

APPENDIX B
VELOCITY MEASUREMENT DATA

Table B-1. Raw Solids Velocity Data for Liquid-Solid Fluidized Bed
with Uniform Distributor at X= 4.0 cm and Y= 4.5 cm
(Superficial Liquid Velocity = 4.0 cm/sec)

$V_{s,y}$ (cm/sec)	$V_{s,x}$ (cm/sec)
25.46	8.81
30.18	11.68
32.99	14.55
24.33	16.54
33.94	14.54
46.23	21.19
60.42	29.73
24.62	0.98
24.53	7.85
34.80	20.30
44.42	13.52
31.27	11.96
16.70	40.33
27.24	3.89
12.46	38.71
-6.89	22.64

Table B-1 (Continue)

$V_{s,y}$ (cm/sec)	$V_{s,x}$ (cm/sec)
33.00	13.59
33.00	13.59
30.25	6.83
30.25	7.80
30.25	6.83
2.81	42.14
15.70	13.73
19.60	12.75
21.38	18.46
25.09	27.99
29.99	21.28
24.42	12.70
28.11	19.38
40.60	15.46
29.83	32.71
23.26	20.35
28.21	14.59

Table B-1 (Continue)

$V_{s,y}$	$V_{s,x}$
<u>(cm/sec)</u>	<u>(cm/sec)</u>
19.44	18.47
27.19	17.47
33.91	16.47
-26.51	0.98
37.85	6.79
31.06	15.53
48.20	16.38
38.61	21.23
28.32	8.79
31.21	6.83
34.80	20.30
22.44	14.64
39.76	3.88
43.53	8.70
39.68	12.58
36.87	9.70
38.77	9.62

Table B-1 (Continue)

$V_{s,y}$	$V_{s,x}$
<u>(cm/sec)</u>	<u>(cm/sec)</u>
37.71	17.40
27.46	0.98
49.60	6.43
37.83	8.73
-22.71	0.98
19.98	10.90
45.43	7.73
25.45	9.78
35.03	3.89
29.30	6.83
21.67	7.88
22.42	15.59
34.04	7.78
23.48	11.74
37.77	13.56
34.00	10.69
33.82	21.26

Table B-1 (Continue)

$V_{s,y}$	$V_{s,x}$
<u>(cm/sec)</u>	<u>(cm/sec)</u>
41.57	13.53
28.32	8.79
47.28	12.54
31.91	21.27
30.16	12.65
26.51	1.96
34.91	13.57
34.21	4.88
24.53	7.85
41.62	9.67
17.03	2.00

Table B-2. Statistical Analysis on Solids Velocities Data in Table B-1

	For Axial component	For Radial component
Minimum Value	-26.51	0.98
Maximum Value	60.42	42.14
Sum	2283.91	1056.66
Mean Value	29.28	13.55
Median Value	30.25	12.67
Variance	180.37	72.82
Standard Deviation	13.43	8.53
Standard Error	1.52	0.97
Valid Observations	78.00	78.00
Total Observations	78.00	78.00
95% Confidence Interval	3.03	1.92

Table B-3. Frequency Distribution for Axial Solids Velocity from Table B-1

<u>$V_{s,y}$ (cm/sec)</u>	<u>Frequency</u>
-37.50	0.01
-25.00	0.01
-12.50	0.01
0.00	0.03
12.50	0.22
25.00	0.47
37.50	0.23
50.00	0.01
62.50	0.00

Table B-4. Frequency Distribution for Radial Solids Velocity from Table B-1

<u>$V_{s,x}$ (cm/sec)</u>	<u>Frequency</u>
-2.50	0.08
2.50	0.13
7.50	0.26
12.50	0.31
17.50	0.14
22.50	0.01
27.50	0.03
32.50	0.01
37.50	0.04
42.50	0.00

Table B-5. Raw Solids Velocity Data for Liquid-Solid Fluidized Bed
with Uniform Distributor at X= 4.0 cm and Y= 4.5 cm
(Superficial Liquid Velocity = 6.0 cm/sec)

$V_{s,y}$ (cm/s)	$V_{s,x}$ (cm/s)
26.45	6.85
35.96	4.86
41.75	0.97
33.04	11.66
-33.12	4.87
-46.40	1.93
35.98	1.94
29.21	12.65
36.92	2.91
40.70	4.84
22.72	34.08
60.37	34.50
52.85	24.98
34.88	15.50
28.37	5.86

Table B-5 (Continue)

$V_{s,y}$	$V_{s,x}$
<u>(cm/s)</u>	<u>(cm/s)</u>
41.64	8.71
28.32	8.79
26.42	8.81
22.39	16.55
14.90	8.94
29.30	6.83
16.56	21.43
37.87	1.94
23.41	14.63
27.93	28.90
29.30	6.83
27.35	9.77
29.26	9.75
23.81	3.96
16.04	4.01
34.09	0.97
24.69	0.08

Table B-5 (Continue)

$V_{s,y}$	$-V_{s,x}$
<u>(cm/s)</u>	<u>(cm/s)</u>
29.16	14.58
24.44	11.73
46.39	2.89
-29.35	0.97
34.94	11.64
50.98	16.99
-29.34	3.91
-40.71	0.96
53.95	7.70
28.05	22.24
37.86	2.91
51.13	1.92
-9.92	13.89
-20.78	4.94
49.16	15.42
23.60	68.83
57.76	0.96

Table B-5 (Continue)

$V_{s,y}$	$V_{s,x}$
<u>(cm/s)</u>	<u>(cm/s)</u>
-33.78	0.99
24.59	3.94
14.16	3.04
29.34	2.93
31.24	2.93
-22.68	4.93
-37.87	2.91
-21.77	0.99
25.55	2.95
-25.56	1.97
27.46	0.98
31.25	0.98
26.38	10.75
9.77	27.36
29.34	2.10
20.12	0.73
32.18	3.90

Table B-5 (Continue)

$V_{s,y}$ <u>(cm/s)</u>	$V_{s,x}$ <u>(cm/s)</u>
-23.66	1.97
33.14	0.97
-29.33	4.89
-35.04	0.97
24.60	9.85
18.73	9.86
-31.25	0.98
-34.08	2.92
-25.55	2.94
38.76	10.65

Table B-6. Statistical Analysis on Solids Velocities Data in Table B-5

	For Axial component	For Radial component
Minimum Value	-46.40	0.08
Maximum Value	60.37	68.83
Sum	1306.32	652.15
Mean Value	17.19	8.58
Median Value	26.90	4.86
Variance	791.89	111.85
Standard Deviation	28.14	10.58
Standard Error	3.23	1.21
Valid Observations	76.00	76.00
Total Observations	76.00	76.00
95% Confidence Interval	6.43	2.42

Table B-7. Frequency Distribution for Axial Solids Velocity from Table B-5

<u>$V_{s,y}$ (cm/sec)</u>	<u>Frequency</u>
-56.25	0.01
-43.75	0.08
-31.25	0.13
-18.75	0.01
-6.25	0.00
6.25	0.08
18.75	0.38
31.25	0.20
43.75	0.08
56.25	0.03

Table B-8. Frequency Distribution for Radial Solids Velocity from Table B-5

<u>$V_{s,r}$ (cm/sec)</u>	<u>Frequency</u>
-3.13	0.41
3.13	0.26
9.38	0.20
15.63	0.04
21.88	0.04
28.13	0.03
34.38	0.01
40.63	0.00
46.88	0.00
53.13	0.00
59.38	0.00

Table B-9. Raw Solids Velocity Data for Gas-Liquid-Solid Fluidized Bed with Uniform Distributor at X= 4.0 cm and Y= 4.5 cm (Superficial Liquid Velocity = 6.0 cm/sec, Superficial Gas Velocity = 3.36 cm/sec)

V	V _{s,y}	V _{s,x}
(cm/sec)	(cm/s)	(cm/s)
40.41	-40.38	1.76
28.55	-28.34	3.54
33.46	29.00	16.70
37.72	32.42	19.28
26.12	25.75	4.44
36.92	34.31	8.80
-2.32	29.20	2.65
27.50	26.58	7.09
31.27	30.00	8.82
31.51	30.90	6.18
26.52	5.96	25.84
19.07	-15.15	11.59
34.50	32.55	11.44
26.89	-26.73	2.95
47.06	43.70	17.48

Table B-9 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
13.33	-12.82	3.66
10.63	-9.51	4.75
38.42	34.19	17.53
12.68	10.96	6.39
14.83	14.58	2.73
23.76	-23.15	5.34
33.16	20.18	26.32
34.98	-31.53	14.94
37.88	31.52	21.02
18.58	15.18	10.72
28.59	23.79	15.86
21.68	17.76	12.43
18.54	17.99	4.50
21.21	17.79	11.56
29.36	27.38	10.60
25.09	19.42	15.89
30.05	25.54	15.85

Table B-9 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
28.05	24.73	13.25
16.41	16.31	1.81
24.57	19.44	15.02
30.01	27.35	12.35
46.59	46.38	4.38
56.86	56.70	4.36
37.92	36.90	8.78
34.50	32.55	11.44
41.23		
23.37	22.26	7.12
19.07	-18.88	2.70
29.41	-29.20	3.54
39.52	-39.52	0.88
25.83	-25.77	1.78
30.97	-30.92	1.77
43.26	-42.94	5.26
24.05		

Table B-9 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
29.22	29.21	0.89
42.65	-42.07	7.01
38.81	-38.65	3.51
39.96	35.92	17.52
37.02	36.94	2.64
19.76		
35.97	27.12	23.62
31.51	28.18	14.09
33.06	14.08	29.92
19.59	5.38	18.84
25.54	17.60	18.48
34.79	32.54	12.31
22.35	22.33	0.89
29.41	29.20	3.54

Table B-10. Raw Solids Velocity Data for Gas-Liquid-Solid Fluidized Bed with Uniform Distributor at X= 7.5 cm and Y= 9.0 cm (Superficial Liquid Velocity = 4.0 cm/sec, Superficial Gas Velocity = 3.36 cm/sec)

V	V _{s,y}	V _{s,x}
(cm/sec)	(cm/s)	(cm/s)
18.70	-15.43	10.56
14.13	13.71	3.34
8.18	-2.59	7.76
16.48	-16.45	0.82
31.59	27.23	16.02
9.40	0.00	9.40
9.47	-4.24	8.47
10.66	-3.37	10.11
11.96	-9.95	6.64
8.65	-8.61	0.86
17.77	-12.96	12.15
15.08	14.87	2.48
16.01	-15.48	4.07
7.01	-5.53	6.06
26.65		

Table B-10 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
22.85	-22.72	2.43
20.35	19.53	5.70
19.98	17.87	8.94
18.45	17.99	4.04
36.31	35.22	8.81
15.08	14.87	2.48
12.76	-12.51	2.50
11.65	-10.87	4.18
11.76		
10.46	-10.14	2.54
12.27	10.80	5.82
12.76	9.02	9.02
14.41	-13.20	5.77
18.23	-16.30	8.15
18.63	-17.97	4.90
15.22	-14.86	3.30
10.66	-8.32	6.66

Table B-10 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
5.71	-1.80	5.41
7.84	-5.95	5.10
10.46	-2.54	10.14
8.94	-8.56	2.57
14.45	-10.62	9.80
10.54	-7.45	7.45
9.91	-9.32	3.39
16.31	-13.05	9.78
10.04	-6.67	7.50
15.87	-13.08	8.99
13.69	2.25	13.50
14.13	-11.50	8.21
11.14	7.45	8.28
10.89	-9.19	5.85
15.87	-5.75	14.79
11.30	-2.11	11.10
16.53	-8.98	13.88

Table B-10 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
18.88	-13.74	12.94
13.39	-4.97	12.43
17.61	-9.77	14.65
14.13	-11.50	8.21
14.13	-13.23	4.96
17.31	-17.23	1.64
16.96	-9.78	13.85
10.22	-8.37	5.86
17.12	-16.39	4.92
13.48	-8.22	10.69
11.94	-10.84	5.00
15.77	-13.94	7.38
14.73	-13.17	6.59
34.95	32.82	12.01
12.64	12.53	1.67
9.70	-9.35	2.55
7.23	-5.11	5.11

Table B-10 (Continue)

V	$V_{s,y}$	$-V_{s,x}$
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
18.04	-18.02	0.82
15.20	14.84	3.30
13.69	-12.40	5.79
12.17	11.70	3.34

Table B-11. Raw Solids Velocity Data for Gas-Liquid-Solid Fluidized Bed with Uniform Distributor at X= 7.5 cm and Y= 9.0 cm (Superficial Liquid Velocity = 7.23 cm/sec, Superficial Gas Velocity = 3.36 cm/sec)

V (<u>cm/sec</u>)	$V_{s,y}$ (<u>cm/s</u>)	$V_{s,x}$ (<u>cm/s</u>)
19.98	-13.72	14.53
11.30	-9.14	6.65
16.96	-13.85	9.78
23.58	-22.67	6.48
19.98	-19.56	4.08
16.66	-11.37	12.18
13.71	7.41	11.53
12.24	-8.24	9.06
16.77	-10.58	13.02
21.41	-8.92	19.46
14.97	10.59	10.59
14.41	13.20	5.77
21.10	-17.80	11.33
12.66	-11.64	4.99
13.32		

Table B-11 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
15.40	14.84	4.12
10.46	-10.14	2.54
17.61	-16.35	6.54
7.39	-6.02	4.30
29.46	-25.68	14.44
13.35	-13.32	0.83
12.64	12.47	2.08
11.78	-11.75	0.84
19.36	17.91	7.33
18.63	17.97	4.90
13.88	4.14	13.24
14.97	-14.88	1.65
16.37	-15.61	4.93
20.15	-19.55	4.89
16.63	-16.44	2.47
25.67	25.04	5.65
25.08		

Table B-11 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>- V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
20.62	20.36	3.26
24.47	-24.26	3.23
25.53	-24.22	8.07
12.76	12.51	2.50
15.75	-15.67	1.65
23.63	-23.50	2.43
10.52	-9.23	5.04
13.35	-9.02	9.84
17.21	-14.68	8.97
9.44	-6.67	6.67
14.13	-11.50	8.21
18.96	-18.80	2.45
23.63	-23.50	2.43
15.22	14.86	3.30
27.72	-25.96	9.73
25.09	24.24	6.46
21.10	20.32	5.69

Table B-11 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
20.62	20.36	3.26
24.47	-24.26	3.23
25.53	-24.22	8.07
12.76	12.51	2.50
15.75	-15.67	1.65
23.63	-23.50	2.43
10.52	-9.23	5.04
13.35	-9.02	9.84
17.21	-14.68	8.97
9.44	-6.67	6.67
14.13	-11.50	8.21
18.96	-18.80	2.45
23.63	-23.50	2.43
15.22	14.86	3.30
27.72	-25.96	9.73
25.09	24.24	6.46
21.10	20.32	5.69

Table B-11 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
16.37	15.61	4.93
14.11		
16.88	15.56	6.55
21.41	19.46	8.92
18.45	18.15	3.30
11.96	9.95	6.64
20.15	19.55	4.89
16.16	15.63	4.11
10.46	-10.14	2.54
12.54		
16.16	-15.63	4.11
16.37	-4.93	15.61
16.61	-5.74	15.58
12.76	2.50	12.51
15.77	-7.38	13.94
17.87	-4.91	17.18
15.56	-11.40	10.58

Table B-11 (Continue)

V	$V_{s,y}$	$V_{s,x}$
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
18.63	-17.12	7.34
14.13	14.10	0.83
14.73	-13.17	6.59
19.78	-13.99	13.99
8.48	-5.09	6.78

Table B-12. Raw Solids Velocity Data for Gas-Liquid-Solid Fluidized Bed with Central Jet Distributor at X = 23.0 cm and Y = 10.0 cm (Inlet Liquid Velocity = 439.52 cm/sec, Inlet Gas Velocity = 578.88 cm/sec, Inlet Gas Velocity of Left Gas Inlet = 370 cm/sec, Inlet Gas Velocity of Right Gas Inlet 243 cm/sec)

V (cm/sec)	$V_{s,y}$ (cm/s)	$V_{s,x}$ (cm/s)
33.76	11.27	31.82
26.45	6.56	25.63
30.25	1.74	30.20
5.15	2.19	4.66
-7.74	-4.92	-5.97
6.54	4.79	4.45
27.62	4.83	27.20
8.51	0.00	8.51
1.72	1.00	1.40
11.92	2.46	11.66
21.07	2.46	20.93
14.71	1.17	14.66
-10.87	-0.98	-10.82
-36.05	-4.47	-35.77
9.68	5.10	8.23

Table B-12 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
-44.21	-1.19	-44.19
-20.14	-1.12	-20.11
29.78	4.80	29.39
9.06	3.36	8.41
-19.36	-18.36	-6.12
-24.83	-2.25	-24.73
9.71	3.83	8.93
8.07	6.46	4.84
10.85	2.51	10.55
-19.15	-18.50	-4.93
5.17	4.70	2.14
6.65	5.32	3.99
-19.05	-9.60	-16.45
4.95	3.83	3.14
-26.81	-26.75	-1.86
9.25	1.52	9.13
5.14	0.00	5.14

Table B-12 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
10.15	2.16	9.92
12.88	5.29	11.75
-24.81	-0.00	-24.81
-22.08	-21.19	-6.23
8.41	0.84	8.37
16.54	3.05	16.26
10.77	3.84	10.07
9.25	4.76	7.93
-15.70	-11.10	-11.10
8.66	5.00	7.08
8.07	2.22	7.76
-16.40	-9.70	-13.23
-22.33	-12.65	-18.40
12.20	4.53	11.33
-20.47	-4.49	-19.98
3.84	3.24	2.06
5.70	5.50	1.50

Table B-12 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
5.25	0.94	5.16
4.76	4.70	0.78
-18.55	-6.18	-17.50
-14.21	-7.63	-11.99
-14.25	-10.95	-9.12
16.27	1.94	16.15
16.37	1.68	16.28
20.72	0.61	20.71
22.01	4.06	21.64
19.49	2.48	19.33
23.84	8.96	22.10
14.13	1.87	14.01
16.23	0.51	16.22
30.11	2.12	30.04
30.97	0.70	30.96
12.52	1.49	12.43
15.13	2.79	14.87

Table B-12 (Continue)

V	V _{s,y}	V _{s,x}
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
12.75	5.28	11.61
16.50	5.38	15.60
-19.68	-8.35	-17.82
-22.03	-10.55	-19.34
2.22	1.92	1.13
23.86	10.03	21.65
16.86	7.37	15.17
17.18	11.86	12.43
14.77	1.23	14.72
20.43	3.36	20.16
23.35	5.20	22.76
26.81	6.88	25.91
12.46	5.93	10.95
33.71	5.86	33.20
27.77	6.87	26.90
-35.25	-28.61	-20.60
14.16	7.72	11.87

Table B-12 (Continue)

<u>V</u>	<u>V_{s,y}</u>	<u>V_{s,x}</u>
<u>(cm/sec)</u>	<u>(cm/s)</u>	<u>(cm/s)</u>
10.96	9.04	6.21
3.88	3.47	1.74
4.55	3.59	2.79
12.19	4.17	11.46
15.94	6.74	14.45
20.39	9.35	18.12
30.04	17.74	24.24
16.69	10.17	13.23
16.59	7.42	14.84
8.27	3.87	7.31
15.31	5.69	14.22
-15.28	-5.42	-14.29
9.04	6.40	6.40