

APPENDIX A

FLUID BED GASIFIER YIELD PERIOD DATA

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Data for the 18 yield periods (Yield Period 202 to Yield Period 219) which included complete solids analysis workup are shown in this appendix. The last four pages for each yield period list "measured" and "reconciled" summaries of all the process variables which entered into the yield period data analysis. The "measured" values are raw data taken from on-line data acquisition and from laboratory analyses of samples. The "reconciled" data result from an off-line computer program which statistically analyzes the raw data to provide consistent and best estimate data for use in correlations and kinetic model development. The reconciled data are internally consistent and forced to satisfy 31 independent constraints, primarily material balances and summations of stream components. These constraints are listed in Table A-1.

The heart of the program is an algorithm developed for use in reconciling commercial processing unit data. The procedure involves an iterative process which simultaneously compares the deviation between the measured and reconciled values for each variable. The algorithm minimizes an objective function, which is the sum of the squares of these deviations, while satisfying the physical constraints. If the measured deviation is significantly greater than the standard deviation, then that variable's contribution to the total objective function will be large.

Three categories of input are required: (1) the measured data, (2) the standard deviation for the measured variables, and (3) the physical constraints that bound the system. The standard deviations were based on unit experience, rather than manufacturer's equipment specifications.

Program output includes reconciled material balances and constraint residuals (to tell how well each has been satisfied).

The constraints have the greatest influence on the program results. For this reason, considerable care was required to realistically, yet fully, constrain the system.

TABLE A-1

CONSTRAINTS USED IN RECONCILING FBG OPERATIONS DATA

Constraint No.	Description	
1.	Hydrogen Balance	} Overall Material Balance
2.	Carbon Balance	
3.	Oxygen Balance	
4.	Sulfur Balance	
5.	Chlorine Balance	
6.	(Acid Soluble) Potassium Balance	
7.	(Acid Soluble) Sodium Balance	
8.	SiO ₂ (SO ₃ -Free Ash) Balance	
9.	Fe ₂ O ₃ (SO ₃ -Free Ash) Balance	
10.	Al ₂ O ₃ (SO ₃ -Free Ash) Balance	
11.	CaO (SO ₃ -Free Ash) Balance	
12.	MgO (SO ₃ -Free Ash) Balance	
13.	TiO ₂ (SO ₃ -Free Ash) Balance	
14.	P ₂ O ₅ (SO ₃ -Free Ash) Balance	
15.	ASTM Ash Balance	
16.	C/H Test Residue Balance	} Close to 100%
17.	SO ₃ -Free C/H Test Residue Balance	
18.	Σ Product Gas Components	
19.	Σ Syn Gas Components	
20.	Σ Feed Coal Components	
21.	Σ Feed Coal (SO ₃ -Free Ash) Components	
22.	Σ Char Carryover Components	
23.	Σ Char Carryover (SO ₃ -Free Ash) Components	
24.	Σ Bottom Char Components	
25.	Σ Bottom Char (SO ₃ -Free Ash) Components	
26.	Σ Bed Char (Beginning) Components	
27.	Σ Bed Char (Beginning, SO ₃ -Free Ash) Components	
28.	Σ Bed Char (Ending) Components	
29.	Σ Bed Char (Ending, SO ₃ -Free Ash) Components	
30.	Total Bed ΔP = Incremental Bed ΔP's (Beginning)	
31.	Total Bed ΔP = Incremental Bed ΔP's (Ending)	

RECONCILED DATA

YIELD PERIOD 202

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	11:30	2-11-77
To	11:30	2-12-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	99	
Steam	99	
Syngas	99	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1203	
38.4	1238	
32.1	1287	
26.6	1306	
21.2	1302	
16.0	1305	
10.9	1290	
6.4	1274	
0.4	1140	

YIELD PERIOD 202
UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	227	243
Lockhopper 1 Bottom	197	156
Lockhopper 2 Top	335	335
Lockhopper 2 Bottom	275	405
Gasifier Feed Line	674	823
Gasifier Steam Line	908	893
Gasifier		
Top of Bed	1306	1346
Bottom of Bed	1140	1258
Total Bed Average	1270	1307
Rough Cut Cyclone		
Cyclone Top	951	994
Cyclone Bottom	697	1019
Standpipe Top	815	1000
Standpipe Mid	838	1016
Standpipe Bottom	772	989
Standpipe Slope Top	-	1051
Standpipe Slope Bottom	1186	1003
Gasifier Backend		
Cyclone Inlet	-	570
Filter Inlet	-	563
Scrubber Inlet	581	530
Scrubber Outlet	71	-
Product Gas Meter	88	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	63.5	
Gasifier Feed Line	114.7	
Bypass N ₂	155.7	
Syngas In	163.7	
Gasifier		
Gasifier Top	112.7	
Gasifier Bottom	117.0	
Rough Cut Cyclone Outlet	112.5	
Filter Outlet	112.6	
Scrubber Outlet	112.6	
Product Gas Meter	114.7	

YIELD PERIOD 202

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	26.7
Bed Top Density (lbs/cf)	12.8
Bed Average Density (lbs/cf)	19.8
Bed Height (ft)	31.5
Bed Holdup (lbs)	111.0
Bed Volume (cf)	5.0
Average Bed Temperature (°F)	1295.4
Space Velocity (bed) (cf/cf/hr)	89.3
Bottom Superficial Velocity (ft/sec)	0.61
Top Superficial Velocity (ft/sec)	0.70

Cyclone Performance

Temperature (°F)	570.0
Pressure (psia)	112.7
Inlet Gas Rate (SCFH)	1015.3
Inlet Gas Rate (ACFH)	262.4
Inlet Gas Velocity (ft/sec)	20.6
Solids Entering (lbs/hr)	4.2
Dust Loading (lbs/acf)	0.0160
Solids Captured (lbs/hr)	3.8
Solids Escaping (lbs/hr)	0.4
Overall Efficiency (Captured/Entering, wt.%)	90.0

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	10.14
Total Carryover (lbs/hr)	4.19
Cyclone (lbs/hr)	3.77
Filter (lbs/hr)	0.42
Carryover/Feed (Wt.%)	41.3

Solids Carbon Loss

Carbon in Feed (lbs/hr)	6.50
Carbon in Carryover (lbs/hr)	2.95
Carryover/Feed (Wt.%)	45.5

YIELD PERIOD 202

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	6.50
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.59
Carbon Gasified (by difference) (lbs/hr)	1.11
Total Carbon Converted (lbs/hr)	2.69

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	17.0
Total, Including Devolatilization (%)	41.4

Carbon Distribution

Total Converted (%)	41.4
Entrained (%)	43.7
Withdrawn (%)	15.2
Accumulated (%)	-0.3
Conversion (Entrainment Backed Out)	73.5

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	1.8
Including Devolatilization	4.5

Steam Consumption

Steam into Unit (lbs/hr)	15.86
Steam Reacted with Carbon (lbs/hr)	1.66
Total Steam Consumed (lbs/hr)	4.75

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	10.5
Total Steam Converted (%)	30.0

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.070
Carbon Converted/Steam Fed (mol/mol)	0.105
Carbon Converted/Bed Volume (lbs/hr)/cft	0.197
Carbon Converted/Bed Volume (mol/hr)/cft	0.016
Carbon in Bed/Steam Fed lbs/(lbs/hr)	3.774
Carbon in Bed/Steam Fed mol/(mol/hr)	5.663

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 202

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	7.1	14.5	14.2	15.1	13.0
K as K ₂ CO ₃	10.5	21.2	20.9	22.2	19.2
K as K	5.9	12.0	11.8	12.5	10.8
K Water/Acid, Soluble Ratio	0.519	0.555	0.563	0.566	0.687
K ₂ O, H ₂ O-Insoluble	3.4	6.4	6.2	6.6	4.1
K ₂ CO ₃ , H ₂ O-Insoluble	5.0	9.4	9.1	9.6	6.0
K, H ₂ O-Insoluble	2.9	5.3	5.2	5.4	3.4
Carbon	64.1	56.6	54.0	48.4	67.7
K on Carbon	9.2	21.2	21.9	25.9	16.0
ASTM Ash	21.5	40.4	41.3	47.1	31.6
K on Ash	27.6	29.7	28.6	26.6	34.2
K ₂ CO ₃ Free-Ash	10.8	18.7	20.0	24.4	12.0
K on K ₂ CO ₃ Free-Ash	55.0	64.2	59.1	51.4	89.9

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	9.9	11.3	22.5	44.4	70.5	83.1	99.9
Top Char	4.6	3.7	11.3	29.7	57.3	72.4	98.4
Mid Char	1.5	1.5	9.3	31.6	56.5	72.3	98.8
Bottom Char	0.6	1.8	4.7	16.6	44.2	64.4	99.5
Cyclone	-	-	-	-	-	-	-
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	24	132	509	48.2
Top Char	24	224	650	27.0
Mid Char	29	300	659	19.1
Bottom Char	35	414	796	26.3
Cyclone	-	-	-	-
Filter	-	-	-	-

*Based on acid soluble analysis

YIELD PERIOD 202

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.15	0.98	0.64
C	64.1	52.7	67.7
S	3.8	3.6	2.1
O	10.6	1.5	2.4
N	1.13	0.36	0.36
Cl	0.09	0.11	0.18
SO ₃ -Free Ash	16.2	40.8	26.6
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	10.03	1.88	4.19

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	30.8	35.2	27.5
Fe ₂ O ₃	10.1	11.5	9.3
Al ₂ O ₃	11.4	12.1	10.4
CaO	1.50	1.51	1.52
MgO	0.58	0.67	0.56
TiO ₂	0.57	0.57	0.58
P ₂ O ₅	0.21	0.30	0.12
Na ₂ O	0.82	0.70	0.94
K ₂ O, Catalyst	44.09	37.40	49.08
Total	100.0	100.0	100.0

YIELD PERIOD 202PRODUCT GAS DATAProduct Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	112.7
H ₂	43.5
CO	9.9
CH ₄	7.3
CO ₂	11.3
H ₂ S	0.3
H ₂ O	25.9
N ₂	14.5
H ₂ O/CO	2.6
H ₂ O/CO ₂	2.3

Unit Gas Data

Syngas MWT, lbs/mol	10.5
Product Gas MWT (dry), lbs/mol	16.1

Product Gas

At DTM (dry), SCFH	781.6
(Dry, N ₂ -Free), SCFH	650.9
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1015.3
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	423.5
At Gasifier Outlet, SCFH (Excludes N ₂)	884.6
At Gasifier Outlet, ACFH (Excludes N ₂)	369.0

YIELD PERIOD 202PRODUCT GAS DATAUnit Gas YieldsProduct Gas (Dry), Mol%

H ₂	50.1
CO	11.4
CO ₂	13.0
CH ₄	8.4
H ₂ S	0.4
N ₂	16.7

Product Gas (Dry, N₂-Free)

H ₂	60.2
CO	13.6
CO ₂	15.6
CH ₄	10.1
H ₂ S	0.5

Product Gas

H ₂	38.6
CO	8.7
CO ₂	10.0
CH ₄	6.5
H ₂ S	0.3
H ₂ O	23.0
N ₂	12.9

Product Gas (N₂-Free)

H ₂	52.2
CO	11.8
CO ₂	13.5
CH ₄	8.7
H ₂ S	0.4
H ₂ O	26.4

SCFH CH₄/lb C Active Bed 1.1SCFH CH₄/lb C Feed 10.1Moles CH₄/mole C Feed 0.32

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1295.4°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.7217	1.1238	1251.9
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5433	1.9200	1210.3
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0747	0.0504	1320.6
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3417	0.1222	-

YIELD PERIOD 202
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	10.03	Product Gas (ex N ₂)	23.50
Gasifier Steam	15.86	Product Gas N ₂	9.66
Gasifier Syngas	14.54	Product Water	11.11
		Char Entrained	4.19
		Solids Withdrawn	1.88
Total (ex N ₂)	40.43	Total (ex N ₂)	40.68
Accumulation:	-0.25		
Closure: (Output + Accum)/Input, %			100.0

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	527.2	H ₂ + CO in Product Gas	480.6
N ₂ Mol%	67.6	H ₂ Mol%	50.1
CO Mol%	32.4	CO Mol%	11.4
Balance: (Output/Input), %			91.2

YIELD PERIOD 202
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	6.50	0.42	1.07	0.386	0.009
Gasifier Steam	-	1.78	14.09	-	-
Gasifier Syngas	5.42	1.89	7.22	-	-
Total	11.92	4.09	22.38	0.386	0.009
<u>Output:</u>					
Product Gas	8.11	2.80	12.33	0.255	-
Product Water	-	1.24	9.87	0.004	-
Char Entrained	2.84	0.03	0.10	0.088	0.007
Solids Withdrawn	0.99	0.02	0.03	0.068	0.002
Total	11.94	4.09	22.33	0.415	0.009
Accumulation:	-0.02	0.00	0.05	-0.029	-0.000
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	0.60	0.31
<u>Output:</u>		
Char Entrained	0.45	0.31
Product Water	0.00	0.00
Solid Withdrawn	0.24	0.13
Total	0.69	0.44
Accumulation:	-0.09	0.01
Closure (out + accum)/In, %	100.0	146.1

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 202

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.18	2.04	1.64	1.54
<u>Output:</u>				
Entrained Char	1.32	1.28	1.11	1.11
Solids Withdrawn	0.89	0.83	0.77	0.66
Total	2.21	2.12	1.88	3.08
Accumulation:	-0.03	-0.08	-0.24	-0.22
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.505	0.166	0.187	0.025	0.010	0.560	0.013	0.009	0.003
<u>Output:</u>									
Entrained Char	0.307	0.104	0.115	0.017	0.006	2.281	0.010	0.006	0.001
Solids Withdrawn	0.270	0.088	0.093	0.012	0.005	0.166	0.006	0.004	0.002
Total	0.576	0.192	0.208	0.028	0.011	0.447	0.016	0.011	0.004
Accumulation:	-0.072	-0.026	-0.022	-0.004	-0.002	0.032	-0.003	-0.001	-0.000
Closure (out + accum)/in, %	100	100	100	100	100	86	100	100	100

YIELD PERIOD 202

MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
<u>Gas Input</u>					
H ₂	(0.940)	-	1.879	-	-
CO	(0.451)	0.451	-	0.451	-
H ₂ O	(0.880)	-	1.761	0.880	-
Total		0.451	3.640	1.332	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.541	0.418	0.067	0.012
<u>Total Input</u>		0.992	4.058	1.399	0.012
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
<u>Product Gas</u>					
H ₂	(1.034)	-	2.068	-	-
CO	(0.234)	0.234	-	0.234	-
CO ₂	(0.268)	0.268	-	0.536	-
CH ₄	(0.173)	0.173	0.693	-	-
H ₂ S	(0.008)	-	0.016	-	0.008
H ₂ O	(0.617)	-	1.233	0.617	-
Total		0.675	4.010	1.387	0.008
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.236	0.027	0.006	0.003
Char Samples Withdrawn		0.082	0.017	0.002	0.002
Char Accumulation		-0.002	0.004	0.003	-0.001
Total Solids		0.317	0.048	0.011	0.004
<u>Total Output + Accumulation</u>		0.992	4.058	1.398	0.012

YIELD PERIOD 202PROCESS VARIABLES

		<u>Measured</u>	<u>Reconciled</u>
V100	Gasifier Steam (lbs/hr)	15.91	15.86
V111	Char Withdrawn (lbs/hr)	1.88	1.89
V165	H in Char Entrained (wt%)	0.64	0.64
V166	H in Char Withdrawn (wt%)	0.93	0.93
V168	H in Coal + Catalyst Feed (wt%)	4.16	4.15
V173	H in Gasifier Starting Mid Char (wt%)	0.68	0.68
V174	H in Gasifier Ending Mid Char (wt%)	0.81	0.81
V183	CO in Syngas (mol%)	32.10	32.45
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	6.88	7.13
V188	O in Coal + Catalyst Feed (wt%)	10.57	10.55
V193	H ₂ in Syngas (mol%)	67.10	67.55
V205	CO ₂ in Product Gas (mol%)	13.00	13.00
V207	CH ₄ in Product Gas (mol%)	8.40	8.40
V208	CO in Product Gas (mol%)	11.60	11.35
V212	H ₂ in Product Gas (mol%)	50.20	50.13
V214	H ₂ in Product Gas (mol%)	16.80	16.72
V215	H ₂ S in Product Gas (mol%)	0.40	0.38
V222	Carbon in Char Withdrawn (wt%)	52.22	52.71
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	13.02	13.05
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	15.11	15.26
V257	Carbon in Gasifier Starting Mid Char (wt%)	56.17	55.80
V258	Carbon in Gasifier Ending Mid Char (wt%)	58.00	58.21
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	15.08	15.66
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	14.57	14.03
V289	ASTM Ash in Char Entrained (wt%)	31.62	31.63
V292	ASTM Ash in Char Withdrawn (wt%)	47.08	47.09
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	21.47	21.46
V294	C/H Residue in Feed Coal + Catalyst (wt%)	20.23	20.14
V295	C/H Residue in Char Entrained (wt%)	30.58	30.66
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	40.38	39.96
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	40.86	41.27

YIELD PERIOD 202PROCESS VARIABLES

		<u>Measured</u>	<u>Reconciled</u>
V310	C/H Residue in Char Withdrawn (wt%)	44.27	44.35
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	40.05	39.82
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	39.99	40.20
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	15.97	16.18
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	28.51	26.59
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	41.31	40.80
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	37.08	37.41
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	34.23	34.04
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.72	15.22
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	27.23	26.52
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	35.44	34.90
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	32.79	33.96
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	31.82	30.77
V407	Coal + Catalyst Feed (lbs/hr)	10.00	10.14
V473	Char Entrained (lbs/hr)	4.19	4.19
V495	Carbon in Feed Coal (wt%)	64.35	64.09
V498	Carbon in Char Entrained (wt%)	65.78	67.73
F384	Syngas Flow Meter (CFH)	50.00	49.80
F385	Product Gas Flow Meter (CFH)	104.00	106.22
PGK0	Product Gas Condensate (lbs/hr)	10.04	10.86
U(114)	Starting Bed ΔP (B-A) (in Hg)	4.20	4.21
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.90	1.90
U(116)	Starting Bed ΔP (D-C) (in Hg)	2.80	2.80
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	8.90	8.92
U(119)	Ending Bed ΔP (B-A) (in Hg)	3.80	3.79
U(120)	Ending Bed ΔP (C-B) (in Hg)	1.90	1.90
U(121)	Ending Bed ΔP (D-C) (in Hg)	2.80	2.80
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	0.50	0.49
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 202

PROCESS VARIABLES

YIELD PERIOD 202

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.00	0.00
JPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	3.28	3.31
V281	S in Gasifier Ending Mid Char (wt%)	2.85	2.83
V187	S in Coal + Catalyst Feed (wt%)	3.74	3.80
V246	S in Char Withdrawn (wt%)	3.62	3.64
V244	S in Char Entrained (wt%)	2.10	2.09
V243	S in Product Gas Condensate (wt%)	0.03	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	33.34	32.80
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	32.80	33.23
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	31.15	30.76
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	33.92	35.18
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	27.01	27.53
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.80	10.23
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.71	10.10
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	10.60	10.10
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.16	11.53
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	9.03	9.31
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	12.10	12.05
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	12.47	12.51
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	11.42	11.38
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.99	12.14
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	10.29	10.36
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.88	0.91
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.82	0.80
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.42	1.50
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.54	1.51
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.58	1.52
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.12	0.13
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.14	0.13
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.08	0.09

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.11	0.11
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.20	0.18
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.33	0.30
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.26	0.28
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.14	0.13
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.28	0.29
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.24	0.25
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.63	0.62
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.59	0.60
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.59	0.58
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.66	0.67
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.55	0.56
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.58	0.57
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.55	0.56
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.58	0.57
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.56	0.57
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.57	0.58
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.17	0.17
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.17	0.17
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.21	0.20
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.30	0.30
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.12	0.12
V813	N in Starting Mid Char (wt%)	0.21	0.21
V814	N in Ending Mid Char (wt%)	0.26	0.26
V818	N in Coal + Catalyst Feed (wt%)	1.13	1.13
V819	N in Char Withdrawn (wt%)	0.36	0.36
V820	N in Char Entrained (wt%)	0.36	0.36
V805	O in Starting Mid Char (wt%)	2.46	2.46
V806	O in Ending Mid Char (wt%)	3.71	3.72
V810	O in Char Withdrawn (wt%)	1.45	1.46
V811	O in Char Entrained (wt%)	2.40	2.41

RECONCILED DATA
YIELD PERIOD 203
UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	11:30	2-19-77
To	6:30	2-20-77
Duration	19 Hrs	

Percent of Time on Stream

Coal Feed	99
Steam	100
Syngas	100

Gasifier Process Temperatures

Gasifier Bed Height (ft)	Gasifier Temperature (°F)
43.2	1185
38.4	1222
32.1	1287
26.6	1306
21.2	1303
16.0	1302
10.9	1287
6.4	1265
0.4	1073

YIELD PERIOD 203
UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	223	243
Lockhopper 1 Bottom	190	158
Lockhopper 2 Top	304	304
Lockhopper 2 Bottom	225	345
Gasifier Feed Line	717	892
Gasifier Steam Line	847	842
Gasifier		
Top of Bed	1287	1315
Bottom of Bed	1073	1232
Total Bed Average	1260	1300
Rough Cut Cyclone		
Cyclone Top	938	996
Cyclone Bottom	710	1018
Standpipe Top	812	1000
Standpipe Mid	805	1013
Standpipe Bottom	776	988
Standpipe Slope Top		1049
Standpipe Slope Bottom	1150	1002
Gasifier Backend		
Cyclone Inlet	-	536
Filter Inlet	-	520
Scrubber Inlet	578	519
Scrubber Outlet	74	-
Product Gas Meter	84	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	117.7	
Gasifier Feed Line	115.8	
Bypass N2	155.5	
Syngas In	163.5	
Gasifier		
Gasifier Top	113.7	
Gasifier Bottom	118.2	
Rough Cut Cyclone Outlet	113.2	
Filter Outlet	113.6	
Scrubber Outlet	113.6	
Product Gas Meter	114.7	

YIELD PERIOD 203

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	25.3
Bed Top Density (lbs/cf)	21.0
Bed Average Density (lbs/cf)	18.5
Bed Height (ft)	35.2
Bed Holdup (lbs)	115.9
Bed Volume (cf)	5.7
Average Bed Temperature (°F)	1291.7
Space Velocity (bed) (cf/cf/hr)	66.0
Bottom Superficial Velocity (ft/sec)	0.49
Top Superficial Velocity (ft/sec)	0.58

Cyclone Performance

Temperature (°F)	536.0
Pressure (psia)	113.7
Inlet Gas Rate (SCFH)	857.0
Inlet Gas Rate (ACFH)	212.3
Inlet Gas Velocity (ft/sec)	16.7
Solids Entering (lbs/hr)	3.2
Dust Loading (lbs/acf)	0.0149
Solids Captured (lbs/hr)	2.8
Solids Escaping (lbs/hr)	0.3
Overall Efficiency (Captured/Entering, Wt.%)	89.9

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	9.36
Total Carryover (lbs/hr)	3.16
Cyclone (lbs/hr)	2.84
Filter (lbs/hr)	0.32
Carryover/Feed (Wt.%)	33.8

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.86
Carbon in Carryover (lbs/hr)	2.04
Carryover/Feed (Wt.%)	36.3

YIELD PERIOD 203

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	5.86
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.53
Carbon Gasified (by difference) (lbs/hr)	1.46
Total Carbon Converted (lbs/hr)	2.99

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	24.9
Total, Including Devolatilization (%)	51.0

Carbon Distribution

Total Converted (%)	51.0
Entrained (%)	34.8
Withdrawn (%)	12.3
Accumulated (%)	1.9
Conversion (Entrainment Backed Out)	78.2

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	2.3
Including Devolatilization	4.8

Steam Consumption

Steam into Unit (lbs/hr)	14.07
Steam Reacted with Carbon (lbs/hr)	2.19
Total Steam Consumed (lbs/hr)	4.65

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	15.6
Total Steam Converted (%)	33.0

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.104
Carbon Converted/Steam Fed (mol/mol)	0.156
Carbon Converted/Bed Volume (lbs/hr)/cft	0.233
Carbon Converted/Bed Volume (mol/hr)/cft	0.019
Carbon in Bed/Steam Fed lbs/(lbs/hr)	4.457
Carbon in Bed/Steam Fed mol/(mol/hr)	6.688

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 203

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	7.0	-	14.8	14.7	12.6
K as K ₂ CO ₃	10.3	-	21.7	21.5	18.6
K as K	5.8	-	12.3	12.2	10.5
K Water/Acid, Soluble Ratio	0.614	-	0.481	0.664	0.702
K ₂ O, H ₂ O-Insoluble	2.7	-	7.7	4.9	3.8
K ₂ CO ₃ , H ₂ O-Insoluble	3.9	-	11.3	7.2	5.5
K, H ₂ O-Insoluble	2.2	-	6.4	4.1	3.1
Carbon	62.7	-	54.1	45.3	64.7
K on Carbon	9.3	-	22.7	26.8	16.2
STM Ash	22.1	-	41.5	46.0	30.9
K on Ash	26.4	-	29.6	26.4	34.0
K ₂ CO ₃ Free-Ash	11.6	-	19.3	24.1	12.0
K on K ₂ CO ₃ Free-Ash	50.6	-	63.6	50.5	87.2

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	5.6	6.6	18.4	32.0	81.2	91.5	98.8
Top Char	-	-	-	-	-	-	-
Mid Char	0.9	1.3	5.7	25.5	64.9	84.6	99.9
Bottom Char	1.0	1.7	8.6	31.9	70.1	87.7	99.9
Cyclone	-	-	-	-	-	-	-
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	25	176	441	45.5
Top Char	0	0	0	19.4
Mid Char	33	331	582	26.9
Bottom Char	34	293	529	28.9
Cyclone	-	-	-	-
Filter	-	-	-	-

*Based on acid soluble analysis

YIELD PERIOD 203

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.28	1.46	0.80
C	62.7	50.0	64.7
S	4.2	4.8	2.2
O	11.0	1.7	4.6
N	1.07	0.76	0.24
Cl	0.08	0.11	0.17
SO ₃ -Free Ash	16.7	41.2	27.2
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	9.28	1.43	3.16

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	29.8	30.9	28.3
Fe ₂ O ₃	12.1	15.6	10.8
Al ₂ O ₃	11.2	11.1	10.5
CaO	2.56	4.42	1.87
MgO	0.63	0.71	0.65
TiO ₂	0.58	0.45	0.59
P ₂ O ₅	0.30	0.55	0.12
Na ₂ O	0.89	0.59	0.68
K ₂ O, Catalyst	42.04	35.69	46.44
Total	100.0	100.0	100.0

YIELD PERIOD 203

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	43.5
CO	12.4
CH ₄	8.9
CO ₂	11.5
H ₂ S	0.3
H ₂ O	26.3
N ₂	10.6
H ₂ O/CO	2.1
H ₂ O/CO ₂	2.3

Unit Gas Data

Syngas MMT, lbs/mol	10.8
Product Gas MMT (dry), lbs/mol	16.0

Product Gas

At DTM (dry), SCFH	658.8
(Dry, N ₂ -Free), SCFH	579.1
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	857.0
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	350.5
At Gasifier Outlet, SCFH (Excludes N ₂)	777.2
At Gasifier Outlet, ACFH (Excludes N ₂)	317.9

YIELD PERIOD 203

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mo%

H ₂	49.8
CO	14.2
CO ₂	13.2
CH ₄	10.2
H ₂ S	0.4
N ₂	12.1

Product Gas (Dry, N₂-Free)

H ₂	56.7
CO	16.1
CO ₂	15.0
CH ₄	11.6
H ₂ S	0.4

Product Gas

H ₂	38.3
CO	10.9
CO ₂	10.2
CH ₄	7.8
H ₂ S	0.3
H ₂ O	23.1
N ₂	9.3

Product Gas (N₂-Free)

H ₂	41.8
CO	11.9
CO ₂	11.1
CH ₄	8.5
H ₂ S	0.3
H ₂ O	26.4

SCFH CH₄/lb C Active Bed 1.1

SCFH CH₄/lb C Feed 11.5

Moles CH₄/mole C Feed 0.36

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1291.7°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.6612	1.3970	1273.8
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5574	1.5411	1296.0
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0793	0.0495	1321.8
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3408	0.1489	-

YIELD PERIOD 203
MATERIAL BALANCES

Overall Material Balance

Input:	lbs/hr	Output:	lbs/hr
Coal Feed (ex H ₂)	9.26	Product Gas (ex H ₂)	21.04
Gasifier Steam	14.07	Product Gas (ex H ₂)	7.30
Gasifier Syngas	12.94	Product Water	3.42
		Char Entrained	3.15
		Solids Withdrawn	1.43
Total (ex H ₂)	36.27	Total (ex H ₂)	36.30
Accumulation:	0.01		
Closure: (Output - Accum) / Input	100.0		

Synthesis Gas Balance

Input:	SCFH	Output:	SCFH
Gasifier Syngas	455	H ₂ + CO (ex H ₂)	455
H ₂ Mol%	66.2	H ₂ Mol%	66.2
CO Mol%	33.7	CO Mol%	33.7
Balance: (Output/Input), %	100.0		

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YIELD PERIOD 203
MATERIAL BALANCES

Elemental Balances

Input (lbs/hr)	Carbon*	Hydrogen	Oxygen	Sulfur	Chlorine
Coal + Catalyst**	5.86	0.40	3.50	0.04	0.04
Gasifier Steam	-	1.57	15.00	-	-
Gasifier Syngas	4.86	1.61	6.47	-	-
Total	10.73	3.58	24.97	0.04	0.04
Output:					
Product Gas	7.85	2.47	13.25	0.21	-
Product Water	-	1.05	6.37	0.00	-
Char Entrained	2.04	0.03	0.15	0.00	0.00
Solids Withdrawn	0.72	0.02	0.02	0.05	0.00
Total	10.61	3.57	19.80	0.26	0.00
Accumulation	0.12	0.01	5.17	0.02	0.04
Total	100.0	100.0	100.0	100.0	100.0

Carbon Balance

Input (lbs/hr)	Acid Sol	Alkali Sol
Coal + Catalyst**	0.25	0.00
Gasifier Steam	0.00	0.00
Gasifier Syngas	0.35	0.00
Total	0.60	0.00
Output:		
Product Gas	0.17	0.00
Product Water	0.00	0.00
Char Entrained	0.00	0.00
Solids Withdrawn	0.00	0.00
Total	0.17	0.00
Accumulation	0.43	0.00
Total	100.0	100.0

* Includes catalyst carbonate
** Catalyst is oxygenated in catalyst

YIELD PERIOD 203

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.07	1.94	1.57	1.42
<u>Output:</u>				
Entrained Char	0.98	1.10	0.86	0.99
Solids Withdrawn	0.66	0.67	0.59	0.51
Total	1.63	1.77	1.45	1.50
Accumulation:	0.44	0.17	0.12	-0.08
Closure (out + accum)/in,	100.0	100.0	100.0	100.0

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.467	0.183	0.175	0.040	0.010	0.549	0.014	0.009	0.005
<u>Output:</u>									
Entrained Char	0.244	0.093	0.091	0.016	0.006	0.231	0.005	0.005	0.001
Solids Withdrawn	0.187	0.052	0.065	0.026	0.004	0.164	0.003	0.003	0.003
Total	0.426	0.184	0.156	0.042	0.010	0.377	0.009	0.008	0.004
Accumulation:	0.041	0.005	0.019	-0.002	0.0	0.097	0.003	0.001	0.0
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0	100.0	86.0	100.0	100.0	100.0

YIELD PERIOD 203

MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(0.798)	-	1.596	-	-
CO	(0.405)	0.405	-	0.405	-
H ₂ O	(0.781)	-	1.562	0.781	-
Total	(1.984)	0.405	3.157	1.185	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.489	0.398	0.054	0.012
Total Input		0.893	3.555	1.250	0.012
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Product Gas					
H ₂	(0.856)	-	1.732	-	-
CO	(0.247)	0.247	-	0.247	-
CO ₂	(0.230)	0.230	-	0.459	-
CH ₄	(0.177)	0.177	0.709	-	-
H ₂ S	(0.007)	-	0.013	-	0.007
H ₂ O	(0.523)	-	1.046	0.523	-
Total	(2.050)	0.653	3.500	1.222	0.007
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.170	0.025	0.009	0.002
Char Samples Withdrawn		0.050	0.021	0.002	0.002
Char Accumulation		0.010	0.009	0.005	0.001
Total Solids		0.239	0.055	0.017	0.005
Total Output + Accumulation		0.893	3.555	1.240	0.012



YIELD PERIOD 203

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	14.10	14.07
V111	Char Withdrawn (lbs/hr)	1.43	1.43
V165	H in Char Entrained (wt%)	0.60	0.80
V166	H in Char Withdrawn (wt%)	1.46	1.46
V168	H in Coal + Catalyst Feed (wt%)	4.28	4.28
V173	H in Gasifier Starting Mid Char (wt%)	0.97	0.97
V174	H in Gasifier Ending Mid Char (wt%)	1.07	1.07
V183	CO in Syngas (mol%)	34.70	33.65
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	7.43	7.04
V188	O in Coal + Catalyst Feed (wt%)	11.03	11.01
V193	H ₂ in Syngas (mol%)	62.60	66.35
V205	CO ₂ in Product Gas (mol%)	13.20	13.20
V207	CH ₄ in Product Gas (mol%)	10.20	10.20
V208	CO in Product Gas (mol%)	13.40	14.19
V212	H ₂ in Product Gas (mol%)	50.80	49.80
V214	N ₂ in Product Gas (mol%)	12.20	12.10
V215	H ₂ S in Product Gas (mol%)	0.45	0.38
V222	Carbon in Char Withdrawn (wt%)	49.84	50.01
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	12.74	12.64
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	14.55	14.69
V257	Carbon in Gasifier Starting Mid Char (wt%)	58.83	57.33
V258	Carbon in Gasifier Ending Mid Char (wt%)	56.23	55.72
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	14.79	14.18
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	14.79	14.12
V289	ASTM Ash in Char Entrained (wt%)	30.90	30.92
V292	ASTM Ash in Char Withdrawn (wt%)	46.00	46.02
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	22.16	22.14
V294	C/H Residue in Feed Coal + Catalyst (wt%)	20.51	20.68
V295	C/H Residue in Char Entrained (wt%)	34.90	34.73
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	40.57	39.35
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	42.51	44.05

YIELD PERIOD 203

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	46.51	46.82
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	40.71	40.42
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	41.01	40.83
V331	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	16.27	16.75
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	25.91	27.23
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	41.28	41.10
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	33.55	34.83
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	33.84	34.07
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.63	14.20
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	32.26	31.31
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	36.23	35.70
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	31.09	32.57
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	31.09	29.61
V407	Coal + Catalyst Feed (lbs/hr)	9.29	9.36
V472	Char Entrained (lbs/hr)	3.16	3.16
V495	Carbon in Feed Coal (wt%)	63.44	62.66
V498	Carbon in Char Entrained (wt%)	66.07	64.71
F304	Syngas Flow Meter (CFH)	43.00	42.72
F355	Product Gas Flow Meter (CFH)	85.90	88.78
PGK0	Product Gas Condensate (lbs/hr)	8.71	9.25
U(114)	Starting Bed ΔP (B-A) (in Hg)	3.80	3.81
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.50	1.50
U(116)	Starting Bed ΔP (D-C) (in Hg)	2.60	2.60
U(117)	Starting Bed ΔP (E-E) (in Hg)	0.0	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	8.60	8.62
U(119)	Ending Bed ΔP (B-A) (in Hg)	3.70	3.69
U(120)	Ending Bed ΔP (C-B) (in Hg)	0.80	0.80
U(121)	Ending Bed ΔP (D-C) (in Hg)	4.10	4.09
U(122)	Ending Bed ΔP (E-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	9.20	9.18
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.70	0.70

YIELD PERIOD 198

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed SP (E-D) (in Hg)	0.60	0.60
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	3.26	3.42
V281	S in Gasifier Ending Mid Char (wt%)	4.01	3.74
V187	S in Coal + Catalyst Feed (wt%)	3.83	4.15
V246	S in Char Withdrawn (wt%)	4.82	4.76
V244	S in Char Entrained (wt%)	2.25	2.20
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	31.57	31.08
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	31.57	31.27
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	30.32	29.76
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	30.71	30.93
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	28.82	28.34
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	12.48	12.64
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	12.48	12.18
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	12.00	12.08
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	15.64	15.59
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	10.92	10.77
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	11.22	11.03
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	11.22	11.32
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	11.34	11.16
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.99	11.05
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	10.56	10.54
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	2.43	2.53
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	2.43	2.30
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	2.48	2.56
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	4.52	4.42
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.91	1.87
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.13	0.13
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.14	0.14
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.06	0.08

YIELD PERIOD 203

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.11	0.11
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.17	0.17
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.25	0.22
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.25	0.27
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.16	0.16
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.24	0.24
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.18	0.16
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.64	0.66
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.64	0.62
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.62	0.63
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.72	0.71
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.65	0.66
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.54	0.52
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.58	0.56
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.60	0.58
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.45	0.45
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.59	0.59
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.24	0.24
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.20	0.24
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.30	0.30
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.55	0.55
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.12	0.12
V813	N in Starting Mid Char (wt%)	0.07	0.07
V814	N in Ending Mid Char (wt%)	0.11	0.11
V818	N in Coal + Catalyst Feed (wt%)	1.07	1.07
V819	N in Char Withdrawn (wt%)	0.76	0.76
V820	N in Char Entrained (wt%)	0.24	0.24
V805	O in Starting Mid Char (wt%)	3.09	3.09
V806	O in Ending Mid Char (wt%)	4.56	4.54
V810	O in Char Withdrawn (wt%)	1.73	1.73
V811	O in Char Entrained (wt%)	4.66	4.64

YIELD PERIOD 204
UNIT PROCESS VARIABLES

RECONCILED DATA

YIELD PERIOD 204

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	15:30	3-09-77
To	7:30	3-10-77
Duration	16 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1111	
38.4	1069	
32.1	1276	
26.6	1323	
21.2	1313	
15.0	1320	
10.9	1307	
6.4	1294	
0.4	1217	

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	282	306
Lockhopper 1 Bottom	249	205
Lockhopper 2 Top	235	303
Lockhopper 2 Bottom	219	321
Gasifier Feed Line	662	917
Gasifier Steam Line	1079	1140
Gasifier		
Top of Bed	1323	1361
Bottom of Bed	1217	1233
Total Bed Average	1295	1315
Rough Cut Cyclone		
Cyclone Top	948	992
Cyclone Bottom	683	1021
Standpipe Top	824	1000
Standpipe Mid	819	1014
Standpipe Bottom	789	1041
Standpipe Slope Top		1051
Standpipe Slope Bottom	1178	999
Gasifier Backend		
Cyclone Inlet		546
Filter Inlet		519
Scrubber Inlet	43	415
Scrubber Outlet	68	-
Product Gas Meter	85	-

<u>Unit Pressures</u>	<u>Psia</u>
Lockhopper 2	117.5
Gasifier Feed Line	116.7
Bypass N ₂	172.8
Syngas In	163.0
Gasifier	
Gasifier Top	113.7
Gasifier Bottom	116.7
Rough Cut Cyclone Outlet	113.1
Filter Outlet	113.6
Scrubber Outlet	113.6
Product Gas Meter	114.7

YIELD PERIOD 204

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cv)	19.3
Bed Top Density (lbs/cf)	10.1
Bed Average Density (lbs/cf)	14.7
Bed Height (ft)	29.7
Bed Holdup (lbs)	77.9
Bed Volume (cf)	4.7
Average Bed Temperature (°F)	1311.4
Space Velocity (bed) (cf/cf/hr)	96.4
Bottom Superficial Velocity (ft/sec)	0.65
Top Superficial Velocity (ft/sec)	0.70

Cyclone Performance

Temperature (°F)	548.0
Pressure (psia)	113.7
Inlet Gas Rate (SCFH)	1023.7
Inlet Gas Rate (ACF ⁴)	256.7
Inlet Gas Velocity (ft/sec)	20.1
Solids Entering (lbs/hr)	0.1
Dust Loading (lbs/acf)	0.0003
Solids Captured (lbs/hr)	0.1
Solids Escaping (lbs/hr)	0.0
Overall Efficiency (Captured/Entering, Wt.%)	50.0

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	10.18
Total Carryover (lbs/hr)	0.08
Cyclone (lbs/hr)	0.07
Filter (lbs/hr)	0.01
Carryover/Feed (Wt.%)	0.8

Solids Carbon Loss

Carbon in Feed (lbs/hr)	6.44
Carbon in Carryover (lbs/hr)	0.02
Carryover/Feed (Wt.%)	0.3

YIELD PERIOD 204

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed (lbs/hr)	6.44
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.76
Carbon Gasified (by difference) (lbs/hr)	4.00
Total Carbon Converted (lbs/hr)	5.77

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	62.2
Total, Including Devolatilization (%)	89.5

Carbon Distribution

Total Converted (%)	89.5
Entrained (%)	0.3
Withdrawn (%)	0.4
Accumulated (%)	7.8
Conversion (Entrainment Backed Out)	89.8

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/hr)	23.8
Including Devolatilization	34.3

Steam Consumption

Steam into Unit (lbs/hr)	14.79
Steam Reacted with Carbon (lbs/hr)	6.01
Total Steam Consumed (lbs/hr)	8.66

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification (%)	40.1
Total Steam Converted (%)	53.6

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.271
Carbon Converted/Steam Fed (mol/mol)	0.406
Carbon Converted/Bed Volume (lbs/hr)/cft	0.750
Carbon Converted/Bed Volume (mol/hr)/cft	0.063
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.136
Carbon in Bed/Steam Fed mol/(mol/hr)	1.705

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

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YIELD PERIOD 204

UNIT COMPOSITIONS

YIELD PERIOD 204

SOLIDS COMPOSITION

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	7.9	-	33.7	33.3	32.9
K as K ₂ CO ₃	11.5	-	49.4	48.9	48.3
K as K	6.5	-	27.9	27.6	27.3
K Water/Acid, Soluble Ratio	0.748	-	0.714	0.727	0.737
K ₂ O, H ₂ O-Insoluble	2.0	-	9.6	9.1	8.7
K ₂ CO ₃ , H ₂ O-Insoluble	2.9	-	14.2	13.4	12.7
K, H ₂ O-Insoluble	1.6	-	8.0	7.6	7.2
Carbon	63.3	-	21.6	19.3	26.9
K on Carbon	10.3	-	129.5	143.3	101.6
ASTM Ash	23.1	-	72.8	74.7	70.2
K on Ash	28.3	-	38.4	37.0	38.9
K ₂ CO ₃ Free-Ash	11.4	-	22.6	25.1	21.0
K on K ₂ CO ₃ Free-Ash	57.2	-	123.8	110.1	129.8

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	0.4	1.3	11.2	40.2	78.0	93.8	100.0
Top Char	-	-	-	-	-	-	-
Mid Char	0.7	2.5	12.3	33.5	68.1	85.8	99.9
Bottom Char	0.4	0.8	6.3	26.9	54.4	89.3	99.7
Cyclone	95.4	97.6	98.7	99.4	99.4	99.7	100.0
Filter	97.2	97.6	98.6	99.3	99.7	99.9	100.0

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	54	276	445	42.8
Top Char	-	-	-	-
Mid Char	40	279	541	21.2
Bottom Char	44	351	572	28.0
Cyclone	22	23	32	
Filter	22	23	29	

*Based on acid soluble analysis

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.20	0.58	1.41
C	63.3	20.2	26.9
S	3.8	5.4	3.6
O	12.4	9.1	8.8
N	0.57	0.17	0.10
Cl	0.04	0.18	0.28
SO ₃ -Free Ash	15.8	64.4	58.9
Total	100.0	100.0	100.0

Solids Flow Rate
(lbs/hr)

10.18 2.03 0.08

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	27.8	26.6	24.5
Fe ₂ O ₃	8.7	9.6	7.8
Al ₂ O ₃	9.8	9.6	8.1
CaO	1.53	1.91	1.61
MgO	0.59	0.55	0.50
TiO ₂	0.92	0.45	0.60
P ₂ O ₅	0.23	0.31	0.15
Na ₂ O	0.51	0.69	0.85
K ₂ O, Catalyst	49.89	50.29	55.93
Total	100.0	100.0	100.0

YIELD PERIOD 204

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	43.6
CO	16.2
CH ₄	9.7
CO ₂	13.0
H ₂ S	0.3
H ₂ O	14.3
N ₂	16.6
H ₂ O/CO	0.9
H ₂ O/CO ₂	1.1

Unit Gas Data

Syngas BWT, lbs/mol	11.2
Product Gas BWT (dry), lbs/mol	17.6

Product Gas

At DTM (dry), SCFH	894.8
(Dry, N ₂ -Free), SCFH	745.4
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1023.7
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	399.9
At Gasifier Outlet, SCFH (Excludes N ₂)	874.3
At Gasifier Outlet, ACFH (Excludes N ₂)	341.5

YIELD PERIOD 204

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	43.8
CO	16.3
CO ₂	13.1
CH ₄	9.8
H ₂ S	0.3
N ₂	16.7

Product Gas (Dry, N ₂ -Free)	
H ₂	52.6
CO	19.5
CO ₂	15.7
CH ₄	11.8
H ₂ S	0.4

Product Gas	
H ₂	38.3
CO	14.2
CO ₂	11.4
CH ₄	6.6
H ₂ S	0.3
H ₂ O	12.6
N ₂	14.6

Product Gas (N ₂ -Free)	
H ₂	42.3
CO	15.7
CO ₂	12.6
CH ₄	9.5
H ₂ S	0.3
H ₂ O	19.6

SCFH CH ₄ /lb C Active Bed	5.2
SCFH CH ₄ /lb C Feed	13.6
Moles CH ₄ /mole C Feed	0.43

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1303.0°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	2.0036	3.3456	1367.7
Shift: CO + H ₂ O = CO ₂ + H ₂	1.4847	2.4495	1124.6
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0581	0.0226	1374.4
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3462	0.6195	-

YIELD PERIOD 204
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex H ₂)	30.12	Product Gas (ex H ₂)	30.41
Gasifier Steam	14.79	Product Gas H ₂	11.04
Gasifier Syngas	14.11	Product Water	6.11
		Char Entrained	0.08
		Solids Withdrawn	2.03
Total (ex H ₂)	39.01	Total (ex H ₂)	39.02
Accumulation:	0.77		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	479.0	H ₂ + CO in Product Gas	537.8
H ₂ Mol% 64.5		H ₂ Mol% 43.8	
CO Mol% 35.2		CO Mol% 16.3	
Balance: (Output/Input), %	112.3		

YIELD PERIOD 204
MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.35	2.14	1.60	1.56
<u>Output:</u>				
Entrained Char	1.06	0.06	0.05	0.06
Solids Withdrawn	1.52	1.64	1.31	1.30
Total	1.58	1.70	1.36	1.35
Accumulation:	0.77	0.43	0.25	0.21
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.445	0.140	0.157	0.025	0.010	0.661	0.013	0.015	0.004
<u>Output:</u>									
Entrained Char	0.012	0.004	0.004	0.001	0.0	0.007	0.0	0.0	0.0
Solids Withdrawn	0.348	0.126	0.126	0.025	0.007	0.284	0.007	0.006	0.004
Total	0.359	0.129	0.130	0.025	0.007	0.291	0.007	0.006	0.004
Accumulation:	0.086	0.011	0.028	-0.001	0.002	0.132	0.006	0.009	-0.0
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0	100.0	64.0	100.0	100.0	100.0

YIELD PERIOD 204

MATERIAL BALANCES

Element Balances

Input (Lbs/Hr):	Carbon*	Hydrogen	Oxygen	Sulfur	Chlorine
Coal + Catalyst**	6.44	0.33	1.26	0.386	0.004
Gasifier Steam	0.0	1.65	13.14	-	-
Gasifier Syngas	5.34	1.65	7.11	-	-
Total	11.78	3.73	21.51	0.386	0.004
Output:					
Product Gas	11.11	3.03	16.04	0.228	0.0
Product Water	0.0	0.69	5.45	0.002	0.0
Char Entrained	0.02	0.0	0.01	0.003	0.0
Solids Withdrawn	0.41	0.01	0.18	0.110	0.004
Total	11.54	3.73	21.68	0.343	0.004
Accumulation:	0.24	0.0	-0.17	0.043	0.0
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

Input (Lbs/Hr):	Acid Sol. K	Water Sol. K
Coal + Catalyst	0.66	0.50
Output:		
Char Entrained	0.02	0.02
Product Water	0.0	0.0
Solid Withdrawn	0.55	0.41
Total	0.57	0.42
Accumulation:	0.10	-0.10
Closure (out + accum)/in, %	100.0	65.1

*Carbon balance excludes catalyst carbonate
 **Excludes carbon and oxygen in catalyst

YIELD PERIOD 204

MATERIAL BALANCES

Mole Balance

Gas Input	Lb-Moles/Hr			
	C	H	O	S
H ₂	(0.819)	-	1.638	-
CO	(0.445)	0.445	0.0	0.445
H ₂ O	(0.281)	-	1.642	0.821
Total	(1.545)	0.445	3.280	1.226

Solids Input

	C	H	O	S	K
Coal + Cat Feed	0.536	0.424	0.079	0.012	0.017
Total Input	0.981	3.704	1.344	0.012	0.017

Gas Output

Product Gas	C	H	O	S
H ₂	(1.035)	-	2.070	-
CO	(0.384)	0.384	0.0	0.384
CO ₂	(0.309)	0.309	-	0.618
CH ₄	(0.231)	0.231	0.926	-
H ₂ S	(0.007)	-	0.014	-
H ₂ O	(0.340)	-	0.681	-
Total	(2.306)	0.925	3.691	1.343

Solids Output

	C	H	O	S	K
Char Entrained	0.002	0.001	0.0	0.0	0.001
Char Samples Withdrawn	0.034	0.012	0.012	0.003	0.014
Char Accumulation	0.020	0.001	-0.011	0.001	0.002
Total Solids	0.056	0.014	0.001	0.005	0.017
Total Output + Accumulation	0.981	3.704	1.344	0.012	0.017

YIELD PERIOD 204

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	14.78	14.79
V111	Char Withdrawn (lbs/hr)	2.03	2.03
V165	H in Char Entrained (wt%)	0.00	1.41
V166	H in Char Withdrawn (wt%)	0.58	0.58
V168	H in Coal + Catalyst Feed (wt%)	4.21	4.20
V173	H in Gasifier Starting Mid Char (wt%)	0.38	0.38
V174	H in Gasifier Ending Mid Char (wt%)	0.37	0.37
V183	CO in Syngas (mol%)	33.30	35.18
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	7.35	7.86
V188	O in Coal + Catalyst Feed (wt%)	12.30	12.36
V193	H ₂ in Syngas (mol%)	61.50	64.81
V205	CO ₂ in Product Gas (mol%)	13.10	13.10
V207	CH ₄ in Product Gas (mol%)	9.80	9.80
V208	CO in Product Gas (mol%)	16.70	16.27
V212	H ₂ in Product Gas (mol%)	43.30	43.84
V214	N ₂ in Product Gas (mol%)	16.70	16.69
V215	H ₂ S in Product Gas (mol%)	0.30	0.30
V222	Carbon in Char Withdrawn (wt%)	20.25	20.16
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	32.53	32.92
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	33.29	32.39
V257	Carbon in Gasifier Starting Mid Char (wt%)	20.89	20.71
V258	Carbon in Gasifier Ending Mid Char (wt%)	24.10	23.91
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	34.20	33.66
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	33.10	33.49
V289	ASTM Ash in Char Entrained (wt%)	70.23	70.23
V292	ASTM Ash in Char Withdrawn (wt%)	74.74	74.86
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	23.13	23.07
V294	C/H Residue in Feed Coal + Catalyst (wt%)	21.52	20.98
V295	C/H Residue in Char Entrained (wt%)	79.07	79.13
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	74.58	67.66
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	71.00	77.76

YIELD PERIOD 204

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	79.31	80.77
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	77.58	72.84
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	71.64	75.99
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	16.61	15.76
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	61.30	58.85
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	63.82	64.40
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	64.39	64.50
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	64.45	64.70
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	15.00	15.38
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	70.14	70.08
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	65.35	63.93
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	64.79	68.09
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	71.64	67.29
V407	Coal + Catalyst Feed (lbs/hr)	10.54	10.18
V473	Char Entrained (lbs/hr)	0.08	0.08
V495	Carbon in Feed Coal (wt%)	62.53	61.27
V498	Carbon in Char Entrained (wt%)	26.06	25.90
F384	Syngas Flow Meter (CFH)	45.60	45.20
F385	Product Gas Flow Meter (CFH)	114.80	121.01
PGK0	Product Gas Condensate (lbs/hr)	5.96	5.89
U(114)	Starting Bed ΔP (B-A) (in Hg)	3.10	3.03
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.80	1.78
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.20	1.17
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	6.00	6.00
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.60	2.64
U(120)	Ending Bed ΔP (C-B) (in Hg)	1.50	1.51
U(121)	Ending Bed ΔP (D-C) (in Hg)	2.30	2.33
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	8.40	8.48
END(1)	Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 204

PROCESS VARIABLES

	Measured	Reconciled
EDD(6) Ending Bed ΔP (E-D) (in Hg)	0.00	0.00
DPGST Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280 S in Gasifier Starting Mid Char (wt%)	5.08	5.08
V281 S in Gasifier Ending Mid Char (wt%)	5.58	5.55
V187 S in Coal + Catalyst Feed (wt%)	3.74	3.80
V246 S in Char Withdrawn (wt%)	5.53	5.41
V244 S in Char Entrained (wt%)	3.61	3.64
V243 S in Product Gas Condensate (wt%)	0.03	0.04
V862 SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	27.13	26.83
V863 SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	27.13	27.42
V867 SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	27.40	27.78
V868 SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	27.58	26.57
V869 SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	23.97	24.47
V871 Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.08	8.22
V872 Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.08	7.93
V876 Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.59	8.73
V877 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.84	9.60
V878 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.73	7.78
V880 Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	9.78	9.73
V881 Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.78	9.83
V885 Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.77	9.81
V886 Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.73	9.61
V887 Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.05	8.11
V889 CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.21	1.27
V890 CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.21	1.14
V894 CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.48	1.53
V895 CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.01	1.91
V896 CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.60	1.61
V822 Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.27	0.26
V823 Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.24	0.25
V827 Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.04	0.04

YIELD PERIOD 204

PROCESS VARIABLES

	Measured	Reconciled
V828 Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.18	0.18
V829 Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.28	0.28
V836 Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.49	0.50
V837 Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.45	0.44
V841 Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.08	0.08
V842 Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.45	0.45
V843 Acid Sol. Na ₂ O in Char Entrained (wt%)	0.50	0.50
V898 MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.54	0.53
V899 MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.54	0.55
V903 MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.60	0.59
V904 MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.55	0.55
V905 MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.50	0.50
V916 TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.46	0.35
V917 TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.46	0.58
V921 TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.52	0.92
V922 TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.42	0.45
V923 TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.59	0.60
V925 P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.10	0.08
V926 P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.10	0.08
V930 P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.21	0.23
V931 P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.37	0.31
V932 P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.15	0.15
V813 N in Starting Mid Char (wt%)	0.13	0.13
V814 N in Ending Mid Char (wt%)	0.21	0.21
V818 N in Coal + Catalyst Feed (wt%)	0.57	0.57
V819 N in Char Withdrawn (wt%)	0.17	0.17
V820 N in Char Entrained (wt%)	0.10	0.10
V805 O in Starting Mid Char (wt%)	8.86	8.94
V806 O in Ending Mid Char (wt%)	5.05	5.00
V810 O in Char Withdrawn (wt%)	9.47	9.78
V811 O in Char Entrained (wt%)	8.65	8.81

RECONCILED DATA

YIELD PERIOD 205

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	00:30	3-12-77
To	16:30	3-12-77
Duration	16 Hrs	

Percent of Time on Stream

Coal Feed	92
Steam	100
Syngas	93

Gasifier Process Temperatures

Gasifier Bed Height (ft)	Gasifier Temperature (°F)
43.2	1175
38.4	1256
32.1	1308
26.6	1322
21.2	1310
16.0	1309
10.9	1290
6.4	1266
0.4	1178

YIELD PERIOD 205

UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Atmos, °F</u>
Lockhopper 1 Top	300	316
Lockhopper 1 Bottom	280	227
Lockhopper 2 Top	228	271
Lockhopper 2 Bottom	188	320
Gasifier Feed Line	611	809
Gasifier Steam Line	1049	1138
Gasifier		
Top of Bed	1322	1363
Bottom of Bed	1178	1218
Total Bed Average	1279	1311

Rough Cut Cyclone		
Cyclone Top	974	994
Cyclone Bottom	714	1021
Standpipe Top	817	1007
Standpipe Mid	809	1015
Standpipe Bottom	785	1042
Standpipe Slope Top		1050
Standpipe Slope Bottom	1179	997

Gasifier Back End		
Cyclone Inlet		612
Filter Inlet		558
Scrubber Inlet	471	481
Scrubber Outlet	72	
Product Gas Meter	87	

<u>Unit Pressures</u>	<u>Psia</u>
Lockhopper 2	122.7
Gasifier Feed Line	117.9
Bypass H ₂	155.7
Syngas In	162.7
Gasifier	
Gasifier Top	113.7
Gasifier Bottom	117.8
Rough Cut Cyclone Outlet	113.0
Filter Outlet	113.6
Scrubber Outlet	113.6
Product Gas Meter	114.7

YIELD PERIOD 005
FLUID-SOLIDS DATA

Gasifier Fluidized-Bed Properties

Bed Bottom Density (lbs/cf)	24.0
Bed Top Density (lbs/cf)	26.9
Bed Average Density (lbs/cf)	20.4
Bed Height (ft)	29.1
Bed Volume (cf)	106.0
Average Bed Temperature (°F)	4.6
Space Velocity (bed) (cf/cf/hr)	1299.4
Bottom Superficial Velocity (ft/sec)	135.7
Top Superficial Velocity (ft/sec)	0.87

Cyclone Performance

Temperature (°F)	612.0
Pressure (psia)	113.7
Inlet Gas Rate (SCFH)	1420.3
Inlet Gas Rate (ACFH)	478.7
Inlet Gas Velocity (ft/sec)	29.7
Solids Entering (lbs/hr)	2.8
Dust Loading (lbs/acf)	0.0068
Solids Captured (lbs/hr)	2.3
Solids Escaping (lbs/hr)	0.3
Overall Efficiency (Captured/Entering, Wt.%)	89.8

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	13.37
Total Carryover (lbs/hr)	2.56
Cyclone (lbs/hr)	2.30
Filter (lbs/hr)	0.26
Carryover/Feed (Wt.%)	17.8

Solids Carbon Loss

Carbon in Feed (lbs/hr)	8.95
Carbon in Carryover (lbs/hr)	0.53
Carryover/Feed (Wt.%)	11.2

YIELD PERIOD 005
UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	8.55
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.81
Carbon Gasified (by difference) (lbs/hr)	2.24
Total Carbon Converted (lbs/hr)	8.06

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	89.6
Total, including Devolatilization (%)	90.0

Carbon Distribution

Total Converted (%)	90.0
Entrained (%)	70.9
Withdrawn (%)	4.5
Accumulated (%)	-5.4
Conversion (Entrainment Backed Out)	95.6

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/hr)	18.8
Including Devolatilization	28.8

Steam Consumption

Steam into Unit (lbs/hr)	22.72
Steam Reacted with Carbon (lbs/hr)	7.87
Total Steam Consumed (lbs/hr)	12.88

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	34.6
Total Steam Converted (%)	56.7

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.231
Carbon Converted/Steam Fed (mol/mol)	0.347
Carbon Converted/Bed Volume (lbs/hr)/cft	3.012
Carbon Converted/Bed Volume (mol/hr)/cft	0.084
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.231
Carbon in Bed/Steam Fed mol/(mol/hr)	1.847

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

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YIELD PERIOD 205

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	10.1	31.0	30.7	36.0	27.6
K as K ₂ CO ₃	14.8	45.5	45.1	52.9	40.5
K as K	8.4	25.7	25.5	29.9	22.9
K Water/Acid, Soluble Ratio	0.659	0.619	0.641	0.565	0.731
K ₂ O, H ₂ O-Insoluble	3.4	11.3	11.1	15.7	7.4
K ₂ CO ₃ , H ₂ O-Insoluble	5.1	17.3	16.2	23.0	10.9
K, H ₂ O-Insoluble	2.9	9.8	9.2	13.0	6.2
Carbon	62.3	28.5	26.4	19.4	38.2
K on Carbon	13.5	90.1	96.7	154.3	59.9
ASTM Ash	24.9	69.4	71.0	83.5	54.6
K on Ash	33.7	37.0	36.0	35.8	42.0
K ₂ CO ₃ Free-Ash	9.9	23.3	25.2	30.6	13.5
K on K ₂ CO ₃ Free-Ash	84.9	110.3	101.4	97.7	169.1

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	1.6	2.2	11.9	41.1	79.0	93.5	99.8
Top Char	2.2	5.3	22.7	48.4	79.4	91.5	99.9
Mid Char	2.5	5.3	18.9	46.2	80.4	93.2	100.0
Bottom Char	0.4	1.0	7.3	31.4	73.7	91.5	100.0
Cyclone	50.0	62.2	97.9	99.3	99.5	100.0	100.0
Filter	84.0	83.0	98.8	99.6	100.0	100.0	100.0

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	31	244	438	46.4
Top Char	32	192	422	21.6
Mid Char	30	158	418	24.5
Bottom Char	45	313	497	25.3
Cyclone	23	36	66	
Filter	22	25	46	

*Based on acid soluble analysis

YIELD PERIOD 205

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.04	0.68	0.97
C	62.3	19.3	38.2
S	3.6	5.1	3.4
O	9.1	7.4	7.0
N	1.09	0.16	0.36
Cl	0.09	0.15	0.05
SO ₃ -Free Ash	19.8	67.2	49.4
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	14.38	2.05	2.46

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	27.7	27.2	24.1
Fe ₂ O ₃	8.2	8.6	7.7
Al ₂ O ₃	10.1	11.0	9
CaO	1.15	1.81	1.12
MgO	0.55	0.62	0.64
TiO ₂	0.44	0.45	0.40
P ₂ O ₅	0.13	0.21	0.09
K ₂ O	0.51	0.06	0.35
K ₂ O, Catalyst	51.10	49.93	45.43
Total	100.0	100.0	100.0

YIELD PERIOD 205

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	42.1
CO	11.9
CH ₄	8.0
CO ₂	11.5
H ₂ S	0.3
H ₂ O	16.5
N ₂	23.3
H ₂ O/CO	1.4
H ₂ O/CO ₂	1.4

Unit Gas Data

Syngas MMT, lbs/mol	9.3
Product Gas MMT (dry), lbs/mol	17.7

Product Gas

At DTM (dry), SCFH	1213.4
(Dry, N ₂ -Free), SCFH	922.8
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1420.3
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	577.4
At Gasifier Outlet, SCFH (Excludes N ₂)	1129.7
At Gasifier Outlet, ACFH (Excludes N ₂)	459.2

YIELD PERIOD 205

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%

H ₂	43.3
CO	12.3
CO ₂	11.8
CH ₄	8.3
H ₂ S	0.4
N ₂	23.9

Product Gas (Dry, N₂-Free)

H ₂	56.9
CO	16.2
CO ₂	15.5
CH ₄	10.9
H ₂ S	0.5

Product Gas

H ₂	37.0
CO	10.5
CO ₂	10.1
CH ₄	7.1
H ₂ S	0.3
H ₂ O	14.6
N ₂	20.5

Product Gas (N₂-Free)

H ₂	46.5
CO	13.2
CO ₂	12.7
CH ₄	8.9
H ₂ S	0.4
H ₂ O	18.3

SCFH CH₄/lb C Active Bed

3.6

SCFH CH₄/lb C Feed

11.2

Moles CH₄/mole C Feed

0.35

Equilibrium Constants	Reaction	Equilibrium at	Actual	Corresponding
		Active Bed Temp	Equilibrium	Temperature
		(1259.1°F)	Expression	(°F)
Graphite-H ₂ O:	C + H ₂ O = CO + H ₂	1.7887	2.0633	1310.5
Shift:	CO + H ₂ O = CO ₂ + H ₂	1.5283	2.4384	1126.1
Methanation:	CO + 3H ₂ = CH ₄ + H ₂ O	0.0701	0.0325	1349.7
Gas. H ₂ :	2C + CH ₄ O = CH ₄ + CO ₂	0.3427	0.3373	

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YIELD: 205
MATERIAL BALANCES

YIELD: 205
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex H ₂)	18.22	Product Gas (ex H ₂)	34.09
Gasifier Steam	22.72	Product Gas H ₂	21.49
Gasifier Syngas	12.15	Product Water	9.24
		Char Entrained	2.56
		Solids Withdrawn	2.05
Total (ex H ₂)	40.09	Total (ex H ₂)	40.09
Accumulation:	-0.61		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	694.6	H ₂ + CO in Product Gas	674.
H ₂ Mol%	72.0	H ₂ Mol%	43.3
CO Mol%	28.0	CO Mol%	12.3
Balance: (Output/Input), %	100.0		

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	8.95	0.586	1.31	0.512	0.013
Gasifier Steam	-	2.52	20.07	0.0	-
Gasifier Syngas	4.40	1.87	5.86	0.0	-
Total	13.35	4.98	27.34	0.512	0.013
<u>Output:</u>					
Product Gas	12.45	3.86	18.38	0.362	-
Product Water	-	1.09	8.74	0.004	-
Char Entrained	0.98	0.01	0.20	0.086	0.007
Solids Withdrawn	0.40	0.01	0.15	0.105	0.003
Total	13.83	4.98	27.47	0.557	0.010
Accumulation:	-0.48	0.00	-0.13	-0.044	0.003
Closure (Out + Accum)/in, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	1.21	0.80
<u>Output:</u>		
Char Entrained	0.59	0.43
Product Water	0.0	0.0
Solid Withdrawn	0.57	0.35
Total	1.16	0.77
Accumulation:	0.05	-0.05
Closure (out + accum)/in, %	100.0	91.2

*Carbon balance excludes catalyst carbonate
**excludes carbon and oxygen in catalyst

YIELD PERIOD 205

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	3.58	2.79	2.85	2.32
<u>Output:</u>				
Entrained Char	1.40	1.35	1.26	1.22
Solids Withdrawn	1.71	1.59	1.38	1.25
Total	3.11	2.94	2.64	2.46
Accumulation:	0.47	-0.15	0.20	-0.14
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.788	0.237	0.286	0.033	0.016	0.996	0.014	0.014	0.004
<u>Output:</u>									
Entrained Char	0.307	0.097	0.118	0.014	0.006	0.255	0.008	0.006	0.001
Solids Withdrawn	0.375	0.119	0.152	0.025	0.009	0.342	0.0	0.006	0.003
Total	0.682	0.216	0.270	0.039	0.015	0.597	0.008	0.012	0.004
Accumulation:	0.106	0.020	0.016	-0.006	0.001	-0.001	0.006	0.002	-0.001
Closure (out + accum)/in, %	100	100	100	100	100	60	100	100	100

YIELD PERIOD 205

MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(0.939)	-	1.878	-	-
CO	(0.366)	0.366	0.0	0.366	-
H ₂ O	(1.261)	-	2.522	1.261	-
Total	(2.566)	0.366	4.400	1.627	-

<u>Solids Input</u>	<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
Coal + Cat Feed	0.746	0.577	0.082	0.016	0.031
<u>Total Input</u>	1.112	4.976	1.709	0.016	0.031

Gas Output

<u>Product Gas</u>	<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.387)	-	2.773	-
CO	(0.393)	0.393	-	0.393
CO ₂	(0.378)	0.378	-	0.755
CH ₄	(0.266)	0.266	1.063	-
H ₂ S	(0.011)	-	0.023	0.011
H ₂ O	(0.546)	-	1.092	0.546
Total	(2.981)	1.037	4.951	1.695

<u>Solids Output</u>	<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
Char Entrained	0.082	0.012	0.013	0.003	0.015
Char Samples Withdrawn	0.033	0.014	0.009	0.003	0.015
Char Accumulation	-0.040	-0.001	-0.008	-0.001	0.001
Total Solids	0.075	0.025	0.014	0.005	0.031
<u>Total Output + Accumulation</u>	1.112	4.976	1.709	0.016	0.031

YIELD PERIOD 205

PROCESS VARIABLES

YIELD PERIOD 205

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	22.63	22.72
V111	Char Withdrawn (lbs/hr)	2.05	2.05
V165	H in Char Entrained (wt%)	0.47	0.47
V166	H in Char Withdrawn (wt%)	0.68	0.68
V168	H in Coal + Catalyst Feed (wt%)	4.04	4.04
V173	H in Gasifier Starting Mid Char (wt%)	0.57	0.57
V174	H in Gasifier Ending Mid Char (wt%)	0.60	0.60
V183	CO in Syngas (mol%)	27.10	28.05
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	9.36	10.11
V188	O in Coal + Catalyst Feed (wt%)	9.06	9.11
V193	H ₂ in Syngas (mol%)	68.90	71.95
V205	CO ₂ in Product Gas (mol%)	11.80	11.80
V207	CH ₄ in Product Gas (mol%)	8.30	9.30
V208	CO in Product Gas (mol%)	12.90	12.29
V212	H ₂ in Product Gas (mol%)	43.00	43.31
V214	N ₂ in Product Gas (mol%)	23.90	23.95
V215	H ₂ S in Product Gas (mol%)	0.35	0.35
V222	Carbon in Char Withdrawn (wt%)	19.37	19.31
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	27.47	27.59
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	33.92	33.53
V257	Carbon in Gasifier Starting Mid Char (wt%)	27.01	28.97
V258	Carbon in Gasifier Ending Mid Char (wt%)	25.76	28.97
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	28.13	28.47
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	33.34	31.41
V289	ASTM Ash in Char Entrained (wt%)	54.55	54.60
V292	ASTM Ash in Char Withdrawn (wt%)	83.53	83.62
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	24.96	24.90
V294	C/H Residue in Feed Coal + Catalyst (wt%)	19.51	19.45
V295	C/H Residue in Char Entrained (wt%)	52.61	52.69
V296	ASTM Ash in Gasifier Starting Mid Char (wt%)	70.31	64.95
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	71.58	76.77

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	77.55	77.69
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	66.99	66.47
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	68.36	68.86
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	21.53	19.80
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	49.58	49.38
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	66.89	67.17
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	58.41	56.09
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	60.63	63.19
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	16.08	16.14
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	47.64	47.55
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	60.91	60.79
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	55.09	55.42
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	57.41	57.08
V407	Coal + Catalyst Feed (lbs/hr)	14.73	14.37
V473	Char Entrained (lbs/hr)	2.56	2.56
V495	Carbon in Feed Coal (wt%)	60.66	62.30
V498	Carbon in Char Entrained (wt%)	38.34	38.25
F384	Syngas Flow Meter (CFH)	46.88	46.84
F385	Product Gas Flow Meter (CFH)	165.80	164.57
PGK0	Product Gas Condensate (lbs/hr)	10.28	9.49
U(114)	Starting Bed ΔP (B-A) (in Hg)	2.40	2.39
U(115)	Starting Bed ΔP (C-B) (in Hg)	3.90	3.86
U(116)	Starting Bed ΔP (D-C) (in Hg)	2.40	2.39
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	8.70	8.64
U(119)	Ending Bed ΔP (B-A) (in Hg)	1.80	1.81
U(120)	Ending Bed ΔP (C-B) (in Hg)	4.10	4.14
U(121)	Ending Bed ΔP (D-C) (in Hg)	2.10	2.11
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	8.00	8.08
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 205

PROCESS VARIABLES

	Measured	Reconciled
EDD(6) Ending Bed ΔP (E-D) (in Hg)		
DP051 Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280 S in Gasifier Starting Mid Char (wt%)	4.32	4.37
V281 S in Gasifier Ending Mid Char (wt%)	4.04	3.99
V187 S in Coal + Catalyst Feed (wt%)	3.48	3.56
V246 S in Char Withdrawn (wt%)	5.19	5.13
V244 S in Char Entrained (wt%)	3.36	3.36
V243 S in Product Gas Condensate (wt%)	0.04	0.04
V862 SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	28.37	28.52
V863 SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	30.18	29.70
V867 SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	27.09	27.70
V868 SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	27.75	27.24
V869 SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	24.11	24.28
V871 Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	7.12	7.26
V872 Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	7.58	7.39
V876 Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.13	8.31
V877 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	8.76	8.64
V878 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.74	7.71
V883 Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.26	10.85
V881 Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	11.55	10.71
V885 Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.61	10.06
V886 Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.38	11.04
V887 Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	9.45	9.32
V889 CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.00	0.90
V890 CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.66	0.70
V894 CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.26	1.15
V895 CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.72	1.81
V896 CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.08	1.12
V822 Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.21	0.18
V823 Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.21	0.24
V827 Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.10	0.09

YIELD PERIOD 205

PROCESS VARIABLES

	Measured	Reconciled
V828 Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.15	0.15
V829 Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.25	0.26
V836 Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.33	0.33
V837 Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.43	0.42
V841 Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.10	0.10
V842 Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.04	0.04
V843 Acid Sol. Na ₂ O in Char Entrained (wt%)	0.32	0.32
V898 MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.59	0.59
V899 MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.59	0.59
V903 MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.55	0.55
V904 MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.62	0.62
V905 MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.48	0.48
V916 TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.44	0.45
V917 TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.49	0.47
V921 TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.48	0.49
V922 TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.46	0.45
V923 TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.50	0.50
V925 P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.05	0.06
V926 P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.05	0.04
V930 P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.11	0.13
V931 P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.26	0.21
V932 P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.10	0.09
V813 N in Starting Mid Char (wt%)	0.20	0.20
V814 N in Ending Mid Char (wt%)	0.22	0.21
V818 N in Coal + Catalyst Feed (wt%)	1.08	1.09
V819 N in Char Withdrawn (wt%)	0.16	0.16
V820 N in Char Entrained (wt%)	0.34	0.34
V805 O in Starting Mid Char (wt%)	9.28	9.62
V806 O in Ending Mid Char (wt%)	8.54	8.21
V810 O in Char Withdrawn (wt%)	7.56	7.40
V811 O in Char Entrained (wt%)	7.97	7.93

YIELD PERIOD 206

UNIT PROCESS VARIABLES

RECONCILED DATA

YIELD PERIOD 206

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	16:30	3-12-77
To	8:30	3-13-77
Duration	16 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1182	
38.4	1268	
32.1	1308	
26.6	1322	
21.2	1309	
16.0	1310	
10.9	1294	
6.4	1275	
0.4	1223	

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	310	125
Lockhopper 1 Bottom	289	132
Lockhopper 2 Top	241	275
Lockhopper 2 Bottom	240	338
Gasifier Feed Line	646	903
Gasifier Steam Line	1046	1105
Gasifier		
Top of Bed	1308	1333
Bottom of Bed	1223	1227
Total Bed Average	1292	1316
Rough Cut Cyclone		
Cyclone Top	980	991
Cyclone Bottom	704	1021
Standpipe Top	817	1007
Standpipe Mid	811	1015
Standpipe Bottom	782	1043
Standpipe Slope Top		1051
Standpipe Slope Bottom	1201	996
Gasifier Backend		
Cyclone Inlet	-	126
Filter Inlet	-	126
Scrubber Inlet	481	472
Scrubber Outlet	66	
Product Gas Meter	85	
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	117.7	
Gasifier Feed Line	116.4	
Bypass H ₂	156.7	
Syngas In	162.2	
Gasifier		
Gasifier Top	112.7	
Gasifier Bottom	116.3	
Rough Cut Cyclone Outlet	112.0	
Filter Outlet	112.6	
Scrubber Outlet	112.6	
Product Gas Meter	114.7	

YIELD PERIOD 206FLUID-SOLIDS DATAGasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	12.0
Bed Top Density (lbs/cf)	28.3
Bed Average Density (lbs/cf)	20.1
Bed Height (ft)	34.9
Bed Holdup (lbs)	124.0
Bed Volume (cf)	5.6
Average Bed Temperature (°F)	1303.0
Space Velocity (bed) (cf/cf/hr)	121.0
Bottom Superficial Velocity (ft/sec)	0.98
Top Superficial Velocity (ft/sec)	1.06

Cyclone Performance

Temperature (°F)	627.0
Pressure (psia)	112.7
Inlet Gas Rate (SCFH)	1533.5
Inlet Gas Rate (ACFH)	418.3
Inlet Gas Velocity (ft/sec)	32.8
Solids Entering (lbs/hr)	3.0
Dust Loading (lbs/acf)	0.0073
Solids Captured (lbs/hr)	2.7
Solids Escaping (lbs/hr)	0.3
Overall Efficiency (Captured/Entering, Wt.%)	90.1

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	15.37
Total Carryover (lbs/hr)	3.04
Cyclone (lbs/hr)	2.74
Filter (lbs/hr)	0.30
Carryover/Feed (Wt.%)	19.8

Solids Carbon Loss

Carbon in Feed (lbs/hr)	9.29
Carbon in Carryover (lbs/hr)	1.03
Carryover/Feed (Wt.%)	11.2

YIELD PERIOD 206UNIT CONVERSIONSCarbon Consumption

Carbon in Feed* (lbs/hr)	9.29
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.69
Carbon Gasified (by difference) (lbs/hr)	5.15
Total Carbon Converted (lbs/hr)	7.84

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	55.4
Total, Including Devolatilization (%)	84.3

Carbon Distribution

Total Converted (%)	84.3
Entrained (%)	10.8
Withdrawn (%)	4.8
Accumulated (%)	0.1
Conversion (Entrainment Backed Out)	94.5

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	18.9
Including Devolatilization	28.8

Steam Consumption

Steam into Unit (lbs/hr)	23.83
Steam Reacted with Carbon (lbs/hr)	7.72
Total Steam Consumed (lbs/hr)	11.83

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	32.4
Total Steam Converted (%)	49.6

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.216
Carbon Converted/Steam Fed (mol/mol)	0.324
Carbon Converted/Bed Volume (lbs/hr)/cft	0.829
Carbon Converted/Bed Volume (mol/hr)/cft	0.069
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.943
Carbon in Bed/Steam Fed mol/(mol/hr)	1.715

*Excludes carbon in catalyst

**Assumed to be standard ASTM devolatilization test of feed coal



YIELD PERIOD 206

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as H_2O	9.7	-	30.8	41.1	33.3
K as K_2CO_3	14.2	-	45.2	45.7	48.8
K as K	8.0	-	25.6	25.8	27.6
K Water Acid, Soluble Ratio	0.661	-	0.0694	0.456	0.798
K_2O, H_2O -Insoluble	3.3	-	9.4	10.7	6.7
K_2CO_3, H_2O -Insoluble	4.8	-	13.8	15.7	9.8
K, H_2O -Insoluble	2.7	-	7.8	8.9	5.6
Carbon	60.5	-	21.8	20.9	33.0
K on Carbon	13.3	-	117.2	123.9	93.7
ASTM Ash	25.6	-	76.4	79.3	60.7
K on Ash	71.3	-	33.5	32.6	45.5
K_2CO_3 Free-Ash	11.3	-	30.5	33.0	11.0
K on K_2CO_3 Free-Ash	71.2	-	33.9	78.2	251.3

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	1.4	2.4	13.8	44.5	81.5	94.9	100.0
Top Char	-	-	-	-	-	-	-
Mid Char	0.4	2.5	16.8	43.6	84.3	92.6	100.0
Bottom Char	0.4	1.6	10.8	36.4	75.7	91.7	100.0
Cyclone	75.0	87.5	99.8	99.9	100.0	100.0	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number		Volume/ Surface		Weight		Bulk Density lbs/cf
	Mean	Mean	Mean	Mean	Mean	Mean	
Feed Coal + Catalyst	34	236	415		51.0		
Top Char	-	-	-		-		
Mid Char	57	244	422		22.6		
Bottom Char	54	285	475		23.6		
Cyclone	22	27	38				
Filter	-	-	-				

*Based on acid soluble analysis

YIELD PERIOD 206

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.93	0.45	0.47
C	60.5	20.9	33.0
S	3.7	5.2	3.4
O	12.3	7.4	10.2
N	1.11	0.12	0.08
Cl	0.09	0.19	0.20
SO_3 -Free Ash	18.4	65.8	52.7
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	15.2	2.15	3.04

Ash Element Analysis

	Wt% of SO_3 -Free Ash		
	Feed	Solids W/D	Entrained
SiO_2	26.4	30.5	20.2
Fe_2O_3	8.5	8.2	7.0
Al_2O_3	9.4	11.0	7.1
CaO	0.99	1.11	0.58
MgO	0.52	0.60	0.34
TiO_2	0.46	0.45	0.47
P_2O_5	0.11	0.20	0.09
Na_2O	0.48	0.55	0.96
K_2O , Catalyst	52.59	47.47	63.17
Total	100.0	100.0	100.0

YIELD PERIOD 206

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	112.7
H ₂	44.6
CO	12.4
CH ₄	8.4
CO ₂	10.8
H ₂ S	0.3
H ₂ O	18.5
N ₂	17.6
H ₂ O/CO	1.5
H ₂ O/CO ₂	1.7

Unit Gas Data

Syngas MWT, lbs/mol	9.2
Product Gas MWT (dry), lbs/mol	16.5

Product Gas

At DTM (dry), SCFH	1281.2
(Dry, N ₂ -Free), SCFH	1041.1
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1533.5
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	631.6
At Gasifier Outlet, SCFH (Excludes N ₂)	1293.4
At Gasifier Outlet, ACFH (Excludes N ₂)	532.7

YIELD PERIOD 206

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	47.4
CO	12.1
CO ₂	11.5
CH ₄	8.9
H ₂ S	0.3
N ₂	18.7

Product Gas (Dry, N ₂ -Free)	
H ₂	58.3
CO	16.2
CO ₂	14.2
CH ₄	11.0
H ₂ S	0.4

Product Gas	
H ₂	39.6
CO	11.0
CO ₂	9.6
CH ₄	7.4
H ₂ S	0.3
H ₂ O	16.5
N ₂	15.7

Product Gas (N ₂ -Free)	
H ₂	47.0
CO	13.0
CO ₂	11.4
CH ₄	8.8
H ₂ S	0.4
H ₂ O	19.4

SCFH CH ₄ /lb C Active Bed	4.2
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SCFH CH ₄ /lb C Feed	12.3
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Moles CH ₄ /mole C Feed	0.39
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Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1303.0°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.8509	2.0234	1312.4
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5150	2.1075	1176.4
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0663	0.0306	1353.7
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3441	0.264	-

YIELD PERIOD 205
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	10.20	Product Gas (ex N ₂)	37.92
Gasifier Steam	23.83	Product Gas N ₂	17.74
Gasifier Syngas	16.01	Product Water	12.00
		Char Entrained	3.04
		Solids Withdrawn	2.15
Total (ex N ₂)	55.04	Total (ex N ₂)	55.15
Accumulation:	-0.14		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	660.6	N ₂ + CO in Product Gas	775.3
H ₂ Mol%	72.4	H ₂ Mol%	47.4
CO Mol%	27.6	CO Mol%	12.1
Balance: (Output/Input), %	117.4		

YIELD PERIOD 206
MATERIAL BALANCES

Elemental Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Slack</u>
Coal + Catalyst**	9.29	0.60	1.59	0.470	-
Gasifier Steam	-	2.67	21.16	-	-
Gasifier Syngas	5.78	2.54	7.59	-	-
Total	15.07	5.81	30.75	0.570	0.01
<u>Output:</u>					
Product Gas	13.61	4.47	19.54	0.376	-
Product Water	-	1.34	10.66	0.005	-
Char Entrained	1.00	0.01	0.31	0.102	0.002
Solids Withdrawn	0.45	0.00	0.16	0.111	0.004
Total	15.07	5.82	30.66	0.594	0.011
Accumulation:	0.0	-0.03	0.08	-0.024	0.007
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. %</u>
Coal + Catalyst	1.23	0.81
<u>Output:</u>		
Char Entrained	0.84	0.53
Product Water	0.0	0.0
Solid Withdrawn	0.56	0.36
Total	1.40	1.09
Accumulation:	-0.17	-0.12
Closure (out + accum)/in	100.0	112.3

*Carbon balance excludes catalyst carbonate
**includes carbon and oxygen in catalyst

YIELD PERIOD 206

MATERIAL BALANCES

Gas Balances

Input (Lbs/Hr):	ASTM Ash	C/H Residue	S0 ₂ -Free ASTM Ash	S0 ₂ -free C/H Residue
Coal + Catalyst	3.03	3.14	2.82	2.00
Output:				
Entrained Char	1.85	1.90	1.60	1.61
Solids Withdrawn	1.77	1.93	1.42	0.75
Total	3.55	2.84	3.02	2.36
Accumulation:	0.38	0.30	-0.19	-0.36
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0

Ash Element Balance

Input (Lbs/Hr):	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	TiO ₂	P ₂ O ₅
Coal + Catalyst	0.758	0.241	0.266	0.028	0.015	1.186	0.013	0.013	0.003
Output:									
Entrained Char	0.324	0.112	0.114	0.009	0.005	0.253	0.015	0.007	0.001
Solids Withdrawn	0.431	0.116	0.155	0.016	0.008	0.289	0.007	0.006	0.003
Total	0.755	0.228	0.269	0.025	0.014	0.542	0.022	0.014	0.004
Accumulation:	0.003	0.013	-0.003	0.003	0.001	0.035	-0.009	-0.001	-0.001
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0	100.0	49.0	100.0	100.0	100.0

YIELD PERIOD 206

MATERIAL BALANCES

Mole Balances

Gas Input	Lb-Moles/Hr			
	C	H	O	S
H ₂ (1.262)	-	2.524	-	-
CO (0.481)	0.481	-	0.481	-
H ₂ O (1.322)	-	2.046	1.322	-
Total (3.065)	0.481	5.109	1.802	-
Solids Input	K	C	H	O
	0.031	0.774	0.599	0.113
Total Input	0.031	1.255	5.768	1.922
Gas Output	C	H	O	S
Product Gas				
H ₂ (1.602)	-	3.204	-	-
CO (0.444)	0.444	-	0.444	-
CO ₂ (0.389)	0.389	-	0.777	-
CH ₄ (0.301)	0.301	1.204	-	-
H ₂ S (0.012)	-	0.023	-	0.012
H ₂ O (0.666)	-	1.332	0.666	-
Total (3.414)	1.133	5.763	1.887	0.012
Solids Output	K	C	H	O
Char Entrained	0.021	0.084	0.014	0.019
Char Samples Withdrawn	0.014	0.037	0.010	0.010
Char Accumulation	-0.004	0.0	-0.019	0.005
Total Solids	0.031	0.121	0.005	0.034
Total Output + Accumulation	0.031	1.255	5.768	1.922

YIELD PERIOD 206

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	23.76	23.82
V111	Char Withdrawn (lbs/hr)	2.15	2.15
V165	H in Char Entrained (wt%)	0.47	0.47
V166	H in Char Withdrawn (wt%)	0.45	0.45
V168	H in Coal + Catalyst Feed (wt%)	3.93	3.93
V173	H in Gasifier Starting Mid Char (wt%)	0.57	0.57
V174	H in Gasifier Ending Mid Char (wt%)	0.27	0.27
V183	C in Syngas (mol%)	27.50	27.50
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	9.52	9.65
V188	O in Coal + Catalyst Feed (wt%)	12.30	12.33
V193	H ₂ in Syngas (mol%)	69.20	72.41
V205	CO ₂ in Product Gas (mol%)	11.50	11.50
V207	CH ₄ in Product Gas (mol%)	8.90	8.90
V208	CO in Product Gas (mol%)	12.90	13.13
V212	H ₂ in Product Gas (mol%)	47.80	47.39
V214	N ₂ in Product Gas (mol%)	19.00	18.74
V215	H ₂ S in Product Gas (mol%)	0.35	0.35
V222	Carbon in Char Withdrawn (wt%)	20.85	20.85
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	33.56	33.27
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	31.12	31.24
V257	Carbon in Gasifier Starting Mid Char (wt%)	22.45	21.02
V258	Carbon in Gasifier Ending Mid Char (wt%)	21.17	21.61
V260	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	31.58	31.64
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	30.01	29.15
V299	ASTM Ash in Char Entrained (wt%)	60.65	60.70
V292	ASTM Ash in Char Withdrawn (wt%)	79.33	79.39
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	25.62	25.57
V294	C/H Residue in Feed Coal + Catalyst (wt%)	40.45	40.42
V295	C/H Residue in Char Entrained (wt%)	62.56	62.62
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	76.47	72.29
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	76.26	80.31

YIELD PERIOD 206

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	43.50	43.52
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	74.66	74.62
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	80.93	81.20
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	17.80	18.36
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	52.33	52.67
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	65.92	65.82
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	60.46	64.97
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	68.41	63.42
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	12.71	13.05
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	54.24	53.08
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	35.15	34.81
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	61.65	64.70
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	63.71	60.50
V407	Coal + Catalyst Feed (lbs/hr)	15.69	15.37
V473	Char Entrained (lbs/hr)	3.04	3.04
V495	Carbon in Feed Coal (wt%)	61.03	60.48
V498	Carbon in Char Entrained (wt%)	33.57	32.90
F384	Syngas Flow Meter (CFH)	63.13	62.55
F385	Product Gas Flow Meter (CFH)	162.41	173.61
PGK0	Product Gas Condensate (lbs/hr)	12.44	11.64
U(114)	Starting Bed ΔP (B-A) (in Hg)	1.70	1.70
U(115)	Starting Bed ΔP (C-B) (in Hg)	4.29	4.29
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.90	1.90
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.01	0.01
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	7.89	7.89
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.07	2.07
U(120)	Ending Bed ΔP (C-B) (in Hg)	4.00	4.00
U(121)	Ending Bed ΔP (D-C) (in Hg)	1.60	1.60
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	7.80	7.80
EU0(1)	Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 206

PROCESS VARIABLES

YIELD PERIOD 206

PROCESS VARIABLES

		Measured	Reconciled
LOD(6)	Ending Bed ΔP (E-D) (in Hg)	0.00	0.00
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.99	4.97
V281	S in Gasifier Ending Mid Char (wt%)	4.73	4.70
V187	S in Coal + Catalyst Feed (wt%)	3.67	3.71
V246	S in Char Withdrawn (wt%)	5.17	5.18
V244	S in Char Entrained (wt%)	3.38	3.36
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	29.62	30.12
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	32.51	31.70
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.52	26.88
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	30.45	30.48
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	20.54	20.22
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	7.51	7.67
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.59	8.38
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.39	8.53
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	8.23	8.18
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.10	7.02
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.62	10.85
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	11.61	11.31
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.30	9.44
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.01	10.95
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.22	7.15
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.96	0.78
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.78	0.89
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.17	0.99
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.04	1.11
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	0.56	0.58
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.21	0.19
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.19	0.21
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.10	0.09

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.18	0.18
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.27	0.29
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.47	0.45
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.33	0.34
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.09	0.09
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.36	0.36
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.50	0.51
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.61	0.61
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.67	0.67
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.52	0.52
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.60	0.60
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.34	0.34
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.48	0.49
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.50	0.49
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.46	0.46
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.45	0.45
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.47	0.47
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.09	0.08
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.05	0.05
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.12	0.11
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.19	0.20
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.09	0.09
V813	N in Starting Mid Char (wt%)	0.16	0.16
V814	N in Ending Mid Char (wt%)	0.07	0.07
V818	N in Coal + Catalyst Feed (wt%)	1.11	1.11
V819	N in Char Withdrawn (wt%)	0.12	0.12
V820	N in Char Entrained (wt%)	0.08	0.08
V805	O in Starting Mid Char (wt%)	8.16	8.12
V806	O in Ending Mid Char (wt%)	9.83	9.72
V810	O in Char Withdrawn (wt%)	7.33	7.36
V811	O in Char Entrained (wt%)	10.37	10.16

RECONCILED DATA

YIELD PERIOD 207UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	8:30	3-13-77
To	8:30	3-14-78
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1187	
38.4	1271	
32.1	1309	
26.6	1324	
21.2	1311	
16.0	1313	
10.9	1296	
6.4	1276	
0.4	1225	

YIELD PERIOD 207UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	301	319
Lockhopper 1 Bottom	286	231
Lockhopper 2 Top	240	276
Lockhopper 2 Bottom	240	326
Gasifier Feed Line	645	900
Gasifier Steam Line	1043	1102
Gasifier		
Top of Bed	1309	1335
Bottom of Bed	1225	1227
Total Bed Average	1293	1317
Rough Cut Cyclone		
Cyclone Top	981	991
Cyclone Bottom	698	1023
Standpipe Top	818	1003
Standpipe Mid	814	1016
Standpipe Bottom	786	1043
Standpipe Slope Top		1052
Standpipe Slope Bottom	1202	998
Gasifier Backend		
Cyclone Inlet	-	631
Filter Inlet	-	581
Scrubber Inlet	486	478
Scrubber Outlet	73	-
Product Gas Meter	88	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	118.4	
Gasifier Feed Line	117.3	
Bypass N ₂	162.4	
Syngas In	162.6	
Gasifier		
Gasifier Top	113.7	
Gasifier Bottom	117.2	
Rough Cut Cyclone Outlet	113.7	
Filter Outlet	113.6	
Scrubber Outlet	113.6	
Product Gas Meter	114.7	

YIELD PERIOD 207
FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	10.7
Bed Top Density (lbs/cf)	19.5
Bed Average Density (lbs/cf)	15.1
Bed Height (ft)	30.2
Bed Holdup (lbs)	91.7
Bed Volume (cf)	5.5
Average Bed Temperature (°F)	1304.8
Space Velocity (bed) (cf/cf/hr)	123.3
Bottom Superficial Velocity (ft/sec)	0.96
Top Superficial Velocity (ft/sec)	1.05

Cyclone Performance

Temperature (°F)	631.0
Pressure (psia)	113.7
Inlet Gas Rate (SCFH)	1539.2
Inlet Gas Rate (ACFH)	417.7
Inlet Gas Velocity (ft/sec)	32.8
Solids Entering (lbs/hr)	2.8
Dust Loading (lbs/acf)	0.0368
Solids Captured (lbs/hr)	2.6
Solids Escaping (lbs/hr)	0.3
Overall Efficiency (Captured/Entering, Wt.%)	90.1

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	15.46
Total Carryover (lbs/hr)	2.00
Cyclone (lbs/hr)	2.56
Filter (lbs/hr)	0.20
Carryover/Feed (Wt.%)	13.4

Solids Carbon Loss

Carbon in Feed (lbs/hr)	9.52
Carbon in Carryover (lbs/hr)	1.16
Carryover/Feed (Wt.%)	12.2

YIELD PERIOD 207

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	9.52
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.45
Carbon Gasified (by difference) (lbs/hr)	5.35
Total Carbon Converted (lbs/hr)	7.80

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	58.2
Total, Including Devolatilization (%)	81.9

Carbon Distribution

Total Converted (%)	81.9
Entrained (%)	11.6
Withdrawn (%)	5.8
Accumulated (%)	0.7
Conversion (Entrainment Backed Out)	92.7

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	26.9
Including Devolatilization	39.3

Steam Consumption

Steam into Unit (lbs/hr)	22.95
Steam Reacted with Carbon (lbs/hr)	6.02
Total Steam Consumed (lbs/hr)	16.65

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	35.0
Total Steam Converted (%)	46.6

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.233
Carbon Converted/Steam Fed (mol/mol)	0.350
Carbon Converted/Bed Volume (lbs/hr)/cft	0.879
Carbon Converted/Bed Volume (mol/hr)/cft	0.073
Carbon in Bed/Steam Fed lbs/(lbs/hr)	0.865
Carbon in Bed/Steam Fed mol/(mol/hr)	1.208

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal



YIELD PERIOD 207

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	8.9	-	33.3	29.7	28.2
K as K ₂ CO ₃	13.0	-	48.9	43.6	41.3
K as K	7.4	-	27.7	24.6	23.4
K Water/Acid, Soluble Ratio	0.602	-	0.590	0.585	0.744
K ₂ O, H ₂ O-Insoluble	3.5	-	13.7	12.3	7.2
K ₂ CO ₃ , H ₂ O-Insoluble	5.2	-	20.1	18.1	10.6
K, H ₂ O-Insoluble	2.9	-	11.3	10.2	6.0
Carbon	61.6	-	21.6	24.9	39.1
K on Carbon	12.0	-	127.8	99.1	59.8
ASTM Ash	25.4	-	70.8	69.3	59.4
K on Ash	29.0	-	39.0	35.6	39.4
K ₂ CO ₃ Free-Ash	12.1	-	21.0	25.0	17.3
K on K ₂ CO ₃ Free-Ash	60.7	-	131.4	98.6	135.0

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	1.2	2.2	12.3	43.2	81.2	96.2	100.0
Top Char	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mid Char	3.8	6.6	21.4	49.0	81.9	94.2	99.9
Bottom Char	1.6	2.7	13.6	41.2	78.2	93.3	100.0
Cyclone	68.2	83.4	99.1	99.7	99.6	98.9	100.0
Filter	87.9	87.3	97.6	99.9	100.0	100.0	100.0

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	35	245	411	45.0
Top Char	-	-	-	-
Mid Char	28	175	396	21.9
Bottom Char	32	238	442	25.0
Cyclone	23	29	53	
Filter	22	24	40	

*Based on acid soluble analysis

YIELD PERIOD 207

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, lbs		
	Feed	Solids W/O	Entrained
H	3.64	0.95	0.26
C	61.6	26.4	70.1
S	4.2	4.9	4.6
O	12.5	5.8	9.1
N	0.87	0.12	0.13
Cl	0.08	0.15	0.28
SO ₃ -Free Ash	17.2	61.7	60.2
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	15.32	2.07	2.84

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/O	Entrained
SiO ₂	26.8	29.9	21.0
Fe ₂ O ₃	8.6	9.6	7.0
Al ₂ O ₃	9.6	11.3	7.5
CaO	1.44	1.50	1.34
MgO	0.60	0.67	0.43
TiO ₂	0.52	0.46	0.56
P ₂ O ₅	0.11	0.14	0.08
Na ₂ O	0.85	0.63	0.93
K ₂ O, Catalyst	51.48	45.77	60.97
Total	100.0	100.0	100.0

YIELD PERIOD 207

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	48.3
CO	11.5
CH ₄	8.9
CO ₂	9.9
H ₂ S	0.4
H ₂ O	19.1
N ₂	15.6
H ₂ O/CO	1.7
H ₂ O/CO ₂	1.9

Unit Gas Data

Syngas MWT, lbs/mol	7.8
Product Gas MWT (dry), lbs/mol	15.3

Product Gas

At DTM (dry), SCFH	1280.5
(Dry, N ₂ -Free), SCFH	1069.0
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1539.2
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	630.3
At Gasifier Outlet, SCFH (Excludes N ₂)	1327.6
At Gasifier Outlet, ACFH (Excludes N ₂)	543.6

YIELD PERIOD 207

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%

H ₂	51.1
CO	12.1
CO ₂	10.5
CH ₄	9.4
H ₂ S	0.4
N ₂	16.5

Product Gas (Dry, N₂-Free)

H ₂	61.2
CO	14.5
CO ₂	12.6
CH ₄	11.3
H ₂ S	0.5

Product Gas

H ₂	42.5
CO	10.1
CO ₂	8.7
CH ₄	7.8
H ₂ S	0.3
H ₂ O	16.8
N ₂	13.7

Product Gas (N₂-Free)

H ₂	49.2
CO	11.7
CO ₂	10.2
CH ₄	9.1
H ₂ S	0.4
H ₂ O	19.4

SCFH CH ₄ /lb C Active Bed	6.1
SCFH CH ₄ /lb C Feed	12.6
Moles CH ₄ /mole C Feed	0.40

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1304.8°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.8833	1.9748	1309.9
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5083	2.1865	1163.4
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0644	0.0284	1358.7
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3445	0.2421	

YIELD PERIOD 207
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	15.32	Product Gas (ex N ₂)	36.11
Gasifier Steam	22.95	Product Gas N ₂	15.64
Gasifier Syngas	15.20	Product Water	12.30
		Char Entrained	2.84
		Solids Withdrawn	2.07
Total (ex N ₂)	53.47	Total (ex N ₂)	52.33
Accumulation:	0.14		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	739.3	H ₂ + CO in Product Gas	405.2
H ₂ Mol%	77.8	H ₂ Mol%	51.1
CO Mol%	22.2	CO Mol%	12.1
Balance: (Output/Input), %	104.5		

YIELD PERIOD 207
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	9.52	0.56	1.93	0.642	0.012
Gasifier Steam	0.0	2.57	20.38	0.0	0.0
Gasifier Syngas	5.20	3.06	6.93	0.0	0.0
Total	14.72	6.19	29.24	0.642	0.012
<u>Output:</u>					
Product Gas	13.00	4.78	17.92	0.411	0.0
Product Water	0.0	1.38	10.92	0.005	0.0
Char Entrained	1.11	0.01	0.27	0.126	0.008
Solids Withdrawn	0.55	0.02	0.12	0.102	0.003
Total	14.66	6.19	29.23	0.644	0.011
Accumulation:	0.06	0.0	0.01	-0.003	0.001
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	1.14	0.69
<u>Output:</u>		
Char Entrained	0.66	0.49
Product Water	0.0	0.0
Solid Withdrawn	0.49	0.30
Total	1.15	0.79
Accumulation:	-0.01	0.02
Closure (out + accum)/In	100.0	119.1

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 207

MATERIAL BALANCES

YIELD PERIOD 207

MATERIAL BALANCES

Ash Balances

Input (Lbs/Hr):	ASTM Ash	C/H Residue	SO ₃ -Free ASTM Ash	SO ₃ -Free C/H Residue
Coal + Catalyst	3.93	3.42	2.66	2.38
Output:				
Entrained Char	1.69	1.80	1.31	1.45
Solids Withdrawn	1.44	1.42	1.28	1.10
Total	3.13	3.21	2.59	2.55
Accumulation:	100.0%	100.0%	100.0%	100.0%
Closure (out + accum)/in, %				

Ash Element Balance

Input (Lbs/Hr):	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	TiO ₂	P ₂ O ₅
Coal + Catalyst	0.715	0.229	0.255	0.038	0.016	1.217	0.023	0.014	0.003
Output:									
Entrained Char	0.279	0.092	0.098	0.018	0.006	0.278	0.012	0.007	0.001
Solids Withdrawn	0.382	0.123	0.145	0.019	0.009	0.270	0.008	0.008	0.002
Total	0.662	0.214	0.243	0.037	0.014	0.549	0.020	0.012	0.003
Accumulation:	0.053	0.015	0.012	0.002	0.002	0.126	0.003	0.001	0.0
Closure (out + accum)/in, %	100	100	100	100	100	55	100	100	100

Mole Balance

Gas Input		Lb-Moles/Hr			
		C	H	O	S
H ₂	(1.517)	-	3.035	-	-
CO	(0.433)	0.433	-	0.433	-
H ₂ O	(1.274)	-	2.547	1.274	-
Total		0.433	5.582	1.707	-
Solids Input					
		C	H	O	S
Coal + Cat Feed		0.792	0.558	0.120	0.020
Total Input					
		1.226	6.140	1.827	0.020

Gas Output

Product Gas		C	H	O	S
H ₂	(1.725)	-	3.450	-	-
CO	(0.410)	0.410	-	0.410	-
CO ₂	(0.355)	0.355	-	0.710	-
CH ₄	(0.318)	0.318	1.271	-	-
H ₂ S	(0.013)	-	0.026	-	0.013
H ₂ O	(0.683)	-	1.365	0.683	0.0
Total		1.083	6.112	1.802	0.013

Solids Output

Solids Output		C	H	O	S	K
Char Entrained		0.093	0.008	0.017	0.004	0.017
Char Samples Withdrawn		0.045	0.020	0.007	0.003	0.012
Char Accumulation		0.005	0.001	0.001	0.0	0.0
Total Solids		0.143	0.028	0.025	0.007	0.029
Total Output + Accumulation						
		0.226	6.140	1.827	0.020	0.029

YIELD PERIOD 207

PROCESS VARIABLES

	Measured	Reconciled
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V100	Gasifier Steam (lbs/hr)	22.88	22.95
V111	Char Withdrawn (lbs/hr)	2.07	2.07
V165	H in Char Entrained (wt%)	0.28	0.28
V166	H in Char Withdrawn (wt%)	0.95	0.95
V168	H in Coal + Catalyst Feed (wt%)	3.63	3.64
V173	H in Gasifier Starting Mid Char (wt%)	0.46	0.46
V174	H in Gasifier Ending Mid Char (wt%)	0.46	0.46
V183	CO in Syngas (mol%)	22.60	22.21
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	9.11	8.87
V188	O in Coal + Catalyst Feed (wt%)	12.41	12.46
V193	H ₂ in Syngas (mol%)	73.50	77.78
V205	CO ₂ in Product Gas (mol%)	19.50	10.50
V207	CH ₄ in Product Gas (mol%)	9.40	9.40
V208	CO in Product Gas (mol%)	11.40	12.14
V212	H ₂ in Product Gas (mol%)	51.90	51.05
V214	N ₂ in Product Gas (mol%)	16.70	16.52
V215	H ₂ S in Product Gas (mol%)	0.45	0.38
V222	Carbon in Char Withdrawn (wt%)	26.77	26.36
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	27.68	28.16
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	29.69	28.25
V257	Carbon in Gasifier Starting Mid Char (wt%)	22.77	23.37
V258	Carbon in Gasifier Ending Mid Char (wt%)	22.77	24.08
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	33.31	37.27
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	33.31	35.58
V289	ASTM Ash in Char Entrained (wt%)	58.22	59.40
V292	ASTM Ash in Char Withdrawn (wt%)	69.25	69.43
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	25.59	25.40
V294	C/H Residue in Feed Coal + Catalyst (wt%)	22.51	22.12
V295	C/H Residue in Char Entrained (wt%)	62.75	63.31
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	70.82	61.95
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	70.82	80.02

YIELD PERIOD 207

PROCESS VARIABLES

	Measured	Reconciled
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V310	C/H Residue in Char Withdrawn (wt%)	67.84	68.32
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	69.76	68.42
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	69.76	71.15
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	17.66	17.23
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	49.68	46.20
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	60.57	61.71
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	62.78	61.82
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	62.78	61.44
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.58	15.39
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	52.96	50.99
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	54.83	53.29
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	58.62	61.86
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	58.62	55.26
V407	Coal + Catalyst Feed (lbs/hr)	16.28	15.46
V473	Char Entrained (lbs/hr)	2.84	2.84
V495	Carbon in Feed Coal (wt%)	61.56	61.57
V498	Carbon in Char Entrained (wt%)	35.95	39.13
F384	Syngas Flow Meter (CFH)	70.50	70.16
F385	Product Gas Flow Meter (CFH)	167.20	174.13
PGKQ	Product Gas Condensate (lbs/hr)	12.88	11.92
U(114)	Starting Bed ΔP (B-A) (in Hg)	1.40	1.40
U(115)	Starting Bed ΔP (C-B) (in Hg)	3.00	2.99
U(116)	Starting Bed ΔP (D-C) (in Hg)	2.80	2.79
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	7.20	7.17
U(119)	Ending Bed ΔP (B-A) (in Hg)	1.70	1.70
U(120)	Ending Bed ΔP (C-B) (in Hg)	2.90	2.92
U(121)	Ending Bed ΔP (D-C) (in Hg)	2.80	2.82
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	7.40	7.44
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 207

PROCESS VARIABLES

YIELD PERIOD 207

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed AP (E-D) (in Hg)	0.00	0.00
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.53	4.68
V281	S in Gasifier Ending Mid Char (wt%)	4.53	4.45
V187	S in Coal + Catalyst Feed (wt%)	3.78	4.15
V246	S in Char Withdrawn (wt%)	5.30	4.94
V244	S in Char Entrained (wt%)	4.44	4.43
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	23.32	22.95
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	23.32	24.45
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	28.43	26.84
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	31.92	29.92
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	20.44	21.29
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	5.66	5.47
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	5.66	5.90
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.29	8.59
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.51	9.60
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	6.75	6.98
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.99	8.93
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.99	9.16
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.75	9.56
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.57	11.31
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.38	7.49
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.81	0.79
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.81	0.84
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.54	1.44
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.48	1.50
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.30	1.34
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.18	0.17
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.18	0.19
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.09	0.08

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.15	0.15
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.26	0.28
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.51	0.50
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.51	0.52
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.15	0.15
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.39	0.39
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.42	0.43
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.45	0.42
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.45	0.48
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.68	0.60
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.64	0.67
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.41	0.42
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.34	0.32
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.34	0.36
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.60	0.52
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.45	0.46
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.47	0.50
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.04	0.04
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.04	0.04
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.12	0.11
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.14	0.14
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.08	0.08
V813	N in Starting Mid Char (wt%)	0.11	0.11
V814	N in Ending Mid Char (wt%)	0.11	0.11
V818	N in Coal + Catalyst Feed (wt%)	0.87	0.87
V819	N in Char Withdrawn (wt%)	0.12	0.12
V820	N in Char Entrained (wt%)	0.13	0.13
V805	O in Starting Mid Char (wt%)	9.17	9.38
V806	O in Ending Mid Char (wt%)	9.17	9.27
V810	O in Char Withdrawn (wt%)	6.14	5.76
V811	O in Char Entrained (wt%)	9.26	9.55

RECONCILED DATA
YIELD PERIOD 208
UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	8:30	3-16-77
To	0:30	3-17-77
Duration	16 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1137	
38.4	1168	
32.1	1213	
26.6	1230	
21.2	1220	
16.0	1220	
10.9	1206	
6.4	1200	
0.4	1077	

YIELD PERIOD 208
UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	296	311
Lockhopper 1 Bottom	286	238
Lockhopper 2 Top	246	301
Lockhopper 2 Bottom	232	322
Gasifier Feed Line	670	919
Gasifier Steam Line	1072	1140
Gasifier		
Top of Bed	1230	1267
Bottom of Bed	1077	1108
Total Bed Average	1192	1210
Rough Cut Cyclone		
Cyclone Top	933	994
Cyclone Bottom	701	1023
Standpipe Top	820	999
Standpipe Mid	818	1017
Standpipe Bottom	791	1042
Standpipe Slope Top		1052
Standpipe Slope Bottom	1083	1000
Gasifier Backend		
Cyclone Inlet	-	519
Filter Inlet	-	461
Scrubber Inlet	422	400
Scrubber Outlet	79	
Product Gas Meter	91	-
<u>Unit Pressures</u>	<u>Psig</u>	
Lockhopper 2	115.8	
Gasifier Feed Line	116.9	
Bypass N ₂	161.7	
Syngas In	161.7	
Gasifier		
Gasifier Top	112.7	
Gasifier Bottom	117.1	
Rough Cut Cyclone Outlet	112.3	
Filter Outlet	112.6	
Scrubber Outlet	112.6	
Product Gas Meter	116.7	

YIELD PERIOD 208

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	18.0
Bed Top Density (lbs/cf)	22.2
Bed Average Density (lbs/cf)	20.1
Bed Height (ft)	32.1
Bed Holdup (lbs)	114.8
Bed Volume (cf)	5.1
Average Bed Temperature (°F)	1215.2
Space Velocity (bed) (cf/cf/hr)	74.4
Bottom Superficial Velocity (ft/sec)	0.52
Top Superficial Velocity (ft/sec)	0.59

Cyclone Performance

Temperature (°F)	519.0
Pressure (psia)	112.7
Inlet Gas Rate (SCFH)	903.0
Inlet Gas Rate (ACFH)	221.8
Inlet Gas Velocity (ft/sec)	17.4
Solids Entering (lbs/hr)	1.0
Dust Loading (lbs/acf)	0.0053
Solids Captured (lbs/hr)	0.9
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.0

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	8.55
Total Carryover (lbs/hr)	0.95
Cyclone (lbs/hr)	0.85
Filter (lbs/hr)	0.10
Carryover/Feed (Wt.%)	11.2

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.49
Carbon in Carryover (lbs/hr)	0.55
Carryover/Feed (Wt.%)	10.1

YIELD PERIOD 208

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	5.49
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.77
Carbon Gasified (by difference) (lbs/hr)	1.73
Total Carbon Converted (lbs/hr)	3.49

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	31.5
Total, Including Devolatilization (%)	63.7

Carbon Distribution

Total Converted (%)	63.7
Entrained (%)	9.6
Withdrawn (%)	29.3
Accumulated (%)	-2.6
Conversion (Entrainment Backed Out)	70.5

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	3.3
Including Devolatilization	6.7

Steam Consumption

Steam into Unit (lbs/hr)	13.08
Steam Reacted with Carbon (lbs/hr)	2.59
Total Steam Consumed (lbs/hr)	5.18

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	19.8
Total Steam Converted (%)	39.6

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.132
Carbon Converted/Steam Fed (mol/mol)	0.198
Carbon Converted/Bed Volume (lbs/hr)/cft	0.302
Carbon Converted/Bed Volume (mol/hr)/cft	0.025
Carbon in Bed/Steam Fed lbs/(lbs/hr)	3.985
Carbon in Bed/Steam Fed mol/(mol/hr)	5.979

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 208
UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	9.4	-	20.1	17.8	18.2
K as K ₂ CO ₃	13.8	-	29.5	26.1	26.7
K as K	7.8	-	16.7	14.8	15.1
K Water/Acid, Soluble Ratio	0.676	-	0.724	0.601	0.838
K ₂ O, H ₂ O-Insoluble	3.1	-	5.5	7.1	2.9
K ₂ CO ₃ , H ₂ O-Insoluble	4.5	-	8.1	10.4	4.3
K, H ₂ O-Insoluble	2.5	-	4.6	5.9	2.4
Carbon	64.1	-	45.4	44.9	55.6
K on Carbon	12.2	-	36.7	32.9	27.1
ASTM Ash	24.4	-	50.9	51.9	42.3
K on Ash	32.0	-	32.7	28.5	35.7
K ₂ CO ₃ Free-Ash	10.5	-	21.1	25.3	15.2
K on K ₂ CO ₃ Free-Ash	74.8	-	79.1	58.3	99.1

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	0.8	1.6	11.5	39.8	76.8	93.4	100.0
Top Char	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mid Char	0.5	1.0	11.3	35.9	74.0	90.4	100.0
Bottom Char	0.1	0.9	7.7	31.7	72.4	90.9	100.0
Cyclone	38.5	46.9	65.1	82.3	96.3	97.9	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	39	266	452	50.9
Top Char	-	-	-	-
Mid Char	47	287	489	20.0
Bottom Char	81	322	504	21.9
Cyclone	23	46	176	-
Filter	-	-	-	-

*Based on acid soluble analysis

YIELD PERIOD 208
SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.19	1.11	0.40
C	64.1	45.8	55.6
S	3.9	3.7	2.4
O	8.7	8.3	9.2
N	1.11	0.31	0.28
Cl	0.08	0.15	0.17
SO ₃ -Free Ash	18.0	40.7	32.0
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	8.57	3.51	0.96

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	27.7	32.8	24.8
Fe ₂ O ₃	7.9	8.6	6.9
Al ₂ O ₃	9.4	10.3	8.9
CaO	1.19	1.25	0.88
MgO	0.53	0.61	0.49
TiO ₂	0.47	0.45	0.45
P ₂ O ₅	0.10	0.10	0.09
Na ₂ O	0.44	0.65	0.69
K ₂ O, Catalyst	52.34	45.21	56.80
Total	100.0	100.0	100.0

YIELD PERIOD 208

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	112.7
H ₂	48.9
CO	8.0
CH ₄	8.6
CO ₂	9.7
H ₂ S	0.3
H ₂ O	20.7
N ₂	16.4
H ₂ O/CO	2.6
H ₂ O/CO ₂	2.1

Unit Gas Data

Syngas MMT, lbs/mol	7.7
Product Gas MMT (dry), lbs/mol	14.8

Product Gas

At DTM (dry), SCFH	736.7
(Dry, N ₂ -Free), SCFH	605.3
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	903.0
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	361.7
At Gasifier Outlet, SCFH (Excludes N ₂)	771.5
At Gasifier Outlet, ACFH (Excludes N ₂)	309.1

YIELD PERIOD 208

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%

H ₂	53.2
CO	8.7
CO ₂	10.6
CH ₄	9.4
H ₂ S	0.3
N ₂	17.8

Product Gas (Dry, N₂-Free)

H ₂	64.7
CO	10.6
CO ₂	12.9
CH ₄	11.4
H ₂ S	0.3

Product Gas

H ₂	43.4
CO	7.1
CO ₂	816
CH ₄	7.7
H ₂ S	0.2
H ₂ O	18.4
N ₂	14.6

Product Gas (N₂-Free)

H ₂	50.8
CO	8.3
CO ₂	10.7
CH ₄	9.0
H ₂ S	0.2
H ₂ O	21.6

SCFH CH₄/lb C Active Bed

SCFH CH₄/lb C Feed

Moles CH₄/mole C Feed

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1215.2°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	0.7708	1.2790	1264.9
Shift: CO + H ₂ O = CO ₂ + H ₂	1.8947	2.8811	1072.1
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.2829	0.0415	1333.3
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3185	0.1956	-

YIELD PERIOD 208
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	3.47	Product Gas (ex N ₂)	19.00
Gasifier Steam	13.08	Product Gas N ₂	9.72
Gasifier Syngas	9.39	Product Water	7.91
		Char Entrained	0.96
		Solids Withdrawn	3.51
Total (ex N ₂)	30.94	Total (ex N ₂)	31.37
Accumulation:	-0.43		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	462.9	H ₂ + CO in Product Gas	455.8
H ₂ Mol%	78.2	H ₂ Mol%	53.2
CO Mol%	21.8	CO Mol%	8.7
Balance: (Output/Input), %	98.5		

YIELD PERIOD 208
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	5.49	0.36	0.74	0.332	0.007
Gasifier Steam	-	1.46	11.62	-	-
Gasifier Syngas	3.20	1.93	4.26	-	-
Total	8.69	3.75	16.62	-0.332	0.007
<u>Output:</u>					
Product Gas	6.69	2.83	9.29	0.179	-
Product Water	-	0.88	7.02	0.003	-
Char Entrained	0.53	0.0	0.09	0.023	0.02
Solids Withdrawn	1.61	0.04	0.29	0.131	0.05
Total	8.83	3.75	16.69	0.336	0.07
Accumulation:	-0.15	0.0	-0.07	-0.003	0.0
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	0.67	0.45
<u>Output:</u>		
Char Entrained	0.14	0.12
Product Water	0.0	0.0
Solid Withdrawn	0.54	0.31
Total	0.68	0.43
Accumulation:	-0.01	-0.27
Closure (out + accum)/in	100.0	36.8

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 208

MATERIAL BALANCES

Ash Balances

Input (Lbs/Hr):	ASTM Ash	C/H Residue	SO ₃ -Free ASTM Ash	SO ₃ -Free C/H Residue
Coal + Catalyst	2.09	1.55	1.54	1.10
Output:				
Entrained Char	0.41	0.38	0.31	0.30
Solids Withdrawn	1.82	1.64	1.43	1.27
Total	2.23	2.02	1.74	1.57
Accumulation:	-0.14	-0.46	-0.19	-0.47
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0

Ash Element Balance

Input (Lbs/Hr):	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	TiO ₂	P ₂ O ₅
Coal + Catalyst	0.427	0.121	0.145	0.018	0.008	0.612	0.007	0.007	0.002
Output:									
Entrained Char	0.076	0.021	0.027	0.003	0.002	0.075	0.0	0.001	0.0
Solids Withdrawn	0.469	0.123	0.147	0.018	0.009	0.348	0.009	0.006	0.001
Total	0.545	0.145	0.174	0.021	0.010	0.423	0.009	0.008	0.002
Accumulation:	-0.119	-0.023	-0.029	-0.002	-0.002	-0.059	-0.001	0.0	0.0
Closure (out + accum)/in, %	100	100	100	100	100	59	100	100	100

YIELD PERIOD 208

MATERIAL BALANCES

Mole Balance

Gas Balance		Lb-Moles/Hr				
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	
H ₂	(0.955)	-	1.910	0.0	-	
CO	(0.266)	0.266	0.0	0.266	-	
H ₂ O	(0.726)	-	1.452	0.726	-	
Total	(1.947)	0.266	3.362	0.992	-	
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
Coal + Cat Feed		0.457	0.356	0.046	0.010	0.017
<u>Total Input</u>		0.723	3.718	1.039	0.010	0.017
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	
Product Gas						
H ₂	(1.034)	-	2.068	-	-	
CO	(0.169)	0.169	-	0.169	-	
CO ₂	(0.206)	0.206	-	0.412	-	
CH ₄	(0.183)	0.183	0.731	-	-	
H ₂ S	(0.006)	-	0.011	-	0.006	
H ₂ O	(0.439)	-	0.878	0.439	-	
Total	(2.037)	0.557	3.688	1.019	0.006	
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>X</u>
Char Entrained		0.044	0.004	0.006	0.001	0.004
Char Samples Withdrawn		0.134	0.039	0.018	0.004	0.014
Char Accumulation		0.0	-0.012	-0.004	0.0	0.0
Total Solids		0.166	0.030	0.019	0.005	0.017
<u>Total Output + Accumulation</u>		0.723	3.718	1.039	0.010	0.017

YIELD PERIOD 208

PROCESS VARIABLES

YIELD PERIOD 208

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	13.01	13.08
V111	Char Withdrawn (lbs/hr)	3.51	3.51
V165	H in Char Entrained (wt%)	0.40	0.40
V166	H in Char Withdrawn (wt%)	1.11	1.11
V168	H in Coal + Catalyst Feed (wt%)	4.17	4.19
V173	H in Gasifier Starting Mid Char (wt%)	1.04	1.04
V174	H in Gasifier Ending Mid Char (wt%)	0.93	0.93
V183	CO in Syngas (mol%)	22.20	21.82
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	8.42	9.42
V188	O in Coal + Catalyst Feed (wt%)	8.59	8.67
V193	H ₂ in Syngas (mol%)	77.60	78.18
V205	CO ₂ in Product Gas (mol%)	10.60	10.60
V207	CH ₄ in Product Gas (mol%)	9.40	9.49
V208	CO in Product Gas (mol%)	8.40	8.67
V212	H ₂ in Product Gas (mol%)	53.50	53.20
V214	N ₂ in Product Gas (mol%)	17.90	17.84
V215	H ₂ S in Product Gas (mol%)	0.26	0.29
V222	Carbon in Char Withdrawn (wt%)	44.93	45.75
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	17.96	18.16
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	17.78	18.40
V257	Carbon in Gasifier Starting Mid Char (wt%)	43.74	45.95
V258	Carbon in Gasifier Ending Mid Char (wt%)	47.09	46.62
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	20.38	20.54
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	20.67	21.60
V289	ASTM Ash in Char Entrained (wt%)	42.24	42.25
V292	ASTM Ash in Char Withdrawn (wt%)	51.88	51.94
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	24.45	24.42
V294	C/H Residue in Feed Coal + Catalyst (wt%)	18.02	18.11
V295	C/H Residue in Char Entrained (wt%)	39.52	39.47
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	53.30	49.98
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	48.46	51.04

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	46.85	46.60
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	47.18	47.95
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	44.88	44.22
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	18.99	18.00
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	34.42	31.97
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	41.99	40.69
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	42.72	40.26
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	39.27	39.95
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	12.56	12.81
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	31.70	31.52
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	36.96	36.07
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	36.60	38.45
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	35.69	34.03
V407	Coal + Catalyst Feed (lbs/hr)	8.77	8.56
V473	Char Entrained (lbs/hr)	0.96	0.96
V495	Carbon in Feed Coal (wt%)	61.07	64.06
V498	Carbon in Char Entrained (wt%)	53.04	55.57
F384	Syngas Flow Meter (CFH)	44.54	44.43
F385	Product Gas Flow Meter (CFH)	97.48	100.73
PGKO	Product Gas Condensate (lbs/hr)	9.20	7.67
U(114)	Starting Bed ΔP (B-A) (in Hg)	1.40	1.40
U(115)	Starting Bed ΔP (C-B) (in Hg)	4.90	4.89
U(116)	Starting Bed ΔP (D-C) (in Hg)	3.00	3.00
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	9.40	9.29
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.70	2.72
U(120)	Ending Bed ΔP (C-B) (in Hg)	3.20	3.22
U(121)	Ending Bed ΔP (D-C) (in Hg)	2.80	2.82
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	8.80	8.76
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 208

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.00	0.00
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	3.50	3.30
V281	S in Gasifier Ending Mid Char (wt%)	3.28	3.45
V187	S in Coal + Catalyst Feed (wt%)	4.00	3.88
V246	S in Char Withdrawn (wt%)	3.54	3.73
V244	S in Char Entrained (wt%)	2.40	24.2
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	28.26	28.68
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	26.49	26.42
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.70	27.68
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	30.94	32.83
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	24.36	24.80
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	7.90	7.73
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	7.28	7.43
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	7.88	7.86
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	8.38	8.63
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	6.89	6.94
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.36	10.05
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.41	9.69
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.42	9.38
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.92	10.28
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.77	8.85
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.93	0.85
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.77	0.82
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.26	1.19
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.17	1.25
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	0.87	0.88
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.15	0.15
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.17	0.16
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.08	0.08

YIELD PERIOD 208

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.15	0.15
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.17	0.07
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.22	0.22
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.18	0.18
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.08	0.08
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.26	0.26
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.22	0.22
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.62	0.59
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.54	0.56
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.54	0.53
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.60	0.62
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt)	0.49	0.49
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.44	0.44
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.45	0.45
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.47	0.47
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.44	0.45
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.45	0.45
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.10	0.10
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.09	0.09
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.10	0.10
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.10	0.10
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.09	0.09
V813	N in Starting Mid Char (wt%)	0.29	0.29
V814	N in Ending Mid Char (wt%)	0.30	0.30
V818	N in Coal + Catalyst Feed (wt%)	1.09	1.11
V819	N in Char Withdrawn (wt%)	0.31	0.31
V820	N in Char Entrained (wt%)	0.28	0.28
V805	O in Starting Mid Char (wt%)	8.56	9.00
V806	O in Ending Mid Char (wt%)	8.96	8.58
V810	O in Char Withdrawn (wt%)	7.99	8.26
V811	O in Char Entrained (wt%)	9.11	9.19

RECONCILED DATA

YIELD PERIOD 209

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	21:30	3-24-77
To	21:30	3-25-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1121	
38.4	1177	
32.1	1302	
26.6	1333	
21.2	1318	
16.0	1318	
10.9	1302	
6.4	1285	
0.4	1178	

YIELD PERIOD 209

UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	310	323
Lockhopper 1 Bottom	303	256
Lockhopper 2 Top	256	306
Lockhopper 2 Bottom	225	304
Gasifier Feed Line	735	961
Gasifier Steam Line	1004	1139
Gasifier		
Top of Bed	1302	1343
Bottom of Bed	1178	1198
Total Bed Average	1291	1316
Rough Cut Cyclone		
Cyclone Top	943	995
Cyclone Bottom	695	1026
Standpipe Top	818	1001
Standpipe Mid	810	1017
Standpipe Bottom	783	1043
Standpipe Slope Top		1052
Standpipe Slope Bottom	1171	990
Gasifier Backend		
Cyclone Inlet	-	541
Filter Inlet	-	484
Scrubber Inlet	419	409
Scrubber Outlet	73	
Product Gas Meter	88	
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	116.1	
Gasifier Feed Line	114.9	
Bypass N2	162.0	
Syngas In	162.2	
Gasifier		
Gasifier Top	112.7	
Gasifier Bottom	115.0	
Rough Cut Cyclone Outlet	112.2	
Filter Outlet	112.6	
Scrubber Outlet	112.6	
Product Gas Meter	114.7	

YIELD PERIOD 209FLUID-SOLIDS DATAGasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	12.0
Bed Top Density (lbs/cf)	3.8
Bed Average Density (lbs/cf)	9.7
Bed Height (ft)	34.7
Bed Holdup (lbs)	59.9
Bed Volume (cf)	5.6
Average Bed Temperature (°F)	1311.2
Space Velocity (bcd) (cf/cf/hr)	78.9
Bottom Superficial Velocity (ft/sec)	0.6
Top Superficial Velocity (ft/sec)	0.7

Cyclone Performance

Temperature (°F)	541.0
Pressure (psia)	112.7
Inlet Gas Rate (SCFH)	989.3
Inlet Gas Rate (ACFH)	248.5
Inlet Gas Velocity (ft/sec)	19.5
Solids Entering (lbs/hr)	0.8
Dust Loading (lbs/acf)	0.0033
Solids Captured (lbs/hr)	0.7
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.1

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	9.16
Total Carryover (lbs/hr)	0.81
Cyclone (lbs/hr)	0.73
Filter (lbs/hr)	0.08
Carryover/Feed (Wt.%)	8.8

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.74
Carbon in Carryover (lbs/hr)	0.41
Carryover/Feed (Wt.%)	7.1

YIELD PERIOD 209UNIT CONVERSIONSCarbon Consumption

Carbon in Feed* (lbs/hr)	5.74
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.14
Carbon Gasified (by difference) (lbs/hr)	1.42
Total Carbon Converted (lbs/hr)	3.56

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	24.8
Total, Including Devolatilization (%)	62.1

Carbon Distribution

Total Converted (%)	62.1
Entrained (%)	7.1
Withdrawn (%)	28.4
Accumulated (%)	2.4
Conversion (Entrainment Backed Out)	69.2

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	4.7
Including Devolatilization	11.9

Steam Consumption

Steam into Unit (lbs/hr)	14.81
Steam Reacted with Carbon (lbs/hr)	2.13
Total Steam Consumed (lbs/hr)	6.17

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	14.4
Total Steam Converted (%)	41.6

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.096
Carbon Converted/Steam Fed (mol/mol)	0.144
Carbon Converted/Bed Volume (lbs/hr)/cft	0.577
Carbon Converted/Bed Volume (mol/hr)/cft	0.048
Carbon in Bed/Steam Fed lbs/(lbs/hr)	2.025
Carbon in Bed/Steam Fed mol/(mol/hr)	3.038

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 209

UNIT COMPOSITIONS

Catalyst Distribution*

	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	4.7	10.8	11.4	10.8	11.8
K as K ₂ CO ₃	7.0	15.8	16.7	15.9	17.4
K as K	3.9	8.9	9.4	9.0	9.8
K Water/Acid, Soluble Ratio	0.64	0.53	0.48	0.51	0.59
Na as Na ₂ O	3.3	7.6	7.9	7.4	8.4
Na as Na ₂ CO ₃	5.7	13.0	13.5	12.7	14.4
Na as Na	2.5	5.6	5.8	5.5	6.3
Na Water/Acid, Soluble Ratio	0.98	0.94	0.93	0.87	0.97
Carbon	62.6	55.4	50.1	48.2	50.3
Total M** on Carbon	10.2	26.3	30.5	30.0	32.0
ASTM Ash	24.7	40.9	46.4	47.7	42.2
Total M on Ash	25.9	35.6	32.9	30.4	38.1
M ₂ CO ₃ Free Ash	12.0	12.1	16.3	19.1	10.4
Total M on M ₂ CO ₃ Free Ash	53.2	120.0	93.8	75.9	154.6

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	3.2	5.7	18.3	46.4	80.7	93.8	99.8
Top Char	6.1	10.4	33.0	59.0	83.4	93.1	100.0
Mid Char	3.5	6.4	19.9	46.2	78.7	92.7	99.9
Bottom Char	4.6	5.9	14.6	38.8	79.1	92.1	99.9
Cyclone	83.5	94.0	99.3	99.4	99.7	100.0	100.0
Filter	99.7	99.7	100.0	100.0	100.0	100.0	100.0

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	28	190	410	30.6
Top Char	27	135	362	14.0
Mid Char	28	184	423	17.0
Bottom Char	25	188	448	20.5
Cyclone	22	25	34	
Filter	22	22	22	

*Based on acid soluble analysis

YIELD PERIOD 209

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.09	0.78	0.09
C	62.6	50.4	50.3
S	4.0	3.1	2.0
O	11.5	1.5	7.4
N	1.14	0.33	0.28
Cl	0.08	0.15	0.21
SO ₃ -Free Ash	16.5	43.8	39.7
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	9.06	3.23	0.81

Ash Element Analysis

Wt% of SO ₃ -Free Ash		
SiO ₂	29.7	33.0
Fe ₂ O ₃	8.3	10.3
Al ₂ O ₃	10.7	11.6
CaO	1.25	1.77
MgO	0.62	0.68
TiO ₂	0.52	0.47
P ₂ O ₅	0.12	0.18
Na ₂ O	20.06	17.26
K ₂ O, Catalyst	28.74	24.74
Total	100.0	100.0

YIELD PERIOD 209

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	112.7
H ₂	52.8
CO	10.2
CH ₄	6.3
CO ₂	10.8
H ₂ S	0.4
H ₂ O	20.7
N ₂	11.5
H ₂ O/CO	2.0
H ₂ O/CO ₂	1.9

Unit Gas Data

Syngas MWT, lbs/mol	8.5
Product Gas MWT (dry), lbs/mol	14.2

Product Gas

At DTM (dry), SCFH	807.5
(Dry, N ₂ -Free), SCFH	706.2
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	589.3
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	352.3
At Gasifier Outlet, SCFH (Excludes N ₂)	588.0
At Gasifier Outlet, ACFH (Excludes N ₂)	352.1

YIELD PERIOD 209

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	57.4
CO	11.1
CO ₂	11.7
CH ₄	6.8
H ₂ S	0.4
N ₂	12.5

Product Gas (Dry, N ₂ -Free)	
H ₂	65.7
CO	12.7
CO ₂	13.4
CH ₄	7.8
H ₂ S	0.5

Product Gas	
H ₂	46.9
CO	9.1
CO ₂	9.5
CH ₄	5.6
H ₂ S	0.3
H ₂ O	18.4
N ₂	10.2

Product Gas (N ₂ -Free)	
H ₂	52.3
CO	10.2
CO ₂	10.6
CH ₄	6.2
H ₂ S	0.3
H ₂ O	20.5

SCFH CH₄/lb C Active Bed 1.8SCFH CH₄/lb C Feed 9.6Moles CH₄/mole C Feed 0.30

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1311°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	2.000	1.770	1239
Shift: CO + H ₂ O = CO ₂ + H ₂	1.585	2.880	1095
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.053	0.018	1368
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.344	0.152	-

YIELD PERIOD 209

MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal feed (ex N ₂)	9.05	Product Gas (ex N ₂)	22.69
Gasifier Steam	14.01	Product Gas N ₂	7.49
Gasifier Syngas	17.41	Product Water	8.64
		Char Entrained	0.81
		Solids Withdrawn	2.23
Total (ex N ₂)	35.99	Total (ex N ₂)	35.38
Accumulation:	-0.09		
Closure: (Output + Accum)/input, % 100.0			

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	508.5	H ₂ + CO in Product Gas	553.6
H ₂ Mol%	75.1	H ₂ Mol%	57.4
CO Mol%	24.9	CO Mol%	31.1
Balance: (Output/Input), % 108.8			

YIELD PERIOD 209

MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	5.74	0.372	1.06	0.370	0.007
Gasifier Steam	-	1.644	13.15	-	-
Gasifier Syngas	4.02	2.015	5.36	-	-
Total	9.67	4.030	19.57	0.370	0.007
<u>Output:</u>					
Product Gas	7.58	3.043	11.77	0.270	-
Product Water	-	0.959	7.68	0.003	-
Char Entrained	0.41	0.000	0.06	0.016	0.002
Solids Withdrawn	1.63	0.025	0.05	0.099	0.005
Total	9.62	4.029	19.56	0.388	0.007
Accumulation:	0.14	0.002	0.01	-0.018	0.001
Closure (Out + Accum)/in, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>	<u>Acid Sol. Na</u>	<u>Water Sol. Na</u>
Coal + Catalyst	0.36	0.23	0.23	0.22
<u>Output:</u>				
Char Entrained	0.08	0.05	0.05	0.05
Product Water	-	-	-	-
Solid Withdrawn	0.29	0.15	0.18	0.15
Total	0.37	0.19	0.23	0.20
Accumulation:	-0.01	0.01	-0.01	-0.01
Closure (out + accum)/in, %	100.0	88.2	100.0	88.5

*Carbon balance excludes catalyst carbonate

**Excludes carbon and oxygen in catalyst

YIELD PERIOD 209
MATERIAL BALANCES

YIELD PERIOD 209
MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.26	1.89	1.51	1.32
<u>Output:</u>				
Entrained Char	0.34	0.38	0.32	0.33
Solids Withdrawn	1.56	1.60	1.42	1.25
Total	1.90	1.98	1.74	1.58
Accumulation:	0.36	-0.09	-0.22	-0.26
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.450	0.125	0.162	0.019	0.009	0.332	0.008	0.002
<u>Output:</u>								
Entrained Char	0.082	0.034	0.030	0.007	0.002	0.035	0.002	0.000
Solids Withdrawn	0.467	0.145	0.165	0.025	0.010	0.150	0.007	0.003
Total	0.549	0.180	0.195	0.032	0.011	0.185	0.008	0.003
Accumulation:	-0.099	-0.054	-0.033	-0.013	-0.002	0.037	-0.001	-0.001
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Mole Balance

<u>Gas Input</u>		<u>Lb-Moles/Hr</u>						
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>			
H ₂	(1.007)	-	2.015	-	-			
CO	(0.335)	0.335	-	2.335	-			
H ₂ O	(0.822)	-	1.644	0.822	-			
Total	(2.164)	0.335	3.659	1.157	-			
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>	<u>Na</u>	
Coal + Cat Feed		0.478	0.372	0.066	0.012	0.009	0.010	
<u>Total Input</u>		0.812	4.030	1.223	0.012	0.009	0.010	
<u>Gas Output</u>								
<u>Product Gas</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>			
H ₂	(1.224)	-	2.447	-	-			
CO	(0.237)	0.237	-	0.237	-			
CO ₂	(0.249)	0.249	-	0.498	-			
CH ₄	(0.145)	0.145	0.580	-	-			
H ₂ S	(0.008)	-	0.017	-	0.008			
H ₂ O	(0.480)	-	0.960	0.480	0.0			
Total	(2.343)	0.631	4.003	1.215	0.009			
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>	<u>Na</u>	
Char Entrained		0.034	0.001	0.004	0.000	0.002	0.002	
Char Samples Withdrawn		0.136	0.025	0.003	0.003	0.007	0.008	
Char Accumulation		0.012	0.001	0.001	-0.001	0.000	0.000	
Total Solids		0.181	0.027	0.007	0.003	0.009	0.010	
<u>Total Output + Accumulation</u>		0.812	4.030	1.223	0.012	0.009	0.010	

YIELD PERIOD 209

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	14.80	14.81
V111	Char Withdrawn (lbs/hr)	3.23	3.23
V165	H in Char Entrained (wt%)	0.09	0.09
V166	H in Char Withdrawn (wt%)	0.78	0.78
V168	H in Coal + Catalyst Feed (wt%)	4.09	4.09
V173	H in Gasifier Starting Mid Char (wt%)	0.56	0.56
V174	H in Gasifier Ending Mid Char (wt%)	0.64	0.64
V183	CO in Syngas (mol%)	25.00	24.94
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	4.62	4.75
V188	O in Coal + Catalyst Feed (wt%)	11.52	11.54
V193	H ₂ in Syngas (mol%)	75.00	75.06
V205	CO ₂ in Product Gas (mol%)	11.70	11.70
V207	CH ₄ in Product Gas (mol%)	6.80	6.80
V208	CO in Product Gas (mol%)	11.60	11.13
V212	H ₂ in Product Gas (mol%)	56.38	57.43
V214	N ₂ in Product Gas (mol%)	12.70	12.54
V215	H ₂ S in Product Gas (mol%)	0.49	0.40
V222	Carbon in Char Withdrawn (wt%)	49.68	50.39
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	11.92	11.84
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	10.81	10.84
V257	Carbon in Gasifier Starting Mid Char (wt%)	48.03	46.10
V258	Carbon in Gasifier Ending Mid Char (wt%)	52.68	53.74
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	11.22	11.43
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	11.20	11.38
V289	ASTM Ash in Char Entrained (wt%)	42.12	42.24
V292	ASTM Ash in Char Withdrawn (wt%)	47.69	48.29
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	25.14	24.67
V294	C/H Residue in Feed Coal + Catalyst (wt%)	21.32	20.65
V295	C/H Residue in Char Entrained (wt%)	50.14	37.60
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	50.14	37.60
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	44.65	54.23

YIELD PERIOD 209

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	48.38	49.60
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	50.96	49.49
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	46.41	47.58
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	16.75	16.52
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	37.84	39.70
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	44.48	43.80
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	43.15	45.02
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	38.32	37.30
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	13.14	14.44
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	42.09	40.90
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	43.87	38.74
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	42.25	45.84
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	39.53	36.50
V407	Coal + Catalyst Feed (lbs/hr)	9.53	9.16
V473	Char Entrained (lbs/hr)	0.81	0.81
V495	Carbon in Feed Coal (wt%)	62.72	62.50
V498	Carbon in Char Entrained (wt%)	52.08	50.31
F384	Syngas Flow Meter (CFH)	49.02	48.62
F385	Product Gas Flow Meter (CFH)	106.40	109.80
PGK0	Product Gas Condensate (lbs/hr)	8.54	8.40
U(114)	Starting Bed ΔP (B-A) (in Hg)	1.50	1.50
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.70	1.70
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.10	1.10
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	4.60	4.59
U(119)	Ending Bed ΔP (B-A) (in Hg)	1.60	1.61
U(120)	Ending Bed ΔP (C-B) (in Hg)	1.90	1.91
U(121)	Ending Bed ΔP (D-C) (in Hg)	0.60	0.60
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	4.40	4.42
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.30	0.30

YIELD PERIOD 209

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed AP (E-D) (in Hg)	0.30	0.30
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	3.16	3.22
V281	S in Gasifier Ending Mid Char (wt%)	2.60	2.56
V187	S in Coal + Catalyst Feed (wt%)	3.70	4.03
V246	S in Char Withdrawn (wt%)	3.09	3.05
V244	S in Char Entrained (wt%)	1.99	1.98
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	31.18	31.14
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	27.31	27.66
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	29.70	29.69
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	32.24	32.98
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	26.00	25.47
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.74	11.32
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.24	8.00
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	7.85	8.28
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.97	10.26
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	10.93	10.66
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	11.30	11.25
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.23	10.31
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	10.78	10.72
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.49	11.65
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	9.52	9.46
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.80	2.02
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.10	1.04
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.13	1.25
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.16	1.77
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	2.28	2.16
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.15	0.15
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.18	0.18
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.08	0.08

YIELD PERIOD 209

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.15	0.15
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.21	0.21
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	7.86	7.95
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	7.77	7.97
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	3.19	3.31
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	7.44	7.56
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	9.20	8.44
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.61	0.62
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.54	0.54
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.61	0.62
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.69	0.68
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt)	0.55	0.55
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.44	0.45
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.51	0.50
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.50	0.52
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.49	0.47
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.55	0.54
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.14	0.16
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.10	0.09
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.11	0.12
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.26	0.18
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.06	0.06
V813	N in Starting Mid Char (wt%)	0.18	0.18
V814	N in Ending Mid Char (wt%)	0.23	0.23
V818	N in Coal + Catalyst Feed (wt%)	1.14	1.14
V819	N in Char Withdrawn (wt%)	0.33	0.33
V820	N in Char Entrained (wt%)	0.28	0.28
V805	O in Starting Mid Char (wt%)	4.77	4.77
V806	O in Ending Mid Char (wt%)	5.35	5.34
V810	O in Char Withdrawn (wt%)	1.49	1.50
V811	O in Char Entrained (wt%)	7.51	7.43

RECONCILED DATA

YIELD PERIOD 210

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	21:30	3-25-77
To	21:30	3-26-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.7	1123	
38.4	1188	
42.1	1315	
26.6	1330	
21.2	1314	
16.0	1317	
10.9	1300	
6.4	1282	
0.4	1161	

YIELD PERIOD 210

UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	299	317
Lockhopper 1 Bottom	283	233
Lockhopper 2 Top	229	305
Lockhopper 2 Bottom	227	306
Gasifier Feed Line	740	964
Gasifier Steam Line	994	1128
Gasifier		
Top of Bed	1330	1378
Bottom of Bed	1161	1196
Total Bed Average	1284	1313
Rough Cut Cyclone		
Cyclone Top	943	995
Cyclone Bottom	687	1026
Standpipe Top	821	1001
Standpipe Mid	814	1019
Standpipe Bottom	786	1043
Standpipe Slope Top		1054
Standpipe Slope Bottom	1168	991
Gasifier Backend		
Cyclone Inlet		648
Filter Inlet		492
Scrubber Inlet	424	615
Scrubber Outlet	76	
Product Gas Meter	92	
<u>Unit Pressures</u>		
Lockhopper 2	1.1	
Gasifier Feed Line	1.1	
Bypass N2	1.1	
Syngas In	1.1	
Gasifier		
Gasifier Top	1.1	
Gasifier Bottom	1.1	
Rough Cut Cyclone Outlet	1.1	
Filter Outlet	1.1	
Scrubber Outlet	1.1	
Product Gas Meter	1.1	

YIELD PERIOD 210FLUID-SOLIDS DATAGasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	11.3
Bed Top Density (lbs/cf)	13.5
Bed Average Density (lbs/cf)	12.4
Bed Height (ft)	31.2
Bed Holdup (lbs)	68.9
Bed Volume (cf)	5.0
Average Bed Temperature (°F)	1308.6
Space Velocity (bed) (cf/cf/hr)	90.8
Bottom Superficial Velocity (ft/sec)	0.63
Top Superficial Velocity (ft/sec)	0.70

Cyclone Performance

Temperature (°F)	548.0
Pressure (psia)	113.7
Inlet Gas Rate (SCFH)	1021.8
Inlet Gas Rate (ACFH)	256.2
Inlet Gas Velocity (ft/sec)	20.1
Solids Entering (lbs/hr)	0.9
Dust Loading (lbs/acf)	0.0036
Solids Captured (lbs/hr)	0.8
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.0

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	8.58
Total Carryover (lbs/hr)	0.92
Cyclone (lbs/hr)	0.83
Filter (lbs/hr)	0.09
Carryover/Feed (Wt.%)	10.7

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.49
Carbon in Carryover (lbs/hr)	0.47
Carryover/Feed (Wt.%)	8.6

YIELD PERIOD 210UNIT CONVERSIONSCarbon Consumption

Carbon in Feed* (lbs/hr)	5.49
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.63
Carbon Gasified (by difference) (lbs/hr)	1.63
Total Carbon Converted (lbs/hr)	3.26

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	29.8
Total, Including Devolatilization (%)	59.4

Carbon Distribution

Total Converted (%)	59.4
Entrained (%)	8.6
Withdrawn (%)	22.6
Accumulated (%)	9.4
Conversion (Entrainment Backed Out)	65.0

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	4.6
Including Devolatilization	9.1

Steam Consumption

Steam into Unit (lbs/hr)	15.18
Steam Reacted with Carbon (lbs/hr)	2.45
Total Steam Consumed (lbs/hr)	6.07

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	16.1
Total Steam Converted (%)	40.0

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.107
Carbon Converted/Steam Fed (mol/mol)	0.161
Carbon Converted/Bed Volume (lbs/hr)/cft	0.587
Carbon Converted/Bed Volume (mol/hr)/cft	0.049
Carbon in Bed/Steam Fed lbs/(lbs/hr)	2.350
Carbon in Bed/Steam Fed mol/(mol/hr)	3.526

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 210
UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	4.7	9.8	10.9	9.9	11.7
K as K ₂ CO ₃	6.9	14.4	15.9	14.5	17.2
K as K	3.9	8.1	9.0	8.2	9.7
K Water/Acid, Soluble Ratio	0.67	0.57	0.59	0.51	0.61
Na as Na ₂ O	3.3	7.7	7.7	6.4	8.9
Na as Na ₂ CO ₃	5.6	13.1	13.2	11.0	15.2
Na as Na	2.4	5.7	5.7	4.8	6.6
Na Water/Acid, Soluble Ratio	0.88	0.93	0.89	0.84	0.92
Carbon	64.1	53.3	51.8	59.0	51.4
Total M** on Carbon	9.8	25.9	28.4	22.0	31.7
ASTM Ash	24.7	42.9	43.9	43.9	43.3
Total M on Ash	25.6	32.2	33.5	29.5	37.7
M ₂ CO ₃ Free Ash	12.2	15.4	14.8	18.5	10.9
Total M on M ₂ CO ₃ Free Ash	51.9	89.7	99.3	70.2	150.7

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	6.3	6.7	19.9	50.5	83.8	95.9	100.0
Top Char	3.8	6.4	23.9	49.9	80.3	93.0	100.0
Mid Char	8.9	10.5	26.3	54.3	84.3	95.0	100.0
Bottom Char	4.1	5.6	14.2	39.0	76.1	92.9	99.9
Cyclone	79.5	91.4	99.5	99.7	99.9	100.0	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	25	155	376	46.3
Top Char	28	172	405	14.9
Mid Char	24	128	364	19.7
Bottom Char	26	196	451	25.0
Cyclone	22	26	35	
Filter	-	-	-	

YIELD PERIOD 210
SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	4.29	1.42	0.44
C	64.0	58.7	51.4
S	3.9	2.5	2.2
O	9.8	0.5	6.4
N	1.19	0.30	0.25
Cl	0.08	0.15	0.23
SO ₃ -Free Ash	16.8	36.3	39.1
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	8.48	2.11	0.92

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	31.3	31.3	24.4
Fe ₂ O ₃	9.9	10.4	10.6
Al ₂ O ₃	10.2	10.9	8.9
CaO	1.86	2.03	2.13
MgO	0.68	0.93	0.65
TiO ₂	0.51	0.49	0.54
P ₂ O ₅	0.18	0.25	0.10
Na ₂ O	19.6	16.7	22.7
K ₂ O, Catalyst	27.9	27.0	30.0
Total	100.0	100.0	100.0

*Based on acid soluble analysis

YIELD PERIOD 210

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	52.1
CO	9.9
CH ₄	5.8
CO ₂	10.4
H ₂ S	0.3
H ₂ O	21.3
N ₂	13.9
H ₂ O/CO	2.2
H ₂ O/CO ₂	2.0

Unit Gas Data

Syngas MWT, lbs/mol	8.6
Product Gas MWT (dry), lbs/mol	14.4

Product Gas

At DTM (dry), SCFH	830.2
(Dry, N ₂ -Free), SCFH	705.6
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1021.8
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	402.2
At Gasifier Outlet, SCFH (Excludes N ₂)	897.2
At Gasifier Outlet, ACFH (Excludes N ₂)	353.1

YIELD PERIOD 210

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	56.4
CO	10.7
CO ₂	11.3
CH ₄	6.3
H ₂ S	0.3
N ₂	15.0

Product Gas (Dry, N ₂ -Free)	
H ₂	66.4
CO	12.6
CO ₂	13.3
CH ₄	7.4
H ₂ S	0.3

Product Gas	
H ₂	45.8
CO	8.7
CO ₂	9.2
CH ₄	5.1
H ₂ S	0.2
H ₂ O	18.8
N ₂	12.2

Product Gas (N ₂ -Free)	
H ₂	52.2
CO	9.9
CO ₂	10.5
CH ₄	5.8
H ₂ S	0.2
H ₂ O	21.4

SCFH CH₄/lb C Active Bed 1.5

SCFH CH₄/lb C Feed 9.5

Moles CH₄/mole C Feed 0.30

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1309°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.952	1.643	1290
Shift: CO + H ₂ O = CO ₂ + H ₂	1.495	2.581	1107
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.061	0.019	1386
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.347	0.132	-

YIELD PERIOD 210
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex H ₂)	8.48	Product Gas (ex H ₂)	22.38
Gasifier Steam	15.18	Product Gas H ₂	9.21
Gasifier Syngas	11.82	Product Water	9.11
		Char Entrained	0.92
		Solids Withdrawn	2.11
Total (ex H ₂)	35.48	Total (ex H ₂)	34.52
Accumulation:	0.91		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	518.5	H ₂ + CO in Product Gas	557.1
H ₂ Mol%	74.5	H ₂ Mol%	55.4
CO Mol%	25.5	CO Mol%	10.7
Balance: (Output/Input), %	107.5		

YIELD PERIOD 210
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	5.49	0.365	0.84	0.334	0.007
Gasifier Steam	-	1.685	13.48	-	-
Gasifier Syngas	4.19	2.039	5.58	-	-
Total	9.67	4.089	19.90	0.334	0.007
<u>Output:</u>					
Product Gas	7.44	3.036	11.67	0.206	-
Product Water	-	1.012	8.09	0.034	-
Char Entrained	0.47	0.004	0.06	0.020	0.002
Solids Withdrawn	1.24	0.030	0.01	0.054	0.003
Total	9.16	4.081	19.83	0.314	0.005
Accumulation:	0.52	0.008	0.07	0.020	0.002
Closure (Out + Accum)/in, %	100.0	100.0	110.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>	<u>Acid Sol. Na</u>	<u>Water Sol. Na</u>
Coal + Catalyst	0.33	0.22	0.21	0.18
<u>Output:</u>				
Char Entrained	0.09	0.05	0.06	0.06
Product Water	0.0	0.0	0.0	0.0
Solid Withdrawn	0.17	0.09	0.10	0.08
Total	0.26	0.14	0.16	0.14
Accumulation:	0.07	0.05	0.05	0.06
Closure (out + accum)/in, %	100.0	85.6	100.0	110.4

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 210

MATERIAL BALANCES

Ash Balance

Input (Lbs/Hr):	ASTM Ash	C/H Residue	SO ₃ -Free ASTM Ash	SO ₃ -Free C/H Residue
Coal + Catalyst	2.12	1.71	1.44	1.17
Output:				
Entrained Char	0.40	0.39	0.36	0.33
Solids Withdrawn	0.93	0.87	0.77	0.71
Total	1.33	1.26	1.13	1.04
Accumulation:	0.79	0.45	0.30	0.13
Closure (out + accum)/in, %	100.0	100.0	98.7	100.0

Ash Element Balance

Input (Lbs/Hr):	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	SO ₃	TiO ₂	P ₂ O ₅
Coal + Catalyst	0.423	0.143	0.147	0.027	0.010	0.694	0.007	0.003
Output:								
Entrained Char	0.088	0.038	0.032	0.008	0.002	0.046	0.002	0.0
Solids Withdrawn	0.240	0.080	0.084	0.016	0.007	0.168	0.004	0.002
Total	0.327	0.118	0.116	0.023	0.010	0.214	0.006	0.002
Accumulation:	0.095	0.025	0.031	0.004	0.0	0.128	0.002	0.0
Closure (out + accum)/in, %	100.0	100.0	100.0	100.0	100.0	49.0	100.0	100.0

YIELD PERIOD 210

MATERIAL BALANCES

Mole Balance

<u>Gas Input</u>		<u>Lb-Moles/Hr</u>			
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.019)	-	2.039	-	-
CO	(0.348)	0.348	-	0.348	-
H ₂ O	(0.483)	-	1.685	0.843	-
Total	(2.211)	0.348	3.724	1.191	-

<u>Solids Input</u>	<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>	<u>Na</u>
Coal + Cat Feed	0.457	0.365	0.052	0.010	0.009	0.009
Total Input	0.805	4.090	1.243	0.010	0.009	0.009

<u>Gas Output</u>					
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.236)	-	2.471	-	-
CO	(0.234)	0.234	-	0.234	-
CO ₂	(0.247)	0.247	-	0.495	-
CH ₄	(0.138)	0.138	0.552	-	-
H ₂ S	(0.006)	-	0.013	-	0.006
H ₂ O	(0.506)	-	1.011	0.506	0.001
Total	(2.368)	0.620	4.048	1.235	0.007

<u>Solids Output</u>	<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>	<u>Na</u>
Char Entrained	0.039	0.004	0.004	0.001	0.002	0.003
Char Samples Withdrawn	0.103	0.030	0.001	0.002	0.004	0.004
Char Accumulation	0.043	0.008	0.004	0.001	0.002	0.002
Total Solids	0.186	0.042	0.009	0.003	0.009	0.009
Total Output + Accumulation	0.805	4.090	1.243	0.010	0.009	0.009

YIELD PERIOD 210
PROCESS VARIABLES

	Measured	Reconciled
V100 Gasifier Steam (lbs/hr)	15.16	15.18
V111 Char Withdrawn (lbs/hr)	2.11	2.11
V165 H in Char Entrained (wt%)	0.44	0.44
V166 H in Char Withdrawn (wt%)	1.42	1.42
V168 H in Coal + Catalyst Feed (wt%)	4.30	4.29
V173 H in Gasifier Starting Mid Char (wt%)	0.92	0.92
V174 H in Gasifier Ending Mid Char (wt%)	0.92	0.92
V183 CO in Syngas (mol%)	25.00	25.47
V185 Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	4.62	4.69
V188 O in Coal + Catalyst Feed (wt%)	9.75	9.75
V193 H ₂ in Syngas (mol%)	75.00	74.53
V205 CO ₂ in Product Gas (mol%)	11.30	11.30
V207 CH ₄ in Product Gas (mol%)	6.30	6.30
V208 CO in Product Gas (mol%)	11.70	10.70
V212 H ₂ in Product Gas (mol%)	56.80	56.41
V214 N ₂ in Product Gas (mol%)	15.20	15.00
V215 H ₂ S in Product Gas (mol%)	0.35	0.29
V222 Carbon in Char Withdrawn (wt%)	59.01	58.74
V227 Acid Sol. K ₂ O in Char Entrained (wt%)	11.77	11.73
V232 Acid sol. K ₂ O in Char Withdrawn (wt%)	9.87	9.80
V257 Carbon in Gasifier Starting Mid Char (wt%)	51.80	50.50
V258 Carbon in Gasifier Ending Mid Char (wt%)	51.80	52.17
V265 Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	10.85	10.92
V266 Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	10.85	10.54
V289 ASTM Ash in Char Entrained (wt%)	43.19	43.28
V292 ASTM Ash in Char Withdrawn (wt%)	43.94	44.15
V293 ASTM Ash in Feed Coal + Catalyst (wt%)	24.98	24.71
V294 C/H Residue in Feed Coal + Catalyst (wt%)	20.57	19.98
V295 C/H Residue in Char Entrained (wt%)	42.29	42.56
V306 ASTM Ash in Gasifier Starting Mid Char (wt%)	43.89	38.22
V307 ASTM Ash in Gasifier Ending Mid Char (wt%)	43.89	51.78

YIELD PERIOD 210
PROCESS VARIABLES

	Measured	Reconciled
V310 C/H Residue in Char Withdrawn (wt%)	40.62	41.19
V320 C/H Residue in Gasifier Starting Mid Char (wt%)	42.21	41.23
V321 C/H Residue in Gasifier Ending Mid Char (wt%)	42.21	43.57
V333 SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	16.75	16.82
V334 SO ₃ -Free ASTM Ash in Char Entrained (wt%)	38.26	39.08
V336 SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	36.00	36.32
V337 SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	36.78	38.03
V338 SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	36.78	36.52
V350 SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	12.39	13.65
V351 SO ₃ -Free C/H Residue in Char Entrained (wt%)	37.36	36.13
V353 SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	36.09	33.46
V354 SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	35.10	37.85
V355 SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	35.10	31.27
V407 Coal + Catalyst Feed (lbs/hr)	8.75	8.58
V473 Char Entrained (lbs/hr)	0.92	0.92
V495 Carbon in Feed Coal (wt%)	64.35	63.96
V498 Carbon in Char Entrained (wt%)	52.21	51.43
F384 Syngas Flow Meter (CFH)	50.30	49.91
F385 Product Gas Flow Meter (CFH)	111.30	113.69
PGK0 Product Gas Condensate (lbs/hr)	9.31	8.83
U(114) Starting Bed ΔP (B-A) (in Hg)	1.30	1.30
U(115) Starting Bed ΔP (C-B) (in Hg)	1.60	1.60
U(116) Starting Bed ΔP (D-C) (in Hg)	1.50	1.50
U(117) Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118) Starting Overall Bed ΔP (F-A) (in Hg)	4.40	4.40
U(119) Ending Bed ΔP (B-A) (in Hg)	1.70	1.70
U(120) Ending Bed ΔP (C-B) (in Hg)	2.10	2.11
U(121) Ending Bed ΔP (D-C) (in Hg)	2.30	2.31
U(122) Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123) Ending Overall Bed ΔP (F-A) (in Hg)	6.10	6.12
EDD(1) Starting Bed ΔP (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 210

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.00	0.00
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	2.53	2.57
V281	S in Gasifier Ending Mid Char (wt%)	2.53	2.47
V187	S in Coal + Catalyst Feed (wt%)	3.58	3.89
V246	S in Char Withdrawn (wt%)	2.60	2.55
V244	S in Char Entrained (wt%)	2.21	2.19
V243	S in Product Gas Condensate (wt%)	0.39	0.39
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	29.19	28.75
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	29.19	29.56
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	29.94	29.28
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	31.43	31.25
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	24.46	24.37
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.55	8.57
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.55	8.50
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.83	9.88
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.51	10.41
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	10.62	10.57
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.37	10.35
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.37	10.37
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	10.20	10.18
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.97	10.92
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.92	8.90
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.24	1.24
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.24	1.24
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.86	1.86
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.04	0.03
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	2.14	2.13
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.21	0.21
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.21	0.21
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.08	0.08

YIELD PERIOD 210

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.15	0.15
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.23	0.23
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	7.69	7.85
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	7.69	7.30
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	3.19	3.29
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	6.43	6.07
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	9.26	8.88
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	1.00	1.11
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.00	0.85
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.61	0.68
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.04	0.93
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.67	0.65
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.53	0.52
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.53	0.54
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.52	0.51
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.49	0.49
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.54	0.54
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.09	0.09
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.09	0.09
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.18	0.18
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.25	0.25
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.10	0.10
V813	N in Starting Mid Char (wt%)	0.22	0.22
V814	N in Ending Mid Char (wt%)	0.22	0.22
V818	N in Coal + Catalyst Feed (wt%)	1.19	1.19
V819	N in Char Withdrawn (wt%)	0.30	0.30
V820	N in Char Entrained (wt%)	0.25	0.25
V805	O in Starting Mid Char (wt%)	7.54	7.55
V806	O in Ending Mid Char (wt%)	7.54	0.50
V810	O in Char Withdrawn (wt%)	0.52	0.52
V811	O in Char Entrained (wt%)	6.40	6.37

RECONCILED DATA
YIELD PERIOD 211
UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	6:30	4-17-77
To	6:30	4-18-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	97	
Steam	100	
Syngas	98	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1242	
38.4	1187	
32.1	1324	
26.6	1325	
21.2	1307	
16.0	1308	
10.9	1297	
6.4	1272	
0.4	1152	

YIELD PERIOD 211
UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	281	289
Lockhopper 1 Bottom	278	244
Lockhopper 2 Top	258	290
Lockhopper 2 Bottom	247	308
Gasifier Feed Line	628	815
Gasifier Steam Line	1076	1160
Gasifier		
Top of Bed	1325	1374
Bottom of Bed	1152	1198
Total Bed Average	1277	1307
Rough Cut Cyclone		
Cyclone Top	956	1004
Cyclone Bottom	708	1045
Standpipe Top	826	953
Standpipe Mid	780	991
Standpipe Bottom	719	1006
Standpipe Slope Top		950
Standpipe Slope Bottom	1158	998
Gasifier Backend		
Cyclone Inlet	-	539
Filter Inlet	-	508
Scrubber Inlet	425	429
Scrubber Outlet	79	-
Product Gas Meter	95	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	116.6	
Gasifier Feed Line	117.5	
Bypass N ₂	158.3	
Syngas In	161.5	
Gasifier		
Gasifier Top	113.5	
Gasifier Bottom	116.9	
Rough Cut Cyclone Outlet	113.1	
Filter Outlet	113.4	
Scrubber Outlet	113.4	
Product Gas Meter	114.7	

YIELD PERIOD 211

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	19.3
Bed Top Density (lbs/cf)	12.1
Bed Average Density (lbs/cf)	15.7
Bed Height (ft)	31.8
Bed Holdup (lbs)	89.3
Bed Volume (cf)	5.1
Average Bed Temperature (°F)	1301.8
Space Velocity (bed) (cf/cf/hr)	87.2
Bottom Superficial Velocity (ft/sec)	0.61
Top Superficial Velocity (ft/sec)	0.69

Cyclone Performance

Temperature (°F)	539.4
Pressure (psia)	113.5
Inlet Gas Rate (SCFH)	1006.1
Inlet Gas Rate (ACFH)	250.6
Inlet Gas Velocity (ft/sec)	19.7
Solids Entering (lbs/hr)	1.7
Dust Loading (lbs/acf)	0.0069
Solids Captured (lbs/hr)	1.5
Solids Escaping (lbs/hr)	0.2
Overall Efficiency (Captured/Entering, Wt.%)	90.0

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	10.84
Total Carryover (lbs/hr)	1.72
Cyclone (lbs/hr)	1.55
Filter (lbs/hr)	0.17
Carryover/Feed (Wt.%)	15.9

Solids Carbon Loss

Carbon in Feed (lbs/hr)	6.46
Carbon in Carryover (lbs/hr)	0.64
Carryover/Feed (Wt.%)	9.9

YIELD PERIOD 211

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	6.47
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.16
Carbon Gasified (by difference) (lbs/hr)	3.26
Total Carbon Converted (lbs/hr)	5.42

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	50.4
Total, Including Devolatilization (%)	83.9

Carbon Distribution

Total Converted (%)	83.9
Entrained (%)	9.4
Withdrawn (%)	8.0
Accumulated (%)	-1.3
Conversion (Entrainment Backed Out)	92.6

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	13.9
Including Devolatilization	23.2

Steam Consumption

Steam into Unit (lbs/hr)	15.08
Steam Reacted with Carbon (lbs/hr)	4.89
Total Steam Consumed (lbs/hr)	7.08

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	32.4
Total Steam Converted (%)	46.9

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.216
Carbon Converted/Steam Fed (mol/mol)	0.324
Carbon Converted/Bed Volume (lbs/hr)/cf	0.575
Carbon Converted/Bed Volume (mol/hr)/cf	0.048
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.550
Carbon in Bed/Steam Fed mol/(mol/hr)	2.325

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 211

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	11.0	31.6	31.9	31.5	32.0
K as K ₂ CO ₃	16.1	46.3	46.8	46.2	47.0
K as K	9.1	26.2	26.4	26.1	26.6
K Water/Acid, Soluble Ratio	0.688	0.792	0.729	0.679	0.796
K ₂ O, H ₂ O-Insoluble	3.4	6.5	8.6	10.1	6.5
K ₂ CO ₃ , H ₂ O-Insoluble	5.0	9.6	12.7	14.8	9.6
K, H ₂ O-Insoluble	2.8	5.4	7.2	8.4	5.4
Carbon	59.6	29.6	26.2	29.6	35.7
K on Carbon	15.3	88.4	101.0	88.4	74.5
ASTM Ash	28.8	72.0	71.5	67.9	59.9
K on Ash	31.6	36.4	37.0	38.5	44.4
K ₂ CO ₃ Free-Ash	12.5	24.8	23.9	20.8	12.2
K on K ₂ CO ₃ Free-Ash	73.1	105.7	110.7	125.7	217.4

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	1.1	4.0	10.9	44.0	84.0	96.6	100.0
Top Char	2.2	7.4	29.0	52.1	78.3	90.0	100.0
Mid Char	1.0	4.7	18.6	44.1	78.4	92.6	99.9
Bottom Char	20.7	4.1	13.5	37.0	75.2	91.8	99.7
Cyclone	90.5	95.7	97.4	98.6	100.0	100.0	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	37	239	399	44.7
Top Char	34	177	421	20.8
Mid Char	40	223	431	23.9
Bottom Char	28	222	465	25.7
Cyclone	22	24	34	
Filter	-	-	-	

*Based on acid soluble analysis

YIELD PERIOD 211

SOLID COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	36.2	0.70	0.94
C	59.6	29.1	35.7
S	3.6	4.4	3.1
O	12.6	7.9	6.4
N	0.98	0.23	0.22
Cl	0.07	0.13	0.20
SO ₃ -Free Ash	19.6	57.5	53.5
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	10.84	1.79	1.72

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	24.6	25.2	22.7
Fe ₂ O ₃	7.5	9.5	6.8
Al ₂ O ₃	8.8	9.2	7.7
CaO	1.35	1.77	1.20
MgO	0.46	0.55	0.41
TiO ₂	0.42	0.37	0.47
P ₂ O ₅	0.18	0.35	0.09
Na ₂ O	0.67	0.82	0.73
K ₂ O, Catalyst	56.03	52.23	59.85
Total	100.0	100.0	100.0

YIELD PERIOD 211

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.5
H ₂	50.5
CO	13.5
CH ₄	10.9
CO ₂	11.3
H ₂ S	0.3
H ₂ O	19.0
N ₂	7.9
H ₂ O/CO	1.4
H ₂ O/CO ₂	1.7

Unit Gas Data

Syngas MMT, lbs/mol	8.7
Product Gas MMT (dry), lbs/mol	14.7

Product Gas

At DTM (dry), SCFH	837.8
(Dry, N ₂ -Free), SCFH	767.5
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1006.1
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	426.4
At Gasifier Outlet, SCFH (Excludes N ₂)	935.8
At Gasifier Outlet, ACFH (Excludes N ₂)	396.6

YIELD PERIOD 211

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	53.5
CO	14.3
CO ₂	12.0
CH ₄	11.5
H ₂ S	0.3
N ₂	8.4

Product Gas (Dry, N ₂ -Free)	
H ₂	58.4
CO	15.6
CO ₂	13.1
CH ₄	12.6
H ₂ S	0.4

Product Gas	
H ₂	44.5
CO	11.9
CO ₂	10.0
CH ₄	9.6
H ₂ S	0.3
H ₂ O	16.7
N ₂	7.0

Product Gas (N ₂ -Free)	
H ₂	47.8
CO	12.8
CO ₂	10.8
CH ₄	10.3
H ₂ S	0.3
H ₂ O	18.0

SCFH CH ₄ /lb C Active Bed	8.1
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SCFH CH ₄ /lb C Feed	14.9
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Moles CH ₄ /mole C Feed	0.47
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Equilibrium Constants	Reaction Equilibrium at Active Bed Temp	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.8296	2.4464	1332.9
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5195	2.2335	1156.0
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0676	0.0256	1365.8
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3438	0.3422	-

YIELD PERIOD 211
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	10.73	Product Gas (ex N ₂)	27.25
Gasifier Steam	15.08	Product Gas N ₂	5.20
Gasifier Syngas	13.03	Product Water	8.00
		Char Entrained	1.72
		Solids Withdrawn	1.79
Total (ex N ₂)	38.84	Total (ex N ₂)	38.76
Accumulation:	0.08		
Closure: (Output + Accum)/Input, % = 100.0%			

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	570.7	H ₂ + CO in Product Gas	567.7
H ₂ Mol%	74.5	H ₂ Mol%	53.5
CO Mol%	25.5	CO Mol%	14.2
Balance: (Output/Input), % = 99.5%			

YIELD PERIOD 211
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	6.46	0.39	1.36	0.388	0.007
Gasifier Steam	-	1.69	13.32	-	-
Gasifier Syngas	4.62	2.26	6.15	-	-
Total	11.07	4.34	20.91	0.388	0.007
<u>Output:</u>					
Product Gas	10.04	3.42	13.55	0.245	-
Product Water	0.0	0.90	7.11	0.003	-
Char Entrained	0.61	0.02	0.11	0.054	0.003
Solids Withdrawn	0.52	0.01	0.14	0.078	0.002
Total	11.17	4.35	20.91	0.381	0.006
Accumulation:	-0.10	-0.01	0.0	0.007	0.001
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	0.99	0.68
<u>Output:</u>		
Char Entrained	0.46	0.36
Product Water	0.0	0.0
Solids Withdrawn	0.45	0.32
Total	0.90	0.68
Accumulation:	0.08	0.01
Closure (out + accum)/in	100.0	102.5

*Carbon balance excludes catalyst carbonate
**includes carbon and oxygen in catalyst

YIELD PERIOD 211

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	3.12	2.50	2.12	1.73
<u>Output:</u>				
Entrained Char	1.03	1.04	0.92	0.93
Solids Withdrawn	1.22	1.21	1.03	0.95
Total	2.25	2.26	1.95	1.89
Accumulation:	0.87	0.24	0.17	-0.16
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.522	0.160	0.186	0.029	0.010	0.920	0.014	0.009	0.004
<u>Output:</u>									
Entrained Char	0.209	0.063	0.071	0.011	0.004	0.138	0.006	0.004	0.001
Solids Withdrawn	0.259	0.098	0.095	0.018	0.006	0.215	0.008	0.004	0.004
Total	0.469	0.160	0.166	0.029	0.009	0.353	0.014	0.008	0.004
Accumulation:	0.054	0.0	0.020	-0.001	0.0	0.133	0.0	0.001	-0.001
Closure (out + accum)/in, %	100	100	100	100	100	53	100	100	100

YIELD PERIOD 211

MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
<u>Gas Input</u>					
H ₂	(1.121)	-	2.243	-	-
CO	(0.384)	0.384	-	0.384	-
H ₂ O	(0.837)	-	1.674	0.837	-
Total	(2.342)	0.384	3.917	1.221	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.538	0.390	0.085	0.012
Total Input		0.922	4.307	1.307	0.012
<u>Gas Output</u>					
<u>Product Gas</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.182)	-	2.363	-	-
CO	(0.316)	0.316	-	0.316	-
CO ₂	(0.265)	0.265	-	0.531	-
CH ₄	(0.254)	0.254	1.017	-	-
H ₂ S	(0.008)	-	-	-	0.008
H ₂ O	(0.444)	-	0.889	0.444	-
Total	(2.469)	0.836	4.284	1.291	0.008
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.051	0.016	0.007	0.002
Char Samples Withdrawn		0.043	0.012	0.009	0.002
Char Accumulation		-0.008	-0.006	0.0	0.0
Total Solids		0.086	0.022	0.016	0.014
Total Output + Accumulation		0.922	4.307	1.307	0.012

YIELD PERIOD 211

PROCESS VARIABLES

	Measured	Reconciled
V100 Gasifier Steam (lbs/hr)	14.08	15.08
V111 Char Withdrawn (lbs/hr)	1.79	1.79
V165 H in Char Entrained (wt%)	0.0	0.94
V166 H in Char Withdrawn (wt%)	0.70	0.70
V168 H in Coal + Catalyst Feed (wt%)	3.62	3.62
V173 H in Gasifier Starting Mid Char (wt%)	0.66	0.66
V174 H in Gasifier Ending Mid Char (wt%)	0.47	0.47
V183 CO in Syngas (mol%)	25.40	25.52
V185 Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	11.00	10.90
V188 O in Coal + Catalyst Feed (wt%)	12.55	12.58
V193 H ₂ in Syngas (mol%)	71.90	74.48
V205 CO ₂ in Product Gas (mol%)	12.09	12.00
V207 CH ₄ in Product Gas (mol%)	11.50	11.50
V208 CO in Product Gas (mol%)	14.10	14.30
V212 H ₂ in Product Gas (mol%)	53.60	52.46
V214 N ₂ in Product Gas (mol%)	8.40	8.40
V215 H ₂ S in Product Gas (mol%)	0.35	0.35
V222 Carbon in Char Withdrawn (wt%)	29.50	29.09
V227 Acid Sol. K ₂ O in Char Entrained (wt%)	31.57	32.01
V232 Acid sol. K ₂ O in Char Withdrawn (wt%)	31.50	30.04
V257 Carbon in Gasifier Starting Mid Char (wt%)	27.22	27.58
V258 Carbon in Gasifier Ending Mid Char (wt%)	25.94	24.13
V265 Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	30.14	28.83
V266 Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	33.06	31.05
V289 ASTM Ash in Char Entrained (wt%)	59.73	59.88
V292 ASTM Ash in Char Withdrawn (wt%)	67.92	68.13
V293 ASTM Ash in Feed Coal + Catalyst (wt%)	29.02	28.80
V294 C/H Residue in Feed Coal + Catalyst (wt%)	23.70	23.07
V295 C/H Residue in Char Entrained (wt%)	60.91	60.65
V306 ASTM Ash in Gasifier Starting Mid Char (wt%)	70.81	60.18
V307 ASTM Ash in Gasifier Ending Mid Char (wt%)	72.43	83.83

YIELD PERIOD 211

PROCESS VARIABLES

	Measured	Reconciled
V310 C/H Residue in Char Withdrawn (wt%)	66.99	67.82
V320 C/H Residue in Gasifier Starting Mid Char (wt%)	69.27	66.86
V321 C/H Residue in Gasifier Ending Mid Char (wt%)	69.75	72.26
V333 SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	20.47	19.59
V334 SO ₃ -Free ASTM Ash in Char Entrained (wt%)	55.69	53.49
V336 SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	55.95	57.52
V337 SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	57.68	57.23
V338 SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	59.72	60.87
V350 SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	15.15	15.94
V351 SO ₃ -Free C/H Residue in Char Entrained (wt%)	55.97	54.27
V353 SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	55.02	53.30
V354 SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	56.14	59.52
V355 SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	57.04	53.47
V407 Coal + Catalyst Feed (lbs/hr)	11.12	10.84
V473 Char Entrained (lbs/hr)	1.72	1.72
V495 Carbon in Feed Coal (wt%)	58.82	59.57
V498 Carbon in Char Entrained (wt%)	34.49	35.67
F384 Syngas Flow Meter (CFM)	55.37	55.40
F385 Product Gas Flow Meter (CFM)	115.49	115.39
PGK0 Product Gas Condensate (lbs/hr)	7.70	7.70
U(114) Starting Bed ΔP (B-A) (in Hg)	2.60	2.59
U(115) Starting Bed ΔP (C-B) (in Hg)	2.00	1.99
U(116) Starting Bed ΔP (D-C) (in Hg)	1.80	1.79
U(117) Starting Bed ΔP (F-E) (in Hg)	0.0	0.00
U(118) Starting Overall Bed ΔP (F-A) (in Hg)	6.40	6.38
U(119) Ending Bed ΔP (B-A) (in Hg)	2.80	2.82
U(120) Ending Bed ΔP (C-B) (in Hg)	1.90	1.91
U(121) Ending Bed ΔP (D-C) (in Hg)	1.80	1.81
U(122) Ending Bed ΔP (F-E) (in Hg)	0.0	0.00
U(123) Ending Overall Bed ΔP (F-A) (in Hg)	6.50	6.53
EPD(1) Starting Bed ΔP (E-D) (in Hg)	0.0	0.00

YIELD PERIOD 211

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.0	0.00
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.0	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.98	5.01
V281	S in Gasifier Ending Mid Char (wt%)	5.18	5.08
V187	S in Coal + Catalyst Feed (wt%)	3.50	3.58
V246	S in Char Withdrawn (wt%)	4.64	4.43
V244	S in Char Entrained (wt%)	3.10	3.11
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	26.97	26.91
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	27.77	27.23
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	24.44	24.59
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	26.98	25.18
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	22.32	22.73
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	9.05	8.56
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	7.53	7.86
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	7.94	7.55
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.42	9.48
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	6.65	6.81
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	9.48	9.75
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.31	9.88
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.50	8.76
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.63	9.25
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.75	7.71
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	2.20	2.30
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	2.20	2.08
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.31	1.35
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.84	1.77
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.21	1.20
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.11	0.12
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.17	0.16
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.05	0.07

YIELD PERIOD 211

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.13	0.12
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.21	0.20
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.45	0.51
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.59	0.48
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.12	0.13
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.51	0.47
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.41	0.39
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.56	0.53
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.48	0.50
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.48	0.46
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.54	0.55
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.40	0.51
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.36	0.37
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.39	0.38
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.41	0.42
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.38	0.37
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.47	0.47
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.30	0.32
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.30	0.27
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.17	0.18
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.37	0.35
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.09	0.09
V813	N in Starting Mid Char (wt%)	0.14	0.14
V814	N in Ending Mid Char (wt%)	0.24	0.24
V818	N in Coal + Catalyst Feed (wt%)	0.98	0.98
V819	N in Char Withdrawn (wt%)	0.23	0.23
V820	N in Char Entrained (wt%)	0.22	0.22
V805	O in Starting Mid Char (wt%)	9.21	9.25
V806	O in Ending Mid Char (wt%)	9.28	9.05
V810	O in Char Withdrawn (wt%)	8.58	7.91
V811	O in Char Entrained (wt%)	6.30	6.37

RECONCILED DATA
YIELD PERIOD 212
UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	7:30	4-25-77
To	7:30	4-26-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	94	
Steam	95	
Syngas	99	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1257	
38.4	1280	
32.1	1309	
26.6	1311	
21.2	1293	
16.0	1288	
10.9	1272	
6.4	1247	
0.4	1126	

YIELD PERIOD 212
UNIT PROCESS VARIABLES

Unit Temperatures	Process, °F	Metal, °F
Lockhopper 1 Top	272	284
Lockhopper 1 Bottom	266	224
Lockhopper 2 Top	292	283
Lockhopper 2 Bottom	213	368
Gasifier Feed Line	686	943
Gasifier Steam Line	1085	1193
Gasifier		
Top of Bed	1280	1357
Bottom of Bed	1126	1173
Total Bed Average	1265	1313
Rough Cut Cyclone		
Cyclone Top	983	1020
Cyclone Bottom	888	1046
Standpipe Top	895	992
Standpipe Mid	812	1040
Standpipe Bottom	774	1040
Standpipe Slope Top		1033
Standpipe Slope Bottom	1170	1033
Gasifier Backend		
Cyclone Inlet	-	614
Filter Inlet	-	583
Scrubber Inlet	469	472
Scrubber Outlet	78	-
Product Gas Meter	92	-
Unit Pressures	Psia	
Lockhopper 2	116.5	
Gasifier Feed Line	117.7	
Bypass N2	158.6	
Syngas In	162.2	
Gasifier		
Gasifier Top	113.5	
Gasifier Bottom	117.1	
Rough Cut Cyclone Outlet	112.9	
Filter Outlet	113.4	
Scrubber Outlet	113.4	
Product Gas Meter	114.7	

YIELD PERIOD 212

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	20.0
Bed Top Density (lbs/cf)	7.7
Bed Average Density (lbs/cf)	13.4
Bed Height (ft)	38.8
Bed Holdup (lbs)	92.9
Bed Volume (cf)	6.3
Average Bed Temperature (°F)	1286.4
Space Velocity (bed) (cf/cf/hr)	90.4
Bottom Superficial Velocity (ft/sec)	0.78
Top Superficial Velocity (ft/sec)	0.89

Cyclone Performance

Temperature (°F)	613.7
Pressure (psia)	113.5
Inlet Gas Rate (SCFH)	1311.2
Inlet Gas Rate (ACFH)	350.8
Inlet Gas Velocity (ft/sec)	27.5
Solids Entering (lbs/hr)	3.6
Dust Loading (lbs/acf)	0.0102
Solids Captured (lbs/hr)	3.2
Solids Escaping (lbs/hr)	0.4
Overall Efficiency (Captured/Entering, Wt.%)	90.0

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	16.90
Total Carryover (lbs/hr)	3.56
Cyclone (lbs/hr)	3.20
Filter (lbs/hr)	0.36
Carryover/Feed (Wt.%)	21.1

Solids Carbon Loss

Carbon in Feed (lbs/hr)	10.21
Carbon in Carryover (lbs/hr)	1.60
Carryover/Feed (Wt.%)	15.7

YIELD PERIOD 212

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	10.21
Carbon from Devolatilization** of Feed Coal (lbs/hr)	3.08
Carbon Gasified (by difference) (lbs/hr)	4.74
Total Carbon Converted (lbs/hr)	7.83

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	46.4
Total, Including Devolatilization (%)	76.6

Carbon Distribution

Total Converted (%)	76.6
Entrained (%)	15.1
Withdrawn (%)	9.0
Accumulated (%)	-0.7
Conversion (Entrainment Backed Out)	90.0

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	16.5
Including Devolatilization	27.2

Steam Consumption

Steam into Unit (lbs/hr)	22.80
Steam Reacted with Carbon (lbs/hr)	7.12
Total Steam Consumed (lbs/hr)	10.99

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	31.2
Total Steam Converted (%)	48.2

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.208
Carbon Converted/Steam Fed (mol/mol)	0.312
Carbon Converted/Bed Volume (lbs/hr)/cft	0.686
Carbon Converted/Bed Volume (mol/hr)/cft	0.057
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.261
Carbon in Bed/Steam Fed mol/(mol/hr)	1.892

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 212

UNIT COMPOSITIONS

YIELD PERIOD 212

SOLIDS COMPOSITION

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	10.6	27.4	27.1	27.1	26.0
K as K ₂ CO ₃	15.6	40.2	39.8	39.7	38.1
K as K	8.8	22.7	22.5	22.5	21.6
K Water/Acid Soluble Ratio	0.851	0.785	0.759	0.735	0.832
K ₂ O, H ₂ O-Insoluble	1.6	5.9	6.5	7.2	4.4
K ₂ CO ₃ , H ₂ O-Insoluble	2.3	8.6	9.6	10.5	6.4
K, H ₂ O-Insoluble	1.3	4.9	5.4	6.0	3.6
Carbon	60.4	31.7	31.0	27.8	43.3
K on Carbon	14.6	71.8	72.7	80.9	49.8
ASTM Ash	28.2	65.4	65.4	68.5	51.0
K on Ash	31.3	34.8	34.4	32.8	42.3
K ₂ CO ₃ Free-Ash	12.3	24.5	24.9	28.1	11.9
K on K ₂ CO ₃ Free-Ash	71.9	92.9	90.2	79.8	181.2

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	3.3	4.8	16.5	48.1	85.1	96.9	99.9
Top Char	1.4	3.1	19.2	44.4	74.4	88.5	100.0
Mid Char	2.8	4.4	18.0	46.5	78.1	95.0	100.0
Bottom Char	1.7	4.1	9.3	32.1	72.9	90.9	99.9
Cyclone	54.9	76.2	90.4	96.5	98.9	99.9	100.0
Filter	90.5	91.3	93.9	97.3	99.1	99.7	100.0

Particle Diameter (Microns)	Number Mean	Volume/Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	28	191	379	47.9
Top Char	35	224	472	18.5
Mid Char	29	199	412	22.5
Bottom Char	30	256	495	25.7
Cyclone	23	33	73	
Filter	22	24	48	

*Based on acid soluble analysis

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.71	1.01	0.50
C	60.4	27.7	43.3
S	3.6	5.0	2.9
O	11.6	10.5	10.6
N	1.05	0.21	0.26
Cl	0.06	0.14	0.17
SO ₃ -Free Ash	19.6	55.5	42.3
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	16.89	3.34	3.56

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	24.3	27.7	20.1
Fe ₂ O ₃	8.5	9.6	7.2
Al ₂ O ₃	8.7	9.9	7.2
CaO	2.06	2.45	1.73
MgO	0.49	0.62	0.40
TiO ₂	0.39	0.41	0.41
P ₂ O ₅	0.29	0.49	0.15
Na ₂ O	0.89	0.67	1.26
K ₂ O, Catalyst	54.29	48.22	61.45
Total	100.0	100.0	100.0

YIELD PERIOD 212

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.5
H ₂	47.2
CO	12.5
CH ₄	10.8
CO ₂	12.0
H ₂ S	0.3
H ₂ O	21.5
N ₂	9.3
H ₂ O/CO	1.7
H ₂ O/CO ₂	1.8

Unit Gas Data

Syngas MMT, lbs/mol	8.8
Product Gas MMT (dry), lbs/mol	15.4

Product Gas

At DTM (dry), SCFH	1062.8
(Dry, N ₂ -Free), SCFH	955.8
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1311.2
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	560.6
At Gasifier Outlet, SCFH (Excludes N ₂)	1204.2
At Gasifier Outlet, ACFH (Excludes N ₂)	514.9

YIELD PERIOD 212

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	51.3
CO	13.6
CO ₂	13.0
CH ₄	11.7
H ₂ S	0.4
N ₂	10.1

Product Gas (Dry, N ₂ -Free)	
H ₂	57.0
CO	15.1
CO ₂	14.5
CH ₄	13.0
H ₂ S	0.4

Product Gas	
H ₂	41.6
CO	11.0
CO ₂	10.5
CH ₄	9.5
H ₂ S	0.3
H ₂ O	18.9
N ₂	8.2

Product Gas (N ₂ -Free)	
H ₂	45.3
CO	12.0
CO ₂	11.4
CH ₄	10.3
H ₂ S	0.3
H ₂ O	20.7

SCFH CH ₄ /lb C Active Bed	4.3
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SCFH CH ₄ /lb C Feed	12.2
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Moles CH ₄ /mole C Feed	0.39
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Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1286.4°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.5795	1.8683	1304.0
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5776	2.0949	1178.6
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0862	0.0381	1339.0
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3393	0.2725	-

YIELD PERIOD 212
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	16.72	Product Gas (ex N ₂)	35.24
Gasifier Steam	22.80	Product Gas N ₂	7.91
Gasifier Syngas	14.28	Product Water	11.81
		Char Entrained	3.56
		Solids Withdrawn	3.34
Total (ex N ₂)	53.80	Total (ex N ₂)	53.95
Accumulation:	-0.15		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	617.9	H ₂ + CO in Product Gas	689.5
H ₂ Mol%	74.1	H ₂ Mol%	51.3
CO Mol%	25.9	CO Mol%	13.6
Balance: (Output/Input), %	111.6		

YIELD PERIOD 212
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	10.21	0.63	1.95	0.609	0.010
Gasifier Steam	-	2.55	20.25	-	-
Gasifier Syngas	5.08	2.43	6.76	-	-
Total	15.29	5.61	28.96	0.609	0.010
<u>Output:</u>					
Product Gas	12.90	4.24	17.77	0.320	-
Product Water	0.0	1.32	10.49	0.004	-
Char Entrained	1.54	0.02	0.38	0.103	0.006
Solids Withdrawn	0.02	0.03	0.35	0.167	0.005
Total	15.37	5.61	28.99	0.594	0.011
Accumulation:	-0.08	0.0	-0.03	0.015	-0.001
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	1.49	1.27
<u>Output:</u>		
Char Entrained	0.77	0.64
Product Water	0.0	0.0
Solid Withdrawn	0.74	0.55
Total	1.51	1.19
Accumulation:	-0.02	-0.08
Closure (out + accum)/in, %	100.0	87.6

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 212
MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	4.76	3.85	3.31	2.60
<u>Output:</u>				
Entrained Char	1.81	1.76	1.51	1.40
Solids Withdrawn	2.30	2.10	1.85	1.54
Total	4.12	3.85	3.36	2.94
Accumulation:	0.65	0.0	-0.05	-0.34
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.806	0.283	0.288	0.068	0.016	1.460	0.029	0.013	0.09
<u>Output:</u>									
Entrained Char	0.303	0.109	0.109	0.026	0.006	0.275	0.019	0.006	0.002
Solids Withdrawn	0.513	0.178	0.183	0.045	0.012	0.452	0.012	0.008	0.009
Total	0.812	0.287	0.292	0.071	0.018	0.727	0.031	0.014	0.011
Accumulation:	-0.010	-0.004	-0.004	-0.003	-0.001	0.162	-0.002	-0.001	-0.002
Closure (out + accum)/in, %	100	100	100	100	100	61	100	100	100

YIELD PERIOD 212

MATERIAL BALANCES

Mole Balance

<u>Gas Input</u>		<u>Lb-Moles/Hr</u>			
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.207)	-	2.415	-	-
CO	(0.423)	0.423	-	0.423	-
H ₂ O	(1.205)	-	2.531	1.265	-
Total	(2.895)	0.423	4.946	1.688	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.850	0.622	0.122	0.019
<u>Total Input</u>		1.273	5.568	1.810	0.019
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Product Gas					
H ₂	(1.438)	-	2.875	-	-
CO	(0.382)	0.382	-	0.382	-
CO ₂	(0.365)	0.365	-	0.729	-
CH ₄	(0.328)	0.328	1.312	0.0	-
H ₂ S	(0.070)	-	1.311	0.656	-
H ₂ O	(0.656)	-	1.311	0.656	-
Total	(3.179)	1.074	5.519	1.767	0.010
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.129	0.018	0.024	0.003
Char Samples Withdrawn		0.077	0.033	0.022	0.005
Char Accumulation		-0.007	-0.002	-0.002	0.0
Total Solids		0.199	0.049	0.044	0.009
<u>Total Output + Accumulation</u>		1.273	5.568	1.810	0.019

YIELD PERIOD 212

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	22.81	22.80
V111	Char Withdrawn (lbs/hr)	3.34	3.34
V165	H in Char Entrained (wt%)	0.50	0.50
V166	H in Char Withdrawn (wt%)	1.01	1.01
V168	H in Coal + Catalyst Feed (wt%)	3.71	3.71
V173	H in Gasifier Starting Mid Char (wt%)	0.48	0.48
V174	H in Gasifier Ending Mid Char (wt%)	0.44	0.44
V183	CO in Syngas (mol%)	26.10	25.93
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	10.51	10.63
V188	O in Coal + Catalyst Feed (wt%)	11.54	11.56
V193	H ₂ in Syngas (mol%)	72.90	74.07
V205	CO ₂ in Product Gas (mol%)	13.00	13.00
V207	CH ₄ in Product Gas (mol%)	11.70	11.70
V208	CO in Product Gas (mol%)	13.40	13.61
V212	H ₂ in Product Gas (mol%)	51.60	51.27
V214	N ₂ in Product Gas (mol%)	10.10	10.06
V215	H ₂ S in Product Gas (mol%)	0.35	0.36
V222	Carbon in Char Withdrawn (wt%)	27.77	27.67
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	25.87	25.98
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	27.06	26.74
V257	Carbon in Gasifier Starting Mid Char (wt%)	30.95	32.20
V258	Carbon in Gasifier Ending Mid Char (wt%)	31.52	31.31
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	26.07	27.38
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	27.69	27.84
V289	ASTM Ash in Char Entrained (wt%)	50.75	50.96
V292	ASTM Ash in Char Withdrawn (wt%)	68.49	68.85
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	28.49	28.17
V294	C/H Residue in Feed Coal + Catalyst (wt%)	22.84	22.79
V295	C/H Residue in Char Entrained (wt%)	49.28	49.33
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	64.28	54.77
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	64.49	73.72

YIELD PERIOD 212

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	62.66	62.73
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	61.63	61.51
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	63.69	63.81
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	19.76	19.58
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	43.05	42.29
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	55.07	55.46
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	53.27	51.84
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	52.27	52.52
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.11	15.38
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	41.58	39.25
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	49.24	46.17
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	50.62	54.47
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	51.47	47.63
V407	Coal + Catalyst Feed (lbs/hr)	17.30	16.90
V473	Char Entrained (lbs/hr)	3.56	3.56
V495	Carbon in Feed Coal (wt%)	60.24	60.43
V498	Carbon in Char Entrained (wt%)	42.65	43.34
F384	Syngas Flow Meter (CFH)	59.51	59.30
F385	Product Gas Flow Meter (CFH)	140.52	145.46
PGKO	Product Gas Condensate (lbs/hr)	0.00	11.46
U(114)	Starting Bed ΔP (B-A) (in Hg)	3.00	2.99
U(115)	Starting Bed ΔP (C-B) (in Hg)	2.10	2.10
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.20	1.20
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	7.50	7.49
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.90	2.91
U(120)	Ending Bed ΔP (C-B) (in Hg)	1.90	1.90
U(121)	Ending Bed ΔP (D-C) (in Hg)	1.20	1.20
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	7.20	7.22
E00(1)	Starting Bed ΔP (E-D) (in Hg)	1.20	1.20

YIELD PERIOD 212

PROCESS VARIABLES

	Measured	Reconciled
EDD(6) Ending Bed ΔP (E-D) (in Hg)	1.20	1.20
DPOST Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280 S in Gasifier Starting Mid Char (wt%)	4.05	4.06
V281 S in Gasifier Ending Mid Char (wt%)	4.60	4.61
V187 S in Coal + Catalyst Feed (wt%)	3.63	3.60
V246 S in Char Withdrawn (wt%)	5.03	4.99
V244 S in Char Entrained (wt%)	2.87	2.88
V243 S in Product Gas Condensate (wt%)	0.04	0.04
V862 SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	26.11	26.39
V863 SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	26.50	26.52
V867 SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	24.27	24.34
V868 SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	28.21	27.67
V869 SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	20.03	20.14
V871 Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	7.71	7.82
V872 Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	7.90	7.81
V876 Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.37	8.55
V877 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.81	9.61
V878 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.28	7.24
V880 Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	9.29	9.37
V881 Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.45	9.41
V885 Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.63	8.70
V886 Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.97	9.86
V887 Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.24	7.24
V889 CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.38	1.42
V890 CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.33	1.29
V894 CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.93	2.06
V895 CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.60	2.45
V896 CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.77	1.72
V322 Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.17	0.16
V823 Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.15	0.16
V827 Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.07	0.06

YIELD PERIOD 212

PROCESS VARIABLES

	Measured	Reconciled
V828 Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.13	0.14
V829 Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.16	0.17
V836 Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.43	0.41
V837 Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.37	0.39
V841 Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.19	0.18
V842 Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.36	0.37
V843 Acid Sol. Na ₂ O in Char Entrained (wt%)	0.51	0.53
V898 MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.64	0.62
V899 MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.56	0.57
V903 MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.51	0.49
V904 MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.61	0.62
V905 MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.39	0.40
V916 TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.45	0.44
V917 TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.40	0.41
V921 TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.40	0.37
V922 TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.40	0.41
V923 TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.40	0.41
V925 P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.34	0.34
V926 P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.25	0.25
V930 P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.29	0.28
V931 P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.48	0.47
V932 P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.15	0.15
V813 N in Starting Mid Char (wt%)	0.18	0.18
V814 N in Ending Mid Char (wt%)	0.21	0.21
V818 N in Coal + Catalyst Feed (wt%)	1.05	1.05
V819 N in Char Withdrawn (wt%)	0.21	0.21
V820 N in Char Entrained (wt%)	0.26	0.26
V805 O in Starting Mid Char (wt%)	10.90	11.09
V806 O in Ending Mid Char (wt%)	10.81	10.75
V810 O in Char Withdrawn (wt%)	10.80	10.53
V811 O in Char Entrained (wt%)	10.52	10.56

RECONCILED DATA

YIELD PERIOD 213UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	7:30	6-3-77
To	7:30	6-4-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	98	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1139	
38.4	1144	
32.1	1307	
26.6	1342	
21.2	1312	
16.0	1317	
10.9	1305	
6.4	1287	
0.4	1220	

YIELD PERIOD 213
UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	294	305
Lockhopper 1 Bottom	289	255
Lockhopper 2 Top	297	343
Lockhopper 2 Bottom	214	277
Gasifier Feed Line	733	990
Gasifier Steam Line	882	964
Gasifier		
Top of Bed	1307	1360
Bottom of Bed	1220	1236
Total Bed Average	1299	1338
Rough Cut Cyclone		
Cyclone Top	919	995
Cyclone Bottom	838	1030
Standpipe Top	585	1009
Standpipe Mid	438	1022
Standpipe Bottom	779	1041
Standpipe Slope Top		1057
Standpipe Slope Bottom	1189	989
Gasifier Backend		
Cyclone Inlet	-	551
Filter Inlet	-	487
Scrubber Inlet	439	433
Scrubber Outlet	89	-
Product Gas Meter	100	-
<u>Unit Pressures</u>		<u>Psia</u>
Lockhopper 2		115.3
Gasifier Feed Line		116.7
Bypass N2		160.7
Syngas In		163.7
Gasifier		
Gasifier Top		113.7
Gasifier Bottom		116.3
Rough Cut Cyclone Outlet		113.2
Filter Outlet		113.7
Scrubber Outlet		113.7
Product Gas Meter		114.7

YIELD PERIOD 213

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	16.0
Bed Top Density (lbs/cf)	6.8
Bed Average Density (lbs/cf)	10.4
Bed Height (ft)	36.6
Bed Holdup (lbs)	67.5
Bed Volume (cf)	5.9
Average Bed Temperature (°F)	1311.7
Space Velocity (bed) (cf/cf/hr)	79.4
Bottom Superficial Velocity (ft/sec)	0.68
Top Superficial Velocity (ft/sec)	0.73

Cyclone Performance

Temperature (°F)	551.0
Pressure (psia)	113.7
Inlet Gas Rate (SCFH)	1065.3
Inlet Gas Rate (ACFH)	267.8
Inlet Gas Velocity (ft/sec)	21.0
Solids Entering (lbs/hr)	1.2
Dust Loading (lbs/scf)	0.0046
Solids Captured (lbs/hr)	1.1
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.3

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	10.97
Total Carryover (lbs/hr)	1.24
Cyclone (lbs/hr)	1.12
Filter (lbs/hr)	0.12
Carryover/Feed (Wt.%)	11.3%

Solids Carbon Loss

Carbon in Feed (lbs/hr)	6.47
Carbon in Carryover (lbs/hr)	0.47
Carryover/Feed (Wt.%)	7.3%

YIELD PERIOD 213

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	6.47
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.06
Carbon Gasified (by difference) (lbs/hr)	3.37
Total Carbon Converted (lbs/hr)	5.43

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	52.2
Total, Including Devolatilization (%)	83.9

Carbon Distribution

Total Converted (%)	83.9
Entrained (%)	7.0
Withdrawn (%)	11.1
Accumulated (%)	-2.0
Conversion (Entrainment Backed Out)	90.1

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	16.5
Including Devolatilization	26.6

Steam Consumption

Steam into Unit (lbs/hr)	15.26
Steam Reacted with Carbon (lbs/hr)	5.06
Total Steam Consumed (lbs/hr)	7.68

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	33.2
Total Steam Converted (%)	50.3

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.221
Carbon Converted/Steam Fed (mol/mol)	0.332
Carbon Converted/Bed Volume (lbs/hr)/cft	0.518
Carbon Converted/Bed Volume (mol/hr)/cft	0.043
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.339
Carbon in Bed/Steam Fed mol/(mol/hr)	2.009

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 213

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	10.9	29.9	30.5	29.7	32.1
K as K ₂ CO ₃	16.0	43.9	44.8	43.6	47.1
K as K	9.1	24.8	25.3	24.6	26.6
K Water/Acid, Soluble Ratio	0.683	0.773	0.772	0.692	0.867
K ₂ O, H ₂ O-Insoluble	3.5	6.8	7.0	9.1	4.3
K ₂ CO ₃ , H ₂ O-Insoluble	5.1	10.0	10.2	13.4	6.3
K, H ₂ O-Insoluble	2.9	5.6	5.8	7.6	3.6
Carbon	59.0	31.3	30.3	28.2	36.5
K on Carbon	15.4	79.3	83.7	87.4	73.0
ASTM Ash	28.5	65.5	65.6	69.3	58.3
K on Ash	31.9	37.9	38.6	35.5	45.7
K ₂ CO ₃ Free-Ash	12.1	20.6	19.8	24.8	10.2
K on K ₂ CO ₃ Free-Ash	75.0	120.1	128.3	99.3	261.4

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	2.4	5.7	16.6	42.9	78.2	94.7	99.9
Top Char	7.6	15.1	35.9	58.3	82.9	94.1	99.9
Mid Char	3.4	8.4	25.3	51.2	81.5	95.1	99.9
Bottom Char	1.1	4.0	9.0	28.7	67.2	90.6	100.0
Cyclone	51.5	97.4	99.4	99.7	99.8	99.6	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)

	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	30	206	423	50.8
Top Char	26	120	352	20.4
Mid Char	29	167	301	21.3
Bottom Char	34	279	522	23.7
Cyclone	24	32	45	-
Filter	-	-	-	-

*Based on acid soluble analysis

YIELD PERIOD 213

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.58	0.39	0.01
C	59.0	28.2	36.5
S	3.8	5.0	3.2
O	13.1	9.5	9.3
N	1.05	0.21	0.34
Cl	0.08	0.22	0.26
SO ₃ -Free Ash	15.4	56.5	50.4
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	10.85	2.56	1.24

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	25.1	27.3	20.2
Fe ₂ O ₃	7.3	7.6	7.1
Al ₂ O ₃	8.0	9.1	5.9
CaO	1.00	0.99	1.11
MgO	0.49	0.52	0.35
TiO ₂	0.40	0.37	0.38
P ₂ O ₅	0.25	0.26	0.16
Na ₂ O	0.91	0.95	1.15
K ₂ O, Catalyst	56.53	52.93	63.66
Total	100.0	100.0	100.0

YIELD PERIOD 213
PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	
H ₂	113.7
CO	53.7
CH ₄	14.6
CO ₂	10.5
H ₂ S	12.2
H ₂ O	0.3
N ₂	17.0
H ₂ O/CO	1.2
H ₂ O/CO ₂	1.4

Unit Gas Data

Syngas MWT, lbs/mol	9.2
Product Gas MWT (dry), lbs/mol	14.3

Product Gas

At DTM (dry), SCFH	905.9
(Dry, N ₂ -Free), SCFH	855.3
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1055.3
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	122.5
At Gasifier Outlet, SCFH (Excludes N ₂)	1014.6
At Gasifier Outlet, ACFH (Excludes N ₂)	103.4

YIELD PERIOD 213
PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	55.5
CO	15.1
CO ₂	12.6
CH ₄	10.8
H ₂ S	0.3
N ₂	5.6
Product Gas (Dry, N ₂ -Free)	
H ₂	58.8
CO	16.0
CO ₂	13.4
CH ₄	11.5
H ₂ S	0.3
Product Gas	
H ₂	47.2
CO	12.8
CO ₂	10.7
CH ₄	9.2
H ₂ S	0.3
H ₂ O	15.0
N ₂	4.8
Product Gas (N ₂ -Free)	
H ₂	49.5
CO	13.5
CO ₂	11.2
CH ₄	9.6
H ₂ S	0.3
H ₂ O	15.9
SCFH CH ₄ /lb C Active Bed	4.8
SCFH CH ₄ /lb C Feed	15.2
Moles CH ₄ /mole C Feed	0.48

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1311.7°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Boudouard-H ₂ O: C + H ₂ O = CO + H ₂	2.0086	3.1369	1360.1
Shift: CO + H ₂ O = CO ₂ + H ₂	1.4837	2.6342	1108.7
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0070	0.0170	1397.1
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3466	0.4407	-

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YIELD PERIOD 213
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex H ₂)	10.85	Product Gas (ex H ₂)	30.48
Gasifier Steam	15.26	Product Gas H ₂	3.74
Gasifier Syngas	15.65	Product Water	7.58
		Char Entrained	1.24
		Solids Withdrawn	2.56
Total (ex H ₂)	41.76	Total (ex H ₂)	41.86
Accumulation:	-0.1		
Closure: (Output + Accum)/Input, %	100		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	647.5	H ₂ + CO in Product Gas	640.0
H ₂ Mol%	12.5	H ₂ Mol%	55.5
CO Mol%	27.5	CO Mol%	15.1
Balance: (Output/Input), %	98.8		

YIELD PERIOD 213

MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	6.47	0.39	1.44	0.420	0.009
Gasifier Steam	-	1.71	13.55	-	-
Gasifier Syngas	5.64	2.50	7.51	-	-
Total	12.11	4.60	22.50	0.420	0.009
<u>Output:</u>					
Product Gas	11.07	3.74	15.43	0.249	-
Product Water	-	0.85	6.73	0.003	-
Char Entrained	0.45	0.0	0.12	0.040	0.003
Solids Withdrawn	0.72	0.01	0.24	0.127	0.006
Total	12.24	4.60	22.52	0.418	0.009
Accumulation:	-0.14	0.0	-0.01	0.002	0.0
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	1.00	0.68
<u>Output:</u>		
Char Entrained	0.33	0.29
Product Water	0.0	0.0
Solid Withdrawn	0.64	0.44
Total	0.97	0.72
Accumulation:	0.03	0.003
Closure (out + accum)/in, %	100.0	111.0

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 213
MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	3.12	2.58	2.12	1.75
<u>Output:</u>				
Entrained Char	0.72	0.73	0.63	0.62
Solids Withdrawn	1.79	1.75	1.45	1.33
Total	2.51	2.48	2.07	1.94
Accumulation:	0.61	0.10	0.05	-0.19
Closure (out + accum)/in, %				

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.533	0.155	0.170	0.021	0.010	0.972	0.919	0.009	0.005
<u>Output:</u>									
Entrained Char	0.126	0.045	0.037	0.007	0.002	0.092	0.007	0.002	0.001
Solids Withdrawn	0.394	0.109	0.132	0.014	0.008	0.328	0.010	0.005	0.004
Total	0.520	0.154	0.169	0.021	0.010	0.420	0.017	0.008	0.005
Accumulation:	0.013	0.002	0.001	0.0	0.001	0.121	0.002	0.001	0.001
Closure (out + accum)/in, %	100	100	100	100	100	56	100	100	100

YIELD PERIOD 213
MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.239)	-	2.478	-	-
CO	(0.469)	0.469	0.0	0.469	-
H ₂ O	(0.847)	-	1.694	0.847	-
Total		0.469	4.172	1.316	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.539	0.390	0.090	0.013
Total Input		1.008	4.562	1.406	0.013
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Product Gas					
H ₂	(1.327)	-	2.655	-	-
CO	(0.361)	0.361	-	0.361	-
CO ₂	(0.301)	0.301	-	0.603	-
CH ₄	(0.259)	0.259	1.035	-	-
H ₂ S	(0.008)	-	0.016	-	0.008
H ₂ O	(0.421)	-	0.842	0.421	0.0
Total		0.921	4.547	1.385	0.008
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.038	0.0	0.007	0.001
Char Samples Withdrawn		0.060	0.010	0.015	0.004
Char Accumulation		-0.011	0.005	-0.001	0.0
Total Solids		0.087	0.015	0.022	0.005
Total Output + Accumulation		1.008	4.562	1.406	0.013

YIELD PERIOD 213

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	15.29	15.26
V111	Char Withdrawn (lbs/hr)	2.56	2.56
V165	H in Char Entrained (wt%)	0.01	0.01
V166	H in Char Withdrawn (wt%)	0.39	0.39
V168	H in Coal + Catalyst Feed (wt%)	3.58	3.58
V173	H in Gasifier Starting Mid Char (wt%)	0.06	0.06
V174	H in Gasifier Ending Mid Char (wt%)	0.23	0.23
V183	CO in Syngas (mol%)	27.40	27.48
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	10.59	10.94
V188	O in Coal + Catalyst Feed (wt%)	13.11	13.12
V193	H ₂ in Syngas (mol%)	72.40	72.52
V205	CO ₂ in Product Gas (mol%)	12.61	12.61
V207	CH ₄ in Product Gas (mol%)	10.83	10.83
V208	CO in Product Gas (mol%)	14.88	15.11
V212	H ₂ in Product Gas (mol%)	55.25	55.53
V214	N ₂ in Product Gas (mol%)	5.58	5.59
V215	H ₂ S in Product Gas (mol%)	0.35	0.32
V222	Carbon in Char Withdrawn (wt%)	28.17	28.23
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	31.96	32.09
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	29.67	29.88
V257	Carbon in Gasifier Starting Mid Char (wt%)	30.42	31.36
V258	Carbon in Gasifier Ending Mid Char (wt%)	28.14	27.46
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	30.04	29.24
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	30.53	31.51
V289	ASTM Ash in Char Entrained (wt%)	58.16	58.30
V292	ASTM Ash in Char Withdrawn (wt%)	69.30	69.72
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	28.76	28.45
V294	C/H Residue in Feed Coal + Catalyst (wt%)	23.96	23.49
V295	C/H Residue in Char Entrained (wt%)	58.47	58.78
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	65.14	54.90
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	68.00	78.81

YIELD PERIOD 213

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	67.53	68.39
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	64.39	63.13
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	67.32	68.66
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	19.80	19.35
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	50.75	50.42
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	56.62	56.45
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	54.43	53.36
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	56.18	56.98
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	15.00	16.00
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	51.05	49.75
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	54.86	51.75
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	53.68	57.00
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	55.50	52.06
V407	Coal + Catalyst Feed (lbs/hr)	11.06	10.97
V473	Char Entrained (lbs/hr)	1.24	1.24
V495	Carbon in Feed Coal (wt%)	58.23	58.98
V498	Carbon in Char Entrained (wt%)	36.20	36.47
F384	Syngas Flow Meter (CFH)	61.96	62.17
F385	Product Gas Flow Meter (CFH)	129.92	126.16
PGK0	Product Gas Condensate (lbs/hr)	6.92	7.19
U(114)	Starting Bed ΔP (B-A) (in Hg)	2.40	2.39
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.30	1.30
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.10	1.10
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	5.40	5.39
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.40	2.41
U(120)	Ending Bed ΔP (C-B) (in Hg)	1.30	1.30
U(121)	Ending Bed ΔP (D-C) (in Hg)	0.90	0.90
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	5.20	5.22
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.60	0.60

YIELD PERIOD 213

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.60	0.60
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.26	4.33
V281	S in Gasifier Ending Mid Char (wt%)	4.62	4.54
V187	S in Coal + Catalyst Feed (wt%)	3.63	3.83
V246	S in Char Withdrawn (wt%)	5.00	4.96
V244	S in Char Entrained (wt%)	3.22	3.21
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	25.66	26.08
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	26.44	26.01
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	24.28	25.11
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	27.60	27.29
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	20.18	20.15
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	7.13	7.23
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	7.20	7.10
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	7.15	7.31
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	7.65	7.55
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.15	7.12
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.89	9.02
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.89	8.76
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	7.82	7.99
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.26	9.14
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	5.94	5.92
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.64	0.71
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.80	0.68
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.83	1.00
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.25	0.99
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.22	1.11
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.25	0.26
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.29	0.28
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.08	0.08

YIELD PERIOD 213

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.23	0.22
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.27	0.26
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.60	0.63
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.64	0.61
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.17	0.18
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.55	0.53
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.59	0.58
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.48	0.50
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.55	0.52
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.46	0.49
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.55	0.52
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt)	0.35	0.35
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.39	0.40
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.44	0.43
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.39	0.40
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.38	0.37
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.38	0.38
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.09	0.10
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.05	0.13
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.20	0.25
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.36	0.25
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.17	0.16
V813	N in Starting Mid Char (wt%)	0.10	0.10
V814	N in Ending Mid Char (wt%)	0.18	0.18
V818	N in Coal + Catalyst Feed (wt%)	1.05	1.05
V819	N in Char Withdrawn (wt%)	0.21	0.21
V820	N in Char Entrained (wt%)	0.34	0.34
V805	O in Starting Mid Char (wt%)	10.48	10.52
V806	O in Ending Mid Char (wt%)	10.36	10.33
V810	O in Char Withdrawn (wt%)	9.39	9.54
V811	O in Char Entrained (wt%)	9.23	9.29

RECONCILED DATA

YIELD PERIOD 214

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	7:30	6-14-77
To	7:30	6-15-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	99	
Steam	99	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1143	
38.4	1231	
32.1	1307	
26.6	1336	
21.2	1306	
16.0	1310	
10.9	1301	
6.4	1289	
0.4	1253	

YIELD PERIOD 214

UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	265	279
Lockhopper 1 Bottom	251	218
Lockhopper 2 Top	264	259
Lockhopper 2 Bottom	236	303
Gasifier Feed Line	730	988
Gasifier Steam Line	877	949
Gasifier		
Top of Bed	1336	1391
Bottom of Bed	1253	1290
Total Bed Average	1299	1344
Rough Cut Cyclone		
Cyclone Top	646	987
Cyclone Bottom	775	1107
Standpipe Top	711	1007
Standpipe Mid	642	1066
Standpipe Bottom	703	961
Standpipe Slope Top		1054
Standpipe Slope Bottom	1151	991
Gasifier Backend		
Cyclone Inlet	-	539
Filter Inlet	-	474
Scrubber Inlet	431	425
Scrubber Outlet	81	
Product Gas Meter	93	
<u>Unit Pressures</u>		<u>Psia</u>
Lockhopper 2	117.4	
Gasifier Feed Line	116.8	
Bypass N2	163.7	
Syngas In	163.7	
Gasifier		
Gasifier Top	113.7	
Gasifier Bottom	116.5	
Rough Cut Cyclone Outlet	113.7	
Filter Outlet	106.4	
Scrubber Outlet	104.9	
Product Gas Meter	114.7	

YIELD PERIOD 214

FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	16.7
Bed Top Density (lbs/cf)	9.4
Bed Average Density (lbs/cf)	13.1
Bed Height (ft)	30.7
Bed Holdup (lbs)	71.4
Bed Volume (cf)	4.9
Average Bed Temperature (°F)	1308.4
Space Velocity (bed) (cf/cf/hr)	97.1
Bottom Superficial Velocity (ft/sec)	0.70
Top Superficial Velocity (ft/sec)	0.74

Cyclone Performance

Temperature (°F)	539.0
Pressure (psia)	110.3
Inlet Gas Rate (SCFH)	1073.4
Inlet Gas Rate (ACFH)	274.8
Inlet Gas Velocity (ft/sec)	21.6
Solids Entering (lbs/hr)	1.1
Dust Loading (lbs/acf)	0.0040
Solids Captured (lbs/hr)	1.0
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.9

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	10.57
Total Carryover (lbs/hr)	1.10
Cyclone (lbs/hr)	1.00
Filter (lbs/hr)	0.10
Carryover/Feed (Wt.%)	10.4

Solids Carbon Loss

Carbon in Feed (lbs/hr)	6.37
Carbon in Carryover (lbs/hr)	0.40
Carryover/Feed (Wt.%)	6.2

YIELD PERIOD 214

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	6.37
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.73
Carbon Gasified (by difference) (lbs/hr)	3.83
Total Carbon Converted (lbs/hr)	5.57

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	60.2
Total, Including Devolatilization (%)	87.4

Carbon Distribution

Total Converted (%)	87.4
Entrained (%)	6.0
Withdrawn (%)	7.7
Accumulated (%)	-1.1
Conversion (Entrainment Backed Out)	93.0

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	21.1
Including Devolatilization	30.6

Steam Consumption

Steam into Unit (lbs/hr)	16.19
Steam Reacted with Carbon (lbs/hr)	5.75
Total Steam Consumed (lbs/hr)	8.94

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	35.5
Total Steam Converted (%)	55.2

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.237
Carbon Converted/Steam Fed (mol/mol)	0.355
Carbon Converted/Bed Volume (lbs/hr)/cft	0.701
Carbon Converted/Bed Volume (mol/hr)/cft	0.058
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.122
Carbon in Bed/Steam Fed mol/(mol/hr)	1.683

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 214
UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	8.8	29.2	29.3	30.1	30.8
K as K ₂ CO ₃	12.9	42.8	42.9	44.2	45.2
K as K	7.3	24.3	24.3	25.0	25.5
K Water/Acid, Soluble Ratio	0.833	0.803	0.812	0.778	0.925
K ₂ O, H ₂ O-Insoluble	1.5	5.8	5.5	6.7	2.3
K ₂ CO ₃ , H ₂ O-Insoluble	2.2	8.4	8.1	9.8	3.4
K, H ₂ O-Insoluble	1.2	4.8	4.6	5.5	1.9
Carbon	60.2	28.9	25.4	22.4	34.4
K on Carbon	12.1	83.7	95.5	111.6	74.2
ASTM Ash	26.7	69.3	72.2	77.7	62.0
K on Ash	27.3	34.9	33.6	32.2	41.2
K ₂ CO ₃ Free-Ash	13.6	25.5	28.3	32.6	15.8
K on K ₂ CO ₃ Free-Ash	53.7	94.8	85.8	76.7	161.2

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	0.8	2.8	14.1	44.8	84.2	96.5	100.0
Top Char	1.7	8.7	34.8	64.9	90.3	96.8	100.0
Mid Char	2.7	8.0	23.5	53.2	84.8	96.1	99.9
Bottom Char	2.0	6.4	22.6	53.2	86.3	96.6	100.0
Cyclone	75.0	90.9	99.9	99.4	99.7	100.0	100.0
Filter	93.2	94.0	94.6	97.2	99.4	100.0	100.0

Particle Diameter (Microns)	Volume/ Surface Weight				Bulk Density lbs/cf
	Number Mean	Surface Mean	Weight Mean		
Feed Coal + Catalyst	41	240	394		46.4
Top Char	39	158	306		18.5
Mid Char	31	174	362		23.5
Bottom Char	34	185	358		30.2
Cyclone	22	27	38		
Filter	22	23	41		

*Based on acid soluble analysis

YIELD PERIOD 214
SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.82	0.28	0.47
C	60.2	22.4	34.4
S	4.0	6.0	3.4
O	13.4	9.4	10.0
N	1.12	0.14	0.20
Cl	0.09	0.24	0.34
SO ₃ -Free Ash	17.4	61.5	51.2
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	10.57	1.10	2.20

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
SiO ₂	26.5	26.9	20.5
Fe ₂ O ₃	9.9	10.2	8.4
Al ₂ O ₃	8.8	9.2	6.0
CaO	2.06	2.17	2.87
MgO	0.54	0.57	0.43
TiO ₂	0.43	0.40	0.45
P ₂ O ₅	0.36	0.46	0.14
Na ₂ O	0.83	0.87	1.12
K ₂ O, Catalyst	50.58	49.31	60.11
Total	100.0	100.0	100.0

YIELD PERIOD 214

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	51.3
CO	14.5
CH ₄	8.5
CO ₂	12.7
H ₂ S	0.3
H ₂ O	16.1
N ₂	10.3
H ₂ O/CO	1.1
H ₂ O/CO ₂	1.3

Unit Gas Data

Syngas MWT, lbs/mol	9.7
Product Gas MWT (dry), lbs/mol	15.4

Product Gas

At DTM (dry), SCFH	921.0
(Dry, N ₂ -Free), SCFH	824.2
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1073.4
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	427.8
At Gasifier Outlet, SCFH (Excludes N ₂)	976.6
At Gasifier Outlet, ACFH (Excludes N ₂)	389.2

YIELD PERIOD 214

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	52.6
CO	14.9
CO ₂	13.0
CH ₄	8.7
H ₂ S	0.3
N ₂	10.5

Product Gas (Dry, N ₂ -Free)	
H ₂	58.7
CO	16.7
CO ₂	14.5
CH ₄	9.7
H ₂ S	0.3

Product Gas	
H ₂	45.1
CO	12.8
CO ₂	11.2
CH ₄	7.5
H ₂ S	0.3
H ₂ O	14.2
N ₂	9.0

Product Gas (N ₂ -Free)	
H ₂	49.0
CO	14.1
CO ₂	12.3
CH ₄	8.2
H ₂ S	0.3
H ₂ O	15.5

SCFH CH₄/lb C Active Bed 4.4SCFH CH₄/lb C Feed 12.6Moles CH₄/mole C Feed 0.40

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1308.4°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.9478	3.1437	1360.7
Shift: CO + H ₂ O = CO ₂ + H ₂	1.4954	2.7689	1084.7
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0609	0.0151	1402.5
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3455	0.4132	-

YIELD PERIOD 214
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	10.46	Product Gas (ex N ₂)	30.28
Gasifier Steam	16.19	Product Gas N ₂	7.16
Gasifier Syngas	13.99	Product Water	7.25
		Char Entrained	1.10
		Solids Withdrawn	2.20
Total (ex N ₂)	40.64	Total (ex N ₂)	40.83
Accumulation:	-0.19		
Closure: (Output + Accum)/Input, % 100.0			

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	548.8	H ₂ + CO in Product Gas	621.5
H ₂ Mol%	70.4	H ₂ Mol%	52.6
CO Mol%	29.6	CO Mol%	14.9
Balance: (Output/Input), % 113.6			

YIELD PERIOD 214

MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	6.37	0.4	1.42	0.422	0.009
Gasifier Steam	-	1.81	14.38	-	-
Gasifier Syngas	5.12	2.05	6.82	-	-
Total	11.49	4.26	22.61	0.422	0.009
<u>Output:</u>					
Product Gas	10.69	3.44	15.91	0.244	-
Product Water	-	0.81	6.44	0.003	-
Char Entrained	0.38	0.01	0.11	0.006	0.0
Solids Withdrawn	0.49	0.01	0.21	0.133	0.005
Total	11.56	4.27	22.66	0.416	0.009
Accumulation:	-0.07	-0.01	-0.05	0.006	0.0
Closure (Out + Accum)/in, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	0.77	* 0.64
<u>Output:</u>		
Char Entrained	0.28	0.26
Product Water	0.0	0.0
Solid Withdrawn	0.55	0.43
Total	0.84	0.69
Accumulation:	-0.06	-0.09
Closure (out + accum)/in, %	100.0	92.3

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 214MATERIAL BALANCESAsh Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.83	2.32	1.84	1.58
<u>Output:</u>				
Entrained Char	0.68	0.68	0.56	0.57
Solids Withdrawn	1.72	1.70	1.35	1.57
Total	2.40	2.38	1.92	1.85
Accumulation:	0.43	-0.06	-0.08	-0.26
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.486	0.182	0.162	0.038	0.010	0.799	0.015	0.008	0.007
<u>Output:</u>									
Entrained Char	0.115	0.047	0.034	0.016	0.002	0.103	0.006	0.003	0.001
Solids Withdrawn	0.364	0.137	0.124	0.029	0.008	0.360	0.012	0.005	0.006
Total	0.479	0.185	0.158	0.045	0.010	0.463	0.018	0.008	0.007
Accumulation:	0.007	-0.003	0.004	-0.008	0.0	0.141	-0.003	0.0	0.0
Closure (out + accum)/in, %	100	100	100	100	100	76	100	100	100

YIELD PERIOD 214MATERIAL BALANCESMole Balance

		<u>Lb-Moles/Hr</u>			
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.016)	-	2.033	-	-
CO	(0.426)	0.426	-	0.426	-
H ₂ O	(0.898)	-	1.797	0.898	-
Total	(2.380)	0.426	3.830	1.325	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.530	0.401	0.088	0.013
Total Input		0.957	4.231	1.413	0.013
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Product Gas					
H ₂	(1.277)	-	2.555	-	-
CO	(0.362)	0.362	0.0	0.362	-
CO ₂	(0.316)	0.316	0.0	0.632	-
CH ₄	(0.211)	0.211	0.846	-	-
H ₂ S	(0.008)	-	0.015	-	0.008
H ₂ O	(0.402)	-	0.805	0.402	-
Total	(2.576)	0.890	4.220	1.397	0.008
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.032	0.005	0.007	0.001
Char Samples Withdrawn		0.041	0.006	0.013	0.004
Char Accumulation		-0.006	0.0	-0.003	0.0
Total Solids		0.067	0.011	0.017	0.005
Total Output + Accumulation		0.957	4.231	1.413	0.013

YIELD PERIOD 214

PROCESS VARIABLES

YIELD PERIOD 214

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	16.17	16.19
V111	Char Withdrawn (lbs/hr)	2.20	2.20
V165	H in Char Entrained (wt%)	0.47	0.47
V166	H in Char Withdrawn (wt%)	0.28	0.28
V168	H in Coal + Catalyst Feed (wt%)	3.83	3.82
V173	H in Gasifier Starting Mid Char (wt%)	0.22	0.22
V174	H in Gasifier Ending Mid Char (wt%)	0.22	0.22
V183	CO in Syngas (mol%)	29.70	29.55
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	9.16	8.79
V188	O in Coal + Catalyst Feed (wt%)	13.46	13.39
V193	H ₂ in Syngas (mol%)	70.10	70.45
V205	CO ₂ in Product Gas (mol%)	13.00	13.00
V207	CH ₄ in Product Gas (mol%)	8.70	8.70
V208	CO in Product Gas (mol%)	14.50	14.91
V212	H ₂ in Product Gas (mol%)	52.50	52.56
V214	N ₂ in Product Gas (mol%)	10.50	10.51
V215	H ₂ S in Product Gas (mol%)	0.35	0.31
V222	Carbon in Char Withdrawn (wt%)	22.38	22.39
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	30.49	30.77
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	30.09	30.32
V257	Carbon in Gasifier Starting Mid Char (wt%)	25.42	25.90
V258	Carbon in Gasifier Ending Mid Char (wt%)	25.41	25.20
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	30.10	29.75
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	28.39	29.08
V289	ASTM Ash in Char Entrained (wt%)	61.90	61.99
V292	ASTM Ash in Char Withdrawn (wt%)	77.67	77.96
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	26.89	26.72
V294	C/H Residue in Feed Coal + Catalyst (wt%)	22.08	21.97
V295	C/H Residue in Char Entrained (wt%)	62.12	62.21
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	70.80	62.51
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	73.57	81.95

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	76.78	77.05
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	69.57	69.13
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	71.42	71.86
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	19.27	17.38
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	52.59	51.18
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	61.35	61.49
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	58.22	57.48
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	58.42	58.65
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.46	14.99
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	52.81	52.08
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	59.71	57.84
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	56.99	59.32
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	56.27	54.14
V407	Coal + Catalyst Feed (lbs/hr)	10.72	10.57
V473	Char Entrained (lbs/hr)	1.00	1.10
V495	Carbon in Feed Coal (wt%)	61.98	60.21
V498	Carbon in Char Entrained (wt%)	33.59	34.41
F384	Syngas Flow Meter (CFH)	51.79	51.75
F385	Product Gas Flow Meter (CFH)	127.00	126.44
PGK0	Product Gas Condensate (lbs/hr)	7.08	6.93
U(114)	Starting Bed ΔP (B-A) (in Hg)	2.50	2.40
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.50	1.50
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.30	1.30
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	5.70	5.69
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.50	2.51
U(120)	Ending Bed ΔP (C-B) (in Hg)	1.40	1.40
U(121)	Ending Bed ΔP (D-C) (in Hg)	1.40	1.40
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	5.30	5.31
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.40	0.40

YIELD PERIOD 214

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.00	0.00
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.90	5.05
V281	S in Gasifier Ending Mid Char (wt%)	5.80	5.62
V187	S in Coal + Catalyst Feed (wt%)	3.82	3.99
V246	S in Char Withdrawn (wt%)	6.17	6.03
V244	S in Char Entrained (wt%)	3.39	3.38
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	26.18	26.35
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	28.11	28.01
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.46	26.47
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	26.76	26.89
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	20.29	20.50
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.80	8.71
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.85	8.95
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	10.06	9.90
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.02	10.15
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.34	8.41
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.98	9.00
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.69	9.68
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.83	8.83
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.16	9.18
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	5.95	5.97
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.95	1.82
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.38	1.44
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	2.24	2.06
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.05	2.17
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	2.77	2.87
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.24	0.23
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.24	0.25
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.09	0.08

YIELD PERIOD 214

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.23	0.24
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.33	0.34
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.55	0.58
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.57	0.54
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.14	0.14
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.55	0.54
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.58	0.57
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.58	0.56
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.55	0.57
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.56	0.54
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.55	0.57
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.43	0.43
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.41	0.41
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.44	0.44
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.43	0.43
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.40	0.40
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.45	0.45
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.40	0.39
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.38	0.39
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.37	0.36
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.45	0.46
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.14	0.14
V813	N in Starting Mid Char (wt%)	0.22	0.22
V814	N in Ending Mid Char (wt%)	0.18	0.18
V818	N in Coal + Catalyst Feed (wt%)	1.13	1.12
V819	N in Char Withdrawn (wt%)	0.14	0.14
V820	N in Char Entrained (wt%)	0.20	0.20
V805	O in Starting Mid Char (wt%)	10.78	10.90
V806	O in Ending Mid Char (wt%)	9.95	9.89
V810	O in Char Withdrawn (wt%)	9.44	9.44
V811	O in Char Entrained (wt%)	9.90	10.02

RECONCILED DATA

YIELD PERIOD 215

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	7:30	6-20-77
To	7:30	6-21-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1146	
38.4	1156	
32.1	1309	
26.6	1335	
21.2	1308	
16.0	1312	
10.9	1302	
6.4	1289	
0.4	1242	

YIELD PERIOD 215

UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	245	263
Lockhopper 1 Bottom	216	190
Lockhopper 2 Top	236	280
Lockhopper 2 Bottom	250	316
Gasifier Feed Line	724	987
Gasifier Steam Line	1016	1069
Gasifier		
Top of Bed	1309	1359
Bottom of Bed	1242	1256
Total Bed Average	1300	1343
Rough Cut Cyclone		
Cyclone Top	645	987
Cyclone Bottom	746	1107
Standpipe Top	701	1009
Standpipe Mid	644	1066
Standpipe Bottom	715	1010
Standpipe Slope Top		1057
Standpipe Slope Bottom	1200	994
Gasifier Backend		
Cyclone Inlet	-	543
Filter Inlet	-	479
Scrubber Inlet	436	431
Scrubber Outlet	89	-
Product Gas Meter	99	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	117.3	
Gasifier Feed Line	116.7	
Bypass N ₂	163.7	
Syngas In	162.7	
Gasifier		
Gasifier Top	113.7	
Gasifier Bottom	116.3	
Rough Cut Cyclone Outlet	113.7	
Filter Outlet	106.8	
Scrubber Outlet	105.3	
Product Gas Meter	114.7	

YIELD PERIOD 215FLUID-SOLIDS DATAYIELD PERIOD 215UNIT CONVERSIONSGasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	14.0
Bed Top Density (lbs/cf)	12.8
Bed Average Density (lbs/cf)	10.4
Bed Height (ft)	36.6
Bed Holdup (lbs)	67.5
Bed Volume (cf)	5.9
Average Bed Temperature (°F)	1309.2
Space Velocity (bed) (cf/cf/hr)	82.9
Bottom Superficial Velocity (ft/sec)	0.72
Top Superficial Velocity (ft/sec)	0.76

Cyclone Performance

Temperature (°F)	543.0
Pressure (psia)	110.7
Inlet Gas Rate (SCFH)	1114.2
Inlet Gas Rate (ACFH)	285.5
Inlet Gas Velocity (ft/sec)	22.4
Solids Entering (lbs/hr)	0.9
Dust Loading (lbs/acf)	0.0032
Solids Captured (lbs/hr)	0.8
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.1

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	11.00
Total Carryover (lbs/hr)	0.91
Cyclone (lbs/hr)	0.82
Filter (lbs/hr)	0.09
Carryover/Feed (Wt.%)	8.3

Solids Carbon Loss

Carbon in Feed (lbs/hr)	6.61
Carbon in Carryover (lbs/hr)	0.36
Carryover/Feed (Wt.%)	5.5

Carbon Consumption

Carbon in Feed* (lbs/hr)	6.61
Carbon from Devolatilization** of Feed Coal (lbs/hr)	2.02
Carbon Gasified (by difference) (lbs/hr)	3.78
Total Carbon Converted (lbs/hr)	5.80

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	57.2
Total, Including Devolatilization (%)	87.7

Carbon Distribution

Total Converted (%)	87.7
Entrained (%)	5.3
Withdrawn (%)	9.2
Accumulated (%)	-2.2
Conversion (Entrainment Backed Out)	92.6

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	19.2
Including Devolatilization	29.4

Steam Consumption

Steam into Unit (lbs/hr)	16.48
Steam Reacted with Carbon (lbs/hr)	5.67
Total Steam Consumed (lbs/hr)	9.58

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	34.4
Total Steam Converted (%)	58.1

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.229
Carbon Converted/Steam Fed (mol/mol)	0.344
Carbon Converted/Bed Volume (lbs/hr)/cft	0.580
Carbon Converted/Bed Volume (mol/hr)/cft	0.048
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.195
Carbon in Bed/Steam Fed mol/(mol/hr)	1.793

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 215

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	9.2	27.2	28.8	30.9	27.6
K as K ₂ CO ₃	13.5	39.9	42.3	45.4	40.5
K as K	7.6	22.6	23.9	25.7	22.9
K Water/Acid, Soluble Ratio	0.697	0.798	0.737	0.678	0.875
K ₂ O, H ₂ O-Insoluble	2.8	5.5	7.6	10.0	3.4
K ₂ CO ₃ , H ₂ O-Insoluble	4.1	8.0	11.1	14.6	5.1
K, H ₂ O-Insoluble	2.3	4.5	6.3	8.3	2.9
Carbon	60.1	33.1	29.2	24.3	38.5
K on Carbon	12.7	68.2	81.9	105.7	59.5
ASTM Ash	25.9	64.3	70.9	77.9	56.4
K on Ash	29.5	35.1	33.7	33.0	40.6
K ₂ CO ₃ Free-Ash	12.1	24.4	28.6	32.5	14.9
K on K ₂ CO ₃ Free-Ash	63.1	92.4	83.6	79.1	153.9

Size Distribution

	Cumulative Wt% Less Than Mesh Size					
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	10 Mesh
Feed Coal + Catalyst	1.1	3.1	13.2	43.0	81.8	95.8
Top Char	1.8	6.2	27.1	56.2	86.2	96.3
Mid Char	0.9	4.6	20.0	48.7	86.4	95.3
Bottom Char	0.8	3.1	13.7	40.2	77.4	93.6
Cyclone	72.9	89.3	99.4	99.6	99.9	99.9
Filter	0.0	0.0	0.0	0.0	0.0	0.0

Particle Diameter (Microns)	Volume/ Surface		Weight Mean	Bulk Density lbs/cf
	Number Mean	Mean		
Feed Coal + Catalyst	36	239	411	46.8
Top Char	36	180	349	17.4
Mid Char	42	213	387	18.9
Bottom Char	41	251	443	27.8
Cyclone	23	27	40	
Filter	-	-	-	

*Based on acid soluble analysis

YIELD PERIOD 215

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.86	0.39	0.87
C	60.1	24.3	38.5
S	4.3	6.2	3.5
O	11.2	6.8	9.8
N	1.01	0.06	0.12
Cl	0.07	0.23	0.38
SO ₃ -Free Ash	19.4	62.0	47.2
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	11.01	0.91	2.51

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	27.4	27.6	22.2
Fe ₂ O ₃	11.0	10.6	8.1
Al ₂ O ₃	9.4	9.4	7.0
CaO	2.45	2.33	2.01
MgO	0.56	0.63	0.42
TiO ₂	0.42	0.44	0.43
P ₂ O ₅	0.66	0.51	0.13
Na ₂ O	0.90	0.87	1.24
K ₂ O, Catalyst	47.26	47.63	58.40
Total	100.0	100.0	100.0

YIELD PERIOD 215

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	
H ₂	113.7
CO	53.1
CH ₄	14.0
CO ₂	7.8
H ₂ S	12.2
H ₂ O	0.3
N ₂	11.6
H ₂ O/CO	1.1
H ₂ O/CO ₂	1.2

Unit Gas Data

Syngas MWT, lbs/mol	9.1
Product Gas MWT (dry), lbs/mol	15.1

Product Gas

At DTM (dry), SCFH	969.0
(Dry, N ₂ -Free), SCFH	855.7
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	114.2
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	444.9
At Gasifier Outlet, SCFH (Excludes N ₂)	1000.9
At Gasifier Outlet, ACFH (Excludes N ₂)	399.6

YIELD PERIOD 215

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	53.7
CO	14.1
CO ₂	12.3
CH ₄	7.9
H ₂ S	0.3
N ₂	11.7

Product Gas (Dry, N ₂ -Free)	
H ₂	60.8
CO	16.0
CO ₂	13.9
CH ₄	8.9
H ₂ S	0.3

Product Gas	
H ₂	46.7
CO	12.3
CO ₂	10.7
CH ₄	6.9
H ₂ S	0.3
H ₂ O	13.0
N ₂	10.2

Product Gas (N ₂ -Free)	
H ₂	52.0
CO	13.7
CO ₂	11.9
CH ₄	7.7
H ₂ S	0.3
H ₂ O	14.4

SCFH CH ₄ /lb C Active Bed	3.9
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SCFH CH ₄ /lb C Feed	11.6
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Moles CH ₄ /mole C Feed	0.37
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Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1309.2°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.9620	3.4059	1369.8
Shift: CO + H ₂ O = CO ₂ + H ₂	1.4926	3.1207	1047.7
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0602	0.0120	1419.2
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3459	0.4344	-

YIELD PERIOD 215

MATERIAL BALANCE

Overall Material Balance

Input:	Lbs/hr	Output:	Lbs/hr
Coal Feed (ex N ₂)	10.89	Product Gas (ex N ₂)	30.07
Gasifier Steam	16.43	Product Gas H ₂	8.37
Gasifier Syngas	13.16	Product Water	4.90
		Char Entrained	0.35
		Solids Withdrawn	2.15
Total (ex N ₂)	40.48		
Accumulation:	0.11		
Closure: (Output/Input) %			100.0

Synthesis Gas Balance

Input:	SCFH	Output:	SCFH
Gasifier Syngas	548.6	H ₂ + CO (ex N ₂)	459.1
H ₂ Mol%	72.7	H ₂ Mol%	72.7
CO Mol%	27.3	CO Mol%	27.3

Balance: (Output/Input) % = 100.0

YIELD PERIOD 215

MATERIAL BALANCES

Elemental Balances

Input (Lbs/hr):	Carbon*	Hydrogen	Oxygen	Sulfur	Chlorine
Coal + Catalyst**	6.61	0.43	1.23	0.477	0.036
Gasifier Steam	-	1.84	14.43	-	-
Gasifier Syngas	4.74	2.12	6.42	-	-
Total	11.36	4.39	22.18	0.477	0.036

Outputs:

Product Gas	10.54	3.60	15.08	0.294	-
Product Water	-	0.78	6.13	0.093	-
Char Entrained	0.35	-	0.09	0.032	0.002
Solids Withdrawn	0.61	0.07	0.17	0.156	0.004
Total	11.50	4.39	22.23	0.435	0.018
Accumulation	-0.14	0.0	-0.05	0.036	0.0
Closure	100.0	100.0	100.0	100.0	100.0

Gasifier Effluents

Input (Lbs/hr):	Acid Sol. K	NaOH Sol.
Coal + Catalyst	0.84	0.15
Outputs:		
Char Entrained	0.21	0.1
Product Water	0.0	0.0
Solids Withdrawn	0.61	0.7
Total	0.82	0.8
Accumulation	0.02	0.1
Closure	100.0	100.0
Net Accumulation %		

* Carbon balance excludes catalyst carbonate
 ** Catalyst contains 0.5% oxygen in catalyst

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YIELD PERIOD 215

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.85	2.42	2.14	1.66
<u>Output:</u>				
Entrained Char	0.51	0.50	0.43	0.41
Solids Withdrawn	1.95	1.84	1.55	1.38
Total	2.46	2.34	1.98	1.79
Accumulation:	0.38	0.08	0.16	-0.13
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.586	0.236	0.200	0.052	0.012	0.798	0.019	0.009	0.014
<u>Output:</u>									
Entrained Char	0.095	0.035	0.030	0.009	0.002	0.086	0.005	0.002	0.001
Solids Withdrawn	0.428	0.165	0.146	0.036	0.010	0.409	0.013	0.007	0.008
Total	0.524	0.200	0.176	0.045	0.012	0.494	0.018	0.009	0.009
Accumulation:	0.062	0.036	0.024	0.008	0.0	0.141	0.001	0.0	0.006
Closure (out + accum)/in, %	100	100	100	100	100	80	100	100	100

YIELD PERIOD 215

MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.053)	-	2.107	-	-
CO	(0.395)	0.395	-	0.395	-
H ₂ O	(0.915)	-	1.829	0.915	-
Total	(2.363)	0.395	3.936	1.309	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.551	0.422	0.077	0.015
Total Input		0.945	4.357	1.386	0.015
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
<u>Gas Output</u>					
Product Gas		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.373)	-	2.745	-	-
CO	(0.361)	0.361	-	0.361	-
CO ₂	(0.314)	0.314	-	0.629	-
CH ₄	(0.202)	0.202	0.808	-	-
H ₂ S	(0.008)	-	0.015	-	0.008
H ₂ O	(0.383)	-	0.766	0.383	-
Total	(2.641)	0.878	4.335	1.373	0.008
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.029	0.004	0.006	0.001
Char Samples Withdrawn		0.051	0.010	0.011	0.005
Char Accumulation		-0.012	0.009	-0.003	0.001
Total Solids		0.068	0.023	0.013	0.007
Total Output + Accumulation		0.945	4.357	1.386	0.015

YIELD PERIOD 215

PROCESS VARIABLES

		<u>Measured</u>	<u>Reconciled</u>
V100	Gasifier Steam (lbs/hr)	16.40	16.48
V111	Char Withdrawn (lbs/hr)	2.51	2.51
V165	H in Char Entrained (wt%)	0.47	0.47
V166	H in Char Withdrawn (wt%)	0.39	0.39
V168	H in Coal + Catalyst Feed (wt%)	3.87	3.86
V173	H in Gasifier Starting Mid Char (wt%)	0.21	0.21
V174	H in Gasifier Ending Mid Char (wt%)	0.52	0.52
V183	CO in Syngas (mol%)	27.10	27.26
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	8.77	9.19
V188	O in Coal + Catalyst Feed (wt%)	11.20	11.21
V193	H ₂ in Syngas (mol%)	72.70	72.74
V205	CO ₂ in Product Gas (mol%)	12.30	12.30
V207	CH ₄ in Product Gas (mol%)	7.90	7.90
V208	CO in Product Gas (mol%)	14.00	14.12
V212	H ₂ in Product Gas (mol%)	53.30	53.69
V214	N ₂ in Product Gas (mol%)	11.70	11.69
V215	H ₂ S in Product Gas (mol%)	0.35	0.30
V222	Carbon in Char Withdrawn (wt%)	24.30	24.25
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	27.66	27.57
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	30.23	29.53
V257	Carbon in Gasifier Starting Mid Char (wt%)	32.71	30.93
V258	Carbon in Gasifier Ending Mid Char (wt%)	24.73	25.71
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	29.45	27.67
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	28.85	28.31
V289	ASTM Ash in Char Entrained (wt%)	56.35	56.35
V292	ASTM Ash in Char Withdrawn (wt%)	77.86	77.88
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	25.84	25.87
V294	C/H Residue in Feed Coal + Catalyst (wt%)	21.38	22.01
V295	C/H Residue in Char Entrained (wt%)	55.37	55.02
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	64.71	64.40
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	77.47	77.92

YIELD PERIOD 215

PROCESS VARIABLES

		<u>Measured</u>	<u>Reconciled</u>
V310	C/H Residue in Char Withdrawn (wt%)	75.37	73.58
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	64.97	67.10
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	72.33	69.68
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	18.62	19.45
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	46.95	47.21
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	61.46	61.98
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	52.42	54.12
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	60.33	59.56
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.12	15.11
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	45.97	45.10
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	59.00	55.08
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	52.68	56.15
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	55.19	51.37
V407	Coal + Catalyst Feed (lbs/hr)	10.58	11.00
V473	Char Entrained (lbs/hr)	0.91	0.91
V495	Carbon in Feed Coal (wt%)	61.20	60.12
V498	Carbon in Char Entrained (wt%)	38.98	38.50
F384	Syngas Flow Meter (CFH)	53.42	53.02
F385	Product Gas Flow Meter (CFH)	131.17	134.67
PGK0	Product Gas Condensate (lbs/hr)	7.16	6.50
U(114)	Starting Bed ΔP (B-A) (in Hg)	2.10	2.12
U(115)	Starting Bed ΔP (C-B) (in Hg)	0.70	0.70
U(116)	Starting Bed ΔP (D-C) (in Hg)	2.00	2.02
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	5.20	5.24
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.00	1.98
U(120)	Ending Bed ΔP (C-B) (in Hg)	0.50	0.50
U(121)	Ending Bed ΔP (D-C) (in Hg)	2.00	1.98
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	5.30	5.26
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.40	0.40

YIELD PERIOD 215

PROCESS VARIABLES

Measured Reconciled

EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.80	0.80
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.79	4.92
V281	S in Gasifier Ending Mid Char (wt%)	6.45	6.21
V187	S in Coal + Catalyst Feed (wt%)	3.91	4.28
V246	S in Char Withdrawn (wt%)	6.58	6.24
V244	S in Char Entrained (wt%)	3.57	3.53
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	27.17	26.80
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	28.08	28.02
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	27.11	27.39
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	28.60	27.58
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	22.31	22.21
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.65	8.96
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.89	10.27
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	10.27	11.01
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.42	10.62
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.25	8.14
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	9.11	9.18
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.94	9.79
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	9.17	9.36
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	9.63	9.38
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.04	7.01
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.60	1.68
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	2.17	1.98
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	2.20	2.45
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.61	2.33
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	2.06	2.01
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.30	0.27
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.22	0.24
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.08	0.07

YIELD PERIOD 215

PROCESS VARIABLES

Measured Reconciled

V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.22	0.23
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.33	0.34
V835	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.60	0.61
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.64	0.62
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.17	0.17
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.55	0.54
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.59	0.59
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.57	0.56
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.52	0.53
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.57	0.56
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.62	0.63
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.42	0.42
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.48	0.44
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.39	0.41
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.46	0.42
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.42	0.44
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.42	0.43
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.10	0.10
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.49	0.42
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.55	0.66
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.61	0.51
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.13	0.13
V813	N in Starting Mid Char (wt%)	0.11	0.11
V814	N in Ending Mid Char (wt%)	0.01	0.01
V818	N in Coal + Catalyst Feed (wt%)	1.01	1.01
V819	N in Char Withdrawn (wt%)	0.06	0.06
V820	N in Char Entrained (wt%)	0.13	0.13
V805	O in Starting Mid Char (wt%)	9.46	9.44
V806	O in Ending Mid Char (wt%)	7.74	7.75
V810	O in Char Withdrawn (wt%)	6.96	6.84
V811	O in Char Entrained (wt%)	9.92	9.82

YIELD PERIOD 216
UNIT PROCESS VARIABLES

RECONCILED DATA
YIELD PERIOD 216
UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	7:30	6-30-77
To	7:30	6-31-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1158	
38.4	1179	
32.1	1327	
26.6	1336	
21.2	1298	
16.0	1306	
10.9	1292	
6.4	1278	
0.4	1232	

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	204	214
Lockhopper 1 Bottom	193	175
Lockhopper 2 Top	302	259
Lockhopper 2 Bottom	239	302
Gasifier Feed Line	716	1000
Gasifier Steam Line	929	973
Gasifier		
Top of Bed	1327	1362
Bottom of Bed	1232	1231
Total Bed Average	1296	1338
Rough Cut Cyclone		
Cyclone Top	659	978
Cyclone Bottom	749	1106
Standpipe Top	694	1011
Standpipe Mid	650	1066
Standpipe Bottom	715	1025
Standpipe Slope Top		1056
Standpipe Slope Bottom	1170	986
Gasifier Backend		
Cyclone Inlet	-	553
Filter Inlet	-	504
Scrubber Inlet	425	423
Scrubber Outlet	89	-
Product Gas Meter	100	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	118.9	
Gasifier Feed Line	116.7	
Bypass N ₂	154.7	
Syngas In	163.7	
Gasifier		
Gasifier Top	113.7	
Gasifier Bottom	116.0	
Rough Cut Cyclone Outlet	111.5	
Filter Outlet	106.8	
Scrubber Outlet	105.1	
Product Gas Meter	114.7	

YIELD PERIOD 216
FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	12.0
Bed Top Density (lbs/cf)	11.5
Bed Average Density (lbs/cf)	9.7
Bed Height (ft)	32.5
Bed Holdup (lbs)	56.1
Bed Volume (cf)	5.2
Average Bed Temperature (°F)	1366.2
Space Velocity (bed) (cf/cf/hr)	92.0
Bottom Superficial Velocity (ft/sec)	0.70
Top Superficial Velocity (ft/sec)	0.74

Cyclone Performance

Temperature (°F)	553.0
Pressure (psia)	110.7
Inlet Gas Rate (SCFH)	1086.4
Inlet Gas Rate (ACFH)	281.0
Inlet Gas Velocity (ft/sec)	22.1
Solids Entering (lbs/hr)	1.0
Dust Loading (lbs/acf)	0.0037
Solids Captured (lbs/hr)	0.9
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	90.3

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	0.98
Total Carryover (lbs/hr)	1.03
Cyclone (lbs/hr)	0.93
Filter (lbs/hr)	0.10
Carryover/Feed (Wt.%)	11.5

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.46
Carbon in Carryover (lbs/hr)	0.51
Carryover/Feed (Wt.%)	9.4

YIELD PERIOD 216

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	5.46
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.75
Carbon Gasified (by difference) (lbs/hr)	2.66
Total Carbon Converted (lbs/hr)	4.31

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	46.9
Total, Including Devolatilization (%)	79.0

Carbon Distribution

Total Converted (%)	79.0
Entrained (%)	9.0
Withdrawn (%)	12.1
Accumulated (%)	-0.1
Conversion (Entrainment Backed Out)	86.8

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/hr)	12.4
Including Devolatilization	20.8

Steam Consumption

Steam into Unit (lbs/hr)	15.80
Steam Reacted with Carbon (lbs/hr)	3.85
Total Steam Consumed (lbs/hr)	7.74

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	24.3
Total Steam Converted (%)	49.0

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.162
Carbon Converted/Steam Fed (mol/mol)	0.243
Carbon Converted/Bed Volume (lbs/hr)/cft	0.443
Carbon Converted/Bed Volume (mol/hr)/cft	0.037
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.311
Carbon in Bed/Steam Fed mol/(mol/hr)	1.967

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

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YIELD PERIOD 216

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	9.0	21.9	23.5	25.5	24.1
K as K ₂ CO ₃	13.2	32.2	34.5	37.4	35.4
K as K	7.5	18.2	19.5	21.1	20.0
K Water/Acid, Soluble Ratio	0.803	0.802	0.787	0.716	0.875
K ₂ O, H ₂ O-Insoluble	1.8	4.3	5.0	7.2	3.0
K ₂ CO ₃ , H ₂ O-Insoluble	2.6	6.4	7.4	10.6	4.4
K, H ₂ O-Insoluble	1.5	3.6	4.2	6.0	2.5
Carbon	60.8	43.5	36.9	28.8	48.0
K on Carbon	12.3	41.9	52.9	73.4	41.8
ASTM Ash	25.1	54.1	61.1	72.8	47.7
K on Ash	29.8	33.6	32.0	29.0	42.0
K ₂ CO ₃ Free-Ash	11.6	21.1	25.6	34.5	11.4
K on K ₂ CO ₃ Free-Ash	74.3	86.3	76.2	61.3	176.5

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	2.9	7.6	18.4	41.4	77.6	95.3	100.0
Top Char	1.5	5.0	25.1	51.9	82.2	94.4	100.0
Mid Char	0.8	2.3	13.0	35.7	72.3	90.9	100.0
Bottom Char	1.1	2.6	10.3	30.3	68.3	89.7	100.0
Cyclone	72.2	88.1	99.8	100.0	100.0	100.0	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	29	192	421	51.0
Top Char	37	194	385	15.5
Mid Char	39	268	488	17.2
Bottom Char	34	281	523	25.9
Cyclone	23	27	39	
Filter	-	-	-	

*Based on acid soluble analysis

YIELD PERIOD 216

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.87	0.78	0.32
C	60.8	29.0	48.0
S	4.1	5.2	2.9
O	12.4	6.0	9.2
N	1.04	0.09	0.17
Cl	0.09	0.19	0.36
SO ₃ -Free Ash	17.7	58.8	39.0
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	8.98	1.03	2.29

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	27.5	31.1	20.2
Fe ₂ O ₃	8.9	10.3	7.7
Al ₂ O ₃	9.1	10.3	6.5
CaO	1.48	1.91	1.42
MgO	0.53	0.65	0.36
TiO ₂	0.44	0.46	0.54
P ₂ O ₅	0.36	0.46	0.10
Na ₂ O	0.89	0.90	1.33
K ₂ O, Catalyst	50.80	43.89	61.85
Total	100.0	100.0	100.0

YIELD PERIOD 216

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	50.3
CO	11.8
CH ₄	6.2
CO ₂	11.3
H ₂ S	0.3
H ₂ O	17.7
N ₂	16.0
H ₂ O/CO	1.5
H ₂ O/CO ₂	1.6

Unit Gas Data

Syngas MMT, lbs/mol	9.2
Product Gas MMT (dry), lbs/mol	15.5

Product Gas

At DTM (dry), SCFH	917.0
(Dry, N ₂ -Free), SCFH	763.9
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1086.4
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	437.0
At Gasifier Outlet, SCFH (Excludes N ₂)	933.3
At Gasifier Outlet, ACFH (Excludes N ₂)	375.4

YIELD PERIOD 216

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	52.4
CO	12.3
CO ₂	11.8
CH ₄	6.5
H ₂ S	0.3
N ₂	16.7

Product Gas (Dry, N₂-Free)

H ₂	62.9
CO	14.8
CO ₂	14.2
CH ₄	7.8
H ₂ S	0.4

Product Gas

H ₂	44.2
CO	10.4
CO ₂	10.0
CH ₄	5.5
H ₂ S	0.2
H ₂ O	15.6
N ₂	14.1

Product Gas (N₂-Free)

H ₂	51.5
CO	12.1
CO ₂	11.6
CH ₄	6.4
H ₂ S	0.2
H ₂ O	18.2

SCFH CH₄/lb C Active Bed 2.9SCFH CH₄/lb C Feed 10.9Moles CH₄/mole C Feed 0.35

Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (13062°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.9072	2.2824	1325.4
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5035	2.7127	1091.2
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0631	0.0159	1398.8
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3451	0.2247	-

YIELD PERIOD 216

MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex H ₂)	5.89	Product Gas (ex H ₂)	26.24
Gasifier Steam	15.80	Product Gas H ₂	11.32
Gasifier Syngas	12.12	Product Water	8.06
		Char Entrained	1.03
		Solids Withdrawn	2.29
Total (ex H ₂)	37.41	Total (ex H ₂)	37.61
Accumulation:	0.20		
Closure: (Output + Accum)/input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	245.4	H ₂ + CO in Product Gas	593.4
H ₂ Mol%	72.6	H ₂ Mol%	52.4
CO Mol%	27.6	CO Mol%	12.3
Balance: (Output/input) %	113.2		

YIELD PERIOD 216

MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	5.46	0.34	1.12	0.366	0.008
Gasifier Steam	-	1.77	14.03	-	-
Gasifier Syngas	4.59	2.02	6.11	-	-
Total	10.05	4.13	21.26	0.366	0.008
<u>Output:</u>					
Product Gas	8.90	3.20	13.91	0.228	-
Product Water	-	0.90	7.15	0.003	-
Char Entrained	0.49	0.00	0.09	0.030	0.004
Solids Withdrawn	0.66	0.02	0.14	0.118	0.004
Total	10.06	4.12	21.29	0.380	0.008
Accumulation:	-0.01	0.01	-0.04	-0.013	0.0
Closure (Out + Accum)/in, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	0.67	0.54
<u>Output:</u>		
Char Entrained	0.21	0.18
Product Water	0.0	0.0
Solid Withdrawn	0.49	0.35
Total	0.70	0.53
Accumulation:	-0.03	-0.09
Closure (out + accum)/in	100.0	81.4

*Carbon balance excludes catalyst carbonate
 **Excludes carbon and oxygen in catalyst

YIELD PERIOD 216

MATERIAL BALANCES

Ash Balances

Input (Lbs/Hr):	ASTM Ash	C/H Residue	SO ₃ -Free ASTM Ash	SO ₃ -Free C/H Residue
Coal + Catalyst	2.25	1.91	1.59	1.33
Output:				
Entrained Char	0.49	0.48	0.40	0.38
Solids Withdrawn	1.67	1.57	1.35	1.119
Total	2.16	2.05	1.75	1.57
Accumulation:	0.009	-0.14	-0.16	-0.24
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

Input (Lbs/Hr):	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	TiO ₂	P ₂ O ₅
Coal + Catalyst	0.437	0.142	0.144	0.023	0.008	0.650	0.014	0.007	0.006
Output:									
Entrained Char	0.081	0.031	0.026	0.006	0.001	0.084	0.005	0.002	0.0
Solids Withdrawn	0.419	0.139	0.139	0.026	0.009	0.315	0.012	0.006	0.006
Total	0.500	0.170	0.165	0.031	0.010	0.400	0.017	0.008	0.007
Accumulation:	-0.063	-0.028	-0.020	-0.008	-0.002	0.015	-0.003	-0.001	-0.001
Closure (out + accum)/in, %	100	100	100	100	100	92	100	100	100

YIELD PERIOD 216

MATERIAL BALANCES

Mole Balance

Gas balance		Lb-Moles/Hr				
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	
H ₂	(1.002)	-	2.003	-	-	
CO	(0.382)	0.382	-	0.382	-	
H ₂ O	(0.877)	-	1.754	0.877	-	
Total	(2.261)	0.382	3.757	1.259	-	
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
Coal + Cat Feed		0.455	0.345	0.070	0.011	0.017
<u>Total Input</u>						
		0.837	4.103	1.329	0.011	0.017
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	
Product Gas						
H ₂	(1.267)	-	2.535	-	-	
CO	(0.298)	0.298	-	0.298	-	
CO ₂	(0.285)	0.285	-	0.571	-	
CH ₄	(0.157)	0.157	0.629	-	-	
H ₂ S	(0.007)	-	0.017	-	0.007	
H ₂ O	(0.447)	-	0.894	0.447	-	
Total	(2.461)	0.741	4.072	1.316	0.007	
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
Char Entrained		0.041	0.003	0.006	0.001	0.005
Char Samples Withdrawn		0.055	0.018	0.009	0.004	0.013
Char Accumulation		-0.001	0.009	-0.002	0.0	-0.001
Total Solids		0.096	0.030	0.012	0.004	0.017
<u>Total Output + Accumulation</u>						
		0.837	4.102	1.329	0.011	0.017

YIELD PERIOD 216

PROCESS VARIABLES

	Measured	Reconciled
V100 Gasifier Steam (lbs/hr)	15.77	15.80
V111 Char Withdrawn (lbs/hr)	2.29	2.29
V165 H in Char Entrained (wt%)	0.32	0.32
V166 H in Char Withdrawn (wt%)	0.78	0.78
V168 H in Coal + Catalyst Feed (wt%)	3.88	3.87
V173 H in Gasifier Starting Mid Char (wt%)	0.30	0.30
V174 H in Gasifier Ending Mid Char (wt%)	0.72	0.72
V183 CO in Syngas (mol%)	26.90	27.60
V185 Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	9.06	8.99
V188 O in Coal + Catalyst Feed (wt%)	12.40	12.42
V193 H ₂ in Syngas (mol%)	73.00	72.40
V205 CO ₂ in Product Gas (mol%)	11.80	11.80
V207 CH ₄ in Product Gas (mol%)	6.50	6.50
V208 CO in Product Gas (mol%)	12.80	12.33
V212 H ₂ in Product Gas (mol%)	51.60	52.38
V214 N ₂ in Product Gas (mol%)	16.70	16.70
V215 H ₂ S in Product Gas (mol%)	0.35	0.29
V222 Carbon in Char Withdrawn (wt%)	28.81	29.00
V227 Acid Sol. K ₂ O in Char Entrained (wt%)	24.03	24.14
V232 Acid sol. K ₂ O in Char Withdrawn (wt%)	25.46	25.81
V257 Carbon in Gasifier Starting Mid Char (wt%)	38.15	38.28
V258 Carbon in Gasifier Ending Mid Char (wt%)	39.48	41.26
V265 Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	24.59	24.19
V266 Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	22.44	24.94
V289 ASTM Ash in Char Entrained (wt%)	47.64	47.69
V292 ASTM Ash in Char Withdrawn (wt%)	72.78	73.05
V293 ASTM Ash in Feed Coal + Catalyst (wt%)	25.20	25.07
V294 C/H Residue in Feed Coal + Catalyst (wt%)	21.36	21.30
V295 C/H Residue in Char Entrained (wt%)	46.51	46.54
V306 ASTM Ash in Gasifier Starting Mid Char (wt%)	60.79	55.60
V307 ASTM Ash in Gasifier Ending Mid Char (wt%)	59.65	64.25

YIELD PERIOD 216

PROCESS VARIABLES

	Measured	Reconciled
V310 C/H Residue in Char Withdrawn (wt%)	68.47	68.62
V320 C/H Residue in Gasifier Starting Mid Char (wt%)	58.39	58.22
V321 C/H Residue in Gasifier Ending Mid Char (wt%)	57.32	57.47
V333 SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	17.94	17.79
V334 SO ₃ -Free ASTM Ash in Char Entrained (wt%)	39.34	39.04
V336 SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	59.07	58.81
V337 SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	50.19	49.93
V338 SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	49.26	47.55
V350 SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.04	14.81
V351 SO ₃ -Free C/H Residue in Char Entrained (wt%)	37.65	37.01
V353 SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	54.76	51.76
V354 SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	47.79	50.33
V355 SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	46.93	44.68
V407 Coal + Catalyst Feed (lbs/hr)	9.06	8.98
V473 Char Entrained (lbs/hr)	1.03	1.03
V495 Carbon in Feed Coal (wt%)	60.97	60.81
V498 Carbon in Char Entrained (wt%)	47.41	47.97
F384 Syngas Flow Meter (CFH)	50.83	50.35
F385 Product Gas Flow Meter (CFH)	124.04	127.70
PGK0 Product Gas Condensate (lbs/hr)	8.00	7.66
U(114) Starting Bed ΔP (B-A) (in Hg)	1.90	1.90
U(115) Starting Bed ΔP (C-B) (in Hg)	0.80	0.80
U(116) Starting Bed ΔP (D-C) (in Hg)	1.90	1.90
U(117) Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118) Starting Overall Bed ΔP (F-A) (in Hg)	4.80	4.80
U(119) Ending Bed ΔP (B-A) (in Hg)	1.80	1.80
U(120) Ending Bed ΔP (C-B) (in Hg)	0.70	0.70
U(121) Ending Bed ΔP (D-C) (in Hg)	1.80	1.80
U(122) Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123) Ending Overall Bed ΔP (F-A) (in Hg)	4.40	4.41
EDD(1) Starting Bed ΔP (E-D) (in Hg)	0.20	0.20

YIELD PERIOD 216

PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed AP (E-D) (in Hg)	0.10	0.10
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.05	4.17
V281	S in Gasifier Ending Mid Char (wt%)	4.05	3.96
V187	S in Coal + Catalyst Feed (wt%)	3.73	4.07
V246	S in Char Withdrawn (wt%)	5.24	5.16
V244	S in Char Entrained (wt%)	2.97	2.95
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	28.12	28.96
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	27.47	27.38
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.48	27.48
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	31.49	31.11
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	20.24	20.21
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.94	9.16
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.06	7.96
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.67	8.94
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.56	10.32
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.76	7.72
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	9.43	9.67
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	9.33	9.20
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.81	9.08
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.54	10.31
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	6.49	6.47
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.25	1.31
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.81	0.79
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.38	1.48
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.08	1.91
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.44	1.42
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.28	0.25
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.23	0.25
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.10	0.08

YIELD PERIOD 216

PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.18	0.19
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.34	0.36
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.53	0.56
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.54	0.51
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.15	0.16
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.55	0.53
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.53	0.52
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.60	0.60
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.52	0.52
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.53	0.53
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.65	0.65
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.36	0.36
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.51	0.50
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.45	0.46
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.45	0.46
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.45	0.46
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.54	0.54
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.20	0.22
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.19	0.18
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.31	0.36
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.66	0.46
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.10	0.10
V813	N in Starting Mid Char (wt%)	0.01	0.01
V814	N in Ending Mid Char (wt%)	0.08	0.08
V818	N in Coal + Catalyst Feed (wt%)	1.04	1.04
V819	N in Char Withdrawn (wt%)	0.09	0.09
V820	N in Char Entrained (wt%)	0.17	0.17
V805	O in Starting Mid Char (wt%)	7.02	7.06
V806	O in Ending Mid Char (wt%)	6.17	6.18
V810	O in Char Withdrawn (wt%)	5.86	5.96
V811	O in Char Entrained (wt%)	9.18	9.19

YIELD PERIOD 217
UNIT PROCESS VARIABLES

RECONCILED DATA

YIELD PERIOD 217

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	7:30	7-04-77
To	7:30	7-05-77
Duration	24 Hrs	
Percent of Time on Stream		
Coal Feed	100	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1158	
38.4	1193	
32.1	1337	
26.6	1336	
21.2	1301	
16.0	1308	
10.9	1294	
6.4	1280	
0.4	1231	

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	188	202
Lockhopper 1 Bottom	176	160
Lockhopper 2 Top	229	247
Lockhopper 2 Bottom	259	30
Gasifier Feed Line	710	969
Gasifier Steam Line	913	975
Gasifier		
Top of Bed	1337	1365
Bottom of Bed	1231	1232
Total Bed Average	1298	1339
Rough Cut Cyclone		
Cyclone Top	703	980
Cyclone Bottom	757	1107
Standpipe Top	693	1006
Standpipe Mid	650	1066
Standpipe Bottom	719	1027
Standpipe Slope Top		1058
Standpipe Slope Bottom	1188	990
Gasifier Backend		
Cyclone Inlet	-	551
Filter Inlet	-	502
Scrubber Inlet	426	423
Scrubber Outlet	91	-
Product Gas Meter	101	-

<u>Unit Pressures</u>	<u>Psia</u>
Lockhopper 2	120.4
Gasifier Feed Line	116.5
Bypass N ₂	154.7
Syngas In	162.7
Gasifier	
Gasifier Top	113.7
Gasifier Bottom	115.9
Rough Cut Cyclone Outlet	113.5
Filter Outlet	106.8
Scrubber Outlet	105.1
Product Gas Meter	114.7

UNIT PERIOD 217FLUID SOLIDS DATAGasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	12.0
Bed Top Density (lbs/cf)	10.8
Bed Average Density (lbs/cf)	9.5
Bed Height (ft)	11.0
Bed Holdup (lbs)	57.3
Bed Volume (cf)	5.4
Average Bed Temperature (°F)	1309.3
Space Velocity (bed) (cf/cf/hr)	8.7
Bottom Superficial Velocity (ft/sec)	0.66
Top Superficial Velocity (ft/sec)	0.70

Cyclone Performance

Temperature (°F)	551.0
Pressure (psia)	110.7
Inlet Gas Rate (SCFH)	1024.9
Inlet Gas Rate (ACFH)	254.6
Inlet Gas Velocity (ft/sec)	20.8
Solids Entering (lbs/hr)	1.0
Dust Loading (lbs/acf)	0.0036
Solids Captured (lbs/hr)	0.9
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	93.8

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	9.08
Total Carryover (lbs/hr)	0.96
Cyclone (lbs/hr)	0.90
Filter (lbs/hr)	0.06
Carryover/Feed (Wt.%)	10.6

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.31
Carbon in Carryover (lbs/hr)	0.48
Carryover/Feed (Wt.%)	9.0

UNIT PERIOD 217UNIT CONVERSIONSCarbon Consumption

Carbon in Feed* (lbs/hr)	5.31
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.43
Carbon Gasified (by difference) (lbs/hr)	2.86
Total Carbon Converted (lbs/hr)	4.29

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	53.8
Total, Including Devolatilization (%)	80.7

Carbon Distribution

Total Converted (%)	60.7
Entrained (%)	8.7
Withdrawn (%)	17.7
Accumulated (%)	-1.1
Conversion (Entrainment Backed Out)	38.4

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	12.1
Including Devolatilization	18.2

Steam Consumption

Steam into Unit (lbs/hr)	15.70
Steam Reacted with Carbon (lbs/hr)	4.28
Total Steam Consumed (lbs/hr)	7.64

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	27.3
Total Steam Converted (%)	48.6

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.182
Carbon Converted/Steam Fed (mol/mol)	0.273
Carbon Converted/Bed Volume (lbs/hr)/cft	0.473
Carbon Converted/Bed Volume (mol/hr)/cft	0.039
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.500
Carbon in Bed/Steam Fed mol/(mol/hr)	2.251

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

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YIELD PERIOD 217UNIT COMPOSITIONSCatalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	9.3	21.0	22.9	25.2	24.7
K as K ₂ CO ₃	13.6	30.8	33.6	36.9	36.3
K as K	7.7	17.4	19.0	20.9	20.5
K Water/Acid, Soluble Ratio	0.771	0.776	0.749	0.700	0.835
K ₂ O, H ₂ O-Insoluble	2.1	4.7	5.7	7.6	4.1
K ₂ CO ₃ , H ₂ O-Insoluble	3.1	6.9	8.4	11.1	6.0
K, H ₂ O-Insoluble	1.8	3.9	4.8	6.3	3.4
Carbon	58.5	44.4	41.1	24.8	48.0
K on Carbon	13.1	39.2	46.2	84.2	42.7
ASTM Ash	26.3	53.0	48.7	76.8	50.0
K on Ash	29.3	32.9	39.1	27.2	41.0
K ₂ CO ₃ Free-Ash	12.4	21.3	14.2	38.9	12.9
K on K ₂ CO ₃ Free-Ash	62.0	81.6	134.1	53.7	159.2

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	0.8	4.8	13.1	36.4	76.6	94.6	100.0
Top Char	1.2	6.3	28.6	56.6	86.1	96.9	100.0
Mid Char	2.7	8.8	25.2	52.1	83.1	99.5	100.0
Bottom Char	0.2	1.0	5.5	23.5	61.7	88.0	99.9
Cyclone	73.5	89.5	99.7	99.9	100.0	100.0	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	41	249	447	49.0
Top Char	42	182	343	13.7
Mid Char	31	171	373	18.1
Bottom Char	55	363	572	26.8
Cyclone	23	27	38	
Filter	-	-	-	

*Based on acid soluble analysis

YIELD PERIOD 217SOLIDS COMPOSITIONUltimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	2.98	0.68	0.81
C	58.5	25.2	48.0
S	4.2	5.8	3.0
O	14.1	7.7	8.0
N	1.19	0.07	0.013
Cl	0.11	0.24	0.039
SO ₃ -Free Ash	19.0	60.3	39.6
Total	100	100	100
Solids Flow Rate (lbs/hr)	9.08	2.47	0.96

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	28.1	31.5	20.0
Fe ₂ O ₃	9.5	10.6	7.4
Al ₂ O ₃	9.0	10.1	6.3
CaO	2.14	2.32	1.77
MgO	0.59	0.67	0.37
TiO ₂	0.44	0.46	0.41
P ₂ O ₅	0.45	0.55	0.12
Na ₂ O	0.91	0.87	1.29
K ₂ O, Catalyst	48.81	42.84	62.36
Total	100	100	100

YIELD PERIOD 217

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	113.7
H ₂	51.1
CO	11.8
CH ₄	6.5
CO ₂	12.0
H ₂ S	0.3
H ₂ O	18.8
N ₂	13.1
H ₂ O/CO	1.6
H ₂ O/CO ₂	1.6

Unit Gas Data

Syngas MWT, lbs/mol	9.0
Product Gas MWT (dry), lbs/mol	15.2

Product Gas

At DTM (dry), SCFH	855.3
(Dry, N ₂ -Free), SCFH	737.0
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1024.9
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	412.0
At Gasifier Outlet, SCFH (Excludes N ₂)	908.0
At Gasifier Outlet, ACFH (Excludes N ₂)	351.0

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YIELD PERIOD 217

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%

H ₂	53.9
CO	12.4
CO ₂	12.7
CH ₄	6.8
H ₂ S	0.3
N ₂	13.8

Product Gas (Dry, N₂-Free)

H ₂	62.5
CO	14.4
CO ₂	14.7
CH ₄	7.9
H ₂ S	0.3

Product Gas

H ₂	45.0
CO	10.4
CO ₂	10.6
CH ₄	5.7
H ₂ S	0.3
H ₂ O	16.5
N ₂	11.5

Product Gas (N₂-Free)

H ₂	50.8
CO	11.8
CO ₂	12.0
CH ₄	6.4
H ₂ S	0.3
H ₂ O	18.7

SCFH CH₄/lb C Active Bed 2.5SCFH CH₄/lb C Feed 11.0Moles CH₄/mole C Feed 0.35

	Reaction Equilibrium at Active Bed Temp (1305.2 F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (F)
Graphitic Hydrogen	$C + H_2O \rightleftharpoons CO + H_2$	0.0500	1320.0
Water Gas	$CO + H_2O \rightleftharpoons CO_2 + H_2$	1.0000	1000.0
Water Gas Shift	$CO + H_2 \rightleftharpoons C + H_2O$	0.0167	1300.0
Overall	$CO + H_2O \rightleftharpoons CH_4 + CO_2$	0.0000	1300.0

YIELD PERIOD: 1

PERIOD: 100 HOURS

Overall Material Balance

Input:	Lbs/Hr	Output:	Lbs/Hr
Coal Feed (ex H ₂)	8.66	Product Gas (ex H ₂)	25.64
Gasifier Steam	15.12	Product Gas H ₂	8.74
Gasifier Syngas	12.21	Product Water	8.06
		Char Entrained	0.96
		Solids Withdrawn	2.42
Total (ex H ₂)	26.49	Total (ex H ₂)	21.14
Accumulation:	0.20		
Closure: (Output/Input) x 100 =			

Syngas Gas Balance

Input:	Lbs	Output:	SCFH
Gasifier Syngas	541.0	H ₂ & CO in Product Gas	667.3
H ₂ Feed	11.5	H ₂ Waste	51.0
CO Waste	0.7	CO Waste	1.0
Balance: (Output/Input) x 100 =			

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YIELD PERIOD: 212

MATERIAL BALANCES

Element Balances

Input (Lbs/Hr):	Carbon*	Hydrogen	Oxygen	Sulfur	Chlorine
Coal + Catalyst**	5.31	0.27	1.28	0.378	0.010
Gasifier Steam	-	1.76	13.94	-	-
Gasifier Syngas	4.38	1.98	5.84	-	-
Total	9.70	4.01	21.06	0.378	0.010
Output:					
Product Gas	8.67	3.08	13.66	0.213	0
Product Water	0.0	0.90	7.16	0.003	0
Char Entrained	0.46	0.01	0.08	0.030	0.004
Solids Withdrawn	0.62	0.02	0.19	0.144	0.006
Total	9.75	4.01	21.09	0.394	0.010
Accumulation:	-0.006	0.0	-0.03	-0.016	0.0
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

Input (Lbs/Hr):	Acid Sol. K	Water Sol. K
Coal + Catalyst	0.70	0.54
Output:		
Char Entrained	0.20	0.16
Product Water	0.0	0.0
Solid Withdrawn	0.53	0.36
Total	0.73	0.53
Accumulation:	-0.03	0.04
Closure (out + accum)/in	100.0	91.0

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 217

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.39	2.01	1.72	1.35
<u>Output:</u>				
Entrained Char	0.48	0.47	0.38	0.73
Solids Withdrawn	1.91	1.79	1.49	1.30
Total	2.39	2.26	1.87	1.69
Accumulation:	0.0	-0.25	-0.15	-0.33
Closure (out + accum)/in, %	100	100	100	100

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.485	0.164	0.155	0.037	0.010	0.705	0.015	0.008	0.008
<u>Output:</u>									
Entrained Char	0.076	0.28	0.24	0.007	0.001	0.075	0.005	0.002	0.0
Solids Withdrawn	0.471	0.159	0.151	0.035	0.010	0.385	0.013	0.007	0.008
Total	0.547	0.187	0.175	0.041	0.011	0.461	0.018	0.009	0.009
Accumulation:	-0.062	-0.023	-0.020	-0.005	-0.001	0.0	-0.003	-0.001	-0.001
Closure (out + accum)/in, %	100	100	100	100	100	65	100	100	100

YIELD PERIOD 217

MATERIAL BALANCES

Mole Balance

Gas Input

H ₂	(0.986)
CO	(0.365)
H ₂ O	(0.871)
Total	(2.222)

<u>Lb-Moles/Hr</u>			
<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
-	1.971	-	-
0.365	-	0.365	-
-	1.743	0.871	-
0.365	3.714	1.236	-

Solids Input

Coal + Cat Feed

Total Input

<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
0.442	0.268	0.080	0.012	0.018
0.018	0.807	3.982	1.316	0.012

Gas Output

Product Gas

H ₂	(1.216)
CO	(0.281)
CO ₂	(0.287)
CH ₄	(0.154)
H ₂ S	(0.007)
H ₂ O	(0.448)
Total	(2.393)

<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
-	2.432	-	-
0.281	-	0.281	-
0.287	-	0.573	-
0.154	0.617	-	-
-	0.014	-	0.007
-	0.895	0.448	-
0.722	3.958	1.302	0.007

Solids Output

Char Entrained	0.038
Char Samples Withdrawn	0.052
Char Accumulation	-0.005
Total Solids	0.085

<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>	<u>K</u>
0.038	0.008	0.005	0.001	0.005
0.052	0.017	0.012	0.004	0.014
-0.005	-0.001	-0.002	0.0	-0.001
0.085	0.024	0.005	0.005	0.018
0.807	3.982	1.316	0.012	0.018

Total Output + Accumulation

YIELD PERIOD 217

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	15.70	15.70
V111	Char Withdrawn (lbs/hr)	2.48	2.47
V165	H in Char Entrained (wt%)	0.81	0.81
V166	H in Char Withdrawn (wt%)	0.68	0.68
V168	H in Coal + Catalyst Feed (wt%)	2.98	2.98
V173	H in Gasifier Starting Mid Char (wt%)	0.20	0.2-
V174	H in Gasifier Ending Mid Char (wt%)	0.20	0.20
V183	CO in Syngas (mol%)	26.70	27.02
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	8.94	9.26
V188	O in Coal + Catalyst Feed (wt%)	14.14	14.10
V193	H ₂ in Syngas (mol%)	72.60	72.98
V205	CO ₂ in Product Gas (mol%)	12.70	12.70
V207	CH ₄ in Product Gas (mol%)	6.84	6.84
V208	CO in Product Gas (mol%)	12.50	12.44
V212	H ₂ in Product Gas (mol%)	53.50	53.88
V214	N ₂ in Product Gas (mol%)	13.80	13.83
V215	H ₂ S in Product Gas (mol%)	0.35	0.30
V222	Carbon in Char Withdrawn (wt%)	24.82	25.17
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	24.39	24.70
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	25.16	25.84
V257	Carbon in Gasifier Starting Mid Char (wt%)	41.08	37.87
V258	Carbon in Gasifier Ending Mid Char (wt%)	41.08	39.57
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	22.89	20.02
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	22.89	20.70
V289	ASTM Ash in Char Entrained (wt%)	49.98	50.02
V292	ASTM Ash in Char Withdrawn (wt%)	76.77	77.04
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	26.39	26.27
V294	C/H Residue in Feed Coal + Catalyst (wt%)	21.36	22.15
V295	C/H Residue in Char Entrained (wt%)	49.26	48.82
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	48.66	45.95
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	48.66	51.10

YIELD PERIOD 217

PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	75.12	72.46
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	57.42	59.70
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	57.42	55.37
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	18.59	18.98
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	42.13	39.61
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	61.25	60.32
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	39.45	43.00
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	39.45	41.25
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	13.56	14.89
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	41.41	40.10
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	59.60	52.61
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	48.21	52.87
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	48.21	44.02
V407	Coal + Catalyst Feed (lbs/hr)	8.63	9.08
V473	Char Entrained (lbs/hr)	0.96	0.96
V495	Carbon in Feed Coal (wt%)	59.11	58.48
V498	Carbon in Char Entrained (wt%)	45.64	47.99
F384	Syngas Flow Meter (CFH)	49.71	49.63
F385	Product Gas Flow Meter (CFH)	120.25	119.36
PGK0	Product Gas Condensate (lbs/hr)	7.67	7.68
U(114)	Starting Bed ΔP (B-A) (in Hg)	1.80	1.82
U(115)	Starting Bed ΔP (C-B) (in Hg)	0.80	0.80
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.80	1.82
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	4.70	4.75
U(119)	Ending Bed ΔP (B-A) (in Hg)	1.80	1.78
U(120)	Ending Bed ΔP (C-B) (in Hg)	0.70	0.70
U(121)	Ending Bed ΔP (D-C) (in Hg)	1.60	1.59
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	4.30	4.27
EDD(1)	Starting Bed ΔP (E-D) (in Hg)	0.30	0.30

YIELD PERIOD 217PROCESS VARIABLES

		Measured	Reconciled
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.20	0.20
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.34	4.42
V281	S in Gasifier Ending Mid Char (wt%)	4.34	4.22
V187	S in Coal + Catalyst Feed (wt%)	3.87	4.16
V246	S in Char Withdrawn (wt%)	5.71	5.80
V244	S in Char Entrained (wt%)	3.12	3.12
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	29.31	29.64
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	29.31	27.76
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.46	28.15
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	31.52	31.53
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	19.88	20.03
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.74	9.29
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.74	8.23
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.65	9.51
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	11.71	10.63
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	7.46	7.37
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.04	10.22
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.04	9.74
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.66	9.01
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.33	10.12
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	6.28	6.28
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.56	1.67
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.56	1.45
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.86	2.14
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	2.79	2.32
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.82	1.77
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.28	0.25
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.28	0.30
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.13	0.11

YIELD PERIOD 217PROCESS VARIABLES

		Measured	Reconciled
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.22	0.24
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.37	0.39
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.52	0.52
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.52	0.51
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.17	0.17
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.53	0.53
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.51	0.51
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.62	0.64
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.62	0.60
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.56	0.59
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.71	0.67
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt)	0.37	0.37
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.52	0.52
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.52	0.52
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.44	0.44
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.45	0.46
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.41	0.41
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.31	0.33
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.31	0.29
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.39	0.45
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.72	0.55
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.12	0.12
V813	N in Starting Mid Char (wt%)	0.11	0.11
V814	N in Ending Mid Char (wt%)	0.11	0.11
V818	N in Coal + Catalyst Feed (wt%)	1.19	1.19
V819	N in Char Withdrawn (wt%)	0.07	0.07
V820	N in Char Entrained (wt%)	0.13	0.13
V805	O in Starting Mid Char (wt%)	14.54	14.14
V806	O in Ending Mid Char (wt%)	14.54	14.35
V810	O in Char Withdrawn (wt%)	7.25	7.72
V811	O in Char Entrained (wt%)	7.83	7.95

RECONCILED DATA
YIELD PERIOD 218
UNIT OPERATIONS

	Time	Date
From	7:30	7-11-77
To	7:30	7-12-77
Duration	24 Hrs	

Percent of Time on Stream

Coal Feed	100
Steam	100
Syngas	100

Gasifier Process Temperatures

Gasifier Bed Height (ft)	Gasifier Temperature (°F)
43.2	1171
38.4	1151
32.1	1298
26.6	1334
21.2	1303
16.0	1314
10.9	1304
6.4	1291
0.4	1227

YIELD PERIOD 218
UNIT PROCESS VARIABLES

Unit Temperatures	Process, °F	Metal, °F
Lockhopper 1 Top	249	259
Lockhopper 1 Bottom	247	224
Lockhopper 2 Top	263	247
Lockhopper 2 Bottom	229	329
Gasifier Feed Line	655	879
Gasifier Steam Line	862	875
Gasifier		
Top of Bed	1298	1374
Bottom of Bed	1227	1258
Total Bed Average	1296	1345
Rough Cut Cyclone		
Cyclone Top	903	971
Cyclone Bottom	752	1108
Standpipe Top	694	1006
Standpipe Mid	642	1066
Standpipe Bottom	719	1024
Standpipe Slope Top		1057
Standpipe Slope Bottom	1203	998
Gasifier Backend		
Cyclone Inlet	-	536
Filter Inlet	-	485
Scrubber Inlet	481	428
Scrubber Outlet	88	-
Product Gas Meter	99	-
Unit Pressures	Psia	
Lockhopper 2	118.2	
Gasifier Feed Line	117.6	
Bypass N2	155.7	
Syngas In	163.7	
Gasifier		
Gasifier Top	114.7	
Gasifier Bottom	117.2	
Rough Cut Cyclone Outlet	114.5	
Filter Outlet	107.5	
Scrubber Outlet	105.7	
Product Gas Meter	114.7	

YIELD PERIOD 218
FLUID-SOLIDS DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	16.0
Bed Top Density (lbs/cf)	8.3
Bed Average Density (lbs/cv)	10.4
Bed Height (ft)	35.2
Bed Holdup (lbs)	65.0
Bed Volume (cf)	5.7
Average Bed Temperature (°F)	1207.3
Space Velocity (bed) (cf/cf/hr)	76.0
Bottom Superficial Velocity (ft/sec)	0.63
Top Superficial Velocity (ft/sec)	0.67

Cyclone Performance

Temperature (°F)	535.0
Pressure (psia)	111.6
Inlet Gas Rate (SCFH)	989.3
Inlet Gas Rate (ACFH)	249.7
Inlet Gas Velocity (ft/sec)	19.6
Solids Entering (lbs/hr)	1.2
Dust Loading (lbs/acf)	0.0047
Solids Captured (lbs/hr)	1.1
Solids Escaping (lbs/hr)	0.1
Overall Efficiency (Captured/Entering, Wt.%)	93.2

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	8.50
Total Carryover (lbs/hr)	1.18
Cyclone (lbs/hr)	1.10
Filter (lbs/hr)	0.08
Carryover/Feed (Wt.%)	13.9

Solids Carbon Loss

Carbon in Feed (lbs/hr)	5.12
Carbon in Carryover (lbs/hr)	0.49
Carryover/Feed (Wt.%)	9.7

YIELD PERIOD 218

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	5.12
Carbon from Devolatilization** of Feed Coal (lbs/hr)	1.61
Carbon Gasified (by difference) (lbs/hr)	2.64
Total Carbon Converted (lbs/hr)	4.25

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	51.5
Total, Including Devolatilization (%)	83.1

Carbon Distribution

Total Converted (%)	83.1
Entrained (%)	9.2
Withdrawn (%)	9.2
Accumulated (%)	-1.5
Conversion (Entrainment Backed Out)	91.5

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	11.6
Including Devolatilization	18.7

Steam Consumption

Steam into Unit (lbs/hr)	15.65
Steam Reacted with Carbon (lbs/hr)	3.96
Total Steam Consumed (lbs/hr)	7.37

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	25.3
Total Steam Converted (%)	47.1

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.169
Carbon Converted/Steam Fed (mol/mol)	0.253
Carbon Converted/Bed Volume (lbs/hr)/cft	0.420
Carbon Converted/Bed Volume (mol/hr)/cft	0.035
Carbon in Bed/Steam Fed lbs/(lbs/hr)	1.449
Carbon in Bed/Steam Fed mol/(mol/hr)	2.175

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization test of feed coal

YIELD PERIOD 218

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	9.5	8.9	24.7	27.7	27.1
K as K ₂ CO ₃	14.0	13.0	36.2	40.7	39.8
K as K	7.9	7.4	20.5	23.0	22.5
K Water/Acid, Soluble Ratio	0.590	0.680	0.653	0.631	0.865
K ₂ O, H ₂ O-Insoluble	3.9	2.8	8.6	10.2	3.7
K ₂ CO ₃ , H ₂ O-Insoluble	5.7	4.2	12.6	15.0	5.4
K ₂ H ₂ O-Insoluble	3.2	2.4	7.1	8.5	3.1
Carbon	60.2	39.9	34.9	22.7	40.2
K on Carbon	13.1	18.5	58.7	101.1	56.0
ASTM Ash	27.6	57.3	61.7	72.4	58.2
K on Ash	28.7	12.9	33.2	31.8	38.7
K ₂ CO ₃ Free-Ash	13.1	44.0	24.3	30.5	17.2
K on K ₂ CO ₃ Free-Ash	60.4	16.7	84.4	75.4	131.2

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	8.2	10.5	23.2	48.7	82.8	95.7	100.0
Top Char	11.8	35.9	75.3	88.7	98.0	100.0	100.0
Mid Char	2.4	7.8	25.7	52.4	83.6	95.0	100.0
Bottom Char	1.1	4.4	15.1	40.9	77.9	95.0	100.0
Cyclone	-	-	-	-	-	-	-
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Number Mean	Volume/ Surface Mean	Weight Mean	Bulk Density lbs/cf
Feed Coal + Catalyst	24	135	378	49.4
Top Char	28	72	146	18.6
Mid Char	32	175	374	20.3
Bottom Char	38	234	429	24.9
Cyclone	-	-	-	-
Filter	-	-	-	-

*Based on acid soluble analysis

YIELD PERIOD 218

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids W/D	Entrained
H	3.7	0.75	0.20
C	60.2	22.7	40.2
S	4.2	4.7	3.8
O	11.9	11.1	9.0
N	1.04	0.08	0.17
Cl	0.14	0.32	0.42
SO ₃ -Free Ash	18.9	60.3	46.2
Total	100.0	100.0	100.0
Solids Flow Rate (lbs/hr)	8.50	1.18	2.08

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids W/D	Entrained
SiO ₂	27.3	31.1	21.4
Fe ₂ O ₃	8.1	8.4	8.4
Al ₂ O ₃	9.0	10.6	6.3
CaO	2.18	1.67	2.70
MgO	0.47	0.61	0.39
TiO ₂	0.37	0.49	0.41
P ₂ O ₅	0.49	0.58	0.15
Na ₂ O	1.64	1.28	1.55
K ₂ O, Catalyst	50.44	45.25	58.75
Total	1.64	1.28	1.55

YIELD PERIOD 218

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	114.7
H ₂	55.8
CO	11.4
CH ₄	8.4
CO ₂	12.8
H ₂ S	0.3
H ₂ O	20.2
N ₂	5.9
H ₂ O/CO	1.8
H ₂ O/CO ₂	1.6

Unit Gas Data

Syngas MMT, lbs/mol	8.8
Product Gas MMT (dry), lbs/mol	13.8

Product Gas

At DTM (dry), SCFH	815.3
(Dry, N ₂ -Free), SCFH	764.7
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	989.3
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	397.7
At Gasifier Outlet, SCFH (Excludes N ₂)	938.7
At Gasifier Outlet, ACFH (Excludes N ₂)	377.4

YIELD PERIOD 218

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	59.0
CO	12.1
CO ₂	13.5
CH ₄	8.9
H ₂ S	0.3
N ₂	6.2

Product Gas (Dry, N ₂ -Free)	
H ₂	62.9
CO	12.9
CO ₂	14.4
CH ₄	9.5
H ₂ S	0.3

Product Gas	
H ₂	48.6
CO	10.0
CO ₂	11.1
CH ₄	7.3
H ₂ S	0.3
H ₂ O	17.6
N ₂	5.1

Product Gas (N ₂ -Free)	
H ₂	51.2
CO	10.5
CO ₂	11.7
CH ₄	7.7
H ₂ S	0.3
H ₂ O	18.6

SCFH CH ₄ /lb C Active Bed	3.2
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SCFH CH ₄ /lb C Feed	14.2
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Moles CH ₄ /mole C Feed	0.45
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Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1307.3°F)	Actual Equilibrium, Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.9284	2.1462	1318.8
Shift: CO + H ₂ O = CO ₂ + H ₂	1.4992	3.0896	1050.7
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0619	0.0185	1388.1
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3451	0.2633	-

YIELD PERIOD 218
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	8.41	Product Gas (ex N ₂)	25.92
Gasifier Steam	15.65	Product Gas N ₂	3.74
Gasifier Syngas	13.08	Product Water	8.28
		Char Entrained	1.18
		Solids Withdrawn	2.00
Total (ex N ₂)	37.14	Total (ex N ₂)	37.46
Accumulation:	-0.32		
Closure: (Output + Accum)/Input, %	100.0		

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	564.6	H ₂ + CO in Product Gas	579.5
H ₂ Mol%	74.4	H ₂ Mol%	59.0
CO Mol%	25.4	CO Mol%	12.1
Balance: (Output/Input), %	102.6		

YIELD PERIOD 218

MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	5.12	0.315	1.01	0.354	0.012
Gasifier Steam	0.0	1.750	13.89	0.0	0.0
Gasifier Syngas	4.66	2.222	6.20	0.0	0.0
Total	9.77	4.287	21.10	0.354	0.012
<u>Output:</u>					
Product Gas	8.91	3.345	13.45	0.224	0.0
Product Water	0.0	0.926	7.35	0.003	0.0
Char Entrained	0.47	0.002	0.11	0.045	0.005
Solids Withdrawn	0.47	0.015	0.23	0.097	0.007
Total	9.85	4.288	21.13	0.370	0.012
Accumulation:	-0.08	-0.001	-0.03	-0.016	0.0
Closure (Out + Accum)/In, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	0.67	0.40
<u>Output:</u>		
Char Entrained	0.27	0.23
Product Water	0.0	0.0
Solid Withdrawn	0.47	0.30
Total	0.74	0.53
Accumulation:	-0.07	-0.04
Closure (out + accum)/in, %	100.0	123.3

*Carbon balance excludes catalyst carbonate
**excludes carbon and oxygen in catalyst

YIELD PERIOD 218

MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	2.34	1.95	1.60	1.36
<u>Output:</u>				
Entrained Char	0.69	0.70	0.54	0.57
Solids Withdrawn	1.51	1.47	0.25	0.14
Total	2.20	2.17	1.80	1.71
Accumulation:	0.14	-0.22	-0.20	-0.35
Closure (out + accum)/in, %				

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.439	0.239	0.145	0.035	0.007	0.661	0.026	0.006	0.008
<u>Output:</u>									
Entrained Char	0.117	0.046	0.034	0.015	0.002	0.110	0.008	0.002	0.001
Solids Withdrawn	0.390	0.106	0.133	0.021	0.008	0.259	0.016	0.006	0.007
Total	0.507	0.151	0.167	0.036	0.010	0.369	0.026	0.008	0.008
Accumulation:	-0.068	-0.022	-0.023	-0.001	-0.002	-0.024	-0.002	-0.002	0.0
Closure (out + accum)/in, %	100	100	100	100	100	59	100	100	100

YIELD PERIOD 218

MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
<u>Gas Input</u>					
H ₂	(1.102)	-	2.204	-	-
CO	(0.388)	0.388	-	0.388	-
H ₂ O	(0.868)	-	1.737	0.868	-
Total	(2.358)	0.388	3.941	1.256	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.426	0.312	0.063	0.011
Total Input		0.814	4.253	1.319	0.011
<u>Gas Output</u>					
<u>Product Gas</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(1.269)	-	2.538	-	-
CO	(0.260)	0.260	-	0.260	-
CO ₂	(0.290)	0.290	-	0.581	-
CH ₄	(0.191)	0.191	0.766	-	-
H ₂ S	(0.007)	-	0.014	-	0.007
H ₂ O	(0.459)	-	0.919	0.459	-
Total	(2.478)	0.742	4.237	1.300	0.007
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.039	0.002	0.007	0.001
Char Samples Withdrawn		0.039	0.015	0.014	0.003
Char Accumulation		-0.007	-0.002	-0.002	0.0
Total Solids		0.072	0.016	0.019	0.004
Total Output + Accumulation		0.814	4.253	1.319	0.011

YIELD PERIOD 218

PROCESS VARIABLES

YIELD PERIOD 218

PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	15.64	15.64
V111	Char Withdrawn (lbs/hr)	2.08	2.08
V165	H in Char Entrained (wt%)	0.20	0.20
V166	H in Char Withdrawn (wt%)	0.75	0.75
V168	H in Coal + Catalyst Feed (wt%)	3.71	3.70
V173	H in Gasifier Starting Mid Char (wt%)	0.48	0.48
V174	H in Gasifier Ending Mid Char (wt%)	0.48	0.48
V183	CO in Syngas (mol%)	25.00	26.02
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	8.78	9.52
V188	O in Coal + Catalyst Feed (wt%)	11.81	11.85
V193	H ₂ in Syngas (mol%)	74.20	73.98
V205	CO ₂ in Product Gas (mol%)	13.50	13.50
V207	CH ₄ in Product Gas (mol%)	8.90	8.90
V208	CO in Product Gas (mol%)	12.80	12.07
V212	H ₂ in Product Gas (mol%)	57.90	59.00
V214	N ₂ in Product Gas (mol%)	6.20	6.20
V215	H ₂ S in Product Gas (mol%)	0.35	0.32
V222	Carbon in Char Withdrawn (wt%)	22.74	22.69
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	26.74	27.12
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	27.70	27.31
V257	Carbon in Gasifier Starting Mid Char (wt%)	34.91	32.50
V258	Carbon in Gasifier Ending Mid Char (wt%)	34.91	33.51
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	24.67	22.41
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	24.67	22.13
V289	ASTM Ash in Char Entrained (wt%)	58.10	58.20
V292	ASTM Ash in Char Withdrawn (wt%)	72.40	72.69
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	27.75	27.58
V294	C/H Residue in Feed Coal + Catalyst (wt%)	22.80	22.97
V295	C/H Residue in Char Entrained (wt%)	59.38	59.22
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	61.69	54.71
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	61.69	67.85

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	71.25	70.84
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	60.03	60.58
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	60.03	59.54
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	19.92	18.87
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	48.63	46.17
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	59.97	60.34
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	51.42	53.93
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	51.42	52.99
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	14.97	16.04
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	50.11	48.45
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	58.82	54.79
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	49.76	53.59
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	49.76	46.38
V407	Coal + Catalyst Feed (lbs/hr)	8.50	8.50
V473	Char Entrained (lbs/hr)	1.18	1.18
V495	Carbon in Feed Coal (wt%)	59.44	60.21
V498	Carbon in Char Entrained (wt%)	37.77	40.18
F384	Syngas Flow Meter (CFH)	54.82	54.21
F385	Product Gas Flow Meter (CFH)	108.80	113.31
PGK0	Product Gas Condensate (lbs/hr)	8.00	7.94
U(114)	Starting Bed ΔP (B-A) (in Hg)	2.30	2.30
U(115)	Starting Bed ΔP (C-B) (in Hg)	1.30	1.30
U(116)	Starting Bed ΔP (D-C) (in Hg)	1.10	1.10
U(117)	Starting Bed ΔP (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed ΔP (F-A) (in Hg)	5.20	5.21
U(119)	Ending Bed ΔP (B-A) (in Hg)	2.30	2.39
U(120)	Ending Bed ΔP (C-B) (in Hg)	0.60	0.60
U(121)	Ending Bed ΔP (D-C) (in Hg)	1.50	1.50
U(122)	Ending Bed ΔP (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed ΔP (F-A) (in Hg)	4.60	4.60
EDD(1)	Starting Bed ΔP (F-D) (in Hg)	0.50	0.50

YIELD PERIOD 218

PROCESS VARIABLES

		<u>Measured</u>	<u>Reconciled</u>
EDD(6)	Ending Bed ΔP (E-D) (in Hg)	0.20	0.20
DPOST	Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280	S in Gasifier Starting Mid Char (wt%)	4.01	4.04
V281	S in Gasifier Ending Mid Char (wt%)	4.01	3.94
V187	S in Coal + Catalyst Feed (wt%)	3.93	4.17
V246	S in Char Withdrawn (wt%)	4.78	4.68
V244	S in Char Entrained (wt%)	3.83	3.85
V243	S in Product Gas Condensate (wt%)	0.04	0.04
V862	SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	30.16	29.81
V863	SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	30.16	29.06
V867	SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.48	27.34
V868	SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	32.32	31.08
V869	SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	21.04	21.42
V871	Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	7.97	8.17
V872	Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	7.97	7.70
V876	Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	7.75	8.05
V877	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	8.75	8.43
V878	Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.39	8.36
V880	Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.65	10.63
V881	Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.65	10.49
V885	Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.90	9.01
V886	Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.76	10.60
V887	Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	6.24	6.27
V889	CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.23	1.16
V890	CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.23	1.28
V894	CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	2.44	2.18
V895	CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.59	1.67
V896	CaO in SO ₃ -Free Ash in Char Entrained (wt%)	2.57	2.70
V822	Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.34	0.32
V823	Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.34	0.36
V827	Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.15	0.14

YIELD PERIOD 218

PROCESS VARIABLES

		<u>Measured</u>	<u>Reconciled</u>
V828	Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.31	0.32
V829	Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.41	0.42
V836	Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.70	0.62
V837	Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.70	0.76
V841	Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.35	0.31
V842	Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.73	0.77
V843	Acid Sol. Na ₂ O in Char Entrained (wt%)	0.69	0.72
V898	MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.59	0.63
V899	MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.59	0.55
V903	MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.44	0.47
V904	MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.66	0.61
V905	MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.40	0.39
V916	TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	8.05	6.75
V917	TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	8.05	7.58
V921	TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.37	0.37
V922	TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.49	0.49
V923	TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.41	0.41
V925	P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.04	0.14
V926	P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.14	0.14
V930	P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.47	0.49
V931	P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.61	0.58
V932	P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.15	0.15
V813	N in Starting Mid Char (wt%)	0.10	0.10
V814	N in Ending Mid Char (wt%)	0.10	0.10
V818	N in Coal + Catalyst Feed (wt%)	1.04	1.04
V819	N in Char Withdrawn (wt%)	0.08	0.08
V820	N in Char Entrained (wt%)	0.17	0.17
V805	O in Starting Mid Char (wt%)	8.74	8.63
V806	O in Ending Mid Char (wt%)	8.74	8.62
V810	O in Char Withdrawn (wt%)	11.37	11.13
V811	O in Char Entrained (wt%)	8.79	9.00

RECONCILED DATA

YIELD PERIOD 219

UNIT OPERATIONS

	<u>Time</u>	<u>Date</u>
From	17:30	8-5-77
To	11:30	8-6-77
Duration	18 Hrs	
Percent of Time on Stream		
Coal Feed	99.0	
Steam	100	
Syngas	100	
Gasifier Process Temperatures		
Gasifier Bed Height (ft)	Gasifier Temperature (°F)	
43.2	1182	
38.4	1165	
32.1	1309	
26.6	1326	
21.2	1293	
16.0	1297	
10.9	1281	
6.4	1263	
0.4	1183	

YIELD PERIOD 219
UNIT PROCESS VARIABLES

<u>Unit Temperatures</u>	<u>Process, °F</u>	<u>Metal, °F</u>
Lockhopper 1 Top	259	278
Lockhopper 1 Bottom	247	214
Lockhopper 2 Top	283	309
Lockhopper 2 Bottom	237	180
Gasifier Feed Line	607	873
Gasifier Steam Line	888	902
Gasifier		
Top of Bed	1326	1399
Bottom of Bed	1183	1235
Total Bed Average	1274	1336
Rough Cut Cyclone		
Cyclone Top	900	943
Cyclone Bottom	754	1103
Standpipe Top	691	1002
Standpipe Mid	747	1062
Standpipe Bottom	722	1026
Standpipe Slope Top		1054
Standpipe Slope Bottom	1195	997
Gasifier Backend		
Cyclone Inlet	-	564
Filter Inlet	-	519
Scrubber Inlet	479	438
Scrubber Outlet	81	-
Product Gas Meter	93	-
<u>Unit Pressures</u>	<u>Psia</u>	
Lockhopper 2	117.7	
Gasifier Feed Line	117.7	
Bypass N ₂	163.7	
Syngas In	162.7	
Gasifier		
Gasifier Top	114.7	
Gasifier Bottom	117.1	
Rough Cut Cyclone Outlet	114.6	
Filter Outlet	108.1	
Scrubber Outlet	106.6	
Product Gas Meter	114.7	

YIELD PERIOD DATA
FLUID-COOLING DATA

Gasifier Fluidized Bed Properties

Bed Bottom Density (lbs/cf)	17.3
Bed Top Density (lbs/cf)	12.1
Bed Average Density (lbs/cf)	11.7
Bed Height (ft)	29.9
Bed Holdup (lbs)	62.5
Bed Volume (cf)	4.7
Average Bed Temperature (°F)	1292.0
Space Velocity (bed) (cf/cf/hr)	103.1
Bottom Superficial Velocity (ft/sec)	0.74
Top Superficial Velocity (ft/sec)	0.80

Cyclone Performance

Temperature (°F)	564.0
Pressure (psia)	111.6
Inlet Gas Rate (SCFH)	1193.9
Inlet Gas Rate (ACFH)	309.8
Inlet Gas Velocity (ft/sec)	24.3
Solids Entering (lbs/hr)	2.5
Dust Loading (lbs/acf)	0.0091
Solids Captured (lbs/hr)	2.0
Solids Escaping (lbs/hr)	0.5
Overall Efficiency (Captured/Entering, Wt.%)	79.7

Solids Carryover Loss

Coal + Catalyst Feed (lbs/hr)	15.63
Total Carryover (lbs/hr)	2.51
Cyclone (lbs/hr)	2.00
Filter (lbs/hr)	0.51
Carryover/Feed (Wt.%)	16.0

Solids Carbon Loss

Carbon in Feed (lbs/hr)	9.50
Carbon in Carryover (lbs/hr)	0.97
Carryover/Feed (Wt.%)	10.2

YIELD PERIOD DATA

UNIT CONVERSIONS

Carbon Consumption

Carbon in Feed* (lbs/hr)	9.50
Carbon from Devolatilization** of Feed Coal (lbs/hr)	3.48
Carbon Gasified (by difference) (lbs/hr)	4.02
Total Carbon Converted (lbs/hr)	7.92

Carbon Conversion (C Converted/C in Feed)

Gasification Only (%)	45.2
Total, Including Devolatilization (%)	82.3

Carbon Distribution

Total Converted (%)	82.3
Entrained (%)	9.8
Withdrawn (%)	9.1
Accumulated (%)	1.2
Conversion (Entrainment Backed Out)	91.2

Specific Reaction Rates (C Converted/C in Bed)

Gasification Only (%/Hr)	23.0
Including Devolatilization	41.9

Steam Consumption

Steam into Unit (lbs/hr)	24.16
Steam Reacted with Carbon (lbs/hr)	6.44
Total Steam Consumed (lbs/hr)	13.29

Steam Conversion (Steam Consumed/Steam into Bed)

Gasification* (%)	26.7
Total Steam Converted (%)	55.0

Reaction Rate Parameters

Carbon Converted/Steam Fed (lbs/lbs)	0.170
Carbon Converted/Steam Fed (mol/mol)	0.267
Carbon Converted/Bed Volume (lbs/hr)/cft	0.805
Carbon Converted/Bed Volume (mol/hr)/cft	0.067
Carbon in Bed/Steam Fed lbs/(lbs/hr)	0.772
Carbon in Bed/Steam Fed mol/(mol/hr)	1.158

*Excludes carbon in catalyst

**Assumed from standard ASTM devolatilization tests of feed coal



YIELD PERIOD 219

UNIT COMPOSITIONS

Catalyst Distribution*

Wt%	Feed	Gasifier Char			Entrained
		Top	Mid	Bottom	
K as K ₂ O	9.8	27.6	29.5	32.7	32.2
K as K ₂ CO ₃	14.4	40.5	43.2	48.0	47.2
K as K	8.1	22.9	24.1	27.2	26.7
K Water/Acid, Soluble Ratio	0.445	0.770	0.716	0.628	0.828
K ₂ O, H ₂ O-Insoluble	5.4	6.3	8.4	12.2	5.5
K ₂ CO ₃ , H ₂ O-Insoluble	8.0	9.3	12.3	17.9	8.1
K ₂ H ₂ O-Insoluble	4.5	5.3	6.9	10.1	4.6
Carbon	60.8	33.0	29.8	23.8	37.1
K on Carbon	13.4	69.6	82.0	114.0	72.0
ASTM Ash	24.9	65.6	68.4	75.1	59.7
K on Ash	32.6	35.0	35.7	36.2	44.7
K ₂ CO ₃ Free-Ash	10.3	24.2	24.3	26.3	11.6
K on K ₂ CO ₃ Free-Ash	78.9	94.8	100.5	103.1	229.9

Size Distribution

	Cumulative Wt% Less Than Mesh Size						
	325 Mesh	200 Mesh	100 Mesh	50 Mesh	30 Mesh	20 Mesh	10 Mesh
Feed Coal + Catalyst	4.5	11.4	27.8	53.3	83.2	96.0	100.0
Top Char	1.7	7.0	30.2	55.3	81.4	91.8	100.0
Mid Char	2.7	8.2	28.8	58.3	89.1	99.6	100.0
Bottom Char	0.7	2.4	10.9	33.6	72.3	91.0	99.9
Cyclone	67.3	78.1	97.1	97.7	98.6	99.1	100.0
Filter	-	-	-	-	-	-	-

Particle Diameter (Microns)	Volume/ Surface Weight Bulk Density			
	Number Mean	Surface Mean	Weight Mean	lbs/cf
Feed Coal + Catalyst	28	149	361	51.2
Top Char	37	176	392	19.6
Mid Char	32	162	311	21.9
Bottom Char	41	280	493	25.8
Cyclone	22	29	64	
Filter	-	-	-	

*Based on acid soluble analysis

YIELD PERIOD 219

SOLIDS COMPOSITION

Ultimate Analysis

Component	Wt% of Total Solids, Dry		
	Feed	Solids Wt%	Entrained
H	2.78	0.33	0.91
C	60.8	23.8	27.1
S	3.4	4.7	3.4
O	14.6	7.2	9.5
N	0.16	0.19	0.19
Cl	0.09	0.19	0.32
SO ₃ -Free Ash	18.2	63.7	49.5
Total	100	100	100
Solids Flow Rate (lbs/hr)	15.63	3.64	2.51

Ash Element Analysis

	Wt% of SO ₃ -Free Ash		
	Feed	Solids Wt%	Entrained
SiO ₂	25.7	29.6	16.8
Fe ₂ O ₃	8.2	6.7	8.9
Al ₂ O ₃	8.7	10.8	5.6
CaO	1.64	1.45	1.54
MgO	0.63	0.62	0.43
TiO ₂	0.45	0.43	0.45
P ₂ O ₅	0.28	0.25	0.27
Na ₂ O	0.77	0.69	1.01
K ₂ O, Catalyst	53.71	49.46	64.99
Total	100	100	100

YIELD PERIOD 219

PRODUCT GAS DATA

Product Gas Partial Pressures at Gasifier Exit

Total Pressure, psia	114.7
H ₂	49.0
CO	17.0
CH ₄	7.2
CO ₂	14.7
H ₂ S	0.3
H ₂ O	22.0
N ₂	4.5
H ₂ O/CO	1.3
H ₂ O/CO ₂	1.5

Unit Gas Data

Syngas MWT, lbs/mol	10.8
Product Gas MWT (dry), lbs/mol	15.9

Product Gas

At DTM (dry), SCFH	965.3
(Dry, N ₂ -Free), SCFH	918.1
At Gasifier Outlet, SCFH (Includes N ₂ + H ₂ O)	1193.9
At Gasifier Outlet, ACFH (Includes N ₂ + H ₂ O)	483.2
At Gasifier Outlet, SCFH (Excludes N ₂)	1146.7
At Gasifier Outlet, ACFH (Excludes N ₂)	464.1

YIELD PERIOD 219

PRODUCT GAS DATA

Unit Gas Yields

Product Gas (Dry), Mol%	
H ₂	52.8
CO	18.3
CO ₂	15.8
CH ₄	7.8
H ₂ S	0.4
N ₂	4.9

Product Gas (Dry, N ₂ -Free)	
H ₂	55.5
CO	19.3
CO ₂	16.6
CH ₄	8.2
H ₂ S	0.4

Product Gas	
H ₂	42.7
CO	14.8
CO ₂	12.8
CH ₄	6.3
H ₂ S	0.3
H ₂ O	19.1
N ₂	4.0

Product Gas (N ₂ -Free)	
H ₂	44.5
CO	15.4
CO ₂	13.3
CH ₄	6.6
H ₂ S	0.3
H ₂ O	19.9

SCFH CH ₄ /lb C Active Bed	4.0
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SCFH CH ₄ /lb C Feed	7.9
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Moles CH ₄ /mole C Feed	0.25
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Equilibrium Constants	Reaction Equilibrium at Active Bed Temp (1292.0°F)	Actual Equilibrium Expression	Corresponding Equilibrium Temperature (°F)
Graphite-H ₂ O: C + H ₂ O = CO + H ₂	1.6665	2.5791	1338.7
Shift: CO + H ₂ O = CO ₂ + H ₂	1.5561	1.9205	1210.2
Methanation: CO + 3H ₂ = CH ₄ + H ₂ O	0.0789	0.0172	1393.3
Overall: 2C + 2H ₂ O = CH ₄ + CO ₂	0.3410	0.2197	-

YIELD PERIOD 212
MATERIAL BALANCES

Overall Material Balance

<u>Input:</u>	<u>Lbs/Hr</u>	<u>Output:</u>	<u>Lbs/Hr</u>
Coal Feed (ex N ₂)	15.60	Product Gas (ex N ₂)	37.02
Gasifier Steam	24.16	Product Gas H ₂	3.49
Gasifier Syngas	13.34	Product Water	10.87
		Char Entrained	1.51
		Solids Withdrawn	2.63
Total (ex N ₂)	53.11	Total (ex N ₂)	54.04
Accumulation:	-0.93		
Closure: (Output + Accum)/input, % 100.0			

Synthesis Gas Balance

<u>Input:</u>	<u>SCFH</u>	<u>Output:</u>	<u>SCFH</u>
Gasifier Syngas	467.1	H ₂ + CO in Product Gas	686.0
H ₂ Mol%	66.1	H ₂ Mol%	52.0
CO Mol%	33.9	CO Mol%	19.3
Balance: (Output/Input), % 147			

YIELD PERIOD 213
MATERIAL BALANCES

Element Balances

<u>Input (Lbs/Hr):</u>	<u>Carbon*</u>	<u>Hydrogen</u>	<u>Oxygen</u>	<u>Sulfur</u>	<u>Chlorine</u>
Coal + Catalyst**	9.50	0.434	2.27	0.532	0.014
Gasifier Steam	-	2.703	21.46	-	-
Gasifier Syngas	5.02	1.643	6.68	-	-
Total	14.51	4.780	30.41	0.533	0.014
<u>Output:</u>					
Product Gas	12.83	3.531	20.35	0.306	-
Product Water	-	1.216	9.66	0.004	-
Char Entrained	0.93	0.024	0.21	0.085	0.006
Solids Withdrawn	0.86	0.012	0.26	0.170	0.007
Total	14.63	4.783	30.48	0.565	0.019
Accumulation:	-0.12	-0.003	-0.07	-0.032	-0.005
Closure (Out + Accum)/in, %	100.0	100.0	100.0	100.0	100.0

Catalyst Balance

<u>Input (Lbs/Hr):</u>	<u>Acid Sol. K</u>	<u>Water Sol. K</u>
Coal + Catalyst	1.27	0.57
<u>Output:</u>		
Char Entrained	0.67	0.55
Product Water	0.0	0.0
Solid Withdrawn	0.95	0.62
Total	1.62	1.17
Accumulation:	-0.35	-0.16
Closure (out + accum)/in, %	100.0	100.0

*Carbon balance excludes catalyst carbonate
**Excludes carbon and oxygen in catalyst

YIELD PERIOD 219
MATERIAL BALANCES

Ash Balances

<u>Input (Lbs/Hr):</u>	<u>ASTM Ash</u>	<u>C/H Residue</u>	<u>SO₃-Free ASTM Ash</u>	<u>SO₃-Free C/H Residue</u>
Coal + Catalyst	3.90	3.38	2.85	2.30
<u>Output:</u>				
Entrained Char	1.50	1.45	1.24	1.16
Solids Withdrawn	2.74	2.71	2.31	2.10
Total	4.24	4.16	3.56	3.25
Accumulation:	-0.34	-0.78	-0.70	-0.95
Closure (out + accum)/in, %				

Ash Element Balance

<u>Input (Lbs/Hr):</u>	<u>SiO₂</u>	<u>Fe₂O₃</u>	<u>Al₂O₃</u>	<u>CaO</u>	<u>MgO</u>	<u>SO₃</u>	<u>Na₂O</u>	<u>TiO₂</u>	<u>P₂O₅</u>
Coal + Catalyst	0.731	0.233	0.248	0.047	0.018	1.402	0.022	0.013	0.008
<u>Output:</u>									
Entrained Char	0.209	0.110	0.070	0.019	0.005	0.243	0.013	0.006	0.003
Solids Withdrawn	0.686	0.154	0.250	0.034	0.014	0.422	0.016	0.010	0.006
Total	0.895	0.264	0.320	0.053	0.020	0.665	0.029	0.016	0.009
Accumulation:	-0.163	-0.031	-0.071	-0.006	-0.002	-0.055	-0.007	-0.003	-0.001
Closure (out + accum)/in, %	100	100	100	100	100	44	100	100	100

YIELD PERIOD 219
MATERIAL BALANCES

Mole Balance

		<u>Lb-Moles/Hr</u>			
<u>Gas Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
H ₂	(0.815)	-	1.630	-	-
CO	(0.418)	0.418	-	0.418	-
H ₂ O		0	2.682	1.341	-
Total	(2.574)	0.418	4.312	1.759	-
<u>Solids Input</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Coal + Cat Feed		0.791	0.430	0.142	0.017
Total Input		1.208	4.743	1.901	0.017
<u>Gas Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Product Gas					
H ₂	(1.345)	-	2.689	-	-
CO	(0.467)	0.467	-	0.467	-
CO ₂	(0.403)	0.403	-	0.805	-
CH ₄	(0.199)	0.199	0.795	-	-
H ₂ S	(0.010)	-	0.019	0	0.010
H ₂ O	(0.604)	-	1.207	0.604	-
Total	(3.028)	1.068	4.710	1.870	0.010
<u>Solids Output</u>		<u>C</u>	<u>H</u>	<u>O</u>	<u>S</u>
Char Entrained		0.078	0.024	0.013	0.003
Char Samples Withdrawn		0.072	0.012	0.016	0.005
Char Accumulation		-0.010	-0.003	-0.004	-0.001
Total Solids		0.140	0.033	0.025	0.007
Total Output + Accumulation		1.208	4.743	1.901	0.017

YIELD PERIOD 219PROCESS VARIABLES

		Measured	Reconciled
V100	Gasifier Steam (lbs/hr)	24.03	24.16
V111	Char Withdrawn (lbs/hr)	3.64	3.63
V165	H in Char Entrained (wt%)	0.97	0.97
V166	H in Char Withdrawn (wt%)	0.33	0.33
V168	H in Coal + Catalyst Feed (wt%)	2.77	2.78
V173	H in Gasifier Starting Mid Char (wt%)	0.35	0.35
V174	H in Gasifier Ending Mid Char (wt%)	0.35	0.35
V183	CO in Syngas (mol%)	35.30	33.88
V185	Acid Sol. K ₂ O in Coal + Catalyst Feed (wt%)	8.82	9.80
V188	O in Coal + Catalyst Feed (wt%)	14.53	14.56
V193	H ₂ in Syngas (mol%)	64.60	66.12
V205	CO ₂ in Product Gas (mol%)	15.80	15.80
V207	CH ₄ in Product Gas (mol%)	7.80	7.80
V208	CO in Product Gas (mol%)	16.60	18.34
V212	H ₂ in Product Gas (mol%)	53.90	52.79
V214	N ₂ in Product Gas (mol%)	4.90	4.89
V215	H ₂ S in Product Gas (mol%)	0.35	0.37
V222	Carbon in Char Withdrawn (wt%)	23.83	23.78
V227	Acid Sol. K ₂ O in Char Entrained (wt%)	32.65	32.18
V232	Acid sol. K ₂ O in Char Withdrawn (wt%)	32.72	31.50
V257	Carbon in Gasifier Starting Mid Char (wt%)	29.83	27.38
V258	Carbon in Gasifier Ending Mid Char (wt%)	29.83	31.64
V265	Acid Sol. K ₂ O in Gasifier Starting Mid Char (wt%)	29.45	31.89
V266	Acid Sol. K ₂ O in Gasifier Ending Mid Char (wt%)	29.45	28.00
V289	ASTM Ash in Char Entrained (wt%)	59.64	59.72
V292	ASTM Ash in Char Withdrawn (wt%)	75.13	75.32
V293	ASTM Ash in Feed Coal + Catalyst (wt%)	25.02	24.93
V294	C/H Residue in Feed Coal + Catalyst (wt%)	21.11	21.65
V295	C/H Residue in Char Entrained (wt%)	58.63	57.97
V306	ASTM Ash in Gasifier Starting Mid Char (wt%)	68.39	63.98
V307	ASTM Ash in Gasifier Ending Mid Char (wt%)	68.39	71.81

YIELD PERIOD 219PROCESS VARIABLES

		Measured	Reconciled
V310	C/H Residue in Char Withdrawn (wt%)	76.18	74.55
V320	C/H Residue in Gasifier Starting Mid Char (wt%)	68.71	70.89
V321	C/H Residue in Gasifier Ending Mid Char (wt%)	68.71	67.02
V333	SO ₃ -Free ASTM Ash in Feed Coal + Catalyst (wt%)	17.34	18.25
V334	SO ₃ -Free ASTM Ash in Char Entrained (wt%)	49.95	49.52
V336	SO ₃ -Free ASTM Ash in Char Withdrawn (wt%)	63.55	63.69
V337	SO ₃ -Free ASTM Ash in Starting Mid Char (wt%)	57.21	59.87
V338	SO ₃ -Free ASTM Ash in Ending Mid Char (wt%)	57.21	55.24
V350	SO ₃ -Free C/H Residue in Feed Coal + Catalyst (wt%)	13.43	14.72
V351	SO ₃ -Free C/H Residue in Char Entrained (wt%)	48.94	46.18
V353	SO ₃ -Free C/H Residue in Char Withdrawn (wt%)	64.60	57.64
V354	SO ₃ -Free C/H Residue in Starting Mid Char (wt%)	57.53	63.84
V355	SO ₃ -Free C/H Residue in Ending Mid Char (wt%)	57.53	52.63
V407	Coal + Catalyst Feed (lbs/hr)	15.25	15.63
V473	Char Entrained (lbs/hr)	2.51	2.51
V495	Carbon in Feed Coal (wt%)	61.57	60.76
V498	Carbon in Char Entrained (wt%)	37.58	37.18
F384	Syngas Flow Meter (CFH)	44.72	44.64
F385	Product Gas Flow Meter (CFH)	128.10	132.52
PGK0	Product Gas Condensate (lbs/hr)	12.00	10.54
U(114)	Starting Bed Δ P (B-A) (in Hg)	2.20	2.23
U(115)	Starting Bed Δ P (C-B) (in Hg)	1.60	1.62
U(116)	Starting Bed Δ P (D-C) (in Hg)	2.00	2.02
U(117)	Starting Bed Δ P (F-E) (in Hg)	0.00	0.00
U(118)	Starting Overall Bed Δ P (F-A) (in Hg)	5.80	5.87
U(119)	Ending Bed Δ P (B-A) (in Hg)	1.40	1.30
U(120)	Ending Bed Δ P (C-B) (in Hg)	2.40	2.37
U(121)	Ending Bed Δ P (D-C) (in Hg)	0.60	0.60
U(122)	Ending Bed Δ P (F-E) (in Hg)	0.00	0.00
U(123)	Ending Overall Bed Δ P (F-A) (in Hg)	4.00	4.50
EDD(1)	Starting Bed Δ P (E-D) (in Hg)	0.00	0.00

YIELD PERIOD 219PROCESS VARIABLES

	Measured	Reconciled
EDD(6) Ending Bed ΔP (E-D) (in Hg)	0.20	0.20
DPOST Deposits Accumulated on Gasifier Walls (lbs)	0.00	0.00
V280 S in Gasifier Starting Mid Char (wt%)	4.28	4.16
V281 S in Gasifier Ending Mid Char (wt%)	4.28	4.37
V187 S in Coal + Catalyst Feed (wt%)	3.63	3.41
V246 S in Char Withdrawn (wt%)	4.63	4.67
V244 S in Char Entrained (wt%)	3.38	3.40
V243 S in Product Gas Condensate (wt%)	0.04	0.04
V862 SiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	28.60	27.64
V863 SiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	28.60	29.38
V867 SiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	26.40	25.65
V868 SiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	29.92	29.64
V869 SiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	16.81	16.82
V871 Fe ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	5.70	5.47
V872 Fe ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	5.70	5.87
V876 Fe ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.78	8.17
V877 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	6.45	6.67
V878 Fe ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	8.63	8.85
V880 Al ₂ O ₃ in SO ₃ -Free Ash in Starting Mid Char (wt%)	10.76	10.65
V881 Al ₂ O ₃ in SO ₃ -Free Ash in Ending Mid Char (wt%)	10.76	10.85
V885 Al ₂ O ₃ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	8.77	8.71
V886 Al ₂ O ₃ in SO ₃ -Free Ash in Char Withdrawn (wt%)	10.86	10.89
V887 Al ₂ O ₃ in SO ₃ -Free Ash in Char Entrained (wt%)	5.63	5.63
V889 CaO in SO ₃ -Free Ash in Starting Mid Char (wt%)	1.07	1.03
V890 CaO in SO ₃ -Free Ash in Ending Mid Char (wt%)	1.07	1.10
V894 CaO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	1.75	1.64
V895 CaO in SO ₃ -Free Ash in Char Withdrawn (wt%)	1.40	1.45
V896 CaO in SO ₃ -Free Ash in Char Entrained (wt%)	1.51	1.54
V822 Cl in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.22	0.20
V823 Cl in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.22	0.23
V827 Cl in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.10	0.09

YIELD PERIOD 219PROCESS VARIABLES

	Measured	Reconciled
V828 Cl in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.18	0.19
V829 Cl in SO ₃ -Free Ash in Char Entrained (wt%)	0.30	0.32
V836 Acid Sol. Na ₂ O in Gasifier Starting Mid Char (wt%)	0.49	0.49
V837 Acid Sol. Na ₂ O in Gasifier Ending Mid Char (wt%)	0.49	0.49
V841 Acid Sol. Na ₂ O in Coal + Catalyst Feed (wt%)	0.14	0.14
V842 Acid Sol. Na ₂ O in Char Withdrawn (wt%)	0.44	0.44
V843 Acid Sol. Na ₂ O in Char Entrained (wt%)	0.50	0.50
V898 MgO in SO ₃ -Free Ash Starting Mid Char (wt%)	0.58	0.52
V899 MgO in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.58	0.62
V903 MgO in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.73	0.63
V904 MgO in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.57	0.62
V905 MgO in SO ₃ -Free Ash in Char Entrained (wt%)	0.42	0.43
V916 TiO ₂ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.47	0.45
V917 TiO ₂ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.47	0.48
V921 TiO ₂ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.47	0.45
V922 TiO ₂ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.42	0.43
V923 TiO ₂ in SO ₃ -Free Ash in Char Entrained (wt%)	0.44	0.45
V925 P ₂ O ₅ in SO ₃ -Free Ash in Starting Mid Char (wt%)	0.13	0.14
V926 P ₂ O ₅ in SO ₃ -Free Ash in Ending Mid Char (wt%)	0.13	0.12
V930 P ₂ O ₅ in SO ₃ -Free Ash in Coal + Catalyst Feed (wt%)	0.24	0.28
V931 P ₂ O ₅ in SO ₃ -Free Ash in Char Withdrawn (wt%)	0.31	0.25
V932 P ₂ O ₅ in SO ₃ -Free Ash in Char Entrained (wt%)	0.30	0.27
V813 N in Starting Mid Char (wt%)	0.10	0.10
V814 N in Ending Mid Char (wt%)	0.10	0.10
V818 N in Coal + Catalyst Feed (wt%)	0.16	0.16
V819 N in Char Withdrawn (wt%)	0.19	0.19
V820 N in Char Entrained (wt%)	0.19	0.19
V805 O in Starting Mid Char (wt%)	8.01	7.93
V806 O in Ending Mid Char (wt%)	8.01	8.07
V810 O in Char Withdrawn (wt%)	7.29	7.15
V811 O in Char Entrained (wt%)	8.60	8.49