

TABLE I
SUMMARY OF DATA

Lab.	Run No.	R FF	H2 CO (FF)	CO2 (FF) CO	CH4 CO (FF)	% Contr.	H2 Conv.	CO Conv.	CO to CO2	CO to CH4	CO to C2S	CO to C3S	CO to C3/ (includ- ing alc. (C bal.))	CO to Alc. (reported)	% Unsat. in C2	% Unsat. in C3	% Unsat. in C4	Tot.CH4 % CO in FF	Tot.CO2 % CO in FF	H2 to H2O (meas- ured)	Lgt. of Catalyst per- iod (hrs.)	Temp. of.	Press.	v/hr/w	% Contr. Correct- ed for CO2 & CH4	Vel.	
Lab.B	5A	0.92	1.52	42.9	5.2	21.0	34.39	36.11	6.63	6.23	1.79	2.41	21.46					11.43	49.53		17	627	264	5.5	25.5	.48	
	5B	0.87	1.62	42.0	4.7	57.7	69.51	75.48	- 3.45	7.45	5.16	4.40	66.32					12.15	38.55		13	621	273	6.0	69.8	.44	
	6B	2.19	1.19	40.9	3.7	45.9	72.57	87.82	33.94	9.16	8.36	10.58	36.36		20.62	55.26	58.91	12.86	74.84	26.5	65	576	278	1.8	56.8	.42	
	6C	2.13	1.18	37.9	3.4	45.0	78.34	91.00	42.55	11.85	10.86	13.14	25.74					15.25	80.45	24.7	.48	600	290	1.8	55.0	.42	
	6D	1.31	1.18	36.9	3.1	44.6	75.34	89.58	38.78	14.54	9.60	11.02	26.66			7.13	10.72	17.64	75.68	17.9	71	601	343	3.2	54.1	.47	
	6E	1.34	1.17	34.9	2.7	37.9	63.51	81.01	34.92	8.20	8.76	10.68	29.13		2.91	11.47	18.09	10.90	69.82	16.0	65	582	345	3.0	45.6	.45	
	6F	1.74	1.23	47.0	8.5	53.7	81.36	90.48	20.60	9.92	9.42	10.26	50.54					18.42	67.60	15.8	49	601	279	2.3	68.6	.49	
	6GA	1.51	1.25	53.8	12.2	47.5	71.46	82.87	16.96	9.14	6.66	9.35	50.11					21.34	70.76	21.7	21	598	283	4.2	64.8	.51	
	6GB	1.87	1.24	55.5	16.8	45.9	73.54	83.84	22.85	6.82	7.78	10.30	46.39					23.62	78.35	18.1	37	590	285	3.4	62.3	.46	
	6H	1.90	1.22	55.4	15.6	58.4	82.00	86.36	3.88	1.09	6.38	8.02	75.01					16.69	59.28	7.0	9	555	265	3.2	78.5	.34	
	11A	2.02	2.14	26.6	3.5	75.1	83.6	94.1	- 0.3	5.7	4.7	6.75	80.0	4.0				9.2	26.3	31.7	13	Fresh Ammonia Syn.Cat.	637	240	31.5	83.6	1.3
	11B	1.96	2.07	25.7	4.4	73.1	83.8	92.74	2.17	7.19	6.44	7.72	74.14	2.9	46.61	78.60	74.17	11.59	27.87	38.2	48	"	657	235	44.9	81.6	1.4
	11E	2.98	2.08	28.70	7.36	81.65	91.5	95.5	-7.45	4.13								11.49	21.25	45.1	144	"	675	400		93.4	
	11FA	2.38	2.11	29.55	6.52	73.13	87.70	93.53	0.02	11.24	8.41	11.66	22.29					17.76	29.57		106	"	660	399	88.7	83.4	0.8
	11FB	3.02	2.06	27.56	7.77	73.40	89.86	94.27	4.01	11.12	9.59	13.53	25.56	2.9				18.89	31.57		13	"	660	400	82.9	84.8	0.7
	11FC	3.58	2.04	27.93	5.52	63.12	81.81	87.41	8.95	17.75	9.66	12.21	24.80	2.5				23.27	36.88		13	"	612	391	79.4	71.6	0.7
	11FD	4.58	2.02	27.40	6.51	52.53	65.46	76.43	10.32	12.52	6.83	12.19	22.76	2.0				19.03	37.72		13	"	564	396	77.7	59.6	0.7
	12B	2.16	2.13	31.28	9.44	85.97	95.2	98.6	-14.6	4.9				4.5				14.34	16.68		7	"	664	400	55.0	99.6	0.9
	12DA	2.17	2.00	26.12	4.80	69.10	83.0	94.5	6.38	14.4				2.1				19.20	32.50		12	"	647	399	69.0	79.1	0.9
	12DB	1.96	2.10	25.24	5.87		72.1	87.9	15.7	19.0				1.8				24.87	40.94		12	"	647	399	84.0		0.9

TABLE I
SUMMARY OF DATA
STANOLIND

Lab.	Run No.	$\frac{R}{FF}$	$\frac{H_2}{CO}$ (FF)	$\frac{CO_2}{CO}$ (FF)	$\frac{CH_4}{CO}$ (FF)	% Contr.	H ₂ Conv.	CO Conv.	CO to CO ₂	CO to CH ₄	CO to C ₂ S	CO to C ₃ S	CO to C ₃ (Incl- (Alc. C (Bal.))	CO to Alc. (Report- (ed))	% Unsat. in C ₂	% Unsat. in C ₃	% Unsat. in C ₄	Tot. CH ₄ % CO in FF	Tot. CO ₂ % CO in FF	H ₂ to H ₂ O (Measured)	Lgt. of Period (Hrs.)	Catalyst	Temp. of.	Press.	v/hr/w	v/hr/v	Vel.	
Stanolind Tulsa	298(1)	0.46	4.39	55.3	72.1	(24.6)	32.54	79.1	9.83	-0.11				7.90				72.0	65.13	11.9	56		633.14	208.57				
	320(2)	1.82	2.31	37.2	12.1	(75.3)	75.08	89.7	0.68	8.55				9.00				20.7	37.9	36.1	40		624.2	252.4				
	325(3)	1.83	2.32	41.1	13.7	(66.9)	69.47	91.2	16.61	7.25				9.11				21.0	57.7	35.1	32		632.75	250.50				
	19 (4)	2.61	4.93	46.6	14.2	51.7	88.72	95.7	-48.66	-1.94				8.70				12.3	- 2.06	37.9	40		586.80	84.76				
	29 (5)	2.62	5.01	48.3	32.0	97.1	81.28	97.8	-44.47	16.39				8.35				48.39	3.83	41.4	32		584.3	153.3				
	12 (6)	2.99	4.13	48.8	18.3	Error 100	103.35	103.2	-51.53	6.37				9.29				24.67	- 2.73	39.1	48		587.8	84.3				
	38 (7)	1.35	4.54	39.5	30.3	75.4	76.42	97.1	-24.69	19.60				8.29				49.90	14.81		64		581.3	163.6				
	64 (8)	0.85	4.46	37.16	33.03	53.6	56.43	89.7	- 6.76	25.22				7.65				58.25	30.40		72		585.8	163.1				
	91 (9)	1.12	3.68	43.72	42.79	52.6	66.16	86.9	- 6.69	31.10				7.45				73.89	37.03		48		596.5	163.7				
	104 (10)	0.85	4.40	47.16	52.08	50.9	54.00	89.4	- 5.41	-11.05				7.91				41.03	41.75		32		599.3	164.0				
	109 (11)	0.81	4.19	46.92	47.54	50.4	54.74	86.9	-12.02	3.23				7.38				50.77	34.90		40		599.0	164.0				
	127 (12)	0.99	3.36	52.79	41.80	54.2	59.74	88.6	-11.59	0.44				7.39				42.24	41.20		32		599	164.4				
	177 (13)	0.36	4.11	50.84	55.39	31.0	35.83	77.7	3.13	- 3.15				6.87				52.24	53.97		32		606.50	163.00				
	181 (14)	0.64	4.10	49.63	45.80	(42.3)	35.76	76.4	0.44	6.25				6.54				52.05	50.07		72		601.3	163.2				
	136 (15)	0.44	4.05			36.5	45.4	91.1	-10.9	4.7																		
	46 (16)	1.38	4.37	36.46	34.2	67.2	77.0	96.0	-14.36	43.88				8.26				78.08	22.10		32		580.3	164.0				
	55 (17)	1.00	4.31	34.89	36.07	57.8	66.81	95.1	- 5.01	45.62				8.11				81.69	29.88		72		585.7	163.7				

TABLE IA

HRI SUMMARY

RUN NUMBER	H-13	H-14	H-11	H-12	H-10A	H-18	H-17	H-10B	H-2	H-5B	H-6	H-3	H-5A	H-1
POINT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14
HOURS														
Start	347	360	208	299	74	4	54	138	35	244	325	58	112	5
End	355	408	282	347	134	12	86	184	55	320	365	74	244	14
Period	8	48	74	48	60	8	32	46	20	76	40	16	132	9

REACTOR DATA

Number and Size of Cooling Tubes
Ft² Cooling Surface/Ft³ Bed Volume
Free Cross-Section in Reaction Zone, Ft²
Hydraulic Radius in Reaction Zone, Ft.

K-3
55, 7/8" 16 BWG tubes, 18'5" long
21.2
0.735
0.0455

REACTION CONDITIONS

Catalyst Number.
Catalyst Type
Maximum Reaction Temperature, °F.
Pressure, psig.
Space Velocity, SCFH FF/lb. Fe
Linear Velocity, Ft/Sec
Recycle/Fresh Feed
Catalyst Density, Lbs./Ft³
Initial
Final
Total C in Catalyst, % on Fe
Initial
Final

90	90	90	90	90	96	101 ⁽¹⁾	90	92	92	92	92	92	71
621	632	598	592	608	625	635	602	625	607	618	630	610	620
227	222	219	223	218	220	230	220	190	235	205	210	225	190
56	176	51	51	44	38	84	26	44	18	---	12	15	7
.53	.68	0.62	.61	0.63	1.25	1.37	0.54	1.64	1.03	1.23	1.75	1.49	1.86
0.3	0.5	0.7	0.7	1.2	1.3	1.9	2.8	5.4	5.6	5.7	6.7	7.2	10.1
22	12	22	22	22	35	21.6	20	---	38.5	---	52	47	---
22	7.4	22	21	20	42	15.4	19	23.2	36	---	53.9	38.5	---
---	---	27	---	24	7.5	23	---	---	---	---	---	---	---
32	---	25	---	---	10.9	32	---	---	---	24	---	---	9.2

REACTION DATA

Contraction, % on Fresh Feed
CO Reacted, % on Fresh Feed
CO Converted, % on Total Feed
% CO Converted to
CO₂
C₂-
C₃+
Alcohols
Carbon
H₂ in FF Converted, %
% Contraction (Adj'd. for CO₂ in Feed)

58	49	68	59	80	75	80	86	87	88	88	87	86	78
99	90	99	97	100	99	99	99	100	100	99	100	100	98
98	82	98	93	97	95	94	88	89	89	65	92	82	49
28	37	20	26	8	17	11	1	2	9	12	2	0	3
8	16	15	16	20	8	10	20	24	15	10	24	26	15
57	44	59	50	67	70	74	73	70	73	97	70	72	79
7	3	6	8	5	5	5	6	4	3	5	4	2	3
---	---	---	---	1.1	0.35	---	---	---	---	---	---	---	---
67.5	54.0	72.0	61.6	86.9	83.4	84.8	94.5	95.6	100	95.1	95.8	95.9	87.0
60	50	69.9	60.6	81.4	76.7	82.1	89.6	89.0	90.1	97.4	89.7	88.9	83.6

CORRELATING DATA FOR HYDROCOL, SERIES 14 and SERIES 15 RUNS

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TABLE IA

HRI SUMMARY

RUN NUMBER	H-13	H-14	H-11	H-12	H-10A	H-18	H-17	H-10B	H-2	H-5B	H-6	H-3	H-5A	H-1
POINT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<u>GAS COMPOSITIONS</u>														
Fresh Feed, % as														
H ₂	66.3	64.1	66.5	66.4	67.4	63.8	65.5	66.0	68.0	64.5	63.4	67.5	68.5	67.2
CO	29.8	32.8	30.1	30.3	29.8	33.4	31.5	28.9	29.5	32.3	24.7	28.4	27.5	25.3
CO ₂	--	--	0.2	--	0.3	--	0.1	2.1	--	0.1	6.6	0.1	0.3	--
CH ₄	3.3	2.0	2.4	2.6	1.6	2.2	2.5	1.8	2.2	2.3	3.0	2.9	3.0	6.7
Recycle Gas, % as														
H ₂	60.1	57.5	54.5	60.3	42.6	48.4	45.8	25.7	24.8	10.0	14.1	20.5	17.1	40.3
CO	0.9	6.7	0.6	1.9	0.6	1.2	0.9	1.4	0.7	0.7	2.4	0.3	0.8	2.5
CO ₂	19.3	21.1	19.0	18.6	13.6	22.9	17.3	16.5	4.4	24.3	29.7	3.7	2.1	3.0
C ₂ -	10.0	10.3	17.0	13.2	28.9	15.4	21.7	39.3	55.5	45.7	34.3	58.5	60.2	36.3
C ₃ +	6.9	4.4	7.8	5.9	14.1	10.8	13.5	17.0	14.6	19.3	19.5	15.7	19.8	11.1
Reactor Feed, % as														
H ₂	65.2	61.7	61.5	63.9	53.9	55.2	52.6	36.1	31.6	18.4	21.4	26.8	23.4	42.8
CO	23.2	24.1	17.9	18.6	13.9	15.2	11.5	8.6	5.2	5.5	5.6	4.0	4.1	.6
CO ₂	4.5	7.1	8.0	7.7	7.6	13.0	11.4	12.7	3.7	20.6	26.2	3.2	1.9	2.7
C ₂ -	4.9	4.8	8.4	7.0	16.5	9.7	15.1	29.5	47.2	39.1	29.7	52.0	53.1	33.7
C ₃ +	1.6	1.5	3.2	2.4	7.7	6.1	8.9	12.5	12.3	16.4	16.5	13.7	17.5	10.1
<u>H₂/CO RATIO</u>														
In Fresh Feed	2.2	2.0	2.2	2.2	2.3	1.9	2.1	2.3	2.3	2.0	2.6	2.4	2.5	2.7
In Reactor Feed	2.8	2.6	3.4	3.4	3.9	3.6	4.6	4.3	6.1	3.4	3.7	6.8	5.7	9.3
At Reactor Outlet	67	8.6	91	32	71	40	51	18	36	14	6	68	21	16
Consumed	1.5	1.2	1.6	1.4	2.0	1.6	1.8	2.2	2.2	2.0	2.5	2.3	2.4	2.4
H ₂ /CO + CO ₂ in Reactor Feed	2.35	1.98	2.38	2.43	2.50	1.96	2.3	1.70	3.55	0.71	0.67	3.73	3.90	5.86
C ₃ +/C ₂ - in Product	7.1	2.8	3.9	3.1	3.4	8.8	7.4	3.7	2.9	4.9	9.7	2.9	2.8	5.3
<u>HEAT LIBERATED, BTU/HR.</u>														
Total, x 10 ⁻³	368	412	323	340	348	537	592	195	252	223	210	254	221	159
Per Lb ₂ of Iron	2470	7100	2120	2280	2440	2020	4630	1470	2600	1050	---	721	877	356
Per Ft ² Heat Transfer Surface	1690	1880	1480	1550	1590	2970	2800	890	1330	2100	---	1500	1720	---
Avg. ΔT Bed-Coolant, °F.	37	42	35	28	24	51	53	16	23	33	21	22	25	29
Avg. Overall Heat Transfer Coefficient, BTU/Hr. - Ft ² - °F.	44.5	44.7	42.3	55.3	66.2	58.2	52.8	55.6	57.8	63.6	---	68.2	68.8	---

CORRELATING DATA FOR HYDROCOL, SERIES 14 and SERIES 15 RUNS

14

TABLE IA

HRI SUMMARY

RUN NUMBER	14-7	14-8	14-7	14-8	14-8	14-7	14-4	H-30	H-30	14-1
POINT NUMBER	21	22	23	24	25	26	27	28	29	30
HOURS										
Start	153	254	105	206	370	9	35	---	---	20
End	185	314	153	242	394	93	107	---	---	90
Period	32	60	48	36	24	84	72	62	12	70
REACTOR DATA	← K-5 → 0 11.4 .126 .100 ← K-4 → 4 1/2" 20.6 .111 .0518 ← K-3A → 19.1" 9.9 .78 .078 ← K-4 →									
Number and Size of Cooling Tubes										
Ft ² Cooling Surface/Ft ³ Bed Volume										
Free Cross-Section in Reaction Zone, Ft ²										
Hydraulic Radius in Reaction Zone, Ft.										
REACTION CONDITIONS										
Catalyst Number	135	135	135	135	135	135	129	119	119	123
Catalyst Type					Fresh Trail	(1)				Spent Sterl-
Maximum Reaction Temperature, °F.	650	605	645	615	615	655	645	646	649	ington
Pressure, psig.	250	150	250	215	155	250	215	209	209	610
Space Velocity, SCFH FF/Lb. Fe	32	45	30	20	103	17	15	70	40	215
Recycle/Fresh Feed	1.3	1.5	1.5	2.2	2.5	2.8	2.9	1.7	2.2	68
Linear Velocity, Ft/Sec	1.09	1.13	1.10	1.01	0.90	1.02	.81	0.88	1.07	1.6
Catalyst Density, Lbs./Ft ³										1.24
Initial	61	31	73	46	0	96	109	20	36	55
Final	50	7	64	38	0	78	34	13	23	52
Total C in Catalyst, % on Fe										
Initial	16.0	28.0	13.0	25.7	30.1	02.0	15.8	13.8	---	---
Final	18.7	33.4	16.0	27.3	33.6	11.0	25.3	26.5	13.8	24
REACTION DATA										
Contraction, % on Fresh Feed	54	31	57	50	43	71	81	76	83	56
CO Reacted, % on Fresh Feed	91	62	92	85	82	91	97	98	99	88
CO Converted, % on Total Feed	73	34	73	51	46	48	64	85	86	63
% CO Converted to										
CO ₂	32	38	27	30	32	15	7	11	7	21
C ₂ -	25	26	28	28	39	16	11	14	10	14
C ₃ +	42	34	43	40	28	66	76	68	78	61
Alcohols	1	2	2	2	1	3	6	7	5	4
Carbon	.27	.34	.21	.27	.18	.67	.92	.30	---	---
H ₂ in FF Converted, %	65.6	43.4	71.5	63.7	57.4	86.1	97	83.3	93.6	87.0
% Contraction (Adj'd for CO ₂ in Feed)	56.8	33.6	59.9	53.8	46.7	75	87.1	---	---	61

CORRELATING DATA FOR HYDROCOL, SERIES 14 and SERIES 15 RUNS

TABLE IA
HRI SUMMARY

RUN NUMBER	14-7	14-8	14-7	14-8	14-8	14-7	14-4	H-30	H-30	14-1
POINT NUMBER	21	22	23	24	25	26	27	28	29	30
<u>GAS COMPOSITIONS</u>										
Fresh Feed, % as										
H ₂	60.5	61.5	61.1	61.9	61.0	61.4	60.9	61.3	61.0	61.6
CO	34.0	30.5	33.5	30.8	30.7	32.8	31.3	31.3	31.5	29.6
CO ₂	3.8	5.5	3.8	5.4	5.6	3.9	5.1	4.9	4.9	5.4
CH ₄	1.2	2.3	1.1	1.7	2.3	1.3	1.9	2.0	1.8	2.7
Recycle Gas, % as										
H ₂	42.2	51.2	41.7	38.8	43.2	34.6	20.8	31.7	23.1	47.4
CO	6.5	16.5	5.9	13.6	9.6	8.9	5.7	2.9	2.2	7.4
CO ₂	29.5	18.5	28.4	26.2	23.7	30.1	37.0	34.0	40.9	25.7
C ₂ -	15.9	9.0	17.3	14.8	18.0	16.9	20.7	19.8	22.3	13.0
C ₃ +	5.4	2.1	4.4	4.5	3.2	7.2	13.4	8.9	10.8	4.0
Reactor Feed, % as										
H ₂	50.2	55.4	49.6	49.0	48.4	41.0	31.1	42.8	34.8	52.9
CO	18.5	22.1	17.0	16.1	15.7	16.3	12.2	13.4	11.3	16.0
CO ₂	12.3	13.3	18.9	19.7	18.6	23.2	28.7	23.2	29.6	17.9
C ₂ -	9.5	6.3	11.0	10.7	13.5	12.8	15.8	13.2	15.8	9.1
C ₃ +	3.0	1.3	2.6	3.1	2.3	5.3	9.9	5.6	7.4	2.5
<u>H₂/CO RATIO</u>										
In Fresh Feed	1.8	2.0	1.8	2.0	2.0	1.9	1.9	2.0	1.9	2.1
In Reactor Feed	2.7	2.5	2.8	3.1	3.1	2.5	2.3	3.5	3.1	3.2
At Reactor Outlet	6.5	3.1	7.1	2.9	4.5	3.9	3.7	10.9	10.5	6.4
Consumed	1.3	1.4	1.4	1.5	1.4	1.8	1.9	1.7	1.8	1.6
H ₂ /(CO + CO ₂) in Reactor Feed	1.37	1.56	1.38	1.37	1.41	1.04	0.76	1.17	0.85	1.56
C ₃ +/C ₂ - in Product	1.7	1.3	1.6	1.4	0.72	4.1	6.9	4.9	7.8	4.4
<u>HEAT LIBERATED, BTU/HR.</u>										
Total, x 10 ⁻³	87.3	34.1	82.3	49.3	27.5	55.2	36.0	357	376	60.4
Per Lb. of Iron	1450	1330	1380	860	4000	873	750	3730	3350	2880
Per Ft ² Heat Transfer Surface	4960	1080	5740	2100	--	5410	1230	3020	3170	4930
Avg. ΔT Bed-Coolant, °F.	95	130	99	107	98	87	0	40	56	-5
Avg. Overall Heat Transfer Coefficient, BTU/Hr. - Ft ² - °F.	52.2	8.3	58.0	20.1	--	62.1	--	75.5	56.6	--

TABLE IA
HRI SUMMARY

RUN NUMBER	←-----14-10-----→								
POINT NUMBER	31	32	33	34	35	36	37	38	39
<u>GAS COMPOSITIONS</u>									
Fresh Feed, % as									
H ₂	60.5	60.8	60.5	60.7	60.4	61.1	60.2	60.8	60.3
CO	30.7	30.7	30.4	30.9	31.0	30.8	30.8	31.0	30.7
CO ₂	6.3	6.4	6.3	6.0	6.0	5.9	6.3	5.8	6.0
CH ₄	2.1	1.9	2.6	2.1	1.7	2.0	2.4	1.7	2.4
Recycle Gas, % as									
H ₂	50.1	53.2	42.0	56.5	57.0	37.7	58.8	54.3	51.5
CO	10.5	11.0	8.3	15.4	18.3	6.2	26.9	17.3	16.1
CO ₂	24.7	23.0	28.0	18.9	15.5	31.3	9.2	16.5	17.3
C ₂ -	11.3	9.3	15.6	6.2	6.7	18.5	3.7	8.3	9.8
C ₃ +	3.3	3.5	4.6	1.9	2.1	5.7	1.1	2.2	2.6
Reactor Feed, % as									
H ₂	57.6	58.3	53.7	58.8	58.6	46.4	59.1	56.5	54.3
CO	25.0	24.1	22.1	24.0	24.1	15.3	28.2	21.9	20.8
CO ₂	11.6	11.9	14.5	11.7	11.2	21.9	8.2	12.9	13.5
C ₂ -	4.7	4.4	7.5	3.9	4.4	12.4	3.3	6.1	7.3
C ₃ +	0.9	1.2	1.8	0.8	1.1	3.6	0.7	1.5	1.7
<u>H₂/CO RATIO</u>									
In Fresh Feed	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
In Reactor Feed	2.3	2.4	2.3	2.6	2.4	2.9	2.1	2.6	2.6
At Reactor Outlet	4.8	4.8	5.1	3.7	3.1	6.1	2.2	3.1	3.1
Consumed	1.3	1.1	1.1	1.5	1.0	1.7	1.2	1.2	1.3
H ₂ /(CO + CO ₂) in Reactor Feed	1.58	1.62	1.47	1.65	1.66	1.25	1.63	1.62	1.59
C ₃ +/C ₂ - in Product	1.7	1.9	3.1	2.2	1.6	2.9	3.1	1.4	1.2
<u>HEAT LIBERATED, BTU/HR.</u>									
Total, x 10 ⁻³	90.4	85.5	79.1	57.9	41.6	51.9	20.3	33.3	36.2
Per Lb. of Iron	8200	7760	8800	3760	3480	4320	1840	3030	3290
Per Ft ² Heat Transfer Surface	6410	6060	5690	4100	2950	3730	1440	2360	2530
Avg. ΔT Bed-Coolant, °F.	66	68	65	59	54	30	19	45	60
Avg. Overall Heat Transfer Coefficient, BTU/Hr. - Ft ² - °F.	97.1	89.1	87.5	69.5	54.6	124	75.6	52.4	42.2

CORRELATING DATA HYDROCOL, SERIES 14 and SERIES 15 RUNS

18

TABLE IA

HRI SUMMARY

RUN NUMBER

POINT NUMBER

HOURS

Start
End
Period

← 14-6 →
41 A 42 B 43 C 44 D 45 E

← H-25 →
46 B 47 C 48 A

← H-24 →
49 B 50 A

360 428 231 384 400
372 436 348 396 420
12 8 117 12 20

101 141 45 23 7
137 229 97 39 23
36 88 52 16 16

REACTOR DATA

Number and Size of Cooling Tubes
Ft² Cooling Surface/Ft³ Bed Volume
Free Cross-Section in Reaction Zone, Ft²
Hydraulic Radius in Reaction Zone, Ft.

← K-4 →
0
11.4
.1263
0.100

← K-3A →
19-1" XH
9.9
.78
0.0780

REACTION CONDITIONS

Catalyst Number
Catalyst Type
Maximum Reaction Temperature, °F.
Pressure, psig.
Space Velocity, SCFH FF/Lb. Fe
Recycle/Fresh Feed
Linear Velocity, Ft/Sec
Catalyst Density, Lbs./Ft³
Initial
Final
Total C in Catalyst, % on Fe
Initial
Final

664 658 645 663 660 644 646 648 650 643
130 200 240 200 200 215 215 232 230 232
44 57 38 39 32 56 53 56 35 30
0.3 0.8 0.9 1.3 2.6 0.8 1.0 1.1 1.4 2.3
0.84 0.94 0.63 0.98 1.04 0.91 1.04 1.05 1.16 1.40
23 25 40 26 23 43 35 58 72 73
27 25 29 25 23 39 27 42 66 70
44.5 50.3 36.0 51.4 50.3 38 40.4 24 17.3 ---
50.5 55.5 48.0 51.0 49.0 39.6 45.4 38 --- 17.3

103
Spent Trail, Ground C & W Original

REACTION DATA

Contraction, % on Fresh Feed
CO Reacted, % on Fresh Feed
CO Converted, % on Total Feed
% CO Converted to
CO₂
C₂-
C₃+
Alcohols
Carbon
H₂ in FF Converted, %
% Contraction (Adj'd. for CO₂ in Feed)

43 38 64 62 72 78 79 83 83 87
91 78 97 92 91 99 98 99 99 99
87 89 72 90 85 --- 50 94 94 89
33 21 18 18 11 13 11 7 9 6
15 18 14 13 17 7 8 7 3 6
47 54 61 61 64 74 75 80 82 82
5 7 7 8 8 6 6 6 6 6
.11 1.5 .17 .12 .09 .10 .11 .36 1.4 1.6
50 54.6 77.6 73.6 86.6 88.5 92.7 93.6 93.6 99
46.6 49.5 69.7 67.5 78.0 83.2 84.6 88.4 88.8 91.2

94.5
A = $\sqrt{16.43 \times 2 - 1.94.5}$
 $(40.5) / (1.26) = 51.1$

TABLE IA
HRI SUMMARY

RUN NUMBER	← 14-6 →					← H-25 →			← H-24 →	
POINT NUMBER	41 A	42 B	43 C	44 D	45 E	46 B	47 C	48 A	49 B	50 A
<u>GAS COMPOSITIONS</u>										
Fresh Feed, % as										
H ₂	61.6	51.1	60.9	61.6	61.8	61.4	61.1	61.2	61.0	61.8
CO	30.7	25.2	30.8	30.3	30.0	31.5	31.5	31.8	31.7	31.9
CO ₂	6.0	21.2	6.0	6.0	5.8	4.0	4.1	4.2	3.6	3.3
CH ₄	1.7	1.9	2.2	2.1	1.9	2.3	2.4	1.9	2.9	2.2
Recycle Gas, % as										
H ₂	53.3	52.0	40.6	42.5	29.7	35.6	31.2	31.5	33.2	25.1
CO	4.8	12.1	2.9	6.4	9.4	2.0	2.7	1.5	2.3	2.2
CO ₂	27.0	19.4	32.2	29.2	31.0	34.8	35.0	35.4	36.2	35.3
C ₂ -	7.8	9.3	13.6	11.1	18.3	16.2	17.9	17.9	16.6	23.7
C ₃ +	4.1	4.2	7.5	6.8	9.1	7.5	9.2	9.7	7.7	9.7
Reactor Feed, % as										
H ₂	59.7	--	51.3	50.8	38.7	50.0	46.2	44.6	44.8	36.2
CO	24.7		17.6	16.8	15.1	18.4	17.1	16.0	14.6	11.2
CO ₂	10.8		18.4	19.1	24.0	17.7	19.6	20.5	22.7	25.6
C ₂ -	3.1		7.6	7.2	13.7	8.5	10.2	10.3	10.9	17.2
C ₃ +	0.9		3.6	3.8	6.6	3.3	4.6	5.1	4.5	6.8
<u>H₂/CO RATIO</u>										
In Fresh Feed	2.0	2.0	2.0	2.0	2.1	1.9	1.9	1.9	1.9	1.9
In Reactor Feed	2.4	2.5	2.9	3.0	2.6	2.7	2.7	2.8	3.2	3.3
At Reactor Outlet	11.1	--	14	6.6	3.2	18	12	21	15	11
Consumed	1.1	1.4	1.6	1.6	2.0	1.7	1.8	1.8	1.8	1.9
H ₂ /(CO + CO ₂) in Reactor Feed	1.68		1.42	1.41	0.99	1.38	1.26	1.22	1.20	0.98
C ₃ +/C ₂ - in Product	3.1	3.0	4.4	4.7	3.8	10.6	9.4	11.4	27.0	13.7
<u>HEAT LIBERATED, BTU/HR.</u>										
Total, x 10 ⁻³	49.5	45.0	60.3	58.6	32.0	565	572	572	544	503
Per Lb ₂ of Iron	1650	1700	--	--	1630	1870	2890	1790	1900	1720
Per Ft ² Heat Transfer Surface	1820	1900	2700	2250	1660	2830	2870	3360	5170	5101
Avg. ΔT Bed-Coolant, °F.	35	10	33	29	9	84	92	92	100	98
Avg. Overall Heat Transfer Coefficient, BTU/Hr. - Ft ² - °F.	52.0	190	81.8	77.6	184	33.7	31.2	36.5	51.7	52.0

CORRELATING DATA FOR HYDROCOL, SERIES 14 and SERIES 15 RUNS

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TABLE IA

HRI SUMMARY

RUN NUMBER	← 14-9 →					← 14-11 →			← 14-12 →	
POINT NUMBER	61 A	62 B	63 C	64 D	65 E	66 A	67 B	68 C	69	70
HOURS										
Start	168-204	384	8	288	336	49-93	171	105	21	37
End	444-460	444	132	324	372	127-159	195	117	33	57
Period	52	60	124	36	36	108	24	12	12	20
REACTOR DATA	← K-5 →					← K-6 →				
Number and Size of Cooling Tubes			0				Below 9'		Above 9'	
Ft ² Cooling Surface/Ft ³ Bed Volume			11.4				4 1/2" XHSS		None	
Free Cross-Section in Reaction Zone, Ft ²			.126				20.6		11.4	
Hydraulic Radius in Reaction Zone, Ft.			0.100				0.111		0.126	
							0.098		0.100	
REACTION CONDITIONS	140 Jersey Pyrites					160 Coarse #140			165 Zircon	166 Zircon
Catalyst Number			585	575	575	603	588	556	638	635
Catalyst Type			255	255	250	259	258	259	154	154
Maximum Reaction Temperature, °F.	570	565	12	11	9	17	18	17	1950	264
Pressure, psig.	225	250	2.3	3.8	5.0	1.8	1.8	1.9	.37	.38
Space Velocity, SCFH FF/Lb. Fe	19	18	0.71	0.85	0.84	0.92	.93	.92	1.21	1.20
Recycle/Fresh Feed	1.7	2.1								
Linear Velocity, Ft/Sec	.98	0.98								
Catalyst Density, Lbs./Ft ³										
Initial	38	39	43	36	35	50	46	45	103	100
Final	42	42	38	36	34	43	47	46	103	101
Total C in Catalyst, % on Fe										
Initial	10.5 19.4	17.0	3.1	14.0	15.3	7.6 12.1	13.0	10.3	---	---
Final	11.0 20.0	19.4	9.6	15.1	16.4	9.5 12.1 19.6	13.1 19.6	11.3 19.7	---	96
Bed Height, Ft.										
REACTION DATA										
Contraction, % on Fresh Feed	63	67	75	75	76	77	75	73	.6	-.7
CO Reacted, % on Fresh Feed	97	95	98	97	96	99	98	98	1.3	-1.1
CO Converted, % on Total Feed	83	77	85	64	57	90	86	78	1.0	-0.8
% CO Converted to										
CO ₂	23	18	13	12	13	10	14	15	60	---
C ₂ -	22	25	19	22	21	15	15	16	40	---
C ₃ +	52	54	65	64	64	71	65	64	---	---
Alcohols	3	3	3	2	2	4	6	5	---	---
Carbon	.12	.16	.46	.24	.36	(0.26 0.0	.02	.50		
H ₂ in FF Converted, %	81.6	84.9	88.2	91.8	91.2	89.1	88.1	87.6		
% Contraction (Adj'd. for CO ₂ in Feed	68	72.4	81.2	81.5	82.4	83.7	81	78.8		

TABLE IA
HRI SUMMARY

RUN NUMBER	← 14-9 →					← 14-11 →			← 14-12 →	
POINT NUMBER	61	62	63	64	65	66	67	68	69	70
<u>GAS COMPOSITIONS</u>										
Fresh Feed, % as										
H ₂	60.7	60.2	60.8	60.5	60.9	60.5	60.8	60.7	61.0	60.6
CO	31.4	31.6	31.0	31.4	30.9	31.0	31.2	31.4	30.7	30.7
CO ₂	5.2	5.6	5.5	5.8	5.1	5.8	5.7	5.2	6.0	6.1
CH ₄	2.1	1.9	2.1	2.2	2.6	2.2	1.7	2.1	1.6	1.9
Recycle Gas, % as										
H ₂	34.0	28.5	22.4	18.4	15.3	21.5	27.8	34.0	61.0	60.6
CO	3.2	3.5	2.1	4.2	4.2	1.7	2.4	3.2	30.5	30.8
CO ₂	33.4	34.2	38.5	37.4	37.0	38.7	38.6	33.4	6.3	6.1
C ₂ ⁻	20.9	24.1	24.2	28.6	28.9	23.9	18.8	20.9	1.7	1.6
C ₃ ⁺	6.2	7.9	11.0	11.4	12.9	12.3	10.9	6.2	--	--
Reactor Feed, % as										
H ₂	43.9	38.8	34.0	27.2	22.9	35.4	39.7	43.9	38.8	38.4
CO	13.6	12.6	10.8	9.9	8.7	12.2	12.7	13.6	19.4	19.5
CO ₂	23.0	25.0	28.5	29.7	31.8	27.0	26.9	23.0	3.9	3.9
C ₂ ⁻	14.0	17.0	17.5	23.0	24.6	16.2	12.7	14.0	1.0	1.1
C ₃ ⁺	3.9	5.4	7.7	9.2	10.7	7.9	7.0	3.9	--*	--*
									36.4	36.6
<u>H₂/CO RATIO</u>										
In Fresh Feed	1.9	1.9	2.0	1.9	2.0	2.0	2.0	1.9	1.99	1.97
In Reactor Feed	3.4	3.0	2.9	2.7	2.8	3.0	3.1	3.3	2.00	1.97
At Reactor Outlet	11	8	11	4.4	3.6	13	12	11	2.00	1.97
Consumed	1.6	1.7	1.8	1.8	1.9	1.8	1.8	1.7	--	--
H ₂ /(CO + CO ₂) in Reactor Feed	1.20	1.03	0.87	0.69	0.57	0.91	1.00	1.20	1.67	1.64
C ₃ ⁺ /C ₂ ⁻ in Product	2.4	2.2	3.4	2.9	3.0	4.7	4.3	4.0	--	--
<u>HEAT LIBERATED, BTU/HR.</u>										
Total, x 10 ⁻³	64.4	70.3	52.2	43.1	34.1	68.5	69.6	68.6	--	--
Per Lb. of Iron	939	926	645	600	494	926	954	893	--	--
Per Ft ² Heat Transfer Surface	2140	2400	1800	1390	1080	1910	1940	1910	--	--
Avg. ΔT Bed-Coolant, °F.	78	58	83	26	7	33	45	34	4	10
Avg. Overall Heat Transfer Coefficient, BTU/Hr. - Ft ² - °F.	27.4	41.4	21.7	53.5	154	57.8	43.1	56.2	--	--

TABLE IA

HRI SUMMARY

RUN NUMBER	15-2	← 15-3 →			15-4	15-4	15-5	15-5	15-5	15-5
POINT NUMBER	71	72	73	74	75	76	77	78	79	80
HOURS										
Start	250	371	407	439	484	506	3	23	51	69
End	418	403	427	455	494	530	19	39	63	75
Period	168	32	20	16	10	24	16	16	12	6

REACTOR DATA

Number and Size of Cooling Tubes
 Ft² Cooling Surface/Ft³ Bed Volume
 Free Cross-Section in Reaction Zone, Ft²
 Hydraulic Radius in Reaction Zone, Ft.

	← K-4 →									
	4 1/2"									
	20.6									
	0.111									
	0.0518									

REACTION CONDITIONS

Catalyst Number
 Catalyst Type
 Maximum Reaction Temperature, °F.
 Pressure, psig.
 Space Velocity, SCFH FF/Lb. Fe
 Recycle/Fresh Feed
 Linear Velocity, Ft/Sec
 Catalyst Density, Lbs./Ft³
 Initial
 Final
 Total C in Catalyst, % on Fe
 Initial
 Final

103	90			90	90	123			
Spent Trail						Spent Sterlington			
645	659	664	664	655	658	658	657	657	662
220	210	200	200	212	240	200	200	200	240
23	22	40	47	47	49	---	9.1	12	12
2.71	3.21	1.83	2.06	1.69	1.62	1.55	1.13	0.62	0.67
1.19	1.40	1.51	1.66	1.34	1.21	1.35	1.45	1.51	1.31
36	36	30	27	27	24	96	131	152	152
23	31	29	26	26	27	117	143	152	152
40	33	40	38	--	52.5	--	10	11.6	12.5
64	40	36	--	48.8	50.8	--	11	12.3	12.8

REACTION DATA

Contraction, % on Fresh Feed
 CO Reacted, % on Fresh Feed
 CO Converted, % on Feed
 % CO Converted to
 CO₂
 C₂-
 C₃+
 Alcohols
 Carbon

79	73	61	48	67	70	92.1	71	60.0	60
96	92	82	89	94	88	98	98	92	91
63	48	61	63	95	97	99	98	89	89
6.7	13.3	20.4	17.2	14.8	14.6	2.3	12.9	18.8	20.6
10.3	17.0	25.8	32.1	23.7	16.9	22.8	12.8	17.5	12.2
77.7	67.5	51.6	47.5	57.5	63.5	70.7	69.2	59.5	62.3
5.3	2.2	2.2	3.2	4.0	5.0	4.2	5.1	4.2	4.9
.67	1.1	-.58	--	--	-0.17	--	.71	.54	.18

TABLE IA
HRI SUMMARY

RUN NUMBER	15-2	← 15-3 →			15-4	15-4	15-5	15-5	15-5	15-5
POINT NUMBER	71	72	73	74	75	76	77	78	79	80
<u>GAS COMPOSITIONS</u>										
Fresh Feed, % as										
H ₂	60.3	60.5	60.1	60.5	60.6	60.5	60.9	60.8	61.1	61.0
CO	30.8	30.7	30.2	30.7	30.6	30.8	31.2	31.2	31.5	30.4
CO ₂	5.6	5.6	5.8	5.8	6.0	5.7	5.7	5.7	5.8	5.8
CH ₄	3.0	3.0	3.7	2.8	2.7	2.6	1.7	1.6	1.0	2.2
Recycle Gas, % as										
H ₂	18.4	17.8	32.8	49.3	29.2	25.8	25.1	39.2	45.5	45.8
CO	6.0	9.4	7.9	6.3	5.5	11.7	4.0	2.5	6.5	6.9
CO ₂	36.4	33.4	29.1	20.4	31.1	32.0	34.5	33.4	28.0	28.8
C ₂ ⁻	23.4	24.9	23.1	19.0	23.2	18.9	25.2	16.4	12.4	11.6
C ₃ ⁺	12.6	10.6	6.1	4.0	7.0	8.3	10.3	7.2	5.1	3.9
Reactor Feed, % as										
H ₂	29.7	27.9	42.4	53.0	40.8	39.0	39.2	49.3	55.0	54.7
CO	12.7	14.5	15.8	14.3	14.9	19.0	14.6	15.9	21.8	21.0
CO ₂	28.1	26.7	20.9	15.6	21.8	22.0	23.2	20.5	14.4	15.1
C ₂ ⁻	17.9	19.7	16.2	13.7	15.6	12.7	16.0	9.5	5.4	6.0
C ₃ ⁺	9.2	8.1	3.9	2.7	4.4	5.1	6.3	3.8	2.0	1.6
H ₂ /CO RATIO										
In Fresh Feed	1.96	1.97	1.99	1.97	1.98	1.97	1.95	1.95	1.94	2.01
In Reactor Feed	2.33	1.92	2.68	3.71	2.74	2.74	2.68	3.10	2.52	2.60
At Reactor Outlet	3.03	1.89	4.15	7.83	5.32	2.20	6.28	15.7	7.00	6.64
Consumed	1.91	1.98	1.74	1.27	1.77	1.93	1.85	1.65	1.48	1.55
H ₂ /(CO + CO ₂) in Reactor Feed	0.73	0.69	1.16	1.77	1.11	0.95	1.04	1.35	1.52	1.52
C ₃ ⁺ /C ₂ ⁻ in Product	7.54	3.97	1.99	1.48	2.43	3.76	3.10	5.40	3.40	5.10
<u>HEAT LIBERATED, BTU/HR.</u>										
Total, x 10 ⁻³	48.2	46.6	63.6	53.9	70.0	73.4	77.9	90.1	113	111
Per Lb. of Iron	1270	1170	1860	1830	2360	2470	--	450	540	530
Per Ft ² Heat Transfer Surface	1176	1140	1551	1315	1710	1790	1900	2200	2760	2710
Avg. ΔT Bed-Coolant, °F.	16	21	31	34	34	37	48	47	41	48
Avg. Overall Heat Transfer Coefficient, BTU/Hr. - Ft ² - °F.	73.5	54.3	50.0	38.7	50.3	48.4	39.6	46.8	67.3	56.5