TRACE ELEMENT AND MAJOR COMPONENT BALANCES AROUND THE SYNTHANE PDU GASIFIER

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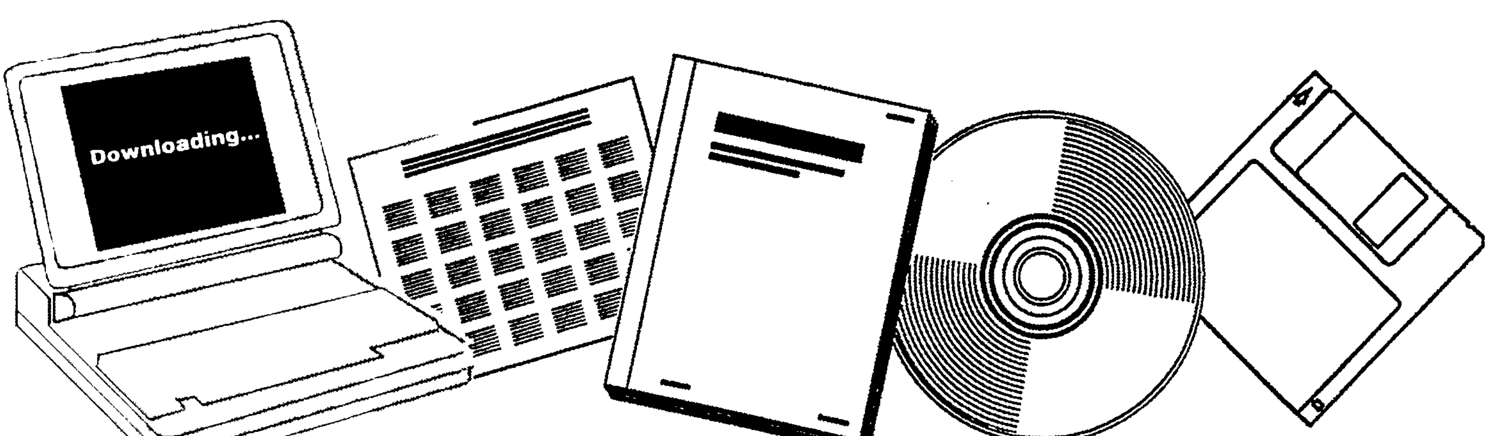

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around the gasifier.

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We also wish to acknowledge those in our group who helped collect the data: R. Schehl and T. Hunter of the Data Analysis Group and R. Kenny who operated the gasifier.

THE GASIFIER

A schematic diagram of the laboratory gasifier is shown in Figure 1. The gasification section is a 6 foot long section of 4-inch diameter pipe (310 SS) inside a 10" pipe (304 SS) acting as a pressure shell, with heaters and refractories in the annulus. Above the gasification section is another 6 ft. section of 10" diameter pipe. The 4-inch section contains the high (1832° F) temperature fluid bed. Coal, steam and oxygen are the feeds to the gasifier (plus some nitrogen) and the products are the char, filter fines, tar, water and gas. With a mildly caking coal like Illinois #6 it was necessary to pretreat the coal. While commercially the pretreating feed gases would be steam plus oxygen, in the small unit nitrogen plus oxygen is used to avoid problems due to steam condensation. The products from the pretreater enter the gasifier so there are no separate by products. Other analysis from the gasifier are discussed in more detail in an earlier publication.(3)

THE TESTS

A series of gasification tests were made in the gasifier using Illinois #6 coal. Attempts were made to hold conditions as constant as possible. The overall results of 3 of the tests are shown in Table 1. In addition to the regular analysis made on the feed coal and the product streams, trace element analyses were made on the coal feed, the feed water and the char, fines, tar, water and gases. The trace element analysis was done by spark source mass spectrometric analysis (SSMS) on all except the gas. Trace elements in the gas were determined by

TRACE ELEMENTS AND MAJOR COMPONENT BALANCES AROUND THE SYNTHANE PDU GASIFIER

by

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ABSTRACT

A series of gasification tests were run in the SYNTHANE P.D.U. gasifier in an attempt to define the distribution in the effluent streams of the trace elements that enter the gasifier in the coal. The feed coal and non-gaseous products were analyzed for 65 trace elements. Results indicate most of the elements are found in the char and dusts with some specifically in the tars and waters. More accurate methods of analysis are needed to make reasonable balances of the trace elements.

INTRODUCTION

Many coal-to-gas plants are expected to be constructed in the 1980's in the United States to supplement the dwindling supplies of gas. Because of environmental considerations it is important to know the fate of various trace elements fed into the gasifier in the coal during coal gasification. This report is a first attempt to analyze all feed and product streams of the small SYNTHANE laboratory gasifier. This gasifier has the advantage that all feed and effluent streams are representative of those that will be obtained from a commercial operation. In these experiments, only one coal--Illinois #6 (River King Mine, Monroe Co., Illinois) was used since it is believed that the Illinois coals, (because of their high sulfur content and enormous reserves) are the prime candidates to be used in the first commercial coal-to-gas plants east of the Mississippi.

Other authors have discussed trace elements, (1,2)[6] but this we believe is a first attempt to make balances of trace elements

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[2]Supervisory Chemical Engineer
[3]Chemical Engineer
[4]Research Chemist
[5]Supervisory Research Physicist
[6]underlined numbers in parenthesis refer to items in the list of references.

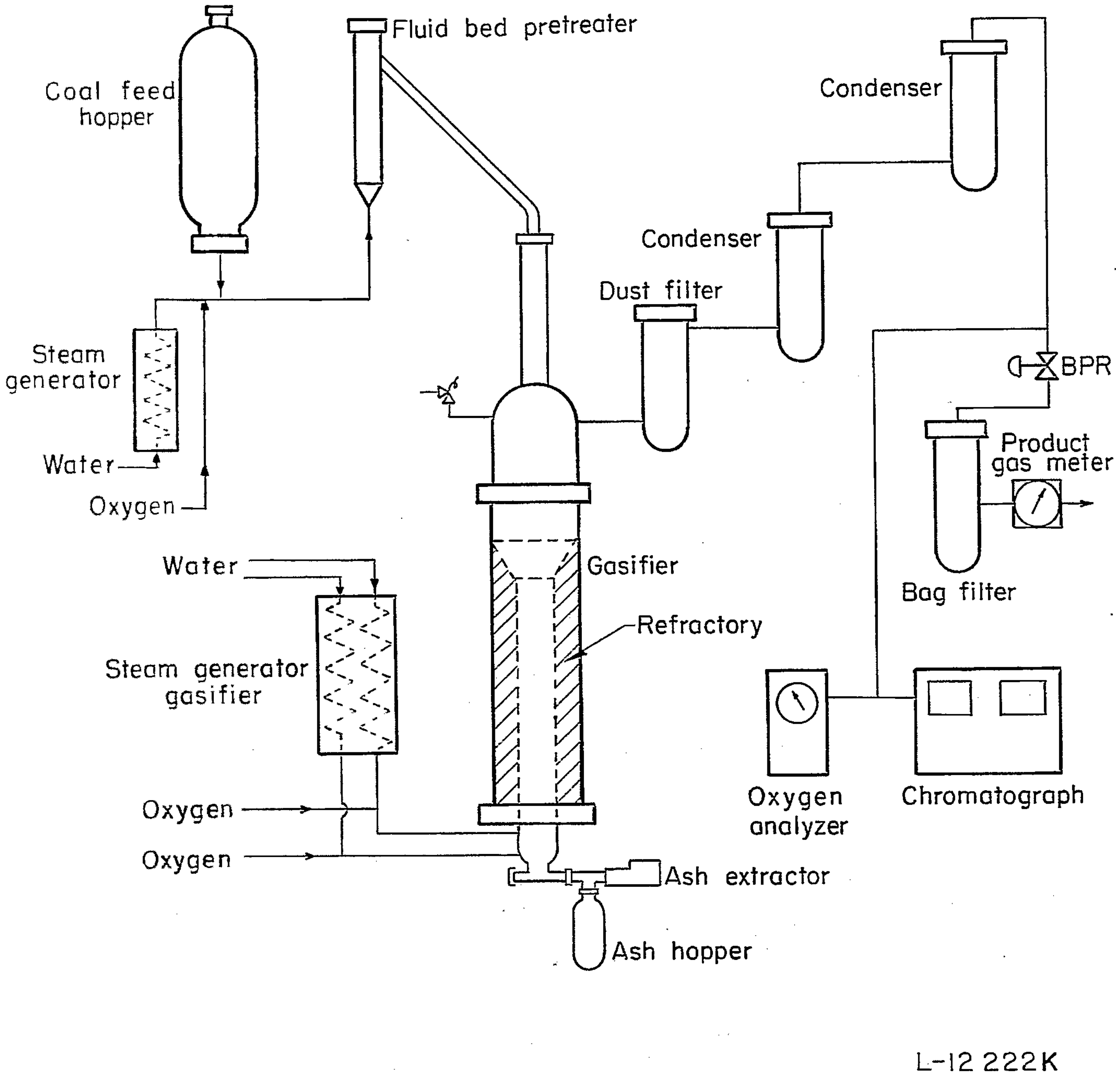

Figure 1. - Bruceton 40-atmosphere gasifier

neutron activation but results were incomplete and not conclusive. Determinations on the feed water were also incomplete. Mercury analysis was done by flameless atomic absorption procedures.

Samples were taken as follows:

1. Solids are collected from hoppers by a vacuum connected to a cyclone separator tank. Samples are then taken by randomly scooping some coal or char out with the sample can.

2. Condensate and tar mixture is drained from the condenser into 5 gallon steel buckets, decanted and individual tar and condensate samples are taken randomly by dipping glass jars into the buckets of decanted condensate and tar.

There were 3 separate sets of data obtained for each separate test, #162, 163 and 164.

DISCUSSION OF RESULTS

Table 1 shows the overall results of 3 tests. They were roughly duplicates of each other; for example, the percent steam decomposition and percent carbon gasified for each experiment are in good agreement with each other.

Tables 2 and 3 show the feed plus product streams of the gasifier. Table 4 shows the overall weight balances of the five main components for each test. As can be seen they are good--ranging from 96% to 100%. Table 5 shows the analysis of 65 trace elements made by spark source mass spectrometry. The results in this table are reported as ppm wt. (ug/g) while the water is reported as ug/ml. It is recognized higher accuracy can be achieved and will be done on selected elements in the next series of tests rather than getting so many analysis. However, it is believed for this first attempt the coverage of elements analyzed should be as wide as possible. Some of these values on the feed coal do not agree with Ruch. (4)

Table 6 shows the percent recovery of 16 selected elements which are considered the most important of the 65 analyzed. While the elements Hg, U, As, Zn, Mn, Cr, V, P, F, B, and Be indicate some reasonable degree of recovery, Pb, Cd, Se, Ni, are too inaccurate. Other elements, while not listed in Table 6 are as inaccurate as Sr, Fe and Al. It is recognized that SSMS values are usually considered good to within a factor of 3.

These wide ranges, both plus and minus, would indicate more precise analytical methods are needed to get better yield data.

Tables 7, 8 and 9 show where these trace elements are in the various streams for 3 experiments. The first part of each table was made by totalling the yields from the gasifier and then, calculating of the total, where the percentage of the elements are in the water, tar, fines and char. The 2nd part shows how much of the feed quantities are found in each of the off streams. It is seen (Table 9) in both cases that the greatest percentage of the 16 elements (remembering the accuracy discussed with Table 6) is in the chars and dusts except Hg, B, Se and F some of which are found in the water. Almost all of the chlorine is in the water. The tars contain some As, Pb, Cd and Hg. While the determinations of elemental analysis of the feed water and off gas were incomplete and not used, it is believed these are too small to affect the balances. This belief is strengthened by the analysis shown in TPR-6 (3) in the gas.

Table 10 shows the results of a comparison of trace element concentrations in the condensate from the gasifier compared to the same type analysis on a Monongahela River sample. As can be seen, except for elements such as B, Hg and Se, in many cases the percentages of the trace elements is actually higher in the river water.

CONCLUSIONS

These 3 gasifier tests made in the small pdu gasifier at Bruceton, Pa. indicate that the trace elements primarily remain in the chars and dusts emanating from the gasifier. Some elements, such as boron, chlorine, fluorine and selenium are found in the water and some such as arsenic, lead and cadmium are in the tars. Of course, the high sulfur percentage in the tars was already known from the major component analysis. Further tests are needed to concentrate on better analyses of fewer elements to obtain greater accuracy and better balances. Unfortunately, the mercury analyses were incomplete, but most of the mercury appears in the tar and water, with little remaining in the char or dust.

Table 1. - Run Conditions and Results for all Tests

Run Conditions	162	163	164
Time (Hrs)	6.25	5.50	6.67
Coal Feed Rate #/hr.	20.0	20.4	23.7
Coal Feed #/hr·ft^3	42.6	43.3	50.4
#Steam/#Coal Feed	1.68	1.75	1.54
#O_2/#Coal Feed	0.37	0.37	0.30
Pressure (ATM)	40	40	40
Temperature Pretreater, °C			
Max.	408	409	406
Avg.	363	364	349
Temperature Gasifier, °C			
Max.	985	1020	990
Avg.	917	918	925
Gasifier Sup. L. Vel.(ft/sec)	0.29	0.30	0.29
Pretreater Sup. L. Vel. (ft/sec)	0.79	0.80	0.71
Run Results			
SCF Prod[1/] Gas/#Coal	12.3	12.6	11.7
SCF CH_4 Eq/#Coal	3.08	3.01	3.15
Steam Decomp, %	17.8	17.6	19.0
Carbon Gasified, %	67.1	68.5	66.5
Carbon Converted, %	71.4	72.2	71.7
#Tar/#Coal Feed	0.03	0.02	0.04
CH_4 (EQU) % of Purified Gas	24.6	23.4	26.3
Gas Analysis, Dry, N_2 Free (%)			
H_2	35.1	35.7	35.4
O_2	0.0	0.0	0.0
CO	12.0	13.3	12.3
CH_4	12.8	12.4	13.9
CO_2	37.4	35.8	35.3
C_2H_6	1.29	1.30	1.56
H_2S	1.43	1.41	1.62

[1/] $H_2 + CO + CH_4 + C_2H_6$

Gas Analysis, Dry, N_2 Free (%)			
CH_3SH	0.002	0.002	0.003
COS	0.014	0.020	0.030
SO_2	0.001	0.001	0.001
C_4H_4S	0.004	0.001	0.004
C_6H_8S	0.001	0.001	0.001
C_6H_6	0.039	0.012	0.022
C_7H_8	0.010	0.003	0.005
C_8H_{10}	0.002	0.002	0.002
HCN	8.8×10^{-9}	3.2×10^{-8}	9.1×10^{-9}
C_5H_6S	0.001	0.001	0.001

Table 2. - Feed Stream Into the Gasifier

	162	163	164
Coal Feed (gms)	56750	50848	71749
	wt%	wt%	wt%
C	65.0	63.0	65.0
H	4.9	4.9	4.8
O	11.6	13.4	11.1
N	1.2	1.2	1.2
S	3.6	3.6	3.7
Ash	13.7	13.9	14.2
Moisture	3.7	5.5	2.7
Fixed Carbon	44.5	43.0	45.1
Volatile Matter	38.1	37.6	38.0
Water (gms)	95350	88757	110549
	wt%	wt%	wt%
H	11.1	11.1	11.1
O	88.9	88.9	88.9
Oxygen (gms)1/	20884	18614	21338
	wt%	wt%	wt%
O	100.0	100.0	100.0
Nitrogen2/ (gms)	84802	82567	89117
	wt%	wt%	wt%
N	100.0	100.0	100.0

1/ Not Analyzed

2/ Not Analyzed

TABLE 3 - Streams from the Gasifier

	162	163	164
Condensate (gms)	81723	75894	90721
	wt%	wt%	wt%
C	1.6	1.6	1.6
H	10.9	10.9	10.9
O	87.0	87.0	87.0
S	0.5	0.5	0.5
Filter Dust (gms)	684	269	871
	wt%	wt%	wt%
C	75.0	72.8	74.9
H	1.7	1.7	1.9
O	2.1	2.2	2.0
N	0.8	0.8	0.9
S	1.3	1.4	1.4
Extractor Hopper (gms)	12939	11804	22019
	wt%	wt%	wt%
C	50.9	61.3	48.7
H	0.7	0.7	0.6
N	0.3	0.4	0.3
S	0.6	0.7	0.5
Tar (gms)	1844	1368	2920
	wt%	wt%	wt%
C	83.0	82.8	83.1
H	6.4	6.3	6.4
O	6.4	6.0	6.4
N	1.2	1.2	1.3
S	2.7	2.6	2.7
Gas (gms)	154682	143195	206444
	wt%	wt%	wt%
C	15.2	14.2	15.1
H	2.6	2.5	2.6
O	26.5	24.8	23.4
N	54.8	57.7	43.2
S	0.9	0.9	1.0
Gasifier[1/] (gms)	3355	2740	590
	wt%	wt%	wt%
C	69.3	62.6	60.8
H	0.8	1.0	1.2
O	0.7	1.5	0.9
N	0.4	0.6	0.9
S	0.8	1.1	1.4

[1/] Char left in Gasifier at the End of Run

Table 4. - Overall Mass Balances of the Major Components

	$\sum$ In Kg	$\sum$ Out Kg	% Recovery
162			
C	36.9	35.8	97.0
H	13.4	13.3	99.5
O	112.2	112.2	100.0
N	85.5	84.9	99.3
S	2.0	2.0	100.0
163			
C	32.0	31.8	99.4
H	12.3	12.1	97.6
O	104.3	101.7	97.4
N	83.2	82.6	99.4
S	1.8	1.8	100.0
164			
C	46.6	46.7	100.2
H	15.7	15.4	98.2
O	127.6	127.4	99.9
N	89.9	89.2	99.2
S	2.7	2.6	96.3

TABLE 5. - Trace Element Analysis of all Streams

162	Feed Coal PPM (ug/g)	Filter Fines PPM (ug/g)	Char PPM (ug/g)	Tar PPM (ug/g)	H_2O PPM (ug/g)
Ag	0.01	< 0.01	< 0.05	--	--
Al	> 0.5%	540	1800	29	0.007
As	0.87	3.7	6.5	0.71	0.001
B	86	64	380	12	43
Ba	170	130	98	3.6	0.10
Be	1.5	7.2	4.6	0.03	--
Bi	< 0.10	< 1.7	< 0.44	0.20	--
Br	0.23	0.65	1.6	0.02	0.001
Ca	> 1%	> 0.5%	> 1%	450	2.4
Cd	0.097	0.88	1.6	-	-
Ce	47	25	54	0.29	-
Cl	93	11	33	1.5	300
Co	14	17	95	0.09	0.002
Cr	170	47	240	7.1	0.043
Cs	0.26	1.2	0.65	-	-
Cu	39	70	40	0.74	0.003
Dy	1.4	3.9	1.6	-	-
Er	2.1	0.41	0.80	-	-
Eu	0.55	0.39	0.65	-	-
F	490	610	150	0.97	39
Fe	> 1%	> 0.5%	> 1%	240	0.081
Ga	8.3	3.6	4.5	0.08	-
Gd	1.9	1.2	0.48	-	-
Ge	1.1	1.3	5.4	0.08	-
Hf	0.83	3.5	11	-	-
Hg	0.10	0.20	*	1.2	0.027
Ho	0.43	0.16	0.45	-	-
I	0.4	1.9	0.27	0.02	-
K	> 1%	190	5400	14	0.31
La	22	6.7	17	0.03	-
Li	0.8	34	67	0.51	0.001
Lu	0.085	< 0.18	0.40	-	-
Mg	2800	4600	3500	240	0.57
Mn	160	48	240	2.2	0.20
Mo	15	21	14	0.31	-
Na	1900	> 1%	4700	360	6.6
Nb	4.7	7	13	0.08	-
Nd	23	19	11	0.06	-
Ni	43	12	25	1.2	0.018
P	130	460	460	14	0.04
Pb	0.55	2.2	21	0.22	0.003
Pr	7.3	7.5	4.2	0.02	-
Rb	180	36	27	0.10	-
S	> 1%	7700	2100	120	1.6
Sb	0.18	0.04	1.9	-	-
Sc	5.3	6.4	17	0.02	-

* Insufficient results.

cont.

TABLE 5 - Trace Element Analysis of all Streams

162	Feed Coal PPM (ug/g)	Filter Fines PPM (ug/g)	Char PPM (ug/g)	Tar PPM (ug/g)	H_2O PPM (ug/g)
Se	2.2	15	4.7	0.23	0.14
Si	>1%	>1%	>1%	500	2.8
Sm	2.7	0.30	0.86	0.01	-
Sn	0.6	0.75	1.9	0.03	-
Sr	3.3	44	70	4.5	0.12
Ta	0.73	0.64	1.2	-	-
Tb	0.2	0.20	0.89	-	-
Te	<0.29	<0.19	0.15	-	-
Th	3	5.8	4.3	0.06	-
Ti	880	1800	3300	8.4	0.003
Tl	<0.12	<0.19	<0.25	0.11	-
Tm	0.24	0.10	0.20	-	-
U	1.4	5.6	5.4	0.01	-
V	100	44	190	0.21	-
W	0.08	2.2	4.8	0.09	-
Y	21	37	48	0.10	-
Yb	0.35	2.7	2.2	-	-
Zn	25	11	100	0.48	0.13
Zr	10	22	28	0.26	-

TABLE - 5 - Trace Element Analysis of all Streams

163	Feed Coal PPM (ug/g)	Filter Fines PPM (ug/g)	Char PPM (ug/g)	Tar PPM (ug/g)	H_2O PPM (ug/g)
Ag	< 0.009	< 0.054	< 0.054	-	-
Al	2400	1000	790	30	0.006
As	1.3	6.5	3.3	1.6	< 0.001
B	86	32	300	52	17
Ba	190	80	98	6.0	0.095
Be	1.3	4.6	2.1	0.07	-
Bi	< 0.10	3.1	1.2	0.17	-
Br	0.13	3.2	1.6	0.08	-
Ca	> 1%	> 0.5%	> 1%	2000	3.6
Cd	0.097	1.6	0.77	0.15	-
Ce	22	22	89	1.5	-
Cl	220	33	14	1.2	170
Co	6	4.1	9.5	0.35	-
Cr	100	120	120	10	0.004
Cs	0.13	0.33	0.65	0.04	-
Cu	27	18	40	6.4	0.002
Dy	0.7	1.21	3.4	0.10	-
Er	1.6	0.40	0.54	-	-
Eu	< 0.22	0.65	1.3	0.02	-
F	420	740	320	12	37
Fe	> 0.5%	> 1%	> 1%	530	0.18
Ga	5.8	2.1	2.1	0.17	-
Gd	0.081	0.48	0.95	0.01	-
Ge	2.1	2.5	2.5	0.08	-
Hf	0.73	2.2	1.1	0.04	-
Hg	0.14	0.07	*	0.47	0.029
Ho	0.19	0.30	0.30	-	-
I	0.23	2.7	0.23	0.08	-
K	> 0.5%	2300	2300	130	0.46
La	11	7.7	7.7	0.16	-
Li	0.8	38	38	0.48	0.001
Lu	< 0.081	0.35	0.40	-	-
Mg	1600	3500	3500	820	1.0
Mn	220	140	500	4.7	0.01
Mo	11	14	28	0.32	-
Na	1900	> 0.5%	> 1%	780	6.8
Nb	4.7	13	6.5	0.18	-
Nd	23	4.6	11	0.31	-
Ni	10	11	25	1.6	0.002
P	63	1100	2100	31	0.04
Pb	1.1	8.9	21	0.48	0.002
Pr	7.3	1.8	4.2	0.12	-
Rb	67	23	27	1.1	-
S	> 1%	4300	2100	1000	0.74
Sb	0.10	0.95	0.95	-	-
Sc	7	8.3	8.3	0.10	-
Se	1.2	4.7	4.7	0.24	0.002

* Insufficient results.

TABLE 5. - Trace Element Analysis of all Streams

163	Feed Coal PPM (ug/g)	Filter Fines PPM (ug/g)	Char PPM (ug/g)	Tar PPM (ug/g)	H_2O PPM (ug/g)
Si	> 1%	> 1%	> 1%	4000	4.7
Sm	1.1	0.86	1.7	0.04	-
Sn	1.0	1.4	1.9	0.07	-
Sr	2.3	33	70	9.8	0.055
Ta	0.31	1.2	1.2	0.02	-
Tb	0.086	0.11	0.22	-	-
Te	< 0.29	< 0.11	< 0.11	-	-
Th	6.4	4.3	9.2	0.21	-
Ti	800	590	1700	67	-
Tl	< 0.12	0.25	< 0.25	0.24	-
Tm	0.24	0.12	0.13	-	-
U	3	2.7	14	0.06	-
V	43	41	95	2.6	0.001
W	< 0.024	4.8	9.6	0.21	-
Y	10	9.5	20	0.37	-
Yb	0.4	0.96	0.96	0.03	-
Zn	49	48	100	3.3	0.007
Zr	4.8	9.3	28	0.57	-

TABLE 5. - Trace Element Analysis of all Streams

164	Feed Coal PPM (ug/g)	Filter Fines PPM (ug/g)	Char PPM (ug/g)	Tar PPM (ug/g)	H_2O PPM (ug/g)
Ag	0.013	<0.09	0.21	-	-
Al	2000	330	3200	20	0.009
As	1.5	6.1	2.9	1.1	0.001
B	86	40	160	12	82
Ba	83	80	140	1.5	0.058
Be	0.64	2.6	5.7	0.05	-
Bi	<0.10	1.5	<0.99	0.30	-
Br	0.13	0.75	1.9	0.01	0.001
Ca	>1%	3500	>1%	240	2.0
Cd	0.087	0.73	1.4	-	-
Ce	16.5	16	15	0.20	-
Cl	93	6.7	14	0.42	190
Co	3.5	11	10	0.24	-
Cr	100	29	220	3.0	0.006
Cs	0.13	0.73	0.69	-	-
Cu	39	23	22	0.85	0.003
Dy	1.1	1.8	3.8	-	-
Er	1.6	0.6	0.57	-	-
Eu	<0.22	0.21	0.34	-	-
F	280	690	240	1.4	32
Fe	>1%	>1%	>1%	200	0.11
Ga	1.9	2.3	4.6	0.02	-
Gd	1.4	0.37	0.35	-	-
Ge	0.91	1.9	7.6	0.02	0.001
Hf	0.66	1.4	0.45	-	-
Hg	0.08	0.06	0.04	0.21	0.030
Ho	0.13	0.16	0.15	-	-
I	0.4	1.4	<0.20	-	0.001
K	> 1%	190	5400	14	0.31
La	>0.5%	2300	2300	130	0.46
Li	0.4	21	40	0.33	-
Lu	<0.081	0.14	0.12	-	-
Mg	800	4400	2700	360	0.32
Mn	220	40	160	1.6	0.014
Mo	6.3	13	25	0.11	0.001
Na	1900	>1%	>1%	530	5.4
Nb	4.7	8.7	4.1	0.03	-
Nd	9.9	12	11	0.09	-
Ni	10	18	25	0.95	0.001
P	130	> 1%	630	9.1	0.022
Pb	0.55	2.8	5.7	0.16	-
Pr	7.3	3.5	4.4	0.04	-
Rb	25	4.9	54	0.06	-
S	>0.5%	4800	2300	42	0.57
Sb	0.1	0.06	0.11	-	-
Sc	7	4	11	0.01	-
Se	0.58	9.3	3.8	0.08	0.18
Si	>1%	>1%	>1%	742	6.6
Sm	1.1	0.43	0.61	0.10	-

* Insufficient results.

TABLE 5. - Trace Element Analysis of all Streams

164	Feed Coal PPM (ug/g)	Filter Fines PPM (ug/g)	Char PPM (ug/g)	Tar PPM (ug/g)	H_2O PPM (ug/g)
Sn	0.45	0.93	0.88	0.02	-
Sr	15	59	55	2.4	0.034
Ta	0.73	0.8	0.16	-	-
Tb	0.086	0.12	0.12	-	-
Te	<0.029	<0.12	0.16	-	-
Th	4.5	5.1	4.9	0.04	-
Ti	800	1100	1100	8.1	0.036
Tl	<0.12	<0.12	<0.11	0.16	-
Tm	0.24	0.15	0.14	-	-
U	3	5	4.7	0.02	-
V	35	50	47	0.31	0.002
W	<0.024	1.9	2.9	0.02	-
Y	10	23	22	0.07	-
Yb	0.28	1.7	1.6	-	-
Zn	49	28	66	1.4	0.096
Zr	10	31	13	0.08	-

TABLE 6. - Trace Element Balances of Selected Components

162	Σ In (mg)	Σ Out (mg)	% Recovery
As	49.4	109.9	222.5
B	4880.5	9771.8	200.2
Be	85.1	79.9	93.9
Cd	5.5	26.7	485.5
Cl	5277.7	25065.0	474.9
Cr	9647.5	3959.4	41.0
F	27807.5	6050.4	21.8
Hg	5.7	4.6	80.7
Mn	9080.0	3963.9	43.7
Ni	2440.3	419.3	17.2
P	7377.5	7839.2	106.3
Pb	31.2	344.4	1103.7
Se	124.9	788.5	631.3
U	79.5	100.0	125.8
V	5675.0	3126.4	55.1
Zn	1418.8	1648.5	116.2

163	Σ In (mg)	Σ Out (mg)	% Recovery
As	66.1	52.0	78.7
B	4372.9	5951.9	136.1
Be	66.1	31.9	48.3
Cd	4.9	11.8	240.8
Cl	11186.6	15302.9	136.8
Cr	5084.8	1791.6	35.2
F	21356.2	8153.6	38.2
Hg	7.1	3.2	45.1
Mn	11186.6	7317.0	65.4
Ni	508.5	369.0	72.6
P	3203.4	30884.4	964.1
Pb	55.9	308.6	552.1
Se	61.0	70.6	115.7
U	152.5	204.5	134.1
V	2186.5	1396.4	63.9
Zn	2491.6	1472.5	59.1

164	Σ In (mg)	Σ Out (mg)	% Recovery
As	107.6	74.2	69.0
B	6170.4	11126.5	180.3
Be	45.9	131.3	286.1
Cd	6.2	32.3	521.0
Cl	6672.7	17560.7	263.2

TABLE 6. - Trace Element Balances of Selected Components cont.

164	Σ In (mg)	Σ Out (mg)	% Recovery
Cr	7174.9	5008.6	69.8
F	20089.2	8934.3	44.5
Hg	5.7	4.3	75.4
Mn	15784.8	3658.3	23.2
Ni	717.5	583.9	81.4
P	9327.4	14280.0	153.1
Pb	39.5	131.8	333.7
Se	41.6	111.2	267.3
U	215.2	110.7	51.4
V	2511.2	1107.2	44.1
Zn	3515.7	1529.5	43.5

TABLE 7. - Percentage of Selected Components in Major Effluent Streams
Experiment 162

162	Out (mg)	H_2O,%	Tar,%	Char,%	Fines,%
As	109.9	0.1	1.2	96.4	2.3
B	9771.8	36.0	0.2	63.4	0.4
Be	79.9	-	0.1	93.8	6.1
Cd	26.7	-	-	97.7	2.3
Cl	25065.0	97.8	0.1	2.1	0.0
Cr	3959.4	0.1	0.3	98.8	0.8
F	6050.4	52.7	0.0	40.4	6.9
Hg*					
Mn	3963.9	0.4	0.1	98.7	0.8
Ni	419.3	0.4	0.5	97.1	2.0
P	7839.2	0.0	0.3	95.7	4.0
Pb	344.4	0.1	0.1	99.4	0.4
Se	788.5	1.5	0.1	97.1	1.3
U	100.0	-	0.0	96.2	3.8
V	3126.4	0.0	0.0	99.0	1.0
Zn	1648.5	0.6	0.0	98.9	0.5

	In (mg)	H_2O,%	Tar,%	Char,%	Fines,%
As	49.4	0.2	2.7	214.4	5.2
B	4880.5	72.0	0.5	126.9	0.9
Be	85.1	0.0	0.1	88.1	5.8
Cd	5.5	0.0	0.0	474.0	10.9
Cl	5277.7	464.5	0.05	10.2	0.14
Cr	9647.5	0.1	0.1	40.5	0.3
F	27807.5	11.5	0.0	8.8	1.5
Hg	5.7	38.9	39.1	-	2.5
Mn	9080.0	0.2	0.1	43.1	0.4
Ni	2440.3	0.1	0.1	16.7	0.3
P	7377.5	0.1	0.4	101.6	4.3
Pb	31.2	0.7	1.3	1096.7	4.8
Se	124.9	9.6	0.3	613.1	8.2
U	79.5	0.0	0.1	120.9	4.8
V	5675.0	0.0	0.1	54.6	0.5
Zn	1418.8	0.8	0.1	114.8	0.5

* Insufficient Results

TABLE 8. - Percentage of Selected Components in Major Effluent Streams
Experiment 163

163	Out (mg)	H_2O,%	Tar,%	Char,%	Fines,%
As	52.0	0.3	4.2	92.2	3.3
B	5951.9	25.4	1.2	73.3	0.1
Be	31.9	-	0.3	95.9	3.8
Cd	11.8	-	1.7	94.8	3.5
Cl	15302.9	98.6	0.0	1.3	0.1
Cr	1791.6	0.0	0.8	97.4	1.8
F	8153.6	40.3	0.2	57.1	2.4
Hg*					
Mn	7317.0	0.0	0.1	99.4	0.5
Ni	369.0	0.1	0.6	98.5	0.8
P	30884.4	0.0	0.1	98.9	1.0
Pb	308.6	0.1	0.2	98.9	0.8
Se	70.6	1.0	0.4	96.8	1.8
U	204.5	-	0.0	99.6	0.4
V	1396.4	0.0	0.3	98.9	0.8
Zn	1472.5	0.0	0.3	98.8	0.9

	In (mg)	H_2O,%	Tar,%	Char,%	Fines,%
As	66.1	0.2	3.3	72.6	2.7
B	4372.9	34.5	1.6	99.8	0.2
Be	66.1	0.0	0.2	46.3	1.8
Cd	4.9	0.0	4.1	228.6	8.8
Cl	11186.6	134.9	0.01	1.8	0.08
Cr	5084.8	0.0	0.3	34.3	0.6
F	21356.2	15.4	0.1	21.8	0.9
Hg	7.1	36.1	9.0	-	0.3
Mn	11186.6	0.0	0.1	65.0	0.3
Ni	508.5	0.1	0.4	71.5	0.6
P	3203.4	0.1	1.3	953.4	9.2
Pb	55.9	0.3	1.2	546.3	4.3
Se	61.0	1.1	0.5	112.1	2.1
U	152.5	0.0	0.1	133.6	0.5
V	2186.5	0.0	0.2	63.2	0.5
Zn	2491.6	0.1	0.2	58.4	0.5

* Insufficient Results

TABLE 9. - Percentage of Selected Components in Major Effluent Streams
Experiment 164

164	Out (mg)	H_2O,%	Tar,%	Char,%	Fines,%
As	74.2	0.3	4.3	88.3	7.1
B	11126.5	66.9	0.3	32.5	0.3
Be	131.3	-	0.1	98.2	1.7
Cd	32.3	-	-	98.0	2.0
Cl	17560.7	98.2	0.0	1.8	0.0
Cr	5008.6	0.0	0.2	99.3	0.5
F	8934.3	32.5	0.0	60.8	6.7
Hg	4.3	63.5	14.3	21.0	1.2
Mn	3658.3	0.0	0.1	98.9	1.0
Ni	583.9	0.0	0.5	96.8	2.7
P	14280.0	0.0	0.2	99.7	0.1
Pb	131.8	-	0.4	97.8	1.8
Se	111.2	15.3	0.2	77.2	7.3
U	110.7	-	0.1	96.0	3.9
V	1107.2	0.0	0.1	96.0	3.9
Zn	1529.5	0.6	0.3	97.5	1.6

	In (mg)	H_2O,%	Tar,%	Char,%	Fines,%
As	107.6	0.1	3.0	60.2	4.9
B	6170.4	120.6	0.6	58.6	0.6
Be	45.9	0.0	0.2	280.8	5.0
Cd	6.2	0.0	0.0	509.7	11.5
Cl	6672.7	258.3	0.02	4.7	0.09
Cr	7174.9	0.0	0.1	69.3	0.4
F	20089.7	14.5	0.0	27.0	3.0
Hg	5.7	47.4	10.6	15.7	0.9
Mn	15784.8	0.0	0.0	22.9	0.2
Ni	717.5	0.1	0.4	78.8	2.2
P	9327.4	0.1	0.3	152.7	0.1
Pb	39.5	0.0	1.2	326.3	6.2
Se	41.6	40.8	0.6	206.5	19.5
U	215.2	0.0	0.1	49.4	2.0
V	2511.2	0.0	0.1	42.3	1.7
Zn	3515.7	0.3	0.1	42.4	0.7

Table 10

Trace Element Analysis of Monongahela Riverwater and an Earlier Gasification Condensate

	Mon River: 12th St Bridge, Pgh PPM (vol)	Synthane CHPFI-120 PPM (vol)
Ag	0.025	0.009
Al	0.13	2.7
As	0.010	0.071
B	0.24	85
Ba	0.50	0.51
Br	0.041	0.017
Ca	25	1.5
Cd	-	-
Ce	0.003	0.005
Cl	3.8	0.41
Co	0.005	0.031
Cr	0.004	0.029
Cs	0.015	0.015
Cu	0.012	0.013
Fe	0.88	0.90
Ga	0.007	0.014
Ge	0.020	0.038
Hg	<0.0001	0.015
I	0.005	0.033
K	1.8	<0.1
La	0.016	0.036
Li	-	0.01
Mg	6.5	0.39
Mn	0.19	0.008
Mo	4.9	1.8
Na	16	0.22
Nb	-	0.040
Nd	0.017	-
Ni	-	0.11
P	0.17	0.40
Pb	0.021	0.032
Rb	0.31	0.77
S	21	NR*
Sb	0.009	0.032
Sc	0.012	0.025
Se	-	1.1
Si	16	43
Sm	0.011	-
Sn	-	0.13
Sr	0.56	0.28
Ti	2.2	1.1
U	0.025	0.025
V	0.008	0.008
W	-	-

Table 10 (cont)

	Mon River: 12th St Bridge, Pgh PPM (vol)	Synthane CHPFI-120 PPM (vol)
Y	0.01	0.009
Zn	0.40	0.17
Zr	0.043	0.028

* Not Reported Due to Matrix Difficulties

- Less than 0.001 Mg/ml (ppm)

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