.077	0.061	0.115		0.132	0.079	0.079
56	– Position 2		0.092	0.077	0.122		0.129	0.078	0.070
57	– Position 3		0.077	0.092	0.092		0.092	0.052	0.044
58	– Position 4		0.077	0.061	0.107		0.132	0.062	0.062
59	SCATTER (1) – Position 1	(%)	20.5	26.9	25.4		21.7	20.5	20.5
60	– Position 2	(%)	16.5	20.5	11.7		21.8	41.1	23.3
61	– Position 3	(%)	20.5	16.5	16.5		16.5	63.5	38.3
62	– Position 4	(%)	20.5	26.9	13.7		21.7	26.8	26.8

Filename: COND-418.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA FEB 28, 1991)

CONDUCTIVITY PROBE DATA, RADIAL MIXER, 410 micron SAND, CB = 0.300, 1000 Hz, SQUARE WAVE, 1.0 mA

NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration

POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C	D	E	F	G
8	Run Date	(D M Yr)	280291	260291	50391	50391
9	Mixer Speed	(RPM)	545	545	545	545
10	Temperature	(C)				
11	Tank Position	(z/H)	0.50	0.30	0.30	0.50
12	Tank Position	(r/R)	0.90	0.90	0.90	0.90
13						
14	Position 1 - Eo	(mvAC)	32	32	32	32
15	- Ec - LOW	(mvAC)	58	65	64	54
16	- Ec - HIGH	(mvAC)	62	70	70	58
17	Position 2 - Eo	(mvAC)	32	32	32	32
18	- Ec - LOW	(mvAC)	65	66	64	62
19	- Ec - HIGH	(mvAC)	69	73	69	67
20	Position 3 - Eo	(mvAC)	32	32	32	32
21	- Ec - LOW	(mvAC)	63	56	55	58
22	- Ec - HIGH	(mvAC)	68	61	60	64
23	Position 4 - Eo	(mvAC)	32	32	32	32
24	- Ec - LOW	(mvAC)	57	59	58	54
25	- Ec - HIGH	(mvAC)	62	65	64	58
26						
27	AVERAGE CONCENTRATION - Position 1		0.368	0.425	0.421	0.333
28	- Position 2		0.421	0.438	0.418	0.403
29	- Position 3		0.410	0.355	0.346	0.376
30	- Position 4		0.364	0.384	0.376	0.333
31	SCATTER (1) - Position 1	(%)	9.0	8.1	9.9	11.1
32	- Position 2	(%)	6.6	10.5	8.5	9.2
33	- Position 3	(%)	8.8	12.2	12.8	12.9
34	- Position 4	(%)	11.6	12.4	12.9	11.1

Filename: COND-42B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA MARCH 9, 1991)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 1000 micron SAND, CB = 0.100 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G
8	Run Date		(D M Yr)	50391	50391	50391	50391
9	Mixer Speed		(RPM)	545	545	545	545
10	Temperature		(C)				
11	Tank Position		(z/H)	0.30	0.50	0.30	0.50
12	Tank Position		(r/R)	0.90	0.90	0.90	0.90
13							
14	Position 1 - Eo		(mvAC)	39	39	40	38.5
15	- Ec	- LOW	(mvAC)	41	40	42	40
16	- Ec	- HIGH	(mvAC)	43	42	43	42
17	Position 2 - Eo		(mvAC)	40	39	40	38
18	- Ec	- LOW	(mvAC)	42	40	42	41
19	- Ec	- HIGH	(mvAC)	43	42	43	42
20	Position 3 - Eo		(mvAC)	40	39	40.5	38
21	- Ec	- LOW	(mvAC)	41	40	41	41
22	- Ec	- HIGH	(mvAC)	42	42	43	42
23	Position 4 - Eo		(mvAC)	39	39	40	38.5
24	- Ec	- LOW	(mvAC)	40	40	41	40
25	- Ec	- HIGH	(mvAC)	42	42	42	42
26							
27	AVERAGE C/CB - Position 1			0.049	0.033	0.040	0.041
28	- Position 2			0.040	0.033	0.040	0.058
29	- Position 3			0.024	0.033	0.024	0.058
30	- Position 4			0.033	0.033	0.024	0.041
31	SCATTER (1) - Position 1		(%)	63.8	97.5	38.5	77.2
32	- Position 2		(%)	38.5	97.5	38.5	27.0
33	- Position 3		(%)	65.2	97.5	131.5	27.0
34	- Position 4		(%)	97.5	97.5	65.2	77.2

Filename: COND-43B.WK1 LAST UPDATE: SEPT 9, 1991 (CHECKED WITH RAW DATA MARCH 9, 1991)
CONDUCTIVITY PROBE DATA, RADIAL MIXER, 82 micron SAND, CB = 0.100, 1000 Hz, SQUARE WAVE, 1.0 mA
NOTES: SCATTER (1) = 100*(High Concentration - Low Concentration)/Average Concentration
POSITION 1 = SMALL FE TO MIXER, 2 = LARGE FE TO FRONT, 3 = LARGE FE TO MIXER, 4 = LARGE FE TO BACK (FE = FIELD ELECTRODE)

A	B	C		D	E	F	G	H
8		Run Date	(D M Yr)	80391	80391	80391	80391	80391
9		Mixer Speed	(RPM)	545	545	545	545	545
10		Temperature	(C)					
11		Tank Position	(z/H)	0.50	0.30	0.30	0.50	0.30
12		Tank Position	(r/R)	0.90	0.90	0.90	0.90	0.90
13								
14		Position 1 - Eo	(mvAC)	41	38	37.5	39.5	39.5
15		- Ec - LOW	(mvAC)	48	46	46	45	46
16		- Ec - HIGH	(mvAC)	49	48	48	47	47
17		Position 2 - Eo	(mvAC)	41	39	38	39.5	39.5
18		- Ec - LOW	(mvAC)	48	47	48	45	47
19		- Ec - HIGH	(mvAC)	49	49	49	47	49
20		Position 3 - Eo	(mvAC)	41	39	38	39.5	39.5
21		- Ec - LOW	(mvAC)	47	46	46	45	46
22		- Ec - HIGH	(mvAC)	49	48	48	46	47
23		Position 4 - Eo	(mvAC)	41	38	37.5	39.5	39.5
24		- Ec - LOW	(mvAC)	47	47	46	44	46
25		- Ec - HIGH	(mvAC)	48	48	48	45	47
26								
27		AVERAGE C/CB - Position 1		0.109	0.136	0.144	0.099	0.106
28		- Position 2		0.109	0.133	0.156	0.099	0.125
29		- Position 3		0.102	0.120	0.136	0.092	0.106
30		- Position 4		0.096	0.143	0.144	0.078	0.106
31		SCATTER (1) - Position 1	(%)	11.9	19.2	18.0	27.8	12.8
32		- Position 2	(%)	11.9	19.3	8.0	27.8	20.6
33		- Position 3	(%)	25.7	22.0	19.2	15.1	12.8
34		- Position 4	(%)	13.9	9.0	18.0	18.5	12.8