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PARTIAL SEAM CRIP TEST TAR RESULTS

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PARTIAL SEAM CRIP TEST TAR RESULTS

by

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ABSTRACT

One hundred forty-three tar samples were taken during the Partial Seam CRIP test using a refluxing methylene chloride system. Over 50 samples were analyzed for tar/water ratio (and therefore tar/dry gas and tar/coal ratios); C, H, N, S, and O (by difference); density; simulated distillation; and selected compounds by capillary column gas chromatography.

We found the boiling point curves for the CRIP test tars to be, in general, lower than for other coal tars, including those from pyrolysis and fixed bed gasifiers. Boiling point curves were similar to other UCG-derived tars. The 50% distillation temperature was about 250°C and the end point was near 500°C. The amount of CRIP test tar (0.04 kg/kg MAF coal) was less than that produced by pyrolysis (0.165 kg/kg) and was near the low range of tars produced from fixed bed gasifiers (0.04-0.13 kg/kg).

INTRODUCTION

A considerable amount of underground coal gasification (UCG) data have been reported over the past ten years. However, there has been relatively little information published concerning the organic liquids ("tar") produced from UCG. King and co-workers have published tar analyses from Hanna I and II (King 1975, 1977). More recently, Barbour and Bencini have published results from Rawlins II, (Barbour and Bencini 1982) and Barbour (1984) has published data from Hanna IV B.

All UCG groups report production of less tar than expected from pyrolysis of an equivalent amount of coal. In addition, the tar fractions are lighter, lower in molecular weight and have lower boiling points than that produced from coal pyrolysis. King points out that this is because the UCG derived coal tar is a fractionated portion of the total generated tar. Much of the heavy ends are trapped underground and undergo secondary pyrolysis, or even complete destruction. Therefore one would expect less tar to be produced by UCG, and one would also expect a lighter product to be formed. In general the temperature of the produced gas would tend to influence the tar: higher boiling tars would tend to remain underground, with the possible exceptions of the production of entrained droplets of higher boiling organics.

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A methylene chloride system was employed on the Partial Seam CRIP test, which was conducted by LLNL at the WIDCO mine in October-November, 1983. Tar samples were collected daily; approximately 150 samples were taken. We report here the results and our analysis of the coal tars collected during the test.

Our results are compared to other UCG data on organic fractions, including a more limited set of PSC data by Kilpatrick et al, (1984) to coal pyrolysis data, and to moving bed gasifier results.

Where possible we compare selected data as a function of time, or burn condition. A brief review of the PSC will prove useful in this comparison.

Figures 1a and 1b show a schematic of the PSC burn and a plan view of the gasified region (Hill et al 1984). The test exhibited three general phases: the first cavity, from days 0-14.4, the second or CRIP burn, when we began a new cavity 25 ft upstream from the first injection point, which lasted from day 14.4 to 22.3, and finally a post-collapse period from day 22.3 to test termination on day 29.65. This final phase commenced when a massive roof fall occurred in the underground system causing a permanent change in process geometry.

The first burn phase exhibited good gasification parameters, with an average dry product gas heating value of 250 Btu/scf. The burn rose to the top of the coal within three days, as evidenced by our thermal instrumentation.

The CRIP phase exhibited the best gasification quality, with an average dry gas heating value of 296 Btu/scf. In addition, the burn initially spread out in the lower portion of the seam, and stayed lower in the seam for a longer period of time than the first burn.

A massive roof fall occurred on day 22.3 which dramatically changed the character of the burn. The burn remained at the top of the seam, and the average dry product gas decreased considerably, and averaged only 220 Btu/scf during the period 22.3 - 29.65.

Product gas chemistry and heating value are shown in Figures 2a and 2b for the three burn phases.

Experimental Procedure

The PSC tar samples were collected using a refluxing condenser system fed by a small gas slip stream taken from the product line. The gas stream was first passed through a hot filter to remove particulates. The filter temperature was held at 125°C to eliminate condensation. The filtered gas then went to the refluxing condenser system shown schematically in Fig. 3. The system consists of two refluxing units in series, each with a two liter trap partially filled with solvent on top of which was a one meter long 3/4" i.d. condenser through which 2°C coolant circulated. A control valve and rotometer are present to allow the setup of appropriate gas flow rates.

Methylene chloride was used as the solvent in the traps. Methylene chloride is a very good solvent for tar; has a convenient boiling point, 40°C, for refluxing action and for later separation procedures; and is safe to handle. As the hot gas bubbles into the methylene chloride it is immediately cooled. This condenses all the water and the tar is dissolved. The second stage is present to insure that any fine mist in the gas is effectively trapped and to provide a backup if the first system becomes overfilled. During the test we found that the first stage collected a large fraction of the tars and water.

In taking tar samples during the test the following procedure was followed. First, 1-1/2 liters of methylene chloride were placed in each trap. The gas flow was adjusted to give a dry gas flow of approximately 6 mmol/s. This allowed for a tar sample of nominally

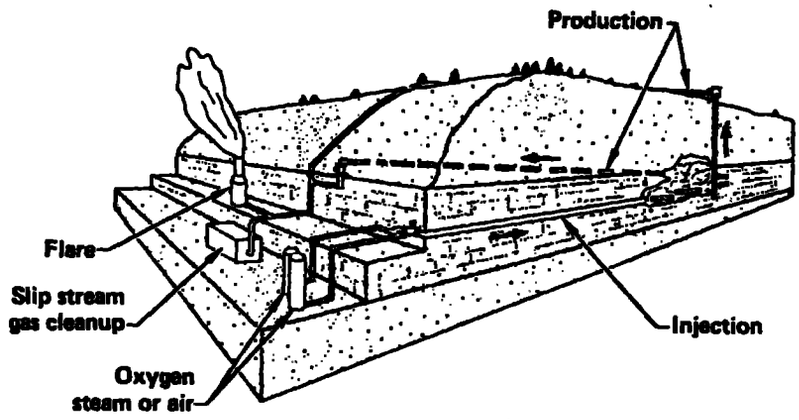
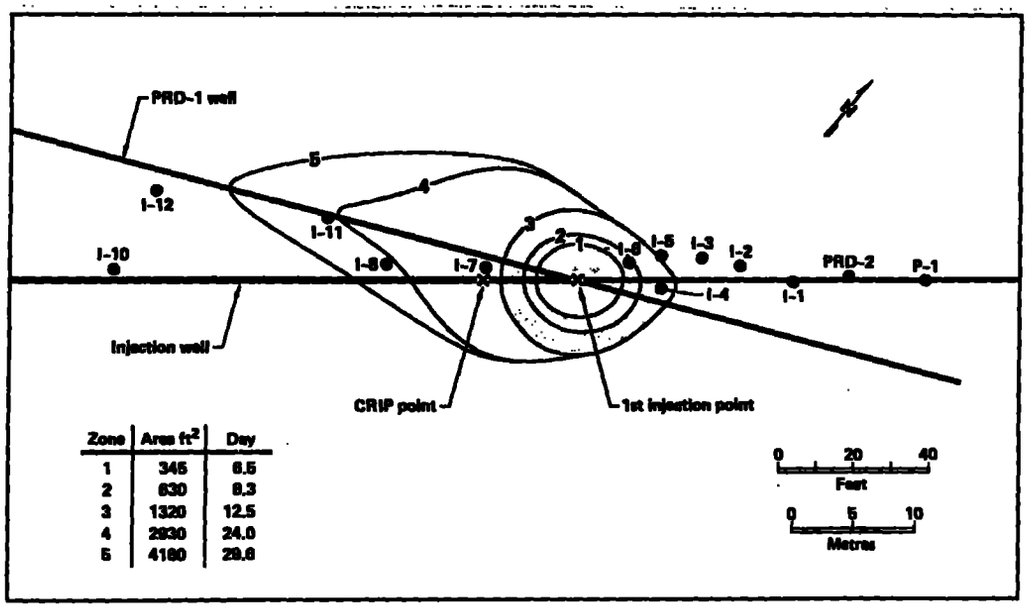


Figure 1a. Planned layout of the Centralia Partial Seam CRIP test. Slant injection and production wells were drilled 900 ft from the coal outings. A vertical production well was drilled 225 ft to the 20 ft thick upper section of the Big Dirty coal seam.



Zone	Area ft²	Day
1	345	6.5
2	630	8.3
3	1320	12.5
4	2930	24.0
5	4180	29.8

Mean cross section plan view

Figure 1b. Approximate burn cavity contours at selected times during the Partial Seam CRIP experiment. Approximately 670 tons of coal were gasified from the first cavity and 1330 tons from the second, for a total of 2000 tons.

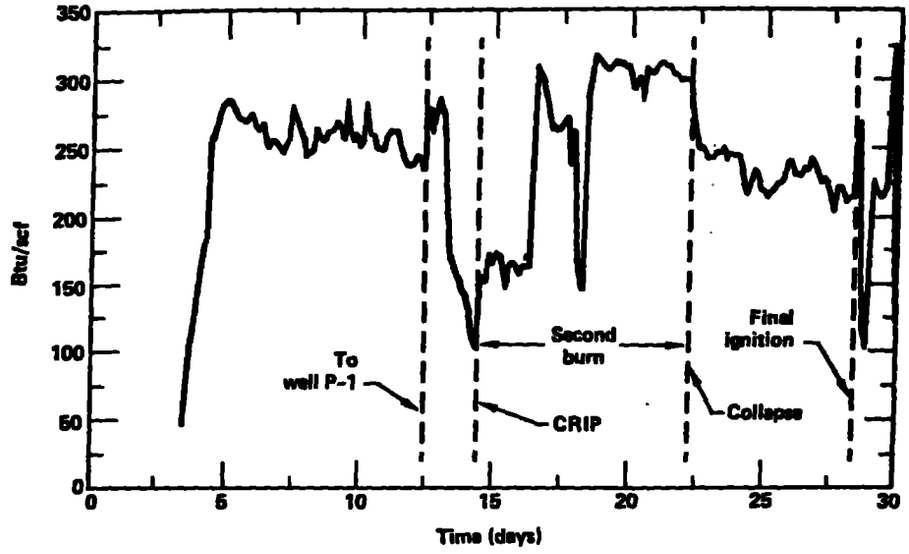


Figure 2a. Product gas quality (heat of combustion) as a function of time for the entire test. Minima are due to air injection forced by power outages and boiler repairs.

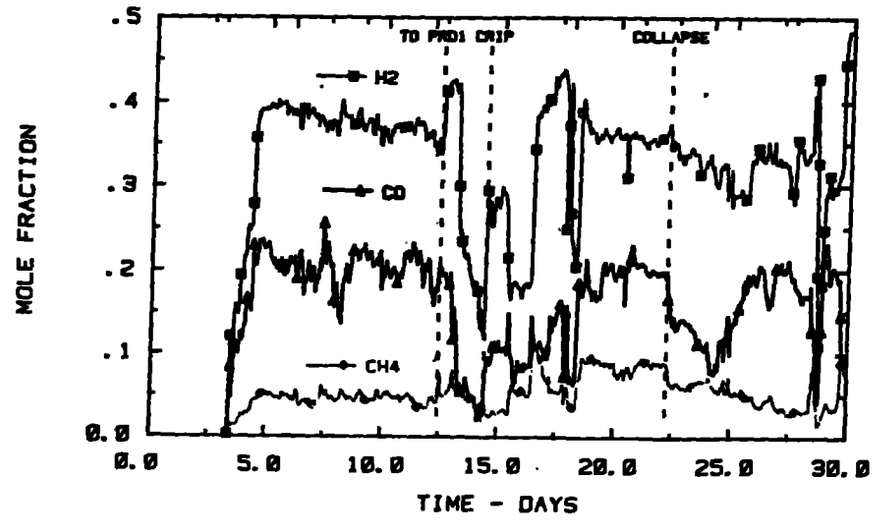


Figure 2b. Variation in the proportions of the three principal combustible components in the product gas. Gas composition is strongly dependent on reaction temperature. Heating value is strongly influenced by the amount of hydrocarbons (e.g., methane) present. Minima are due to air injection forced by power outages and boiler repairs.

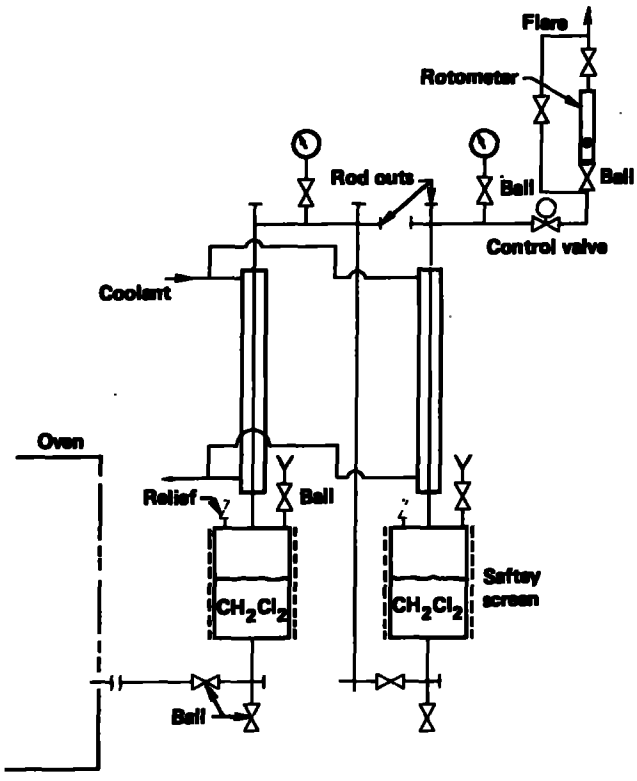


Figure 3. Partial seam CRIP test tar-water collection schematic.

25 grams along with a liter or so of water to be collected in 3 hours. The flow rate was checked from time to time. However, the amount of water collected, not the total dry gas flow, was used to determine the amount of product gas sampled. At the end of the 3 hour period the gas flow was stopped. The contents of both traps were drained into a four liter glass bottle. A small amount of solvent was then used to rinse the traps and this was also added to the collected sample. Approximately 1/4 of the original methylene chloride charge was lost during the 3 hour sample collection, passing out as vapor with the dry product gas. Typical samples contained about 1/2 liter of water.

The samples were transported back to Livermore in the sealed glass containers where the analysis was done. The analysis procedure consisted of the following steps. The sample to be analyzed was placed in a large separatory vessel and the heavier organic phase was withdrawn and filtered in one operation. The amount of water left was then measured. The organic phase was then placed in a vacuum distillation apparatus consisting of two sealed flasks connected by a condenser unit. The air was evacuated from the system and the flasks placed in two temperature baths, the flask with the sample in a 70°C bath and the methylene collection flask in an ice bath. About 2 hours were required for all the methylene chloride to be distilled from the original sample. Weight differences were then used to determine the amount of organics left in the original sample. This is what we define as tar. The distilled methylene chloride and the separated water were then placed back in the original glass container and resealed. The tar sample was placed in a small container and sealed in preparation for the remaining analysis steps. The following measurements were then made on the separated tar samples:

* Density
* Carbon, hydrogen and nitrogen - Perkin & Elmer C, H & N Analyzer
* Sulfur - X-ray Fluorescence
* Simulated distillation - ASTM method D-2887
* Identification of major species by capillary column gas chromatography - 60 m DB-1 methyl-silicone bonded fused silica column
* Thermogravimetric analysis (TGA)-selected samples only, for residue at 500°C

For comparative purposes tar samples were generated from pyrolysis of WIDCO coal. These were generated in the following fashion. A 1.5 kg sample of coal from a core taken at the PSC test site was sieved and sized -3/8 + 1/8. From this sample 0.2 kg of coal was extracted and loaded into a 1 1/4" diameter stainless steel vessel located inside a furnace. An argon sweep gas (1 mmol/s) was used to remove pyrolysis product from the system. The gas passed directly into the tar collection apparatus described above. The furnace

was turned on at about 200°C to drive off the moisture. When the outlet temperature from the bed had been over 150°C for at least 1-1/2 hrs the flow was turned off and the tar traps emptied into a sample bottle and the traps recharged with methylene chloride. The argon flow was turned back on and the furnace was then turned up. The reactor outlet temperature was brought to and held between 500-530°C. After all visible signs of tar production stopped, about 4 hours, the tar trap sample was collected and a fresh methylene chloride charge put in. Heating at 500-550°C was continued for another 3 hours and then terminated. The final trap sample was collected at the end of this period. Essentially all the tar was found in the second sample as anticipated. The experiment was repeated three times.

RESULTS

The Partial Seam CRIP (PSC) test tars, and tars from pyrolysis of WIDCO coal, were analyzed for density, simulated distillation fractions, chemical composition by capillary column gas chromatograph, and C, H, N, S, and O (by difference). Benzene, C_2, C_3, and C_4 from the PSC test were analyzed in the gas phase by mass spectrometer and gas chromatograph.

(a) Density

PSC tar density data are shown in Figure 4 and in Table A1, appendix. WIDCO coal tar data are also shown in the figure and in Table A1.

(b) C, H, N, S, O

PSC tar atomic abundances, expressed as H/C and O/C, are shown in Figure 5. Table A2 presents the C, H, N, S, O weight fractions for both the PSC tars and the WIDCO coal tar.

(c) Simulated Distillation Fractions

Simulated distillation fractions for PSC tars and other UCG-derived tars are shown in Figure 6. Simulated distillation fractions of 10%, 50%, and

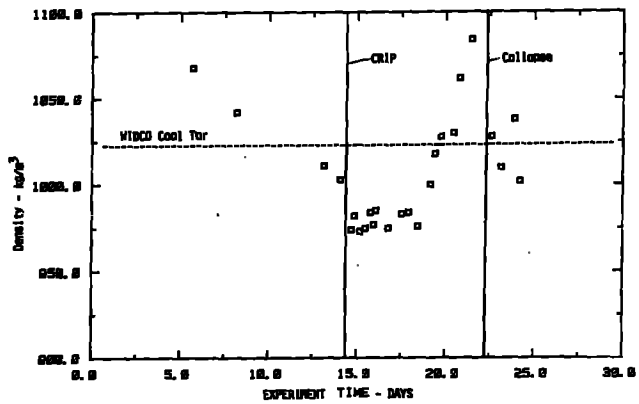


Figure 4. Partial seam CRIP test tar density vs. time. Not all samples taken were analyzed.

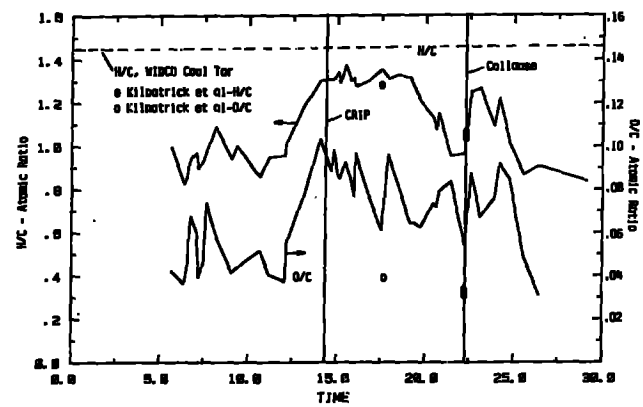


Figure 5. Atomic H/C and O/C ratios for PSC tars.

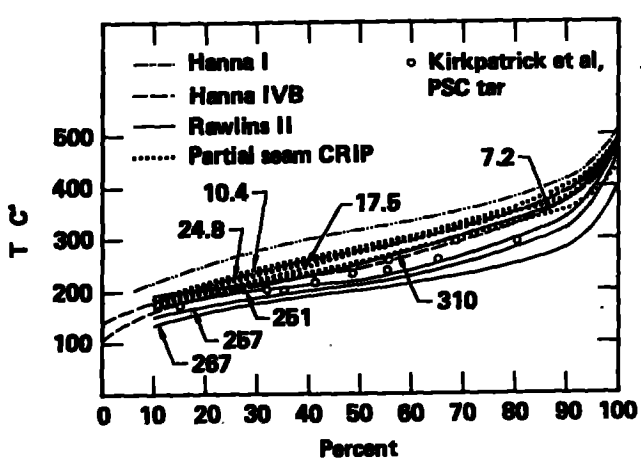


Figure 6. Simulated distillation fractions for UCG coal tars.

90% are shown in Figure 7 for the PSC tars. Simulated distillation fractions for PSC tars sampled on experiment days 7.2, 10.4, 17.5 and 24.8 are given in Table A3A. Figure 8 shows an equivalent WIDCO coal tar simulated distillation; the data are tabulated in Table A3B.

The average residue at 500°C, for the PSC tars was 5% and was 1% for the WIDCO coal tar, as measured by thermogravimetric analysis. The PSC tar residues are probably an upper limit. Some coal fines tend to be entrained in the tar and contribute to the measured residue.

(d) Chemical Compositions

Analyses, all based on kg species per kg of dry, ash-free coal (daf coal), are shown in Figures 9-27 and in Table A4 for total tar, benzene, toluene, O, M, P xylenes, O, M, P, cresols, ethylphenols, trimethylnapthalenes, methylnapthalenes, napthalene, fluorene, acenapthene, anthracene, phenanthrene, fluoranthene, pyrene, ethene, ethane, propene, propane, N- and iso-butane. WIDCO coal tar analyses are also indicated in the figures and are tabulated in Table A5.

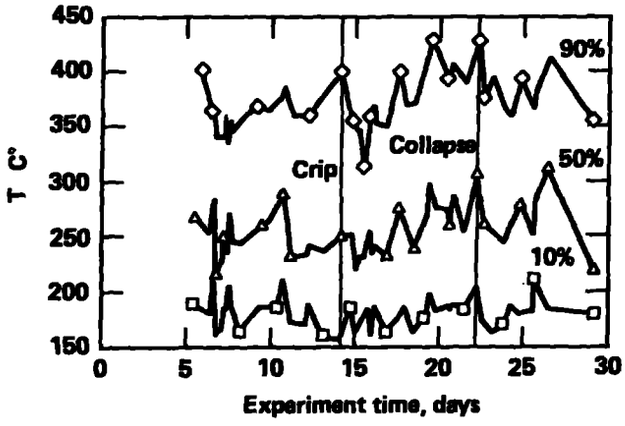


Figure 7. Simulated distillation fractions for PSC tars with time.

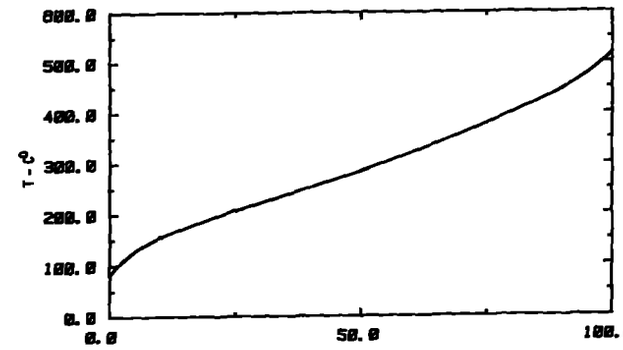


Figure 8. Simulated distillation fraction for WIDCO coal tar pyrolyzed at 500-530°C.

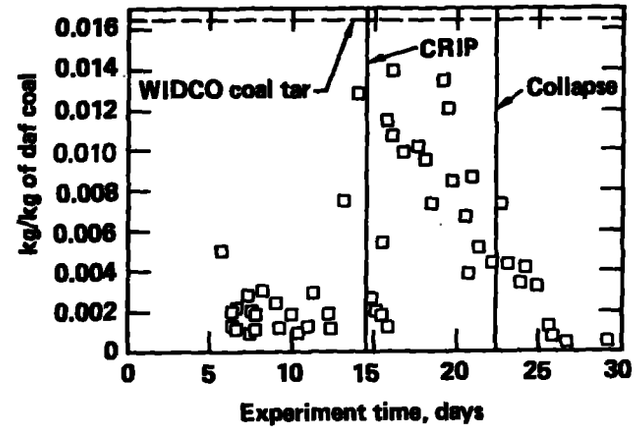


Figure 9. Total PSC tar with time, kg/kg daf coal.

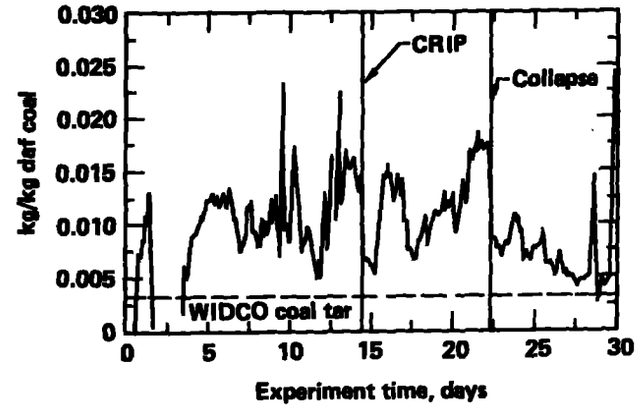


Figure 10. Benzene in PSC tar with time, kg/kg daf coal.

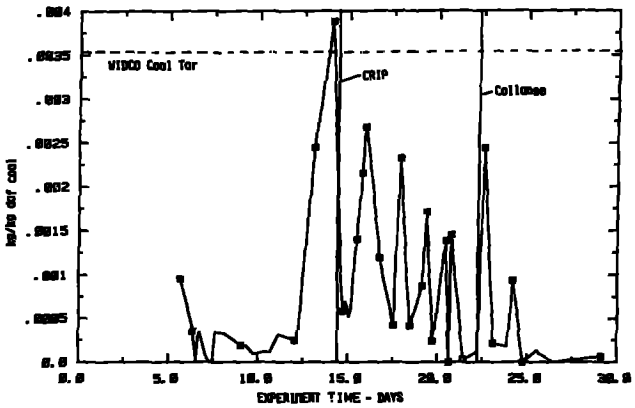


Figure 11. Toluene in PSC tar with time, kg/kg daf coal.

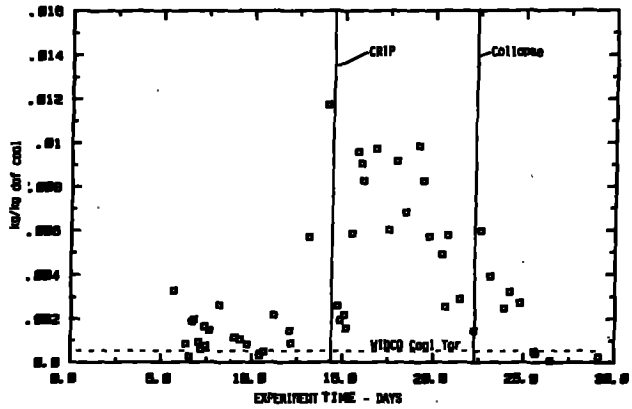


Figure 14. O, M, P, Cresol in PSC tar with time, kg/kg daf coal.

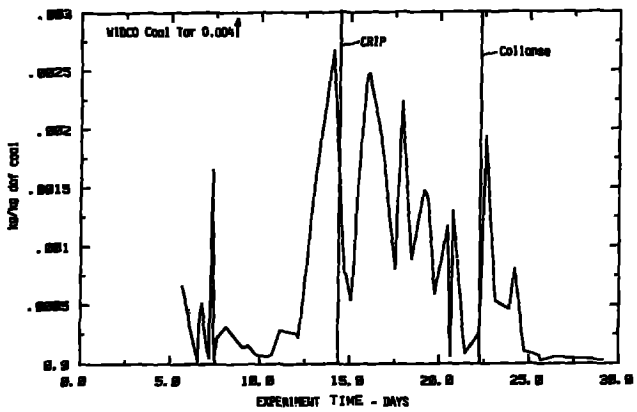


Figure 12. O, M, P, Xylenes in PSC tar with time, kg/kg daf coal.

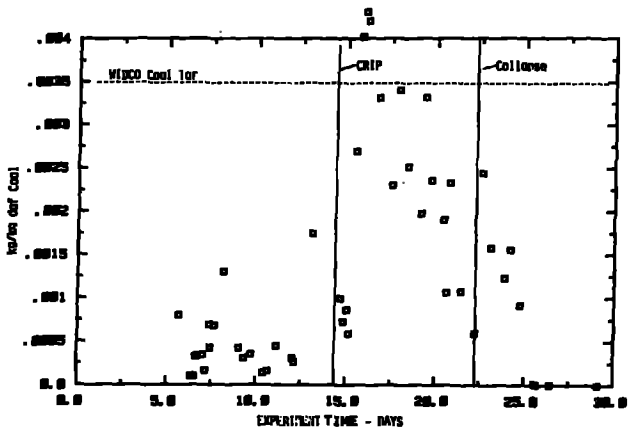


Figure 15. Ethylphenol in PSC tar with time, kg/kg daf coal.

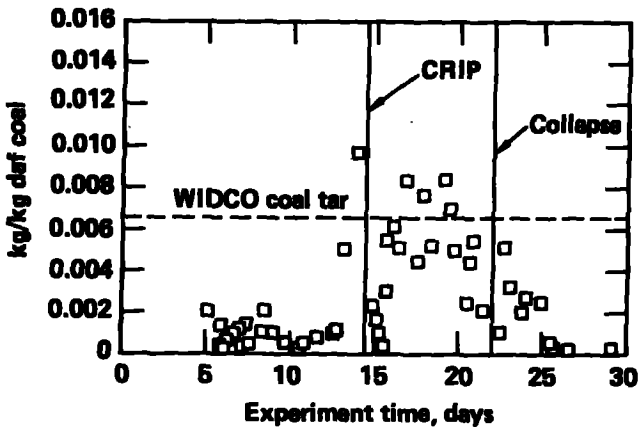


Figure 13. Phenol in PSC tar with time, kg/kg daf coal.

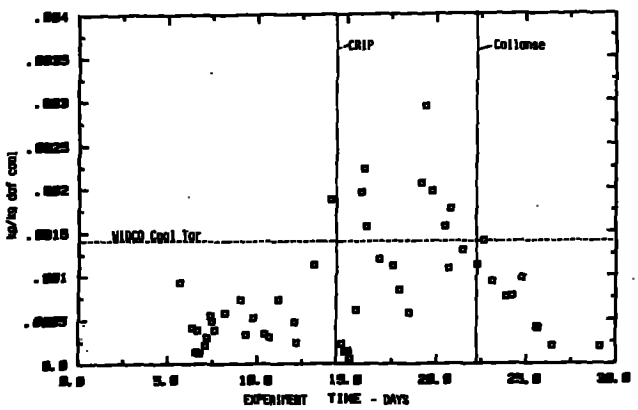


Figure 16. Trimethylnapthalene in PSC tars with time, kg/kg daf coal.

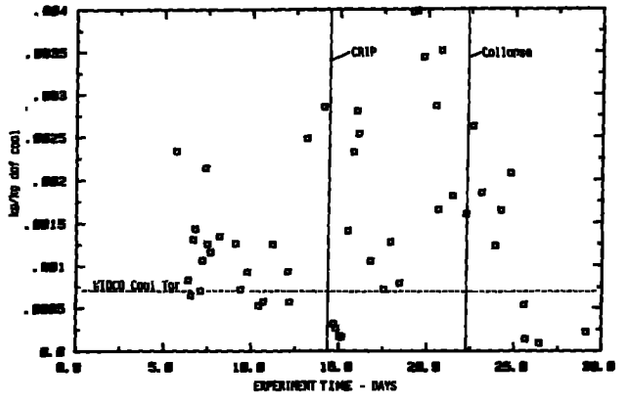


Figure 17. Methyl Napthalene in PSC tar with time, kg/kg daf coal.

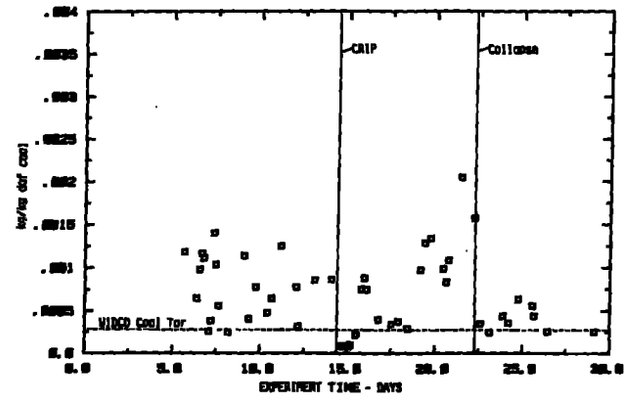


Figure 20. Acenapthene in PSC tars with time, kg/kg daf coal.

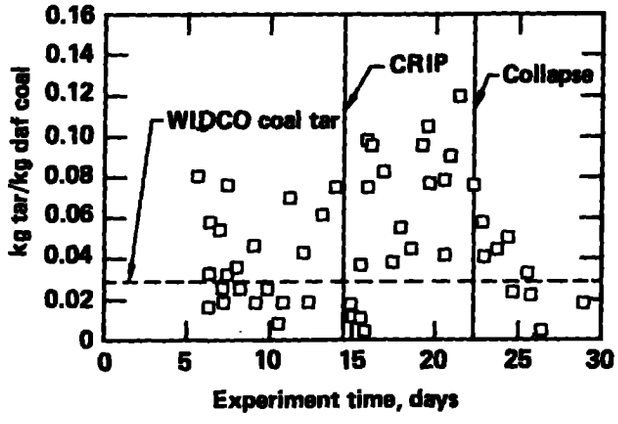


Figure 18. Napthalene in PSC tars with time, kg/kg daf coal.

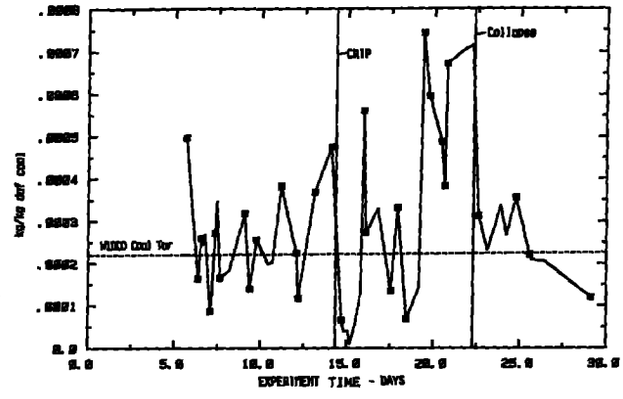


Figure 21. Anthracene in PSC with time, kg/kg daf coal.

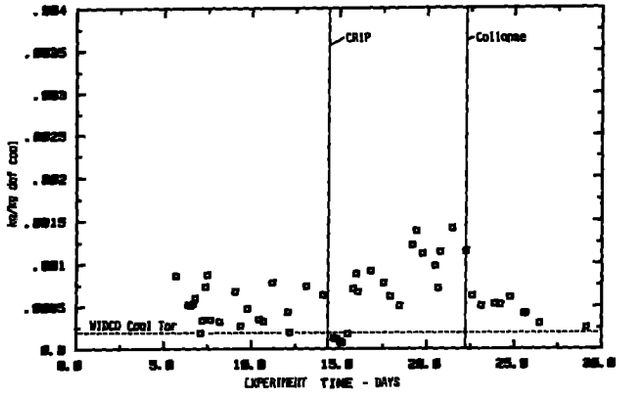


Figure 19. Fluorene in PSC tars with time, kg/kg daf coal.

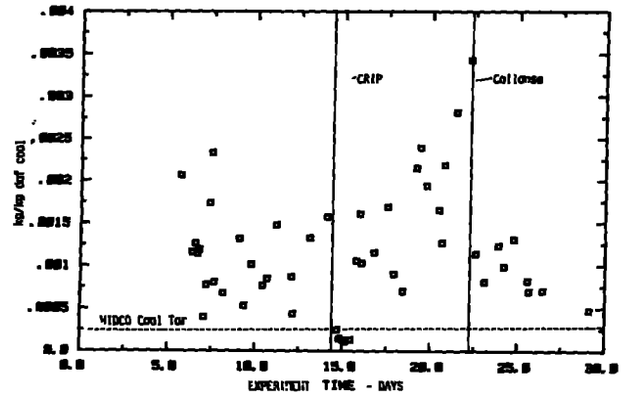


Figure 22. Phenanthrene in PSC tars with time, kg/kg daf coal.

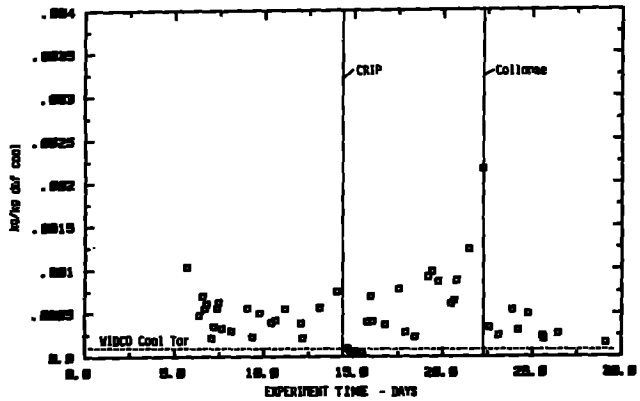


Figure 23. Fluoranthene in PSC tars with time, kg/kg daf coal.

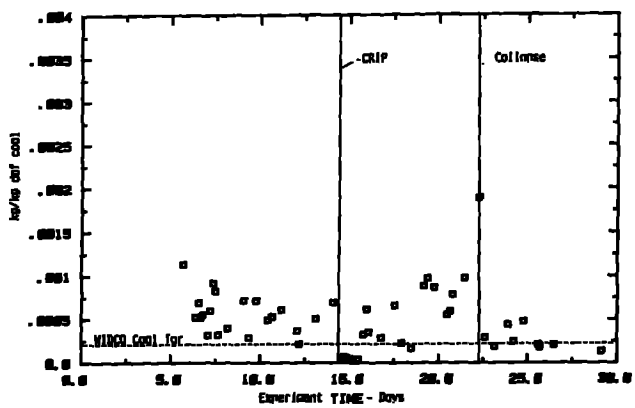


Figure 24. Pyrene in PSC tars with time, kg/kg daf coal.

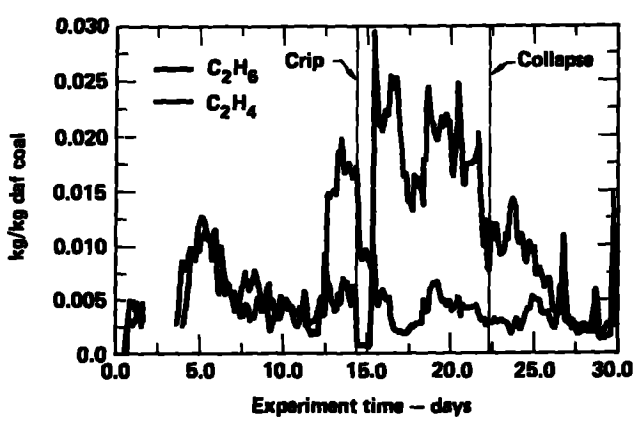


Figure 25. Ethene/ethane in PSC tar with time, kg/kg daf coal.

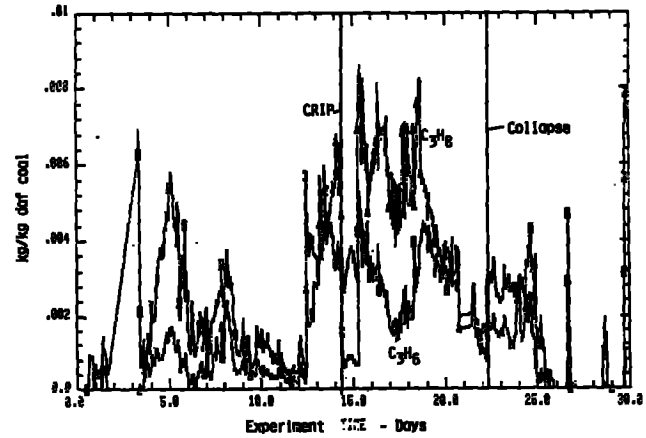


Figure 26. Propene and propane in PSC test with time, kg/kg daf coal.

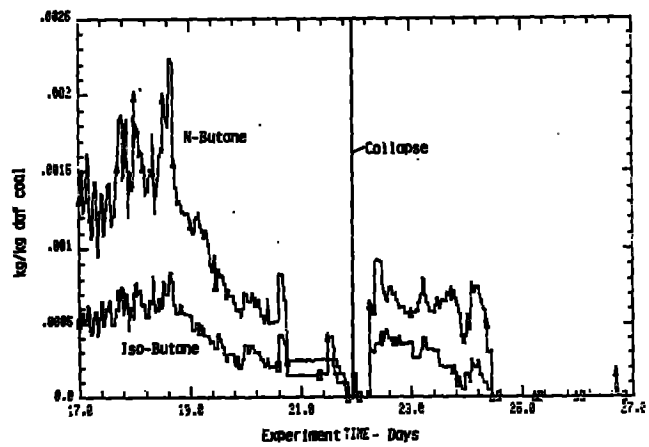


Figure 27. N- and iso-butane in PSC test with time, kg/kg daf coal.

We were concerned that phenols may have concentrated in the water or methylene chloride phases when separated, as well as in the tar phase. However, upon analysis of all three phases, we found that 85-90% of the phenols and cresols were found in the tar phase. Therefore, the data in Figures 13-15 are derived from GC analyses of the tar phase.

DISCUSSION

The data, in agreement with earlier studies of King, et al, of Barbour, and Barbour and Bencini, show the liquid

organic product from the Partial Seam CRIP test to be a somewhat lighter product than expected from coal pyrolysis. The simulated boiling point curves and abundance of light species such as benzene and napthalene are quite different for pyrolysis and for the PSC-derived tars. Figure 8 shows the simulated boiling point curve for WIDCO tar. The WIDCO coal tar, pyrolyzed at 500-530°C, is a fairly light fraction, as can be seen upon comparison of Figure 6 with Figure 8. However, the 50%+ fraction for the WIDCO coal tar exhibits a distillation curve 10-40°C higher than for the PSC tars.

Simulated Distillation Curves

Simulated distillation curves for a Hanna I sample, four Rawlins II samples, two Hanna IV B samples and four typical PSC samples are compared in Figure 5. The four UCG burns produced fairly similar results, with the PSC tars intermediate in boiling point to the higher values of Hanna I and the lower temperatures of Rawlins II. The Hanna IV tars are similar in nature to the PSC samples.

Figure 7 shows the simulated distillation results for 10%, 50%, and 90% distillation with time. Little trend is seen. There may be a small trend of increasing temperatures with time, but the trend, if real, is within the scatter of the data.

The simulated distillation results of Kilpatrick, et al, tend to lie between our PSC data and the Rawlins II results.

Coal Tar Densities

The coal tar specific gravity varies from 0.97 to 1.07, and, although there is an apparently smooth variation with time, no conclusions can be drawn with regard to density as a function of burn conditions. The two measurements of Kilpatrick, et al, of 0.9913 g/ml (11-2-83) and 1.0328 (11-7-83) are in good agreement with our data. The average PSC coal tar density is 1008 kg/m^3.

The Hanna I tar densities were slightly lower than the PSC tars at 962-977 kg/m^3, as were the Rawlins II tars, which were in the range of 955-1007 kg/m^3.

C, H, N, S, O Analyses

Also, few conclusions can be drawn from the C, H and O analyses, as seen in Figure 4. It appears that a higher H/C ratio may have been produced during the CRIP burn than for the first cavity: this also may have been true for the O/C ratio. However, the effects appear to be small. The H/C values of Kilpatrick, et al (1.12-1.27) are in good agreement with our results, but the O/C numbers (.03-.04) are lower. The differences are unexplained.

The H/C ratios for Hanna I (1.46-1.57) somewhat exceed the PSC values, while the Hanna I O/C ratios were 0.02-0.11, similar to the PSC variation. The Rawlins II data show less variation than the PSC values but are in good agreement with them. The Rawlins II H/C ratios were 1.14-1.28 while the O/C were 0.041-0.057.

Individual Species

Light hydrocarbon gases (ethene, ethane, propene, propane, N- and iso-butane), the phenols, and total tars, all expressed as kg/kg coal burned, show a similar correlation with time. As seen in Figures 9, 13-15, 25-27, the relative abundances are lower during the first burn, higher during the CRIP burn, then begin to decrease on day 19-20, before massive roof collapse on day 22.3. The values decrease rapidly with time after day 20.

The lighter ring compounds (2-4 rings), such as napthalene, phenanthrene, methylnapthalene, anthracene, trimethylnapthalene, fluorene, pyrene and fluoranthene, also correlate, as shown in Figures 16-24. There is less variation than the phenols. Relative values are slightly higher during the CRIP burn, and then show a sharp decline beginning on day 20.

Benzene shows little variation during both the first and CRIP burns when expressed as kg/kg coal consumed (Figure 10). There is, however a sharp drop on day 22.3, when a massive roof collapse occurred, and then a lower and decreasing value.

The variation of individual species with time may be indicative of burn conditions. The light hydrocarbons are thermally sensitive and are highly susceptible to cracking, as are the phenols (Stamoudis 1985; Fillo et al 1983; Nakles 1982). The 2-4 ring compounds are less sensitive, and benzene is the least sensitive to cracking.

For example, Stamoudis and co-workers (Stamoudis 1985, Fillo et al 1983) pyrolyzed North Dakota lignite and Montana Rosebud subbituminous coal at 600°C and obtained a complex mixture, high in phenols. But at 1000°C the pyrolysis produced a simple mixture low in alkyls and with no phenols.

Ortuglio, et al (1970) showed that, with cracking of Pittsburgh seam coal, anthracene and napthalene increased, while heavy tars and alkyls decreased. Similar results were reported by Sanner, et al (1969); with cracking, light oil yields and napthalenes increased while tars, pitch, paraffins, olefins and phenols decreased.

Thus the similar correlation of the light hydrocarbons and the phenols with time is expected, and is confirmed in Figures 13-15 and 25-27. Apparently cracking conditions were least severe during the early phase of the CRIP burn; cracking conditions began to increase on day 19-20 and became rapidly more severe with time following this period. Cracking conditions apparently were intermediate during the first burn. This compares reasonably well with field experience. The best gasification phase was during the CRIP burn, and the lowest period followed day 22.3, when a massive roof collapse occurred. Intermediate gasification performance occurred during the first burn. Although a complex matter, we believe increased cracking correlates directly with the increased temperature in the underground system.

It is interesting that the behavior of the light hydrocarbons and phenols anticipated the massive roof fall by two days (day 19-20 instead of day 22.3). By day 19 the burn had reached the roof, but with no degradation in gasification parameters. Apparently, however, cracking conditions underwent a significant change at that point, and cracking intensified with time.

The behavior of the light (2-4) ring compounds is not as dramatic. There is indication that their relative values were somewhat higher during the CRIP burn, but the values during the first and second burns are similar. However their values also declined significantly beginning on day 20, amalogous to the phenols and light hydrocarbons.

Finally benzene shows little variation during the burn, until day 22.3. Apparently benzene was affected only by the roof collapse. Since benzene is relatively stable with respect to cracking, little variation would have been expected. The amount of benzene is also reported to be insensitive to operating conditions in surface gasifiers (Nakles et al 1982). The decrease after day 22.3 is believed to be a result of direct combustion.

The amount of benzene in Figure 9, .01-.02 kg/kg coal, is comparable to that reported (Dermer and Crynes 1983) for 1000°C coking of coal, which is about .02 kg/kg coal.

A comparison of the PSC tar chemical abundance with WIDCO coal tar is instructive. The total tar from pyrolysis is 0.165 kg/kg daf coal, and, as can be seen from Figure 9, little tar was produced during the first cavity, while tar analyses for the CRIP phase approached the amount from pyrolysis.

Approximately three times as much benzene was produced in the PSC tars as that produced from primary pyrolysis. About 0.01 kg benzene/kg daf coal was produced in the PSC tars, while only 0.035 kg/kg daf coal was produced from pyrolysis. This is consistent with the production of benzene from secondary pyrolysis. On the other hand, the PSC tars contained less toluene and xylenes than that produced by pyrolysis.

The abundance of phenol in WIDCO coal tar, 0.0065 kg/kg daf coal, exceeds that in the PSC tars during the first cavity but is comparable to that produced during the CRIP burn. The abundance of ethylphenols is similar, while more cresols were produced in the PSC tars than in the pyrolysis product.

The ring compounds show a differing behavior. The WIDCO coal tar produced comparable amounts of trimethylnapthalenes but little methylnapthalenes compared to the PSC tar. More napthalene, fluorene, acenapthene, phynanthrene, fluoranthene, and pyrene were produced in the PSC tar than in the pyrolysis product. Also, more anthracene was produced during the CRIP burn than from pyrolysis of WIDCO coal. Many of these compounds were apparently produced by secondary reactions, during the the Partial Seam CRIP test. As mentioned previously, other workers have shown that the amounts of anthracene and napthalene are increased by cracking.

Comparison of Surface Gasifier Results with that of UCG

The packed bed character of UCG has been well established for at least the early phases of gasification. For example the excavation of the large block tests at Centralia, Washington clearly showed that early gasification occurred in a rubble bed. Modeling of UCG has shown the necessity of assuming a rubble bed in order to match the field results.

Therefore we compare our tar data with that of packed, moving bed surface gasifiers, specifically, the Lurgi gasifier, rather than entrained or fluidized bed systems. Hebden and Stroud (1981) quote data from both the conventional and slagging Lurgi process: these are given in Table 1. Gruber (1985) has summarized tar and oil data from the Great Plains Lurgi

Table 1. Comparison of Tar Data for Moving Bed Surface Gasification and UCG.

Organic Fraction, kg/kg daf coal					
Slagging Lurgi Westfield, Scotland (Hebden and Stroud)					
	Rosebud	Illinois #5	Illinois #6	Pittsburgh	
.061	.061	.042	0.056		
Dry-Bottom Lurgi					
Great Plains (Gruber) North Dakota Lignite	El Paso New Mexico Subb.	WESCO New Mexico Subb.	Panhandle Wyoming Hard Lignite	American Natural North Dakota Lignite	Northern Natural Wyoming Subb.
0.093	0.112	0.130	0.101	0.073	0.119

plant; these data are also shown in the table. The amount of tar produced in the PSC test, 0.04 kg/kg, is lower than the values for the dry bottom Lurgi of 0.07-0.13 kg/kg. The slagging Lurgi apparently produces less organics, ranging from 0.04 to 0.06 kg/kg. It can be argued that UCG, in general, involves partial slagging, since some glassy slag as well as loose ash was observed when excavating the large block experiments and in post burn coring of most UCG tests. Thus the closer agreement with the slagging Lurgi data is not surprising.

Table 2 compares tar data from UCG (King 1975, 1977; Cena et al 1982; Schrider 1974; Fischer et al 1975; Campbell et al 1974; LERC 1975). One can see that the values of tar/daf coal for UCG vary, in general, from 0.01 to 0.07, and the PSC value of 0.04 is well within this range. The Hanna data (with the exception of Hanna IV) are in the range 0.028-0.041. The Hoe Creek values are in the range .007-.058 and the two Rawlins numbers are .012 and .073. There is some indication that low heating value burns produce lower tar/coal ratios, such as the .007 value for the Hoe Creek #3. There also is an indication that oxygen burns produce lower tar/coal ratios than corresponding air burns. Compare Rawlins II oxygen burn value of .012 kg/kg with Rawlins I air burn number of 0.073. Also, the tar/coal for Hoe Creek #3 is .007 vs Hoe Creek #1 number of 0.057 and Hoe Creek #2 value of 0.027. Such a trend may be real, as one may expect the steam-oxygen burns to produce higher underground temperatures and thus more severe cracking. However the PSC was a steam-oxygen burn and produced an intermediate value of 0.042 kg/kg.

The tar/coal ratios for UCG are considerably lower than the same ratios from pyrolysis. For example, the Hanna I UCG value is 0.028 kg/kg as compared to 0.16 for Hanna coal pyrolysis. The PSC value of 0.042 is considerably less than the 0.165 kg/kg from pyrolysis of WIDCO coal. In general the UCG organic yields are less than half of the values expected for pyrolysis.

UCG-derived tar residues boiling above 500°C vary from essentially zero for Hanna I (King et al) and Rawlins II (Barbour and Bencini) to 5% for the Partial Seam CRIP test.

Lurgi surface coal gasification data have been reported by Moe (1973). Approximately 60% of the organic liquids produced is classified as tar, with a boiling point in excess of 260°C. Weiler (1963) reports that residues boiling above 450°C for a typical coal tar is about 50%. Tars produced in a fluidized bed gasifier,

Table 2. Comparison of Tar/Coal (MAF) Ratios for UCG.

	UCG kg/kg daf	500°C Pyrolysis kg/kg daf
Hanna I	0.028	0.157
Hanna II, Phase 1A	0.033	
Hanna II, Phases II-III	0.028-0.041	
Hanna IV	0.005-0.013	
Hoe Creek #1	0.058	
Hoe Creek #2	0.027	
Hoe Creek #3	0.007	.101
Rawlins I	0.073	
Rawlins II	0.012	
Partial Seam CRIP	0.042	0.165

using North Dakota lignite, exhibited boiling points in excess of 500°C for 80% of the material (Nakles et al 1982). By comparison to Figure 6 and the small tar residues in excess of 500°C for UCG tars, it is clear that UCG-derived tars exhibit lower boiling point distributions than those derived from surface coal gasification, as well as from coal pyrolysis.

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APPENDIX

Table A1(A). Partial Seam CRIP Test Tar Densities with Time.

Time (d)	Density kg/m^3
5.677	1068
8.179	1042
13.114	1011
14.073	1003
14.698	974
14.854	982
15.177	973
15.490	975
15.785	984
15.958	977
16.073	985
16.781	975
17.531	983
17.955	984
18.448	976
19.156	1000
19.385	1018
19.740	1028
20.458	1030
20.760	1062
21.448	1084
22.594	1028
23.115	1010
23.878	1038
24.201	1002

Average 1008

WIDCO Coal Tar 1024

Table A2A. Atomic Compositions of PSC Tars.

	Weight Percent				
TIME (D)	C	H	O	N	S
5.6770	85.19	7.080	4.800	1.030	1.900
6.3850	86.60	5.970	4.200	.7400	2.500
6.5520	82.64	5.910	4.900	.6300	5.900
6.6770	81.27	6.250	6.700	.4100	5.400
6.7810	81.05	6.410	7.300	.8700	4.400
7.0880	81.03	6.550	6.500	.8800	5.000
7.1960	84.00	6.280	4.400	.9400	4.400
7.4690	82.23	6.420	5.100	1.060	5.200
7.6510	78.39	6.390	7.700	1.190	6.300
8.1790	81.95	7.450	6.400	.8000	3.400
9.0730	84.90	6.670	4.700	.6800	3.100
9.3750	76.65	6.400	0.000	1.140	0.000
9.7600	83.99	6.730	5.200	.8800	3.200
10.4270	81.14	5.960	0.000	.8100	0.000
10.6770	78.60	5.620	5.400	1.160	9.200
11.1770	83.35	6.600	4.500	.9100	4.600
12.0730	82.69	6.590	4.100	.7800	5.800
12.1770	78.31	6.660	5.800	.9200	8.300
13.1140	81.67	8.050	8.300	.7300	1.300
14.0730	79.20	8.610	10.90	.6300	.7000
14.6980	78.83	8.580	9.300	.8600	2.400
14.8540	77.00	8.430	10.10	.7200	3.800
15.0630	78.92	8.830	9.100	.3500	2.800
15.1770	79.33	8.540	9.000	.7400	2.400
15.4900	77.87	8.920	9.600	.9800	2.600
15.7850	80.40	8.730	9.100	1.090	.7000
15.9580	81.05	8.860	8.300	1.050	.7000
16.0730	79.10	8.410	10.20	.9700	1.300
16.7810	81.26	8.810	8.400	.8600	.7000
17.5310	82.13	9.270	6.700	.8200	1.100
17.9130	78.88	8.620	10.10	.9900	1.400
18.4480	81.64	9.030	0.000	.5900	0.000
19.1560	81.70	8.950	7.000	.7000	1.700
19.3850	80.64	8.540	6.900	1.180	2.700
19.7400	82.02	8.250	6.800	.8400	2.100
20.4580	80.87	7.610	7.900	1.210	2.400
20.6350	81.58	7.320	7.800	.9600	2.300
20.7600	76.09	7.300	8.000	1.280	7.300
21.4480	80.74	6.430	9.000	1.350	2.500
22.2290	82.82	6.660	6.000	.9500	3.600
22.5940	76.36	7.960	8.900	.9700	5.800
23.1150	78.33	8.270	7.000	.7600	5.600
23.8780	79.67	7.260	8.000	.9600	4.100
24.2010	76.62	7.790	9.400	.9800	5.200
24.7600	75.37	6.400	8.500	.9700	8.800
25.5730	79.53	5.760	5.100	1.080	8.500
26.4480	79.70	6.040	3.300	1.000	10.00
29.1150	75.66	5.280	0.000	.8000	0.000

Table A2(B). Atomic Composition of WIDCO Coal Tars Coal Pyrolyzed at 500-530°C.

	Weight %					Atomic Ratios	
	C	H	O*	N	S	H/C	O/C
Sample 1	61.49	7.46	29.54	0.500	1.01	1.45	0.361
Sample 2	62.67	7.59	28.16	0.460	1.12	1.44	0.337
Sample 3	62.72	7.68	28.00	0.38	1.22	1.46	0.335
Average	62.29	7.58	28.56	0.447	1.12	1.45	0.344

* by difference

Table A3(A). Simulated Distillation Fractions for PSC Tars.

°C	7.196	10.427	17.531	24.760
Initial B.P.	130	33	106	39
10%	185	187	179	180
25%	212	233	211	212
50%	249	285	278	279
75%	315	338	344	338
90%	360	377	401	395
Final B.P.	440	499	484	503

Table A3(B). Simulated Distillation Fractions for WIDCO Coal Tar, Pyrolyzed at 500-530°C.

°C	Sample	Sample	Sample	Average
Initial B.P.	79	79	92	83
10%	148	151	169	156
25%	205	206	212	208
50%	282	281	288	284
75%	373	373	385	377
90%	441	441	450	444
Final B.P.	516	510	527	518

Table A4. Analysis of PSC Tars, kg/kg daf coal

Time (D)	Tars	Toluene	Phenol	Fluorene	O, P, M Ethylphenol	Benzene	Naphthalene	1&2 Methyl-Napthalene	Acenphathene	Trimethyl-napthalene
5.6770	4.8896E-02	9.5787E-04	1.6796E-03	8.6301E-04	8.0531E-04	1.1875E-02	7.9016E-03	2.3446E-03	1.1823E-03	9.2120E-04
6.3850	1.4642E-02	3.4892E-04	3.2608E-04	5.2433E-04	1.0323E-04	1.2556E-02	3.2529E-03	8.3314E-04	6.5143E-04	4.1203E-04
6.5520	1.2784E-02	1.8408E-05	1.0419E-04	5.1709E-04	1.0073E-04	9.6411E-03	1.7089E-03	6.5004E-04	9.8254E-04	1.3883E-04
6.6770	2.1617E-02	2.8232E-04	9.0057E-04	5.3719E-04	3.2772E-04	1.0830E-02	5.6449E-03	1.3091E-03	1.1667E-03	3.8479E-04
6.7810	2.2541E-02	3.4397E-04	5.4797E-04	6.0116E-04	3.3901E-04	9.2202E-03	5.3796E-03	1.4340E-03	1.1097E-03	1.2465E-04
7.0880	1.0818E-02	8.3083E-05	6.7224E-04	1.9061E-04	3.4791E-04	7.3328E-03	1.8000E-03	7.0447E-04	2.5812E-04	2.1020E-04
7.1960	1.2737E-02	2.9931E-05	3.4428E-04	3.4058E-04	1.7118E-04	7.8982E-03	2.7049E-03	1.0690E-03	3.8682E-04	3.0173E-04
7.3660	2.7333E-02	0.000	8.5990E-04	7.3335E-04	6.9645E-04	1.0963E-02	7.5989E-03	2.1462E-03	1.4022E-03	5.5568E-04
7.4690	2.1018E-02	1.5763E-05	4.1594E-04	8.7266E-04	4.2876E-04	1.0765E-02	3.0699E-03	1.2600E-03	1.0341E-03	4.9077E-04
7.6510	2.0089E-02	3.4413E-04	1.0543E-03	3.4493E-04	6.8423E-04	1.1136E-02	3.3225E-03	1.1624E-03	5.6370E-04	3.9033E-04
8.1790	2.9060E-02	3.2373E-04	1.8517E-03	3.2373E-04	1.3010E-03	8.9546E-03	2.6090E-03	1.3481E-03	2.4585E-04	5.8003E-04
9.0730	2.4410E-02	1.8796E-04	7.8723E-04	6.7934E-04	4.2523E-04	1.0655E-02	4.5335E-03	1.2620E-03	1.1375E-03	7.2792E-04
9.3750	1.3043E-02	1.8468E-04	7.7434E-04	2.7168E-04	3.0689E-04	1.9944E-02	1.9051E-03	7.1969E-04	4.0810E-04	3.3598E-04
9.7600	1.6940E-02	8.9784E-05	4.5044E-04	4.7975E-04	3.5236E-04	9.3198E-03	2.7035E-03	9.2867E-04	7.7959E-04	5.2413E-04
10.4270	1.0573E-02	1.1927E-04	1.3735E-04	3.5092E-04	1.4041E-04	9.9316E-03	8.9121E-04	5.2919E-04	4.8224E-04	3.4056E-04
10.6770	1.1578E-02	1.1126E-04	2.7625E-04	3.2568E-04	1.5966E-04	1.5674E-02	1.9991E-03	5.7275E-04	6.4535E-04	3.0843E-04
11.1770	2.8105E-02	3.1309E-04	4.5502E-04	7.8103E-04	4.4911E-04	9.7561E-03	6.9461E-03	1.2543E-03	1.2512E-03	7.2876E-04
12.0730	1.7852E-02	2.4564E-04	7.4531E-04	4.3737E-04	3.1294E-04	6.1019E-03	4.2360E-03	9.3525E-04	7.7655E-04	4.7646E-04
12.1770	1.1129E-02	2.3393E-04	8.5171E-04	1.9621E-04	2.6443E-04	8.6874E-03	1.9115E-03	5.7003E-04	3.2274E-04	2.4473E-04
13.1140	7.4136E-02	2.4458E-03	4.9545E-03	7.3840E-04	1.7459E-03	1.1218E-02	6.1229E-03	2.4865E-03	8.5628E-04	1.1291E-03
14.0730	.1280	3.8788E-03	9.6113E-03	6.3495E-04	4.5727E-03	1.3678E-02	7.4581E-03	2.8522E-03	8.6154E-04	1.8716E-03
14.6980	2.4725E-02	5.8154E-04	2.2547E-03	1.2832E-04	9.9520E-04	6.7744E-03	1.6806E-03	3.1648E-04	8.3819E-05	2.2995E-04
14.8540	2.1194E-02	6.9558E-04	1.6728E-03	1.1784E-04	7.3203E-04	6.0671E-03	1.2697E-03	2.6302E-04	8.3080E-05	1.3776E-04
15.0630	1.9778E-02	5.1878E-04	1.1661E-03	8.6430E-05	8.6529E-04	6.1302E-03	1.2078E-03	1.7167E-04	7.8123E-05	1.4695E-04
15.1770	1.6598E-02	6.5776E-04	7.4838E-04	7.5353E-05	5.9270E-04	6.0081E-03	8.9726E-04	1.6133E-04	1.0058E-04	6.0581E-05
15.4900	5.3744E-02	1.4000E-03	2.8533E-03	1.7897E-04	2.6958E-03	1.1384E-02	3.6783E-03	1.4070E-03	2.1981E-04	6.1269E-04
15.7850	.1141	2.1545E-03	5.6703E-03	7.0865E-04	4.0191E-03	1.3414E-02	7.5315E-03	2.3279E-03	7.4973E-04	1.9570E-03
15.9580	.1392	2.6801E-03	6.2328E-03	8.8086E-04	4.3027E-03	1.5073E-02	9.6825E-03	2.8026E-03	8.7946E-04	2.2321E-03
16.0730	.1069	2.5817E-03	5.2167E-03	6.7320E-04	4.1973E-03	1.5777E-02	9.5316E-03	2.5389E-03	7.4800E-04	1.5633E-03
16.7810	9.9288E-02	1.1934E-03	8.2350E-03	9.1444E-04	3.3142E-03	1.3597E-02	8.1297E-03	1.0564E-03	4.0311E-04	1.1925E-03
17.5310	.1013	4.2044E-04	4.4638E-03	7.7706E-04	2.3018E-03	6.2057E-03	3.8792E-03	7.2337E-04	3.4547E-04	1.1165E-03
17.9130	9.5731E-02	2.3253E-03	7.5350E-03	6.2034E-04	3.4080E-03	8.4944E-03	5.4835E-03	1.2761E-03	3.7910E-04	8.3765E-04
18.4480	7.2914E-02	4.1780E-04	5.1995E-03	5.0967E-04	2.5170E-03	8.1540E-03	4.4069E-03	7.9768E-04	2.9312E-04	5.7675E-04
19.1560	.1334	8.7798E-04	8.2434E-03	1.2156E-03	1.9748E-03	1.1519E-02	9.5577E-03	3.9682E-03	9.6871E-04	2.0615E-03
19.3850	.1197	1.7085E-03	6.7994E-03	1.3817E-03	3.3189E-03	1.3144E-02	1.0324E-02	3.9822E-03	1.2823E-03	2.9369E-03
19.7400	8.3878E-02	2.3654E-04	5.0176E-03	1.1147E-03	2.3612E-03	1.2002E-02	7.7872E-03	3.4365E-03	1.3345E-03	1.9686E-03
20.4580	6.5779E-02	1.3846E-03	4.4105E-03	9.7287E-04	1.9050E-03	1.3760E-02	7.8744E-03	2.8607E-03	9.8471E-04	1.5622E-03
20.6350	3.7488E-02	0.000	2.4161E-03	7.1526E-04	1.0628E-03	1.3963E-02	4.1206E-03	1.6480E-03	8.3297E-04	1.0819E-03
20.7600	8.6594E-02	1.4513E-03	5.3489E-03	1.1370E-03	2.3294E-03	1.1325E-02	9.0421E-03	3.5131E-03	1.0867E-03	1.7656E-03
21.4480	5.1345E-02	3.1321E-05	2.2032E-03	1.4141E-03	1.0783E-03	1.8267E-02	1.1955E-02	1.8094E-03	2.0482E-03	1.2903E-03
22.2290	4.4624E-02	1.1781E-04	1.0473E-03	1.1460E-03	5.9752E-04	1.4769E-02	7.6214E-03	1.5967E-03	1.5752E-03	1.1254E-03
22.5940	7.2167E-02	2.4421E-03	5.0921E-03	6.2713E-04	2.4436E-03	7.3459E-03	5.7625E-03	2.6225E-03	3.5073E-04	1.3971E-03
23.1150	4.4061E-02	2.1457E-04	3.1093E-03	5.0846E-04	1.5765E-03	7.7074E-03	4.2232E-03	1.8492E-03	2.4982E-04	9.3100E-04
23.8780	3.4696E-02	1.7591E-04	2.0120E-03	5.3050E-04	1.2248E-03	1.0257E-02	4.6333E-03	1.2296E-03	4.4272E-04	7.6019E-04
24.2010	4.2828E-02	9.3536E-04	2.5380E-03	5.2293E-04	1.5551E-03	9.2061E-03	4.9209E-03	1.6437E-03	3.5804E-04	7.6705E-04
24.7600	3.3286E-02	0.000	2.3347E-03	6.0513E-04	9.1402E-04	6.8065E-03	2.2721E-03	2.0767E-03	6.3076E-04	9.7094E-04
25.5730	1.1070E-02	1.3362E-04	2.9236E-04	4.1911E-04	1.7491E-05	8.2636E-03	3.1275E-03	5.3823E-04	5.5528E-04	4.1646E-04
25.6560	8.7307E-03	9.7434E-05	1.9164E-04	4.2056E-04	7.9449E-06	7.4750E-03	2.2046E-03	1.3786E-04	4.4195E-04	4.0082E-04
26.4480	5.1200E-03	0.000	5.7396E-05	3.0418E-04	3.9936E-06	6.5920E-03	3.4622E-04	9.1495E-05	2.5923E-04	2.0424E-04
29.1150	5.4919E-03	6.0575E-05	1.0100E-04	2.5219E-04	0.000	4.5327E-03	1.8811E-03	2.1956E-04	2.5471E-04	1.9353E-04

Table A4. Continued

Time (D)	Phenanthrene	Fluoranthene	Pyrene	O, P, M Cresol	Anthracene	O, M, P Xylene
5.6770	2.0639E-03	1.0351E-03	1.1402E-03	3.3117E-03	4.9776E-04	6.6645E-04
6.3850	1.1621E-03	4.7924E-04	5.2858E-04	8.4031E-04	1.6355E-04	1.3851E-04
6.5520	1.2643E-03	7.0399E-04	6.9734E-04	2.7101E-04	2.6066E-04	1.9942E-05
6.6770	1.1446E-03	5.5513E-04	5.2379E-04	1.8762E-03	2.4536E-04	4.2716E-04
6.7810	1.1915E-03	6.0883E-04	5.5450E-04	1.9813E-03	2.6981E-04	5.1911E-04
7.0880	3.9930E-04	2.1431E-04	3.1697E-04	9.2798E-04	8.7194E-05	1.1608E-04
7.1960	7.7542E-04	3.4975E-04	6.0054E-04	5.8373E-04	1.3183E-04	4.9546E-05
7.3660	1.7351E-03	5.5924E-04	9.1976E-04	1.6591E-03	2.7279E-04	1.6591E-03
7.4690	2.3300E-03	6.3138E-04	8.2831E-04	7.5790E-04	3.4806E-04	4.1195E-05
7.6510	8.0698E-04	3.2564E-04	3.2444E-04	1.4663E-03	1.6573E-04	2.2219E-04
8.1790	6.8000E-04	2.9525E-04	3.9667E-04	2.6450E-03	1.8337E-04	3.1472E-04
9.0730	1.3177E-03	5.5607E-04	7.1766E-04	1.1353E-03	3.1904E-04	1.3426E-04
9.3750	5.2966E-04	2.2772E-04	2.8707E-04	1.0313E-03	1.3942E-04	1.5573E-04
9.7600	1.0149E-03	5.0296E-04	7.1742E-04	8.2821E-04	2.5597E-04	7.9281E-05
10.4270	7.6613E-04	3.8973E-04	4.9155E-04	3.1645E-04	1.9856E-04	5.9738E-05
10.6770	8.4807E-04	4.2108E-04	5.3015E-04	4.7446E-04	2.0226E-04	7.5371E-05
11.1770	1.4749E-03	5.5001E-04	6.1268E-04	2.1806E-03	3.8307E-04	2.8414E-04
12.0730	8.7027E-04	3.8453E-04	3.6935E-04	1.4483E-03	2.2493E-04	2.5403E-04
12.1770	4.3715E-04	2.0989E-04	2.1557E-04	8.6495E-04	1.1697E-04	2.2214E-04
13.1140	1.3256E-03	5.6492E-04	5.0932E-04	5.7144E-03	3.6846E-04	1.6132E-03
14.0730	1.5707E-03	7.5401E-04	6.9640E-04	1.1740E-02	4.7493E-04	2.6704E-03
14.6980	2.5022E-04	9.3709E-05	6.8242E-05	2.6313E-03	6.5522E-05	7.8676E-04
14.8540	1.4836E-04	6.1674E-05	4.5355E-05	1.9553E-03	3.9209E-05	7.4390E-04
15.0630	1.3212E-04	6.1312E-05	4.7665E-05	2.1999E-03	3.9951E-05	5.4468E-04
15.1770	1.1353E-04	4.9627E-05	3.5851E-05	1.5681E-03	9.2946E-06	7.1120E-04
15.4900	1.3329E-04	5.3207E-05	4.2996E-05	5.8581E-03	5.6969E-05	1.5855E-03
15.7850	1.0567E-03	3.9940E-04	3.2637E-04	9.5833E-03	1.3123E-04	2.1761E-03
15.9580	1.6072E-03	6.9717E-04	6.1368E-04	9.0618E-03	5.6080E-04	2.4561E-03
16.0730	1.0301E-03	4.0819E-04	3.4942E-04	8.2729E-03	2.7355E-04	2.4737E-03
16.7810	1.1547E-03	3.6836E-04	2.8694E-04	9.7342E-03	3.2964E-04	1.9153E-03
17.5310	1.6868E-03	7.8213E-04	6.6258E-04	6.0199E-03	1.3474E-04	8.0746E-04
17.9130	9.0370E-04	2.8145E-04	2.2688E-04	9.1806E-03	3.3219E-04	2.2363E-03
18.4480	7.0217E-04	2.3041E-04	1.6770E-04	6.8284E-03	6.8540E-05	8.9466E-04
19.1560	2.1509E-03	9.1534E-04	8.8865E-04	9.8472E-03	1.4277E-04	1.4744E-03
19.3850	2.3946E-03	9.7698E-04	9.7698E-04	8.2600E-03	7.4351E-04	1.4056E-03
19.7400	1.9367E-03	8.6562E-04	8.7401E-04	5.7113E-03	5.9553E-04	5.9721E-04
20.4580	1.6484E-03	6.0845E-04	5.5517E-04	4.9097E-03	4.8742E-04	1.1735E-03
20.6350	1.2678E-03	6.4966E-04	5.9530E-04	2.5795E-03	3.8275E-04	6.1105E-05
20.7600	2.1865E-03	8.7806E-04	7.9146E-04	5.7888E-03	6.7370E-04	1.2980E-03
21.4480	2.8158E-03	1.2287E-03	9.7864E-04	2.9159E-03	6.9727E-04	8.6260E-05
22.2290	3.4263E-03	2.1625E-03	1.8912E-03	1.4614E-03	7.1622E-04	2.5302E-04
22.5940	1.1388E-03	3.3774E-04	2.8867E-04	5.9754E-03	3.1320E-04	1.9442E-03
23.1150	8.1159E-04	2.4498E-04	1.9034E-04	3.9258E-03	2.3132E-04	5.3181E-04
23.8780	1.2348E-03	5.4161E-04	4.3821E-04	2.5130E-03	3.3829E-04	4.6250E-04
24.2010	9.8718E-04	3.0665E-04	2.4883E-04	3.2374E-03	2.6725E-04	8.1116E-04
24.7600	1.3058E-03	4.9562E-04	4.7432E-04	2.7434E-03	3.5549E-04	1.0119E-04
25.5730	8.2251E-04	2.3745E-04	2.0967E-04	5.0601E-04	2.2063E-04	6.9520E-05
25.6560	6.9863E-04	2.0168E-04	1.7749E-04	4.0039E-04	2.0823E-04	3.0034E-05
26.4480	7.0457E-04	2.6558E-04	2.0900E-04	5.7856E-05	2.0439E-04	5.7856E-05
29.1150	4.7400E-04	1.5899E-04	1.3010E-04	2.4933E-04	1.1884E-04	3.0370E-05

Table A4. Continued

Time (D)	C_2H_4	C_2H_6	C_3H_6	C_3H_8	Iso-Butane	N-Butane
5.6770	1.0836E-02	9.5065E-03	3.2183E-03	7.4433E-04	0.000	5.4875E-05
6.3850	9.2257E-03	6.1435E-03	1.1705E-03	1.9827E-04	0.000	0.000
6.5520	6.1779E-03	5.4122E-03	1.2803E-03	3.8129E-04	0.000	0.000
6.6770	5.9208E-03	6.2561E-03	1.7990E-03	6.3431E-04	0.000	0.000
6.7810	5.5893E-03	6.3418E-03	1.9677E-03	6.5286E-04	0.000	0.000
7.0880	3.7737E-03	5.7198E-03	1.8840E-03	1.4632E-03	0.000	0.000
7.1960	4.6761E-03	4.4136E-03	1.1782E-03	3.2546E-04	0.000	0.000
7.3660	4.3474E-03	5.3974E-03	1.8789E-03	7.2744E-04	0.000	0.000
7.4690	3.8088E-03	5.9205E-03	2.0279E-03	8.5704E-04	0.000	0.000
7.6510	3.5968E-03	6.6849E-03	2.4213E-03	1.2737E-03	0.000	0.000
8.1790	3.2047E-03	7.7410E-03	3.2035E-03	2.2118E-03	0.000	2.5739E-04
9.0730	4.1439E-03	7.1027E-03	1.6091E-03	8.5439E-04	0.000	0.000
9.3750	2.8418E-03	4.0516E-03	9.7001E-04	6.2275E-04	0.000	0.000
9.7600	3.9547E-03	4.8687E-03	1.3130E-03	6.0838E-04	0.000	0.000
10.4270	4.2812E-03	3.7447E-03	1.2674E-03	4.3816E-04	0.000	0.000
10.6770	3.9933E-03	2.5505E-03	7.8250E-04	3.1593E-04	0.000	0.000
11.1770	4.1446E-03	5.7879E-03	8.2606E-04	4.8592E-04	0.000	0.000
12.0730	3.6514E-03	5.3289E-03	1.2033E-03	5.2775E-04	0.000	0.000
12.1770	3.6890E-03	5.4062E-03	1.2271E-03	5.2990E-04	0.000	0.000
13.1140	4.1159E-03	1.4162E-02	3.2834E-03	2.8154E-03	1.6498E-04	4.9910E-04
14.0730	4.3967E-03	1.5961E-02	3.5580E-03	5.9312E-03	5.8015E-04	1.6224E-03
14.6980	8.0438E-04	8.8205E-03	8.3207E-04	3.2311E-03	4.8749E-04	7.8879E-04
14.8540	8.2596E-04	9.4080E-03	8.5494E-04	3.6474E-03	5.7031E-04	9.6184E-04
15.0630	4.2374E-04	8.4188E-03	6.7332E-04	3.4066E-03	5.2665E-04	9.6553E-04
15.1770	5.0043E-04	8.0133E-03	6.6931E-04	3.1026E-03	4.7904E-04	8.7154E-04
15.4900	7.5716E-03	2.5133E-02	4.4552E-03	7.4693E-03	8.7567E-04	2.0536E-03
15.7850	4.9320E-03	2.0165E-02	3.2054E-03	5.6146E-03	4.8615E-04	1.5704E-03
15.9580	6.1965E-03	2.1867E-02	3.4642E-03	5.5270E-03	4.2331E-04	1.4830E-03
16.0730	4.8659E-03	2.1326E-02	3.0824E-03	5.9796E-03	5.6836E-04	1.6554E-03
16.7810	1.9519E-03	2.2845E-02	2.4022E-03	6.6292E-03	6.7795E-04	1.6857E-03
17.5310	1.9934E-03	1.3175E-02	1.6868E-03	4.6788E-03	5.4921E-04	1.2032E-03
17.9130	2.5495E-03	1.4984E-02	1.9841E-03	5.5350E-03	6.1921E-04	1.5480E-03
18.4480	4.1521E-03	1.9255E-02	2.8291E-03	6.0415E-03	6.1908E-04	1.5327E-03
19.1560	6.6059E-03	1.9071E-02	4.1278E-03	4.8828E-03	4.8494E-04	1.1541E-03
19.3850	5.2352E-03	2.1902E-02	3.3225E-03	4.2607E-03	3.7553E-04	9.8315E-04
19.7400	4.5929E-03	2.1770E-02	3.2273E-03	3.6082E-03	2.7238E-04	6.9024E-04
20.4580	5.4556E-03	2.5222E-02	3.1506E-03	3.4292E-03	2.2602E-04	5.6504E-04
20.6350	4.2808E-03	1.9533E-02	2.7701E-03	3.5078E-03	3.4639E-04	7.1061E-04
20.7600	4.6347E-03	1.6360E-02	2.7750E-03	3.1396E-03	2.9547E-04	5.4946E-04
21.4480	4.4359E-03	1.9363E-02	2.3508E-03	2.3964E-03	2.1874E-04	3.5230E-04
22.2290	2.3448E-03	1.0366E-02	1.5064E-03	2.3935E-03	3.1232E-04	6.2464E-04
22.5940	3.2299E-03	1.1574E-02	1.8830E-03	3.2752E-03	4.3053E-04	7.0567E-04
23.1150	2.8146E-03	9.7876E-03	1.6631E-03	2.6654E-03	2.9363E-04	6.3970E-04
23.8780	2.7574E-03	9.8566E-03	2.3998E-03	2.5314E-03	8.5873E-05	5.2360E-04
24.2010	2.0630E-03	1.0386E-02	1.4066E-03	2.7090E-03	1.7897E-04	7.2415E-04
24.7600	4.3944E-03	8.8338E-03	2.9850E-03	1.3137E-03	0.000	0.000
25.5730	3.7913E-03	5.3257E-03	8.3983E-05	0.000	0.000	0.000
25.6560	3.6553E-03	6.0878E-03	4.2905E-04	0.000	0.000	0.000
26.4480	4.1841E-03	4.1278E-03	0.000	0.000	0.000	0.000
29.1150	1.9326E-03	2.6846E-03	0.000	0.000	0.000	0.000