

Table 1. List of Co-based FT Catalysts Formulated

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Base	Prepared
Co.001	20%	1% Re	1% La ₂ O ₃ , 0.13% K	γ-alumina	U.S. Pat. 4,880,763	P
Co.002	20%	0.43% Ru	1% La ₂ O ₃	γ-alumina	U.S. Pat. 4,413,064	P
Co.003	20%	0.5% Ru	1% La ₂ O ₃	γ-alumina	U.S. Pat. 4,413,064	P
Co.004	20%	0.43% Ru	1% La ₂ O ₃	γ-alumina	Reproduce Co.002	P
Co.005	20%	0.00	0.00	γ-alumina	Base Catalyst	P
Co.005A	20%	0.4% Ru	0.00	γ-alumina	Ru added to calcined Co.005 by IW impreg.	P
Co.006	12%	0.75% Re	0.00	Titania	U.S. Pat. 4,794,009	P
Co.007	20%	0.00	0.00	Titania	Base Catalyst	P
Co.008	20%	0.00	0.00	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded with excess liquid)	P
Co.009	20%	0.5% Ru	0.00	γ-alumina	Ru-Promoted Catalyst (use Ru Chloride, single-step aqueous IW)	P
Co.010	20%	0.00	0.00	γ-alumina	Base Catalyst (non-calcined)	P
Co.010A	20%	0.4% Ru	0.00	γ-alumina	Ru added to dried Co.010 by IW impreg.	P
Co.011	20%	0.00	0.00	Silica	UK Pat. Appl. GB 2 125 062 A (Kneaded)	P
Co.012	20%	0.00	0.00	Silica	Base Catalyst (Inc. Wetness)	P
Co.013	20%	0.00	0.00	Titania	Base Catalyst like Co.007, but all aqueous	P
Co.014	12%	0.5% Ru	0.00	Titania	Ru-Promoted Catalyst (aqueous IW co- impregnation)	P
Co.015	20%	0.43% Ru	1% La ₂ O ₃	γ-Alumina	Similar to Co.002, but all aqueous	P

Table 1. List of Co-based FT Catalysts Formulated (contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Batch	Prepared
Co.016	20%	0.43% Ru	1% La ₂ O ₃	γ -Alumina	Similar to Co.015, but calcined after Co impregnation	P
Co.017	20%	0.5% Ru	1% La ₂ O ₃	γ -Alumina	Similar to Co.003, but all aqueous	P
Co.018	20%	0.5% Ru	0.00	γ -Alumina	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.019	20%	0.5% Ru	0.00	Silica	Ru-Promoted Catalyst (single-step, aqueous IW)	P
Co.020	0.00	0.5% Ru	0.00	γ -Alumina	Ru Base Catalyst	P
Co.020A	20%	0.4% Ru	0.00	γ -Alumina	Co added to dried Co.020 by IW impreg.	P
Co.020B	20%	0.4% Ru	0.00	γ -Alumina	Co added to reduced Co.020 by IW impreg.	P
Co.020C	20%	0.4% Ru	0.00	γ -Alumina	Co added to calcined Co.020 by IW impreg.	P
Co.021	20%	0.00	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 1125 062 A (single-step, aqueous kneaded)	P
Co.022	20%	0.00	0.7% Zr	Silica	U.K. Pat. Appl. GB 2 1125 062 A (aqueous, multiple-steps, kneaded Co pre-impregnation, IW Zr)	P
Co.023	20%	0.00	1.4% Zr	Silica	U.K. Pat. Appl. GB 2 1125 062 A (aqueous, multiple-steps, kneaded Co pre-impregnation, IW Zr)	P
Co.024	20%	0.00	8.5% Zr	Silica	Eur. Pat. Appl. 0 167 215 A2 (non-aqueous, IW, multiple-steps, Zr pre-impregnation)	P
Co.025	20%	0.00	8.5% Zr	Silica	Similar to Co.024 but aqueous Zr pre-impregnation	P
Co.026	20%	0.00	0.00	Silica (Davison Grade 59)	Similar to Co.012 but different grade silica	P

Table 1. List of Co-based FT Catalysts Formulated (contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.027	20%	0.5% Ru	0.00	Silica (Davison Grade 59)	Similar to Co.019 but different grade silica	P
Co.028	20%	0.5% Ru	0.5% K	γ -alumina	Ru- and K-Promoted Catalyst: (single-step IW)	P
Co.029	30%	0.5% Ru	0.5% K	γ -alumina	Similar to Co.028 but 30% Co	P
Co.030	20%	0.00	0.1% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.031	20%	0.00	1.4% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.032	20%	0.00	8.5% Zr	γ -alumina	Zr-Promoted Catalyst (single-step aqueous IW)	P
Co.033	20%	0.00	8.5% Zr	γ -alumina	Multiple-steps, aqueous IW, Co pre-impregnation	P
Co.034	20%	0.00	8.5% Zr	γ -alumina	Multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.035	20%	0.00	8.5% Zr	Silica	Zr-Promoted Catalyst (single-step aqueous, kneaded)	P
Co.036	20%	0.00	8.5% Zr	Silica	Multiple-steps, aq. Co pre-impreg. by kneading, aqueous IW Zr impreg.	P
Co.037	12%	0.00	0.00	Titania	Similar to Co.013, but TiO ₂ mainly anatase	P
Co.038	12%	0.5% Ru	0.00	Titania	Similar to Co.014, but TiO ₂ mainly anatase	P
Co.039	12%	0.00	0.00	Titania	Similar to Co.007, but only 12% Co	P
Co.040	12%	0.00	0.00	Titania	Similar to Co.013, but only 12% Co	P
Co.041	20%	0.5% Ru	8.5% Zr	Silica	Similar to Co.025, but Ru-promoted	P
Co.042	0.00	0.00	8.5% Zr	Silica	Blank Zr-promoted SiO ₂	P

Table 1. List of Co-based FT Catalysts Formulated (contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.043	20%	0.5% Ru	8.5% Zr 0.5% K	Silica	Similar to Co.041, but K-promoted	P
Co.044	20%	0.00	15% Zr	Silica	Similar to Co.025, but 15% Zr	P
Co.045	20%	0.00	4% Zr	Silica	Similar to Co.025, but 4% Zr	P
Co.046	12%	0.75% Re	4% SiO ₂	Titania	Similar to Co.006, but SiO ₂ -promoted	-
Co.047	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.028, but 0.3% K	P
Co.048	20%	0.5% Ru	8.5% Zr 0.3% K	Silica	Similar to Co.043, but 0.3% K	P
Co.049	20%	0.5% Ru	0.1% K	γ -alumina	Similar to Co.047, but 0.1% K	P
Co.050	20%	0.5% Ru	8.5% Zr 0.1% K	Silica	Similar to Co.048, but 0.1% K	P
Co.051	0.00	0.5% Ru	0.00	Titania (R)		P
Co.052	0.00	0.5% Ru	0.00	Titania (A)		P
Co.053	20%	0.5% Ru	0.00	γ -alumina	Similar to Co.018 (New Batch)	P
Co.054	20%	0.00	8.5% Zr 0.3% K	Silica	Similar to Co.043, but without Ru	P
Co.055	20%	1% Re	1% La ₂ O ₃	γ -alumina	Similar to Co.001, but without K	P
Co.056	20%	0.00	8.5% La ₂ O ₃	Silica	Similar to Co.025, but La instead of Zr	P
Co.057	20%	1% Re	1% La ₂ O ₃	Silica	Similar to Co.055, but with SiO ₂ support	P
Co.058	20%	0.00	1% La ₂ O ₃	γ -alumina	Similar to Co.055, but without Re (one-step impreg.)	P
Co.059	20%	0.00	1% La ₂ O ₃	γ -alumina	Similar to Co.015, but without Re (two-step impreg.)	P
Co.060	30%	0.00	0.00	γ -alumina	Similar to Co.005, but with 30% Co	P
Co.061	30%	0.5% Ru	0.00	γ -alumina	Similar to Co.053, but with 30% Co	P
Co.062	30%	0.5% Ru	1.5% K	γ -alumina	Similar to Co.029, but with 1.5% K	P

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CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
Co.063	20%	0.00	8.5% La	γ -alumina	Multiple-steps, aqueous IW, La pre-impregnation	P
Co.064	20%	0.5% Ru	8.5% Zr	γ -alumina	Multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.065	20%	0.5% Ru	8.5% Zr 0.3% K	γ -alumina	Multiple-steps, aqueous IW, Zr pre-impregnation	P
Co.066	15%	0.5% Ru, 5.0% Fe	0.00	γ -alumina	Ru- and Fe-Promoted Catalyst (single-step, aqueous IW)	P
Co.067	20%	2.0% Pd	0.00	γ -alumina	Pd-Promoted Catalyst (single-step, aqueous IW)	P
Co.068	20%	1.0% Pd	0.00	γ -alumina	Similar to Co.067, but with 1% Pd	P
Co.069	20%	2.0% Ru	0.00	γ -alumina	Similar to Co.053, but with 2% Ru	P
Co.070	13%	0	0.00	γ -alumina	Similar to Co.005, but with 13% Co	P
CAL.01 (97E-13E)	20%	0.5% Ru	0.00	γ -alumina	Similar to Co.018 (Calcicat Prep.)	P
CAL.02 (97E-16B)	20%	0.5% Ru	0.00	γ -alumina	Similar to CAL.01 (New Batch)	P
CAL.03 (97E-13F)	20%	0.5% Ru	0.00	γ -alumina	Multiple-step impreg., Similar to CAL.02	P
CAL.04 (97E-50C)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Stand. Calc. in Air	P
CAL.05 (97E-50D)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Stand. Calc. in N ₂	P
CAL.06 (97E-51A)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Red. and Pas. in Air	P
CAL.07 (97E-51B)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Red. and Protected in Paraffin (51.3% Cat. Conc.)	P
CAL.08 (97E-51C)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to Co.047 Calc., Red. and Protected in Paraffin (54.4% Cat. Conc.)	P

Table 1. List of Co-based FT Catalysts Formulated (contd.)

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
CAL.09 (97E-69C)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05, Reduced and Protected in Soya (51.7% Cat. Conc.)	P
CAL.10 (97E-79A)	20%	0.5% Ru	0.3% K	γ -alumina (Condea)	Similar to CAL.05, but on Condea Al_2O_3	P
CAL.11 (29F-07B)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05	P
CAL.12 (29F-05D)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05	P
CAL.13 (29F-07E)	20%	0.5% Ru	0.3% K	γ -alumina	Similar to CAL.05	P
Fe.01	0%	30%Fe	1.5%Cu	Silica		P

Table 2. List of Water-Gas Shift Catalysts and F-T Catalysts with WGS Function

CAT. NO.	wt% Co	wt% M	wt% Prom.	Support	Basis	Prepared
WGS.01	0	5.0% Cu	0	γ -alumina	single-step, aqu. IW	P
WGS.02	0	5.0% Cu	10% Zn	γ -alumina	single-step, aqu. IW	P
WGS.03	0	5.0% Cu	4.0% Cr	γ -alumina	single-step, aqu. IW	P
WGS.04	0	0	4.0% Cr	γ -alumina	single-step, aqu. IW	P
WGS.05	0	0	4.0% Mn	γ -alumina	single-step, aqu. IW	P
WGS.06	0	5.0% Cu	4.0% Mn	γ -alumina	single-step, aqu. IW	P
WGS.07	0	4.0% Fe	0	γ -alumina	single-step, aqu. IW	P
WGS.08	0	4.0% Fe	4.0% Cr	γ -alumina	single-step, aqu. IW	P
WGS.09	0	5.0% Cu	4.0% Cr	γ -alumina	Similar to WGS.03	P
CoW.01	20%	5.0% Cu	10% Zn	γ -alumina	multiple-steps, aqu. IW, Cu,Zn pre-impr.	P
CoW.02	20%	5.0% Cu	4.0% Cr	γ -alumina	multiple-steps, aqu. IW, Cu,Cr pre-impr.	P
CoW.03	10%	5.0% Cu	4.0% Cr	γ -alumina	similar to CoW.02 (10% Co only)	P
CoW.04	10%	10% Cu	8.0% Cr	γ -alumina	similar to CoW.03; 10% Cu and 8% Cr	P
CoW.05	20%	5.0% Cu	4.0% Cr	γ -alumina	similar to CoW.02 with support calcined at 750°C	P
CoW.06	20%	5.0% Cu	4.0% Cr	Silica	multiple-steps, aqu. IW, Cu,Cr pre-impr.	P
CoW.07	20%	5.0% Cu	4.0% Cr	Silica	similar to CoW.06, but with support calcined at 750°C	P
CoW.08	30%	5.0% Cu	4.0% Cr	γ -alumina	Similar to CoW.05, but with 30% Co	P
CoW.09	20%	10.0% Cu	8.0% Cr	Silica	similar to CoW.06, but with 10% Cu and 8% Cr	P
CoW.10	10% Co, 10% Fe	0.5% Ru	0	γ -alumina	Single Step, IW	P
CoW.11	10% Co, 10% Fe	0.5% Ru	0.5% K	γ -alumina	Single Step, IW	P
CoW.12	10% Co, 10% Fe	0.5% Ru	0	Silica	Single Step, IW	P
CoW.13	10% Co, 10% Fe	0.5% Ru	0	γ -alumina	Similar to CoW.10 (2nd batch)	P

Table 3. Summary of Physical Properties

CATALYST	Composition	BET Surface Area (m ² /g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (µm)
Vista-B Al ₂ O ₃	(0-400 mesh)	299	1.69	269	24
Vista-B Al ₂ O ₃	Calcined 500°C	240	0.49	82	
Vista-B Al ₂ O ₃	Calcined 600°C	206	0.49	95	
Vista-B Al ₂ O ₃	Calcined 600°C	174	0.47	109	
Condea Al ₂ O ₃	(as received)	219	0.53	97	77
Davison SiO ₂	(0-400 mesh)	219	0.51	89	121
Degussa P25 TiO ₂	(as received)	47	0.40	335	6
Degussa P25 TiO ₂	Dried 60°C, Calc. 350°C/16hrs	46	0.48	419	51
Degussa P25 TiO ₂	Dried 60°C, Calc. 650°C/16hrs	12	0.17	573	212
Co.001	20Co/1Re/ 1La ₂ O ₃ /0.13K/A	191	0.31	66	42 40
Co.002	20Co/0.43Ru/ 1La ₂ O ₃ /A	149	0.33	89	74
Co.003	20Co/0.5Ru/ 1La ₂ O ₃ /A	122	0.26	87	77
Co.004	20Co/0.43Ru/ 1La ₂ O ₃ /A				78
Co.005	20Co/A	173	0.34	81	65 86
Co.006	12Co/0.75Re/T	16	-	-	121
Co.007	20Co/T	11	0.10	372	
Co.008	20Co/S	181	1.06	234	
Co.009	20Co/0.5/A				
Co.010	20Co/A				
Co.011	20Co/S	211	1.07	203	107
Co.012	20Co/S	211	-	-	105
Co.013	20Co/T				
Co.014	12Co/0.5Ru/T	15	0.12	328	111

CATALYST	Composition	BET Surface Area (m ² /g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (µm)
Co.015	20Co/0.43Ru/ 1La ₂ O ₃ /A	141	-	-	67
Co.016	20Co/0.43Ru/ 1La ₂ O ₃ /A	116	-	-	79
Co.017	20Co/0.5Ru/ 1La ₂ O ₃ /A	123	-	-	73
Co.018	20Co/0.5Ru/A	158	-	-	69
Co.019	20Co/0.5Ru/S				110
Co.021	20Co/0.7Zr/S	213	1.12	210	74
Co.023	20Co/1.4Zr/S	213	-	-	
Co.024	20Co/8.5Zr/S	215	1.08	202	
Co.025	20Co/8.5Zr/S	208	0.97	187	87
Co.026	20Co/S(59)	184	-	-	
Co.027	20Co/S(59)	189	-	-	
Co.028	20Co/0.5Ru/0.5K/A	161	0.33	82	80
Co.029	30Co/0.5Ru/0.5K/A	140	-	-	76
Co.031	20Co/1.4Zr/S				75
Co.032	20Co/8.5Zr/A	155	0.30	77	
Co.034	20Co/8.5Zr/A	150	0.31	83	
Co.035	20Co/8.5Zr/S	207	1.21	233	89
Co.036	20Co/8.5Zr/S	209	-	-	
Co.037	12Co/T(A)	38	-	-	
Co.039	12Co/T(R)	13	-	-	
Co.040	12Co/T				130
Co.041	20Co/0.5Ru/8.5Zr/S	214	-	-	-
Co.044	20Co/15Zr/S				92
Co.047	20Co/0.5Ru/0.3K/A	162	0.31	78	83
Co.048	20Co/0.5Ru/0.3K/ 8.5Zr/S				82

CATALYST	Composition	BET Surface Area (m ² /g)	Pore Volume (cc/g)	Average Pore Dia. (Å)	Average Part. Size (µm)
Co.049	20Co/0.5Ru/0.3K/A				81
Co.053	20Co/0.5Ru/A				75
Co.054	20Co/0.3K/8.5Zr/S				101
Co.055	20Co/1Re/ 1La ₂ O ₃ /A				86
Co.056	20Co/8.5La ₂ O ₃ /S				100
CAL.01	20Co/0.5Ru/A	178	0.34	76	
CAL.02	20Co/0.5Ru/A	158	-	-	74
CAL.03	20Co/0.5Ru/A	158	-	-	
CAL.04	20Co/0.5Ru/0.3K/A	151			72
CAL.05	20Co/0.5Ru/0.3K/A	163			73
CAL.06	20Co/0.5Ru/0.3K/A	162			72
CAL.07	20Co/0.5Ru/0.3K/A	-			
CAL.08	20Co/0.5Ru/0.3K/A	-			63
CAL.09	20Co/0.5Ru/0.3K/A				63
CAL.10	20Co/0.5Ru/0.3K/A	142	-	-	83
CAL.11	20Co/0.5Ru/0.3K/A	177	0.34	76	72
CAL.12	20Co/0.5Ru/0.3K/A	175	0.33	75	73
CAL.13	20Co/0.5Ru/0.3K/A	172	0.33	77	81
WGS.02	5Cu/A	159	-	-	-
WGS.03	5Cu/4Cr/A	190	-	-	-
CoW.01	20Co/5Cu/10Zn/A	121	-	-	-
CoW.02	10Co/5Cu/4Cr/A	137	0.27	79	-
CoW.05	20Co/5Cu/4Cr/A	87	0.26	120	-

Table 4. H₂ Chemisorption^a and TPR Results

Catalyst	H ₂ Chemisorption ^a				TPR	
	Total (μ mol H ₂ /g cat)	Irrev. (μ mol H ₂ /g cat)	Average d_p^b (nm)	% Disp.	%Co Red. ^c (TPR calc. catal.)	%Red. ^d (stand. red.)
Co.001	174 $\pm$ 5	157 $\pm$ 5		10.2		
Co.002	155	130		9.1		
Co.003	165	140		9.6		
Co.004 ^f	(1) 205	185	6.9	12.1	91	
	(1) 147	-	9.6	7.4	-	
	(1) 167	-	8.4	8.4	-	
	(2) 126	-	11.1	6.3	64	
	(3) 132	116	10.6	6.6	55	
	(4) 144	123	9.8	7.2	46	
	(5) 136	122	10.3	6.8	41	
Co.005	48	42	20	2.8	89	58
Co.005a	129	110	11	7.6	92	84
Co.006	44	32	19	4	80	
Co.007	33	23	36	2.0	78	78
Co.008						
Co.009	133	109	13	7.8	98	
Co.010						
Co.010a	124	100	12.5	7.3	91	89
Co.011	82	70	15.6	4.8	75	75
Co.012	89	74	15	5.2	80	80
Co.013	21	17	79	1.2	97	
Co.014	38	30	21	3.7	79	
Co.015 ^e	(1) 146	124	11.7	8.6	94	94
	(2) 181	-	7.8	9.1	-	
	(2) 194	-	7.2	9.7	-	
Co.016	163	146	10.5	9.6	96	96
Co.017	202	183	8.5	11.9	97	97
Co.018	185	165	9.2	11	97	94
Co.018Cl ^h					95	

Table 4. H₂ Chemisorption* and TPR Results (contd.)

Catalyst	H ₂ Chemisorption*				TPR	
	Total (μ mol H ₂ /g cat)	Irrev. (μ mol H ₂ /g cat)	Average d_p^b (nm)	% Disp.	%Co Red. ^c (TPR calc. catal.)	% Red. ^d (stand. red.)
Co.019	112	92		6.6		
Co.020						
Co.020a	153	126	10	9.1	88	
Co.020b	134	113	11	7.9	86	
Co.020c	115	100	13	6.8	88	
Co.021	74	50		4.3		
Co.022	141	122		8.3	80	
Co.023	158	136		9.3	81	
Co.024	87	72		5.1	91	
Co.025	93	77		5.5	75	
Co.026						
Co.027						
Co.028	170	148		10		
Co.029	175	155		7		
Co.030						
Co.031	71	51	20	4.2	82	
Co.032	55	39	26	3.2	85	
Co.033	43	32	31	2.5	79	
Co.034	114	91	14	6.7	96	
Co.035	125	115	11	7.2	82	
Co.036	122	98		7.2		
Co.037	21	3	48	2	99	
Co.038	45	35	21	4.3	91	
Co.039	19	16	40	1.8	72	
Co.040	14	11	53	1.4		
Co.041	70	55		4		

Table 4. H₂ Chemisorption* and TPR Results (contd.)

Catalyst	H ₂ Chemisorption*				TPR	
	Total (μ mol H ₂ /g cat)	Irrev. (μ mol H ₂ /g cat)	Average d_p^b (nm)	% Disp.	%Co Red. ^c (TPR calc. catal.)	% Red. ^d (stand. red.)
Co.043	137	109		8	86	
Co.047	146	-	9.6	7.3		
Co.053 ^f	(1) 168	139	8	8.4	60	
	(2) 101	76	14	5.2	82	
	(3) 138	117	10	6.9	47	
Co.054					57	
Co.055 ^f	(1) 165	139	8.5	8.3	78	
	(2) 179	163	8	9.0	50	
	(3) 103	84	14	5.2	76	
	(4) 192	165	7	9.6	-	
Co.056					58	
Co.60	65		14.4	2.1		
Co.61	277		7.6	9.2		
CAL.01	169	-	8.3(5.8°)	4.4°	54	
CAL.02	-	-	(6.3°)	5.1°	55	
CAL.03	-	-	5.7°	4.2°	85	
CAL.04	93		15.1(5.5°)	3.5°		
CAL.05	100		14.1(5.6°)	4.4°		
CAL.06			5.7°	4.2°		
CAL.10			7.2°	3.7°		
CAL.11	171		8.3	8.5		
CAL.12	146		9.6	7.3		
CAL.13	180		7.8	9.0		

(a) static H₂ chemisorption at 100°C(b) Est. assuming $H_{2,0}/Co_s = 1$, $5.46 \times 10^{-20} \text{ m}^2/Co_s$, and $d_p = 5/S_{Co}/\rho$ S_{Co} is based on amt. Co reducible during standard reduction

(c) % Co reducible from TPR of calcined catalysts up to 900°C

(d) % Co reduced after standard reduction procedure

(e) Based on CO chemisorption

(f) (1)=uncalcined; (2)=flow calcined in air and reduced in H₂; (3)=ROR (4)=calcined in He; (5)=calcined in nitrogen

Table 4. H₂ Chemisorption^a and TPR Results (contd.)

(g) (1)=flow calcined in air; (2)=uncalcined

(h) Co.018Cl = Chlorinated Co.018

(i) (1)=flow calcined in air; (2)=uncalcined; (3)=ROR

(j) (1)=calcined in air; (2)=calcined in nitrogen; (3)=uncalcined; (4)=ROR

Table 5. Summary of Fixed Bed Reactor Data

Catalyst	Rxn	Prep	CO Conv (%)	Rate g CH ₂ /g cat/hr	R-CO+ g CH ₂ /g cat/hr	R (CO) mol/mol Co/s	wt% CH ₄	alpha	CO ₂ (%)	E/g cat/hr	E act kcal/mol	Comment
Co.001	4	(1)	2.6	0.116	0.056	6.8E-04	19.6	0.76	0.4	0.061		
Co.002	4	(2)	6.7	0.258	0.082	1.5E-03	26.1	0.64	0.1	0.012		NSH**
Co.003	1	(3)	5.5	0.185	0.044	1.1E-03	30.8	0.57			28.9	NS
Co.004	1	(2) s	4.3	0.291	0.086	1.7E-03	30.4	0.62	0.1	0.025	25.9	old startup
"	2	u	11.2	0.517	0.155	3.0E-03	28.9	0.61	0.1	0.038		NSH
"	2h	u	47.6	0.548	0.211	3.2E-03	21.9	0.64	2.3	0.090		NSH
"	2a	f	3.8	0.177	0.063	1.0E-03	25.5	0.65	0.1	0.024		NSH, high conv. study
"	3	u	6.7	0.499	0.153	2.9E-03	27.8	0.61	0.1	0.036		NSH, calc. after run 2, T surge
"	3h	u	27.0	0.506	0.164	3.0E-03	27.3	0.62	0.8	0.048		NSH
"	4	u	1.8	0.427	0.241	2.5E-03	24.0	0.79	0.1	0.078		NSH, high conv. study
"	5	f	4.5	0.288	0.150	1.7E-03	19.4	0.75	0.1	0.03		NSH, 10 atm
"	6	n	6.9	0.466	0.151	2.7E-03	27.8	0.61	0.2	0.044		NSH
"	7	ROR	3.9	0.225	0.072	1.3E-03	28.8	0.61	0.2	0.042		NSH
"	8	He	5.8	0.399	0.144	2.3E-03	27.2	0.66	0.1	0.028		NSH
Co.005	2	(1)	3.3	0.087	0.037	5.1E-04	21.4	0.66	0.1	0.005		NSH
"	2a		2.5	0.066	0.021	3.9E-04	25.9	0.59	0.1	0.004		NS
"	2b		2.4	0.064	0.021	3.7E-04	26.3	0.60	0.1	0.006		CO:H ₂ :Ar = 1:2:2
"	3		3.3	0.077	0.024	4.5E-04	28.4	0.62	0.1	0.013		+ H ₂ O (eq. 7.5% CO conv.)
"	4		4.0	0.069	0.021	4.0E-04	30.0	0.62	0.2	0.009	25.1	NSH
"	5		3.9	0.171	0.084	1.0E-03	26.8	0.76	0.1	0.018		NSH
"	6		2.1	0.129	0.044	7.6E-04	25.7	0.64	0.1	0.017		NSH, 10 atm
"	7		6.7	0.084	0.040	4.9E-04	18.8	0.70	0.1	0.003		NSH
"	8		2.7	0.154	0.067	9.0E-04	22.6	0.71	0.1	0.019		S2
"	8a		2.5	0.140	0.059	8.4E-04	23.4	0.72	0.1	0.019		D (1:2), NSH
"	8b		4.2	0.239	0.045	1.4E-03	40.0	0.60	0.1	0.032		Ar added to rxn mix
"	8c		3.5	0.196	0.026	1.1E-03	49.6	0.59	0.1	0.049		Rxn @ 240 °C
"	8d		2.5	0.140	0.059	8.4E-04	23.4	0.72	0.1	0.019		Rxn @ 260 °C
"	9		1.5	0.082	0.025	4.8E-04	27.7	0.60	0.1	0.014		Rxn @ 280 °C
"	9a		1.4	0.075	0.020	4.4E-04	29.9	0.61	0.1	0.016		D (1:4), NSH
"	9b	(1)	1.4	0.078	0.004	4.5E-04	62.9	0.58	0.3	0.055		Ar added to rxn mix
"	10		1.9	0.106	0.045	6.2E-04	23.0	0.70	0.1	0.016		Rxn @ 280 °C
"	10a		1.6	0.090	0.024	5.3E-04	25.3	0.68	0.1	0.017		D (1:2), NSH
"	10b		1.8	0.100	0.005	5.9E-04	48.0	0.65	0.2	0.037		Ar added to rxn mix
"	10c		0.4	0.024	0.010	2.3E-04	25.9	0.76	0.1	0.013	13.8	Rxn @ 280 °C
Co.005a	1	(4a)	3.2	0.227	0.067	1.3E-03	30.0	0.60	0.1	0.034		at 220 after rxn @ 280
Co.005b	1	(1)	2.4	0.040	0.024	2.3E-04	13.9	0.74	0.4	0.023		NSH
Co.005c	1	(1)	5.7	0.071	0.031	4.1E-04	20.3	0.68	1.8	0.076		S2, 1/4 WGS.03 + 3/4 Co.005
Co.006	1	(5)	2.7	0.052	0.007	5.1E-04	45.0	0.49	0.1	0.006		S2, 1/2 WGS.03 + 1/2 Co.005
Co.007	1	(5)	3.2	0.024	33	7.0E-03	49.8	0.50	0.2	0.004		NSH
Co.009	1	(1)	4.9	0.346			31.1	0.57	0.1	0.020		NSH
"	2		4.9	0.338			31.1	0.58	0.1	0.026		NSH
Co.010a	1	(4b) s	3.5	0.246	0.076	1.4E-03	29.5	0.62	0.2	0.040		NSH
"	2		4.1	0.262	0.080	1.5E-03	30.0	0.61	0.1	0.022		NSH

Table 5. Summary of Fixed Bed Reactor Data (cont. 'd)

Catalyst	Run	Prep	CO Conv. (%)	Rate g CH ₂ /g cat/hr	R-C6+ g CH ₂ /g cat/hr	R (Co) mol/mol Co/s	wt% CH ₄	alpha	CO ₂ (%)	g/g cat/hr	E act kcal/mol	Comment
Co.011	2	(6b)	2.9	0.094	0.037	5.5E-04	22.4	0.61	0.3	0.030		NSH
Co.012	1	(1)	3.8	0.083	0.027	4.8E-04	26.3	0.64			22.5	slow CO startup (60 min)
"	2		4.4	0.085	0.030	5.0E-04	29.1	0.64	0.3	0.018		NSH
"	3		2.1	0.081	0.026	4.7E-04	28.6	0.66	0.4	0.049		NSH
"	4		2.5	0.105	0.035	6.2E-04	28.4	0.61	0.4	0.023		NSH
Co.014	1	(1)	1.5	0.028	0.009	2.8E-04	32.3	0.63	0.1	0.003		NSH
"	2		2.6	0.034	0.013	3.3E-04	27.7	0.69	0.1	0.011	26.0	NSH
Co.015	1	(4) s	6.8	0.211	0.063	1.2E-03	26.7	0.60	0.1	0.011		slow CO startup (120 min)
"	2	f	7.0	0.388	0.135	2.3E-03	26.4	0.64	0.1	0.011		NSH
"	3	u	6.7	0.375	0.123	2.2E-03	28.2	0.63	0.2	0.011		NSH
Co.016	1	(4a) s	5.2	0.161	0.035	9.4E-04	33.6	0.56				slow CO startup (30 min)
"	2	f	5.1	0.291	0.112	1.7E-03	25.1	0.68	0.1	0.01		NSH
Co.017	2	(1) s	4.6	0.139	0.066	8.2E-04	22.0	0.69	0.1	0.012		NS
"	2a	s	3.7	0.111	0.043	6.5E-04	25.9	0.64	0.1	0.011		CO:H ₂ :Ar = 1:2:2
"	2b	s	3.4	0.102	0.039	6.0E-04	26.9	0.65	0.1	0.013		+ H ₂ O (eq. 7.5% CO conv.)
"	3	f	4.9	0.274	0.111	1.6E-03	23.0	0.67	0.2	0.030		NSH, calc. flow air
Co.018	2	s	3.4	0.170	0.068	1.0E-03	27.2	0.69	0.1	0.013		NS
"	2a	s	2.7	0.133	0.041	7.8E-04	33.2	0.64	0.1	0.011		CO:H ₂ :Ar = 1:2:2
"	2b	s	3.0	0.147	0.045	8.6E-04	33.6	0.63	0.1	0.015		+ H ₂ O (eq. 7.5% CO conv.)
"	3	s	4.1	0.290	0.086	1.7E-03	30.0	0.62	0.1	0.022		NSH
"	4	s	3.6	0.340	0.180	2.0E-03	25.4	0.80	0.1	0.041		NSH, 10 atm
"	5	f	7.5	0.470	0.136	2.8E-03	29.0	0.60	0.3	0.055		NSH
Co.018Cl	1	(1)	4.5	0.320	0.075	1.9E-03	33.5	0.57	0.1	0.018		NSH
Co.019	1	(1) s	4.4	0.088	0.047	5.2E-04	15.2	0.74				NS
"	2	s	2.2	0.085	0.046	4.9E-04	18.9	0.73	0.3	0.040		NSH
"	3	f	3.4	0.142	0.071	8.3E-04	19.3	0.72	0.2	0.025		NSH
Co.020a	1	(4) s	4.6	0.343	0.085	2.0E-03	33.5	0.57	0.1	0.024		NSH
"	2		4.4	0.315	0.086	1.8E-03	31.2	0.59	0.1	0.028		NSH
Co.020b	1	(4b) s	4.4	0.311	0.084	1.8E-03	31.7	0.58	0.2	0.051		NSH
Co.020c	1	(4a) s	4.0	0.287	0.083	1.7E-03	30.4	0.60	0.1	0.017		NSH
Co.021	1	(6b)	3.4	0.109	0.032	6.4E-04	27.3	0.62	0.1	0.012	28.2	NSH
"	2		3.6	0.114	0.035	6.7E-04	28.0	0.56	0.1	0.012		NSH
Co.022	1	(6c)	3.8	0.121	0.037	7.1E-04	26.7	0.55	0.1	0.015	30.1	NSH
Co.023	1	(6c)	3.8	0.123	0.038	7.2E-04	28.3	0.56	0.2	0.023	29.5	NSH
Co.024	1	(7)	5.1	0.165	0.047	9.7E-04	32.8	0.62	0.5	0.055		NSH
"	2		5.7	0.182	0.060	1.1E-03	28.7	0.62	0.3	0.035		NSH
Co.025	1	(4)	5.0	0.160	0.062	9.4E-04	23.5	0.63	0.2	0.019	26.9	NSH
"	2		2.0	0.113	0.037	6.6E-04	26.8	0.61				NSH
"	2a		0.7	0.040	0.007	2.3E-04	49.5	0.66				NSH
Co.026	1	(1)	4.4	0.129	0.043	5.0E-04	26.9	0.62	0.2	0.022		Rxn @ 280 °C
"	1h		22.9	0.170	0.072	6.6E-04	22.6	0.67	1.5	0.037		NSH
Co.027	1	(1)	4.2	0.169	0.068	6.6E-04	23.0	0.65	0.2	0.026		NSH, high conv. study
"	1h		17.8	0.180	0.085	7.0E-04	19.4	0.71	1.2	0.011		NSH
												NSH, high conv. study

Table 5. Summary of Fixed Bed Reactor Data (cont. 'd)

Catalyst	Run	Prep	CO Conv. (%)	Rate g CH ₂ / g cat/hr	R-C6+ g CH ₂ / g cat/hr	R (C6) mol/mol C6's	wt% CH ₄	alpha	CO ₂ (%)	E act. kcal/ mol	Comment	
Co.028	1	(4)	3.8	0.146	0.076	5.7E-04	18.2	0.76	0.2	0.031	28.4	NSH
"	2		4.3	0.167	0.105	6.5E-04	14.7	0.80	0.2	0.030		NSH
"	3		4.5	0.206	0.126	8.0E-04	15.5	0.79	0.2	0.037		NSH, re-calc. in flow air
Co.029	1	(4)	2.8	0.173	0.105	6.7E-04	15.3	0.79	0.2	0.026		NSH
Co.031	1	(1)	1.9	0.060	0.022	3.5E-04	26.1	0.64	0.3	0.031		NSH
Co.032	1	(1)	3.3	0.183	0.079	1.1E-03	22.0	0.70	0.1	0.022		NSH
Co.033	1	(1)	1.3	0.073	0.027	4.3E-04	24.1	0.67	0.1	0.020		NSH
Co.034	1	(4)	5.0	0.275	0.107	1.6E-03	24.0	0.67	0.1	0.018		NSH
Co.035	2	(6)	4.6	0.147	0.068	8.6E-04	22.0	0.69	0.2	0.019		NSH
Co.036	2	(6c)	3.9	0.125	0.045	7.3E-04	28.9	0.67	0.1	0.013		NSH
Co.037	1	(4a)	2.7	0.053	0.011	5.2E-04	32.8	0.59				NSH
Co.038	1	(4a)	4.5	0.051	0.018	4.9E-04	25.1	0.68	0.3	0.013	24.2	NSH
Co.039	1	(5)	1.1	0.021	0.004	2.0E-04	57.2	0.64	0.2	0.010	25.6	NSH, cracking in the line
"	2		3.9	0.049	0.007	4.7E-04	42.4	0.48	0.2	0.009		NSH
Co.040	1	(4a)	1.9	0.037	0.004	3.7E-04	45.2	0.53	0.2	0.007		NSH
"	2		2.8	0.033	0.004	3.3E-04	44.6	0.46	0.2	0.007		NSH
Co.041	1	(4)	3.5	0.136	0.042	8.0E-04	40.7	0.69	0.6	0.079		NSH, cracking in the line
Co.043	1	(4a)	4.6	0.104	0.062	6.1E-04	15.3	0.78	0.6	0.048		NSH, 2.5 hr on-stream
"	2		3.7	0.078	0.045	4.6E-04	16.3	0.78	0.5	0.035	35.1	NSH
Co.044	1	(4)	3.1	0.179	0.081	1.0E-03	22.7	0.73	0.3	0.020		NSH
Co.045	1	(4)	2.6	0.161	0.076	9.4E-04	22.2	0.73	0.3	0.022		NSH
Co.047	1	(4)	6.4	0.263	0.128	1.5E-03	21.3	0.73	0.3	0.040	26.6	NSH
Co.048	1	(4)	3.5	0.162	0.094	9.5E-04	16.3	0.77	0.2	0.027	28.0	NSH
Co.049	1	(4)	7.1	0.366	0.153	2.1E-03	23.4	0.69	0.3	0.043		NSH
"	2		6.0	0.388	0.160	2.3E-03	23.3	0.68	0.3	0.056		NSH, re-calcined in flow air
"	3	f	6.7	0.410	0.158	2.4E-03	25.2	0.69	0.3	0.059		NSH
"	3h	f	44.9	0.457	0.178	2.7E-03	26.5	0.67	3.8	0.131		NSH, HCS
Co.053	1	(1)	7.0	0.408	0.127	2.4E-03	27.3	0.62	0.2	0.049		NSH
"	1h		28.5	0.417	0.145	2.4E-03	26.8	0.64	1.6	0.081		NSH, high conv. study
"	2	f	6.6	0.433	0.174	2.5E-03	23.4	0.63	0.2	0.052		NSH
"	3		7.8	0.453	0.143	2.7E-03	27.6	0.62	0.1	0.027		NSH
"	3h		31.5	0.457	0.164	2.7E-03	25.4	0.65	0.9	0.044		NSH, high conv. study
"	4	u	6.1	0.426	0.142	2.5E-03	28.3	0.65	0.1	0.030		NSH
"	5	ROR	5.6	0.360	0.118	2.1E-03	27.9	0.64	0.2	0.034		NSH, ROR
"	6	f	8.2	0.485	0.163	2.8E-03	28.9	0.64	0.1	0.030		NSH
"	7	f	9.4	0.552	0.147	3.2E-03	34.3	0.60	0.1	0.044		NSH, Rxn @ 227 °C
"	7a	f	1.7	0.099	0.018	5.8E-04	38.1	0.60	0.2	0.028		xn @ 245 °C, T surge 280 °C
"	7b	f	2.0	0.119	0.031	7.0E-04	32.1	0.62	0.1	0.021		cal(5 hr) & red after run 7
"	8	f	7.7	0.450	0.144	2.6E-03	30.3	0.65	0.1	0.036		NSH
"	8a	f	6.3	0.368	0.103	2.2E-03	32.8	0.65	0.1	0.047		Ar added to the rxn mix.
"	8b	f	3.0	0.177	0.037	1.0E-03	37.3	0.65	0.1	0.033		xn @ 240 °C, T surge 275 °
"	9	f	4.3	0.470	0.225	2.8E-03	21.6	0.69	0.2	0.046		D (1:2), NSH
"	9a	f	7.5	0.411	0.067	2.4E-03	46.9	0.62	0.2	0.070		Ar added to the rxn mix.
"	9b	f	11.9	0.647	0.116	3.8E-03	42.7	0.59	0.1	0.046		Rxn @ 240 °C

Table 5. Summary of Fixed Bed Reactor Data (cont. 'd)

Catalyst	Run	Prep	CO Conv (%)	Rate g CH ₂ /g cat/hr	R-C6+ g CH ₂ /g cat/hr	R (Co) mol/mol Conv	wt% CH ₄	alpha	CO ₂ (%)	P/g cat/hr	E act kcal/ mol	Comment
Co.053	10		5.6	0.304	0.091	1.8E-03	29.2	0.60	0.2	0.008		D(1:2) , NSH
"	10a		11.9	0.647	0.116	3.8E-03	42.7	0.59	0.2	0.046		Rxn @ 240 °C
"	10b		7.5	0.411	0.067	2.4E-03	46.9	0.62	0.4	0.070		Rxn @ 260 °C
"	10c		3.0	0.163	0.035	9.6E-04	38.8	0.69	0.3	0.054		Rxn @ 280 °C
"	11		5.4	0.289	0.102	1.7E-03	26.9	0.64	0.1	0.022		D (1:2) ,NSH
"	11a		3.8	0.205	0.047	1.2E-03	38.7	0.69	0.3	0.060		Rxn @ 280 °C
"	12	f	8.1	0.433	0.145	2.5E-03	26.6	0.60	0.2	0.029		D (1:2) ,NSH
"	12a	f	5.3	0.283	0.063	1.7E-03	39.4	0.69	0.4	0.083		Rxn @ 280 °C
"	12b	f	1.4	0.080	0.054	4.7E-04	20.0	0.78	0.1	0.02		Rxn @ 220
"	13	f	8.3	0.444	0.143	2.6E-03	29.3	0.65	0.2	0.037		Cal(10hr) & red after run 12
"	14		6.7	0.375	0.161	2.2E-03	24.8	0.74	0.1	0.025		Cal(24hr) & red after rxn @EI
Co.054	1	(1)	1.2	0.041	0.023	2.4E-04	17.8	0.79	0.2	0.014		NSH
Co.055	1	(1) f	9.1	0.490	0.159	2.9E-03	28.9	0.63	0.2	0.034		NSH
"	2	u	4.9	0.290	0.105	1.7E-03	25.7	0.65	0.2	0.022		NSH, T surge
"	3	u	11.0	0.611	0.193	3.6E-03	29.4	0.60	0.2	0.033		NSH
"	4	u	5.9	0.380	0.124	2.2E-03	28.3	0.60	0.2	0.047		NSH
"	5	u	6.6	0.409	0.135	2.4E-03	29.6	0.59	0.2	0.030		NSH
"	6	ROR	7.5	0.469	0.145	2.7E-03	30.9	0.63	0.2	0.023		NSH
"	7	n	7.5	0.466	0.119	2.7E-03	33.5	0.60	0.2	0.031		NSH
"	8		6.1	0.344	0.108	2.0E-03	29.7	0.66				NSH
"	8a		0.7	0.037	0.005	2.3E-04	41.2	0.66				NSH
Co.056	1	(1)	2.4	0.137	0.054	8.0E-04	23.9	0.69	0.1	0.029		Rxn @ 280 °C
"	2	u	2.2	0.137	0.054	8.0E-04	23.4	0.68	0.1	0.033		NSH
Co.057	1	(1)	2.8	0.171	0.078	1.0E-03	23.4	0.73	0.1	0.029		NSH
Co.060	1	(2)	3.8	0.244	0.097	1.4E-03	25.0	0.69	0.1	0.023		NSH
Co.061	1	(2)	9.4	0.556	0.188	3.3E-03	29.2	0.67	0.1	0.035		NSH
Co.064	1	(2)	7.1	0.384	0.130	2.2E-03	27.5	0.64	0.1	0.028		NSH
Co.066	1	(1)	1.7	0.100	0.031	7.8E-04	27.7	0.67				NSH
"	1a		0.9	0.050	0.009	3.9E-04	32.9	0.68				NSH
Co.067	1	(1)	2.2	0.130	0.045	7.5E-04	25.0	0.67				Rxn @ 280 °C
"	1a		1.6	0.090	0.010	5.2E-04	46.9	0.61				NSH
Co.068	1	(1)	4.0	0.220	0.065	1.3E-03	28.8	0.62				Rxn @ 280 °C
"	1a		1.7	0.100	0.010	6.8E-04	42.7	0.57				NSH
CAL.01	1	(1)	4.8	0.181	0.068	1.1E-03	24.4	0.66	0.3	0.036		Rxn @ 280 °C
"	2		7.4	0.491	0.142	2.9E-03	28.7	0.61	0.4	0.083		NSH, temp. surge (startup)
"	3		2.5	0.164	0.053	9.6E-04	25.6	0.63	0.2	0.052		NSH
"	4		7.3	0.483	0.103	2.8E-03	35.8	0.57	0.2	0.098		NSH, HT, re-reduced
CAL.02	1	(1)	6.1	0.379	0.121	2.2E-03	27.3	0.63	0.2	0.040		NSH, HT, re-calcined
CAL.03	1	(1)	7.3	0.459	0.133	2.7E-03	29.0	0.60	0.2	0.048		NSH
CAL.04	1	(1)	4.1	0.234	0.123	1.4E-03	19.1	0.71	0.2	0.026		NSH
CAL.05	1	(1)	4.7	0.274	0.134	1.6E-03	20.8	0.75	0.2	0.026		NSH
CAL.06	1	(1)	5.8	0.267	0.135	1.6E-03	20.7	0.74	0.2	0.021		NSH
CAL. 10	1	(1)	3.5	0.196	0.097	1.1E-03	23.5	0.74	0.2	0.05		NSH

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

Catalyst	Run	Prep	CO Conv (%)	Rate g CH ₂ / g cat/hr	R-C ₆ + g CH ₂ / g cat/hr	R (Co) mol/mol Co/s	wt % CH ₄	alpha	CO ₂ (%)	g/g cat/hr	E act kcal/ mol	Comment
CAL.02	1	(1)	6.1	0.379	0.121	2.2E-03	27.3	0.63	0.2	0.040		NSH
CAL.03	1	(1)	7.3	0.459	0.133	2.7E-03	29.0	0.60	0.2	0.048		NSH
CAL.04	1	(1)	4.1	0.234	0.123	1.4E-03	19.1	0.71	0.2	0.026		NSH
CAL.05	1	(1)	4.7	0.274	0.134	1.6E-03	20.8	0.75	0.2	0.026		NSH
CAL.06	1	(1)	5.8	0.267	0.135	1.6E-03	20.7	0.74	0.2	0.021		NSH
CAL. 10	1	(1)	3.5	0.196	0.097	1.1E-03	23.5	0.74	0.2	0.05		NSH
CAL.11	1	(1)	5.2	0.281	0.147	1.6E-03	20.0	0.75	0.2	0.029		NSH
CAL.12	1	(1)	5.2	0.288	0.143	1.7E-03	21.6	0.73	0.2	0.035		NSH
CAL.13	1	(1)	4.6	0.258	0.142	1.5E-03	18.0	0.77	0.2	0.024		NSH
CoW.01	1	(4a)	1.2	0.016	0.003	9.5E-05	30.2	0.58	0.2	0.006		NSH, reduced at 230 °C
"	1		0.5	0.007	0.001	3.4E-05	42.1	0.51	0.1	0.003		NSH, re-reduced at 350 °C
"	2		0.2	0.006	0.000	3.4E-05	40.9	0.51	0.1	0.006		NSH, reduced at 350 °C
CoW.02	1	(4a)	0.3	0.009	0.002	5.4E-05	25.6	0.60	0.1	0.008		NSH, reduced at 230 °C
CoW.03	1	(4a)										NSH, negligible activity
CoW.04	1	(4a)										S2, negligible activity
CoW.05	1	(4c)	2.8	0.035	0.006	2.1E-04	33.1	0.55	0.2	0.008		S2, reduced at 350 °C
"	2	u	4.7	0.058	0.011	3.4E-04	34.8	0.50	0.2	0.009		S2
"	3	(4c)	0.8	0.020	0.005	1.2E-04	32.8	0.64				NSH
"	3a	(4c)	3.5	0.100	0.008	6.0E-04	54.2	0.58				Rxn @ 280 °C
CoW.06	1	(4a)	3.3	0.041	0.012	2.4E-04	26.0	0.59	0.2	0.007		S2, reduced at 250 °C
"	2	u	2.6	0.032	0.004	1.9E-04	39.3	0.46	0.3	0.012		S2
CoW.06	2		17.0	0.207	0.004	1.2E-03	68.7	0.32	1.7	0.07		S2, rxn. at 280 °C
UOP	1	(1)	7.8	0.298	0.104	1.7E-03	22.6	0.61	0.2	0.023		NSH

Table 5. Summary of Fixed Bed Reactor Data (cont.'d)

Reaction Conditions: $T = 220^{\circ}\text{C}$, $\text{H}_2:\text{CO} = 2, 1 \text{ atm}$

All the catalysts are reduced and passivated before loading into reactor, then rereduced in-situ

All catalysts are calcined at UPARC (static) : except where specified in prep. column

s : calcined at Pitt, static

f : calcined at Pitt, flow

u : uncalcined

n : Nitrogen calcined

In some cases, "re-calcined" means calcination of the calcined catalyst from UPARC for a longer period

(1) single step, aqueous incipient wetness

(2) Two step impregnation: aqueous incipient wetness of Co + acetone/ethanol impregnation of Ru, La

(3) three step, with calcination after each step, acetone incipient wetness

(4) two step, aqueous incipient wetness, (a) intermediate calcination, (b) intermediate reduction,
(c) intermediate calcination 750°C

(5) single step, acetone impregnation

(6) single step, aqueous kneading, (a) = 150%, (b) = 110% of pore volume

(6c) aqueous kneading for Co, calcined, then aqueous incipient wetness for Zr

(7) Two step impregnation : organic incipient wetness + aqueous incipient wetness

NS New startup

NSH New startup, heated inlet

S2 was done in the second system

~ Davison Grade 59 Silica, if not specified, S refers Davison Drade 952 Silica

corrected overheated line on 3/6/1994

D (x:y) Catalyst bed dilution with x parts cat. and y parts -alumina

Co.018Cl Chlorinated Co.018

COMPARISON OF CONVERSION AND SELECTIVITY OF
COBALT BASED F-T CATALYSTS AT STARTUP CONDITIONS

Period No.				Temp.	Pres.	H2/CO Ratio							
-----				-----	-----	-----							
1				240 C	450psi	2.0							

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Catalyst Prom%	Composit. Metal%	Suppt

M-3 SBCR													
5	CO.003	15.1	31.7	1.53	16.7	2.4	79.8	1.16	0.71	--	1.0La	0.5Ru	Al
6	CO.011	15.3	14.3	0.67	7.6	1.6	89.4	1.42	0.78	0.83	0.0	0.0	Si
7	CO.012	15.8	13.9	0.63	6.1	1.5	90.6	1.74	0.80	0.89	0.0	0.0	Si
8	CO.015	15.0	28.3	1.37	12.7	2.0	84.1	1.24	0.76	0.80	1.0La	0.43Ru	Al
9	CO.011	15.0	18.5	0.89	8.8	1.7	88.8	0.77	0.78	0.83	0.0	0.0	Si
11	CO.017	15.0	27.2	1.32	11.2	1.8	85.9	1.14	0.77	0.80	1.0La	0.5Ru	Al
12	CO.018	15.6	33.8	1.56	9.7	2.0	86.6	1.68	0.75	0.85	0.0	0.5Ru	Al
13	CO.016	14.7	26.4	1.31	(1)	1.7	89.3	0.68	0.78	0.81	1.0La	0.43Ru	Al
14	CO.019	15.2	13.9	0.66	(2)	1.7	97.2	0.70	0.80	0.86	0.0	0.5Ru	Si
15	CO.005	14.7	27.1	1.34	7.9	1.6	89.7	0.82	0.79	0.82	0.0	0.0	Al
16	CO.002	15.4	30.1	1.42	12.5	2.5	83.9	1.09	0.75	0.80	1.0La	0.43Ru	Al
17	CO.025	15.6	26.6	1.24	10.7	2.1	86.4	0.82	0.76	0.82	8.5Zr	0.0	Si
18	CO.004	15.0	33.9	1.64	15.3	2.4	80.9	1.37	0.74	0.79	1.0La	0.43Ru	Al
19	CO.021	15.6	23.2	1.08	9.4	2.0	88.0	0.73	0.77	0.82	0.7Zr	0.0	Si
20	CO.041	15.8	25.3	1.16	11.0	2.1	86.0	0.88	0.76	0.84	8.5Zr	0.5Ru	Si
21	CO.014	15.1	8.5	0.40	8.3	3.5	85.8	2.43	0.74	0.83	0.0	0.5Ru	Ti
22	CO.040	14.5	1.8	0.09	0.0	4.0	94.1	1.89	0.71	0.82	0.0	0.0	Ti
23	CO.047	15.8	28.2	1.29	7.7	1.5	89.3	1.47	0.79	0.84	0.3K	0.5Ru	Al
24	CO.049	15.6	30.6	1.41	10.9	1.8	85.7	1.66	0.76	0.82	0.1K	0.5Ru	Al
25	CO.047	15.6	28.1	1.30	8.8	1.6	88.1	1.50	0.78	0.85	0.3K	0.5Ru	Al
26	CO.031	15.9	30.9	1.41	12.1	1.9	84.9	1.12	0.75	0.83	1.4Zr	0.0	Al
27	CO.029	15.9	28.3	1.27	8.3	1.6	87.9	2.21	0.77	0.84	0.5K	0.5Ru	Al
28	COW.01	15.0	1.1	0.05	0.0	12.	83.9	4.23	0.58	--	5.0Cu	10.0Zn	Al
29	CO.053	25.2	42.0	1.19	15.8	2.3	79.5	2.42	0.73	--	0.0	0.5Ru	Al
30	CO.053	29.6	41.8	1.02	22.6	2.9	71.5	3.05	0.66	0.77	0.0	0.5Ru	Al
31	CO.055	15.0	30.0	1.46	23.7	3.7	70.2	2.30	0.61	0.81	1.0La	1.0Re	Al
32	CO.044	16.4	20.9	0.93	6.7	1.9	90.8	0.56	0.77	0.83	15.0Zr	0.0	Si
33	CO.053	31.4	41.4	0.94	23.2	3.1	69.6	4.06	0.65	0.76	0.0	0.5Ru	Al
34	CO.060	15.6	31.4	1.46	14.0	2.3	82.2	1.48	0.75	0.79	0.0	0.0	Al
35	CO.041	26.0	35.7	1.00	13.6	2.1	82.9	1.41	0.79	0.82	8.5Zr	0.5Ru	Si
36	CO.032	15.9	24.0	1.10	9.1	1.8	88.2	0.83	0.77	0.83	8.5Zr	0.0	Al
37	CO.045	15.9	14.8	0.67	8.0	1.7	89.4	0.91	0.76	0.84	4.0Zr	0.0	Si
38	Co.058	15.9	28.0	1.28	11.9	2.1	85.1	0.91	0.75	0.85	1.0La	0.0	Al
39	Co.064	15.9	34.2	1.56	13.6	2.3	82.6	1.55	0.73	0.85	8.5Zr	0.5Ru	Al

Note: Catalyst Run 9 screened thru 170 x 400 mesh.
Catalysts For Runs 11 through 28 (except Runs 21 and 22) screened thru 150x 400 mesh.
Catalysts for Runs 21 and 22 screened thru 100 x 400 mesh.
Catalyst No. CO.029 contained 30 wt% cobalt.

G.C.Problems

- (1) Weak TCD filaments in G.C. CH₄ peaks smaller than expected.
- (2) Internal valve in G.C. leaked. CH₄ peak undetected.

Table 6
(continued)

DATE: 07/12/95

COMPARISON OF CONVERSION AND SELECTIVITY OF
COBALT BASED F-T CATALYSTS AT STARTUP CONDITIONS

Period No.				Temp.		Pres.		H2/CO Ratio					
-----				-----		-----		-----					
1				240 C		450psi		2.0					

Run No	Cat. No	Cat. wt,g	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Catalyst Prom%	Composit. Metal%	Suppt
					%CH4	%C2	%C3+	%CO2					

M-3	SBCR												
40	Co.063	15.0	8.7	0.43	6.5	0.9	92.6	0.09	0.74	--	8.5La	0.0	Al
41	Co.062	15.0	6.6	0.32	3.5	0.3	95.3	1.00	0.76	0.89	1.5K	0.5Ru	Al
42	Co.065	15.9	27.6	1.25	7.9	2.0	88.6	1.61	0.79	0.84	8.5Zr 0.3K	0.5Ru	Al
43	COW.12	9.1	6.1	0.47	20.3	6.1	66.3	7.3	0.61	0.83	0.0	0.5Ru	Si
44	COW.11	15.6	4.7	0.20	8.4	6.3	74.4	10.9	0.60		0.5K	0.5Ru	Al
45	Fe.01	15.9	3.4	0.14	0.0	7.5	84.8	7.72	0.72	0.77	0.0	1.5Cu	Si
46	COW.05	15.7	4.9	0.23	10.9	6.5	81.9	0.74	0.60		4.0Cr	5.0Cu	Al
47	Co.070	15.6	22.8	1.07	10.9	2.7	85.7	0.70	0.75	0.85	0.0	0.0	Al

Note: All catalysts except COW.12 were screened thru 150 x 400 mesh.
Catalyst No. COW.12 contains 10% Co plus 10% Fe.
Catalyst No. COW.11 contains 10% Co plus 10% Fe. It is 150 x400 mesh.
Catalyst No. Fe.01 contains 30% Fe and no cobalt.
Catalyst No. Co.070 contains 13% Co with no promoters.

Table 7

ANALYSES OF RECOVERED SBCR
CATALYSTS FOR CARBON CONTENT

<u>Run No.</u>	<u>Catalyst No.</u>	<u>Charge</u> gm	<u>Metals</u> wt %	<u>Promoter</u> wt %	<u>Support</u>	<u>CO Conv.</u> wt %	<u>Carbon</u> wt %
3008	Co.015	15.0	1.0 La	0.43 Ru	Al	28.3	9.4
3009	Co.011	15.0	0	0	Si	18.5	5.3
3011	Co.017	15.0	1.0 La	0.5 Ru	Al	27.2	6.6
3013	Co.016	14.7	1.0 La	0.43 Ru	Al	26.4	1.7
3016	Co.002	15.4	1.0 La	0.43 Ru	Al	30.1	8.1
3017	Co.025	15.6	8.5 Zr	0	Si	26.6	0.5
3018	Co.004	15.0	1.0 La	0.43 Ru	Al	33.9	8.3
3029	Co.053	25.2	0	0.5 Ru	Al	42.0	5.9
3030	Co.053	29.6	0	0.5 Ru	Al	41.8	13.5
3031	Co.055	15.0	1.0 La	1.0 Re	Al	30.0	6.9

Note: All catalysts were tested at 240°C reaction temperature except RN3029 was tested up to 260°C, and RN3030 had reached a maximum of 320°C reaction temperature.

Table 8

SDCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered		Charge		Recovered		Reduction in Particle Size, microns
		(H ₂ Reduced) wt, gm	wt, gm	(Oxidized) wt, gm	wt, gm	Particle Size, mvd, microns	Particle Size at 10% microns	Particle Size, mvd, microns	Particle Size at 10% microns	
Co.001 (Al)	1	14.5		12.63		42.02	24.25	41.06	23.62	2.3
Co.001 (Al)	2	16.5		15.18		42.02	24.25	40.09	22.86	4.6
Co.005 (Al)	3	19.5		18.41		85.66	30.46	64.53	31.27	24.7
Co.002 (Al)	4	20.1		20.4		73.61	32.86	71.19	33.50	3.3
Co.003 (Al)	5	15.1		14.54		76.01	34.40	72.57	34.25	5.5
Co.011 (Si)	6	15.3		16.03		107.09 (1)	53.19	94.02	40.44	12.2
Co.012 (Si)	7	15.8		14.73		105.22 (1)	51.33	101.37	44.44	3.7
Co.015 (Al)	8	15.0		15.52		75.63 (1)	33.15	74.68	32.60	1.3
Co.011 (Si)	9	15.0		15.92		79.00 (2)	40.31	72.44	36.31	9.3
Co.016 (Al)	10	15.5		15.72		64.60 (2)	32.16	64.30	32.70	0.3
Co.017 (Al)	11	15.0		15.09		73.14 (3)	36.29	69.95	35.62	4.4
Co.018 (Al)	12	15.6		16.97		62.89 (3)	32.56	68.16	34.74	---
Co.016 (Al)	13	14.7		13.30		67.69 (3)	35.05	64.79	34.20	4.3
Co.019 (Si)	14	15.2		15.00		92.63 (3)	42.73	84.39	36.52	8.9
Co.005 (Al)	15	14.7		15.30		80.62 (3)	45.07	71.90	36.79	10.8
Co.002 (Al)	16	15.4		14.90		73.61 (3)	32.86	67.62	32.67	8.1
Co.002 (Al)	1 (M4)	15.0		11.00		73.61 (3)	32.86	66.26	35.75	10.0
Co.025 (Si)	17	15.6		14.60		87.19 (3)	47.35	78.31	36.27	10.2
Co.004 (Al)	18	15.0		15.25		78.12 (3)	44.15	66.86	33.83	14.4
Co.021 (Si)	19	15.6		16.06		86.18 (3)	46.54	77.95	35.59	9.55
Co.041 (Si)	20	15.0		17.02		87.48 (3)	49.26	68.74	26.72	17.0
Co.021 (Si)	3 (M4)	15.2		15.1		73.61 (3)	24.46	71.38	32.33	3.03
Co.024 (Al)	4 (M4)	15.4		(4)		---	---	---	---	---
Co.035 (Si)	5 (M4)	15.4		14.08		89.14 (3)	49.29	74.76	31.67	19.2
Co.028 (Al)	6 (M4)	15.4		15.7		80.83 (3)	44.01	71.03	36.34	11.1

(1) Screened through 100x400 mesh screens.
 (3) Screened through 150x400 mesh screens.

(2) Screened through 170x400 mesh screens.
 (4) Did not filter, too waxy

Note: The charge weights are in the hydrogen-reduced state and the recovered weights are in the oxidized state. The particle size is reported as the mean volume diameter (mvd) as measured by a Microtrac particle size analyzer.

Table 8
(Continued)

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered (Oxidized) wt, gm	Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) wt, gm	wt, gm		Particle Size, mvd, microns	Particle Size at 10% microns	Particle Size, mvd. microns	Particle Size at 10% microns	
Co.014 (Ti)	21	15.1	111.70 (1)	15.1	32.65	106.66	33.49	4.51	
Co.040 (Ti)	22	14.5	(5)	8.5	(5)	130.40	51.40	--	
Co.047 (Al)	23	15.8	83.42 (3)	16.95	44.41	76.46	39.02	8.34	
Co.049 (Al)	24	15.6	81.3 (3)	16.54	42.39	70.11	35.87	13.8	
Co.047 (Al)	25	15.6	79.36 (3)	16.69	41.72	69.09	36.16	12.94	
Co.031 (Al)	26	15.9	75.48 (3)	15.37	38.34	68.42	35.39	9.35	
Co.029 (Al)	27	15.9	76.39 (3)	18.28	39.56	60.72	36.04	10.04	
Co.043 (Si)	7 (M4)	15.4	(5)	15.1	(5)	85.51	40.20	--	
Co.006 (Ti)	8 (M4)	15.0	121.38 (1)	9.09	52.80	99.31	38.62	18.2	
Co.048 (Si)	9 (M4)	15.4	82.40 (3)	15.85	40.94	70.69	25.53	14.2	
CAL.02 (Al)	10 (M4)	15.9	74.40 (3)	16.42	37.79	65.89	34.14	11.44	
Co.053 (Al)	12 (M4)	15.9	82.02 (3)	16.95	43.10	69.53	35.76	15.23	
Co.054 (Si)	13 (M4)	15.7	101.17 (3)	17.09	57.54	82.37	37.89	18.58	
Blend A (Al)	14 (M4)	20.0	86.23 (3)	14.61	46.36	77.43	42.81	10.21	
Co.034 (Al)	15 (M4)	13.0	(5)	9.52	(5)	88.26	45.28	--	
CAL.04 (Al)	16 (M4)	16.1	71.54 (3)	21.70	36.28	66.50	32.82	7.05	
CAL.08 (Al)	17 (M4)	15.0 (6)	63.12	14.27	25.60	62.80	26.03	0.51	
CAL.07 (Al)	18 (M4)	14.5 (6)	--	13.37	--	67.02	28.12	--	
CAL.05 (Al)	19 (M4)	15.7	72.75	5.62	36.90	71.62	36.55	1.55	
CAL.06 (Al)	20 (M4)	15.0	72.62	(7)	37.33	--	--	--	
Co.053 (Al)	29 (M3)	25.2	75.63	25.8	40.80	71.09	38.20	6.00	
Co.004 (Al)	21 (M4)	15.9	81.38	15.04	41.82	72.88	37.61	10.44	

- (1) Screened through 100x400 mesh screens.
 (3) Screened through 150x400 mesh screens.
 (5) Insufficient feed sample.
 (6) Wax coated.
 (7) Lost catalyst.

Table 8.
(Continued)

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered (Oxidized) wt. gm	Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) wt. gm	Particle Size, mvd, microns		Particle Size at 10% microns	Particle Size, mvd, microns	Particle Size at 10% microns		
Blend B (Al)	22 (M4)	30.5	77.85	31.75	43.10	73.74	38.80	5.28	
CAL.09 (Al)	23 (M4)	30.0 (6)	63.12	14.34	25.60	62.10	26.32	1.62	
Co.053-3 (Al)	24 (M4)	28.5	75.63	27.85	40.80	70.69	35.03	6.53	
Co.055 (Al)	31 (M3)	15.0	85.58	14.67	46.27	74.56	39.00	12.88	
Co.056 (Si)	25 (M4)	15.0	99.93	14.93	54.62	88.48	43.26	11.46	
Co.044 (Si)	32 (M3)	16.4	92.15	17.01	49.30	84.92	40.21	7.85	
CAL.10 (Al)	26 (M4)	15.6	83.05	14.63	47.11	81.12	45.87	2.32	
Co.053-4 (Al)	33 (M4)	31.4	84.09	31.9	44.40	73.50	37.10	12.6	
Co.050 (Al)	27 (M4)	14.6	(5)	10.62	(5)	91.37	44.07	--	
Co.060 (Al)	34 (M3)	15.6	87.45	15.8	47.08	80.89	43.42	7.50	
Co.041 (Si)	35 (M3)	26.0	87.48	24.23	49.26	80.63	31.75	7.83	
Co.057 (Si)	28 (M4)	15.8	98.85	14.64	55.78	82.94	36.71	16.10	
Co.032 (Al)	36 (M3)	15.9	78.22	14.66	43.34	78.55	36.02	9.81	
Co.045 (Si)	37 (M3)	15.9	95.67	15.67	53.59	68.84	22.06	28.04	
Co.061 (Si)	29 (M4)	45.4	--	10	--	(7)	(7)	--	
Co.011 (Si)	30 (M4)	15.9	83.99	15.82	40.60	54.04	13.72	35.66	
Co.003 (Al)	50%								
Solids		135		130					
CAL.12 (Al)	31 (M4)	15.9	78.93		39.94	73.02	36.97	7.49	
CAL.11 (Al)	32 (M4)	15.9	72.75	11.86	38.67	72.85	40.91	0	
Co.058 (Al)	38 (M3)	15.9	71.92	17.87	38.83	69.91	36.68	2.8	
Co.064 (Al)	39 (M3)	15.9	85.69	15.29	45.95	78.99	42.90	7.82	
			83.74	14.86	44.86	70.37	35.17	16.0	

(5) Insufficient feed sample
(6) Wax coated
(7) Lost catalyst

Table 8
(Continued)

SBCR CATALYST EXTRACTIONS

Catalyst No. (Support)	Run No.	Charge		Recovered (Oxidized) wt, gm	Charge		Recovered		Reduction in Particle Size, %
		(H ₂ Reduced) wt, gm	Particle Size, mvd, microns		Particle Size at 10% microns	Particle Size, mvd, microns	Particle Size at 10% microns		
Co.063 (Al)	40 (M3)	15.0	88.99	12.02	48.36	80.70	44.32	9.32	
Co.062 (Al)	41 (M3)	15.0	82.85	14.48	44.80	72.90	38.55	12.0	
Co.065 (Al)	42 (M3)	15.9	83.08	17.24	44.17	71.81	37.63	13.6	
CoW.12 (Si)	43 (M3)	9.1	(5)	9.44	(5)	105.95	49.99	--	
CoW.11 (Al)	44 (M3)	15.6	80.32	15.24	42.03	66.93	34.40	16.7	
CAL.13 (Al)	33 (M4)	15.9	80.60	14.45 (8)	43.53	104.15	59.24	--	
Fe.01 (Si)	45 (M3)	15.9	84.91	15.96	46.55	78.01	39.01	8.1	
CoW.05	46 (M3)	15.7	79.45	14.14	42.54	76.03	39.88	4.3	
CAL.13 (Al)	35 (M4)	25.0	80.66	27.0	43.53	74.18	36.16	8.0	
Co.070 (Al)	47 (M3)	15.6	85.64	17.0	45.59	78.41	40.91	8.4	

(5) Insufficient feed sample.

(8) Catalyst was rinsed with solvent only,
not Soxhlett extracted.

Table 9

SUMMARY OF M4 SBGR CALSICAT CATALYST AGING RUN

a) Unless otherwise noted, total flow is ca. 15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (X).

c) Conversion and selectivities are calculated using N2 as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C1+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt, g	Per No	Time Start	Time Stop	Temp C	Pres H2: psi	Synfl CO	Conv. cc/hr	Prod. I	Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins C5-18, I	Comments
No	No	wt, g	No	Start	Stop	C	psi	CO	cc/hr	I	Rate	XCH ₄	XC ₂	XC ₃ +	XC ₄ +	GC	Liq	C3	C4	C5-18, I	
33	CAL.13	15.9	1	23	39	241	450	2.0	20	28.1	1.28	6.4	1.4	90.9	1.29	0.81	0.85	3.64	2.15	23.8	
33	CAL.13	15.9	2	47	63	240	450	2.0	20	25.4	1.21	6.7	1.3	90.8	1.17	0.81	--	3.80	2.45	--	
33	CAL.13	15.9	3	71	87	240	450	2.0	20	25.7	1.18	6.8	1.3	90.8	1.14	0.80	--	3.80	2.25	--	
33	CAL.13	15.9	4	95	111	240	450	2.0	20	25.1	1.15	6.7	1.4	90.8	1.24	0.80	--	4.33	2.55	--	
33	CAL.13	15.9	5	119	135	238	450	2.0	20	22.4	1.02	5.7	1.4	91.8	1.14	0.80	--	4.25	2.50	--	
33	CAL.13	15.9	6	143	159	243	450	2.0	20	27.4	1.25	7.9	1.7	89.0	1.40	0.79	--	3.54	2.13	--	
33	CAL.13	15.9	7	162	178	240	450	2.0	20	23.8	1.09	6.4	1.5	91.0	1.13	0.80	--	4.88	2.55	--	
33	CAL.13	15.9	8	186	203	240	450	2.0	20	22.5	1.03	6.3	1.6	91.1	1.07	0.79	--	4.50	2.60	--	G.C. Calib
33	CAL.13	15.9	9	210	231	241	450	2.0	20	23.2	1.06	6.7	1.6	90.5	1.12	0.81	0.86	4.22	2.45	25.2	
33	CAL.13	15.9	10	234	255	240	450	2.0	20	21.9	1.00	6.4	1.6	90.9	1.05	0.79	--	4.50	2.78	--	
33	CAL.13	15.9	11	262	279	240	450	2.0	20	21.9	1.00	6.3	1.6	91.1	1.02	0.80	--	4.37	2.50	--	
33	CAL.13	15.9	12	282	303	240	450	2.0	20	21.4	0.98	6.1	1.5	91.4	1.01	0.80	--	4.25	2.78	--	
33	CAL.13	15.9	13	306	327	240	450	2.0	20	20.1	0.92	5.9	1.6	91.5	1.05	0.80	--	4.71	2.56	--	
33	CAL.13	15.9	14	331	351	240	450	2.0	20	20.3	0.93	6.0	1.7	91.1	1.12	0.79	--	4.13	2.67	--	
33	CAL.13	15.9	15	360	373	240	450	2.0	20	18.5	0.85	7.2	1.5	90.3	0.98	0.80	--	4.20	3.00	--	G.C. Calib
33	CAL.13	15.9	16	385	398	240	450	2.0	20	19.8	0.91	6.8	1.4	90.8	1.02	0.79	0.85	4.71	2.40	24.5	
33	CAL.13	15.9	17	402	423	240	450	2.0	20	18.4	0.84	7.5	1.6	89.9	1.09	0.78	--	4.00	2.50	--	
33	CAL.13	15.9	18	428	447	239	450	2.0	20	17.2	0.78	7.1	1.6	90.3	1.06	0.78	--	4.43	2.88	--	
33	CAL.13	15.9	19	510	519	241	450	2.0	20	15.6	0.71	6.9	1.5	90.6	1.11	0.78	--	4.67	2.63	--	Down 48hr
33	CAL.13	15.9	20	522	543	241	450	2.0	20	14.5	0.66	6.8	1.2	91.1	0.88	0.77	--	4.50	3.00	--	
33	CAL.13	15.9	21	546	567	240	450	2.0	20	13.9	0.64	6.9	1.2	91.1	0.76	0.77	0.88	5.40	3.00	25.6	
33	CAL.13	15.9	22	570	591	240	450	2.0	20	13.6	0.62	6.9	1.5	90.7	0.98	0.77	--	5.40	3.00	--	
33	CAL.13	15.9	23	596	614	240	450	2.0	20	14.1	0.64	7.0	1.5	80.6	0.95	0.77	--	4.50	3.00	--	
33	CAL.13	15.9	24	617	638	240	450	2.0	20	13.5	0.62	7.0	1.5	90.6	0.87	0.77	--	5.40	2.86	--	
33	CAL.13	15.9	25	641	662	240	450	2.0	20	13.1	0.60	7.1	1.5	90.5	0.86	0.76	--	6.50	2.86	--	
33	CAL.13	15.9	26	665	686	240	450	2.0	20	12.8	0.59	7.3	1.4	90.6	0.73	0.76	--	5.20	2.86	--	
33	CAL.13	15.9	27	689	710	240	450	2.0	20	12.6	0.58	7.2	1.4	90.5	0.86	0.76	--	5.20	2.86	--	
33	CAL.13	15.9	28	713	734	240	450	2.0	20	12.4	0.57	7.5	1.6	90.0	1.01	0.76	0.84	5.20	2.86	25.9	
33	CAL.13	15.9	29	737	758	240	450	2.0	20	12.4	0.57	7.6	1.5	90.2	0.74	0.76	--	5.20	2.86	--	
33	CAL.13	15.9	30	761	782	241	450	2.0	20	12.3	0.56	7.9	1.6	89.6	0.82	0.76	--	5.20	3.00	--	
33	CAL.13	15.9	31	785	806	241	450	2.0	20	12.3	0.56	7.8	0.7	90.9	0.52	0.76	--	6.50	2.86	--	
33	CAL.13	15.8	32	811	830	241	450	2.0	20	12.1	0.55	7.7	1.1	90.6	0.61	0.75	--	6.50	2.86	--	
33	CAL.13	15.9	33	833	854	240	450	2.0	20	11.7	0.54	7.7	1.5	90.1	0.74	0.75	0.84	5.20	2.86	--	
33	CAL.13	15.9	34	857	878	241	450	2.0	20	11.8	0.54	8.0	0.6	91.0	0.50	0.76	--	6.50	2.86	--	
33	CAL.13	15.9	35	881	902	240	450	2.0	20	11.5	0.53	8.0	0.3	91.2	0.47	0.76	--	6.50	2.86	25.9	
33	CAL.13	15.9	36	905	926	240	450	2.0	20	11.3	0.52	8.6	1.1	89.9	0.44	0.75	0.88	6.50	3.17	--	
33	CAL.13	15.9	37	929	950	240	450	2.0	20	11.3	0.52	8.8	1.3	89.5	0.46	0.75	--	6.50	3.17	--	
33	CAL.13	15.9	38	953	974	240	450	2.0	20	11.3	0.52	9.2	1.6	88.4	0.81	0.74	--	5.00	2.71	--	
33	CAL.13	15.9	39	977	998	240	450	2.0	20	11.3	0.52	9.3	1.6	88.4	0.75	0.75	--	5.00	3.33	--	
33	CAL.13	15.9	40	1001	1022	241	450	2.0	20	10.8	0.49	10.2	0.8	88.4	0.52	0.74	--	5.00	2.86	--	
33	CAL.13	15.9	41	1031	1046	241	450	2.0	20	12.9	0.60	9.3	0.0	90.7	0.00	0.77	--	5.40	3.00	--	
33	CAL.13	15.9	42	1049	1069	240	450	2.0	20	11.2	0.52	9.4	0.6	89.6	0.37	0.75	0.86	5.50	2.86	22.4	

Table 10

SUMMARY OF M4 SBCE CALSICAT CATALYST AGING RUN

a) Unless otherwise noted, total flow is ca. 15 L/min. STP, or 3 cm/sec linear gas flow.

b) Conversion is total CO conversion over the period (T).

c) Conversion and selectivities are calculated using N₂ as an internal standard in the GC analysis of the offgas.

d) Prod. rate: Rate for production of total hydrocarbons, C₁+ (kg/kg cat., hr).

e) Alpha: Based on GC analysis of offgas and liquid product.

Run No	Cat. No	Cat. wt., g	Per No	Time Start	Time Stop	Temp C	Pres psi	H ₂ : CO	Synfl cc/hr	Conv. %	Prod. Rate	Selectivities				Alpha GC	Alpha Liq	Olefin/Paraf		Olefins CS-18, I	Comments
No	No	wt., g	No	Start	Stop	C	psi	CO	cc/hr	%	Rate	ICH ₄	IC ₂	IC ₃ +	ICO ₂	GC	Liq	C ₃	C ₄	CS-18, I	
35	CAL.13	25.0	1	23	40	220	450	2.0	20	17.2	0.50	7.7	0.9	97.0	0.65	0.86	0.93	6.33	4.00	25.2	
35	CAL.13	25.0	2	51	62	212	450	2.0	20	8.87	0.26	0	1.4	97.9	0.69	0.84	0.91	6.00	3.33	--	
35	CAL.13	25.0	5	143	158	213	450	2.0	20	8.57	0.25	0	0.9	98.4	0.69	0.86	--	4.00	2.50	24.5	Repair G.C
35	CAL.13	25.0	6	162	181	213	450	2.0	20	8.36	0.24	0	5.3	94.0	0.73	0.85	--	3.67	2.25	--	
35	CAL.13	25.0	7	198	205	212	450	2.0	20	8.19	0.24	0	7.3	92.2	0.53	0.81	--	3.33	2.00	--	
35	CAL.13	25.0	8	228	230	212	450	2.0	20	7.49	0.22	0	6.2	93.2	0.66	0.81	--	3.33	2.25	--	
35	CAL.13	25.0	9	237	254	212	450	2.0	20	7.39	0.21	0	4.5	94.9	0.69	0.82	--	--	--	--	
35	CAL.13	25.0	10	263	275	213	450	2.0	20	8.06	0.23	0	1.6	97.7	0.68	0.85	--	--	--	--	
35	CAL.13	25.0	11	285	302	212	450	2.0	20	7.71	0.22	0	2.7	96.5	0.76	0.84	--	--	--	--	
35	CAL.13	25.0	12	309	328	213	450	2.0	20	7.71	0.22	0	3.0	96.1	0.85	0.85	0.81	--	--	24.5	
35	CAL.13	25.0	13	333	350	213	450	2.0	20	7.51	0.22	0	2.7	96.4	0.92	0.85	--	--	--	--	
35	CAL.13	25.0	14	357	374	212	450	2.0	20	7.05	0.21	0	1.5	97.4	1.13	0.84	--	--	--	--	
35	CAL.13	25.0	15	381	398	212	450	2.0	20	8.07	0.23	0	1.3	98.3	0.42	0.86	--	--	--	--	
35	CAL.13	25.0	16	405	422	213	450	2.0	20	7.85	0.23	0	0.8	98.8	0.39	0.85	--	--	--	--	
35	CAL.13	25.0	17	429	446	212	450	2.0	20	7.38	0.22	0	1.3	98.1	0.82	0.86	--	--	--	--	
35	CAL.13	25.0	18	453	470	213	450	2.0	20	7.35	0.22	0	1.9	97.4	0.67	0.86	0.92	--	--	--	
35	CAL.13	25.0	19	477	494	213	450	2.0	20	7.61	0.22	0	2.1	97.2	0.68	0.89	--	--	4.80	--	
35	CAL.13	25.0	20	501	518	213	450	2.0	20	7.57	0.22	0	0.7	98.6	0.70	0.93	--	--	1.50	--	
35	CAL.13	25.0	21	519	524	213	450	2.0	20	7.41	0.22	0	0.7	98.7	0.74	0.94	--	--	--	--	