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**INVESTIGATION OF THE RANK
DEPENDENCE OF TAR EVOLUTION**

CONTRACT NUMBER: DE-AC22-89PC89759

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EXECUTIVE SUMMARY

The following report summarizes the results obtained for the second quarter period, January 1 - March 31, 1990, of contract DE-AC22-89PC89759 entitled "Investigation of The Rank Dependence of Tar Evolution." Sample characterization results include FT-IR spectra of the 4000 - 400 cm^{-1} regime of the parent coal samples and microbomb calorimeter measurements of the calorific values of the parent coals. The calorific values of the parent coals are presented as stand-alone data and in the context of previous measurements (DE-AC22-84PC70768) obtained for other PSOC XXXXD coals and tars. The calorific values of either the tar or parent coal samples are noted to be a complex function of the elemental composition of the samples. Although the chemical compositions of tars from a variety of coal ranks at the same approximate extent of tar evolution are observed to be significantly different, the heating values fall in a narrow range relative to the range of values observed for the parent coals. If verified for a larger span of extents of tar evolution for the range of coals being investigated, the relative constancy in heat of combustion of the rapid heating tars would serve as a convenient basis for pfc combustion modeling.

Long hold time (LHT) tar evolution determinations for the six parent coals as observed in the UTRC heated grid (UTRC-HG) apparatus are presented. Results are presented in tabular and graphical form. The LHT tar yield behavior is phenomenologically associated with the potential tar source terms for semi-empirical modeling of the tar evolution kinetics. Results are presented relative to behavior observed for the HVA bituminous reference coal, PSOC 1451D. As expected, it is observed that the potential tar yields vary significantly with changes in coal rank. However, it is also observed that the LHT tar yields for three ASTM rank-similar, but geologically variant, HVA bituminous coals are significantly different. Since LHT, dry, ash free char yields for the three HVA bituminous coals are quite similar, differences in tar yields in rapid heating conditions is attributed to variations in the thermal stability of the mix of molecular clusters present in the parent coals. Although variations in char re-incorporation or crosslinking reactions of tar precursors might also be expected from parent coal structural considerations, no significant differences in char yield behavior are observed relative to the Pittsburgh seam HVA sample. In rapid heating conditions, intraparticle, tar precursor, char re-incorporation or crosslinking reactions are not competitive with tar pyrolysis and vaporization rates.

The LHT tar and char yield behaviors of the lignite and subbituminous coals vary substantially from the HVA bituminous coals and higher ranks. Preliminary observations indicate significant particle fragmentation occurs in rapid heating of the Great Plains subbituminous coal to temperatures in excess of 700°C. Particle fragmentation also appears to occur for the Texas lignite coal, but to a lesser extent than the subbituminous coal investigated. This rapid heating, high temperature particle fragmentation phenomenon significantly increases the "apparent" volatile yields of these low rank coals relative to the HVA bituminous coal.

PROJECT DESCRIPTION

Objectives:

The objectives of this study are to develop an improved understanding of the process of coal tar evolution, its relationship to the structural characteristics of the parent coal, and the dependence of the chemical and physical properties of the tar products on the conditions of devolatilization. Data from this study are expected to allow hypothesis testing and refinements of coal devolatilization models relevant to the pulverized coal combustion process.

Program Structure:

The program is divided into seven major technical areas in which the following rank dependence issues are addressed:

1. tar evolution rates in rapid heating conditions;
2. molecular weight and vapor pressure characteristics of tars;
3. chemical structure and calorific values of tars;
4. influence of interphase mass transport phenomena;
5. gas phase secondary reactions of "primary" tars;
6. parent coal nitrogen evolution during devolatilization;
7. model hypothesis testing.

The PSOC 1451D coal is the reference coal, that is, its structural characteristics and tar evolution phenomenology become the defined references for the other coals. Parent coal structural parameters, tar yields, chemical and physical properties of tars, nitrogen evolution behavior, and global kinetic parameters are defined relative to it.

Coal Characterization:

A range of coal ranks, from a Texas lignite to a Pennsylvania anthracite, are employed in the investigation. In addition, a high temperature polymer, a polyimide, is utilized as an additional reference case. The polyimide serves as a truly polymeric reference material for examining the nitrogen evolution behavior of coal. The samples are subjected to elemental composition determination (Tables I, II, Figures 1, 2), infrared absorbance characteristics (Figures 3 - 10), calorific value (Tables I, III, Figures 11 - 16), high temperature ash analysis (Tables I, II), and maceral composition (Tables I, II). Consideration is being given to NMR analysis as well as tetrahydrofuran (THF) solubility.

Experimental Measurements:

Potential tar yields are determined by long hold time heated grid investigations of each coal at a final temperature and heating rate observed to maximize tar yields for the reference coal. Relative tar evolution kinetic behavior is determined by zero hold time heated grid (1) investigations of each coal.

"Primary" tar samples are obtained by collecting tar samples from rapid heating of parent coal samples in the UTRC entrained flow reactor and aerosol separation systems

(2). Volatility and molecular weight characteristics of these samples are determined by heated grid revaporization experiments (3) and compound-type calibrated GPC examination of the tars. The compound-type calibration curve employed for each tar type is determined by elemental composition and IR absorbance measurements of each tar type to determine which calibration compound, homologous series most resembles the structural characteristics of the collective tar sample.

Gas phase secondary reactions of "primary" tar samples is investigated by comparing light gas evolution behavior in the heated grid, entrained flow reactor and flash lamp reactor systems.

Nitrogen evolution behavior is a result of the tar evolution properties of a coal and the secondary reaction chemistry of the residual char and evolved tars. Nitrogen balance determinations are made on two of the reactors – heated grid and entrained flow – directly (4) and the flash lamp indirectly. In addition to the reference behavior of PSOC 1451D, the nitrogen evolution behavior of a high temperature polyimide in rapid heating thermal decomposition conditions is investigated to serve as a truly polymeric reference.

Potential Tar Yields – Tar Source Terms:

Heated Grid Determination of "Ultimate" Tar Yields

The calibration and characterization details of the UTRC heated grid technique (UTRC-HG) are given elsewhere (1). In the determination of potential tar yields, long hold times at given peak temperatures are programmed. Temperatures through peak temperatures approaching 700°C are programmed, since it has been demonstrated that for the reference coal, PSOC 1451D, such temperatures are necessary in atmospheric pressure conditions to maximize the tar yields of HVA bituminous coals (1). Hold temperatures of 700°C or greater are necessary to allow time for intraparticle tar formation and evolution. Since the long hold time (LHT) temperature sensitivity characteristics of a coal relative to both the reference coal and its own zero hold time (ZHT) behavior are also of interest, intermediate hold temperatures are also employed in this phase of the investigation.

Figures 17 and 18 display the heating condition data summary sheets for a typical LHT run. A blank, unloaded screen is temperature programmed using the semi-empirical enthalpy and heat loss expressions determined for the particular wire mesh system employed at UTRC (1). An estimation of the enthalpy requirements of the coal sample are taken into account. Figure 17 gives a data sheet summary of a typical blank screen run. The sample is then loaded in the screen and the experiment performed. Figure 18 displays the corresponding "run" data sheet summary. The light gas evolution is monitored using a Fourier Transform Infrared Spectrometer (FTIR) that scans a gas cell attached to the heated grid reactor. The residual char mass is determined directly, as is the evolved tar. The data is entered into a matrix data sheet (See Row 6, Table IV for this particular blank-run pair.). The time resolved current, voltage, pressure and temperature trajectories are stored in a set of corresponding arrays filed under the Run I.D. associated with the blank-run pair. These are available and communicable via standard computer transmission techniques.

Results:

Coal Structure Dependency of Maximum Tar Yields

Table IV summarizes the raw, LHT, char and tar and total "apparent" volatiles determined for the coals being considered, as well as the "reference" polymer, a high temperature polyimide. Figures 19, 20 and 21 display the maximum LHT tar yields observed on dry, ash free bases for each of the samples and with respect to a particular elemental composition parameter.

It is observed that ASTM rank classification, or a single rank classification index such as %C, is a poor predictor of potential tar yields, that is, the tar source terms utilized for kinetic predictions. The HVA bituminous coals - PSOC 1499D, PSOC 1493D and PSOC 1451D - from varying geologic provinces - Colorado Basin, Illinois #6, and Pittsburgh Seam #8, respectively - display very different tar yields. The heating conditions associated with maximizing tar yields for the Pittsburgh Seam HVA coal do not produce comparable yields for the Colorado Basin or Illinois #6 coals. On a dry, ash free basis, these coals yield approximately 22% and 23% tar compared to approximately 30% for the Pittsburgh Seam coal. Although the tar yields of the Rocky Mt. Province, cretaceous era, and the Interior Province, carboniferous era coals are comparable, they are only 66% that of the Eastern Province, carboniferous coal.

The low rank coals - PSOC 1443D, a Texas lignite, and PSOC 1520D, a Wyoming subbituminous - display lower tar yields, as expected, than the HVA bituminous coals. The polyimide displayed greatly reduced tar yields with respect to the coals when viewed in a %C or %(S+O) domain. Its tar yield potential was somewhat consistent with the high rank coals when viewed in a %H domain. However, as is obvious from inspection of Figure 21, tar yields of HVA and lower rank coals are not readily discriminated in a %H domain. The higher rank coals - PSOC 1516D, a low volatile bituminous coal, and PSOC 1468D, an anthracite - show dramatically reduced tar yields, also as expected.

Certainly there is no simple functional relationship that can be used in a predictive mode across any single independent elemental composition variable. The data are to be further subjected to a principal component analysis with respect to both elemental composition and infrared absorbance characteristics. In addition, various multidimensional parameter combinations will be attempted to arrive at predictive tar source terms for kinetic modeling.

As Figure 1 indicates, PSOC 1451D occupies the "knee" position of the coalification band plot. Tar yields systematically decrease from the PSOC 1451D location with increase in (S+O)/C across the coalification plateau corresponding to H/C ratios around 0.85. Tar yields also systematically decrease with decrease in H/C ratio from the PSOC 1451D location for (S+O)/C values between 0.02 and 0.08. The rate of change of potential tar yield is different in each unit vector direction, decreasing significantly faster down the (H/C) direction vector than across the (S+O)/C vector. This behavior is somewhat reflected in the tar yield plots as a function of %C or %(S+O), Figures 20 and 19, respectively.

It is also interesting to note that the tar yield behavior of the polyimide sample is significantly displaced from the tar yield vs. %C or %(S+O) relationships displayed by the coal samples. In view of the location of the polyimide sample in either the {H/C

- $(S+O)/C$ or $\{(S+O)/H - (S+O)/C\}$ spaces (Figures 1, 2), it is expected that its corresponding tar yield behavior would be significantly displaced in plots of tar yields versus a particular domain parameter (Figures 19 - 21). This is observed.

Temperature Sensitivity of LHT Tar Yields

To determine the temperature sensitivity of the LHT tar yield behavior, samples were rapidly heated to intermediate peak temperatures and held for 10 seconds or longer. Figure 22 displays the temperature dependence of the LHT tar evolution behavior of the non-HVA samples with that of the reference coal PSOC 1451D. Figures 23 and 24 display the corresponding plots for the HVA bituminous coals with the reference coal data. Although similar to each other, the Texas lignite and Wyoming subbituminous samples show a weaker temperature dependency in their LHT tar evolution behavior than the 1451D. PSOC 1516D shows a sharp increase in its LHT tar yield behavior between hold temperatures of 500 - 600°C.

It is also interesting to note that the highly crosslinked, high temperature polyimide does not evolve large amounts of tar relative to the reference coal or, indeed, to any of the coals examined. These results emphasize the inadequacy of using crosslinked polymer models and heavy molecular weight crosslinking concepts to explain the volatiles evolution of substances having the complexity of coal structures.

The low temperature LHT tar evolution behaviors of the 1499D sample (Figure 23) and the 1493D (Figure 24) sample are similar to the 1451D coal. However, the tar yields show a different LHT temperature dependence for peak temperature greater than 475°C and, as noted above, asymptotes to significantly lower "ultimate" tar yields than the reference coal. The LHT tar yield behavior of the Illinois #6 and Colorado HVA coals are similar to each other but at variance with the 1451D.

It might be hypothesized that differences in functionality of the HVA coals result in differences in char re-incorporation rates or char crosslinking reactions under these heating conditions. The more functionally rich tar precursors of the 1493D and 1499D HVA coals might lead to reductions in tar yields with corresponding increases in char yields compared to PSOC 1451D. LHT char yield behavior is discussed below.

Calorific Values of "Primary" Coal Tars Relative to Parent Coals:

Figures 11, 12 and 13 display the heat of combustion of the parent coal samples on a dry, ash free basis and as a function of the three major elemental composition values. Figures 14, 15a, and 16 display the same data in the context of other PSOC XXXXD coal samples and some corresponding values for UTRC entrained flow captured tar samples. The determination of tar values were restricted to tars collected under heating conditions wherein transient tar yields were maximized and secondary reactions minimized. Figure 15b illustrates the relationship of the heats of combustion of these tar samples relative to their parent coal generators.

Although the heating values of the primary tars from a wide range of coals and extent of devolatilization are quite similar, the magnitude and temperature sensitivity of the tar evolution process vary significantly with coal type. As a result, the instantaneous

concentration of tar volatiles in the volatiles diffusion flame zone varies significantly with coal type and heating conditions.

From the point of view of pfc modeling, the heating value of the parent coal released as tar volatiles is determined by the product of the tar yield at a particular extent of reaction and the intrinsic heating value of the tars normalized with respect to the value of the parent coal generator. From an engineering point of view, the narrow range of heating values of the tar volatiles relative to the wide range observed for the parent coal species will likely lead to some simplifications for combustion modeling.

"Ultimate" Volatile Yields - Char Yields:

Non-HVA Char Yields

Figure 25 displays the long hold time ("ultimate") char yield of the non-HVA coals and polyimide relative to the reference coal. Several points worth noting are:

1. There is a considerable divergence in the low rank char yield behavior relative to the reference coal, PSOC 1451D, over the 450 to 550°C range.
2. The "ultimate" mass loss of the PSOC 1443D coal appears to be between 35 and 40% on a daf basis. The PSOC 1520D coal shows an "ultimate" mass loss approaching 20% in conditions wherein coal is heated to temperatures of 700°C or above and held for some time. These values compare to a 55% mass loss asymptote for the reference coal.
3. The polyimide polymer shows a lag in mass loss relative to the reference PSOC 1451D coal at low temperatures. (See comments above with respect to differences in tar evolution behavior.) However, at temperatures in excess of 700°C, the mass loss behavior is very similar to the reference HVA bituminous coal.

The Wyoming subbituminous coal, in particular, shows rather dramatic mass loss characteristics on a daf basis. It should be recalled that this is the coal that displays considerable apparent variation in elemental composition with methodology of determination (See DE-AC22-89PC89759 Quarterly report for the period Oct. 1, 1989 - Jan. 1, 1990). The elemental composition results indicate that the subbituminous coal rapidly exchanges H₂O and CO₂ with its environment. It appears to have a rather high oxygen content in the form of carbonyl and carboxylic groups compared to the Texas lignite.

Preliminary results indicate that the "apparent" tar "volatiles" for the PSOC 1520D coal consists of significant amounts of char fines. The results indicate that not only do char incorporation, or crosslinking, reactions play no significant role in reducing total volatile yields of highly functional low rank coals and polymers during rapid heating, but that the oxygen functionality of these coals appears to enhance "apparent" volatile yields by resulting in physically fragile char structures at a given extent of devolatilization. Similar observations have been made with PSOC 1507D, a North Dakota lignite. PSOC 1507D is also a coal which shows methodology-dependent elemental composition behavior similar to PSOC 1520D.

PSOC 1443D elemental composition was relatively methodology-independent compared to the Great Plains low rank coals. Its "apparent" volatile yield is also less extreme

than that of the Great Plains coals. However, the PSOC 1443D tar volatiles for high mass yields also contained observable char fines at high yields, but to a lesser extent than PSOC 1520D. Since these fragmentation observations would have significant impact on both the practical combustion behavior and combustion modeling of low rank coals, the exact conditions at which fragmentation occurs are being examined as part of the crosslinking investigation.

HVA Bituminous Coal Char Yields

Figures 26 and 27 indicate the temperature dependency of HVA bituminous coals LHT char yields on a dry, ash free basis and relative to the mineral matter free parent coal. The magnitude and temperature sensitivity of the HVA bituminous - PSOC 1493D, PSOC 1499D and PSOC 1451D - LHT char yields show significant similarity to the reference coal on a daf basis, despite the observed differences in tar yields. Obviously, their light gas yields must be significantly different in order to maintain total volatile yield similarity while maintaining tar yield differences. Light gas analysis of the runs is being performed. Such behavior is not surprising in view of the fact that PSOC 1493D and PSOC 1499D are significantly displaced toward the low rank coals in compositional space. Low rank coals are characterized by volatile yields having low tar yield fractional components, but large light gas yields.

It is somewhat surprising that the Illinois #6 sample, PSOC 1493D, does not show an increased char yield, a reduced total volatile yield, relative to PSOC 1451D. PSOC 1493D contains between 5 and 6% organic sulfur. Sulfur is commonly used as a crosslinking agent in the carbon and rubber process industry. During heating, one might expect these sulfur functional groups to become crosslinking sites at which potentially volatile organic species, tar precursors, would become incorporated into the char matrix. This is not observed to be the case in these rapid heating experiments for any intermediate yield temperature.

Analogously, the Colorado HVA bituminous coal also shows no significant difference in LHT char yields on a dry, ash free basis, despite its greater functionality than PSOC 1451D (See Figures 5 and 11). If char re-incorporation or crosslinking appreciably influenced the devolatilization pathway in rapid heating conditions, then one would expect significant differences in total volatile yields with the corresponding differences in coal structural parameters observed for the three bituminous coals selected.

Differences in potential tar yields observed for the HVA bituminous coals are apparently due to intrinsic differences in the molecular structures of the parent coals. The distribution of tar precursors generated for the PSOC 1493D and 1499D coals have: a) lower vapor pressures; b) less thermal stability; or c) some combination of these factors, relative to the tar precursors generated in 1451D. The relative vapor pressure characteristics of the low molecular weight tar precursors of 1493D and 1499D can be ascertained by examining the low temperature ZHT tar evolution behavior of the coals relative to 1451D. In any case, the thermal stability of the 1493D and 1499D tar precursors is undoubtedly lower than the 1451D tar precursors, since both the elemental composition results and infrared absorbance characteristics of these samples indicate less aromaticity than the 1451D coal. Differences in tar evolution behavior, in the context of similar total volatile yields,

are the result of differences in pyrolytic fragmentation rates among the tar precursors generated in each coal, the less aromatic tar precursors cracking to lower molecular weight tars and gases before they can be vaporized from the devolatilizing coal "metaplast."

With respect to modeling the devolatilization behavior of these bituminous coals, it is apparent that the tar source terms will vary significantly with type of HVA bituminous coal. Total volatile source terms will not vary significantly with HVA type. Figures 19 and 20, in the context of Figures 26 and 27, strongly imply that the transient tar release will vary with coal type, depending on the extent of devolatilization. The transient tar evolution behavior needs to be detailed in order to ascertain if any adjustments in the kinetic, temperature sensitivity parameters are necessary. Zero hold time tar evolution data will be presented in the following quarterly.

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TABLE I
RANK EFFECTS ELEMENTAL COMPOSITION SUMMARY

	A	B	C	D	E	F	G
1	Coal I.D.	AVE. D, mic.	SEAM, LOCAT.	APP. RANK	AS-RCD H2O%	MB%	%ASTM(ASH)MF
2							
3	PSOC 1443D	69	LOWER WILCOX, TEXAS	LIGNITE	7.13	4.95	20.34
4	PSOC 1520D	69	SMITH ROLAND, WY	SUBC	13.83	4.15	12.45
5	PSOC 1499D	69	COLORADO B, CO	HVA	2.97	1.7	4.88
6	PSOC 1493D	69	ILLINOIS #6, ILL	HVA		2.05	13.34
7	PSOC 1451D	69	PITTSBURGH #8, PA	HVA	NA	1.6	3.35
8	PSOC 1516D	69	LOWER KITTANING, PA	LVB		0.21	16.97
9	PSOC1468D	69	BUCK MOUNTAIN, PA	ANTHRACITE		1.05	6.60
10	POLYIMID E				0.00	0	0.00

	A	H	I	J	K	L
1	Coal I.D.	(%C)DAF	(%H) DAF	(%N)DAF	(%S+O) DAF	HEAT VAL (BTU/LB)
2						
3	PSOC 1443D	66.45	5.16	1.28	27.11	8973
4	PSOC 1520D	69.03	5.04	0.98	24.96	10001
5	PSOC 1499D	79.90	5.49	1.57	13.04	13158
6	PSOC 1493D	75.52	5.02	1.46	18.01	11670
7	PSOC 1451D	83.95	5.62	1.62	8.81	14279
8	PSOC 1516D	87.40	4.69	1.55	6.36	12476
9	PSOC1468D	94.34	1.86	0.74	3.06	
10	POLYIMID E	72.18	2.67	7.12	18.03	

	A	M	N	O	P	Q
1	Coal I.D.	HEAT VAL(BTU/LB)(DAF)	MACERAL GROUPS VOL %		%TAR YIELD (daf), He, 10s	
2			VITRINITE	INERTINITE	LIPTINITE	
3	PSOC 1443D	11264				17.6
4	PSOC 1520D	11423	88.5	5.7	5.8	19.3
5	PSOC 1499D	13834				22.2
6	PSOC 1493D	13466				22.6
7	PSOC 1451D	14766	89	7.4	3.6	31.04
8	PSOC 1516D	15026	84.8	7.7	7.5	10.8
9	PSOC1468D		88.6	11	0.4	2.5
10	POLYIMID E					7.05

TABLE II
RANK EFFECTS ELEMENTAL COMPOSITION

Coal ID.	AVE. D, mic.	%CME	%HME	%NME	(PE-%ASH)ME	(NS-%O)ME	%ASTMASH-ME	AS-ROD-HO%ME	MEK	%ASTMASH-ME	%CME	%HME
PSOC 1443D	69	52.37	4.06	1	16.4	26.17	19.3	7.2	4.9	20.31	55.10	4.27
	69	52.19	4.04	1.04	16.3	26.43	19.5	7.1	5	20.52	54.91	4.25
	69	52.2	4	1	16.3	26.5	19.2	7.1		20.20	54.92	4.21
	69	52.36	4.13	1	16.5	26.01					55.09	4.35
	AVE:	52.28	4.06	1.01	16.38	26.28	19.33	7.13	4.95	20.34	55.00	4.27
PSOC 1520D	69	59.4	4.3	0.83	9.7	27.77	11.9	13.9	4.2	12.42	61.97	4.49
	69	59.46	4.35	0.86	9.7	25.63	11.9	13.9	4.1	12.42	62.03	4.54
	69	59.42	4.34	0.84	9.7	25.7	12	13.7		12.52	61.99	4.53
	69	59.6	4.37	0.83	9.6	25.6					62.18	4.56
	AVE:	59.47	4.34	0.84	9.68	26.18	11.93	13.83	4.15	12.45	62.04	4.53
PSOC 1499D	69	74.97	5.14	1.47	4.4	14.02	4.8	3	1.7	4.88	76.27	5.23
	69	75.02	5.19	1.47	4.5	13.82	4.8	2.9	1.7	4.88	76.32	5.26
	69	74.89	5.15	1.47	4.7	13.79	4.8	3		4.88	76.19	5.24
	69	74.84	5.11	1.47	4.5	14.06					76.13	5.20
	AVE:	74.93	5.15	1.47	4.53	13.92	4.80	2.97	1.7	4.88	76.23	5.24
PSOC 1493D	69	64.39	4.26	1.24	12.8	17.31	13	1.63	2.1	13.27	65.74	4.35
	69	64.37	4.29	1.24	12.8	17.3	13.1	1.63	2	13.37	65.72	4.38
	69	64.45	4.29	1.26	12.5	17.5	13.1	1.65		13.37	65.80	4.36
	69	64.38	4.27	1.24	12.6	17.51					65.73	4.36
	AVE:	64.40	4.28	1.25	12.68	17.41	13.07		2.05	13.34	65.75	4.37
PSOC 1451D	69	79.06	5.30	1.54	4.19	9.91	3.30	NA	1.6	3.35	80.35	5.39
	69	79.28	5.30	1.53	4.09	9.80	3.30	NA	1.6	3.35	80.57	5.39
	69	79.31	5.30	1.47	4.19	9.73	3.30	NA	1.6	3.35	80.80	5.39
	69	79.03	5.30	1.56	3.90	10.21	3.30	NA	1.6	3.35	80.32	5.39
	69	79.17	5.30	1.52	4.09	9.92	3.30	NA	1.6	3.35	80.46	5.39
	AVE:	79.17	5.30	1.53	4.09	9.91	3.30	NA	1.60	3.35	80.46	5.39
PSOC 1516D	69	72.56	3.89	1.28	16.9	5.37	16.9	0.19	0.21	16.94	72.71	3.90
	69	72.4	3.9	1.32	16.7	5.68	16.9	0.16	0.21	16.94	72.55	3.91
	69	72.38	3.87	1.29	16.8	5.66	17	0.22		17.04	72.53	3.88
	69	72.78	3.89	1.26	16.8	5.27					72.93	3.90
	AVE:	72.53	3.89	1.29	16.80	5.50	16.93		0.21	16.97	72.68	3.90
PSOC 1468D	69	87.39	1.73	0.68	6.2	3.7	6.6	3.2	1.1	6.67	88.32	1.75
	69	87.03	1.71	0.69	6.4	4.17	6.4	6.6	1	6.47	87.95	1.71
	69	87.33	1.74	0.68	6.4	3.85	6.6	3.2		6.67	88.26	1.74
	69	87.4	1.74	0.7	6.4	3.76					88.33	1.74
	AVE:	87.29	1.73	0.69	6.43	3.87	6.53		1.05	6.60	88.21	1.73
POLYMER		67.46	2.63	7.12	0	22.79	0	0	0	0.00	67.46	2.63
		67.1	2.66	7.12	0	23.12	0	0	0	0.00	67.10	2.66
		67.57	2.72	7.08	0	22.63	0	0	0	0.00	77.22	2.72
		67.45	2.71	7.2	0	22.64	0	0	0	0.00	77.17	2.71
		67.23	2.67	7.11	0	22.99	0	0	0	0.00	76.83	2.67
		67.31	2.64	7.07	0	22.98	0	0	0	0.00	67.31	2.64
	AVE:	67.35	2.67	7.12	0.00	22.86	0.00	0.00	0.00	0.00	72.18	2.67

TABLE II (continued)
RANK EFFECTS ELEMENTAL COMPOSITION

Coal ID.	PSDAF	%PEASHINE	MS-ONE	%CDAF	%HDAF	%S-ODAF	MOLES C	MOLES H	MOLES N	MOLES (S+O)	H ₂	O ₂	N ₂
PSDC 1443D	1.05	17.25	22.33	66.56	5.16	27.60	5.55	5.16	0.0908	1.69	9.30E-01	3.04E-01	1.64E-02
	1.09	17.15	22.60	66.34	5.14	27.21	5.53	5.14	0.0944	1.70	9.29E-01	3.08E-01	1.71E-02
	1.05	17.15	22.67	66.35	5.08	27.30	5.53	5.08	0.0908	1.71	9.20E-01	3.09E-01	1.64E-02
	1.05	17.36	22.16	66.55	5.25	26.93	5.55	5.25	0.0908	1.68	9.47E-01	3.03E-01	1.64E-02
	1.06	17.23	22.44	66.45	5.16	27.11	5.54	5.16	0.0917	1.69	9.31E-01	3.06E-01	1.66E-02
PSDC 1520D	0.87	10.12	22.56	68.95	4.99	25.10	5.75	4.71	0.0888	1.57	8.69E-01	2.73E-01	1.20E-02
	0.90	10.12	22.41	69.02	5.05	24.93	5.75	5.05	0.0713	1.56	8.78E-01	2.71E-01	1.24E-02
	0.88	10.12	22.48	68.97	5.04	25.01	5.75	5.04	0.0696	1.54	8.78E-01	2.72E-01	1.21E-02
	0.87	10.02	22.38	69.18	5.07	24.78	5.77	5.07	0.0688	1.55	8.60E-01	2.69E-01	1.15E-02
	0.88	10.09	22.46	69.03	5.04	24.96	5.75	5.04	0.0696	1.56	8.78E-01	2.71E-01	1.21E-02
PSDC 1499D	1.50	4.48	12.53	79.95	5.48	13.00	6.60	5.48	0.1120	0.81	8.23E-01	1.22E-01	1.68E-02
	1.50	4.58	12.33	80.00	5.53	12.90	6.67	5.53	0.1120	0.81	8.30E-01	1.21E-01	1.68E-02
	1.50	4.78	12.30	79.86	5.49	13.08	6.66	5.49	0.1120	0.82	8.25E-01	1.23E-01	1.68E-02
	1.50	4.58	12.59	79.81	5.45	13.18	6.65	5.45	0.1120	0.82	8.19E-01	1.24E-01	1.68E-02
	1.50	4.60	12.44	79.90	5.49	13.04	6.66	5.49	0.1120	0.81	8.24E-01	1.22E-01	1.68E-02
PSDC 1493D	1.27	13.07	15.58	75.51	5.00	18.04	6.29	5.00	0.1039	1.13	7.94E-01	1.79E-01	1.65E-02
	1.27	13.07	15.57	75.49	5.03	18.03	6.29	5.03	0.1039	1.13	8.00E-01	1.79E-01	1.65E-02
	1.29	12.76	15.77	75.58	5.03	17.91	6.30	5.03	0.1055	1.12	7.99E-01	1.78E-01	1.68E-02
	1.27	12.86	15.78	75.50	5.01	18.04	6.29	5.01	0.1039	1.13	7.96E-01	1.79E-01	1.65E-02
PSDC 1451D	1.57	4.26	8.45	83.83	5.62	8.91	6.99	5.62	0.1153	0.56	8.04E-01	7.98E-02	1.67E-02
	1.55	4.16	8.33	84.07	5.62	8.69	7.01	5.62	0.1153	0.54	8.02E-01	7.75E-02	1.65E-02
	1.49	4.26	8.26	84.10	5.62	8.72	7.01	5.62	0.1113	0.55	8.02E-01	7.78E-02	1.59E-02
	1.59	3.96	8.75	83.80	5.62	8.93	6.98	5.62	0.1162	0.56	8.05E-01	7.99E-02	1.69E-02
	1.54	4.16	8.46	83.95	5.62	8.82	7.00	5.62	0.1151	0.55	8.03E-01	7.88E-02	1.65E-02
	1.55	4.16	8.45	83.95	5.62	8.81	7.00	5.62	0.12	0.55	8.03E-01	7.87E-02	1.65E-02
PSDC 1518D	1.28	16.94	5.17	87.43	4.69	6.34	7.29	4.69	0.1102	0.40	6.43E-01	5.44E-02	1.51E-02
	1.32	16.74	5.48	87.24	4.71	6.46	7.27	4.71	0.1138	0.40	6.47E-01	5.55E-02	1.57E-02
	1.29	16.84	5.46	87.22	4.67	6.56	7.27	4.67	0.1112	0.41	6.43E-01	5.64E-02	1.53E-02
	1.26	16.84	5.07	87.70	4.69	6.09	7.31	4.69	0.1086	0.38	6.42E-01	5.21E-02	1.49E-02
	1.29	16.84	5.30	87.40	4.69	6.36	7.28	4.69	0.1109	0.40	6.44E-01	5.46E-02	1.52E-02
PSDC 1468D	0.69	6.57	2.68	94.45	1.87	2.95	7.87	1.87	0.0525	0.18	2.38E-01	2.34E-02	6.67E-03
	0.70	6.47	3.17	94.06	1.83	3.36	7.84	1.83	0.0533	0.21	2.33E-01	2.68E-02	6.80E-03
	0.69	6.47	2.85	94.39	1.86	3.02	7.87	1.86	0.0525	0.19	2.37E-01	2.40E-02	6.87E-03
	0.71	6.47	2.76	94.46	1.86	2.92	7.87	1.86	0.0540	0.18	2.36E-01	2.32E-02	6.86E-03
	0.69	6.49	2.66	94.34	1.86	3.06	7.86	1.86	0.0531	0.19	2.36E-01	2.43E-02	6.75E-03
PSDC 1468D	7.12	0	22.79	67.46	2.63	22.79	5.62	2.63	0.5086	1.42	4.78E-01	2.53E-01	9.05E-02
	7.12	0	23.12	67.10	2.66	23.12	5.59	2.66	0.5086	1.45	4.78E-01	2.58E-01	9.10E-02
	7.08	0	12.98	77.22	2.72	12.98	6.44	2.72	0.5057	0.81	4.23E-01	1.26E-01	7.95E-02
	7.2	0	12.92	77.17	2.71	12.92	6.43	2.71	0.5143	0.81	4.21E-01	1.26E-01	8.00E-02
	7.11	0	13.39	76.93	2.67	13.39	6.40	2.67	0.5079	0.84	4.17E-01	1.31E-01	7.93E-02
	7.07	0	22.98	67.31	2.64	22.98	5.61	2.64	0.5050	1.44	4.71E-01	2.56E-01	9.00E-02
	7.12	0.00	18.03	72.18	2.67	18.03	6.02	2.67	0.51	1.13	4.46E-01	1.92E-01	6.48E-02

TABLE II (continued)
RANK EFFECTS ELEMENTAL COMPOSITION

Coal I.D.	OH	HEAT VAL (BTU/LB)	HEAT VAL (BTU/LB)(DAF)	MACERAL GROUPS VOL %		
				VITRINITE	INERTINITE	LIPTINITE
PSOC 1443D	3.27E-01	9027.00	11332			
	3.31E-01	8937.00	11219			
	3.36E-01	8955.00	11242			
	3.21E-01					
	3.20E-01	8973.00	11264.33			
PSOC 1520D	3.14E-01	10220.00	11873	88.5	5.7	5.8
	3.09E-01	9894.00	11301			
	3.10E-01	9890.00	11296			
	3.05E-01					
	3.10E-01	10001.33	11423.33			
PSOC 1499D	1.48E-01	13155.00	13830			
	1.46E-01	13163.00	13839			
	1.49E-01	13157.00	13832			
	1.51E-01					
	1.48E-01	13158.33	13833.67			
PSOC 1493D	2.28E-01	11728.00	13533	89	7.4	3.6
	2.24E-01	11829.00	13419			
	2.23E-01	11853.00	13447			
	2.25E-01					
	2.24E-01	11870.00	13466.33			
PSOC 1451D	9.91E-02	14243.00	14729.08	84.8	7.7	7.5
	9.67E-02	14314.00	14802.48			
	9.70E-02					
	9.93E-02					
	9.81E-02					
	9.80E-02	14278.50	14765.77			
PSOC 1516D	8.45E-02	12412.00	14949	88.6	1.1	0.4
	8.58E-02	12556.00	15122			
	8.77E-02	12481.00	15008			
	8.10E-02					
	8.48E-02	12476.33	15026.33			
PSOC 1488D	9.84E-02					
	1.15E-01					
	1.01E-01					
	9.81E-02					
	1.03E-01					
POLYMADE	5.42E-01					
	5.43E-01					
	2.98E-01					
	2.98E-01					
	3.13E-01					
	5.44E-01					
	4.23E-01					

TABLE III
RANK EFFECTS CALORIFIC VALUES

	SAMPLE	AVE SIZE (MIC)	%C(daf)	% H(daf)	%(S+O)daf	BTU/lb.
1	1451D COAL	69	83.95	5.62	8.81	14765
2	1451D COAL	69	83.95	5.62	8.82	14867
3	1451D COAL	69	83.95	5.62	8.82	14941
4	1451D COAL	25	83.92	5.56	8.88	14897
5	1451D COAL	25	83.92	5.56	8.88	14651
6	1451D COAL	230	80.98	5.63	11.82	13251
7	1451D COAL	230	80.98	5.63	11.82	13203
8	1443D COAL	25	70.93	5.40	22.70	11129
9	1443D COAL	69	66.40	5.16	27.11	11264
10	1443D COAL	69	70.93	5.40	22.70	10335
11	1443D COAL	69	69.90	5.34	24.51	10550
12	1443D COAL	69	69.90	5.34	24.51	10807
13	1507D COAL	69	65.00	4.56	29.55	10335
14	1520D COAL	25	73.67	5.02	28.05	10808
15	1520D COAL	25	73.67	5.02	28.05	10819
16	1520D COAL	69	69.03	5.04	24.96	11423
17	1445D COAL	69	80.62	5.79	12.85	12960
18	1488D COAL	69	71.08	4.81	23.24	11109
19	1499D COAL	69	79.30	5.49	13.04	13833
20	1493D COAL	69	75.52	5.02	18.01	13466
21	1493D COAL	69	79.14	5.45	23.24	13608
22	1508D COAL	20	90.66	4.22	3.90	15728
23	1508D COAL	69	89.90	4.32	4.60	15294
24	1508D COAL	69	89.90	4.32	4.60	15237
25	1516D COAL	25	88.77	4.74	4.99	15761
26	1516D COAL	69	87.45	4.69	6.36	15400
27	1516D COAL	69	87.45	4.69	6.36	15026
28	MILLMERAN	105	78.40	6.40	13.40	15249
29						
30	1451D TAR	20	83.97	6.22	8.24	15559
31	1451D TAR	20	84.07	5.90	8.09	15182
32	1451D TAR	20	84.40	5.55	8.14	15300
33	1451D TAR	20	85.55	5.27	7.44	15383
34	1451D TAR	69	84.31	5.81	7.98	15397
35	1451D TAR	230	84.00	6.35	8.10	15621
36	1451D TAR	230	84.00	6.35	8.10	15621
37	1451D TAR	230	84.60	5.90	7.79	15423
38	1451D TAR	230	84.60	5.90	7.79	15418
39	1451D TAR	230	85.31	5.65	7.20	15476
40	1451D TAR	230	85.31	5.65	7.20	15428
41	1443D TAR	69	80.27	8.88	10.09	15831
42	1508D TAR	69	89.18	5.20	4.64	16316
43	MILLMERAN	105	80.80	6.60	11.41	15249
44						
45	BENZOIC ACID		68.85	4.91	26.23	11342
46	BENZOIC ACID		68.85	4.91	26.23	11358
47	CARBON		100.00	0.00	0.00	14238

TABLE IV
UTRC-HEATED GRID TAR EVOLUTION RANK EFFECTS:
LONG HOLD TIME DATA

1	A	B	C	D	E	F	G	H	I	J	K
	Coal ID	RunID	d1-d2, microns	Atmos.	Sample Size(mg)	Prog. T-asymp (C)	Prog. T-Dot(C/sec)	Prog. Max I, amps	Prog. Max Volts	Prog. Max. Pow. watts	Prog. Hold (sec)
2											
3	PSOC 1443D	39			13.3	400.5	1060.9	32.5	10.2	329.8	10
4	PSOC 1443D	40			14	517.4	1010.5	30.9	9.5	280.1	10
5	PSOC 1443D	41			13.8	616.5	1024.5	33.9	11.4	385.3	10
6	PSOC 1443D	42			15.9	696	917.9	33	12.3	405.6	10
7											
8	PSOC 1520D	44			15.4	417	946.2	31	8.8	272.5	10
9	PSOC 1520D	43			15.9	448.9	926.4	33.6	11	370.4	10
10	PSOC 1520D	45			16.1	506.7	979.1	31.2	9.4	286.8	10
11	PSOC 1520D	46			15.3	612.4	1023.6	32.3	10.5	330.4	10
12	PSOC 1520D	47			13	702.6	961.3	32.8	11.6	379.9	10
13											
14	PSOC 1493D	49			16.7	425	980.9	31	8.8	257.3	10
15	PSOC 1493D	50			15	527.6	976.4	31.7	10.3	322.5	10
16	PSOC 1493D	51			14.3	627.6	1001.3	30.7	10.6	324.2	10
17	PSOC 1493D	48			15.8	712.4	909.3	33.9	11.5	390.2	10
18											
19	PSOC 1451D	400				350	1000				100
20	PSOC 1451D	403A				370	1000				100
21	PSOC 1451D	413B				400	1000				100
22	PSOC 1451D	404				420	1000				100
23	PSOC 1451D	412				450	1000				100
24	PSOC 1451D	406				460	1000				100
25	PSOC 1451D	401				476	1000				100
26	PSOC 1451D	403B				360	1000				100
27	PSOC 1451D	405				560	1000				100
28	PSOC 1451D	407				570	1000				100
29	PSOC 1451D	402				585	1000				100
30	PSOC 1451D	408				520	1000				100
31											
32	PSOC 1451D	409				544	1000				10
33	PSOC 1451D	411				680	1000				10
34											
35	PSOC 1451D	410				710	1000				50
36											
37	PSOC 1499D	52			12.8	424.4	1093.1	33.4	9.8	324.2	10
38	PSOC 1499D	53			13.2	534.3	1029.4	33.3	9.9	328	10
39	PSOC 1499D	54			15.2	622.1	1037.5	33.8	10.9	367.1	10
40	PSOC 1499D	55			14.2	722.2	959.9	35.2	11.5	406.5	10
41											
42	PSOC 1516D	56			13.8	426.3	995.7	33.1	8.7	288.1	10
43	PSOC 1516D	57			14.5	530.9	988.9	33.5	9.6	323	10
44	PSOC 1516D	58			11.8	638.4	1017	34.7	10.1	350.9	10
45	PSOC 1516D	59			14.4	717.3	999	35.7	11.6	416.2	10
46											
47	PSOC 1468D	60			13.7	425.8	940.7	32.1	9.2	293.7	10
48	PSOC 1468D	61			14.6	535.5	979.2	34	10	340.2	10
49	PSOC 1468D	62			15.9	622.7	1018.9	34.5	10.9	375.4	10
50	PSOC 1468D	63			17.2	720.6	956.5	35.9	11.1	382.5	10

TABLE IV (continued)
UTRC-HEATED GRID TAR EVOLUTION RANK EFFECTS:
LONG HOLD TIME DATA

A	L	M	N	O	P	Q	R	S	T
Coal I.D.	Run T-Asym (C)	Run T-dot(C/sec)	Run Max Lamps	Run Max Volts	Run Max Pow, watts	Run Hold (sec)	% Char, Raw	% Tar, Raw	% Vol., Raw
1									
2									
3	332.8	855.3	31	10.4	321	10	85	6	15
4	506.5	661.7	31.2	9.4	281.3	10	52.1	12.1	47.9
5	588.8	754	34	11.5	392.4	10	54.3	12.3	45.7
6	608.1	671.5	33.3	12.2	407.3	10	49.7	14.5	50.3
7									
8	348.5	584.7	31	8.8	273.3	10	83.1	7.8	16.9
9	485.2	797.5	37.1	10.9	404.4	10	71.1	10.1	28.9
10	488.4	604.5	31.9	9.2	293.5	10	62.1	11.8	37.9
11	569.1	852.4	32.7	10.7	348.5	10	41.8	13.1	58.2
12	670.7	817.7	34.8	11.5	398.1	10	39.2	15.4	60.8
13									
14	327.7	747.9	29.4	8.6	251.5	10	93.4	2.4	6.6
15	503.8	653.4	32.2	10.4	333.9	10	70.7	17.3	29.3
16	636.8	599.1	32.6	10.4	340.3	10	61.5	19.6	38.5
17	696.8	845.6	34.8	11.4	396.9	10	58.9	19.6	41.1
18									
19	350	1000				100	96.3	1.1	3.7
20	370	1000				100	95.1	1.8	4.9
21	400	1000				100	91.1	8.9	8.9
22	420	1000				100	86.7	12.3	13.3
23	450	1000				100	72.4	19.4	27.6
24	460	1000				100	10.3	19	89.7
25	476	1000				100	81	15.6	19
26	380	1000				100	83.9	15.1	16.1
27	560	1000				100	65.2	27.1	34.8
28	570	1060				100	62.9	28.4	37.1
29	585	1000				100	63.9	28.2	36.1
30	520	1000				100	71.6	21.6	28.4
31									
32	544	1000				10	69.8	24.3	30.2
33	680	1000				10	60.3	29.1	39.7
34									
35	710	1000				50	58.5	30.5	41.5
36									
37	360.4	779.6	31.9	9.7	308.1	10	89.8	5.5	10.2
38	482.3	704.5	33.3	9.9	328.5	10	77.3	12.9	22.7
39	590.4	656.9	35	10.6	372.1	10	60.5	17.8	39.5
40	696.3	708.9	35.6	11.6	415.1	10	57	21.1	43
41									
42	386.4	812.6	32.2	8.8	284.8	10	97.8	1.4	2.2
43	489.4	802.3	33.3	9.7	324.9	10	93.8	2.1	6.2
44	545.2	696.6	33.8	10.2	345.6	10	89	5.9	11
45	734.1	854.9	37.8	11.6	432.4	10	81.9	9	18.1
46									
47	396.9	777.5	32.2	9.2	288.3	10	95.6	1.5	4.4
48	500.6	760.2	34.1	10.3	351.6	10	95.2	2.1	4.8
49	570.6	689.9	36.2	10.7	386	10	94.3	1.9	5.7
50	664.3	734.4	36.2	11.2	405.1	10	94.2	2.3	5.8

TABLE IV (continued)
UTRC-HEATED GRID TAR EVOLUTION RANK EFFECTS:
LONG HOLD TIME DATA

1	A	B	C	D	E	F	G	H	I	J	K
1	Coal I.D.	Run I.D.	d1-d2, microns	Atmos.	Sample Size(mg)	Prog. T-asymp (C)	Prog. T-Dot(C/sec)	Prog. Max I, amps	Prog. Max Volts	Prog. Max. Pow. watts	Prog. Hold (sec)
51	10.0 POLY	75			17.4	742.5	1017	34.9	11.6	405.7	10
52	5.0 POLY	74			20.8	752	987.2	35.3	11	386.5	10
53	2.0 POLY	73			23.5	748.5	985.6	36.1	12.7	457.8	10
54	10.0 POLY	72			19.1	640.4	970	32.8	11	362.1	10
55	5.0 POLY	71			22.4	637.3	936.5	34.2	11.8	401.4	10
56	2.0 POLY	70			21.3	649.4	1017.8	35.8	12.8	458.5	10
57	10.0 POLY	69			16.9	541.5	970.7	33.3	10.3	340.9	10
58	5.0 POLY	68			20.7	553.1	989.5	32.2	10.2	327.6	10
59	2.0 POLY	67			19.7	547.3	997.3	32.9	10.3	332.9	10
60	10.0 POLY	66			21.1	797	1072	38.7	13	495.9	10
61	5.0 POLY	65			18.5	798.9	949.5	34.6	11.5	395.8	10
62	2.0 POLY	64			18.5	818.5	898.3	33.7	11.8	388.5	10

1	A	L	M	N	O	P	Q	R	S	T
1	Coal I.D.	Run T-Asym (C)	Run T-dot(C/sec)	Run Max I,amps	Run Max Volts	Run Max Pow. watts	Run Hold (sec)	% Char, Raw	% Tar, Raw	% Vol., Raw
51	10.0 POLY	676.3	566.2	36.2	11.7	425.5	10	58.6	5.7	41.4
52	5.0 POLY	614.2	595.6	35.7	11.1	396.2	10	79.3	2.9	20.7
53	2.0 POLY	650.7	699.9	38	12.5	473.9	10	71.9	3.4	28.1
54	10.0 POLY	581.3	537.5	34.7	11	381.4	10	73.8	2.1	26.2
55	5.0 POLY	637.3	936.5	34.2	11.8	401.4	10	88.4	1.3	11.6
56	2.0 POLY	529.4	720.3	37.5	12.6	473.6	10	89.2	1.4	10.8
57	10.0 POLY	443.6	565.3	32.5	10.5	342.2	10	94.7	1.2	5.3
58	5.0 POLY	424.9	612.1	32.3	10.3	330.9	10	94.7	1	5.3
59	2.0 POLY	377.3	675.5	32.1	10.3	328.4	10	98.5	0.5	1.5
60	10.0 POLY	774.4	852.3	41.6	13.1	544.8	10	54.5	7.1	45.5
61	5.0 POLY	761.9	623.7	34.7	11.8	408.5	10	55.1	6.5	44.9
62	2.0 POLY	810.3	657.5	36.2	11.7	424.9	10	53	7.02	4.7

FIGURE 1
COALIFICATION BAND PLOT OF SAMPLES:
63-75 MICRON PARTICLES OF "D" COALS

FIGURE 2
(S+O)/H VS. (S+O)/C

FIGURE 3
IR ABSORBANCE CHARACTERISTICS
KBR/1443D COAL [DRY]

FIGURE 4
IR ABSORBANCE CHARACTERISTICS
KBR/1520D COAL [DRY]

FIGURE 5
IR ABSORBANCE CHARACTERISTICS
KBR/1499D COAL [DRY]

FIGURE 6
IR ABSORBANCE CHARACTERISTICS
KBR/1493D COAL [DRY]

FIGURE 7
IR ABSORBANCE CHARACTERISTICS
KBR/1516D COAL [DRY]

FIGURE 8
IR ABSORBANCE CHARACTERISTICS
KBR/1468D COAL [DRY]

FIGURE 9 - IR ABSORBANCE CHARACTERISTICS
4000 - 2000 wavenumbers

FIGURE 10 - IR ABSORBANCE CHARACTERISTICS
4000 - 2000 wavenumbers

FIGURE 11
HEATING VALUES OF COALS
 OPEN = DRY; CLOSED = DRY, ASH FREE

FIGURE 12
HEATING VALUES VS %(S+O) daf
 OPEN = DRY; CLOSED = DRY, ASH FREE

FIGURE 13
HEATING VALUES VS %H(daf)
OPEN = DRY, CLOSED = DRY, ASH FREE

FIGURE 14
CALORIFIC VALUES
PSOC XXXXD COALS AND TARS
%(S+O)daf as INDEPENDENT VARIABLE

FIGURE 15A
CALORIFIC VALUES VS. %C(daf) SAMPLE
PSOC XXXXD COALS AND TARS

FIGURE 15B
CALORIFIC VALUES OF TARS AND PARENT COALS
DATA PLOTTED WRT TO %C OF PARENT COALS

FIGURE 16
CALORIFIC VALUES
PSOC XXXDCOALS AND TARS
%H AS INDEPENDENT VARIABLE

FIGURE 17

FIGURE 18
EXAMPLE OF UTRC-HG LHT RUN SUMMARY DATA TABLE

FIGURE 19

Potential (Source Term) Tar Yields
Prog. Heating Rate 1000 C/sec to @700C

FIGURE 20

Potential (Source Term) Tar Yields
Prog. Heating Rate 1000C/s to @700C

FIGURE 21
Potential (Source Term) Tar Yields
Prog. Heating Rate 1000 C/sec to @700C

FIGURE 22
Non-HVA LHT Tar Evolution Comparison
Heated Grid; 63-75 Microns; 1 Atmos. He

FIGURE 23
Long Hold Time (Potential) Tar Yields
PSOC 1499D VS. PSOC 1451D

FIGURE 24
Long Hold Time (Potential) Tar Yields
PSOC 1493D VS. PSOC 1451D

FIGURE 25
Non-HVA LHT Char Evolution Comparison
Heated Grid; 63-75 Microns; 1 Atmos. He

FIGURE 26

Long Hold Char Yield (daf) Comparison
PSOC 1493D VS. PSOC 1451D

FIGURE 27

Long Hold Time Char Yield (daf) Comparison
PSOC 1499D VS. PSOC 1451D

-END-

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