

TABLE 2.1
SLURRY REACTOR DESIGN STUDIES

• DEPENDENT VARIABLES	
GAS HOLD-UP	MASS TRANSFER
BUBBLE SIZE	LIQUID DISPERSION
SOLIDS DISPERSION	HEAT TRANSFER
• INDEPENDENT VARIABLES	
SLURRY MEDIUM	: PARAFFIN, WATER
SUPERFICIAL GAS VELOCITY	: 1.52 - 15.2 CM/SEC
SUPERFICIAL SLURRY VELOCITY	: 0 - 3.0 CM/SEC
SOLID	: SILICA, IRON OXIDE
SOLID SIZE	: 1-5 μ m, 45-53 μ m, 90-106 μ m
SOLID CONCENTRATION	: 0, 10, 20, 30 WT %
DISTRIBUTOR HOLE SIZE	: 0.9, 3.2, 12.8 mm
HEAT TRANSFER INTERNALS	: NONE, PLAIN

TABLE 4.0
PHYSICAL PROPERTIES OF
LIQUIDS AND SOLIDS

LIQUID	TEMP.	SURFACE TENSION		VISCOSITY	DENSITY	GAS DIFFUSIVITY	SPECIFIC HEAT	THERMAL CONDUCTIVITY
	°C	N/m	Kg/m·s				J/g °K	W/m °K
WATER	20	72.7×10^{-3}	1.00×10^{-3}	1.00	$2.5 \times 10^{-6} (O_2)$	4.187		0.603
ISOPARAFFIN	20	22×10^{-3}	1.20×10^{-3}	0.74	$1.2 \times 10^{-6} (O_2)^*$	1.08		0.13
RHEINPREUSSEN- TYPE PARAFFINIC OIL*	260	11×10^{-3}	0.33×10^{-3}	0.67	$8 \times 10^{-6} (CO)$	2.93		0.13
SOLID OXIDE								
IRON - HEMATITE	20			4.9		0.67		0.38
- MAGNETITE	20			5.2		0.69		1.26
SILICON (QUARTZ)	20			2.4		0.72		6.95

*ESTIMATED

TABLE 5.3.1
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT ³	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10 ⁻³	GAS HOLDUP				SOLID FRACTION			
				1-2*	2-3	3-5	AVG	1	2	3	4
							(VOL %)			(WT %)	
45.93	0.0	0.0	0.0	0.	0.35		22.7	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.36		22.7	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.36		22.5	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.09		14.8	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.10		22.9	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.09		22.4	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.20		17.1	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.21		18.1	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.0	0.20		17.3	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.	0.05		8.0	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.09	0.13		17.5	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.09	0.10		14.0	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.09	0.29		22.0	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.05	0.10		11.7	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.09	0.10		14.0	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.09	0.29		22.0	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.05	0.10		11.7	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.05	0.10		12.5	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.05	0.11		12.7	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.05	0.19		16.7	0.0	0.0	0.0	0.0

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.3.1 (Cont'd)
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT ³	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS		GAS HOLDUP				SOLID FRACTION			
			X10 ⁻³	X10 ⁻³	1-2"	2-3	3-5 (VOL %)	AVG	1	2	3	4
											(WT %)	
45.93	0.0	0.0	0.0	0.05	0.19			16.5	0.0	0.0	0.0	0.0
45.93	0.0	0.0	0.0	0.05	0.10			11.7	0.0	0.0	0.0	0.0
45.93	149.75	2.5	0.0	0.	0.16			12.1	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.	0.27			14.6	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.	0.19			11.7	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.	0.10			8.8	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.	0.47			20.5	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.	0.35			17.4	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.	0.05			3.5	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.05	0.35			16.7	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.10	0.10			6.7	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.10	0.50			21.0	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.10	0.06			3.8	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.10	0.20			13.4	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.05	0.21			16.7	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.09	0.35			17.9	0.0	0.0	0.0	0.0
45.93	149.76	2.5	0.0	0.10	0.20			13.4	0.0	0.0	0.0	0.0
45.93	149.76	2.5	13.5	0.09	0.19			9.7	12.8	13.6	13.6	14.2
45.93	149.76	2.5	13.8	0.	0.20			10.7	12.8	14.0	14.4	14.2
45.93	149.76	2.5	14.6	0.09	0.05			0.5	14.2	14.6	14.4	15.2

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10 ⁻³ 3		1-2"	GAS HOLDUP			SOLID FRACTION			
			2-3	3-5 (VOL %)		AVG	1	2	3 (WT %)	4		
45.93	149.76	2.5	0.0	0.10	0.25		19.8	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.10	0.15		12.9	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	18.4	0.08	0.10		5.8	19.8	18.2	18.0	17.8	
45.93	149.76	2.5	0.0	0.07	0.19		12.5	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.05	0.50		20.6	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.07	0.35		16.0	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.08	0.05		5.4	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.	0.35		15.4	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.	0.11		6.2	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	35.4	0.	0.21		10.9	36.9	36.5	39.1	29.1	
45.93	149.76	2.5	17.2	0.	0.06		3.3	37.0	0.0	31.7	0.0	
45.93	149.76	2.5	31.2	0.10	0.10		4.3	33.6	29.8	32.6	29.0	
45.93	149.76	2.5	20.7	0.10	0.21		6.0	29.9	29.0	24.1	0.0	
45.93	149.76	2.5	0.0	0.10	0.27		8.3	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	30.0	0.10	0.50		15.9	29.7	29.9	34.6	26.9	
45.93	149.76	2.5	0.0	0.	0.22		1.4	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.05	0.33		14.2	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	26.3	0.	0.08		2.9	27.7	26.6	26.1	25.0	
45.93	149.76	2.5	27.7	0.10	0.08		6.7	27.3	27.6	27.7	28.1	
45.93	149.76	2.5	0.0	0.	0.35		13.4	0.0	0.0	0.0	0.0	

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
 ** Measured at tap 1.

TABLE 5.3.1 (Cont'd)
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10**3		GAS HOLDUP				SOLID FRACTION			
			1-2*	2-3	3-5 (VOL %)	AVG	1	2	3	4		
											(WT %)	
45.93	149.76	2.5	0.0	0.	0.10		4.7	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.	0.50		27.7	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	31.1	0.10	0.20		9.6	29.2	35.0	30.3	30.0	
45.93	149.76	2.5	0.0	0.10	0.10		5.4	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.10	0.20		16.5	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.10	0.20		17.9	0.0	0.0	0.0	0.0	
45.93	149.76	2.5	0.0	0.10	0.20		19.5	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	0.0	0.02	0.50		30.4	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	0.0	0.	0.20		17.3	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	0.0	0.	0.10		5.2	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	0.0	0.06	0.35		21.5	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	0.0	0.	0.35		19.1	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	0.0	0.07	0.10		10.6	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	5.9	0.05	0.43		25.2	0.0	9.2	8.1	6.5	
45.93	324.48	98.0	0.0	0.	0.10		7.1	0.0	0.0	0.0	0.0	
45.93	324.48	98.0	11.5	0.	0.50		22.6	16.1	13.5	9.3	7.2	
45.93	324.48	98.0	21.0	0.06	0.50		26.8	22.5	23.4	21.3	16.9	
45.93	324.48	98.0	11.8	0.	0.10		9.0	16.0	14.3	9.7	7.4	
45.93	324.48	98.0	19.0	0.05	0.35		24.2	18.0	19.9	18.6	19.6	
45.93	324.48	98.0	11.6	0.	0.50		25.0	14.2	11.5	10.9	9.8	

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIC SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10**3		1-2*	GAS HOLDUP			SOLID FRACTION			
			2-3	3-5 (VOL %)		AVG	1	2	3	4		
											(WT %)	
45.93	324.48	98.0	20.2	0.	0.35			20.0	28.0	23.3	15.8	13.6
45.93	324.48	98.0	15.4	0.05	0.10			13.1	15.6	16.5	15.2	14.4
45.93	324.48	98.0	17.0	0.06	0.50			26.8	17.6	19.1	17.0	14.2
45.93	324.48	98.0	21.5	0.07	0.35			21.3	25.5	25.5	14.2	20.8
45.93	324.48	98.0	20.0	0.07	0.06			10.4	19.6	21.4	19.9	19.1
45.93	324.48	98.0	24.1	0.07	0.50			26.0	25.2	25.4	24.3	21.5
45.93	324.48	98.0	18.8	0.	0.10			10.5	27.8	21.5	16.0	10.1
45.93	324.48	98.0	26.1	0.	0.52			25.8	32.9	29.6	24.4	17.4
45.93	324.48	98.0	22.1	0.01	0.10			10.8	22.7	22.7	22.7	20.4
45.93	324.48	98.0	17.9	0.	0.05			6.6	21.0	21.7	15.8	13.2
45.93	324.48	98.0	16.3	0.	0.35			21.9	22.2	18.7	14.4	10.1
45.93	324.48	98.0	21.8	0.	0.10			8.8	41.4	31.3	22.3	17.0
45.93	324.48	98.0	30.1	0.10	0.20			13.3	31.6	35.0	26.9	26.9
45.93	324.48	98.0	23.4	0.	0.35			19.3	0.0	40.6	29.3	23.7
45.93	324.48	49.0	7.6	0.	0.10			9.9	8.7	7.9	6.5	7.4
45.93	324.48	49.0	8.5	0.06	0.37			20.9	11.3	11.0	11.9	0.0
45.93	324.48	49.0	12.9	0.	0.50			24.0	15.6	12.7	13.2	10.1
45.93	324.48	49.0	10.4	0.07	0.12			12.1	10.8	11.0	11.0	8.9
45.93	324.48	49.0	9.3	0.	0.35			13.7	12.5	10.0	8.5	6.4
45.93	324.48	49.0	10.9	0.06	0.20			15.6	120.2	11.9	11.3	10.4

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
 ** Measured at tap 1.

TABLE 5.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10**3		1-2*	GAS HOLDUP			SOLID FRACTION			
			2-3	3-5 (VOL %)		AVG	1	2	3	4		
											(WT %)	
45.93	324.48	49.0	4.4	0.	0.05		7.0	5.1	4.8	3.9	3.7	
45.93	324.48	49.0	5.1	6.	0.52		37.5	5.8	5.5	4.7	4.6	
45.93	324.48	49.0	25.0	0.	0.32		16.2	31.8	27.1	23.3	17.7	
45.93	324.48	49.0	17.5	7.	0.05		10.0	16.7	16.9	17.3	19.1	
45.93	324.48	49.0	20.3	0.	0.10		10.2	22.0	21.0	18.5	19.8	
45.93	324.48	49.0	18.1	8.	0.50		29.2	19.5	18.2	17.4	17.3	
45.93	324.48	49.0	18.7	0.	0.20		15.9	21.9	20.2	17.1	15.6	
45.93	324.48	49.0	14.1	10.	0.20		25.2	12.4	15.4	13.7	15.0	
45.93	324.48	49.0	14.1	7.	0.35		27.6	12.6	13.2	14.2	16.5	
45.93	324.48	49.0	26.6	5.	0.50		8.3	27.7	27.2	27.0	24.6	
45.93	324.48	49.0	27.8	0.	0.20		14.8	33.4	30.2	25.4	22.4	
45.93	324.48	49.0	23.6	5.	0.05		6.0	23.7	25.1	23.2	22.6	
45.93	324.48	49.0	28.9	0.	0.50		23.9	34.6	30.5	25.8	24.8	
45.93	324.48	49.0	27.8	5.	0.35		20.2	27.2	29.6	28.5	26.0	
45.93	324.48	49.0	11.5	0.	0.05		4.3	12.7	12.0	11.2	10.1	
45.93	324.48	49.0	27.9	5.	0.20		18.4	26.6	29.7	28.1	27.3	
45.93	324.48	49.0	32.0	0.	0.10		8.9	35.2	37.2	28.5	27.0	
45.93	324.48	2.5	9.8	0.	0.07		6.3	11.9	11.2	8.2	8.0	
45.93	324.48	2.5	7.7	10.	0.07		100.0	7.9	7.9	7.6	7.6	
45.93	324.48	2.5	9.7	10.	0.38		19.2	9.1	11.2	9.9	8.8	

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.

** Measured at tap 1.

TABLE S.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY L10 SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10**3			1-2*	GAS HOLDUP			SOLID FRACTION			
			2-3	3-5 (VOL %)	AVG		1	2	3	4			
											(WT %)		
45.93	324.48	2.5	10.3	0.	0.50		25.4	11.8	11.5	8.7	9.1		
45.93	324.48	2.5	11.4	0.	0.35		21.1	10.6	13.4	10.6	11.1		
45.93	324.48	2.5	10.1	10.	0.50		25.2	8.7	10.6	11.2	9.8		
45.93	324.48	2.5	9.5	10.	0.10		5.6	7.9	8.2	10.7	11.3		
45.93	324.48	2.5	23.5	0.	0.10		7.5	23.2	22.9	24.8	23.1		
45.93	324.48	2.5	22.4	10.	0.35		17.5	22.1	22.7	22.4	22.6		
45.93	324.48	2.5	28.8	10.	0.50		20.1	28.4	28.8	28.7	29.3		
45.93	324.48	2.5	28.6	0.	0.06		5.5	26.4	28.1	29.2	28.7		
45.93	324.48	2.5	30.3	10.	0.34		14.6	29.8	29.9	30.6	30.8		
45.93	324.48	2.5	30.5	0.	0.50		23.4	30.7	30.7	30.2	30.4		
45.93	324.48	2.5	27.0	0.	0.20		13.1	27.7	27.8	27.1	25.5		
45.93	324.48	2.5	27.1	0.	0.10		8.0	27.0	26.9	27.2	27.3		
45.93	324.48	2.5	28.0	10.	0.10		13.6	25.8	26.3	27.5	32.4		
45.93	324.48	2.5	20.4	10.	0.06		25.8	19.3	21.8	21.1	19.4		
45.93	324.48	2.5	19.5	0.	0.19		15.7	20.0	19.9	19.5	18.8		
45.93	324.48	2.5	20.7	10.	0.18		10.0	20.9	20.9	20.1	21.0		
45.93	324.48	2.5	21.4	0.	0.06		6.4	20.9	21.3	22.0	21.4		
45.93	324.48	2.5	27.6	0.	0.44		23.0	29.8	29.7	28.8	22.3		
45.93	324.48	2.5	20.9	10.	0.36		15.4	21.2	21.1	20.6	20.7		
45.93	324.48	2.5	23.7	10.	0.47		19.4	23.2	23.2	23.5	25.1		

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
 ** Measured at tap 1.

TABLE 5.3.1 (Cont'd)
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS				GAS HOLDUP				SOLID FRACTION			
			X10 ⁻³	1-2"	2-3	3-5 (VOL %)	AVG	1	2	3	4			
45.93	149.76	49.0	6.7	6.	0.34	21.8	19.5	19.5	20.1	8.4	7.6	6.7	4.1	
45.93	149.76	49.0	4.7	0.	0.06	5.5		2.6	7.7	5.5	5.1	4.5	3.7	
45.93	149.76	49.0	7.8	6.	0.50	19.4	24.0	21.7	23.1	9.9	8.7	5.9	6.7	
45.93	149.76	49.0	4.4	0.	0.50	20.0	25.8	24.7	22.6	4.7	7.0	3.5	2.3	
45.93	149.76	49.0	6.6	6.	0.20	14.3	18.8	16.8	17.1	7.1	7.5	6.0	5.9	
45.93	149.76	49.0	0.0	0.	0.10	8.4	8.4	11.3	8.2	0.0	0.0	0.0	0.0	
45.93	149.76	49.0	4.3	6.	0.08	7.0	8.5	8.4	7.8	5.0	4.9	3.9	3.5	
45.93	149.76	49.0	4.7	0.	0.21	8.1	15.6	13.3	14.4	5.7	5.7	4.6	2.7	
45.93	149.76	49.0	17.3	5.	0.52	20.3	22.8	21.3	23.6	20.1	19.1	16.4	13.5	
45.93	149.76	49.0	18.2	0.	0.35	14.7	17.3	18.7	19.4	23.1	21.2	16.0	12.4	
45.93	149.76	49.0	17.1	5.	0.37	15.0	17.7	18.8	20.2	19.6	18.9	16.8	13.3	
45.93	149.76	49.0	17.7	0.	0.11	7.2	6.5	8.9	10.8	21.9	20.2	17.0	11.7	
45.93	149.76	49.0	16.9	5.	0.20	16.1	16.1	16.1	16.5	19.3	18.0	16.2	14.0	
45.93	149.76	49.0	15.0	0.	0.20	6.3	11.5	13.2	13.0	18.8	17.4	13.6	10.3	
45.93	149.76	49.0	11.7	5.	0.06	4.3	5.8	5.3	4.6	14.4	11.4	10.9	10.2	
45.93	149.76	49.0	12.3	0.	0.06	3.7	5.1	6.4	6.7	13.8	14.0	11.6	9.9	
45.93	149.76	49.0	7.9	0.	0.06	0.0	4.0	5.5	5.2	16.0	15.6	0.0	0.0	
45.93	149.76	49.0	16.8	5.	0.07	6.3	7.8	8.8	8.2	18.6	17.4	15.9	15.4	
45.93	149.76	49.0	18.9	0.	0.21	8.5	10.4	12.8	14.0	23.6	20.9	17.3	13.9	
45.93	149.76	49.0	19.5	5.	0.20	14.7	14.7	14.0	14.2	21.1	21.0	18.9	17.0	

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10 ⁻³			1-2*	GAS HOLDUP			SOLID FRACTION			
			2-3	3-5 (VOL %)	AVG		1	2	3	4			
											(WT %)		
45.93	149.76	98.0	14.3	4.	0.50		22.3	25.9	15.9	9.1	6.5		
45.93	149.76	98.0	8.4	0.	0.50		25.4	24.0	4.3	4.3	1.1		
45.93	149.76	98.0	8.3	5.	0.10		11.7	13.3	7.2	8.3	4.4		
45.93	149.76	98.0	1.3	0.	0.06		7.3	1.8	0.9	0.9	1.8		
45.93	149.76	98.0	10.1	4.	0.06		4.6	21.0	11.3	6.3	1.9		
45.93	149.76	98.0	10.1	5.	0.05		7.1	21.0	11.3	6.3	1.9		
45.93	149.76	98.0	4.8	0.	0.27		14.9	7.9	6.0	3.1	2.1		
45.93	149.76	98.0	17.6	6.	0.19		14.1	24.3	20.6	14.2	11.4		
45.93	149.76	98.0	20.3	6.	0.50		23.0	33.3	23.4	14.3	10.1		
45.93	149.76	98.0	15.8	5.	0.07		7.9	21.0	17.3	13.8	11.2		
45.93	149.76	98.0	22.2	6.	0.35		19.2	33.0	25.8	19.4	10.7		
45.93	149.76	98.0	18.3	6.	0.50		21.2	28.5	22.0	15.0	7.8		
45.93	149.76	98.0	18.5	0.	0.35		17.8	27.8	25.8	13.5	7.1		
45.93	149.76	98.0	6.3	0.	0.20		11.3	25.2	0.0	0.0	0.0		
45.93	149.76	98.0	0.0	0.	0.10		6.0	0.0	0.0	0.0	0.0		
45.93	149.76	98.0	28.6	5.	0.52		21.6	39.8	33.3	24.5	17.0		
45.93	149.76	98.0	25.8	6.	0.12		10.2	33.9	28.9	23.4	17.0		
45.93	149.76	98.0	26.9	6.	0.39		18.9	36.3	31.4	23.6	16.5		
45.93	149.76	98.0	23.0	6.	0.06		5.7	26.4	25.2	21.5	19.0		
45.93	149.76	98.0	23.1	0.	0.50		21.4	33.2	29.9	18.0	11.2		

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
 ** Measured at tap 1.

TABLE 5.3.1 (Cont'd)
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT ³	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10 ⁻³			GAS HOLDUP				SOLID FRACTION			
						1-2"	2-3	3-5 (VOL %)	AVG	1	2	3	4
45.93	149.76	49.0	20.9	0.	0.51	19.0	22.1	22.8	22.3	26.4	23.2	19.4	14.7
45.93	149.76	49.0	19.4	5.	0.12	12.4	11.6	12.3	12.5	21.5	20.1	18.8	17.1
45.93	149.76	49.0	19.1	0.	0.12	4.7	12.7	9.0	10.4	24.5	20.9	17.1	14.0
45.93	149.76	49.0	21.8	5.	0.51	19.5	20.9	20.5	22.6	26.9	22.6	20.2	17.4
62.40	149.76	2.5	28.7	0.	0.05	2.4			2.9	28.6	28.4	29.5	28.4
62.40	149.76	2.5	28.4	0.	0.10	6.7	2.9		5.9	28.4	28.7	28.4	28.3
62.40	149.76	2.5	28.4	0.	0.10	6.7	2.9		5.9	28.4	28.7	28.4	28.3
62.40	149.76	2.5	28.2	0.	0.20	9.1	7.8		8.6	28.2	28.2	27.9	28.4
62.40	149.76	2.5	27.8	0.	0.35	14.3	9.3		12.1	27.9	27.8	27.5	28.2
62.40	149.76	2.5	28.2	0.	0.50	14.3	15.2		14.5	28.3	28.2	27.9	28.4
62.40	149.76	2.5	21.5	0.	0.05	3.0	2.2		3.0	21.4	21.9	21.3	21.3
62.40	149.76	2.5	20.8	0.	0.13	7.9	4.0		5.8	19.8	21.0	20.5	22.0
62.40	149.76	2.5	18.8	0.	0.22	8.4	8.9		8.9	18.8	18.9	18.7	19.0
62.40	149.76	2.5	19.8	0.	0.35	11.6	12.1		12.2	20.3	20.0	19.3	19.8
62.40	149.76	2.5	19.5	0.	0.50	18.1	16.8		14.2	19.6	19.5	19.1	19.7
62.40	149.76	2.5	11.3	0.	0.05	4.1	3.8		4.4	11.1	11.0	11.5	11.6
62.40	149.76	2.5	11.1	0.	0.10	7.7	8.0		7.6	11.2	11.2	10.7	11.4
62.40	149.76	2.5	11.3	0.	0.20	10.0	10.6		8.9	11.2	11.4	11.3	11.2
62.40	149.76	2.5	11.2	0.	0.35	12.1	14.8		13.2	11.4	11.1	10.9	11.3
62.40	149.76	2.5	10.8	0.	0.50	19.4	19.4		16.1	10.8	10.9	10.7	11.0
62.40	149.76	98.0	22.0	0.	0.10		2.0		5.5	29.1	27.2	19.5	12.3

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10 ⁻³ 3		GAS HOLDUP				SOLID FRACTION			
			1-2"	2-3	3-5 (VOL %)	AVG	1	2	3	4		
											(WT %)	
62.40	149.76	98.0	23.6	0.	0.20	2.5	7.4	10.4	30.5	28.2	21.6	14.2
62.40	149.76	98.0	24.6	0.	0.30	7.9	9.2	13.0	33.7	28.9	22.0	13.9
62.40	149.76	98.0	24.4	0.	0.40	17.6	15.1	17.2	36.4	29.3	18.2	13.8
62.40	149.76	98.0	25.0	0.	0.50	16.3	16.1	18.8	35.9	29.1	20.2	14.7
62.40	149.76	98.0	14.2	0.	0.10	2.6	3.4	6.4	17.8	17.5	13.0	8.7
62.40	149.76	98.0	14.5	0.	0.20	7.0	8.3	11.8	19.1	17.9	13.2	7.8
62.40	149.76	98.0	17.2	0.	0.35	13.2	15.4	17.5	26.1	19.9	13.3	9.6
62.40	149.76	98.0	16.6	0.	0.28	11.5	14.1	15.3	25.4	20.2	13.0	7.8
62.40	149.76	98.0	15.9	0.	0.50	17.0	19.7	20.0	24.3	18.4	12.5	8.5
62.40	149.76	98.0	5.9	0.	0.10	5.3	5.1	7.8	8.0	7.7	5.1	2.9
62.40	149.76	98.0	7.1	0.	0.20	6.5	10.7	12.0	10.2	8.7	5.9	3.6
62.40	149.76	98.0	9.5	0.	0.30	21.2	21.2	21.6	14.9	12.2	7.1	4.0
62.40	149.76	98.0	9.4	0.	0.40	20.3	21.7	21.0	15.2	11.3	6.6	4.5
62.40	149.76	98.0	8.6	0.	0.50	23.7	23.7	22.2	12.9	10.9	6.4	4.2
62.40	149.76	2.5	11.9	5.	0.28	10.9	10.9	12.1	12.1	12.0	11.8	11.9
62.40	149.76	2.5	29.8	5.	0.23	8.0	8.0	8.8	9.2	29.8	29.7	29.9
62.40	149.76	2.5	22.1	5.	0.17	7.5	6.1	6.6	6.7	22.1	21.8	22.5
62.40	149.76	2.5	21.9	0.	0.27	11.4	8.8	9.1	10.1	22.0	21.9	21.9
62.40	149.76	2.5	20.8	10.	0.29	6.0	4.5	6.6	6.3	20.8	20.6	20.8
62.40	149.76	2.5	20.8	5.	0.44	13.3	13.0	13.4	14.6	20.9	21.0	20.8

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
 ** Measured at tap 1.

TABLE 5.3.1 (Cont'd)

GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT ³	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS		X10 ⁻³	1-2*	GAS HOLDUP			AVG	SOLID FRACTION			
							2-3	3-5	(VOL %)		1	2	3	4
													(WT %)	
62.40	149.76	49.0	10.6	5.	0.15	13.0	14.6	14.0	13.1	11.1	10.7	10.8	9.9	
62.40	149.76	49.0	11.1	0.	0.27	14.5	16.2	16.9	16.9	13.3	12.6	10.0	8.6	
62.40	149.76	49.0	10.3	10.	0.27	15.5	13.9	12.9	12.5	10.3	11.0	10.2	9.7	
62.40	149.76	49.0	11.3	5.	0.51	26.0	26.0	22.2	22.1	12.2	12.3	10.8	10.0	
62.40	149.76	49.0	21.5	0.	0.18	8.3	9.6	8.7	11.0	24.8	23.0	20.3	18.1	
62.40	149.76	49.0	21.1	10.	0.15	9.4	9.4	9.7	8.8	20.7	21.8	21.1	20.9	
62.40	149.76	49.0	22.4	5.	0.33	14.5	13.4	14.3	15.4	23.4	23.2	22.0	21.0	
62.40	149.76	49.0	21.5	5.	0.24	11.6	10.5	11.8	12.1	22.1	22.3	21.5	20.3	
62.40	149.76	49.0	21.7	5.	0.25	13.0	11.4	12.3	12.7	22.5	22.4	21.4	20.5	
62.40	149.76	49.0	20.6	0.	0.51	16.4	18.0	17.2	18.6	23.5	21.8	19.8	17.4	
62.40	149.76	49.0	20.7	10.	0.51	19.1	20.2	19.5	19.6	20.9	20.9	20.8	20.4	
62.40	149.76	49.0	28.6	5.	0.20	13.3	6.6	9.3	9.4	29.0	29.0	29.1	27.4	
62.40	149.76	49.0	25.6	0.	0.28	10.9	9.4	12.1	13.6	28.3	26.4	24.6	23.1	
62.40	149.76	49.0	26.6	10.	0.31	15.2	12.6	14.1	14.6	25.2	27.4	27.0	27.0	
62.40	149.76	49.0	27.7	5.	0.54	19.3	19.9	19.2	20.0	28.4	29.8	26.7	26.1	
62.40	149.76	98.0	10.7	5.	0.16	7.5	7.5	7.5	7.9	121.4	11.8	10.3	8.2	
62.40	149.76	98.0	22.9	5.	0.30	10.6	8.7	11.8	13.0	23.9	26.3	22.8	18.6	
62.40	149.76	98.0	19.4	0.	0.28	8.9	9.7	10.6	12.4	25.3	21.5	17.6	13.3	
62.40	149.76	98.0	18.8	10.	0.31	10.6	12.5	13.9	13.7	19.3	19.9	18.9	17.1	
62.40	149.76	98.0	20.5	5.	0.52	6.0	18.7	21.3	20.8	24.6	22.4	19.3	15.9	

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.

** Measured at tap 1.

TABLE 5.3.1 (Cont'd)
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY L1Q SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS		GAS HOLDUP				SOLID FRACTION				
			X10**3	1-2"	2-3	3-5 (VOL %)	AVG	1	2	3	4		
												(WT %)	
62.40	149.76	98.0	25.4	5.	0.30	9.8	10.6	13.9	14.9	25.4	25.9	24.4	25.9
62.40	324.48	2.5	10.1	5.	0.29	16.1	23.9	20.0	19.6	10.1	10.2	10.1	9.9
62.40	324.48	2.5	17.7	5.	0.24	16.7	16.7	17.2	16.4	17.6	17.7	18.0	17.5
62.40	324.48	2.5	18.7	0	0.29	15.9	15.9	15.9	21.0	19.3	18.4	18.3	18.9
62.40	324.48	2.5	18.6	9.	0.29	25.4	25.4	23.8	23.1	18.7	18.2	18.7	18.8
62.40	324.48	2.5	18.4	5.	0.53	24.48	49.0	10.5	10.	0.30	42.3	39.1	31.5
62.40	324.48	49.0	10.0	9.	0.29	20.7	16.3	15.7	17.5	9.9	10.6	10.0	9.5
62.40	324.48	49.0	8.3	5.	0.54	18.1	18.1	17.7	19.6	9.6	8.7	7.5	7.3
62.40	324.48	49.0	15.2	0.	0.17	6.4	7.8	10.6	10.5	18.7	16.4	13.2	12.5
62.40	324.48	49.0	18.8	5.	0.29	16.5	13.9	17.5	18.2	20.3	19.5	18.4	17.1
62.40	324.48	49.0	19.3	5.	0.29	16.1	13.5	17.1	18.5	21.3	20.5	18.3	17.1
62.40	324.48	49.0	10.9	5.	0.29	16.8	12.4	17.7	18.3	20.4	20.1	18.2	16.8
62.40	324.48	49.0	15.4	11.	0.17	9.4	6.7	8.2	7.9	14.9	15.8	15.5	15.5
62.40	324.48	49.0	18.4	9.	0.49	18.7	17.2	18.1	18.8	18.5	19.4	18.6	17.2
62.40	324.48	49.0	17.4	0.	0.50	19.9	23.3	24.1	25.8	20.9	19.0	15.9	13.7
62.40	324.48	49.0	26.1	0.	0.28	12.8	11.6	14.7	16.0	31.3	27.1	23.8	22.3

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.3.1 (Cont'd)
GAS AND SOLID HOLDUP: 5" COLD FLOW SIMULATOR

DENSITY LIQ SOL LB / FT 3	SOLID SIZE MICRON	WT %	VELOCITY FT/SEC SLURRY GAS X10 ⁻³		GAS HOLDUP				SOLID FRACTION				
			1-2"	2-3	3-5 (VOL %)	AVG	1	2	3	4			
							(WT %)						
62.40	324.48	49.0	19.3	9.	0.28	16.7	18.0	17.0	18.3	19.3	19.6	19.5	19.0
62.40	324.48	49.0	19.0	6.	0.47	22.9	22.9	22.6	24.6	20.0	19.4	19.0	17.8
62.40	324.48	49.0	13.7	6.	0.17	11.2	9.8	10.4	10.8	14.0	13.8	13.8	13.2
62.49	324.48	98.0	9.3	5.	0.28	14.2	26.4	15.9	16.9	11.6	9.9	8.9	7.0
62.40	324.48	98.0	22.6	5.	0.54	20.3	20.3	21.2	24.2	26.5	24.4	21.5	18.0
62.40	324.48	98.0	22.3	0.	0.29	13.7	16.1	16.3	17.3	31.6	26.5	17.4	13.7
62.40	324.48	98.0	20.1	6.	0.17	9.5	8.2	12.0	12.1	23.1	21.4	19.2	16.7
62.40	324.48	98.0	28.0	5.	0.27	11.2	12.4	15.0	16.7	32.8	29.6	26.3	23.2
62.40	324.48	98.0	16.5	0.	0.20	0.0	0.0	0.0	13.3	24.0	19.0	13.0	10.0
62.40	324.48	98.0	16.5	0.	0.50	0.0	0.0	0.0	23.4	24.0	18.0	13.0	11.0

* 1-2 measured between taps 1 and 2; blanks denote taps had not been incorporated at the time of run.
** Measured at tap 1.

TABLE 5.1.2

GAS AND SOLID HOLDUP: 12" COLD FLOW SIMULATOR

Tube Insert	Distributor Hole Size Inches	Density		Solid Size Micron	Solids In Slurry HL %	Slurry ft/sec	Gas ft/sec	Gas Holdup			Solid Fraction			
		Liquid lb/ft ³	Solid lb/ft ³					1-2	2-3	3-4	Avg	1	2	3
										Vol %				HL %
N	.125	62.43	0.0	0.0	0.0	0	0.190	9.4	11.5		0.0	0.0	0.0	0.0
N	.125	62.43	0.0	0.0	0.0	0.015	0.614	23.1	23.1	23.8	0.0	0.0	0.0	0.0
N	.125	47.20	0.0	0.0	0.0	0	0.269	16.9	18.5		0.0	0.0	0.0	0.0
N	.5	47.20	0.0	0.0	0.0	0	0.233	15.1	18.2		0.0	0.0	0.0	0.0
N	.5	47.20	0.0	0.0	0.0	0.015	0.299	15.3	17.8	18.9	0.0	0.0	0.0	0.0
N	.035	47.20	0.0	0.0	0.0	0	0.329	21.4	22.2		0.0	0.0	0.0	0.0
N	.035	47.20	0.0	0.0	0.0	0.008	0.273	18.9	19.7	19.9	0.0	0.0	0.0	0.0
N	.125	47.20	149.76	2.5	25.0	0.008	0.187	0.0	0.0	0.0	24.3	25.2	25.3	25.4
N	.5	47.20	149.76	50.0	29.4	0.008	0.285	0.0	0.0	0.0	40.7	30.2	25.6	21.2
N	.035	47.20	149.76	50.0	30.6	0.008	0.341	0.0	0.0	0.0	36.8	33.4	28.5	23.7
N	.125	47.20	149.76	50.0	26.9	0.015	0.069	0.0	0.0	0.0	34.5	30.4	23.3	19.5
N	.125	47.20	149.76	2.5	15.8	0	0.068	4.0	4.3		16.1	15.5	16.8	14.9
N	.125	47.20	149.76	2.5	16.5	0.015	0.295	12.5	12.5	12.5	15.9	15.6	16.4	18.1
N	.125	47.20	149.76	98.0	25.0	0.015	0.073	7.3	5.2		74.5	15.2	6.5	3.9
N	.125	47.20	149.76	98.0	18.1	0	0.280	6.3	14.9		42.9	19.8	10.9	
Y	.125	46.24	149.76	50.0	20.4	0	0.065		4.6		33.7	26.4	21.6	
Y	.125	46.09	149.76	50.0	32.5	0.015	0.551	0	0	0	38.9	33.1	31.2	26.9
Y	.125	46.05	149.76	50.0	31.2	0.015	0.171	0.0	0.0	0.0	39.0	32.6	27.5	25.8
Y	.125	46.09	149.76	50.0	31.3	0	0.164				34.1	33.4	31.2	26.4
Y	.125	46.15	149.76	50.0	19.2	0.008	0.434	14.2	16.1	18.0	26.3	19.9	16.8	13.8
Y	.125	46.12	149.76	50.0	18.5	0.008	0.414	14.1	16.1	18.0	25.7	18.6	16.6	13.0
Y	.125	46.18	149.76	50.0	19.8	0.008	0.415	14.4	15.4	18.1	28.2	19.6	17.2	14.4
Y	.125	46.08	149.76	50.0	19.4	0.008	0.411	14.4	15.1	17.8	25.9	20.1	17.1	13.4
Y	.125	46.17	149.76	50.0	19.6	0.008	0.420	13.5	16.5	18.2	28.0	19.6	17.2	13.8
Y	.125	46.08	149.76	50.0	19.4	0.008	0.425	14.7	16.4	18.4	25.5	20.7	16.5	14.8
Y	.035	45.97	149.76	98.0	23.0	0.008	0.515	10.3	18.2		51.0	18.8	13.5	8.8
Y	.035	46.05	149.76	98.0	20.4	0.008	0.522	11.3	18.2		35.4	24.2	14.2	7.8
Y	.035	45.91	149.76	98.0	22.0	0.008	0.160		10.3	12.0	60.0	16.9	8.1	3.2
Y	.035	46.03	149.76	98.0	22.5	0.008	0.158		9.4	11.8	62.4	15.6	7.8	4.1
Y	.125	46.05	149.76	98.0	27.3	0.008	0.158		8.0	10.6	70.3	18.9	13.5	6.4
Y	.5	46.04	149.76	98.0	17.4	0.008	0.536	10.2	17.3	21.3	31.3	19.8	12.3	6.3
Y	.5	46.02	149.76	2.5	16.7	0.008	0.159				7.2	16.9	16.8	16.3
Y	.5	46.10	149.76	2.5	17.5	0.008	0.482	13.1	16.6	17.7	18.1	17.6	17.3	17.1
Y	.035	46.15	149.76	2.5	17.5	0.008	0.469	17.6	17.	18.4	18.1	17.6	17.2	17.1

TABLE 5.3.2 (Cont'd)

Tube Insert	Distributor Hole Size Inches	Density		Solid Size Micron	Solids In Slurry Ht %	Slurry ft/sec	Gas ft/sec	Gas Holdup			Solid Fraction				
		Liquid lb/ft ³	Solid lb/ft ³					1-2	2-3	3-4	Avg	1	2	3	4
Y	.035	46.04	149.76	2.5	17.3	0.008	0.150		7.6	7.8	7.7	17.6	17.6	17.2	16.7
Y	.035	46.28	149.76	0.0	1.2	0	0.325	16.4	18.1	19.6	19.5	1.9	1.4	0.6	1.0
Y	.125	46.25	0.0	0.0	0.0	0	0.447	21.2	22.9	24.9	24.4	0.0	0.0	0.0	0.0
Y	.125	46.26	0.0	0.0	0.0	0	0.150	11.1	13.0	14.6	14.3	0.0	0.0	0.0	0.0
Y	.125	46.23	0.0	0.0	0.0	0.015	0.150	9.7	11.7	13.6	13.0	0.0	0.0	0.0	0.0
Y	.125	46.26	0.0	0.0	0.0	0.015	0.508	20.8	23.1	25.0	23.2	0.0	0.0	0.0	0.0
Y	.5	45.83	304.51	2.5	15.7	0.008	0.157	6.9	7.9	9.0	9.1	15.2	16.0	15.8	15.7
Y	.5	45.81	304.51	2.5	15.8	0.008	0.468	18.4	18.4	20.2	18.7	16.6	15.5	15.6	15.7
Y	.125	46.08	304.51	2.5	15.5	0.008	0.148	7.9	8.7	9.1	9.2	15.5	15.6	15.4	15.6
Y	.125	45.98	304.51	2.5	15.4	0.008	0.486	18.7	19.2	20.5	19.2	15.6	15.3	15.5	15.1
Y	.125	46.09	324.48	98.0	27.2	0.008	0.479	16.4	20.6	19.4	19.4	61.3	22.7	15.5	9.3
Y	.125	46.08	324.48	98.0	26.1	0.008	0.151	9.2	11.6	11.2	11.2	78.6	12.2	8.3	5.2
Y	.5	46.16	324.48	98.0	12.8	0.008	0.491	15.5	19.8	18.4	18.4	24.7	16.2	10.5	
Y	.5	46.15	324.48	98.0	9.5	0.008	0.153	7.5	10.4	10.2	10.2	18.0	13.2	6.8	
Y	.5	62.31	0.0	0.0	0.0	0	0.274		15.6	9.1	10.2	0.0	0.0	0.0	0.0
Y	.125	62.35	0.0	0.0	0.0	0	0.290	9.5	11.5	12.2	11.1	0.0	0.0	0.0	0.0
Y	.125	62.31	0.0	0.0	0.0	0	0.277	7.7	11.7	10.9	10.8	0.0	0.0	0.0	0.0
Y	.125	62.22	0.0	0.0	0.0	0	0.274	10.3	12.1	10.9	10.7	0.0	0.0	0.0	0.0
Y	.125	62.33	0.0	0.0	0.0	0.008	0.278	10.9	17.5	16.4	12.5	0.0	0.0	0.0	0.0
Y	.125	62.16	149.76	2.5	26.1	0.008	0.270	8.2	11.4	9.6	7.7	26.1	26.2	26.1	26.2
Y	.035	62.28	149.76	49.0	10.0	0	0.286	9.9	13.5	10.7	12.6	12.7	10.5	8.9	8.1
Y	.035	62.21	149.76	49.0	11.3	0.011	0.267	14.4	17.9	14.8	18.1	13.9	11.9	10.3	9.0
Y	.5	62.21	149.76	49.0	11.7	0	0.277	3.5	8.8	8.8	8.9	11.4	12.8	11.7	10.8
Y	.5	62.11	149.76	49.0	13.6	0.010	0.287	7.5	10.2	9.8	10.6	15.5	14.2	13.1	11.8
Y	.125	63.23	149.76	98.0	23.5	0.008	0.298	3.2	9.8	8.6	10.3	33.1	25.9	19.8	15.1
Y	.125	62.16	304.51	2.5	15.5	0.008	0.271	11.2	14.7	17.5	15.1	15.9	15.7	15.4	15.1
Y	.125	62.19	324.48	98.0	28.1	0.008	0.318		6.8	9.6	12.0	47.8	38.9	25.9	
Y	.035	62.05	324.48	49.0	24.3	0.015	0.071		1.5	1.4	2.3	37.2	21.1	21.3	17.6
Y	.035	62.21	324.48	49.0	22.2	0	0.273		11.2	12.4	13.2	29.3	23.8	20.5	15.2
Y	.5	62.25	324.48	49.0	19.4	0	0.283	2.1	10.1	9.5	9.9	22.2	20.6	18.9	16.0
Y	.5	62.17	324.48	49.0	21.0	0.015	0.309	3.3	8.1	8.8	8.9	24.3	21.9	20.4	17.4
Y	.125	45.72	324.48	49.0	21.1	0.008	0.275	4.0	7.2	8.9	9.1	27.1	20.6	19.6	17.1
Y	.125	45.77	324.48	49.0	20.9	0.008	0.277	9.5	13.9	14.8	14.9	25.2	23.1	20.5	14.8
Y	.125	45.65	324.48	49.0	21.3	0.008	0.297	8.6	15.0	15.4	15.5	25.6	23.7	20.6	15.5

TABLE 5.3.2 (Cont'd)

Tube Insert	Distributor Hole Size Inches	Liquid lb/ft ³	Density Solid lb/ft ³	Solid Size Micron	Solids In Slurry Ht %	Slurry ft/sec	Gas ft/sec	Gas Holdup			Solid Fraction				
								1-2	2-3	3-4	Avg	1	2	3	4
								Vol %			Ht %				
Y	.125	46.06	324.48	49.0	20.4	0.008	0.265	8.7	13.1	14.2	14.2	25.8	22.4	17.9	15.7
Y	.125	45.78	324.48	49.0	21.5	0.008	0.271	7.7	12.9	14.7	14.7	29.3	22.3	19.8	14.7
Y	.125	45.77	324.48	49.0	23.2	0.008	0.267	6.6	12.9	14.6	14.6	34.4	23.6	19.2	15.8
Y	.125	45.60	324.48	49.0	35.9	0.015	0.171	1.8	6.4	6.9	7.7	42.1	36.8	32.8	31.9
Y	.125	45.58	324.48	49.0	36.7	0	0.154		9.3	8.7	9.5	42.7	40.3	34.2	29.8
Y	.125	45.80	324.48	49.0	27.0	0.015	0.071		1.4	1.8	2.9	36.9	36.8	34.4	
Y	.125	45.90	324.48	49.0	41.4	0	0.505	9.8	16.1	18.3	18.6	46.7	44.0	38.7	36.2
Y	.125	45.96	0.0	0.0	0.0	0	0.246	15.5	19.4	19.7	20.3	0.0	0.0	0.0	0.0
Y	.125	45.76	324.48	0.0	0.1	0	0.253	14.8	20.0	19.6	20.2	0.3	0.1	0.1	0.1
Y	.125	45.73	304.51	2.5	6.8	0.015	0.144	9.9	10.1	10.9	11.4	6.9	6.9	6.9	6.7
Y	.125	45.86	304.51	2.5	6.8	0.015	0.143	9.4	10.6	10.6	11.3	6.9	6.9	6.7	6.7
Y	.125	45.67	304.51	2.5	6.7	0	0.255	13.1	18.0	17.7	18.6	6.8	6.8	6.8	6.4
Y	.125	46.05	324.48	98.0	11.3	0	0.427	14.2	21.2	23.4	24.0	28.7	8.0	5.4	3.1
Y	.125	45.98	149.76	2.5	29.4	0.008	0.160	4.1	6.3	6.3	6.5	29.7	29.5	29.2	29.4
N	.5	47.20	149.76	0.0	0.1	0.008	0.202	11.2	17.8	16.4	16.9	0.1	0.1	0.3	0.1
N	.035	47.20	149.76	2.5	24.8	0.008	0.116	5.4	6.5	5.9	6.4	24.8	24.7	24.9	24.7
N	.035	62.43	149.76	49.0	18.9	0.008	0.405	11.2	15.4	14.8	14.7	22.4	20.8	17.8	14.7
N	.035	62.43	149.76	49.0	18.4	0.008	0.154	7.9	6.2	7.5	8.1	21.7	19.9	17.6	14.6
N	.125	47.20	304.51	2.5	15.6	0	0.217	9.6	11.9	12.0	13.3	15.9	15.6	15.7	15.4
N	.125	47.20	304.51	2.5	15.5	0.008	0.059	1.4	4.9	3.5	4.3	15.6	15.9	15.2	15.2
N	.5	47.20	324.48	49.0	21.3	0.008	0.296		9.2	10.3	11.0	0.0	32.9	28.6	23.6
N	.5	47.20	324.48	98.0	5.8	0.008	0.279		15.0	15.0	15.4	0.0	12.1	7.2	4.0
N	.035	47.20	324.48	98.0	23.1	0.015	0.550		20.7	23.2	22.0	43.1	25.8	15.1	8.5

Table 6.3.1

Bubble Diameter - 12" Cold Flow Simulator

Run No.	Dist. Hole in	Inter	Oxide	Solid Size μm	Avg. μm	Liq. Type	Velocity ft/sec		Probe Loc in	Uncorrected** Bubble Diameter			Gamma Distribution	
							Slurry	Gas		Avg in	Sauter cm	Avg Vel cm/sec	d	n
83	0.035	Y	Fe	2.5	6.7	160	0.000	0.26	2	0.166	0.295	28.322	-15.4007	2.5500
84	0.125	Y	Fe	98	11.3	160	0.000	0.43	2	0.187	0.317	28.651	-15.4030	2.8744
85	0.125	Y	Si	2.5	29.4	160	0.008	0.16	2	0.193	0.322	25.659	-15.4039	2.9648
86	0.500	N	-	-	-	160	0.008	0.20	5	0.204	0.333	27.790	-15.4055	3.1355
									3	0.202	0.332	32.179	-15.4052	3.1064
									0	0.174	0.304	35.666	-15.4016	2.6783
87	0.035	N	Si	2.5	24.8	160	0.008	0.12	5	0.303	0.433	25.253	-15.4257	4.6776
									3	0.310	0.440	28.874	-15.4268	4.7840
									0	0.276	0.406	32.646	-15.4189	4.2553
88	0.035	N	Si	49	18.9	WA	0.008	0.50	5	0.203	0.333	27.298	-15.4054	3.1307
89	0.035	N	Si	49	18.5	WA	0.008	0.16	5	0.263	0.393	26.231	-15.4159	4.0532
93	0.125	N	Fe	2.5	15.6	160	0.0	0.22	2	0.206	0.336	30.560	-15.4057	3.1729
94	0.125	N	Fe	2.5	15.5	160	0.008	0.06	2	0.250	0.300	31.724	-15.4134	3.8575
95	0.500	N	Fe	49.0	21.3	160	0.008	0.30	2	0.219	0.349	29.316	-15.4079	3.3791
96	0.500	N	Fe	98.0	5.8	160	0.008	0.28	2	0.185	0.315	32.073	-15.4030	2.8436
97	0.035	N	Fe	98.0	23.1	160	0.015	0.55	5	0.203	0.333	26.727	-15.4054	3.1222
									3	0.183	0.313	28.161	-15.4024	2.8169
									0	0.154	0.284	28.626	-15.3994	2.1690

*Distance from column center

**Distances not corrected for probe interference. Relative order will be the same. Absolute values will be smaller.

TABLE 6.4.1

Bubble Diameter - 12" Cold Flow Simulator

Run No.	Dist Hole In	Inter	Solid		Liq. Type	Velocity		Probe Loc In	Corrected			Sigma Distribution		
			Oxide	Size μ m		Slurry	Gas		Avg cm	Sampler cm	Avg Vel cm/sec			
A3	0.035	Y	Fe	2.5	6.7	Iso	0.000	0.26	2	0.106	0.236	26.322	-15.4007	1.634
A4	0.125	Y	Fe	98	11.3	Iso	0.000	0.43	2	0.124	0.254	26.651	-15.4030	1.905
A5	0.125	Y	Si	2.5	29.4	Iso	0.008	0.16	2	0.120	0.258	25.659	-15.4039	1.967
A6	0.500	N	-	-	-	Iso	0.008	0.20	5 3 0	0.117 0.116 0.113	0.266 0.266 0.243	27.790 32.179 35.666	-15.4035 -15.4032 -15.4016	2.103 2.090 1.715
A7	0.035	N	Si	2.5	24.8	Iso	0.008	0.12	5 3 0	0.217 0.222 0.195	0.146 0.352 0.325	25.253 26.874 32.646	-15.4237 -15.4268 -15.4189	3.343 3.340 3.008
A8	0.035	N	Si	49	18.9	HA	0.008	0.50	5	0.137	0.266	27.298	-15.4034	2.105
A9	0.035	N	Si	49	14.5	HA	0.008	0.16	5	0.165	0.314	26.251	-15.4159	2.845
91	0.125	N	Fe	2.5	15.6	Iso	0.0	0.22	2	0.128	0.258	30.560	-15.4037	1.977
94	0.125	N	Fe	2.5	15.5	Iso	0.008	0.06	2	0.162	0.292	31.724	-15.4134	2.497
95	0.500	N	Fe	49.0	21.3	Iso	0.008	0.30	2	0.138	0.268	29.336	-15.4079	2.130
96	0.500	N	Fe	98.0	5.8	Iso	0.008	0.28	2	0.112	0.242	32.073	-15.4030	1.726
97	0.015	N	Fe	98.0	23.1	Iso	0.015	0.55	5 3 0	0.126 0.111 0.008	0.256 0.240 0.218	26.727 26.161 28.626	-15.4034 -15.4024 -15.3994	1.938 1.702 1.359

*Distance from column center

TABLE 7.3.1

5" COLD FLOW SIMULATOR

Gas/Liquid Mass Transfer Coefficients

System: Three Phase

Gas- Air

Liquid- Water

Run NO.	Velocity		Non Wt%	Solid		K _a	
	Gas	Slurry Ft/sec		Size um	Type	Lower	Upper
						(S ⁻¹)	
6962	76	0.350	0.0001	0.3	2.5 SiO ₂	0.0317	0.0317
6962	77	0.500	0.0001	0.3	2.5 SiO ₂	0.0397	0.0441
6962	78	0.050	0.0001	0.2	2.5 SiO ₂	0.0077	0.0077
6962	79	0.130	0.0001	0.2	2.5 SiO ₂	0.0152	0.0152
6962	80	0.220	0.0001	0.2	2.5 SiO ₂	0.0253	0.0263
6962	81	0.350	0.0001	0.2	2.5 SiO ₂	0.0347	0.0333
6962	82	0.500	0.0001	0.2	2.5 SiO ₂	0.0419	0.0469
6962	83	0.050	0.0001	0.1	2.5 SiO ₂	0.0131	0.0131
6962	84	0.100	0.0001	0.1	2.5 SiO ₂	0.0246	0.0246
6962	85	0.200	0.0001	0.1	2.5 SiO ₂	0.0319	0.0319
6962	86	0.350	0.0001	0.1	2.5 SiO ₂	0.0418	0.0418
6962	87	0.500	0.0001	0.1	2.5 SiO ₂	0.0539	0.0554
6962	88	0.100	0.0001	0.3	98.0 SiO ₂	0.0228	0.0244
6962	90	0.300	0.0001	0.3	98.0 SiO ₂	0.0504	0.0504
6962	91	0.400	0.0001	0.3	98.0 SiO ₂	0.0653	0.0653
6962	92	0.500	0.0001	0.3	98.0 SiO ₂	0.0620	0.0620
6962	93	0.100	0.0001	0.2	98.0 SiO ₂	0.0197	0.0249
6962	94	0.200	0.0001	0.2	98.0 SiO ₂	0.0369	0.0527
6962	95	0.350	0.0001	0.2	98.0 SiO ₂	0.0621	0.0621
6962	96	0.280	0.0001	0.2	98.0 SiO ₂	0.0549	0.0549
6962	97	0.500	0.0001	0.2	98.0 SiO ₂	0.0855	0.0793
6962	98	0.100	0.0001	0.1	98.0 SiO ₂	0.0321	0.0352
6962	99	0.200	0.0001	0.1	98.0 SiO ₂	0.0502	0.0534
6962	100	0.300	0.0001	0.1	98.0 SiO ₂	0.0891	0.0811
6962	101	0.400	0.0001	0.1	98.0 SiO ₂	0.0950	0.0876
6962	102	0.500	0.0001	0.1	98.0 SiO ₂	0.0953	0.0856
7258	14	0.280	0.0500	0.1	2.5 SiO ₂	0.0347	0.0356
7258	15	0.230	0.0500	0.3	2.5 SiO ₂	0.0262	0.0244
7258	16	0.170	0.0500	0.2	2.5 SiO ₂	0.0160	0.0146
7258	18	0.294	0.1000	0.2	2.5 SiO ₂	0.0295	0.0288
7258	19	0.442	0.0500	0.2	2.5 SiO ₂	0.0454	0.0425
7258	20	0.152	0.0500	0.1	49.0 SiO ₂	0.0524	0.0435
7258	22	0.272	0.1000	0.1	49.0 SiO ₂	0.0595	0.0571
7258	25	0.152	0.1000	0.2	49.0 SiO ₂	0.0456	0.0477
7258	26	0.332	0.0500	0.2	49.0 SiO ₂	0.0632	0.0619

TABLE 7.3.1 (CONTINUED)

5" COLD FLOW SIMULATOR

Gas/Liquid Mass Transfer Coefficients

System: Three Phase

Gas- Air

Liquid- Water

Run No.	Velocity		Non Wt%	Solid		K _a	
	Gas Ft/sec	Slurry Ft/sec		Size μm	Type	Lower (s ⁻¹)	Upper
7252	32	0.278	0.0001	0.3	49.0 SiO ₂	0.0562	0.0562
7252	33	0.315	0.1000	0.3	49.0 SiO ₂	0.0674	0.0584
7252	34	0.544	0.0500	0.3	49.0 SiO ₂	0.0805	0.0642
7252	35	0.162	0.0500	0.1	98.0 SiO ₂	0.0276	0.0264
7252	36	0.298	0.0500	0.2	98.0 SiO ₂	0.0472	0.0477
7252	38	0.315	0.1000	0.2	98.0 SiO ₂	0.0607	0.0572
7252	39	0.512	0.0500	0.2	98.0 SiO ₂	0.0758	0.0789
7252	40	0.303	0.0500	0.3	98.0 SiO ₂	0.0404	0.0396
7252	41	0.294	0.0500	0.1	2.5 Fe ₂ O ₃	0.0805	0.0762
7252	42	0.240	0.0500	0.2	2.5 Fe ₂ O ₃	0.0790	0.0602
7252	43	0.290	0.0001	0.2	2.5 Fe ₂ O ₃	0.0659	0.0750
7252	44	0.290	0.0900	0.2	2.5 Fe ₂ O ₃	0.0869	0.0575
7252	45	0.526	0.0500	0.2	2.5 Fe ₂ O ₃	0.1000	0.0756
7252	46	0.290	0.0500	0.3	2.5 Fe ₃ O ₄	0.0499	0.0462
7252	47	0.164	0.0500	0.1	49.0 Fe ₃ O ₄	0.0590	0.0693
7252	48	0.292	0.0001	0.1	49.0 Fe ₃ O ₄	0.0745	0.0737
7252	49	0.298	0.1000	0.1	49.0 Fe ₃ O ₄	0.0977	0.0672
7252	50	0.290	0.0900	0.1	49.0 Fe ₃ O ₄	0.0614	0.0555
7252	51	0.540	0.0500	0.1	49.0 Fe ₃ O ₄	0.0829	0.0633
7252	52	0.168	0.0001	0.2	49.0 Fe ₃ O ₄	0.0612	0.0714
7252	53	0.290	0.0500	0.2	49.0 Fe ₃ O ₄	0.0702	0.0549
7252	54	0.288	0.0500	0.2	49.0 Fe ₃ O ₄	0.0719	0.0543
7252	55	0.288	0.0500	0.2	49.0 Fe ₃ O ₄	0.0745	0.0652
7252	57	0.490	0.0900	0.2	49.0 Fe ₃ O ₄	0.0923	0.0675
7252	58	0.500	0.0001	0.2	49.0 Fe ₃ O ₄	0.0909	0.0909
7252	59	0.282	0.0001	0.3	49.0 Fe ₃ O ₄	0.0594	0.0643
7252	60	0.282	0.0900	0.3	49.0 Fe ₃ O ₄	0.0629	0.0520
7252	61	0.470	0.0600	0.3	49.0 Fe ₃ O ₄	0.0815	0.0640
7252	62	0.174	0.0600	0.3	49.0 Fe ₃ O ₄	0.0503	0.0422
7252	63	0.284	0.0500	0.1	98.0 Fe ₃ O ₄	0.0640	0.0500
7252	64	0.500	0.0500	0.2	98.0 Fe ₃ O ₄	0.0815	0.0270
7252	65	0.290	0.0001	0.2	98.0 Fe ₃ O ₄	0.0602	0.0693
7252	66	0.166	0.0600	0.2	98.0 Fe ₃ O ₄	0.0526	0.0451
7252	67	0.276	0.1100	0.2	98.0 Fe ₃ O ₄	0.0624	0.0423
7252	68	0.272	0.0500	0.3	98.0 Fe ₃ O ₄	0.0631	0.0566

TABLE 10.3.1

SHELLSIDE HEAT TRANSFER COEFFICIENTS: 12" COLD FLOW SIMULATOR

Distributor Hole Size	Density Liquid lb/ft ³	Solid lb/ft ³	Solid Size Micron	Solids in Slurry wt %	Velocity		Heat Coefficient		
					Slurry ft/sec	Gas ft/sec	A	B	C
							Btu/hr ft ² °F		
.125	47.20	324.48	50.0	20.4	0	0.065	189	0	203
.125	46.09	149.76	50.0	32.5	0.015	0.551	297	0	308
.125	46.05	149.76	50.0	31.20	0.015	0.171	241	0	239
.125	46.09	149.76	50.0	31.3	0	0.164	237	0	254
.125	46.15	149.76	50.0	19.2	0.008	0.434	251	0	260
.125	46.12	149.76	50.0	18.5	0.008	0.414	252	0	254
.125	46.18	149.76	50.0	19.8	0.008	0.415	251	0	257
.125	46.08	149.76	50.0	19.4	0.008	0.411	249	0	257
.125	46.17	149.76	50.0	19.6	0.008	0.420	254	0	263
.125	46.08	149.76	50.0	19.4	0.008	0.425	255	0	260
.035	45.97	149.76	98.0	23.0	0.008	0.515	276	0	294
.035	46.05	149.76	98.0	20.4	0.008	0.522	260	0	295
.035	45.91	149.76	98.0	22.0	0.008	0.160	213	0	224
.035	46.03	149.76	98.0	22.5	0.008	0.158	213	0	224
.5	46.05	149.76	98.0	27.3	0.008	0.158	185	0	186
.5	46.04	149.76	98.0	17.4	0.008	0.536	226	0	248
.5	46.02	149.76	2.5	16.7	0.008	0.159	146	0	131
.5	46.10	149.76	2.5	17.5	0.008	0.482	187	0	179
.035	46.15	149.76	2.5	17.5	0.008	0.469	185	0	181
.035	46.04	149.76	2.5	17.3	0.008	0.150	149	0	140
.035	46.28	149.76	2.5	1.2	0	0.325	168	0	169
.125	46.25	0.0	0.0	0.0	0	0.447	180	0	181
.125	46.26	0.0	0.0	0.0	0	0.150	151	0	145
.125	46.23	0.0	0.0	0.0	.015	0.150	148	0	143
.125	46.26	0.0	0.0	0.0	0.015	0.508	175	0	180
.5	45.83	304.51	2.5	15.7	0.008	0.157	138	132	131
.5	45.81	304.51	2.5	15.8	0.008	0.468	174	160	167
.125	45.08	304.51	2.5	15.5	0.008	0.148	129	123	125
.125	45.98	304.51	2.5	15.4	0.008	0.486	152	143	150
.125	46.09	324.48	98.0	27.2	0.008	0.479	196	183	210
.125	46.08	324.48	98.0	26.1	0.008	0.151	156	143	167
.5	46.16	324.48	98.0	12.8	0.008	0.491	194	180	208
.5	46.15	324.48	98.0	9.5	0.008	0.153	157	148	145
.5	62.31	0.0	0.0	0.0	0	0.274	507	402	601
.035	62.35	0.0	0.0	0.0	0	0.290	472	399	564
.125	62.31	0.0	0.0	0.0	0	0.277	491	391	559
.125	62.22	0.0	0.0	0.0	0	0.274	528	442	609
.125	62.33	0.0	0.0	0.0	0.008	0.278	497	425	572
.125	62.16	149.76	2.5	26.1	0.008	0.270	528	454	611
.0.35	62.28	149.76	49.0	10.0	0	0.286	517	436	632
.035	62.21	149.76	49.0	11.3	0.011	0.267	517	454	621
.5	62.21	149.76	49.0	11.7	0	0.277	574	431	648
.5	62.11	149.76	49.0	13.6	0.010	0.287	540	457	650
.125	62.23	149.76	98.0	23.5	0.008	0.298	493	434	607
.125	62.16	304.51	2.5	15.5	0.008	0.271	460	0	539
.125	62.19	324.48	98.0	28.1	0.008	0.318	440	0	492

TABLE 10.3.1 (Contd.)

Distributor Hole Size	Density Liquid lb/ft ³	Solid lb/ft ³	Solid Size Micron	Solids in Slurry wt %	Velocity		Heat Coefficient		
					Slurry ft/sec	Gas ft/sec	A	B	C
							Btu/hr ft ² °F		
.035	62.05	324.48	49.0	24.3	0.015	0.071	368	325	373
.035	62.21	324.48	49.0	22.2	0.015	0.273	427	400	539
.5	62.25	324.48	49.0	19.4	0	0.283	457	428	528
.5	62.17	324.48	49.0	21.0	0.015	0.309	443	428	524
.125	45.72	324.48	49.0	21.1	0.008	0.275	180	180	184
.125	45.77	324.48	49.0	20.9	0.008	0.277	143	135	151
.125	45.65	324.48	49.0	21.3	0.008	0.297	145	140	155
.125	46.06	324.48	49.0	20.4	0.008	0.265	136	130	145
.125	45.78	324.48	49.0	21.5	0.008	0.271	138	133	149
.125	45.77	324.48	49.0	23.2	0.008	0.267	138	130	148
.125	45.60	324.48	49.0	35.9	0.015	0.171	124	124	135
.125	45.58	324.48	49.0	36.7	0	0.154	0	122	142
.125	45.80	324.48	49.0	27.0	0.015	0.071	106	108	110
.125	45.90	324.48	49.0	41.4	0	0.505	145	139	162
.125	45.96	0.0	0.0	0.0	0	0.246	137	106	167
.125	45.76	324.48	49.0	0.1	0	0.253	159	122	171
.125	45.73	304.51	2.5	6.8	0.015	0.144	137	96	136
.125	45.86	304.51	2.5	6.8	0.015	0.143	134	97	138
.035	45.67	304.51	2.5	6.7	0	0.255	153	111	150
.125	46.05	324.48	98.0	11.3	0	0.427	186	146	193
.125	45.98	149.76	2.5	29.4	0.008	0.160	100	72	72

*Heater Locations

A - 2/3 up the center tube

B - 2/3 up an outer tube

C - 1/3 up an outer tube

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TABLE 11.0.1

RHEINPREUSSEN SIMULATION
USING DECKWER CORRELATIONS

Regime	Churn Turbulent		
Catalyst	Base Case	Catalyst A	Catalyst B
Inlet gas velocity, cm/sec	9.00	9.00	9.00
Gas holdup	0.385	0.512	0.526
Interfacial area, cm^2/cm^3	32.66	43.44	44.66
Temperature, °C	260.2	259.7	260.2
Rate Constants:			
Preexponential factor (sec wt.% in slurry)	1.12×10^5	9.03×10^5	1.15×10^7
Activation energy, kJ/mol	70	94.7	94.7
Inlet ratio, mol CO/mol H_2	1.5	1.5	1.98
Usage ratio, mol CO/mol H_2	1.5	1.5	0.65
Hydrogen conversion, %	80.4	34.9	49.8
Rel. mass transfer resistance	0.106	0.021	0.035
Space-time yield, mol CH_2/hr^3	2937	1065	1002
<u>Constants in Case Study</u>			
Reactor length, ft (cm)	26.25 (800)	→	→
Reactor diameter, in (cm)	59 (150)	→	→
Contraction factor	-0.5	→	→
Particle diameter, μm	50	→	→
Reactor pressure, psig (bar)	174 (12)	→	→
Weight fraction catalyst in slurry	0.20	→	→
Specific heat transfer area, cm^2/cm^3	0.10	→	→

TABLE 11.0.2

RHEINPREUSSEN SIMULATION
USING APCI CORRELATIONS

Regime	Churn Turbulent			
Catalyst	Base*	Catalyst A	Catalyst B†	Catalyst B† with shift
Inlet gas velocity, cm/sec	9.0	9.0	9.0	9.0
Gas holdup	0.385	0.149	0.171	0.146
Interfacial area, cm ² /cm ³	32.66	36.06	41.43	35.39
Temperature, °C	260.2	260.4	260.4	261.1
Rate Constants:				
Preexponential factor (sec wt.% in slurry)	1.12x10 ⁵	9.03x10 ⁶	1.15x10 ⁷	1.15x10 ⁷
Activation energy, kJ/mol	70	94.7	94.7	94.7
Inlet ratio, mol CO/mol H ₂	1.5	1.5	1.98	1.98
Usage ratio, mol CO/mol H ₂	1.5	1.5	0.65	1.98
Hydrogen conversion, %	80.4	55.9	62.9	58.5
Rel. mass transfer resistance	0.106	0.043	0.069	0.048
Space time yield, mol CH ₂ /hr ³	2937	2042	1273	2135
<u>Constants in Case Study</u>				
Reactor length, ft (cm)	26.3 (800)	→	→	→
Reactor diameter, in (cm)	59 (150)	→	→	→
Contraction factor	-0.5	→	→	→
Particle diameter, μm	50	→	→	→
Reactor pressure, psig (bar)	174 (12)	→	→	→
Weight fraction catalyst in slurry	0.20	→	→	→
Specific heat transfer area, cm ² /cm ³	0.10	→	→	→

*Operating conditions at Rheinpreussen

†Cold flow model gas holdup correlation

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TABLE 11.0.3

OPTIMUM GAS HOLDUP, GAS VELOCITY*, AND SPACE-TIME YIELD (STY)

$$K_L = 0.0205 \text{ cm/s}$$

$$U = 2$$

Case	K_0 $\text{Sec}^{-1} \text{ wt\%}^{-1}$	w z	d_B cm	α opt $\text{vol } z$	V_G cm/sec	STY STY 1
1	1.4×10^{-3}	20	0.07	6.8	2.13	1.00
2	1.4	60	0.07	11.2	12.75	2.72
3	6.1	60	0.07	20.9	36.43	9.42
4	1.4	20	0.30	13.1	5.29	0.87
5	1.4	60	0.30	20.7	36.00	2.17

*Using APCI cold flow gas holdup correlation.

TABLE 11.1.1
RHEINPREUSSEN SIMULATION
STAGED REACTION SYSTEMS

Number of Stages	1	20	5	20
Dispersion Coeff., cm^2/s	72,130	128.8	572.5	143.8
Gas holdup	0.145	0.148	0.158	0.158
Interfacial area, cm^2/cm^3	4.148	12.717	4.514	4.527
Hydrogen Conversion, %	66.1	85.1	69.2	69.2
Rel. Mass Transfer Resistance	0.556	0.310	0.542	0.541
Space-Time Yield, mol CH_2	2,417	3,128	2,529	2,530
Improvement Ratio	1.000	1.294	1.046	1.047

Constants in Case Study

Reactor length, ft (cm)	26.25 (800)	→	→	→
Reactor diameter, in (cm)	59 (150)	→	→	→
Contraction factor	-0.5	→	→	→
Particle diameter, m	50	→	→	→
Reactor pressure, psig (bar)	174 (12)	→	→	→
Weight fraction catalyst in slurry	0.20	→	→	→
Specific heat transfer area, cm^2/cm^3	0.30	→	→	→
Inlet Gas Velocity, cm/sec	9	→	→	→
Temperature, C	260.0	→	→	→
Preexponential Factor (see wt % in slurry)	3.45×10^7			
Activation Energy, kJ/mol	94.7	→	→	→
Inlet Ratio, mol CO/mol H_2	1.98	→	→	→
Usage Ratio, mol CO/mol H_2	1.98	→	→	→

CONTAINS POTENTIALLY
PATENTABLE DATA—
NOT FOR PUBLICATION