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Wiang Haeng Coal-Water Fuel Preparation and Gasification, Thailand - Task 39

Topical Report
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WIANG HAENG COAL–WATER FUEL PREPARATION AND GASIFICATION, THAILAND

ABSTRACT

In response to an inquiry by the Department of Mineral Resources (DMR) in Thailand, the Energy & Environmental Research Center (EERC) prepared a four-task program to assess the responsiveness of Wiang Haeng coal to the temperature and pressure conditions of hot-water drying (HWD). The results indicate that HWD made several improvements in the coal, notably increases in heating value and carbon content and reductions in equilibrium moisture and oxygen content. The equilibrium moisture content decreased from 37.4 wt% for the raw coal to about 20 wt% for the HWD coals. The energy density for a pumpable coal–water fuel indicates an increase from 4450 to 6650 Btu/lb by hydrothermal treatment. Raw and HWD coal were then gasified at various mild gasification conditions of 700°C and 30 psig. The tests indicated that the coal is probably similar to other low-rank coals, will produce high levels of hydrogen, and be fairly reactive.

EXECUTIVE SUMMARY

In Thailand, coal is the major source for both power and nonpower usages. Over the past 10 years, the Department of Mineral Resources (DMR) in Thailand has been evaluating the ability of the country's coal reserves to meet its increasing utility and industrial energy needs. DMR discovered over 750 million tons of measured coal and subbituminous reserves. The majority of the reserves are the subject of additional exploration and development plans, which include applying clean coal technologies (i.e., coal preparation and beneficiation techniques) to reduce the impact of coal use on the environment.

DMR and other governmental groups in Thailand are leading the charge to this new coal utilization policy. In September of 1993, officials organized a Clean Coal Technology seminar in Chiangmai and a public workshop in Bangkok. As a result of these meetings, technology needs were identified to enhance coal utilization. One need identified is to produce a coal–water fuel (CWF) from coal for gasification systems. CWFs are the most promising of all alternative coal-based fuels. Converting coal into an easily transported liquid fuel could make it an ideal candidate to replace costly imported oil. The economic merits of CWFs are attractive because, on a heating-unit basis, coal is cheaper than oil. Its quasi-liquid form maintains that differential, since the higher cost of dry bulk coal handling and storage is avoided. The CWF technology opens up new markets to coal producers, while it offers price stability and security of supply for the fuel end users.

The Energy & Environmental Research Center (EERC), which has for years been investigating the conversion of coal to energy-dense liquid fuels, was identified as a leading candidate to perform the development program. In response to the inquiry, the EERC prepared a four-task program to assess the responsiveness of the Wiang Haeng coal to the temperature and pressure conditions of hot-water drying (HWD). The treated material was to be slurried in water and gasified at various conditions. The remaining activity focused on Thai personnel training at the EERC in the area of clean coal technologies. The project terms and conditions were accepted in October 1995. Approximately 600 kg of lignite was received in October. Coal was sized and analyzed for testing. A series of six bench-scale hot-water-drying (HWD) tests were completed in October and November. Results indicate an improvement of energy density (slurry basis) from 4450 to 6650 Btu/lb using the EERC-developed HWD technology.

Pilot-scale HWD tests were performed at 300° and 325°C and 7- and 15-minute residence times. Results indicated an improvement of energy density (slurry fuel basis) from 4360 to 5830 Btu/lb at 300°C and 6050 Btu/lb at 325°C and a 7-minute residence time. The effect of increasing residence time to 15 minutes was to further increase the heating value to 5980 and 6130 Btu/lb at 300° and 325°C, respectively.

A pilot-scale HWD production run was performed at 325°C with a 7-minute residence time. All HWD coal produced at 325°C was formulated into approximately 245 kg (540 lb) of CWF for subsequent gasification testing. The CWF had a solids concentration of 50.8 wt%, an estimated heating value of 6200 Btu/lb, and a viscosity of approximately 510 cP.

Mild gasification tests were conducted using raw and HWD Wiang Haeng coal at 700°C at 30 psig. Two different coal sizes were used in the investigation and two steam:carbon ratios. Gas production was approximately 30% based on maf feed. There was a net loss of water from the process, which indicates that the water–gas shift reaction was occurring. Hydrogen production was very high, accounting for 57%–59% of the total gas production. No clear conclusion can be made on the impact of HWD the coal prior to gasification because of the differences in gasification conditions.

Based on the success of CWF experiments, the next stages of the development may include testing new coals or testing CWF in a combustion system. Also, additional data are required to evaluate the storage and transportation properties of the CWF. Continued success may lead to extended pilot-scale testing and eventually to commercial demonstration in Thailand.

Specific tasks the EERC and DMR may consider for future gasification program development include the need to define products for specific gasifier types: slurry fuel, solid fuel product (briquettes, fine char), synfuel, or electrical production. Future product testing may include an evaluation of the amount of gas, char, and tar produced at various temperature conditions. Bench-scale tests would then be conducted to optimize tar production versus volatile content of the char. In order to consider synfuel and electrical production opportunities, laboratory tests may include thermogravimetric analysis matrix testing to investigate steam reactivity. Also, a more thorough ash characterization would be needed to assess slagging characteristics.

Personnel from Thailand's DMR completed interactive training by observing bench- and pilot-scale demonstrations in coal cleaning, briquetting, HWD, CWF preparation and evaluation, and CWF gasification.

WIANG HAENG COAL–WATER FUEL PREPARATION AND GASIFICATION, THAILAND

CHAPTER 1. INTRODUCTION

1.1 Background

Low-rank coal (LRC) is a carbonaceous material that has not undergone a sufficient geological metamorphosis to convert it into a high-volatile bituminous coal. The incomplete coalification process results in a high moisture content because of the porous nature of the coal. To beneficiate LRC requires a significant reduction in moisture; i.e., the coal must be dried. Unfortunately, proven technologies used to remove surface moisture and improve the heating value of bituminous coals are not effective on LRC. The evaporative processes employed in conventional methods for drying bituminous coal involve rapid drying, and under such conditions, LRC disintegrates. This creates a dust nuisance and an increased risk of spontaneous combustion. A further disadvantage is that moisture is quickly reabsorbed when the LRC is exposed to humid air or slurried in water.

During the 1970s, researchers began to use elevated temperature and pressure as a means of producing coal–water fuel from lignites. In simple terms, the process, known as hydrothermal treatment or hot-water drying (HWD), induces coalification in a condensed time scale of minutes rather than geological eras (millions of years), thus effecting a permanent reduction in inherent moisture. In other words, the lignite is changed from hydrophilic to hydrophobic, thus making it similar to some bituminous coals.

As a result of earlier investigations, the Energy & Environmental Research Center (EERC) has developed an economical method of upgrading LRC based on the hydrothermal treatment process. The technical feasibility of this new, nonevaporative technique has been established in the EERC's 7.5-tpd pilot plant, and commercial demonstration of the technology is currently in the planning stage.

1.2 Objectives

The EERC, at Grand Forks, North Dakota, with support from the U.S. Department of Energy (DOE), entered into a jointly sponsored research project with the Thailand Department of Mineral Resources (DMR) to investigate the application of an EERC-developed nonevaporative hydrothermal drying process, HWD, to coal from the chosen Thailand deposit. The evaluation included determining the gasification characteristics and efficiencies of the potential fuels. Figure 1 presents a time line for the main objectives, which are listed below:

- Investigate the hydrothermal treatment conditions for the selected Wiang Haeng coal at the bench and pilot scale.
- Evaluate the gasification performance of the hydrothermally treated Wiang Haeng coal slurry.

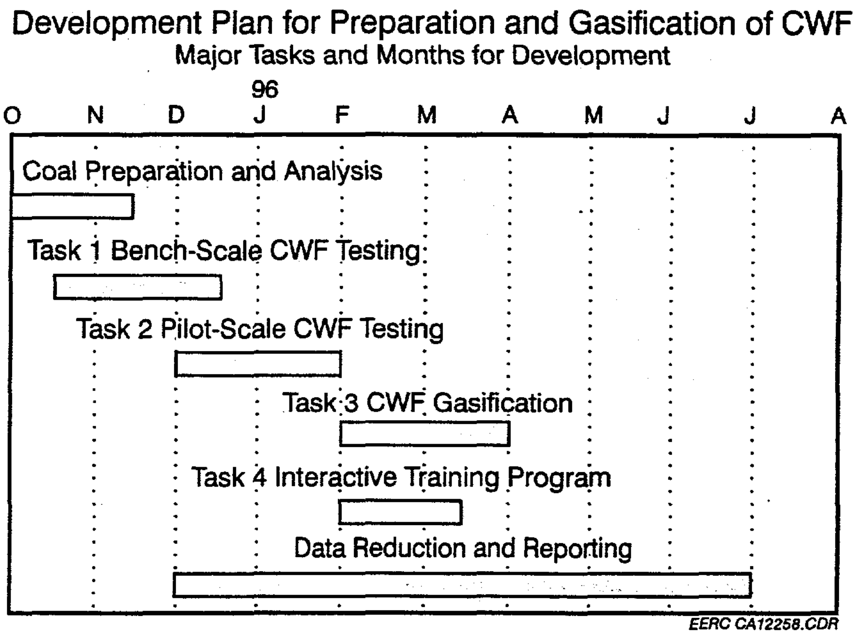


Figure 1. Development plan for preparation and gasification of CWF.

- Provide an interactive technology transfer training program on coal technology for coal applications.

CHAPTER 2. EXPERIMENTAL PROCEDURES AND RESULTS

2.1 Coal Preparation and Analysis

Approximately 600 kg of Wiang Haeng coal was received. The coal was somewhat slacked in appearance, indicating that the sample was not fresh prior to shipment or that some drying occurred during transit. The Wiang Haeng coal, received as lumps up to 0.25 m (estimated), was crushed with a roll crusher, producing nominal 4 cm × 0 cm coal. A 45-kg composite sample was generated, and approximately 543 kg of presized coal was reserved for pilot-scale testing. Test samples for analyses and bench-scale evaluations were prepared from the composite sample. The analysis fraction of the presized as-received (AR) Wiang Haeng coal was submitted for proximate, ultimate, heating value, equilibrium moisture, sulfur forms, x-ray fluorescence analysis (XRFA), and ash fusion determinations. Analytical equipment and methods are presented in Table A-1 (Appendix A), and resulting data are presented in Table 1 below for the AR Wiang Haeng coal.

The Wiang Haeng coal has a low ash content (6.5 wt% moisture-free [mf]), an acidic-type ash (over 92 wt% oxides of silicon, aluminum, and iron), high sulfur and nitrogen contents (2.0 and 1.8 wt% mf, respectively), and an equilibrium moisture content of 37.3 wt% (relative to an

AR value of 31.0 wt%). Sulfur forms analysis indicated that only 22 wt% of total sulfur is present as pyrite.

TABLE 1

Chemical Analysis Results for Wiang Haeng Coal

Analysis	As-Received	Moisture[1]	Moisture-Free	Moisture- and Ash-Free
Proximate, wt%				
Moisture	31.00	37.33	--	--
Volatile Matter	31.64	28.73	45.85	49.04
Fixed Carbon	32.87	29.86	47.64	50.96
Ash	4.49	4.08	6.51	--
Ultimate, wt%				
Hydrogen	6.70	7.11	4.72	5.05
Carbon	46.61	42.33	67.55	72.25
Nitrogen	1.15	1.05	1.67	1.78
Sulfur	1.29	1.18	1.88	2.01
Oxygen	39.75	44.25	17.67	18.91
Ash	4.49	4.08	6.51	--
Higher Heating Value				
MJ/kg	18.7	17.0	27.1	28.9
Btu/lb	8020	7290	11,630	12,430
Sulfur Forms, wt%				
Organic	0.84	0.78	1.25	1.34
Pyritic	0.26	0.24	0.39	0.42
Sulfatic	0.09	0.08	0.13	0.14
Sulfur Dioxide Emission				
g/MJ	1.39	1.39	1.39	1.39
lb/MMBtu	3.23	3.23	3.23	3.23

[1] Equilibrium moisture basis.

The 3.8- × 0-cm coal was stage-crushed to 6.35 × 0 mm using a roller mill and then screened at 20 mesh. The 6.35- × 0-mm mesh sample along with the –20-mesh fines were submitted for short proximate (moisture, ash, sulfur, heating value) analysis.

The 6.35- × 0-mm Wiang Haeng coal was subjected to washability analysis to determine the release of ash (as minerals) and sulfur (as pyrite) under wet-density-based conditions. Float–sink testing using true (homogeneous) heavy liquids was performed at specific gravities of 1.3, 1.4, and 1.6. Static float-sink analysis was performed on the -6.35-mm × 20-mesh coal by placing a 100- to 150-gram sample in a float-sink flask containing 1600 mL of 1.3 specific gravity Certigrav solution. The test was considered complete when the coal separated into distinct float (clean coal) and sink (minerals and pyrite) refuse fractions. The sink fraction was subjected to separation at higher specific gravity (1.4), with this procedure repeated until a total of three separations was performed. The products of float–sink testing included three float fractions and one sink fraction, which were ethanol-washed, air-dried, weighed, and then submitted for short proximate analysis. The washability results for the −6.35 mm × 20-mesh Wiang Haeng coal are presented in Table 2. Calculated values include coal and Btu recovery and ash and sulfur reduction as a function of specific gravity.

TABLE 2

Analysis Results for Wiang Haeng Coal Washability Testing (moisture-free)

Fraction	Coal Recovery, %	Btu Recovery, %	Ash Content, wt%	Sulfur Content, wt%	Heating Value, Btu/lb
Raw Coal			6.51	1.88	11,630
−20 mesh			7.97	2.12	11,310
−6.35 mm × 20 mesh			5.74	1.89	11,840
Direct					
+1.3 Float	75.99	79.76	2.18	1.38	12,410
1.3–1.4 Float	9.91	9.32	7.52	2.40	11,119
1.4–1.6 Float	11.12	9.38	15.94	2.90	9974
−1.6 Sink	2.99	1.55	43.94	4.30	6125
Cumulative					
+1.3 Float	75.99	79.76	2.18	1.38	12,410
+1.4 Float	85.90	89.08	2.80	1.50	12,261
+1.6 Float	97.01	98.45	4.30	1.66	11,999
Total	100	100	5.49	1.74	11,823

2.2 Bench-Scale HWD

The Wiang Haeng coal was roller mill-crushed to produce feed for autoclave HWD. Two particle-size distributions (PSD) were produced from the −6.35- × 0-mm coal. The bench-scale HWD tests with Wiang Haeng coal were performed in the EERC's 7.6-liter batch autoclave shown in Figure 2. The bolted closure autoclave is externally heated and equipped with automatic temperature controllers and a variable-speed magnetically driven stirrer. The autoclave is instrumented to continuously measure and trend pressure plus slurry and vapor temperatures.

Approximately 3000 grams of a 50 wt% coal/50 wt% deionized water feed slurry was used in each HWD test. After feed slurry was charged to the autoclave, residual air was evacuated and the external heaters and stirrer turned on. Heatup to the desired temperature ranged from approximately 2 to 2½ hours, after which the slurry and vapor temperatures were allowed to stabilize. After a 15-minute hold time at temperature, the heaters were shut off, and the autoclave and contents were allowed to cool overnight.

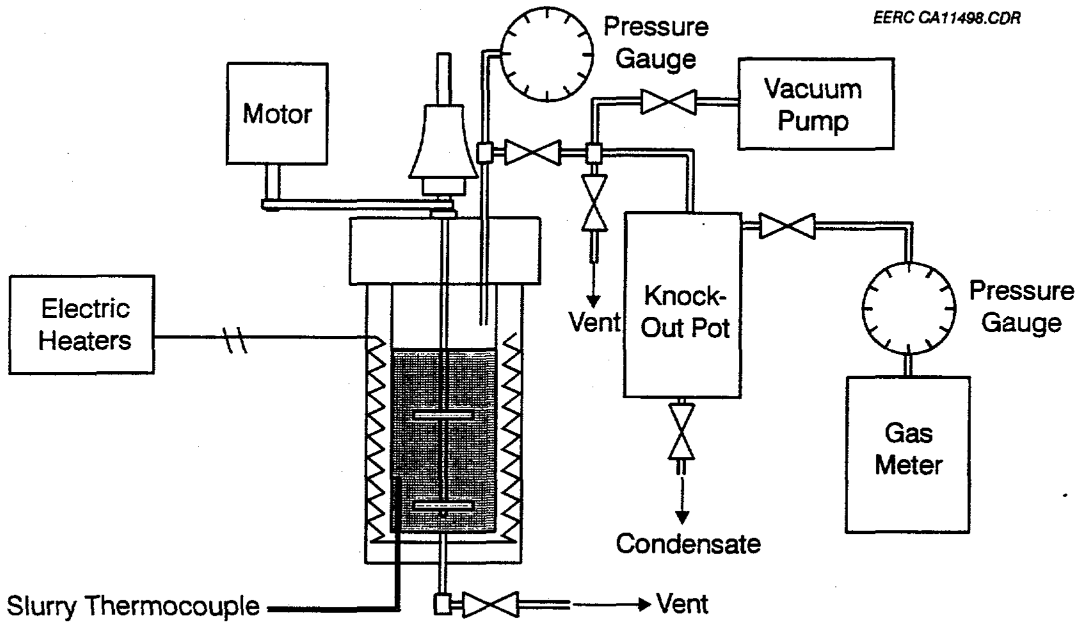


Figure 2. Schematic diagram of autoclave HWD system.

Fractions recovered from the autoclave after cooldown included process gas, product slurry, and condensate. The total volume of process gas (noncondensable decomposition products) was measured with a diaphragm meter. Process gas was sampled for off-line analysis. The product slurry was recovered, weighed, and then dewatered via Büchner filtration. Liquid samples (filtrate and condensate) were refrigerated prior to analysis to inhibit biological activity.

A total of six tests were performed; variables evaluated included PSD and treatment temperature. The HWD-treated solids were then reslurried in water and evaluated for size distribution and rheological performance. The PSD is important, because if the particles are too large, there will be more void spaces and lower packing efficiency, resulting in a decreased fuel solids concentration. The rheological behavior for the coal–liquid mixture, specifically the apparent viscosity, is determined as a function of shear rate and coal–water fuel (CWF) solids concentrations. Since any change in solids loading of a CWF has a direct effect on the resulting flow behavior, several rheograms throughout the possible solids-loading range were gathered. The characterization protocol for products of hydrothermal treatment is presented in Table A-2 (Appendix A), and analytical equipment and methods are presented in Table A-1 (Appendix A).

The first two autoclave tests were performed using a –60-mesh sample and a –200-mesh sample. Figure 3 illustrates that –250 μm (60-mesh) coal produced a fuel 2 to 3 wt% higher than the –75-μm (200 mesh) coal in solids loading, which was attributed to a broader PSD resulting in more efficient particle packing. HWD tests were then performed with –250-μm coal at 275°, 300°, and 325°C. Duplicate tests were also performed at 275° and 325°C. Table 3 summarizes the PSD analysis on raw coal and treated samples. Relatively no change was realized from HWD treatment. Appendix B summarizes the temperatures and pressure conditions during autoclave ıs.

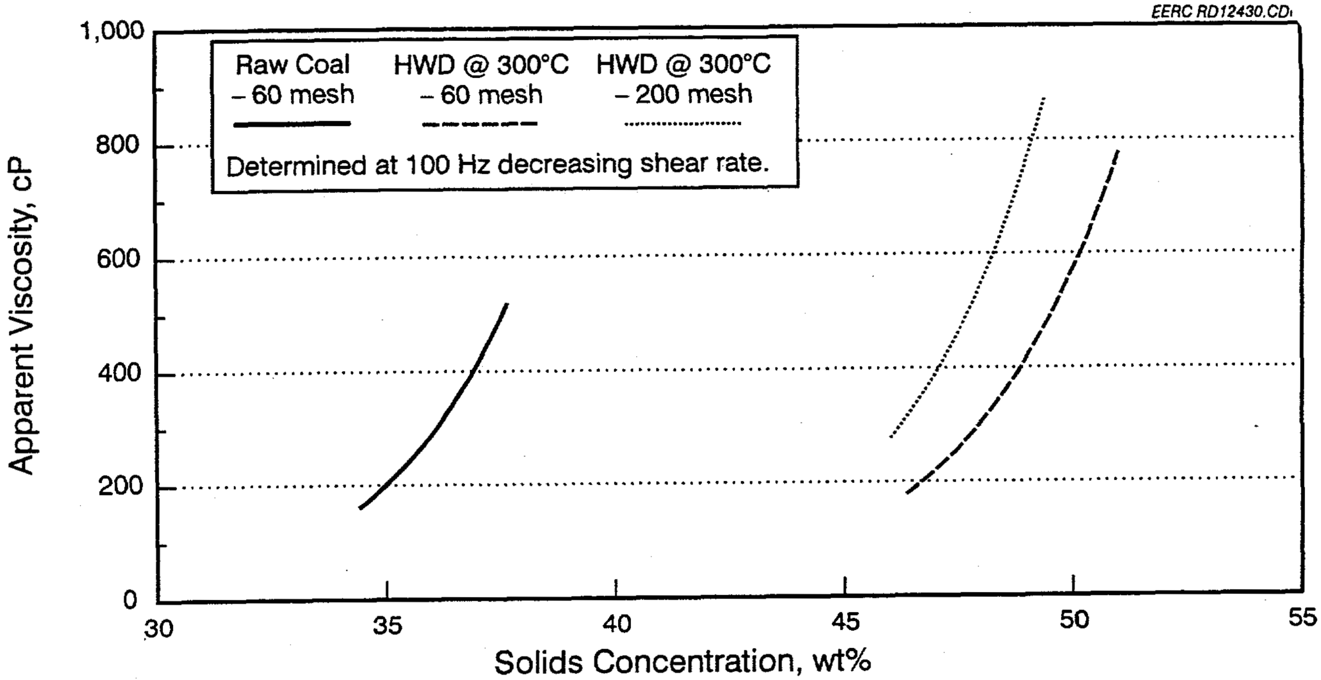


Figure 3. Rheological analysis for raw and HWD coal samples (particle-size effect).

TABLE 3

Particle-Size Distribution Analysis for Raw and HWD Samples

	Cumulative wt% under Size			
Particle Size, μm	Raw Coal	HWD, 275°C	HWD, 300°C	HWD, 325°C
500	100.0	100.0	100.0	100.0
300	100.0	100.0	100.0	100.0
150	98.2	98.0	97.9	98.5
100	89.0	88.0	87.0	85.8
70	75.1	74.1	75.2	75.0
50	64.4	62.5	60.8	63.5
25	45.4	41.6	39.0	44.0
15	32.7	27.9	26.5	31.7
10	23.1	17.6	17.3	21.5
5	9.9	6.9	7.0	9.9
2	0.5	0.2	0.2	0.4
Estimated MMD[1]	30	33	35	31

[1] Mass mean diameter or average particle size.

Table 4 contains a summary of the results from the autoclave tests performed on samples. The table contains the solids recovery and material converted to the gas and water phases. Solids and energy recoveries for each of the four samples were above 90%. Duplicate test results at 275° and 300°C illustrate the reproducibility of the procedures and their effects. Tests were performed on the HWD process water to evaluate the amount of carbonaceous material, the recyclability of the stream, and best treatment methods. Water analysis indicated that the total organic carbon (TOC), chemical oxygen demand (COD), and biological oxygen demand (BOD) concentrations increased as the temperature increased. Suspended solids decreased from 4500 to 1300 mg/L at 325°C, while dissolved solids increased from 230 to 1300 mg/L at 325°C. Gas analysis was performed using a Hewlett-Packard 5880a gas chromatograph to identify the gases produced during HWD. The results indicate that about 95 wt% of the gas evolved as CO_2. Details of the instrumentation and techniques performed on the water and gas can be located in Appendix A. Coal losses mentioned in Table 4 represent all solids that were in the process water and offgases produced during the process. It is estimated that 90% of coal losses were attributed to process gas. As temperature increased, solids recovery decreased; however, energy recovery remained high. This is likely because CO_2 represents a bulk of the loss from the dry solid that contributes no heating value.

TABLE 4

Autoclave Test Summary for HWD

Component	HWD, 275°C	HWD, 275°C	HWD, 300°C	HWD, 300°C	HWD, 325°C	HWD, 325°C
Solids Recovery, %	94.2	96.5	93.1	93.2	91.7	93.1
Coal Loss, %	5.8	3.5	6.9	6.8	8.3	6.9
Energy Recovery, %	98.7	98.7	98.5	97.9	99.9	100.3

Table 5 summarizes the proximate, ultimate, and heating value analyses for the raw and the HWD samples. The results indicate that HWD made several improvements in the coal, notably increases in heating value and carbon content and reductions in equilibrium moisture and oxygen content. The equilibrium moisture content decreased from 37.4 wt% for the raw coal to about 20 wt% for the HWD coals. The moisture-free heating value of the raw coal, 11,630 Btu/lb, increased to 12,080 Btu/lb after HWD at 275°C, and HWD at 325°C increased the heating value to nearly 12,500 Btu/lb. The increase in heating value upon HWD was caused primarily by the reduction in oxygen content from decarboxylation and mild pyrolysis. Reported heating values on an equilibrium moisture basis reflect the drying that occurred to the coal, increasing from 7280 to 9820 Btu/lb at 300°C.

Ash analysis for the HWD Thailand samples is also included in Table 5. The results indicate no substantial differences in the ash for the raw and three HWD temperature samples, except for elimination of calcium and reduction in sulfur and phosphorus concentrations. No change occurred to the ash fusion characteristics of the coal from hydrothermal treatment.

TABLE 5

Equilibrium Moisture, Proximate and Ultimate Analysis, Heating Value, and Ash Analysis for Raw Coal and HWD Coal Samples

Analysis	Raw Coal	HWD, 275°C	HWD, 300°C	HWD, 325°C
Equilibrium Moisture, wt%	37.4	23.4	19.4	21.9
Proximate, mf, wt%				
Volatile Matter	45.9	43.3	41.7	39.8
Fixed Carbon	47.6	51.2	52.0	53.7
Ash	6.5	5.5	6.3	6.6
Ultimate, mf, wt%				
Carbon	67.6	72.3	72.6	73.9
Hydrogen	4.7	4.8	4.5	4.7
Nitrogen	1.7	1.7	1.8	1.8
Sulfur	1.7	1.7	1.7	1.8
Oxygen	17.7	14.1	13.0	11.3
Higher Heating Value, Btu/lb				
Moisture-Free	11,630	12,080	12,310	12,480
@ Equil. Moisture	7280	9250	9820	9750
Ash Component, mf, wt% (as oxides)				
Silicon	35.9	40.2	38.9	39.1
Aluminum	25.1	26.5	25.8	25.5
Iron	31.2	28.2	29.7	30.0
Titanium	0.5	0.9	0.9	0.9
Phosphorus	0.8	0.2	0.1	0.2
Calcium	2.1	0.0	0.0	0.0
Magnesium	1.5	1.6	2.0	1.8
Sodium	0.2	0.2	0.2	0.2
Potassium	1.4	1.5	1.5	1.5
Sulfur	1.2	0.8	0.9	0.8
Ash Fusion, °C				
Initial Temperature	1437	NA	NA	1448
Softening Temperature	1459	NA	NA	1469
Hemi Temperature	1468	NA	NA	1506
Fluid Temperature	+1538	NA	NA	+1538

The rheological profiles in Figure 4 show the effect of HWD temperature on CWF solids concentration and viscosity. The results indicate that HWD definitely improves the solids concentration of the fuel. The differences that are observed at 275° and 325°C are attributed to decarboxylation, a greater amount occurring at the higher temperature. There is a definite improvement from HWD at 300°C compared to 275°C; however, only slight improvement between 300° and 325°C. More information on the rheology of the CWFs is located in Appendix C.

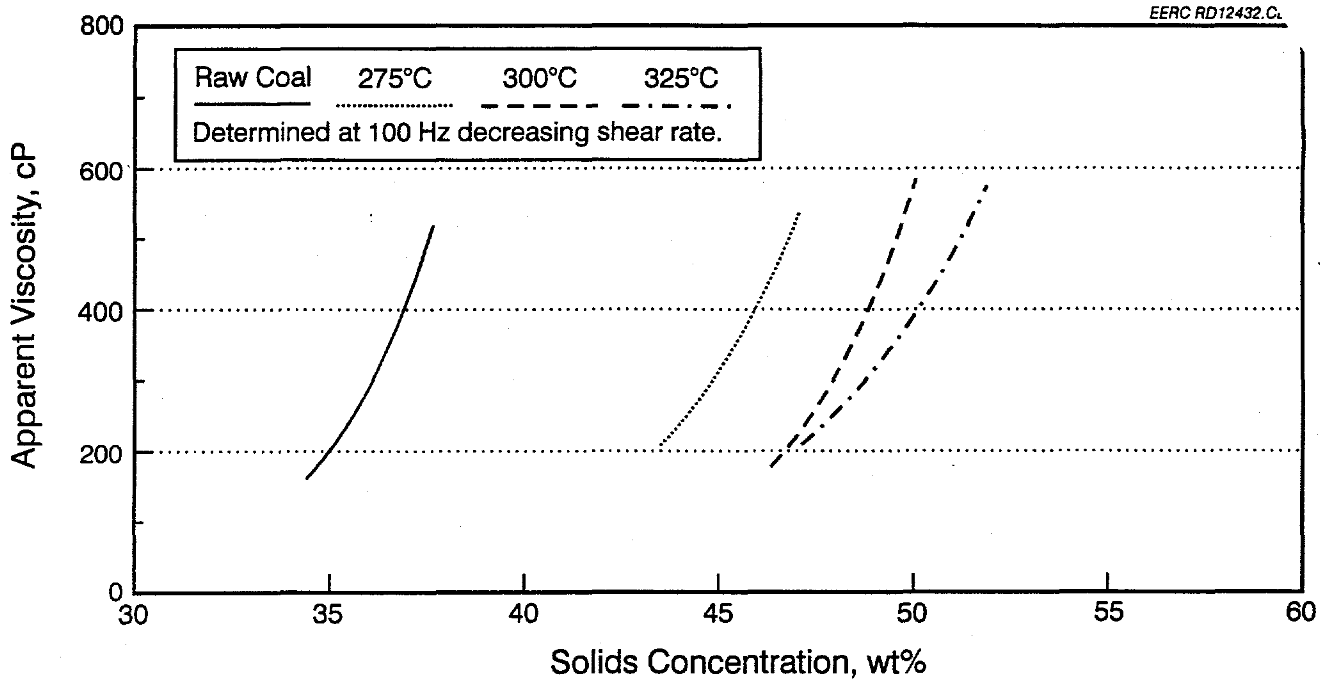


Figure 4. Rheological analysis for raw and HWD coal samples (temperature effect).

2.3 Pilot-Scale HWD

Wiang Haeng coal was processed using the 7.5-tpd HWD process development unit (PDU) shown in Figure 5. Briefly, the PDU system consists of the following major unit operations: slurry preparation, pumping, preheat, reaction, pressure letdown, product recovery, and HWD coal dewatering.

The coal to be processed is first pulverized with a hammer mill and then slurried to the desired coal-to-water ratio. A high-pressure pump, capable of pumping highly viscous feed slurries up to 2500 mPa-s is used to deliver the slurry to the preheat section at the desired system operating pressure. Slurry flow rate is controlled using a variable-speed motor.

A series of four heat exchangers is used to preheat the slurry to the desired processing temperature. A double-pipe steam heat exchanger first heats the slurry up to 80°C, whereafter the slurry is heated in a series of three condensing Dowtherm vapor–liquid heat exchangers. The nominal ratings of the electric immersion heaters are 22, 22, and 30 kW, respectively.

The slurry, after exiting the fourth preheater at the desired processing temperature, is then directed to a series of two downflow reactors. The process piping is configured to allow using a single reactor to attain a residence time of 7 minutes or both reactors to attain a residence time of

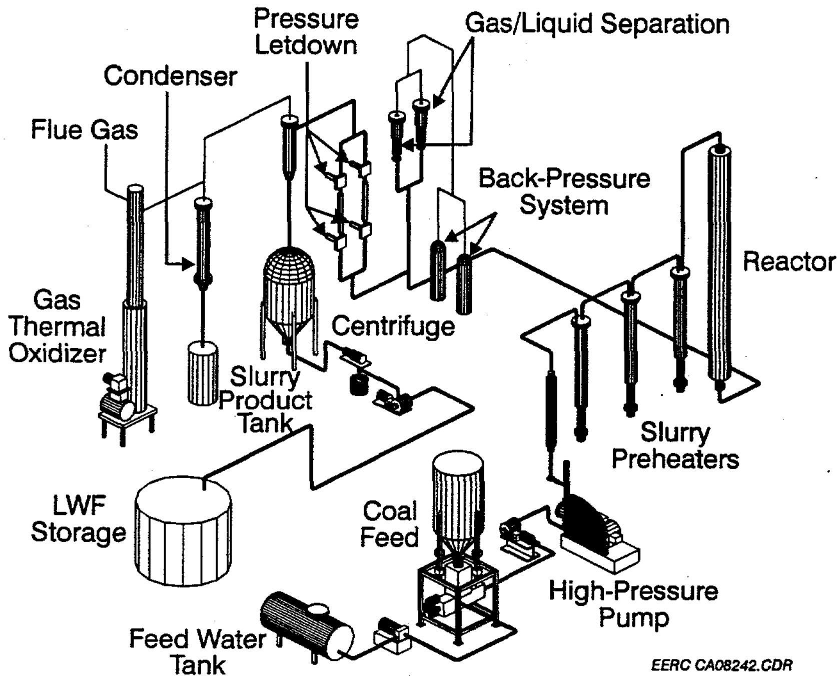


Figure 5. EERC 7.5-tpd HWD PDU.

15 minutes. Each reactor is equipped with four 2-kW externally mounted heaters to achieve isothermal temperature control.

After processing at the desired temperature and residence time, the coal slurry is throttled through pressure-reducing valves with a resultant flashing of steam and process gas. The gas–water vapor stream is cyclonically separated from the concentrated HWD coal slurry. The gas–water vapor stream is drawn through a multipass water-cooled condenser whereafter the noncondensable process gas phase is sent to a natural gas-fired incinerator fired at 800°C. Condensate is collected for possible recycle. The product slurry is dewatered using a recessed filter press, producing damp filter cake and filtrate.

2.3.1 PDU Matrix Testing

Pilot-scale matrix test parameters were based upon the results from bench-scale evaluations, discussed under Task 1 in the October to December progress report. Tests were completed at two residence times (7 and 15 minutes) and two temperatures (300° and 325°C). The Wiang Haeng coal, pulverized to 250-μm (60-mesh) top size and an average size of 30 μm, was processed at a 45%/55% coal-to-water ratio. (For more information on conditions see Appendix D).

The weights of feed slurry, product slurry, condensate, filter cake, and filtrate were collected at each test condition to facilitate calculation of overall material and solids recoveries.

A representative filter cake sample was obtained at each test condition for subsequent short proximate (moisture, ash, sulfur, and heating value) analysis. Gas chromatographic analyses were performed on select samples of process gas.

Rheological evaluations were performed by admixing the damp cake from HWD with water to produce several different fuel concentrations. The rheological behavior of the slurry fuel, including variation of apparent viscosity as a function of shear rate, was determined for three or four solids concentrations using a Haake RV 100 viscometer.

Table 6 summarizes the ash, sulfur, and heating value analysis results for the four PDU HWD samples; the raw coal is included for comparison. The results indicate that HWD made several improvements to the Wiang Haeng coal, including significant reductions in ash and sulfur contents and a modest increase in heating value.

TABLE 6

Short Proximate Analysis for Raw and PDU HWD Coal Samples

Analysis	Raw Coal	300°C 7 min	325°C 7 min	300°C 15 min	325°C 15 min
Ash, mf[1] wt%	6.5	5.4	5.6	5.3	5.5
Sulfur, mf wt%	1.88	1.47	1.51	1.59	1.61
HHV,[2] mf Btu/lb	11,630	12,230	12,300	12,300	12,380

[1] Moisture-free.
[2] High heating value.

The increases in heating value appeared to be consistent with the effect of increasing the processing temperature and/or residence time. That is, the lowest improvement in heating value was attained at the lowest residence time and processing temperature, and the greatest improvement in heating value was attained at the highest residence time and processing temperature. Processing at 325°C and a 7-minute residence time or 300°C and a 15-minute residence time produced an equivalent heating value product.

HWD produced a significant reduction in sulfur content, ranging from 22 wt% at 300°C and 7 minutes to 14 wt% at 325°C and a 15-minute residence time. The lower sulfur reduction at the most severe processing conditions would be consistent with greater coal mass loss to pyrolysis and decarboxylation relative to less severe processing conditions.

The solids recoveries for the four tests ranged from 88 to 93 wt%. These values were lower than bench-scale HWD recovery values but consistent with previous PDU operation.

The rheological profiles in Figures 6 and 7 show the effect of PDU HWD temperature (300° and 325°C, respectively) on CWF solids concentration and viscosity. The rheological profiles for bench-scale HWD at the respective temperatures are included for comparison. Similarly to bench-scale HWD, PDU processing did significantly improve the solids content (and energy density) of the Wiang Haeng coal.

Comparison of energy density (slurry basis), for fuels with a viscosity of 500 cP, showed an increase from 4360 to 5830 Btu/lb at 300°C and 6050 Btu/lb at 325°C and a 7-minute residence time. The effect of increasing residence time to 15 minutes was to further increase the heating value, resulting in slurry fuels with energy densities of 5980 and 6130 Btu/lb at 300° and 325°C, respectively.

Relative to bench-scale HWD, pilot-scale HWD produced fuels 1 to 2 wt% lower in solids loading. This can be explained by the differences in residence time achieved during batch- and continuous-scale processing. During pilot-scale testing, operating temperature is reached after approximately 2 minutes, while bench-scale heatup takes approximately 2 hours. Bench-scale fuel performance results are usually better than pilot-scale results because of the extended time in which the coal is exposed to temperatures above 200°C.

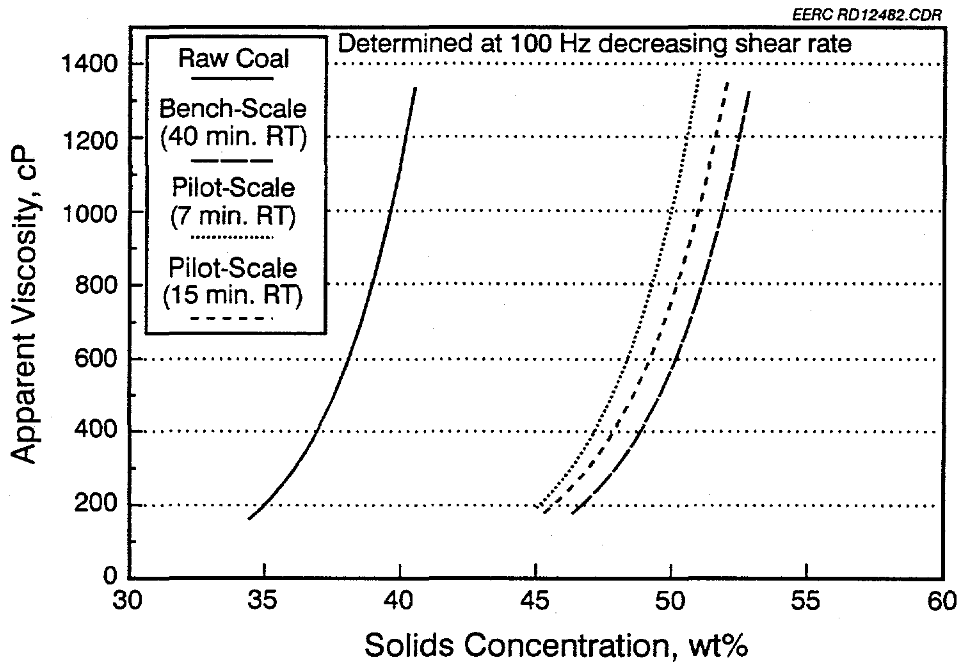


Figure 6. Rheological analysis for coal samples (bench vs. pilot scale, 300°C tests).

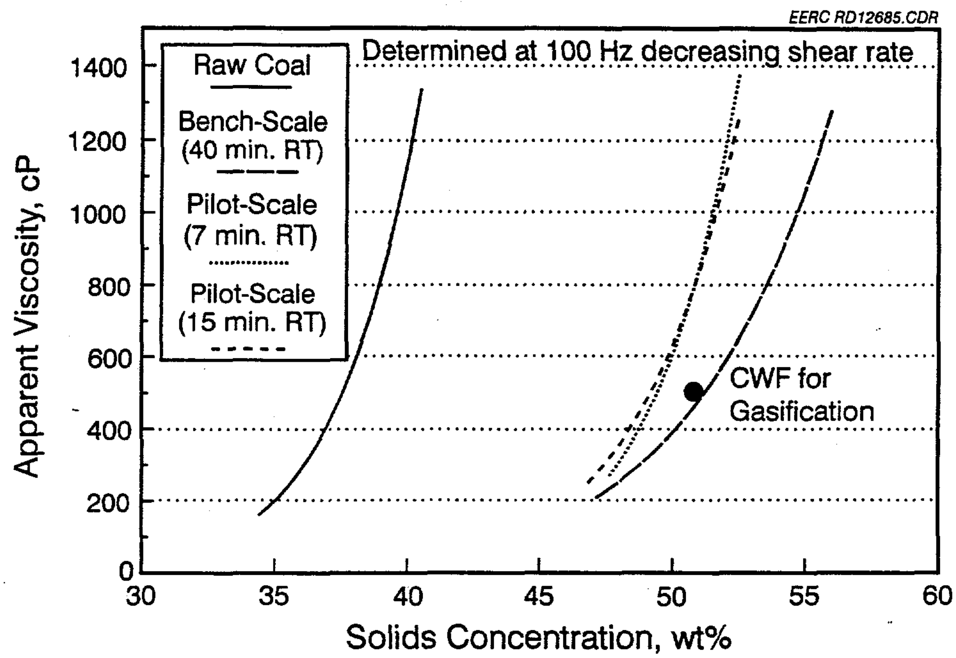


Figure 7. Rheological analysis for coal samples (bench vs. pilot scale, 325°C tests).

Process gas samples obtained during processing at 325°C (at both 7- and 15-minute residence times) were nearly equivalent in composition. Carbon dioxide was the primary component at >93 vol%, with smaller concentrations of hydrogen (~0.3 vol%), methane (~1 vol%), and carbon monoxide (~1 to 2 vol%). The balance (~3 vol%) consisted of mostly hydrogen sulfide. The quantity of process gas was not measured.

2.3.2 PDU Production Testing and CWF Preparation

A production PDU HWD test was performed at a 7-minute residence time and 325°C, processing conditions determined to be optimum from pilot-scale matrix testing. The purpose of the run was to supplement the filter cake produced at 325°C (and 7- and 15-minute residence times) in the PDU matrix tests. The solids recovery in the production test (87 wt%) fell within the range of recovery values obtained in the PDU matrix tests. (For information on conditions see Appendix D).

HWD coal produced in the pilot-scale production run and 325°C matrix tests was formulated into CWF for subsequent gasification testing. Approximately 245 kg (540 lb) of CWF was prepared with a target viscosity of nominally 500 cP. The CWF had a solids concentration of 50.8 wt% and an estimated heating value of 6200 Btu/lb. Fuels prepared in the PDU production run and matrix tests are compared in Figure 7. The proximate, ultimate, and heating value analyses are presented on a moisture-free and slurry basis in Table 7 for the raw and 325°C HWD coals. Process water analyses are presented in Table 8 for the PDU HWD test at 325°C. For more information on process water and process gas from HWD testing, consult Appendix E.

TABLE 7

Thailand CWF Analysis

Analysis	325°C HWD Moisture-Free	325°C HWD CWF	Raw Moisture-Free	Raw CWF
Ultimate, wt%				
Moisture	0.0	49.24	0.0	62.50
Volatile Matter	42.08	21.36	45.85	17.19
Fixed Carbon	51.99	26.39	47.64	17.87
Ash	5.93	3.01	6.51	2.44
Proximate, wt%				
Hydrogen	5.06	8.04	4.72	8.71
Carbon	74.56	37.85	67.55	25.33
Nitrogen	1.62	0.82	1.67	0.63
Sulfur	1.48	0.75	1.88	0.71
Oxygen	11.35	49.53	17.67	62.18
Ash	5.93	3.01	6.51	2.44
Heating Value, Btu/lb	12,210	6200	11,630	4360

TABLE 8

Process Water Analysis, mg/L

Analysis	Filtrate	Condensate
COD	1090	2650
Total Suspended Solids	370	220
Total Dissolved Solids	3860	<10
Total Organic Carbon	475	894
Total Carbon	484	1060

2.4 CWF Gasification and Utilization of By-Products

A diagram of the EERC 4-lb/hr pressurized fluid-bed gasifier utilized for gasification testing is presented in Figure 8. The properties of the CWF prepared for gasification testing were discussed in the previous section.

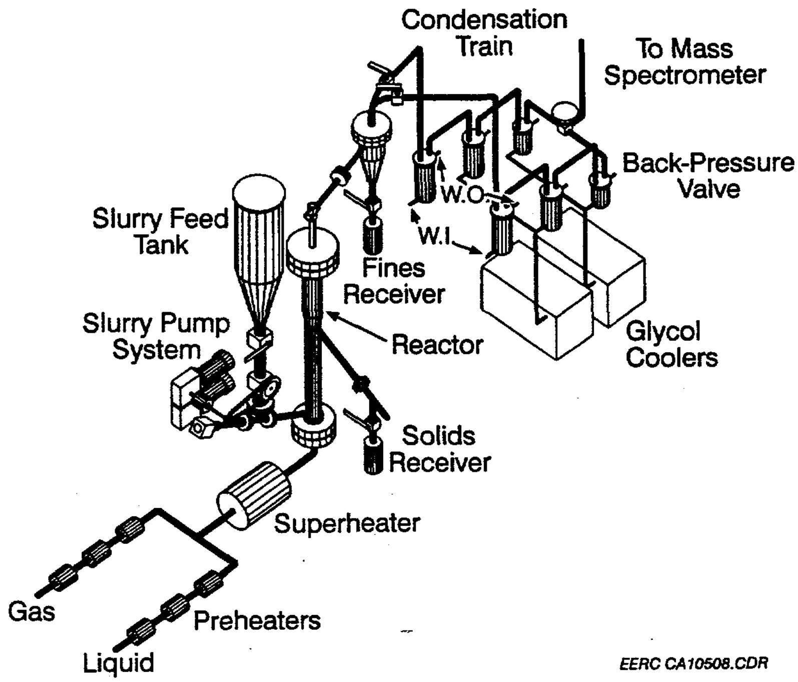


Figure 8. Continuous fluid-bed reactor utilized for gasification testing.

Difficulties were encountered in feeding the slurry into the gasifier, as solids frequently plugged the last inch of the nozzle through which CWF was injected into the gasifier. Several modifications were attempted to improve and prolong pumping, including trying different pumps, varying injection nozzle diameter, and varying injection techniques. Pluggage still occurred in as quickly as 5 minutes, with 4 hours of pumping achieved at the best conditions. This was still far short of the 12-hour run required to complete a single test point.

Consequently, the test program was modified to evaluate gasification of dry feed. Dry feed for gasification was obtained by air-drying the filter cake obtained during HWD at 325°C. The CWF initially prepared for gasification testing was not utilized for preparation of the dry feed. Tests were also conducted using ¼- × 20-mesh HWD sample. Raw Wiang Haeng coal will also be gasified to provide a comparison of the benefits of HWD.

Three tests were conducted using Wiang Haeng coal under mild gasification conditions. Two different coal sizes were used in the investigation and two steam:carbon ratios. All three tests were conducted at 700°C at 30 psig. The coal was fed to the system as a dry solid and not as a slurry because the type of gasifier used was a fluid bed, not an entrained reactor. One test (M537) used a particle size similar to the CWF reported earlier in this report, and the second (M538) and third (M539) tests were conducted on coal that was -¼ × +20 mesh. M538 was the raw coal, while M539 test was conducted on HWD sample.

M538 and M539 had complete material balances. M537 data were inconsistent, and yields could not be determined from the data due to feeding problems caused by the small particle size. Table 9 shows the test conditions from the two tests and Table 10 shows the product yields. Appendices F and G contain the full material balances and product data for Tests M538 and M539.

The temperature (700°C) selected for operation was in the mild gasification range. Products from these conditions will include a low-moisture, volatile char, minor quantities of organic liquids, and low quantities of combustible gases. As can be seen from Table 11, char production in both tests was quite high (85.9–88.4). The increased solids residence time can be seen in the decrease in char volatile content from 15% to 10%. Cyclone fines volatile content is relatively unchanged because the fine particles pass through the reactor quickly.

TABLE 9

Test Conditions

	M538	M539
Temperature, °C	699.7	694.2
Pressure, psig	29.7	29.8
Steam:Feed Ratio	1.86	2.53
Fluid Velocity, ft/s	0.72	0.72
Solids Res. Time, min	66	89

Gas production was approximately 30% based on maf feed. There was a net loss of water from the process, which indicates that the water–gas shift reaction was occurring. Hydrogen production was very high, accounting for 57%–59% of the total gas production. No clear conclusion can be made on the impact of HWD the coal prior to gasification because of the differences in gasification conditions.

The significance of the test results cannot be fully evaluated without determining the final goal of the process: electrical production, char production, etc. In mild gasification, a high quantity of char was produced in a volatile range that is appropriate for the conditions stated. Organic tars were not analyzed for, so an estimate of binding for briquettes cannot be done. The conditions tested did not evaluate the potential for gasification for electrical production; however, the tests did indicate that the coal is probably similar to other low-rank coals and will produce high levels of hydrogen and be fairly reactive. A specific match for a particular gasifier (entrained, fluid bed, agglomerating, etc.) cannot be made without defining further process goals or products.

TABLE 10

Product Yields

	M538	M539
maf[1] Char Out	85.9	88.4
H_2O	-17.7	-23
Ash	0.9	3.6
Gas	30.9	31
Total	100.0	100
Gas Production		
H_2	0.2692	0.3297
CO_2	0.1159	0.0861
C_3H_6	0.0041	0.0030
H_2S	0.0028	0.0059
C_2H_4	0.0069	0.0059
C_2H_6	0.0028	0.0030
N_2	-0.0014	0.0059
CH_4	0.0566	0.0861
CO	0.0179	0.0386
Total, std. m^3/kg	0.4748	0.5642

[1] Moisture and ash-free.

TABLE 11

Product and Cyclone Char Proximate Analysis

			Product		Cyclone	
	AR Coal	mf Coal	M538	M539	M538	M539
Moisture	31.00	----	0.60	0.40	2.40	4.60
Volatiles	31.64	45.85	15.11	10.11	18.31	17.61
Fixed Carbon	32.87	47.64	76.89	79.86	70.27	65.31
Ash	4.49	6.51	7.40	9.36	9.02	12.49

2.5 Interactive Training

The interactive training program, designed to provide first-hand experience with bench- and pilot-scale coal upgrading processes, was completed during the period from February 4 to 23. A calendar showing the training activities of DMR personnel is presented in Figure 9.

Mr. Somchai from the Thailand DMR observed bench-scale demonstrations in float–sink washability testing, autoclave HWD, CWF preparation and rheological evaluation, pressurized fluid-bed gasification and pilot-scale demonstrations in dense-media physical cleaning, PDU HWD, and roll-press briquetting. Further, Mr. Somchai, Mr. Kriangkrai, and Mr. Navee completed comprehensive tours of the EERC's laboratory and combustion facilities.

Although not part of the experimental test program, procedures and results were presented for the pilot-scale physical cleaning and briquetting demonstrations. Approximately 150 lb of Wiang Haeng coal was sized to ¼-in. top size using a roller mill and then screened at 850 μm (20 mesh). The sized coal was subjected to dense-media physical cleaning using a cone-type separator with a nominal capacity of 150 kg/hr (330 lb/hr). Pulverized magnetite, sized at 70 wt% < 45 μm (325 mesh), was used to produce a specific gravity of 1.25 to 1.30. The process was not optimized for the Wiang Haeng coal.

The recoveries of float, sink, and -850-μm (-20-mesh) coal were 62, 30, and 8 wt%, respectively. The ash contents of the float and sink were 6.2 and 25.3 wt% mf, respectively, which compares to 6.5 wt% mf for the as-received Wiang Haeng coal. The results indicate a concentration of ash-bearing minerals in the sink, although the float product did not produce a commensurately lower ash value.

Roll press briquetting demonstrations were performed using the float and sink products from physical cleaning as well as the HWD coal produced during the interactive training demonstration PDU test. Two briquetting tests were performed with the float product, and one test each was performed with the sink and HWD coal fractions. Nominally 8 wt% (dry basis) of a pregelatinized commercial potato starch was used as binder for each test.

The feed (coal and binder) was blended using a batch cement mixer and then densified using a double-roll press briquetter operated with a separation force of 15 tons. Approximately 50 lb (25 kg) of material was processed in each test. The briquettes were air-dried and then stored; no analysis was performed on the briquettes.

CHAPTER 3. STORAGE AND TRANSPORTATION OF CWF

The EERC conducted an initial review of the selected CWF's handling properties. Specifically, the storage and transportation properties for given fuels were evaluated. Storage properties were evaluated using a rod penetrometer test which measures the static stability of the quasi-liquid fuel over time. Pumpability of the slurry fuels was determined based primarily on the rheological profile of the CWF.

3.1 CWF Pumpability Review

The theoretical flow behavior analysis of CWFs indicates that although substantial advances in the technical understanding have taken place in the past few years, the three non-Newtonian categories (power law, yield power law, and Bingham plastic) remain distinct. Non-Newtonian pipeline design methods and techniques which work with one rheological category cannot be applied to another. Laboratory test data are mandatory for credible pipeline design, because the rheological properties of a slurry prepared from any particular coal can be affected by even small concentrations of common contaminants. Theoretical analysis should be carried out, particularly in

FEBRUARY 1996

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4 •Arrived in Grand Forks •Received EERC Biennial Report	5 •Arrived at Center •Introduction to Key Personnel	6 •Slide Presentation on EERC •Tour of Facility	7 •Reviewed Interim Report •Reviewed Conversion Technologies •Slide Presentation on HWD	8 •Reviewed Video Tape of Project •Discussed European CWF Project	9 •Reviewed Gasification System •Technical Journals and Publications •Prepared for Fielding Testing	10
11	12 •Float -Sink Testing •HWD Autoclave Test •Rheology Test •Reviewed Coal Deposits	13 •Physical Cleaning with Dense-Medium System •Collected HWD Products from Autoclave	14 •Reviewed Results from Cleaning •Conducted HWD Pilot Testing •Prepared Briquettes	15 •Recovered Products from HWD Pilot-Scale Testing •Continued Briquetting Coal Samples	16 •Reviewed Week-Long Activities •Discussed Gasification Program	17
18	19 **President's Day**	20 •EERC Review and Tour •Witness Gasification Testing •Problems with Gasification Feed System	21 •Problems Continue with Gasification Testing •Reviewed Gasification/Combustion Options •Reviewed Video Tape on Alaksan CWF Project •Reviewed Video Tape on Thailand Project	22 •Problems Continue with Gasification Testing •Reviewed CWF Testing •Reviewed Next Interim Report •Discussed Future Program Activities	23 •Reviewed Briquetting Information •Continued Discussion with Future Programs •Continued Discussion on Coal Deposits •Discussed Mercury Emissions Relating to Produced Water from Gas Wells •Discussed EERC Mercury Projects and CATM Program	24
25	26 •Reviewed Gasification Systems •Discussed Petroleum Exploration and Production •Discussed Contaminated Water Testing •Discussed Mercury in Soil and Freshwater	27 •Reviewed Gasifiers for Commercialization	28	29	NOTES:	

Figure 9. DMR personnel training activities for February 1996.

situations where an initial assessment is required. Identification and understanding of all variables and their impacts on the coal's stability and rheology are essential for developing design guidelines for transportation and utilization of the CWF.

Based on the rheological performance and computer simulation, pressure-drop analysis indicates that, for coal slurry pipeline transport, high-pressure positive displacement pumps may be used. The size and number of pump stations were determined using a computer program for non-Newtonian fluids developed at the EERC to analyze a frictional pressure drop. The pumping pressure requirements of the simulated slurry pipeline system were calculated from the following inputs: slurry flow rate, slurry solids loading, density, PSD, pipe size, distance of transport, and transport route. The program outputs included pump station power requirements and energy required for slurry transportation.

The pump station power requirements and energy requirements are presented in Figures 10 and 11, respectively, for the raw, 275°, 300°, and 325°C CWFs. The positioning of these pump stations was dependent upon the terrain crossed, the line size, and the economic balance between multiple pump stations and requirements for high-pressure design. Pump stations were spaced at 100- to 150-km intervals, which means that acceptable energy input requirements ranged from 15 to 30 kW/mile or 0.04 to 0.08 kWh/ton-mile. At these energy requirements, the solids concentrations for the four fuels represented in Figures 10 and 11 are 36.1, 44.9, 47.9, and 48.8 wt% for the raw coal, 275°, 300°, and 325°C HWD slurry fuels, respectively, at an approximate viscosity of 300 cP.

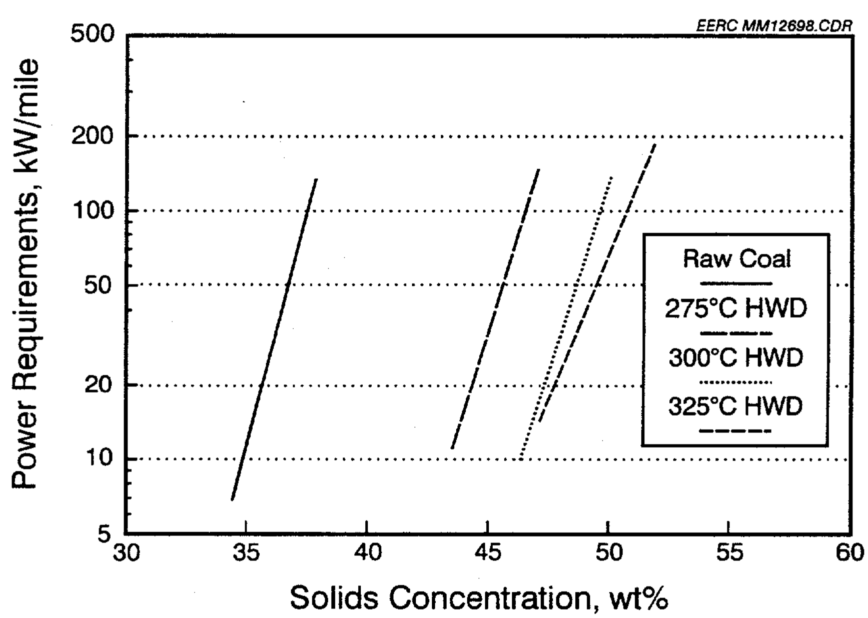


Figure 10. Pump requirements for transporting 3.5 MM tons/yr of Wiang Haeng coal CWF.

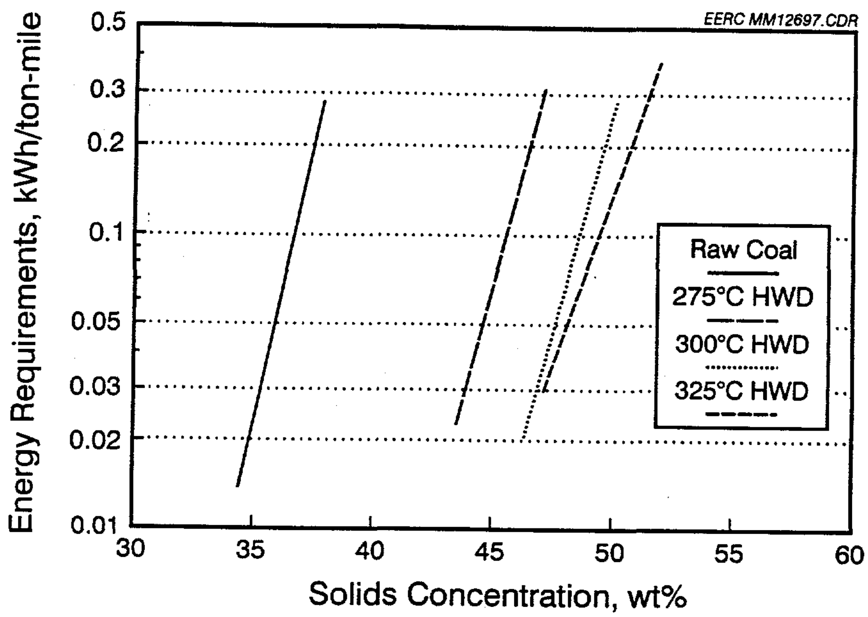


Figure 11. Energy requirements for transporting 3.5 MM tons/yr of Wiang Haeng coal CWF.

3.2 CWF Stability Assessment

A major thrust of the development work at the EERC has been to establish economically viable methods to improve the energy density of the CWF without relying on expensive additives to stabilize CWF. The enhanced technology is a proprietary EERC procedure applied either before or after HWD treatment which relies on mechanical means, not chemicals, to alter the coal surface to enhance the attainable solids by 3 to 5 wt%, compared to just HWD. Figure 12 reflects the comparison of raw coal slurry to enhanced HWD processed fuel. The density, determined at 500 cP, indicates an increase from 4450 to 6650 Btu/lb. In addition, the enhanced fuel, as indicated in Table 12, had stability properties far superior to those of the other fuels. Table 12 indicates the results from the rod penetrometer testing to determine the stability of the CWFs. Tabulated numbers represent the percentage relative to the distance that a rod of certain dimension travels through a coal slurry just after mixing and after various amounts of time: the lower the percentage, the more coal settling. In relation to the stability of the raw coal slurry, the HWD fuels appeared to be less stable over the same time period. More information on the instrument used to perform particle-size analysis and the rod penetrometer method is contained in Appendix A. This information is an initial evaluation of handling properties. To further understand CWF stability, a complete assessment of dynamic and static properties should be conducted using a pipeloop system and conventional storage methods.

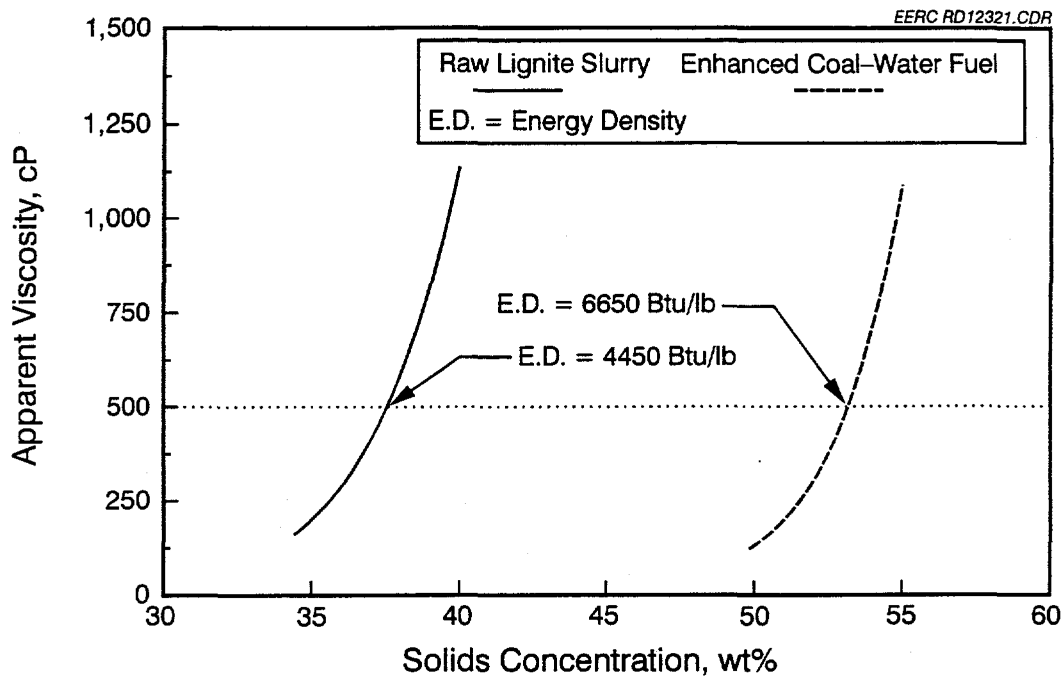


Figure 12. Rheological results for raw coal slurry and enhanced CWF.

TABLE 12

Rod Penetrometer Test Results on Raw and HWD Samples

	% Penetrated			
Time, hours	Raw Coal	HWD, 300°C	HWD, 325°C	HWD, 325°C En[1]
1	97.4	100.0	91.7	100.0
5	89.5	77.1	61.1	86.1
8	89.5	62.9	44.4	86.1
24	73.7	40.0	33.3	61.1
29	71.1	5.7	0.0	5.6
31	57.9	0.0	0.0	0.0
48	0.0	0.0	0.0	0.0

[1] Enhanced CWF.

CHAPTER 4. CONCEPTUALIZED CWF DEVELOPMENT PLAN

Initial efforts by the EERC and DMR have focused on the hot-water-drying technology and its immediate applications. No research has been conducted on the potential site, economics, or marketability of the products. If the coal quality and product specifications are achieved, the next stage of development would be to complete a process review for a specific site; this includes the following:

- Evaluate site and coal reserves
- Establish coal processing capacities based on available raw materials and utilities
- Develop process flow diagram for selected site
- Conduct process economic review
- Review market potential for CWF

After these results are compiled and if the indications are still favorable, developers then need to consider a process demonstration system. This intermediate stage will allow individuals to review process conditions and refine economic and market projections. The EERC offers technical assistance for nearly all aspects of process development. Its role in future development may include technical oversight and technology transfer. Technology transfer is a critical component to the successful project for advancing countries such as Thailand. The EERC has completed numerous training courses for new technologies and has critical insight into the fabrication and operation of hot-water-drying systems and CWF formulation. As technology developers, the EERC will provide input to the selected contractors for the design, fabrication, shakedown, and operation of future demonstration or commercial facilities.

CHAPTER 5. CONCLUSIONS

- Approximately 600 kg of Wiang Haeng coal was received at the EERC for testing.

- HWD enhanced the energy density of a pumpable Wiang Haeng coal slurry by 50%.

- Approximately 250 kg of HWD coal–water fuel was successfully produced using pilot-scale system.

- The existing EERC bench-scale gasification system had difficulties feeding finer grind coal.

- Gasification tests were successfully completed using larger size (6.35 × 00 mm) raw and HWD coal.

- Results from gasification tests indicated gas production was approximately 30% of the feed, with hydrogen production accounting for over 50% of the total gas production.

CHAPTER 6. RECOMMENDATIONS

Based on the success of CWF experiments, the next stages of development may include testing new coals or testing CWF in a combustion system. Also, additional data are required to evaluate the storage and transportation properties of the CWF. Continued success may lead to extended pilot-scale testing and eventually to commercial demonstration in Thailand.

Specific tasks the EERC and DMR may consider for future gasification program development include the need to define products for specific gasifier types: slurry fuel, solid fuel product (briquettes, fine char), synfuel, or electrical production. Future product testing may include an evaluation of the amount of gas, char, and tar produced at various temperature conditions. Bench-scale tests would then be conducted to optimize tar production versus volatile content of the char. In order to consider synfuel and electrical production opportunities, laboratory tests may include thermogravimetric analysis matrix testing to investigate steam reactivity. Also, a more thorough ash characterization would be needed to assess slagging characteristics.

APPENDIX A

ANALYTICAL EQUIPMENT AND PROCEDURES

ANALYTICAL EQUIPMENT AND PROCEDURES

The Energy & Environmental Research Center (EERC) has researched numerous drying and conversion technologies that can be applied to coal and subbituminous coals to upgrade the quality of the coal. Table A-1 summarizes the test procedures used to analyze the coal samples for this project.

TABLE A-1

Analytical Equipment and Procedures

Analysis	Equipment	Procedure
Hot-Water Drying	Two-Gallon Autoclave	NA[1]
Fuel Viscosity	Haake® 100 Rotoviscometer	NA
Static Stability	Rod Penetrometer	
Particle Size	Malvern® 2600c Laser Diffraction	NA
Gas Analysis	Hewlett-Packard® 5880a Gas	
Carbon	Leco® CHN 600 Analyzer	NA
Hydrogen	Leco® CHN 600 Analyzer	NA
Nitrogen	Leco® CHN 600 Analyzer	NA
Sulfur	Leco® Induction Furnace	ASTM D3177
Sulfur Forms	NA	ASTM D2492
Equilibrium Moisture	NA	ASTM D1412
Moisture	Fisher® Coal Analyzer	ASTM D3175
Volatile Matter	Fisher® Coal Analyzer	ASTM D3175
Ash	Fisher® Coal Analyzer	ASTM D3174
Ash Characterization	Kevex® Energy-Dispersive	
Combustion Behavior	Drop-Tube Furnace (DTF)	NA

[1] Not applicable.

PROXIMATE AND ULTIMATE ANALYSIS

Proximate analysis (moisture, ash, volatile matter, fixed carbon) was performed on the raw and treated coal using a Fisher® coal analyzer. The instrument determines moisture at conditions specified in American Society for Testing and Materials (ASTM) Method D3175. Volatile matter is determined by heating the dried sample to 950°C in a nitrogen atmosphere at conditions specified in ASTM D3175. The sample is covered during this process in order to exclude oxygen and prevent the sample from being ashed. Following the volatile matter determination, the sample is uncovered and combusted, and the ash is determined at conditions specified by ASTM D3174. Fixed carbon is determined by difference, following the previously described methods.

Ultimate analysis determines carbon, hydrogen, nitrogen, sulfur, oxygen, and ash content in a sample. Carbon, hydrogen, and nitrogen (CHN) content are determined using a Leco® CHN-600 analyzer. Carbon and hydrogen are determined by infrared cells, and elemental nitrogen is measured by a thermal conductivity cell. This method gives the total percentages of CHN in the organic sample as analyzed and includes the carbon in carbonates and the hydrogen in the moisture and in the water of hydration of minerals. Sulfur is determined using a Leco® SC-132 sulfur analyzer in which a sample is combusted in oxygen, forming sulfur dioxide, which is determined by an infrared cell detector. Ash is determined by the ASTM method described under proximate analysis. Oxygen is determined by difference in order to achieve a balance of the ultimate analysis. Forms of sulfur are determined according to ASTM D2492. Ash characterization is determined using x-ray fluorescence techniques using the equipment in Table A-1.

RHEOLOGICAL CHARACTERIZATION

The rheological properties are determined based on the Yield Power Law equation for fluids. The Haake® RV 100 viscometer, shown in Figure A-1, is used to measure the flow properties of various liquid fuels from shear rates of near zero to 1100 sec^{-1} (Hz) over a temperature range of 4° to 95°C. Results from the Haake® are logged and compiled using a computer network system. annular space between the rotating cylinder and a stationary cup. The torque necessary to rotate the cylinder at a given speed is measured by a torsion spring. Various rotor assemblies allow the

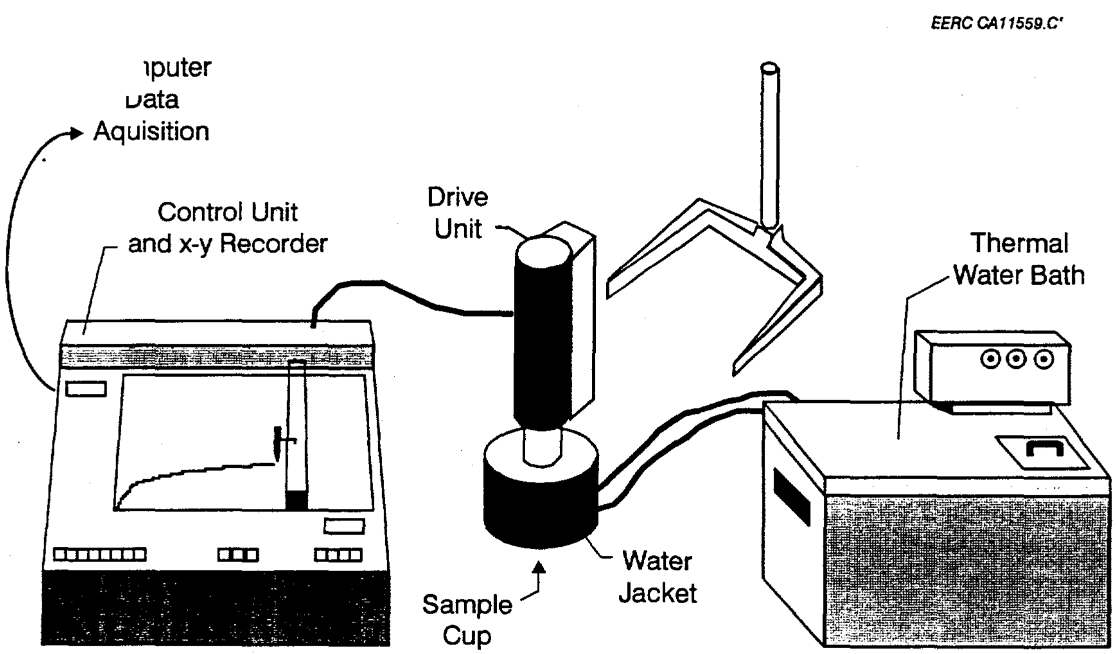


Figure A-1. HAAKE® rheological measuring equipment.

The computer indicates the independent flow behavior, viscosity, and yield stress values for the fluid as each correlates to the Yield Power Law. The Haake® viscometer shears the slurry in the user a complete profile of the rheological characteristics. Rheological data are used to assess the effect of the hot-water drying (HWD) process variables on the relationship between viscosity and dry solids concentrations.

PARTICLE SIZE

The particle-size distribution of the raw and HWD coal is determined using a Malvern® 2600c laser diffraction particle-size analyzer, capable of measuring particle sizes from 0.5 to 564 microns. Figure A-2 depicts the Malvern® instrument setup. The basic principle of the Malvern® involves a He–Ne low-power visible wavelength laser that is first expanded and spatially filtered to provide a clean parallel beam. As particles pass through the beam, they scatter or diffract the light at different angles, depending upon their diameter; large particles scatter at small angles and vice versa. The scattered light is collected by a lens and brought to focus on a multielement solid-state detector that simultaneously measures the light at a number of angles. During analysis, the sample particles move rapidly through the laser beam. The results indicate the volume percentage distribution, as well as report the average particle size.

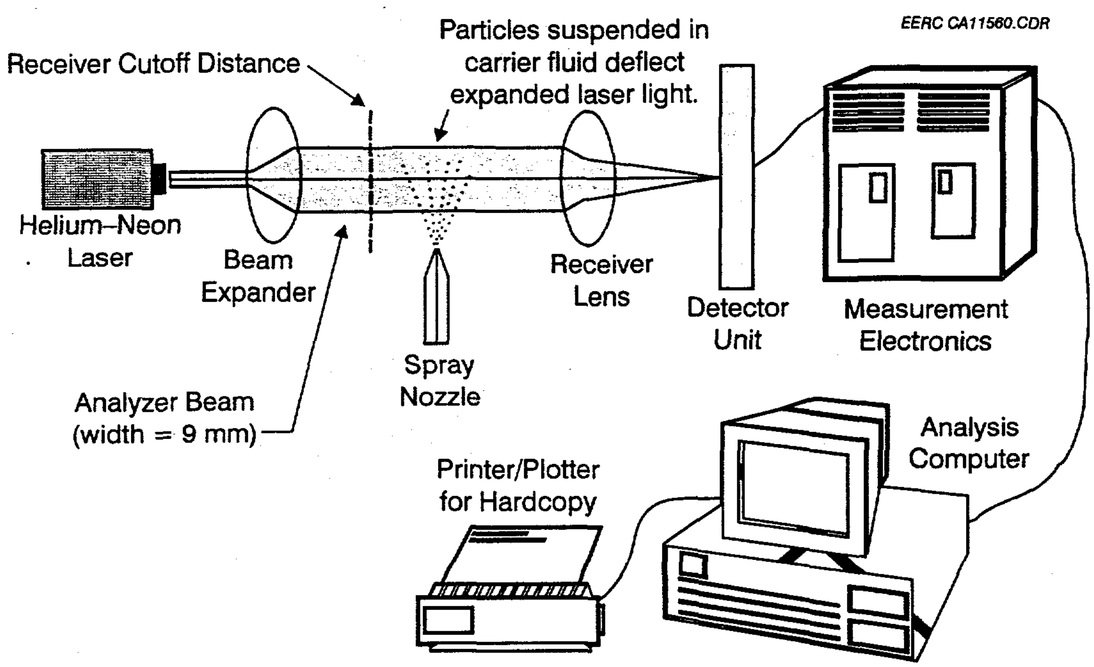


Figure A-2. Malvern® instrument setup.

ROD PENETRATION TEST

The rod penetration test is a static stability method that was developed for coal-liquid slurries. It is based on the distance a glass rod travels through the slurry in comparison to the maximum distance through the slurry. The method involves suspending the glass rod above the slurry and then slowly lowering into the slurry until the rod stops moving. Then a visual measurement using a level and a ruler is taken to determine the amount of penetration. Penetration was calculated according to the following equation:

$$\% \text{ Penetration} = d/d_T \times 100$$

where:

d = distance of rod travel (cm)

$d = d_t$ = maximum distance of rod travel (cm)

EQUILIBRIUM MOISTURE

The moisture contents of the raw and HWD coals as a function of incubation time are determined using a standard or modified ASTM equilibrium moisture method. The standard equilibrium moisture tests use an incubation time of 3 or 4 days, while the modified test uses incubation times of 2 to 30 days. The extended time period is used because the standard 3 or 4 days is often too short to allow the raw and HWD low-rank coals to attain an equilibrium moisture.

PROCESS WATER ANALYSIS

Various tests are performed on the process water produced during HWD to evaluate the amount of carbonaceous material, the recyclability of the stream, and treatability. The most widely used parameter of organic pollution applied to both wastewater and surface water is the 5-day biochemical oxygen demand (BOD) test. The BOD test is completed on the water sample to measure the oxygen required for the biochemical degradation of organic material and the oxygen used to oxidize inorganic material. The BOD is computed from the difference between initial and final dissolved oxygen. The chemical oxygen demand (COD) test is used to measure the content of organic matter of both wastewater and natural waters. The COD of a waste is, in general, higher than the BOD because more compounds can be chemically oxidized than can be biologically oxidized. For many types of wastes, it is possible to correlate COD with BOD. This can be very useful because the COD can be determined in 3 hours, compared to 5 days for the BOD. Once the correlation has been established, COD measurements can be used to good advantage for treatment plant control and operation. Total organic carbon (TOC), another means for measuring the organic matter present in water, is especially applicable to small concentrations of organic matter. To determine the quantity of TOC, the organic molecules must be broken down to single carbon units and converted to a single molecular form that can be measured quantitatively. TOC methods utilize heat and oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants to convert organic carbon to carbon dioxide. Total carbon (TC) is determined by taking a quantity of sample and analyzing directly using an infrared carbon analyzer. In order to determine TOC, the sample must be sparged of the inorganic carbon (IC). Total solids determination is also performed on the sample. This includes total dissolved solids (TDS) and total suspended solids (TSS). TSS includes the portion of total solids retained by a filter, and TDS is the portion of the total solids that passes through the filter.

GAS ANALYSIS

Gas analysis is evaluated using a Hewlett-Packard® Model 5880a gas chromatograph with a refinery gas analyzer package used to detect selected gases in process gas samples. The method of detection is based upon relationships of thermal conductivity of the various gas compounds. The refinery package consists of five different absorbing columns and four heated valves for column switching. The instrument uses two carrier gases, and hydrogen is used for the determination of CO_2, CO, O_2, N_2, H_2S, and carbon chains C_1 through C_5 hydrocarbons. Argon is used for the determination of helium and hydrogen.

WIANG HAENG COAL–WATER FUEL PROGRAM

A total of six tests were performed; variables evaluated included particle-size distribution and treatment temperature. The HWD-treated solids were then reslurried in water and evaluated for size distribution and rheological performance. The particle-size distribution is important, because if the particles are too large, there will be more void spaces and lower packing efficiency, resulting in a decreased fuel solids concentration. The rheological behavior for the coal–liquid mixture, specifically the apparent viscosity, was determined as a function of shear rate and CWF solids concentrations. Since any change in solids loading of a coal–water fuel has a direct effect on the resulting flow behavior, several rheograms throughout the possible solids loading range were gathered. Table A-2 summarizes the characterization protocol for products of hydrothermal treatment.

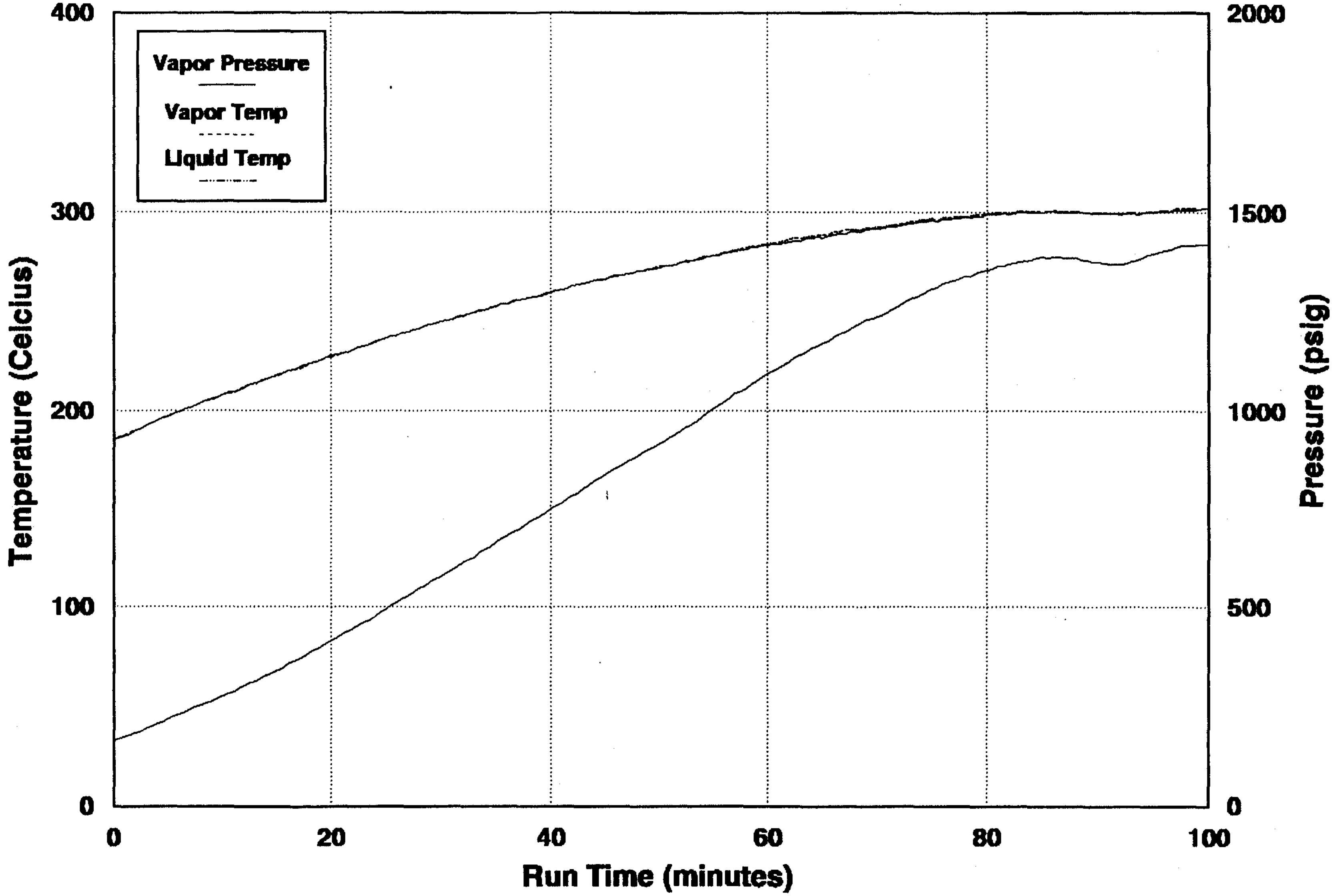
TABLE A-2

Analysis Protocol for Products of Wiang Haeng coal Hydrothermal Treatment

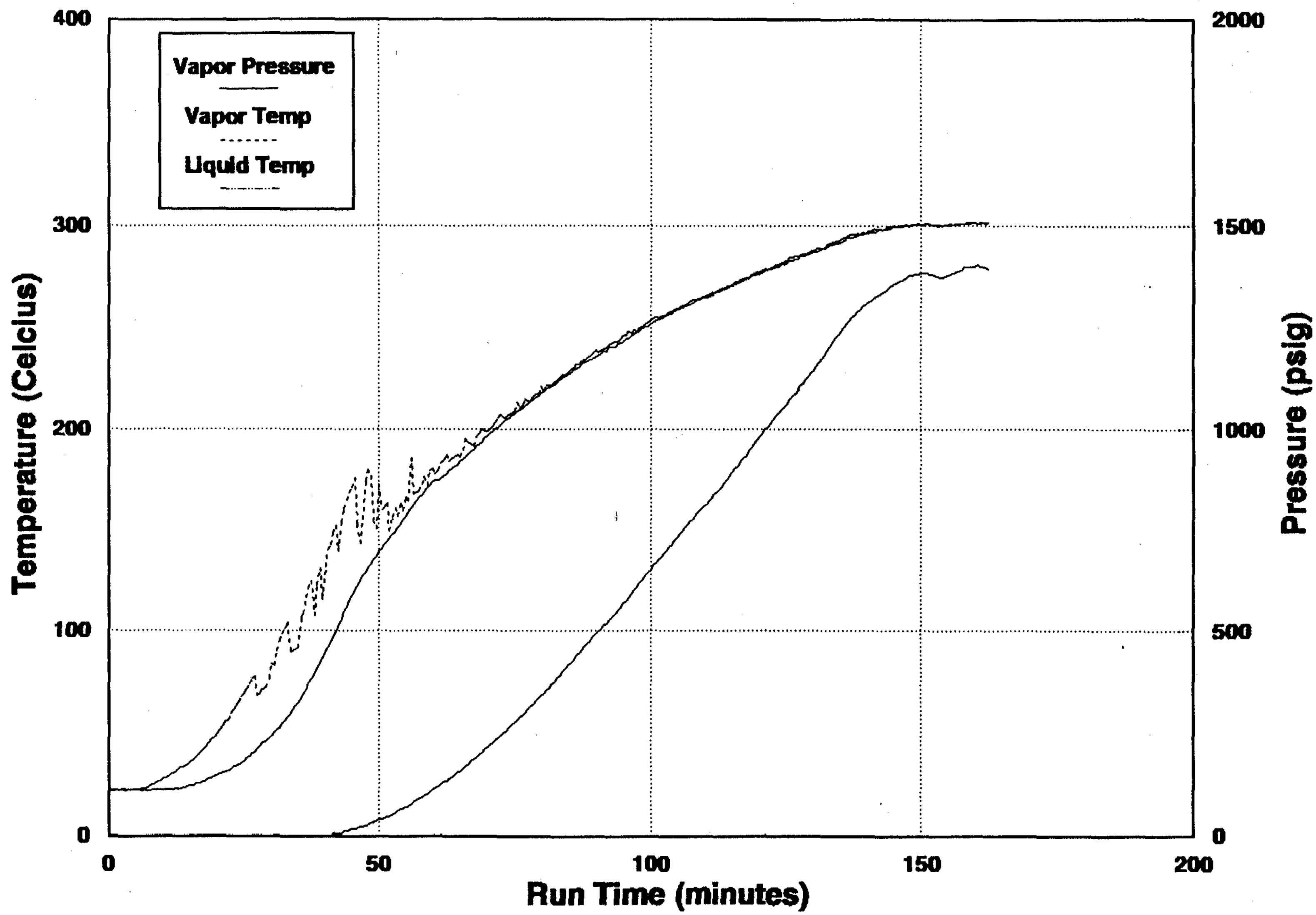
Analysis	275°C	300°C	325°C
Filter Cake			
Proximate	✓	✓	✓
Ultimate	✓	✓	✓
Heating Value	✓	✓	✓
Ash Chemistry	✓	✓	✓
Ash Fusion		✓	✓
Particle Size	✓	✓	✓
Slurry Fuel			
Rheology	✓	✓	✓
Stability	✓	✓	✓
Process Water			
TDS	✓	✓	✓
TSS	✓	✓	✓
COD	✓	✓	✓
BOD	✓	✓	✓
TOC	✓	✓	✓
TC	✓	✓	✓
Process Gas			
Composition	✓	✓	✓
Molecular Weight	✓	✓	✓
Specific Gravity	✓	✓	✓

APPENDIX B

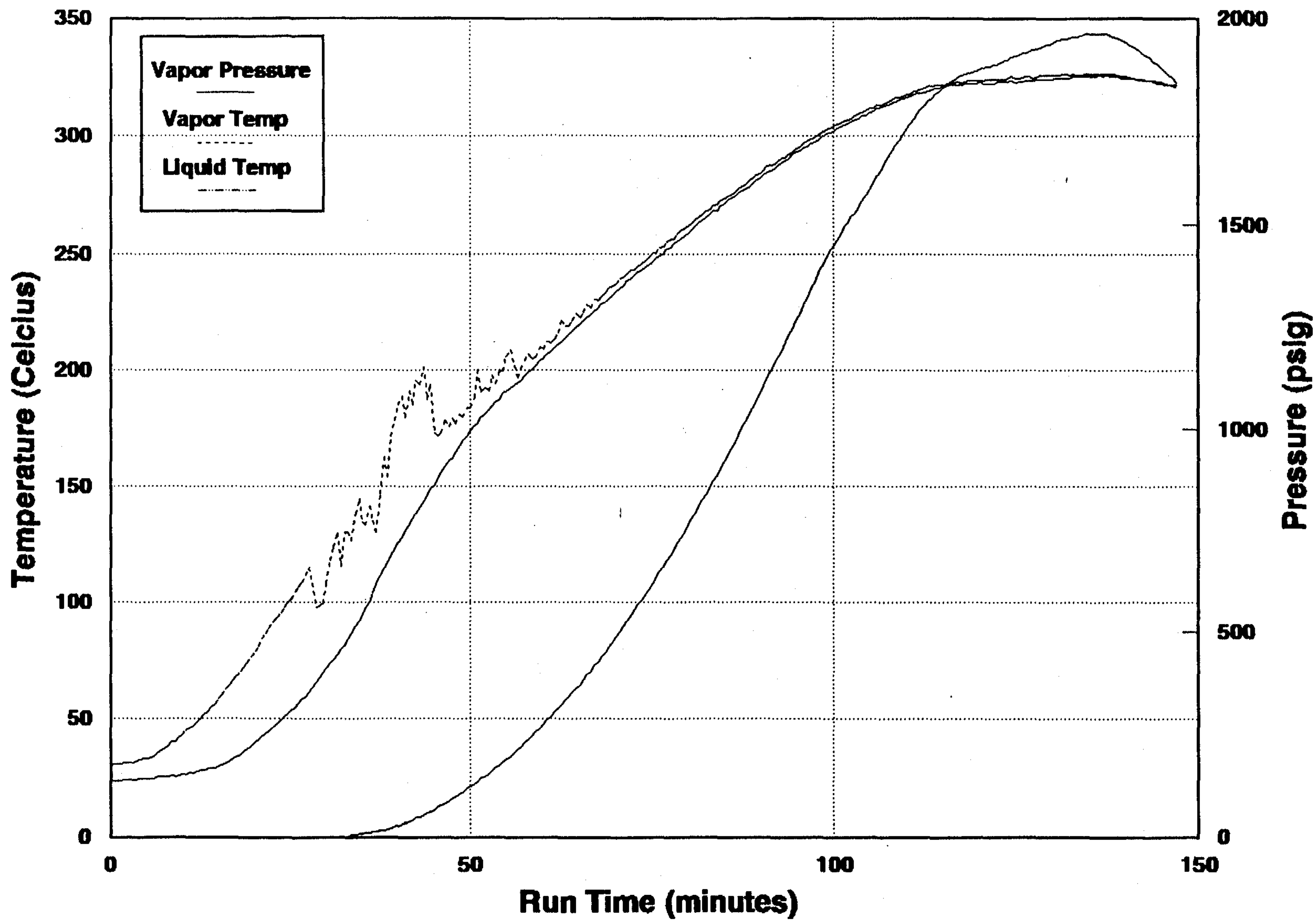
AUTOCLAVE TEMPERATURE AND PRESSURE TRENDS



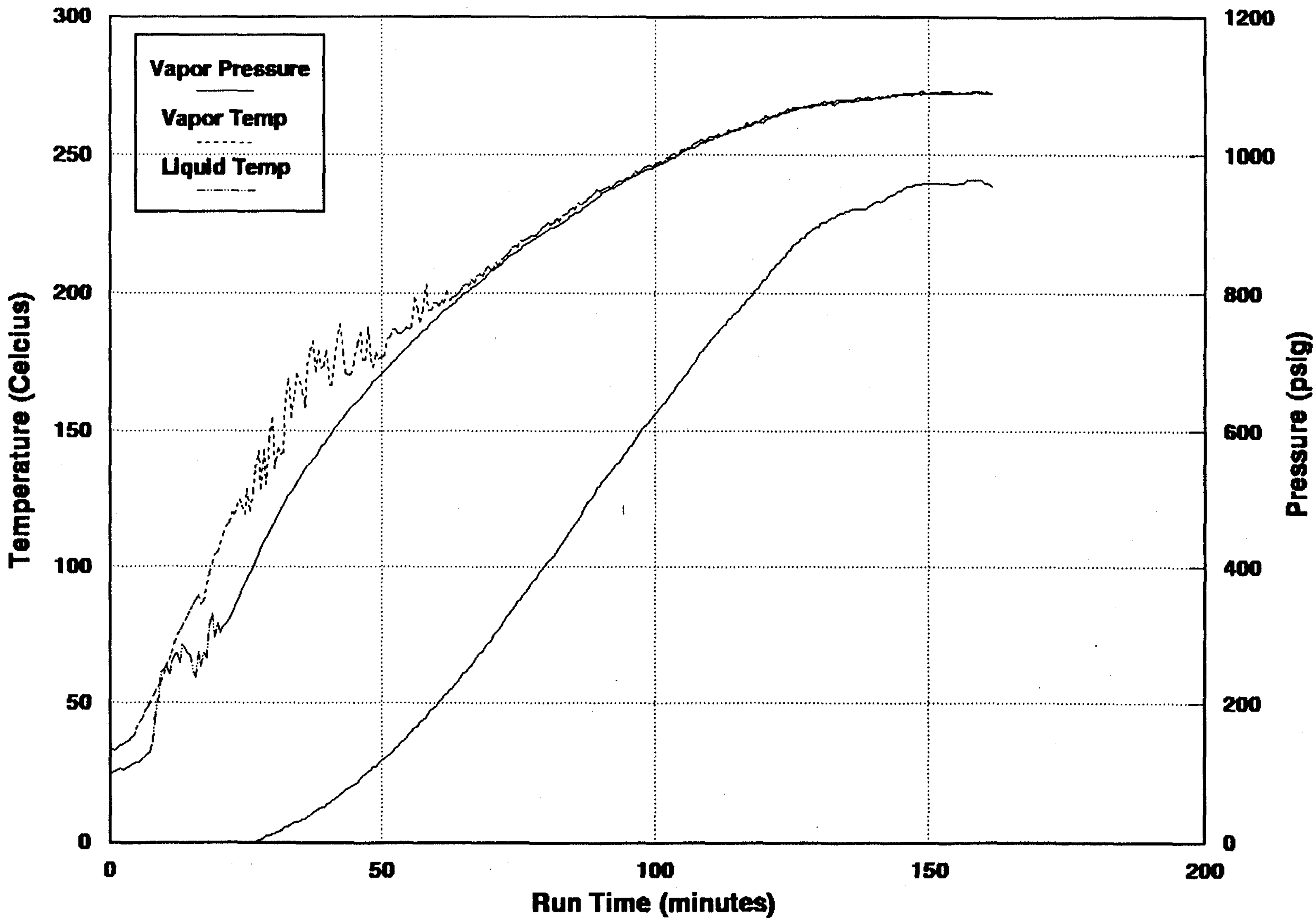
Sample Material: Thailand Lignite (DMR) -60 mesh pulv.
Residence Temperature: 300 °C
Residence Time: 15 minutes



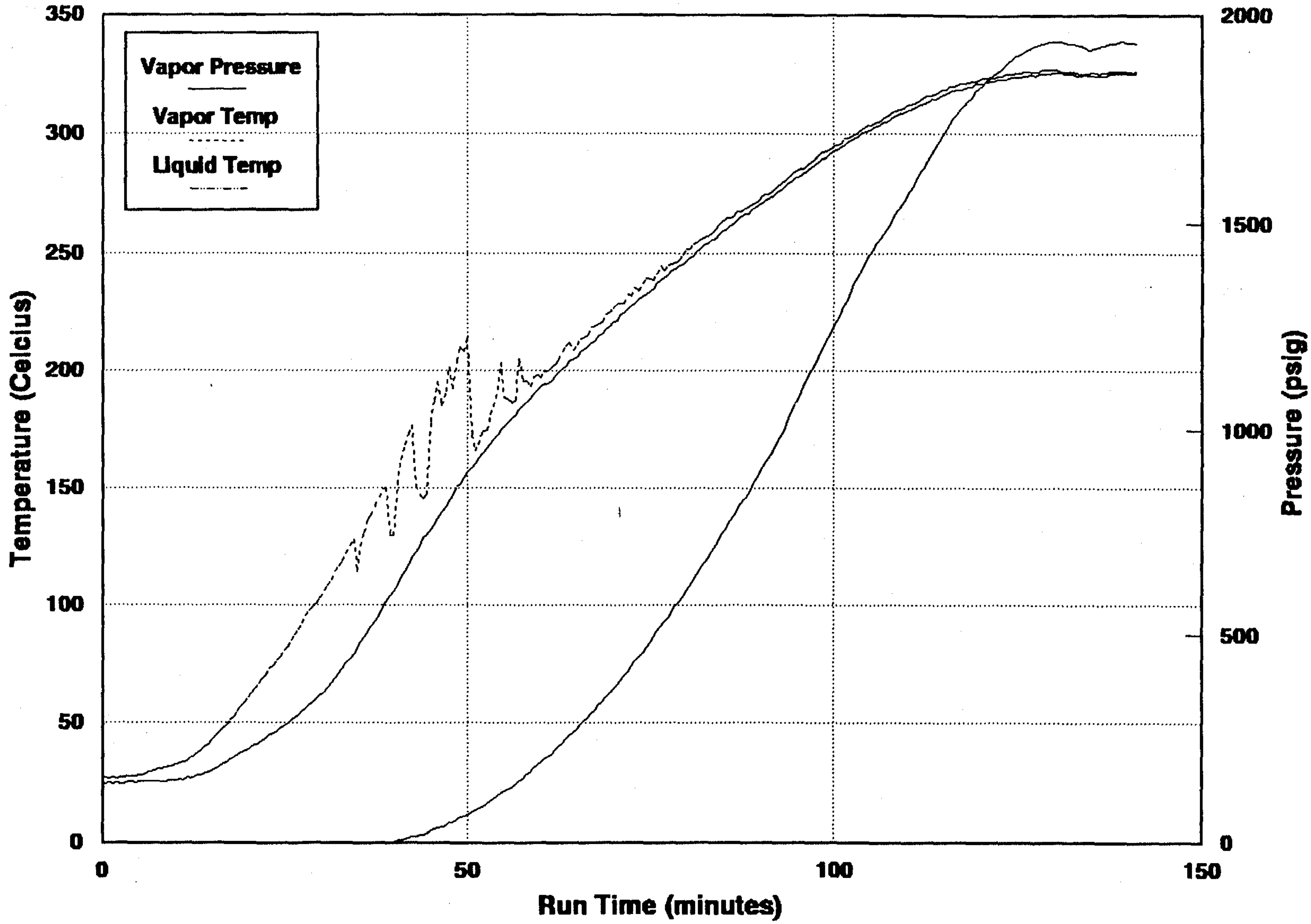
Sample Material: Thailand Lignite (DMR) -200 mesh pulv.
Residence Temperature: 300 °C
Residence Time: 15 minutes



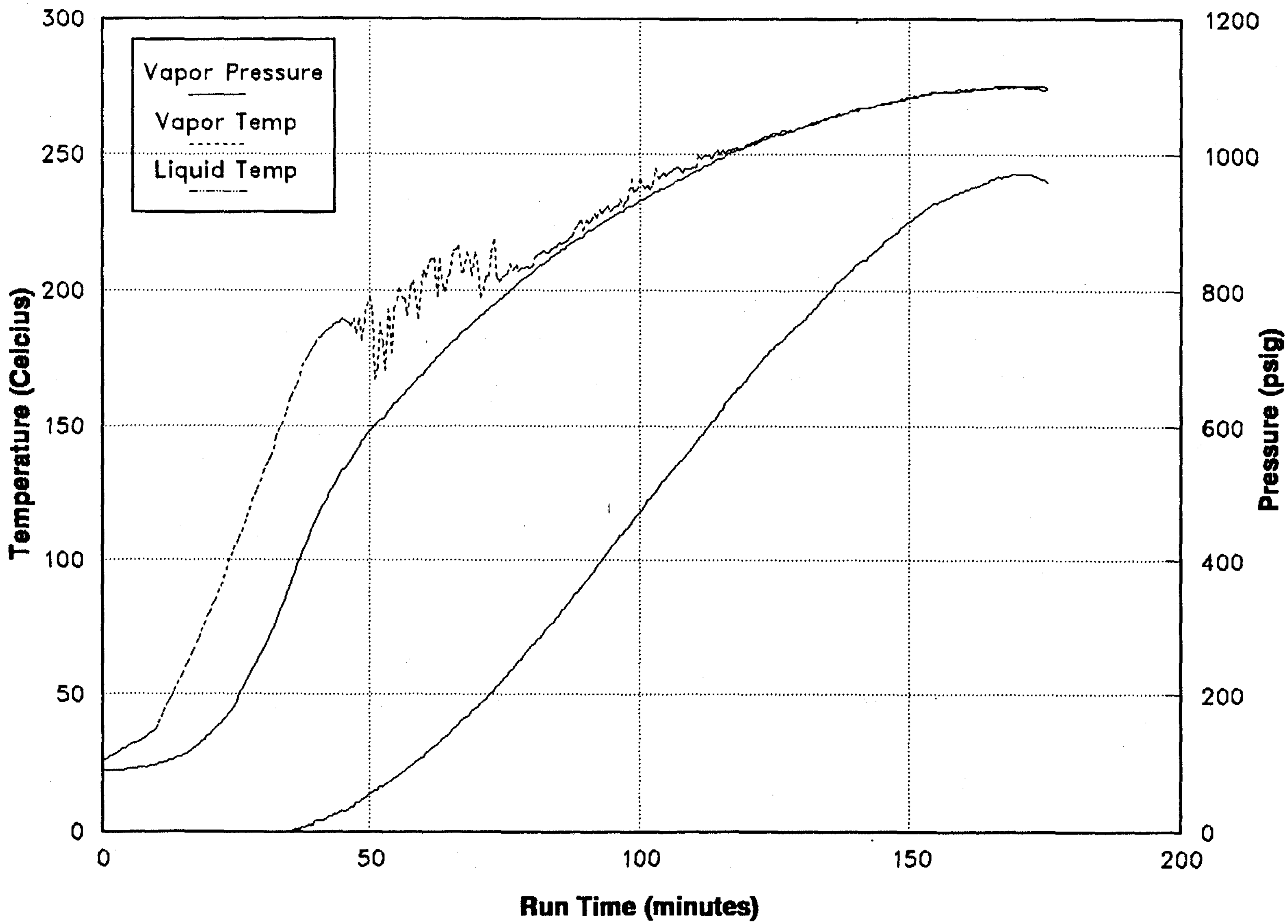
Sample Material: Thailand Lignite (DMR) -60 mesh pulv.
Residence Temperature: 325 °C
Residence Time: 15 minutes



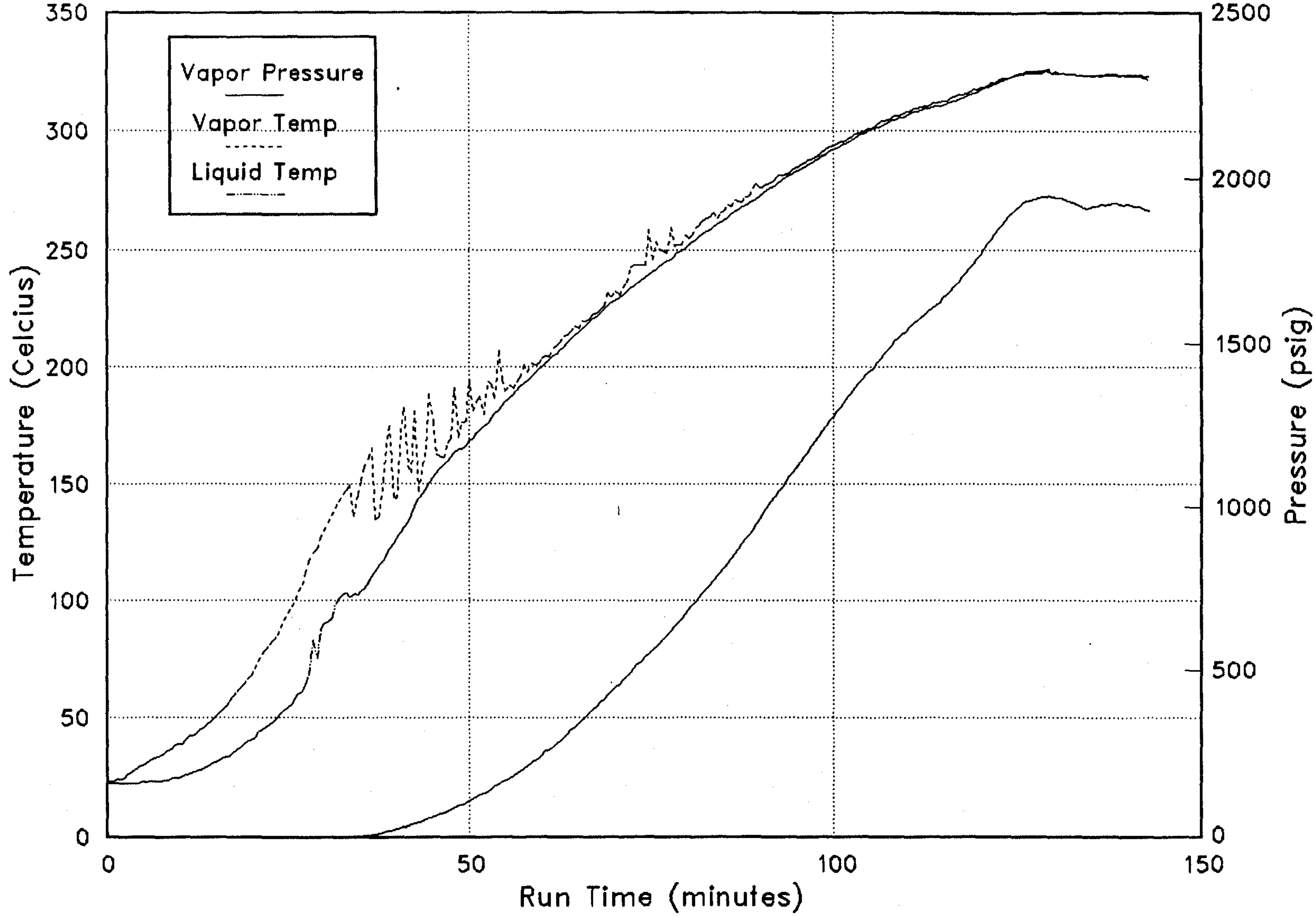
Sample Material: Thailand Lignite (DMR) -60 mesh pulv.
Residence Temperature: 275 °C
Residence Time: 15 minutes



Sample Material: Thailand Lignite (DMR) - 1/4" x 20 mesh, pulv. to -60 mesh
Residence Temperature: 325 °C
Residence Time: 15 minutes



Sample Material: Thailand Lignite (DMR) -60 mesh pulv.
Residence Temperature: 275 °C
Residence Time: 15 minutes



Sample Material: Thailand Lignite (DMR) -200 mesh pulv.
Residence Temperature: 325 °C
Residence Time: 15 minutes

APPENDIX C

RHEOLOGICAL PROFILES FOR COAL–WATER FUELS

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
LOW SOLIDS CONCENTRATION = 49.83 wt%

DATE> Nov 03/95	TIME> 09:41:15	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH034983.prn

SOLIDS CONCENTRATION			
Separate	49.83	49.82	Wt %
Average	49.83		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	99.52•cP
+ 100•Hz	93.84•cP
+ 200•Hz	84.04•cP
+ 300•Hz	81.07•cP
+ 400•Hz	80.38•cP
- 400•Hz	83.95•cP
- 300•Hz	89.96•cP
- 200•Hz	99.92•cP
- 100•Hz	116.17•cP
- 50•Hz	147.02•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.2962	Pascals
CONSISTENCY FACTOR	K	0.2053	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.8346	Dimensionless
CURVE FIT ACCURACY	R^2	99.9133	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
MEDIUM SOLIDS CONCENTRATION = 51.72 wt%

DATE> Nov 03/95	TIME> 09:33:27	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH035172.prn

SOLIDS CONCENTRATION			
Separate	51.71	51.73	Wt %
Average	51.72		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	40.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	340.62•cP
+ 100•Hz	280.73•cP
+ 200•Hz	232.59•cP
+ 300•Hz	219.52•cP
+ 400•Hz	207.09•cP
- 400•Hz	215.27•cP
- 300•Hz	223.22•cP
- 200•Hz	245.01•cP
- 100•Hz	303.45•cP
- 50•Hz	400.40•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	1.4218	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6767	Dimensionless
CURVE FIT ACCURACY	R^2	99.7695	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
HIGH SOLIDS CONCENTRATION = 53.59 wt%

DATE> Nov 03/95	TIME> 09:21:15	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH035359.prn

SOLIDS CONCENTRATION			
Separate	53.57	53.61	Wt %
Average	53.59		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	70.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	829.41•cP
+ 100•Hz	614.59•cP
+ 200•Hz	528.40•cP
+ 300•Hz	468.96•cP
+ 400•Hz	411.04•cP
- 400•Hz	406.36•cP
- 300•Hz	412.83•cP
- 200•Hz	442.57•cP
- 100•Hz	529.02•cP
- 50•Hz	660.04•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	3.2220	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6579	Dimensionless
CURVE FIT ACCURACY	R^2	99.6670	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
MAXIMUM SOLIDS CONCENTRATION = 55.39 wt%

DATE> Nov 03/95	TIME> 09:10:08	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH035539.prn

SOLIDS CONCENTRATION			
Separate	55.32	55.45	Wt %
Average	55.39		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	3036.95•cP
+ 100•Hz	1967.47•cP
+ 200•Hz	1130.88•cP
+ 300•Hz	914.93•cP
+ 400•Hz	759.32•cP
- 400•Hz	738.93•cP
- 300•Hz	774.95•cP
- 200•Hz	930.96•cP
- 100•Hz	1323.66•cP
- 50•Hz	1946.82•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	47.3279	Pascals
CONSISTENCY FACTOR	K	17.1418	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.4511	Dimensionless
CURVE FIT ACCURACY	R^2	98.3525	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
LOW SOLIDS CONCENTRATION = 44.76 wt%

DATE> Nov 06/95	TIME> 16:29:18	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024476.prn

SOLIDS CONCENTRATION			
Separate	44.77	44.74	Wt %
Average	44.76		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	178.67•cP
+ 100•Hz	124.72•cP
+ 200•Hz	88.18•cP
+ 300•Hz	75.24•cP
+ 400•Hz	70.11•cP
- 400•Hz	71.07•cP
- 300•Hz	80.32•cP
- 200•Hz	99.34•cP
- 100•Hz	143.01•cP
- 50•Hz	226.58•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.6739	Pascals
CONSISTENCY FACTOR	K	0.7984	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5837	Dimensionless
CURVE FIT ACCURACY	R^2	99.5274	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
MEDIUM SOLIDS CONCENTRATION = 47.01 wt%

DATE> Nov 06/95	TIME> 16:20:21	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024701.prn

SOLIDS CONCENTRATION			
Separate	47.01	47.00	Wt %
Average	47.01		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	40.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	357.13•cP
+ 100•Hz	248.25•cP
+ 200•Hz	172.53•cP
+ 300•Hz	146.10•cP
+ 400•Hz	133.85•cP
- 400•Hz	139.67•cP
- 300•Hz	160.39•cP
- 200•Hz	195.70•cP
- 100•Hz	282.93•cP
- 50•Hz	445.80•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	1.9895	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5455	Dimensionless
CURVE FIT ACCURACY	R^2	99.4554	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 [illegible])
HIGH SOLIDS CONCENTRATION = 49.66 wt%

DATE> Nov 06/95	TIME> 16:10:16	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024966.prn

SOLIDS CONCENTRATION			
Separate	49.66	49.66	Wt %
Average	49.66		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	70.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	1118.44•cP
+ 100•Hz	783.85•cP
+ 200•Hz	509.70•cP
+ 300•Hz	412.68•cP
+ 400•Hz	375.81•cP
- 400•Hz	389.30•cP
- 300•Hz	434.78•cP
- 200•Hz	515.21•cP
- 100•Hz	729.99•cP
- 50•Hz	1124.53•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	2.8936	Pascals
CONSISTENCY FACTOR	K	5.7770	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5394	Dimensionless
CURVE FIT ACCURACY	R^2	98.6368	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
MAXIMUM SOLIDS CONCENTRATION = 52.08 wt%

DATE> Nov 06/95	TIME> 15:58:12	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH025208.prn

SOLIDS CONCENTRATION			
Separate	52.10	52.06	Wt %
Average	52.08		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	3771.94•cP
+ 100•Hz	2209.50•cP
+ 200•Hz	1392.91•cP
+ 300•Hz	1088.34•cP
+ 400•Hz	904.07•cP
- 400•Hz	871.91•cP
- 300•Hz	908.09•cP
- 200•Hz	1025.45•cP
- 100•Hz	1416.84•cP
- 50•Hz	2108.43•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	45.4242	Pascals
CONSISTENCY FACTOR	K	20.9405	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.4549	Dimensionless
CURVE FIT ACCURACY	R^2	96.6830	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.04 HWD @ 275 C (-60 mesh)
MAXIMUM SOLIDS CONCENTRATION = 47.09 wt%

DATE> Nov 03/95 | TIME> 15:57:26 | RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH044709.prn

SOLIDS CONCENTRATION			
Separate	46.96	47.22	Wt %
Average	47.09		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	2101.64•cP
+ 100•Hz	1293.21•cP
+ 200•Hz	824.23•cP
+ 300•Hz	632.29•cP
+ 400•Hz	490.27•cP
- 400•Hz	451.37•cP
- 300•Hz	419.24•cP
- 200•Hz	436.41•cP
- 100•Hz	527.95•cP
- 50•Hz	715.95•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	35.6043	Pascals
CONSISTENCY FACTOR	K	11.4133	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.4517	Dimensionless
CURVE FIT ACCURACY	R^2	98.1318	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.04 HWD @ 275 C (-60 mesh)
HIGH SOLIDS CONCENTRATION = 46.26 wt%

DATE> Nov 03/95	TIME> 16:09:38	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH044626.prn

SOLIDS CONCENTRATION			
Separate	46.30	46.22	Wt %
Average	46.26		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	70.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	1166.78•cP
+ 100•Hz	820.68•cP
+ 200•Hz	548.93•cP
+ 300•Hz	458.74•cP
+ 400•Hz	392.11•cP
- 400•Hz	365.97•cP
- 300•Hz	351.25•cP
- 200•Hz	369.46•cP
- 100•Hz	457.45•cP
- 50•Hz	622.68•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	12.7876	Pascals
CONSISTENCY FACTOR	K	4.6338	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5754	Dimensionless
CURVE FIT ACCURACY	R^2	98.9794	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.04 HWD @ 275 C (-60 mesh)
MEDIUM SOLIDS CONCENTRATION = 45.03 wt%

DATE> Nov 03/05	TIME> 16:22:08	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH044503.prn

SOLIDS CONCENTRATION			
Separate	45.02	45.03	Wt %
Average	45.03		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% Tau	40.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	523.60•cP
+ 100•Hz	393.09•cP
+ 200•Hz	308.19•cP
+ 300•Hz	279.22•cP
+ 400•Hz	250.88•cP
- 400•Hz	246.59•cP
- 300•Hz	240.06•cP
- 200•Hz	252.19•cP
- 100•Hz	302.02•cP
- 50•Hz	404.36•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.1129	Pascals
CONSISTENCY FACTOR	K	1.6375	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6881	Dimensionless
CURVE FIT ACCURACY	R^2	99.7285	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.04 HWD @ 275 C (-60 mesh)
LOW SOLIDS CONCENTRATION = 43.51 wt%

DATE> Nov 03/95	TIME> 16:30:44	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH044351.prn

SOLIDS CONCENTRATION			
Separate	43.49	43.53	Wt %
Average	43.51		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	295.43•cP
+ 100•Hz	231.58•cP
+ 200•Hz	184.97•cP
+ 300•Hz	170.89•cP
+ 400•Hz	159.07•cP
- 400•Hz	159.65•cP
- 300•Hz	159.51•cP
- 200•Hz	170.52•cP
- 100•Hz	209.97•cP
- 50•Hz	291.75•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	0.9309	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.7021	Dimensionless
CURVE FIT ACCURACY	R^2	99.8432	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
MAXIMUM SOLIDS CONCENTRATION = 51.89 wt%

DATE> Nov 02/95	TIME> 11:18:30	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH035189.prn

SOLIDS CONCENTRATION			
Separate	51.87	51.91	Wt %
Average	51.89		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	2066.77•cP
+ 100•Hz	1204.90•cP
+ 200•Hz	664.20•cP
+ 300•Hz	503.25•cP
+ 400•Hz	444.69•cP
- 400•Hz	444.30•cP
- 300•Hz	440.94•cP
- 200•Hz	469.53•cP
- 100•Hz	595.30•cP
- 50•Hz	828.96•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	18.6870	Pascals
CONSISTENCY FACTOR	K	17.5587	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.3635	Dimensionless
CURVE FIT ACCURACY	R^2	94.7160	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
HIGH SOLIDS CONCENTRATION = 50.23 wt%

DATE> Nov 02/95	TIME> 11:33:11	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH035023.prn

SOLIDS CONCENTRATION			
Separate	50.26	50.20	Wt %
Average	50.23		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	70.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	1243.91•cP
+ 100•Hz	652.24•cP
+ 200•Hz	349.47•cP
+ 300•Hz	270.27•cP
+ 400•Hz	249.40•cP
- 400•Hz	241.56•cP
- 300•Hz	259.64•cP
- 200•Hz	280.55•cP
- 100•Hz	346.95•cP
- 50•Hz	471.35•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	14.9233	Pascals
CONSISTENCY FACTOR	K	9.9307	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.3412	Dimensionless
CURVE FIT ACCURACY	R^2	92.4495	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
MEDIUM SOLIDS CONCENTRATION = 48.66 wt%

DATE> Nov 02/95	TIME> 11:47:33	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH034866.prn

SOLIDS CONCENTRATION			
Separate	48.70	48.62	Wt %
Average	48.66		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	40.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	668.53•cP
+ 100•Hz	479.21•cP
+ 200•Hz	320.71•cP
+ 300•Hz	274.62•cP
+ 400•Hz	242.68•cP
- 400•Hz	233.96•cP
- 300•Hz	234.02•cP
- 200•Hz	256.21•cP
- 100•Hz	326.78•cP
- 50•Hz	474.09•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	1.1274	Pascals
CONSISTENCY FACTOR	K	3.0148	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5791	Dimensionless
CURVE FIT ACCURACY	R^2	99.0889	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.03 HWD @ 325 C (-60 mesh)
LOW SOLIDS CONCENTRATION = 47.13 wt%

DATE> Nov 02/95	TIME> 11:56:40	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH034713.prn

SOLIDS CONCENTRATION			
Separate	47.12	47.14	Wt %
Average	47.13		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	266.68•cP
+ 100•Hz	205.49•cP
+ 200•Hz	163.67•cP
+ 300•Hz	150.84•cP
+ 400•Hz	143.03•cP
- 400•Hz	147.06•cP
- 300•Hz	152.23•cP
- 200•Hz	163.45•cP
- 100•Hz	203.33•cP
- 50•Hz	282.08•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.2707	Pascals
CONSISTENCY FACTOR	K	0.8032	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.7056	Dimensionless
CURVE FIT ACCURACY	R^2	99.8192	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
MAXIMUM SOLIDS CONCENTRATION = 49.39 wt%

DATE> Oct 31/95	TIME> 16:53:37	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024939.prn

SOLIDS CONCENTRATION			
Separate	49.39	49.39	Wt %
Average	49.39		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	2008.71•cP
+ 100•Hz	1231.65•cP
+ 200•Hz	740.54•cP
+ 300•Hz	575.57•cP
+ 400•Hz	470.09•cP
- 400•Hz	461.97•cP
- 300•Hz	498.87•cP
- 200•Hz	578.63•cP
- 100•Hz	801.35•cP
- 50•Hz	1182.40•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	8.8201	Pascals
CONSISTENCY FACTOR	K	12.6584	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.4519	Dimensionless
CURVE FIT ACCURACY	R^2	94.1877	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
HIGH SOLIDS CONCENTRATION = 48.10 wt%

DATE> Oct 31/95	TIME> 17:04:53	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024810.prn

SOLIDS CONCENTRATION			
Separate	48.14	48.06	Wt %
Average	48.10		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	70.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	999.14•cP
+ 100•Hz	757.37•cP
+ 200•Hz	473.98•cP
+ 300•Hz	373.72•cP
+ 400•Hz	326.61•cP
- 400•Hz	353.27•cP
- 300•Hz	385.64•cP
- 200•Hz	438.67•cP
- 100•Hz	586.57•cP
- 50•Hz	863.15•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	2.0497	Pascals
CONSISTENCY FACTOR	K	4.9453	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5514	Dimensionless
CURVE FIT ACCURACY	R^2	97.1625	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
MEDIUM SOLIDS CONCENTRATION = 47.06 wt%

DATE> Oct 31/95	TIME> 17:19:44	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024706.prn

SOLIDS CONCENTRATION			
Separate	47.09	47.02	Wt %
Average	47.06		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	40.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	540.86•cP
+ 100•Hz	437.82•cP
+ 200•Hz	308.75•cP
+ 300•Hz	264.41•cP
+ 400•Hz	243.50•cP
- 400•Hz	257.17•cP
- 300•Hz	284.01•cP
- 200•Hz	330.57•cP
- 100•Hz	487.96•cP
- 50•Hz	777.43•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	1.1828	Pascals
CONSISTENCY FACTOR	K	1.7922	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6659	Dimensionless
CURVE FIT ACCURACY	R^2	99.1100	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.02 HWD @ 300 C (-200 mesh)
LOW SOLIDS CONCENTRATION = 46.00 wt%

DATE> Oct 31/95	TIME> 17:30:18	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH024600.prn

SOLIDS CONCENTRATION			
Separate	45.96	46.04	Wt %
Average	46.00		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	273.52•cP
+ 100•Hz	207.50•cP
+ 200•Hz	152.75•cP
+ 300•Hz	132.67•cP
+ 400•Hz	122.60•cP
- 400•Hz	127.83•cP
- 300•Hz	144.53•cP
- 200•Hz	172.97•cP
- 100•Hz	238.79•cP
- 50•Hz	361.37•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.1294	Pascals
CONSISTENCY FACTOR	K	1.0774	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6346	Dimensionless
CURVE FIT ACCURACY	R^2	99.6560	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.01 HWD @ 300 C (-60 mesh)
MAXIMUM SOLIDS CONCENTRATION = 50.07 wt%

DATE> Oct 31/95	TIME> 14:55:04	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH015007.prn

SOLIDS CONCENTRATION			
Separate	50.01	50.13	Wt %
Average	50.07		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	2142.81•cP
+ 100•Hz	1279.11•cP
+ 200•Hz	825.41•cP
+ 300•Hz	655.39•cP
+ 400•Hz	525.37•cP
- 400•Hz	477.63•cP
- 300•Hz	457.23•cP
- 200•Hz	469.25•cP
- 100•Hz	562.80•cP
- 50•Hz	756.53•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	13.3740	Pascals
CONSISTENCY FACTOR	K	12.1751	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.4744	Dimensionless
CURVE FIT ACCURACY	R^2	95.8465	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.01 HWD @ 300 C (-60 mesh)
HIGH SOLIDS CONCENTRATION = 49.58 wt%

DATE> Oct 31/95	TIME> 14:39:51	RATE> 60 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH014958.prn

SOLIDS CONCENTRATION			
Separate	49.64	49.51	Wt %
Average	49.57		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	1778.69•cP
+ 100•Hz	982.54•cP
+ 200•Hz	618.68•cP
+ 300•Hz	506.39•cP
+ 400•Hz	431.48•cP
- 400•Hz	417.77•cP
- 300•Hz	405.83•cP
- 200•Hz	420.82•cP
- 100•Hz	502.92•cP
- 50•Hz	677.14•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	8.2495	Pascals
CONSISTENCY FACTOR	K	10.0451	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.4668	Dimensionless
CURVE FIT ACCURACY	R^2	95.5398	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: THAI.01 HWD @ 300 C (-60 mesh)
MEDIUM SOLIDS CONCENTRATION = 48.33 wt%

DATE> Oct 31/95	TIME> 15:19:40	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\TH014833.prn

SOLIDS CONCENTRATION			
Separate	48.30	48.36	Wt %
Average	48.33		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	60.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	720.39•cP
+ 100•Hz	582.91•cP
+ 200•Hz	412.95•cP
+ 300•Hz	[illegible]
+ 400•Hz	318.73•cP
- 400•Hz	306.18•cP
- 300•Hz	298.89•cP
- 200•Hz	308.97•cP
- 100•Hz	361.48•cP
- 50•Hz	462.20•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	1.5739	Pascals
CONSISTENCY FACTOR	K	2.7049	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6434	Dimensionless
CURVE FIT ACCURACY	R^2	99.1138	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES TEST#: THAI.01 HWD @ 300 C (-60 mesh) LOW SOLIDS CONCENTRATION = 46.34 wt%		
DATE> Oct 31/95	TIME> 15:33:56	RATE> 120 samples/minute
ARCHIVE FILE NAME>c:\123r3\TH014634.prn		

SOLIDS CONCENTRATION			
Separate	46.38	46.30	Wt %
Average	46.34		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	218.79•cP
+ 100•Hz	183.79•cP
+ 200•Hz	153.35•cP
+ 300•Hz	143.11•cP
+ 400•Hz	136.45•cP
- 400•Hz	139.98•cP
- 300•Hz	140.27•cP
- 200•Hz	146.28•cP
- 100•Hz	172.02•cP
- 50•Hz	227.77•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	0.6248	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	^{n}	0.7449	Dimensionless
CURVE FIT ACCURACY	R^2	99.8903	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL (-60 mesh)
MAXIMUM SOLIDS CONCENTRATION = 37.66 wt%

DATE> Nov 01/95	TIME> 12:21:31	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\THRW3766.prn

SOLIDS CONCENTRATION			
Separate	37.64	37.68	Wt %
Average	37.66		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	1741.18•cP
+ 100•Hz	1041.60•cP
+ 200•Hz	602.90•cP
+ 300•Hz	455.65•cP
+ 400•Hz	377.05•cP
- 400•Hz	357.19•cP
- 300•Hz	351.23•cP
- 200•Hz	372.32•cP
- 100•Hz	454.62•cP
- 50•Hz	613.42•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	15.4387	Pascals
CONSISTENCY FACTOR	K	13.9183	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.3829	Dimensionless
CURVE FIT ACCURACY	R^2	95.7772	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL (-60 mesh)
HIGH SOLIDS CONCENTRATION = 36.59 wt%

DATE> Nov 01/95	TIME> 12:34:51	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\THRW3659.prn

SOLIDS CONCENTRATION			
Separate	36.60	36.57	Wt %
Average	36.59		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	50.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	798.03•cP
+ 100•Hz	603.13•cP
+ 200•Hz	452.64•cP
+ 300•Hz	387.46•cP
+ 400•Hz	325.29•cP
- 400•Hz	310.75•cP
- 300•Hz	306.55•cP
- 200•Hz	333.36•cP
- 100•Hz	422.25•cP
- 50•Hz	591.06•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.3074	Pascals
CONSISTENCY FACTOR	K	3.1680	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6284	Dimensionless
CURVE FIT ACCURACY	R^2	99.4036	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL (-60 mesh)
MEDIUM SOLIDS CONCENTRATION = 35.54 wt%

DATE> Nov 01/95	TIME> 12:50:21	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\THRW3554.prn

SOLIDS CONCENTRATION			
Separate	35.56	35.52	Wt %
Average	35.54		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	30.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	365.56•cP
+ 100•Hz	285.81•cP
+ 200•Hz	227.94•cP
+ 300•Hz	207.22•cP
+ 400•Hz	188.88•cP
- 400•Hz	187.86•cP
- 300•Hz	190.12•cP
- 200•Hz	205.90•cP
- 100•Hz	257.80•cP
- 50•Hz	366.06•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	1.2009	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6907	Dimensionless
CURVE FIT ACCURACY	R^2	99.8437	Percent(%)

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Grand Forks, North Dakota 58202

SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL (-60 mesh)
LOW SOLIDS CONCENTRATION = 34.41 wt%

DATE> Nov 01/95	TIME> 13:01:22	RATE> 120 samples/minute
ARCHIVE FILE NAME>c:\123r3\THRW3441.prn		

SOLIDS CONCENTRATION			
Separate	34.44	34.37	Wt %
Average	34.41		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% τau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	164.26•cP
+ 100•Hz	136.50•cP
+ 200•Hz	115.48•cP
+ 300•Hz	100.76•cP
+ 400•Hz	97.48•cP
- 400•Hz	101.07•cP
- 300•Hz	108.59•cP
- 200•Hz	118.72•cP
- 100•Hz	147.04•cP
- 50•Hz	206.22•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.1202	Pascals
CONSISTENCY FACTOR	K	0.4409	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.7452	Dimensionless
CURVE FIT ACCURACY	R^2	99.9463	Percent(%)

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SAMPLE INFORMATION		
RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES TEST#: RAW COAL -1/4"x 20 mesh pulverized to -60 mesh MAXIMUM SOLIDS CONCENTRATION = 39.24 wt%		
DATE> Nov 07/95	TIME> 11:21:07	RATE> 120 samples/minute
ARCHIVE FILE NAME>c:\123r3\THRW3924.prn		

SOLIDS CONCENTRATION			
Separate	39.29	39.19	Wt %
Average	39.24		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% тau	100.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	2962.10•cP
+ 100•Hz	1734.00•cP
+ 200•Hz	1073.56•cP
+ 300•Hz	730.61•cP
+ 400•Hz	587.06•cP
- 400•Hz	559.50•cP
- 300•Hz	539.62•cP
- 200•Hz	567.72•cP
- 100•Hz	706.19•cP
- 50•Hz	976.84•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	YIELD POWER LAW - PSEUDOPLASTIC		
INITIAL YIELD STRESS	т	46.7134	Pascals
CONSISTENCY FACTOR	K	19.3769	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	^{n}	0.3877	Dimensionless
CURVE FIT ACCURACY	R^2	92.8660	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL -1/4"x 20 mesh pulverized to -60 mesh
HIGH SOLIDS CONCENTRATION = 37.49 wt%

DATE> Nov 07/95	TIME> 11:35:14	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\THRW3749.prn

SOLIDS CONCENTRATION			
Separate	37.47	37.50	Wt %
Average	37.49		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% tau	70.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	1186.33•cP
+ 100•Hz	853.87•cP
+ 200•Hz	638.58•cP
+ 300•Hz	536.15•cP
+ 400•Hz	444.74•cP
- 400•Hz	416.77•cP
- 300•Hz	402.05•cP
- 200•Hz	428.43•cP
- 100•Hz	536.55•cP
- 50•Hz	749.18•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.0000	Pascals
CONSISTENCY FACTOR	K	5.2853	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.5975	Dimensionless
CURVE FIT ACCURACY	R^2	99.1077	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL -1/4"x 20 mesh pulverized to -60 mesh
MEDIUM SOLIDS CONCENTRATION = 35.84 wt%

DATE> Nov 07/95	TIME> 11:47:31	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\THRW3584.prn

SOLIDS CONCENTRATION			
Separate	35.83	35.85	Wt %
Average	35.84		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% tau	40.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	389.43•cP
+ 100•Hz	295.44•cP
+ 200•Hz	233.89•cP
+ 300•Hz	216.68•cP
+ 400•Hz	197.55•cP
- 400•Hz	193.88•cP
- 300•Hz	192.96•cP
- 200•Hz	210.61•cP
- 100•Hz	265.86•cP
- 50•Hz	379.49•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.1198	Pascals
CONSISTENCY FACTOR	K	1.3395	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.6771	Dimensionless
CURVE FIT ACCURACY	R^2	99.8367	Percent(%)

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SAMPLE INFORMATION

RHEOLOGY FOR THAILAND AUTOCLAVE SAMPLES
TEST#: RAW COAL -1/4"x 20 mesh pulverized to -60 mesh
LOW SOLIDS CONCENTRATION = 33.91 wt%

DATE> Nov 07/95	TIME> 11:54:35	RATE> 120 samples/minute

ARCHIVE FILE NAME>c:\123r3\THRW3391.prn

SOLIDS CONCENTRATION			
Separate	33.96	33.86	Wt %
Average	33.91		Wt %

ASH CONCENTRATION			
Separate	*****	*****	Wt %
Average	*****		Wt %

VISCOMETER CONFIGURATION		
Sensor	MV-IIP	Sensor Type
Factor A	3.76	Pascals
Factor M	4.40	1 / sec
Temperature	25.00	°Celcius
% D	100.00	Percent (%)
% Tau	20.00	Percent (%)

SHEAR RATE	APPARENT VISCOSITY
+ 50•Hz	150.54•cP
+ 100•Hz	113.94•cP
+ 200•Hz	89.29•cP
+ 300•Hz	82.14•cP
+ 400•Hz	78.73•cP
- 400•Hz	80.32•cP
- 300•Hz	83.93•cP
- 200•Hz	92.38•cP
- 100•Hz	117.45•cP
- 50•Hz	167.85•cP

SAMPLE DENSITY (grams/cm^3)
******

RHEOLOGICAL CLASSIFICATION	PSEUDOPLASTIC		
INITIAL YIELD STRESS	τ	0.7698	Pascals
CONSISTENCY FACTOR	K	0.4331	Pascal•Sec^n
NON-NEWTONIAN FLOW FACTOR	n	0.7028	Dimensionless
CURVE FIT ACCURACY	R^2	99.7468	Percent(%)

APPENDIX D

HOT-WATER-DRYING PILOT-SCALE INFORMATION

Appendix D

Process Development Unit (PDU) #74

Date: 11/29/95
Feed Material: Thailand lignite slurry
Particle Size: -60 mesh
Feed slurry flowrate (lb/hr): 525

Conditions

temperature (degrees F): 575
set condition pressure (psi): 2100 psi
est. residence time (min): 7 minutes

Length of test (min): 105

PDU Process Data

10:00 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1826.95
E1	Dowtherm Vapor	E6-DVpTm.OUT2	302.71
E1	Dowtherm Liquid	E6-DLqTm.OUT2	502.53
E1	Preheater Coil Inlet	E6-C1 In.OUT2	226.75
E1	Preheater Coil Outlet	E6-C1Out.OUT2	351.42
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1742.35
E2	Dowtherm Vapor	E5-DVpTm.OUT2	479.66
E2	Dowtherm Liquid	E5-DLqTm.OUT2	499.07
E2	Preheater Coil Inlet	E5-C1 In.OUT2	352.71
E2	Preheater Coil Outlet	E5-C1Out.OUT2	452.91
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2095.47
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2103.43
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	608.78
E3	Preheater Coil Inlet	E9-C1 In.OUT2	455.80
E3	Preheater Coil Outlet	E9-C1Out.OUT2	574.90
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	576.31
R1	Reactor Outlet	R3-OtTmp.OUT2	587.06
R1	Heater Zone 1	R3-Zone1.OUT2	572.79
R1	Heater Zone 2	R3-Zone2.OUT2	575.18
R1	Heater Zone 3	R3-Zone3.OUT2	581.51
R1	Heater Zone 4	R3-Zone4.OUT2	590.75
R2	Reactor Outlet	R2OtTmp.OUT	27.81
R2	Heater Zone 1	R2-Zone1.OUT	53.22
R2	Heater Zone 2	R2-Zone2.OUT	55.11
R2	Heater Zone 3	R2-Zone3.OUT2	132.52
R2	Heater Zone 4	R2-Zone4.OUT2	134.12
S1	Separator Liquid	S1-Liqd.OUT2	159.12
S1	Separator Vessel Liquid	S1-Level.OUT	50.58
S1	Separator Wall	S1-Wall.OUT2	122.58
S2	Separator Vessel Liquid	S2-Level.OUT	22.41
CQND	Condenser Inlet	R2-Zone2.OUT2	131.20
	Let Down Inlet	LtDn In.OUT2	560.62
	Let Down Outlet	LtDn Out.OUT2	239.35
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	39.84
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	170.69
	Slurry Mix Tank	MixTank.OUT	42.05

PDU Process Data

10:15 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1846.44
E1	Dowtherm Vapor	E6-DVpTm.OUT2	304.81
E1	Dowtherm Liquid	E6-DLqTm.OUT2	504.31
E1	Preheater Coil Inlet	E6-C1 In.OUT2	225.16
E1	Preheater Coil Outlet	E6-C1Out.OUT2	348.00
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1765.10
E2	Dowtherm Vapor	E5-DVpTm.OUT2	481.56
E2	Dowtherm Liquid	E5-DLqTm.OUT2	500.16
E2	Preheater Coil Inlet	E5-C1 In.OUT2	348.93
E2	Preheater Coil Outlet	E5-C1Out.OUT2	451.95
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2121.79
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2126.31
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	604.44
E3	Preheater Coil Inlet	E9-C1 In.OUT2	454.32
E3	Preheater Coil Outlet	E9-C1Out.OUT2	572.04
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	574.80
R1	Reactor Outlet	R3-OtTmp.OUT2	588.36
R1	Heater Zone 1	R3-Zone1.OUT2	574.75
R1	Heater Zone 2	R3-Zone2.OUT2	574.80
R1	Heater Zone 3	R3-Zone3.OUT2	577.99
R1	Heater Zone 4	R3-Zone4.OUT2	589.33
R2	Reactor Outlet	R2OtTmp.OUT	29.76
R2	Heater Zone 1	R2-Zone1.OUT	53.36
R2	Heater Zone 2	R2-Zone2.OUT	55.63
R2	Heater Zone 3	R2-Zone3.OUT2	134.15
R2	Heater Zone 4	R2-Zone4.OUT2	134.96
S1	Separator Liquid	S1-Liqd.OUT2	175.76
S1	Separator Vessel Liquid	S1-Level.OUT	57.56
S1	Separator Wall	S1-Wall.OUT2	133.91
S2	Separator Vessel Liquid	S2-Level.OUT	22.62
COND	Condenser Inlet	R2-Zone2.OUT2	132.13
	Let Down Inlet	LtDn In.OUT2	564.94
	Let Down Outlet	LtDn Out.OUT2	269.41
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	42.43
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	179.75
	Slurry Mix Tank	MixTank.OUT	40.87

PDU Process Data

10:30 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1841.90
E1	Dowtherm Vapor	E6-DVpTm.OUT2	304.64
E1	Dowtherm Liquid	E6-DLqTm.OUT2	503.31
E1	Preheater Coil Inlet	E6-C1 In.OUT2	223.36
E1	Preheater Coil Outlet	E6-C1Out.OUT2	347.82
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1757.95
E2	Dowtherm Vapor	E5-DVpTm.OUT2	475.61
E2	Dowtherm Liquid	E5-DLqTm.OUT2	497.76
E2	Preheater Coil Inlet	E5-C1 In.OUT2	348.51
E2	Preheater Coil Outlet	E5-C1Out.OUT2	446.73
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2111.32
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2121.47
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	602.16
E3	Preheater Coil Inlet	E9-C1 In.OUT2	450.20
E3	Preheater Coil Outlet	E9-C1Out.OUT2	568.32
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	571.18
R1	Reactor Outlet	R3-OtTmp.OUT2	581.66
R1	Heater Zone 1	R3-Zone1.OUT2	570.07
R1	Heater Zone 2	R3-Zone2.OUT2	570.95
R1	Heater Zone 3	R3-Zone3.OUT2	573.59
R1	Heater Zone 4	R3-Zone4.OUT2	582.52
R2	Reactor Outlet	R2OtTmp.OUT	31.03
R2	Heater Zone 1	R2-Zone1.OUT	53.00
R2	Heater Zone 2	R2-Zone2.OUT	55.32
R2	Heater Zone 3	R2-Zone3.OUT2	132.39
R2	Heater Zone 4	R2-Zone4.OUT2	133.67
S1	Separator Liquid	S1-Liqd.OUT2	189.24
S1	Separator Vessel Liquid	S1-Level.OUT	59.53
S1	Separator Wall	S1-Wall.OUT2	143.08
S2	Separator Vessel Liquid	S2-Level.OUT	22.75
COND	Condenser Inlet	R2-Zone2.OUT2	131.46
	Let Down Inlet	LtDn In.OUT2	557.44
	Let Down Outlet	LtDn Out.OUT2	235.38
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	39.41
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	168.60
	Slurry Mix Tank	MixTank.OUT	40.89

PDU Process Data

10:45 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1852.06
E1	Dowtherm Vapor	E6-DVpTm.OUT2	307.76
E1	Dowtherm Liquid	E6-DLqTm.OUT2	505.26
E1	Preheater Coil Inlet	E6-C1 In.OUT2	230.74
E1	Preheater Coil Outlet	E6-C1Out.OUT2	348.16
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1768.19
E2	Dowtherm Vapor	E5-DVpTm.OUT2	479.21
E2	Dowtherm Liquid	E5-DLqTm.OUT2	498.39
E2	Preheater Coil Inlet	E5-C1 In.OUT2	350.33
E2	Preheater Coil Outlet	E5-C1Out.OUT2	446.96
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2123.87
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2124.20
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	604.21
E3	Preheater Coil Inlet	E9-C1 In.OUT2	450.22
E3	Preheater Coil Outlet	E9-C1Out.OUT2	571.25
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	573.39
R1	Reactor Outlet	R3-OtTmp.OUT2	583.17
R1	Heater Zone 1	R3-Zone1.OUT2	571.92
R1	Heater Zone 2	R3-Zone2.OUT2	572.54
R1	Heater Zone 3	R3-Zone3.OUT2	575.89
R1	Heater Zone 4	R3-Zone4.OUT2	583.64
R2	Reactor Outlet	R2OtTmp.OUT	33.92
R2	Heater Zone 1	R2-Zone1.OUT	54.13
R2	Heater Zone 2	R2-Zone2.OUT	56.00
R2	Heater Zone 3	R2-Zone3.OUT2	134.56
R2	Heater Zone 4	R2-Zone4.OUT2	134.96
S1	Separator Liquid	S1-Liqd.OUT2	197.52
S1	Separator Vessel Liquid	S1-Level.OUT	53.90
S1	Separator Wall	S1-Wall.OUT2	152.57
S2	Separator Vessel Liquid	S2-Level.OUT	22.48
COND	Condenser Inlet	R2-Zone2.OUT2	132.81
	Let Down Inlet	LtDn In.OUT2	560.70
	Let Down Outlet	LtDn Out.OUT2	253.60
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	43.20
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	166.56
	Slurry Mix Tank	MixTank.OUT	40.91

PDU Process Data

11:00 11/25/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1897.75
E1	Dowtherm Vapor	E6-DVpTm.OUT2	307.17
E1	Dowtherm Liquid	E6-DLqTm.OUT2	504.25
E1	Preheater Coil Inlet	E6-C1 In.OUT2	222.20
E1	Preheater Coil Outlet	E6-C1Out.OUT2	345.47
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1810.34
E2	Dowtherm Vapor	E5-DVpTm.OUT2	470.76
E2	Dowtherm Liquid	E5-DLqTm.OUT2	495.95
E2	Preheater Coil Inlet	E5-C1 In.OUT2	346.46
E2	Preheater Coil Outlet	E5-C1Out.OUT2	443.08
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2175.76
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2171.67
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	602.91
E3	Preheater Coil Inlet	E9-C1 In.OUT2	445.10
E3	Preheater Coil Outlet	E9-C1Out.OUT2	567.69
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	570.56
R1	Reactor Outlet	R3-OtTmp.OUT2	582.66
R1	Heater Zone 1	R3-Zone1.OUT2	571.37
R1	Heater Zone 2	R3-Zone2.OUT2	572.66
R1	Heater Zone 3	R3-Zone3.OUT2	574.13
R1	Heater Zone 4	R3-Zone4.OUT2	582.77
R2	Reactor Outlet	R2OtTmp.OUT	34.90
R2	Heater Zone 1	R2-Zone1.OUT	53.13
R2	Heater Zone 2	R2-Zone2.OUT	55.16
R2	Heater Zone 3	R2-Zone3.OUT2	132.58
R2	Heater Zone 4	R2-Zone4.OUT2	133.59
S1	Separator Liquid	S1-Liqd.OUT2	204.94
S1	Separator Vessel Liquid	S1-Level.OUT	70.65
S1	Separator Wall	S1-Wall.OUT2	157.80
S2	Separator Vessel Liquid	S2-Level.OUT	22.99
COND	Condenser Inlet	R2-Zone2.OUT2	131.31
	Let Down Inlet	LtDn In.OUT2	560.05
	Let Down Outlet	LtDn Out.OUT2	255.64
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	42.94
	Raw Coal Hopper	Hopper.OUT	2433.73
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	354.09

PDU Process Data

11:15 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1783.60
E1	Dowtherm Vapor	E6-DVpTm.OUT2	300.33
E1	Dowtherm Liquid	E6-DLqTm.OUT2	504.90
E1	Preheater Coil Inlet	E6-C1 In.OUT2	202.51
E1	Preheater Coil Outlet	E6-C1Out.OUT2	313.79
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1732.56
E2	Dowtherm Vapor	E5-DVpTm.OUT2	478.22
E2	Dowtherm Liquid	E5-DLqTm.OUT2	497.97
E2	Preheater Coil Inlet	E5-C1 In.OUT2	317.18
E2	Preheater Coil Outlet	E5-C1Out.OUT2	451.28
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2080.94
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2084.62
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	615.60
E3	Preheater Coil Inlet	E9-C1 In.OUT2	451.60
E3	Preheater Coil Outlet	E9-C1Out.OUT2	589.66
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	590.10
R1	Reactor Outlet	R3-OtTmp.OUT2	579.81
R1	Heater Zone 1	R3-Zone1.OUT2	579.71
R1	Heater Zone 2	R3-Zone2.OUT2	569.68
R1	Heater Zone 3	R3-Zone3.OUT2	574.89
R1	Heater Zone 4	R3-Zone4.OUT2	581.84
R2	Reactor Outlet	R2OtTmp.OUT	35.93
R2	Heater Zone 1	R2-Zone1.OUT	52.25
R2	Heater Zone 2	R2-Zone2.OUT	53.99
R2	Heater Zone 3	R2-Zone3.OUT2	130.63
R2	Heater Zone 4	R2-Zone4.OUT2	132.16
S1	Separator Liquid	S1-Liqd.OUT2	207.21
S1	Separator Vessel Liquid	S1-Level.OUT	8.99
S1	Separator Wall	S1-Wall.OUT2	159.49
S2	Separator Vessel Liquid	S2-Level.OUT	22.37
COND	Condenser Inlet	R2-Zone2.OUT2	129.13
	Let Down Inlet	LtDn In.OUT2	560.91
	Let Down Outlet	LtDn Out.OUT2	228.85
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	40.88
	Raw Coal Hopper	Hopper.OUT	915.73
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	192.65

PDU Process Data

11:30 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1879.14
E1	Dowtherm Vapor	E6-DVpTm.OUT2	284.52
E1	Dowtherm Liquid	E6-DLqTm.OUT2	500.04
E1	Preheater Coil Inlet	E6-C1 In.OUT2	172.10
E1	Preheater Coil Outlet	E6-C1Out.OUT2	303.04
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1800.06
E2	Dowtherm Vapor	E5-DVpTm.OUT2	464.66
E2	Dowtherm Liquid	E5-DLqTm.OUT2	492.76
E2	Preheater Coil Inlet	E5-C1 In.OUT2	304.25
E2	Preheater Coil Outlet	E5-C1Out.OUT2	424.81
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2143.87
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2144.40
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	611.73
E3	Preheater Coil Inlet	E9-C1 In.OUT2	426.34
E3	Preheater Coil Outlet	E9-C1Out.OUT2	569.13
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	571.10
R1	Reactor Outlet	R3-OtTmp.OUT2	576.22
R1	Heater Zone 1	R3-Zone1.OUT2	571.71
R1	Heater Zone 2	R3-Zone2.OUT2	573.71
R1	Heater Zone 3	R3-Zone3.OUT2	574.20
R1	Heater Zone 4	R3-Zone4.OUT2	582.22
R2	Reactor Outlet	R2OtTmp.OUT	36.19
R2	Heater Zone 1	R2-Zone1.OUT	51.15
R2	Heater Zone 2	R2-Zone2.OUT	53.19
R2	Heater Zone 3	R2-Zone3.OUT2	128.59
R2	Heater Zone 4	R2-Zone4.OUT2	129.90
S1	Separator Liquid	S1-Liqd.OUT2	219.68
S1	Separator Vessel Liquid	S1-Level.OUT	54.36
S1	Separator Wall	S1-Wall.OUT2	166.:0
S2	Separator Vessel Liquid	S2-Level.OUT	22.45
COND	Condenser Inlet	R2-Zone2.OUT2	127.81
	Let Down Inlet	LtDn In.OUT2	565.13
	Let Down Outlet	LtDn Out.OUT2	274.73
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	39.29
	Raw Coal Hopper	Hopper.OUT	840.33
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	179.79

Appendix D

Process Development Unit (PDU) #74

Date: 11/29/95
Feed Material: Thailand lignite slurry
Particle Size: -60 mesh
Feed slurry flowrate (lb/hr): 525

Conditions

temperature (degrees F): 615
set condition pressure (psi): 2100 psi
est. residence time (min): 7 minutes

Length of test (min): 90

PDU Process Data

12:00 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1849.36
E1	Dowtherm Vapor	E6-DVpTm.OUT2	330.43
E1	Dowtherm Liquid	E6-DLqTm.OUT2	506.54
E1	Preheater Coil Inlet	E6-C1 In.OUT2	225.41
E1	Preheater Coil Outlet	E6-C1Out.OUT2	364.45
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1762.25
E2	Dowtherm Vapor	E5-DVpTm.OUT2	503.85
E2	Dowtherm Liquid	E5-DLqTm.OUT2	515.65
E2	Preheater Coil Inlet	E5-C1 In.OUT2	364.46
E2	Preheater Coil Outlet	E5-C1Out.OUT2	474.23
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2114.38
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2118.63
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	634.94
E3	Preheater Coil Inlet	E9-C1 In.OUT2	477.31
E3	Preheater Coil Outlet	E9-C1Out.OUT2	600.04
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	601.75
R1	Reactor Outlet	R3-OtTmp.OUT2	612.17
R1	Heater Zone 1	R3-Zone1.OUT2	597.06
R1	Heater Zone 2	R3-Zone2.OUT2	601.35
R1	Heater Zone 3	R3-Zone3.OUT2	605.63
R1	Heater Zone 4	R3-Zone4.OUT2	614.16
R2	Reactor Outlet	R2OtTmp.OUT	36.44
R2	Heater Zone 1	R2-Zone1.OUT	50.68
R2	Heater Zone 2	R2-Zone2.OUT	52.64
R2	Heater Zone 3	R2-Zone3.OUT2	127.66
R2	Heater Zone 4	R2-Zone4.OUT2	128.92
S1	Separator Liquid	S1-Liqd.OUT2	223.29
S1	Separator Vessel Liquid	S1-Level.OUT	59.39
S1	Separator Wall	S1-Wall.OUT2	170.90
S2	Separator Vessel Liquid	S2-Level.OUT	22.44
COND	Condenser Inlet	R2-Zone2.OUT2	126.75
	Let Down Inlet	LtDn In.OUT2	585.89
	Let Down Outlet	LtDn Out.OUT2	271.34
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	42.66
	Raw Coal Hopper	Hopper.OUT	2631.69
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	383.97

PDU Process Data

12:15 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1862.95
E1	Dowtherm Vapor	E6-DVpTm.OUT2	331.98
E1	Dowtherm Liquid	E6-DLqTm.OUT2	505.90
E1	Preheater Coil Inlet	E6-C1 In.OUT2	228.:0
E1	Preheater Coil Outlet	E6-C1Out.OUT2	366.87
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1772.47
E2	Dowtherm Vapor	E5-DVpTm.OUT2	507.15
E2	Dowtherm Liquid	E5-DLqTm.OUT2	519.27
E2	Preheater Coil Inlet	E5-C1 In.OUT2	368.01
E2	Preheater Coil Outlet	E5-C1Out.OUT2	478.91
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2123.83
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2138.75
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	640.81
E3	Preheater Coil Inlet	E9-C1 In.OUT2	481.15
E3	Preheater Coil Outlet	E9-C1Out.OUT2	606.57
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	607.27
R1	Reactor Outlet	R3-OtTmp.OUT2	619.83
R1	Heater Zone 1	R3-Zone1.OUT2	605.16
R1	Heater Zone 2	R3-Zone2.OUT2	609.61
R1	Heater Zone 3	R3-Zone3.OUT2	613.78
R1	Heater Zone 4	R3-Zone4.OUT2	621.79
R2	Reactor Outlet	R2OtTmp.OUT	35.60
R2	Heater Zone 1	R2-Zone1.OUT	50.18
R2	Heater Zone 2	R2-Zone2.OUT	52.19
R2	Heater Zone 3	R2-Zone3.OUT2	126.69
R2	Heater Zone 4	R2-Zone4.OUT2	128.04
S1	Separator Liquid	S1-Liqd.OUT2	229.58
S1	Separator Vessel Liquid	S1-Level.OUT	61.91
S1	Separator Wall	S1-Wall.OUT2	171.19
S2	Separator Vessel Liquid	S2-Level.OUT	22.41
COND	Condenser Inlet	R2-Zone2.OUT2	125.95
	Let Down Inlet	LtDn In.OUT2	595.17
	Let Down Outlet	LtDn Out.OUT2	274.14
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	40.38
	Raw Coal Hopper	Hopper.OUT	2622.89
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	383.21

PDU Process Data

12:30 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1863.02
E1	Dowtherm Vapor	E6-DVpTm.OUT2	333.87
E1	Dowtherm Liquid	E6-DLqTm.OUT2	504.86
E1	Preheater Coil Inlet	E6-C1 In.OUT2	229.15
E1	Preheater Coil Outlet	E6-C1Out.OUT2	366.63
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1770.70
E2	Dowtherm Vapor	E5-DVpTm.OUT2	510.53
E2	Dowtherm Liquid	E5-DLqTm.OUT2	522.63
E2	Preheater Coil Inlet	E5-C1 In.OUT2	387.43
E2	Preheater Coil Outlet	E5-C1Out.OUT2	482.25
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2125.71
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2133.51
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	642.99
E3	Preheater Coil Inlet	E9-C1 In.OUT2	484.30
E3	Preheater Coil Outlet	E9-C1Out.OUT2	608.45
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	610.52
R1	Reactor Outlet	R3-OtTmp.OUT2	624.65
R1	Heater Zone 1	R3-Zone1.OUT2	609.75
R1	Heater Zone 2	R3-Zone2.OUT2	613.92
R1	Heater Zone 3	R3-Zone3.OUT2	618.29
R1	Heater Zone 4	R3-Zone4.OUT2	626.22
R2	Reactor Outlet	R2OtTmp.OUT	35.02
R2	Heater Zone 1	R2-Zone1.OUT	49.20
R2	Heater Zone 2	R2-Zone2.OUT	50.:0
R2	Heater Zone 3	R2-Zone3.OUT2	125.10
R2	Heater Zone 4	R2-Zone4.OUT2	126.53
S1	Separator Liquid	S1-Liqd.OUT2	231.28
S1	Separator Vessel Liquid	S1-Level.OUT	61.66
S1	Separator Wall	S1-Wall.OUT2	173.09
S2	Separator Vessel Liquid	S2-Level.OUT	22.39
COND	Condenser Inlet	R2-Zone2.OUT2	123.81
	Let Down Inlet	LtDn In.OUT2	598.26
	Let Down Outlet	LtDn Out.OUT2	262.63
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	41.88
	Raw Coal Hopper	Hopper.OUT	2612.55
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	382.62

PDU Process Data

12:45 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1847.52
E1	Dowtherm Vapor	E6-DVpTm.OUT2	336.99
E1	Dowtherm Liquid	E6-DLqTm.OUT2	506.05
E1	Preheater Coil Inlet	E6-C1 In.OUT2	227.77
E1	Preheater Coil Outlet	E6-C1Out.OUT2	368.42
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1752.89
E2	Dowtherm Vapor	E5-DVpTm.OUT2	514.72
E2	Dowtherm Liquid	E5-DLqTm.OUT2	525.11
E2	Preheater Coil Inlet	E5-C1 In.OUT2	370.27
E2	Preheater Coil Outlet	E5-C1Out.OUT2	485.19
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2105.12
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2111.53
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	648.47
E3	Preheater Coil Inlet	E9-C1 In.OUT2	487.92
E3	Preheater Coil Outlet	E9-C1Out.OUT2	612.63
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	614.78
R1	Reactor Outlet	R3-OtTmp.OUT2	628.08
R1	Heater Zone 1	R3-Zone1.OUT2	612.90
R1	Heater Zone 2	R3-Zone2.OUT2	619.56
R1	Heater Zone 3	R3-Zone3.OUT2	622.22
R1	Heater Zone 4	R3-Zone4.OUT2	629.51
R2	Reactor Outlet	R2OtTmp.OUT	35.92
R2	Heater Zone 1	R2-Zone1.OUT	49.89
R2	Heater Zone 2	R2-Zone2.OUT	51.64
R2	Heater Zone 3	R2-Zone3.OUT2	125.81
R2	Heater Zone 4	R2-Zone4.OUT2	127.21
S1	Separator Liquid	S1-Liqd.OUT2	232.67
S1	Separator Vessel Liquid	S1-Level.OUT	59.87
S1	Separator Wall	S1-Wall.OUT2	176.33
S2	Separator Vessel Liquid	S2-Level.OUT	22.56
COND	Condenser Inlet	R2-Zone2.OUT2	124.95
	Let Down Inlet	LtDn In.OUT2	603.40
	Let Down Outlet	LtDn Out.OUT2	239.59
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	40.44
	Raw Coal Hopper	Hopper.OUT	2586.14
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	374.31

PDU Process Data

13:00 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1819.84
E1	Dowtherm Vapor	E6-DVpTm.OUT2	319.87
E1	Dowtherm Liquid	E6-DLqTm.OUT2	503.78
E1	Preheater Coil Inlet	E6-C1 In.OUT2	175.52
E1	Preheater Coil Outlet	E6-C1Out.OUT2	323.79
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1721.43
E2	Dowtherm Vapor	E5-DVpTm.OUT2	500.57
E2	Dowtherm Liquid	E5-DLqTm.OUT2	516.76
E2	Preheater Coil Inlet	E5-C1 In.OUT2	324.96
E2	Preheater Coil Outlet	E5-C1Out.OUT2	456.01
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2072.39
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2063.38
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	643.79
E3	Preheater Coil Inlet	E9-C1 In.OUT2	457.70
E3	Preheater Coil Outlet	E9-C1Out.OUT2	598.16
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	600.32
R1	Reactor Outlet	R3-OtTmp.OUT2	613.27
R1	Heater Zone 1	R3-Zone1.OUT2	596.50
R1	Heater Zone 2	R3-Zone2.OUT2	601.47
R1	Heater Zone 3	R3-Zone3.OUT2	603.11
R1	Heater Zone 4	R3-Zone4.OUT2	618.48
R2	Reactor Outlet	R2OtTmp.OUT	35.36
R2	Heater Zone 1	R2-Zone1.OUT	49.12
R2	Heater Zone 2	R2-Zone2.OUT	50.38
R2	Heater Zone 3	R2-Zone3.OUT2	123.81
R2	Heater Zone 4	R2-Zone4.OUT2	125.63
S1	Separator Liquid	S1-Liqd.OUT2	227.56
S1	Separator Vessel Liquid	S1-Level.OUT	44.22
S1	Separator Wall	S1-Wall.OUT2	176.18
S2	Separator Vessel Liquid	S2-Level.OUT	22.19
COND	Condenser Inlet	R2-Zone2.OUT2	122.71
	Let Down Inlet	LtDn In.OUT2	502.64
	Let Down Outlet	LtDn Out.OUT2	253.01
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	42.08
	Raw Coal Hopper	Hopper.OUT	1106.86
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	207.70

PDU Process Data

13:15 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1825.25
E1	Dowtherm Vapor	E6-DVpTm.OUT2	356.05
E1	Dowtherm Liquid	E6-DLqTm.OUT2	511.88
E1	Preheater Coil Inlet	E6-C1 In.OUT2	218.62
E1	Preheater Coil Outlet	E6-C1Out.OUT2	373.43
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1726.88
E2	Dowtherm Vapor	E5-DVpTm.OUT2	540.47
E2	Dowtherm Liquid	E5-DLqTm.OUT2	547.10
E2	Preheater Coil Inlet	E5-C1 In.OUT2	373.25
E2	Preheater Coil Outlet	E5-C1Out.OUT2	506.73
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2065.66
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2073.15
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	647.34
E3	Preheater Coil Inlet	E9-C1 In.OUT2	508.65
E3	Preheater Coil Outlet	E9-C1Out.OUT2	615.34
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	617.59
R1	Reactor Outlet	R3-OtTmp.OUT2	623.55
R1	Heater Zone 1	R3-Zone1.OUT2	617.30
R1	Heater Zone 2	R3-Zone2.OUT2	617.38
R1	Heater Zone 3	R3-Zone3.OUT2	621.93
R1	Heater Zone 4	R3-Zone4.OUT2	624.98
R2	Reactor Outlet	R2OtTmp.OUT	35.35
R2	Heater Zone 1	R2-Zone1.OUT	47.91
R2	Heater Zone 2	R2-Zone2.OUT	49.69
R2	Heater Zone 3	R2-Zone3.OUT2	123.14
R2	Heater Zone 4	R2-Zone4.OUT2	123.77
S1	Separator Liquid	S1-Liqd.OUT2	217.79
S1	Separator Vessel Liquid	S1-Level.OUT	63.06
S1	Separator Wall	S1-Wall.OUT2	173.86
S2	Separator Vessel Liquid	S2-Level.OUT	22.42
COND	Condenser Inlet	R2-Zone2.OUT2	121.42
	Let Down Inlet	LtDn In.OUT2	609.87
	Let Down Outlet	LtDn Out.OUT2	230.58
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	37.56
	Raw Coal Hopper	Hopper.OUT	159.06
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	150.51

PDU Process Data

13:30 11/29/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1797.79
E1	Dowtherm Vapor	E6-DVpTm.OUT2	380.06
E1	Dowtherm Liquid	E6-DLqTm.OUT2	512.91
E1	Preheater Coil Inlet	E6-C1 In.OUT2	236.54
E1	Preheater Coil Outlet	E6-C1Out.OUT2	404.21
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1693.27
E2	Dowtherm Vapor	E5-DVpTm.OUT2	560.66
E2	Dowtherm Liquid	E5-DLqTm.OUT2	567.08
E2	Preheater Coil Inlet	E5-C1 In.OUT2	405.53
E2	Preheater Coil Outlet	E5-C1Out.OUT2	536.34
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2023.12
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2032.90
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	644.98
E3	Preheater Coil Inlet	E9-C1 In.OUT2	536.87
E3	Preheater Coil Outlet	E9-C1Out.OUT2	617.62
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	618.48
R1	Reactor Outlet	R3-OtTmp.OUT2	629.48
R1	Heater Zone 1	R3-Zone1.OUT2	618.01
R1	Heater Zone 2	R3-Zone2.OUT2	621.57
R1	Heater Zone 3	R3-Zone3.OUT2	627.03
R1	Heater Zone 4	R3-Zone4.OUT2	633.73
R2	Reactor Outlet	R2OtTmp.OUT	34.49
R2	Heater Zone 1	R2-Zone1.OUT	47.55
R2	Heater Zone 2	R2-Zone2.OUT	49.31
R2	Heater Zone 3	R2-Zone3.OUT2	122.08
R2	Heater Zone 4	R2-Zone4.OUT2	122.10
S1	Separator Liquid	S1-Liqd.OUT2	205.26
S1	Separator Vessel Liquid	S1-Level.OUT	54.24
S1	Separator Wall	S1-Wall.OUT2	167.57
S2	Separator Vessel Liquid	S2-Level.OUT	22.08
COND	Condenser Inlet	R2-Zone2.OUT2	120.85
	Let Down Inlet	LtDn In.OUT2	617.62
	Let Down Outlet	LtDn Out.OUT2	300.05
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	37.81
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	196.74
	Slurry Mix Tank	MixTank.OUT	51.01

Appendix D

Process Development Unit (PDU) #75

Date: 11/30/95
Feed Material: Thailand lignite slurry
Particle Size: -60 mesh
Feed slurry flowrate (lb/hr): 525

<u>Conditions</u>

temperature (degrees F): 575
set condition pressure (psi): 2100 psi
est. residence time (min): 15 minutes

Length of test (min): 90

E1	Slurry Pre-Heater Inlet	E51nPres.OUT	1747.86
E1	Dowtherm Vapor	E6-DVpTm.OUT2	341.07
E1	Dowtherm Liquid	E6-DLqTm.OUT2	478.07
E1	Preheater Coil Inlet	E6-C1 In.OUT2	238.75
E1	Preheater Coil Outlet	E6-C1Out.OUT2	376.35
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1666.50
E2	Dowtherm Vapor	E5-DVpTm.OUT2	515.41
E2	Dowtherm Liquid	E5-DLqTm.OUT2	524.58
E2	Preheater Coil Inlet	E5-C1 In.OUT2	378.15
E2	Preheater Coil Outlet	E5-C1Out.OUT2	488.32
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2020.25
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2032.43
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	612.57
E3	Preheater Coil Inlet	E9-C1 In.OUT2	491.33
E3	Preheater Coil Outlet	E9-C1Out.OUT2	583.26
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	584.29
R1	Reactor Outlet	R3-OtTmp.OUT2	573.71
R1	Heater Zone 1	R3-Zone1.OUT2	576.24
R1	Heater Zone 2	R3-Zone2.OUT2	582.63
R1	Heater Zone 3	R3-Zone3.OUT2	584.81
R1	Heater Zone 4	R3-Zone4.OUT2	585.89
R2	Reactor Outlet	R2OtTmp.OUT	175.82
R2	Heater Zone 1	R2-Zone1.OUT	272.76
R2	Heater Zone 2	R2-Zone2.OUT	254.67
R2	Heater Zone 3	R2-Zone3.OUT2	442.53
R2	Heater Zone 4	R2-Zone4.OUT2	391.17
S1	Separator Liquid	S1-Liqd.OUT2	107.:0
S1	Separator Vessel Liquid	S1-Level.OUT	44.13
S1	Separator Wall	S1-Wall.OUT2	92.43
S2	Separator Vessel Liquid	S2-Level.OUT	21.20
COND	Condenser Inlet	R2-Zone2.OUT2	490.40
	Let Down Inlet	LtDn In.OUT2	321.43
	Let Down Outlet	LtDn Out.OUT2	224.83
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	21.10
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	176.02
	Slurry Mix Tank	MixTank.OUT	40.37

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1805.47
E1	Dowtherm Vapor	E6-DVpTm.OUT2	335.23
E1	Dowtherm Liquid	E6-DLqTm.OUT2	475.46
E1	Preheater Coil Inlet	E6-C1 In.OUT2	235.95
E1	Preheater Coil Outlet	E6-C1Out.OUT2	363.58
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1707.59
E2	Dowtherm Vapor	E5-DVpTm.OUT2	508.55
E2	Dowtherm Liquid	E5-DLqTm.OUT2	520.76
E2	Preheater Coil Inlet	E5-C1 In.OUT2	365.60
E2	Preheater Coil Outlet	E5-C1Out.OUT2	480.88
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2059.79
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2076.83
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	610.96
E3	Preheater Coil Inlet	E9-C1 In.OUT2	483.77
E3	Preheater Coil Outlet	E9-C1Out.OUT2	580.38
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	581.32
R1	Reactor Outlet	R3-OtTmp.OUT2	593.66
R1	Heater Zone 1	R3-Zone1.OUT2	580.12
R1	Heater Zone 2	R3-Zone2.OUT2	585.07
R1	Heater Zone 3	R3-Zone3.OUT2	589.53
R1	Heater Zone 4	R3-Zone4.OUT2	596.96
R2	Reactor Outlet	R2OtTmp.OUT	281.53
R2	Heater Zone 1	R2-Zone1.OUT	299.81
R2	Heater Zone 2	R2-Zone2.OUT	300.18
R2	Heater Zone 3	R2-Zone3.OUT2	568.15
R2	Heater Zone 4	R2-Zone4.OUT2	559.15
S1	Separator Liquid	S1-Liqd.OUT2	121.29
S1	Separator Vessel Liquid	S1-Level.OUT	64.82
S1	Separator Wall	S1-Wall.OUT2	98.70
S2	Separator Vessel Liquid	S2-Level.OUT	21.33
CON1	Condenser Inlet	R2-Zone2.OUT2	572.46
	Let Down Inlet	LtDn In.OUT2	503.07
	Let Down Outlet	LtDn Out.OUT2	267.16
	Product Tank Vessel	PrdTKLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	40.53
	Raw Coal Hopper	Hopper.OUT	694.40
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	179.10

E1	Slurry Pre-heater Inlet	E6InPres.OUT	[illegible]
E1	Dowtherm Vapor	E6-DVpTm.OUT2	361.[illegible]
E1	Dowtherm Liquid	E6-DLqTm.OUT2	430.40
E1	Preheater Coil Inlet	E6-C1 In.OUT2	242.98
E1	Preheater Coil Outlet	E6-C1Out.OUT2	388.95
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1716.40
E2	Dowtherm Vapor	E5-DVpTm.OUT2	524.84
E2	Dowtherm Liquid	E5-DLqTm.OUT2	531.70
E2	Preheater Coil Inlet	E5-C1 In.OUT2	388.95
E2	Preheater Coil Outlet	E5-C1Out.OUT2	499.18
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2075.06
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2093.62
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	604.75
E3	Preheater Coil Inlet	E9-C1 In.OUT2	502.34
E3	Preheater Coil Outlet	E9-C1Out.OUT2	580.78
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	581.17
R1	Reactor Outlet	R3-OtTmp.OUT2	593.53
R1	Heater Zone 1	R3-Zone1.OUT2	578.61
R1	Heater Zone 2	R3-Zone2.OUT2	584.85
R1	Heater Zone 3	R3-Zone3.OUT2	588.72
R1	Heater Zone 4	R3-Zone4.OUT2	596.64
R2	Reactor Outlet	R2OtTmp.OUT	303.52
R2	Heater Zone 1	R2-Zone1.OUT	302.47
R2	Heater Zone 2	R2-Zone2.OUT	306.26
R2	Heater Zone 3	R2-Zone3.OUT2	581.79
R2	Heater Zone 4	R2-Zone4.OUT2	582.39
S1	Separator Liquid	S1-Liqd.OUT2	139.76
S1	Separator Vessel Liquid	S1-Level.OUT	61.19
S1	Separator Wall	S1-Wall.OUT2	103.90
S2	Separator Vessel Liquid	S2-Level.OUT	21.12
COND	Condenser Inlet	R2-Zone2.OUT2	583.29
	Let Down Inlet	LtDn In.OUT2	552.99
	Let Down Outlet	LtDn Out.OUT2	280.63
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	28.46
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	193.19
	Slurry Mix Tank	MixTank.OUT	44.96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1775.47
E1	Dowtherm Vapor	E6-DVpTm.OUT2	370.33
E1	Dowtherm Liquid	E6-DLqTm.OUT2	484.43
E1	Preheater Coil Inlet	E6-C1 In.OUT2	256.73
E1	Preheater Coil Outlet	E6-C1Out.OUT2	402.99
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1685.80
E2	Dowtherm Vapor	E5-DVpTm.OUT2	540.42
E2	Dowtherm Liquid	E5-DLqTm.OUT2	546.79
E2	Preheater Coil Inlet	E5-C1 In.OUT2	403.45
E2	Preheater Coil Outlet	E5-C1Out.OUT2	518.52
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2034.10
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2047.03
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	605.13
E3	Preheater Coil Inlet	E9-C1 In.OUT2	520.75
E3	Preheater Coil Outlet	E9-C1Out.OUT2	584.11
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	584.35
R1	Reactor Outlet	R3-OtTmp.OUT2	593.85
R1	Heater Zone 1	R3-Zone1.OUT2	580.70
R1	Heater Zone 2	R3-Zone2.OUT2	583.59
R1	Heater Zone 3	R3-Zone3.OUT2	587.14
R1	Heater Zone 4	R3-Zone4.OUT2	595.65
R2	Reactor Outlet	R2OtTmp.OUT	307.66
R2	Heater Zone 1	R2-Zone1.OUT	303.54
R2	Heater Zone 2	R2-Zone2.OUT	308.19
R2	Heater Zone 3	R2-Zone3.OUT2	585.90
R2	Heater Zone 4	R2-Zone4.OUT2	588.05
S1	Separator Liquid	S1-Liqd.OUT2	160.58
S1	Separator Vessel Liquid	S1-Level.OUT	50.77
S1	Separator Wall	S1-Wall.OUT2	114.51
S2	Separator Vessel Liquid	S2-Level.OUT	21.26
COND	Condenser Inlet	R2-Zone2.OUT2	586.97
	Let Down Inlet	LtDn In.OUT2	554.06
	Let Down Outlet	LtDn Out.OUT2	224.97
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	39.22
	Raw Coal Hopper	Hopper.OUT	2509.17
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	371.72

PDU Process Data

11:00 11/30/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1819.56
E1	Dowtherm Vapor	E6-DVpTm.OUT2	378.65
E1	Dowtherm Liquid	E6-DLqTm.OUT2	485.95
E1	Preheater Coil Inlet	E6-C1 In.OUT2	251.15
E1	Preheater Coil Outlet	E6-C1Out.OUT2	400.27
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1727.22
E2	Dowtherm Vapor	E5-DVpTm.OUT2	554.86
E2	Dowtherm Liquid	E5-DLqTm.OUT2	560.93
E2	Preheater Coil Inlet	E5-C1 In.OUT2	400.64
E2	Preheater Coil Outlet	E5-C1Out.OUT2	530.96
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2082.53
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2089.27
E3	Dowtherm Liquid Temperature	E9-DLqTm.OUT2	594.03
E3	Preheater Coil Inlet	E9-C1 In.OUT2	533.13
E3	Preheater Coil Outlet	E9-C1Out.OUT2	576.09
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	576.36
R1	Reactor Outlet	R3-OtTmp.OUT2	590.93
R1	Heater Zone 1	R3-Zone1.OUT2	573.49
R1	Heater Zone 2	R3-Zone2.OUT2	574.52
R1	Heater Zone 3	R3-Zone3.OUT2	581.26
R1	Heater Zone 4	R3-Zone4.OUT2	591.55
R2	Reactor Outlet	R2OtTmp.OUT	312.84
R2	Heater Zone 1	R2-Zone1.OUT	305.31
R2	Heater Zone 2	R2-Zone2.OUT	310.52
R2	Heater Zone 3	R2-Zone3.OUT2	594.28
R2	Heater Zone 4	R2-Zone4.OUT2	594.48
S1	Separator Liquid	S1-Liqd.OUT2	199.91
S1	Separator Vessel Liquid	S1-Level.OUT	62.54
S1	Separator Wall	S1-Wall.OUT2	153.30
S2	Separator Vessel Liquid	S2-Level.OUT	21.45
COND	Condenser Inlet	R2-Zone2.OUT2	590.99
	Let Down Inlet	LtDn In.OUT2	560.51
	Let Down Outlet	LtDn Out.OUT2	247.10
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	45.88
	Raw Coal Hopper	Hopper.OUT	432.05
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	160.38

Appendix D

Process Development Unit (PDU) #75

Date: 11/30/95
Feed Material: Thailand lignite slurry
Particle Size: -60 mesh
Feed slurry flowrate (lb/hr): 525

Conditions

temperature (degrees F): 620
set condition pressure (psi): 2100 psi
est. residence time (min): 15 minutes

Length of test (min): 90

PDU Process Data

11:30 11/30/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1813.57
E1	Dowtherm Vapor	E6-DVpTm.OUT2	377.04
E1	Dowtherm Liquid	E6-DLqTm.OUT2	487.49
E1	Preheater Coil Inlet	E6-C1 In.OUT2	246.91
E1	Preheater Coil Outlet	E6-C1Out.OUT2	395.20
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1714.16
E2	Dowtherm Vapor	E5-DVpTm.OUT2	552.62
E2	Dowtherm Liquid	E5-DLqTm.OUT2	559.78
E2	Preheater Coil Inlet	E5-C1 In.OUT2	396.36
E2	Preheater Coil Outlet	E5-C1Out.OUT2	525.69
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2074.51
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2074.68
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	649.87
E3	Preheater Coil Inlet	E9-C1 In.OUT2	529.32
E3	Preheater Coil Outlet	E9-C1Out.OUT2	621.46
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	622.07
R1	Reactor Outlet	R3-OtTmp.OUT2	626.11
R1	Heater Zone 1	R3-Zone1.OUT2	617.43
R1	Heater Zone 2	R3-Zone2.OUT2	620.14
R1	Heater Zone 3	R3-Zone3.OUT2	623.37
R1	Heater Zone 4	R3-Zone4.OUT2	629.13
R2	Reactor Outlet	R2OtTmp.OUT	316.29
R2	Heater Zone 1	R2-Zone1.OUT	319.18
R2	Heater Zone 2	R2-Zone2.OUT	319.65
R2	Heater Zone 3	R2-Zone3.OUT2	603.62
R2	Heater Zone 4	R2-Zone4.OUT2	601.20
S1	Separator Liquid	S1-Liqd.OUT2	213.41
S1	Separator Vessel Liquid	S1-Level.OUT	68.27
S1	Separator Wall	S1-Wall.OUT2	163.57
S2	Separator Vessel Liquid	S2-Level.OUT	21.29
COND	Condenser Inlet	R2-Zone2.OUT2	607.33
	Let Down Inlet	LtDn In.OUT2	576.59
	Let Down Outlet	LtDn Out.OUT2	255.19
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	43.31
	Raw Coal Hopper	Hopper.OUT	2567.01
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	370.41

PDU Process Data

11:45 11/30/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1817.3[illegible]
E1	Dowtherm Vapor	E6-DVpTm.OUT2	368.81
E1	Dowtherm Liquid	E6-DLqTm.OUT2	457.54
E1	Preheater Coil Inlet	E6-C1 In.OUT2	246.63
E1	Preheater Coil Outlet	E6-C1Out.OUT2	382.26
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1702.63
E2	Dowtherm Vapor	E5-DVpTm.OUT2	542.46
E2	Dowtherm Liquid	E5-DLqTm.OUT2	552.56
E2	Preheater Coil Inlet	E5-C1 In.OUT2	385.58
E2	Preheater Coil Outlet	E5-C1Out.OUT2	514.70
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2064.76
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2058.46
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	643.42
E3	Preheater Coil Inlet	E9-C1 In.OUT2	517.11
E3	Preheater Coil Outlet	E9-C1Out.OUT2	614.61
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	615.41
R1	Reactor Outlet	R3-OtTmp.OUT2	631.87
R1	Heater Zone 1	R3-Zone1.OUT2	611.39
R1	Heater Zone 2	R3-Zone2.OUT2	615.87
R1	Heater Zone 3	R3-Zone3.OUT2	622.52
R1	Heater Zone 4	R3-Zone4.OUT2	632.47
R2	Reactor Outlet	R2OtTmp.OUT	328.10
R2	Heater Zone 1	R2-Zone1.OUT	326.71
R2	Heater Zone 2	R2-Zone2.OUT	329.39
R2	Heater Zone 3	R2-Zone3.OUT2	623.40
R2	Heater Zone 4	R2-Zone4.OUT2	621.93
S1	Separator Liquid	S1-Liqd.OUT2	216.72
S1	Separator Vessel Liquid	S1-Level.OUT	67.25
S1	Separator Wall	S1-Wall.OUT2	168.36
S2	Separator Vessel Liquid	S2-Level.OUT	21.24
COND	Condenser Inlet	R2-Zone2.OUT2	624.90
	Let Down Inlet	LtDn In.OUT2	596.36
	Let Down Outlet	LtDn Out.OUT2	245.55
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	42.61
	Raw Coal Hopper	Hopper.OUT	2562.30
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	378.05

PDU Process Data

12:00 11/30/90

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1771.66
E1	Dowtherm Vapor	E6-DVpTm.OUT2	414.14
E1	Dowtherm Liquid	E6-DLqTm.OUT2	504.24
E1	Preheater Coil Inlet	E6-C1 In.OUT2	192.46
E1	Preheater Coil Outlet	E6-C1Out.OUT2	409.37
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1700.12
E2	Dowtherm Vapor	E5-DVpTm.OUT2	574.00
E2	Dowtherm Liquid	E5-DLqTm.OUT2	579.34
E2	Preheater Coil Inlet	E5-C1 In.OUT2	411.95
E2	Preheater Coil Outlet	E5-C1Out.OUT2	547.34
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2069.17
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2058.39
E3	Dowtherm Liquid Temperature	E9-DLqTm.OUT2	644.82
E3	Preheater Coil Inlet	E9-C1 In.OUT2	548.89
E3	Preheater Coil Outlet	E9-C1Out.OUT2	619.90
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	620.49
R1	Reactor Outlet	R3-OtTmp.OUT2	628.09
R1	Heater Zone 1	R3-Zone1.OUT2	616.25
R1	Heater Zone 2	R3-Zone2.OUT2	616.96
R1	Heater Zone 3	R3-Zone3.OUT2	620.69
R1	Heater Zone 4	R3-Zone4.OUT2	629.06
R2	Reactor Outlet	R2OtTmp.OUT	330.17
R2	Heater Zone 1	R2-Zone1.OUT	323.62
R2	Heater Zone 2	R2-Zone2.OUT	328.02
R2	Heater Zone 3	R2-Zone3.OUT2	622.63
R2	Heater Zone 4	R2-Zone4.OUT2	623.86
S1	Separator Liquid	S1-Liqd.OUT2	218.53
S1	Separator Vessel Liquid	S1-Level.OUT	48.47
S1	Separator Wall	S1-Wall.OUT2	169.29
S2	Separator Vessel Liquid	S2-Level.OUT	20.94
CDR1	Condenser Inlet	R2-Zone2.OUT2	622.19
	Let Down Inlet	LtDn In.OUT2	601.88
	Let Down Outlet	LtDn Out.OUT2	265.20
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	43.57
	Raw Coal Hopper	Hopper.OUT	1809.23
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	286.03

PDU Process Data

12:15 11/30/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1815.69
E1	Dowtherm Vapor	E6-DVpTm.OUT2	376.30
E1	Dowtherm Liquid	E6-DLqTm.OUT2	494.49
E1	Preheater Coil Inlet	E6-C1 In.OUT2	186.36
E1	Preheater Coil Outlet	E6-C1Out.OUT2	369.43
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1706.98
E2	Dowtherm Vapor	E5-DVpTm.OUT2	567.73
E2	Dowtherm Liquid	E5-DLqTm.OUT2	575.74
E2	Preheater Coil Inlet	E5-C1 In.OUT2	371.80
E2	Preheater Coil Outlet	E5-C1Out.OUT2	527.72
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2056.28
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2057.90
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	641.70
E3	Preheater Coil Inlet	E9-C1 In.OUT2	529.60
E3	Preheater Coil Outlet	E9-C1Out.OUT2	612.86
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	614.67
R1	Reactor Outlet	R3-OtTmp.OUT2	624.96
R1	Heater Zone 1	R3-Zone1.OUT2	610.06
R1	Heater Zone 2	R3-Zone2.OUT2	615.05
R1	Heater Zone 3	R3-Zone3.OUT2	620.44
R1	Heater Zone 4	R3-Zone4.OUT2	624.84
R2	Reactor Outlet	R2OtTmp.OUT	328.93
R2	Heater Zone 1	R2-Zone1.OUT	326.30
R2	Heater Zone 2	R2-Zone2.OUT	326.06
R2	Heater Zone 3	R2-Zone3.OUT2	616.13
R2	Heater Zone 4	R2-Zone4.OUT2	621.34
S1	Separator Liquid	S1-Liqd.OUT2	222.84
S1	Separator Vessel Liquid	S1-Level.OUT	62.69
S1	Separator Wall	S1-Wall.OUT2	172.75
S2	Separator Vessel Liquid	S2 Level.OUT	20.86
CONI	Condenser Inlet	R2-Zone2.OUT2	618.73
	Let Down Inlet	LtDn In.OUT2	605.69
	Let Down Outlet	LtDn Out.OUT2	279.78
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	44.74
	Raw Coal Hopper	Hopper.OUT	425.09
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	144.31

PDU Process Data

12:45 11/30/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1760.89
E1	Dowtherm Vapor	E6-DVpTm.OUT2	402.41
E1	Dowtherm Liquid	E6-DLqTm.OUT2	499.34
E1	Preheater Coil Inlet	E6-C1 In.OUT2	262.20
E1	Preheater Coil Outlet	E6-C1Out.OUT2	425.26
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1670.55
E2	Dowtherm Vapor	E5-DVpTm.OUT2	572.77
E2	Dowtherm Liquid	E5-DLqTm.OUT2	578.82
E2	Preheater Coil Inlet	E5-C1 In.OUT2	423.79
E2	Preheater Coil Outlet	E5-C1Out.OUT2	547.40
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2009.41
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2024.77
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	643.01
E3	Preheater Coil Inlet	E9-C1 In.OUT2	551.47
E3	Preheater Coil Outlet	E9-C1Out.OUT2	621.24
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	621.15
R1	Reactor Outlet	R3-OtTmp.OUT2	628.76
R1	Heater Zone 1	R3-Zone1.OUT2	616.46
R1	Heater Zone 2	R3-Zone2.OUT2	619.31
R1	Heater Zone 3	R3-Zone3.OUT2	625.03
R1	Heater Zone 4	R3-Zone4.OUT2	630.61
R2	Reactor Outlet	R2OtTmp.OUT	330.23
R2	Heater Zone 1	R2-Zone1.OUT	330.24
R2	Heater Zone 2	R2-Zone2.OUT	330.75
R2	Heater Zone 3	R2-Zone3.OUT2	625.92
R2	Heater Zone 4	R2-Zone4.OUT2	628.80
S1	Seperator Liquid	S1-Liqd.OUT2	203.60
S1	Separator Vessel Liquid	S1-Level.OUT	51.73
S1	Separator Wall	S1-Wall.OUT2	167.44
S2	Separator Vessel Liquid	S2-Level.OUT	20.66
COND	Condenser Inlet	R2-Zone2.OUT2	627.30
	Let Down Inlet	LtDn In.OUT2	616.14
	Let Down Outlet	LtDn Out.OUT2	304.10
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	38.34
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	52.63

PDU Process Data

13:00 11/30/95

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1766.41
E1	Dowtherm Vapor	E6-DVpTm.OUT2	425.40
E1	Dowtherm Liquid	E6-DLqTm.OUT2	506.99
E1	Preheater Coil Inlet	E6-C1 In.OUT2	267.72
E1	Preheater Coil Outlet	E6-C1Out.OUT2	444.47
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1666.00
E2	Dowtherm Vapor	E5-DVpTm.OUT2	591.81
E2	Dowtherm Liquid	E5-DLqTm.OUT2	597.10
E2	Preheater Coil Inlet	E5-C1 In.OUT2	443.88
E2	Preheater Coil Outlet	E5-C1Out.OUT2	570.94
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2029.28
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2027.81
E3	Dowtherm Liquid Temperature	E9-DLqTm.OUT2	642.93
E3	Preheater Coil Inlet	E9-C1 In.OUT2	573.52
E3	Preheater Coil Outlet	E9-C1Out.OUT2	624.74
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	625.60
R1	Reactor Outlet	R3-OtTmp.OUT2	631.26
R1	Heater Zone 1	R3-Zone1.OUT2	619.03
R1	Heater Zone 2	R3-Zone2.OUT2	621.07
R1	Heater Zone 3	R3-Zone3.OUT2	624.62
R1	Heater Zone 4	R3-Zone4.OUT2	632.34
R2	Reactor Outlet	R2OtTmp.OUT	332.33
R2	Heater Zone 1	R2-Zone1.OUT	326.54
R2	Heater Zone 2	R2-Zone2.OUT	330.30
R2	Heater Zone 3	R2-Zone3.OUT2	626.77
R2	Heater Zone 4	R2-Zone4.OUT2	628.70
S1	Separator Liquid	S1-Liqd.OUT2	209.67
S1	Separator Vessel Liquid	S1-Level.OUT	36.24
S1	Separator Wall	S1-Wall.OUT2	165.81
S2	Separator Vessel Liquid	S2-Level.OUT	20.63
COND	Condenser Inlet	R2-Zone2.OUT2	526.45
	Let Down Inlet	LtDn In.OUT2	593.30
	Let Down Outlet	LtDn Out.OUT2	256.64
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	46.45
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	0.00
	Slurry Mix Tank	MixTank.OUT	0.00

Appendix D

Process Development Unit (PDU) #76

Date: 1/11/96
Feed Material: Thailand lignite slurry
Particle Size: -60 mesh
Feed slurry flowrate (lb/hr): 525

Conditions

temperature (degrees F): 620
set condition pressure (psi): 2100 psi
est. residence time (min): 7 minutes

Length of test (min): 180

PDU Process Data

10:30 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1757.96
E1	Dowtherm Vapor	E6-DVpTm.OUT2	350.24
E1	Dowtherm Liquid	E6-DLqTm.OUT2	498.57
E1	Preheater Coil Inlet	E6-C1 In.OUT2	242.00
E1	Preheater Coil Outlet	E6-C1Out.OUT2	402.22
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1658.82
E2	Dowtherm Vapor	E5-DVpTm.OUT2	541.32
E2	Dowtherm Liquid	E5-DLqTm.OUT2	547.08
E2	Preheater Coil Inlet	E5-C1 In.OUT2	401.65
E2	Preheater Coil Outlet	E5-C1Out.OUT2	517.77
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2012.39
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2020.84
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	637.76
E3	Preheater Coil Inlet	E9-C1 In.OUT2	522.03
E3	Preheater Coil Outlet	E9-C1Out.OUT2	612.65
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	614.96
R1	Reactor Outlet	R3-OtTmp.OUT2	612.01
R1	Heater Zone 1	R3-Zone1.OUT2	604.39
R1	Heater Zone 2	R3-Zone2.OUT2	608.81
R1	Heater Zone 3	R3-Zone3.OUT2	611.95
R1	Heater Zone 4	R3-Zone4.OUT2	618.52
R2	Reactor Outlet	R2OtTmp.OUT	43.33
R2	Heater Zone 1	R2-Zone1.OUT	30.27
R2	Heater Zone 2	R2-Zone2.OUT	28.94
R2	Heater Zone 3	R2-Zone3.OUT2	81.91
R2	Heater Zone 4	R2-Zone4.OUT2	81.32
S1	Separator Liquid	S1-Liqd.OUT2	193.62
S1	Separator Vessel Liquid	S1-Level.OUT	39.91
S1	Separator Wall	S1-Wall.OUT2	138.45
S2	Separator Vessel Liquid	S2-Level.OUT	20.93
COND	Condenser Inlet	R2-Zone2.OUT2	84.21
	Let Down Inlet	LtDn In.OUT2	580.50
	Let Down Outlet	LtDn Out.OUT2	88.11
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	44.21
	Raw Coal Hopper	Hopper.OUT	2703.97
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	393.92

PDU Process Data

11:45 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1816.97
E1	Dowtherm Vapor	E6-DVpTm.OUT2	372.16
E1	Dowtherm Liquid	E6-DLqTm.OUT2	508.08
E1	Preheater Coil Inlet	E6-C1 In.OUT2	255.22
E1	Preheater Coil Outlet	E6-C1Out.OUT2	418.58
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1719.60
E2	Dowtherm Vapor	E5-DVpTm.OUT2	563.91
E2	Dowtherm Liquid	E5-DLqTm.OUT2	568.90
E2	Preheater Coil Inlet	E5-C1 In.OUT2	418.85
E2	Preheater Coil Outlet	E5-C1Out.OUT2	539.31
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2069.22
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2092.34
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	639.29
E3	Preheater Coil Inlet	E9-C1 In.OUT2	543.:0
E3	Preheater Coil Outlet	E9-C1Out.OUT2	617.74
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	619.62
R1	Reactor Outlet	R3-OtTmp.OUT2	587.62
R1	Heater Zone 1	R3-Zone1.OUT2	610.92
R1	Heater Zone 2	R3-Zone2.OUT2	613.81
R1	Heater Zone 3	R3-Zone3.OUT2	613.49
R1	Heater Zone 4	R3-Zone4.OUT2	609.37
R2	Reactor Outlet	R2OtTmp.OUT	46.30
R2	Heater Zone 1	R2-Zone1.OUT	31.06
R2	Heater Zone 2	R2-Zone2.OUT	29.64
R2	Heater Zone 3	R2-Zone3.OUT2	83.90
R2	Heater Zone 4	R2-Zone4.OUT2	83.93
S1	Separator Liquid	S1-Liqd.OUT2	218.38
S1	Separator Vessel Liquid	S1-Level.OUT	64.11
S1	Separator Wall	S1-Wall.OUT2	167.45
S2	Separator Vessel Liquid	S2-Level.OUT	21.36
COND	Condenser Inlet	R2-Zone2.OUT2	85.35
	Let Down Inlet	LtDn In.OUT2	549.21
	Let Down Outlet	LtDn Out.OUT2	257.17
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	39.:0
	Raw Coal Hopper	Hopper.OUT	2679.69
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	390.70

PDU Process Data

12:00 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1816.87
E1	Dowtherm Vapor	E6-DVpTm.OUT2	358.10
E1	Dowtherm Liquid	E6-DLqTm.OUT2	503.62
E1	Preheater Coil Inlet	E6-C1 In.OUT2	196.15
E1	Preheater Coil Outlet	E6-C1Out.OUT2	376.09
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1707.30
E2	Dowtherm Vapor	E5-DVpTm.OUT2	562.14
E2	Dowtherm Liquid	E5-DLqTm.OUT2	568.40
E2	Preheater Coil Inlet	E5-C1 In.OUT2	377.51
E2	Preheater Coil Outlet	E5-C1Out.OUT2	532.17
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2061.12
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2059.72
E3	Dowtherm Liquid Temperature	E9-DLqTm.OUT2	636.25
E3	Preheater Coil Inlet	E9-C1 In.OUT2	532.20
E3	Preheater Coil Outlet	E9-C1Out.OUT2	612.98
CDR1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	614.04
R1	Reactor Outlet	R3-OtTmp.OUT2	626.38
R1	Heater Zone 1	R3-Zone1.OUT2	612.38
R1	Heater Zone 2	R3-Zone2.OUT2	620.06
R1	Heater Zone 3	R3-Zone3.OUT2	623.86
R1	Heater Zone 4	R3-Zone4.OUT2	630.65
R2	Reactor Outlet	R2OtTmp.OUT	53.22
R2	Heater Zone 1	R2-Zone1.OUT	29.69
R2	Heater Zone 2	R2-Zone2.OUT	28.10
R2	Heater Zone 3	R2-Zone3.OUT2	80.95
R2	Heater Zone 4	R2-Zone4.OUT2	81.27
S1	Separator Liquid	S1-Liqd.OUT2	221.33
S1	Separator Vessel Liquid	S1-Level.OUT	58.95
S1	Separator Wall	S1-Wall.OUT2	167.41
S2	Separator Vessel Liquid	S2-Level.OUT	21.25
COND	Condenser Inlet	R2-Zone2.OUT2	82.57
	Let Down Inlet	LtDn In.OUT2	598.39
	Let Down Outlet	LtDn Out.OUT2	256.69
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	43.11
	Raw Coal Hopper	Hopper.OUT	2194.52
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	325.58

PDU Process Data

12:15 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1800.80
E1	Dowtherm Vapor	E6-DVpTm.OUT2	349.37
E1	Dowtherm Liquid	E6-DLqTm.OUT2	500.14
E1	Preheater Coil Inlet	E6-C1 In.OUT2	194.21
E1	Preheater Coil Outlet	E6-C1Out.OUT2	366.21
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1691.25
E2	Dowtherm Vapor	E5-DVpTm.OUT2	551.26
E2	Dowtherm Liquid	E5-DLqTm.OUT2	558.37
E2	Preheater Coil Inlet	E5-C1 In.OUT2	366.65
E2	Preheater Coil Outlet	E5-C1Out.OUT2	518.39
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2033.98
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2036.08
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	640.58
E3	Preheater Coil Inlet	E9-C1 In.OUT2	518.12
E3	Preheater Coil Outlet	E9-C1Out.OUT2	613.54
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	614.85
R1	Reactor Outlet	R3-OtTmp.OUT2	623.77
R1	Heater Zone 1	R3-Zone1.OUT2	620.97
R1	Heater Zone 2	R3-Zone2.OUT2	622.11
R1	Heater Zone 3	R3-Zone3.OUT2	621.94
R1	Heater Zone 4	R3-Zone4.OUT2	624.78
R2	Reactor Outlet	R2OtTmp.OUT	47.57
R2	Heater Zone 1	R2-Zone1.OUT	28.06
R2	Heater Zone 2	R2-Zone2.OUT	26.67
R2	Heater Zone 3	R2-Zone3.OUT2	78.43
R2	Heater Zone 4	R2-Zone4.OUT2	78.63
S1	Separator Liquid	S1-Liqd.OUT2	218.28
S1	Separator Vessel Liquid	S1-Level.OUT	59.65
S1	Separator Wall	S1-Wall.OUT2	169.04
S2	Separator Vessel Liquid	S2-Level.OUT	21.18
COND	Condenser Inlet	R2-Zone2.OUT2	80.00
	Let Down Inlet	LtDn In.OUT2	610.25
	Let Down Outlet	LtDn Out.OUT2	256.51
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	44.19
	Raw Coal Hopper	Hopper.OUT	782.37
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	180.79

PDU Process Data

12:30 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1785.08
E1	Dowtherm Vapor	E6-DVpTm.OUT2	351.41
E1	Dowtherm Liquid	E6-DLqTm.OUT2	500.23
E1	Preheater Coil Inlet	E6-C1 In.OUT2	181.75
E1	Preheater Coil Outlet	E6-C1Out.OUT2	366.63
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1683.77
E2	Dowtherm Vapor	E5-DVpTm.OUT2	553.20
E2	Dowtherm Liquid	E5-DLqTm.OUT2	561.04
E2	Preheater Coil Inlet	E5-C1 In.OUT2	367.91
E2	Preheater Coil Outlet	E5-C1Out.OUT2	520.35
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2018.79
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2024.29
E3	Dowtherm Liquid Temperature	E9-DLqTm.OUT2	632.92
E3	Preheater Coil Inlet	E9-C1 In.OUT2	520.36
E3	Preheater Coil Outlet	E9-C1Out.OUT2	606.64
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	608.40
R1	Reactor Outlet	R3-OtTmp.OUT2	628.26
R1	Heater Zone 1	R3-Zone1.OUT2	616.12
R1	Heater Zone 2	R3-Zone2.OUT2	622.34
R1	Heater Zone 3	R3-Zone3.OUT2	626.74
R1	Heater Zone 4	R3-Zone4.OUT2	631.14
R2	Reactor Outlet	R2OtTmp.OUT	40.13
R2	Heater Zone 1	R2-Zone1.OUT	27.94
R2	Heater Zone 2	R2-Zone2.OUT	26.41
R2	Heater Zone 3	R2-Zone3.OUT2	77.86
R2	Heater Zone 4	R2-Zone4.OUT2	78.22
S1	Separator Liquid	S1-Liqd.OUT2	199.44
S1	Separator Vessel Liquid	S1-Level.OUT	54.44
	Separator Wall	S1-Wall.OUT2	166.03
S2	Separator Vessel Liquid	S2-Level.OUT	21.10
[illegible]	Condenser Inlet	R2-Zone2.OUT2	79.49
	Let Down Inlet	LtDn In.OUT2	616.80
	Let Down Outlet	LtDn Out.OUT2	249.64
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	40.82
	Raw Coal Hopper	Hopper.OUT	1624.32
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	267.23

PDU Process Data

12:45 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1795.33
E1	Dowtherm Vapor	E6-DVpTm.OUT2	352.45
E1	Dowtherm Liquid	E6-DLqTm.OUT2	501.28
E1	Preheater Coil Inlet	E6-C1 In.OUT2	186.10
E1	Preheater Coil Outlet	E6-C1Out.OUT2	368.15
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1689.91
E2	Dowtherm Vapor	E5-DVpTm.OUT2	554.34
E2	Dowtherm Liquid	E5-DLqTm.OUT2	562.26
E2	Preheater Coil Inlet	E5-C1 In.OUT2	369.56
E2	Preheater Coil Outlet	E5-C1Out.OUT2	517.65
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2020.34
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2030.44
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	632.71
E3	Preheater Coil Inlet	E9-C1 In.OUT2	518.85
E3	Preheater Coil Outlet	E9-C1Out.OUT2	605.88
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	606.94
R1	Reactor Outlet	R3-OtTmp.OUT2	623.20
R1	Heater Zone 1	R3-Zone1.OUT2	614.65
R1	Heater Zone 2	R3-Zone2.OUT2	622.09
R1	Heater Zone 3	R3-Zone3.OUT2	624.90
R1	Heater Zone 4	R3-Zone4.OUT2	627.86
R2	Reactor Outlet	R2OtTmp.OUT	36.18
R1	Heater Zone 1	R2-Zone1.OUT	27.79
R2	Heater Zone 2	R2-Zone2.OUT	26.13
R2	Heater Zone 3	R2-Zone3.OUT2	77.63
R2	Heater Zone 4	R2-Zone4.OUT2	78.00
S1	Separator Liquid	S1-Liqd.OUT2	194.16
S1	Separator Vessel Liquid	S1-Level.OUT	55.70
S1	Separator Wall	S1-Wall.OUT2	160.04
S2	Separator Vessel Liquid	S2-Level.OUT	21.28
COND	Condenser Inlet	R2-Zone2.OUT2	79.02
	Let Down Inlet	LtDn In.OUT2	609.70
	Let Down Outlet	LtDn Out.OUT2	323.88
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	40.55
	Raw Coal Hopper	Hopper.OUT	1345.10
	Raw Coal Feeder	Feeder.OUT	209.00
	Slurry Mix Tank	MixTank.OUT	245.08

PDU Process Data

13:00 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1797.30
E1	Dowtherm Vapor	E6-DVpTm.OUT2	356.84
E1	Dowtherm Liquid	E6-DLqTm.OUT2	501.31
E1	Preheater Coil Inlet	E6-C1 In.OUT2	190.85
E1	Preheater Coil Outlet	E6-C1Out.OUT2	372.06
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1692.00
E2	Dowtherm Vapor	E5-DVpTm.OUT2	558.25
E2	Dowtherm Liquid	E5-DLqTm.OUT2	564.63
E2	Preheater Coil Inlet	E5-C1 In.OUT2	371.86
E2	Preheater Coil Outlet	E5-C1Out.OUT2	519.65
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2020.48
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2031.13
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	632.43
E3	Preheater Coil Inlet	E9-C1 In.OUT2	519.33
E3	Preheater Coil Outlet	E9-C1Out.OUT2	603.93
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	604.88
R1	Reactor Outlet	R3-OtTmp.OUT2	623.22
R1	Heater Zone 1	R3-Zone1.OUT2	614.10
R1	Heater Zone 2	R3-Zone2.OUT2	620.66
R1	Heater Zone 3	R3-Zone3.OUT2	623.20
R1	Heater Zone 4	R3-Zone4.OUT2	628.21
R2	Reactor Outlet	R2OtTmp.OUT	33.69
R2	Heater Zone 1	R2-Zone1.OUT	27.43
R2	Heater Zone 2	R2-Zone2.OUT	25.84
R2	Heater Zone 3	R2-Zone3.OUT2	76.31
R2	Heater Zone 4	R2-Zone4.OUT2	77.38
S1	Separator Liquid	S1-Liqd.OUT2	183.50
S1	Separator Vessel Liquid	S1-Level.OUT	49.27
S1	Separator Wall	S1-Wall.OUT2	154.70
S2	Separator Vessel Liquid	S2-Level.OUT	21.43
COND	Condenser Inlet	R2-Zone2.OUT2	78.51
	Let Down Inlet	LtDn In.OUT2	610.66
	Let Down Outlet	LtDn Out.OUT2	225.20
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	39.81
	Raw Coal Hopper	Hopper.OUT	298.08
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	143.73

PDU Process Data

13:15 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1784.00
E1	Dowtherm Vapor	E6-DVpTm.OUT2	362.53
E1	Dowtherm Liquid	E6-DLqTm.OUT2	501.38
E1	Preheater Coil Inlet	E6-C1 In.OUT2	253.21
E1	Preheater Coil Outlet	E6-C1Out.OUT2	403.62
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1679.09
E2	Dowtherm Vapor	E5-DVpTm.OUT2	542.01
E2	Dowtherm Liquid	E5-DLqTm.OUT2	551.56
E2	Preheater Coil Inlet	E5-C1 In.OUT2	399.50
E2	Preheater Coil Outlet	E5-C1Out.OUT2	515.44
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2006.93
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2016.99
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	641.15
E3	Preheater Coil Inlet	E9-C1 In.OUT2	517.82
E3	Preheater Coil Outlet	E9-C1Out.OUT2	610.86
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	610.99
R1	Reactor Outlet	R3-OtTmp.OUT2	622.84
R1	Heater Zone 1	R3-Zone1.OUT2	612.52
R1	Heater Zone 2	R3-Zone2.OUT2	617.33
R1	Heater Zone 3	R3-Zone3.OUT2	620.59
R1	Heater Zone 4	R3-Zone4.OUT2	626.75
R2	Reactor Outlet	R2OtTmp.OUT	31.00
R2	Heater Zone 1	R2-Zone1.OUT	26.69
R2	Heater Zone 2	R2-Zone2.OUT	25.48
R2	Heater Zone 3	R2-Zone3.OUT2	75.27
R2	Heater Zone 4	R2-Zone4.OUT2	76.06
S1	Separator Liquid	S1-Liqd.OUT2	176.46
S1	Separator Vessel Liquid	S1-Level.OUT	48.56
S1	Separator Wall	S1-Wall.OUT2	149.55
S2	Separator Vessel Liquid	S2-Level.OUT	21.31
COND	Condenser Inlet	R2-Zone2.OUT2	77.86
	Let Down Inlet	LtDn In.OUT2	611.68
	Let Down Outlet	LtDn Out.OUT2	243.68
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condensor Liquid	Cnd-Levl.OUT	42.03
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	200.00
	Slurry Mix Tank	MixTank.OUT	61.55

PDU Process Data

13:30 01/11/96

E1	Slurry Pre-Heater Inlet	E6InPres.OUT	1810.86
E1	Dowtherm Vapor	E6-DVpTm.OUT2	401.19
E1	Dowtherm Liquid	E6-DLqTm.OUT2	511.05
E1	Preheater Coil Inlet	E6-C1 In.OUT2	272.90
E1	Preheater Coil Outlet	E6-C1Out.OUT2	437.02
E2	Slurry Pre-Heater Inlet	E6-E5Prs.OUT	1708.45
E2	Dowtherm Vapor	E5-DVpTm.OUT2	581.08
E2	Dowtherm Liquid	E5-DLqTm.OUT2	585.28
E2	Preheater Coil Inlet	E5-C1 In.OUT2	435.08
E2	Preheater Coil Outlet	E5-C1Out.OUT2	558.99
E3	Slurry Pre-Heater Inlet	E5-E9Prs.OUT	2051.40
E3	Slurry Pre-Heater Outlet	E9OtPres.OUT	2060.05
E3	Downtherm Liquid Temperature	E9-DLqTm.OUT2	633.85
E3	Preheater Coil Inlet	E9-C1 In.OUT2	563.55
E3	Preheater Coil Outlet	E9-C1Out.OUT2	613.52
E3R1	Preheater -> Reactor Transfer Line	E9-R3 Xf.OUT2	614.56
R1	Reactor Outlet	R3-OtTmp.OUT2	630.92
R1	Heater Zone 1	R3-Zone1.OUT2	612.28
R1	Heater Zone 2	R3-Zone2.OUT2	620.66
R1	Heater Zone 3	R3-Zone3.OUT2	629.09
R1	Heater Zone 4	R3-Zone4.OUT2	635.43
R2	Reactor Outlet	R2OtTmp.OUT	30.61
R2	Heater Zone 1	R2-Zone1.OUT	26.71
R2	Heater Zone 2	R2-Zone2.OUT	25.24
R2	Heater Zone 3	R2-Zone3.OUT2	75.70
R2	Heater Zone 4	R2-Zone4.OUT2	76.23
S1	Separator Liquid	S1-Liqd.OUT2	191.25
S1	Separator Vessel Liquid	S1-Level.OUT	49.85
S1	Separator Wall	S1-Wall.OUT2	146.78
S2	Separator Vessel Liquid	S2-Level.OUT	21.44
COND	Condenser Inlet	R2-Zone2.OUT2	77.49
	Let Down Inlet	LtDn In.OUT2	602.36
	Let Down Outlet	LtDn Out.OUT2	263.56
	Product Tank Vessel	PrdTkLvl.OUT	0.00
	Condenser Liquid	Cnd-Levl.OUT	46.03
	Raw Coal Hopper	Hopper.OUT	0.00
	Raw Coal Feeder	Feeder.OUT	179.49
	Slurry Mix Tank	MixTank.OUT	41.45

Energy & Environmental Research Center

APPENDIX E

HWD PROCESS GAS AND WATER ANALYSIS

*Energy &
Environmental
Research
Center*

University of North Dakota

P.O. Box 9018/ Grand Forks, North Dakota 58202-9018

Gas Analysis Report

Process Chemistry & Development Laboratory

Run # THAI
Date: 11-13-95

			Mole Per Cent
	THAI.01	THAI.03	THAI.06
Sample:	300 C	325 C	275 C
Helium	0.06	0.04	0.02
Hydrogen	0.33	0.70	0.54
Carbon Dioxide	43.25	81.77	82.28
Propane			
Propylene		0.19	0.38
Acetylene			
iso-Butane			
Carbonyl Sulfide			
n-Butane		0.02	0.02
Hydrogen Sulfide	0.17	0.27	0.31
1-Butene			
iso-Butylene	0.02	0.06	0.05
t-2-Butene			
iso-Pentane			
c-2-Butene			
n-Pentane			
1,3-Butadiene			
Ethylene	0.05	0.12	0.11
Ethane	0.06	0.23	0.20
Oxygen/Argon	0.69	1.80	1.74
Nitrogen	53.31	10.60	10.50
Methane	0.76	1.90	1.60
Carbon Monoxide	1.30	2.30	2.25
Calc. BTU/SCF			
Sat.	16.3	42.9	42.9
Dry	16.5	43.7	43.7
Calc. Sp. Gravity	1.202	1.413	1.420
Calc. Ave. Mol Wt.	34.79	40.82	41.00

Energy & Environmental Research Center

University of North Dakota

P.O. Box 9018/ Grand Forks, North Dakota 58202-9018

Gas Analysis Report

Process Chemistry & Development Laboratory

Run # THAILAND

Date: 11-9-95

Mole Per Cent

Sample:	THAI.06 275C Repeat
Helium	0.02
Hydrogen	0.53
Carbon Dioxide	82.86
Propane	
Propylene	0.43
Acetylene	
iso-Butane	
Carbonyl Sulfide	
n-Butane	0.02
Hydrogen Sulfide	0.30
1-Butene	
iso-Butylene	0.05
t-2-Butene	
iso-Pentane	
c-2-Butene	
n-Pentane	
1,3-Butadiene	
Ethylene	0.11
Ethane	0.20
Oxygen/Argon	1.56
Nitrogen	10.28
Methane	1.58
Carbon Monoxide	2.06
Calc. BTU/SCF	
Sat.	43.2
Dry	43.9
Calc. Sp. Gravity	1.423
Calc. Ave. Mol Wt.	41.10

ARL Report Form

REQUESTOR Ray DeWall
PROJ. # 4756
SAMPLE INFO Process Water Samples
DATE SUBMITTED 11/9/95

SAMPLE ID.		THAI 01	THAI 03	THAI 06
		HWD@300	HWD@325	HWD@275
LAB #		48986-1	48986-2	48986-3
PARAMETER	units			
TDS	mg/L	400	1300	230
TSS	mg/L	3000	1300	4500
COD	mg/L	260	584	136
BOD	mg/L	465	930	300
TOC	mg/L	640	1300	320
TC	mg/L	654	1300	326

DATE REPORTED 11-15-95

REPORTED BY

DISTRIBUTION

ANALRPT.XLS

APPENDIX F

GASIFICATION TEST M538

	Grams In	Grams Out	Yields	Normalized Yields	
MAF (Coal/char)	307.5	158.2	51.4	49.9	
H2O in coal/Char	128.1	4.7	-40.1	-40.2	
H2O in Steam/Cond.	245.0	379.7	43.8	40.8	
Ash	18.9	19.1	0.1	-0.1	
Sulfur	1.3	0.9	-0.2	-0.2	
Ash (sulfur free)	17.6	18.3	0.2	0.0	
Cond. Total		1.27	0.41	0.40	
ibp-165		0.00	0.00	0.00	
<C10		0.00	0.00	0.00	
BXT		0.00	0.00	0.00	
165-220		0.00	0.00	0.00	
C10-C12		0.00	0.00	0.00	
Phenols		0.00	0.00	0.00	
Cresols		0.00	0.00	0.00	
Naphthal.		0.00	0.00	0.00	
220-375		0.00	0.00	0.00	
C13-C22		0.00	0.00	0.00	
C2-Phenol		0.00	0.00	0.00	
Phytene		0.00	0.00	0.00	
375-550		0.00	0.00	0.00	
C23-C30		0.00	0.00	0.00	
550-1000		0.00	0.00	0.00	
Aliphatics		0.00	0.00	0.00	
Phenolics		0.00	0.00	0.00	
BP>1000		0.64	0.21	0.21	
Char Fines		0.53	0.17	0.17	
Residue		0.10	0.03	0.03	
					SCF
Gas Total	1464.5	1693.1	74.3	49.2	4.5
H2		2.9	0.9	0.9	1.2
CO2	72.1	216.1	46.8	43.6	2.6
C3H8		0.0	0.0	0.0	0.0
C3H6		1.5	0.5	0.5	0.0
i-C4		0.0	0.0	0.0	0.0
COS		0.0	0.0	0.0	0.0
n-C4		0.0	0.0	0.0	0.0
H2S		0.0	0.0	0.0	0.0
1-Bu		0.0	0.0	0.0	0.0
t-2-Bu		0.0	0.0	0.0	0.0
i-C5		0.0	0.0	0.0	0.0
c-2-Bu		0.0	0.0	0.0	0.0
n-C5		0.0	0.0	0.0	0.0
C2H4		0.8	0.3	0.3	0.0
C2H6		1.1	0.3	0.3	0.0
O2	0.0	0.0	0.0	0.0	0.0
N2	1392.4	1459.1	21.7	-0.0	-0.0
CH4		7.1	2.3	2.2	0.4
CO		8.1	2.6	2.5	0.2
NH3		0.0	0.0	0.0	0.0
Total	2164.0	2256.1	130.0	100.0	
Mat. Balance		104.3			

6/11/96	
Run #	M047_322
Wyodak	
Temp. C	600
% Steam	20.7
% CO2	4.9
% N2	95.1
Steam Vol.	32.5
Gas Vol.	125.0

% loss to char	6
% loss to liq	10
% loss to gas	84

Material Balance Sheet Summary

	Gms In	Gms Out	Yields	N Yields		
						3-12-96
Feed In/Residuals Out	2047.5	431.3	21.1	85.9		
H2O in Feed/Residual	811.4	11.3	-39.1	-38.7	Run #	M538
H2O in H2O/Cond.	3002.0	3431.0	21.0	21.0	Thailand Lignite	
Ash	124.1	36.3	-4.3	0.9	Temp	699.7 C
					Pressure	29.7 psig
					% H2O	29.9
					% N2	70.1
					kg H2O / kg Feed	1.86

	Gms In	Gms Out	Yields	N Yields	SCF
Gas Total	10951.1	10354.4	-29.1	30.9	34.4
H2		40.3	2.0	2.2	19.5
CO2		384.0	18.8	21.0	8.4
C3H8		0.0	0.0	0.0	0.0
C3H6		11.4	0.6	0.6	0.3
C2H2		0.0	0.0	0.0	0.0
i-C4H10		0.0	0.0	0.0	0.0
COS		0.0	0.0	0.0	0.0
n-C4H10		0.0	0.0	0.0	0.0
H2S		5.9	0.3	0.3	0.2
1-C4H8		0.0	0.0	0.0	0.0
i-C4H8		0.0	0.0	0.0	0.0
t-2-C4H8		0.0	0.0	0.0	0.0
i-C5H12		0.0	0.0	0.0	0.0
c-2-C4H8		0.0	0.0	0.0	0.0
n-C5H12		0.0	0.0	0.0	0.0
1,3-C4H6		0.0	0.0	0.0	0.0
C2H4		14.6	0.7	0.8	0.5
C2H6		5.8	0.3	0.3	0.2
O2	0.0	0.0	0.0	0.0	0.0
N2	10951.1	9786.0	-56.9	-0.2	-0.1
CH4		68.6	3.3	3.7	4.1
CO		37.8	1.8	2.1	1.3
NH3		0.0	0.0	0.0	0.0
Total	16936.1	14264.3	-30.5	100.0	
Mat. Balance		84.2			

% Cyclone	0
% Main Char Leg	54
% loss to liq	0
% loss to gas	46

06/12/96
08:14

Material Balance Data

Run Number	M538	Date	3-12-96
Fluidization Velocity	0.72	ft/s	
Run Temperature	699.7	C	
Run Pressure	29.7	psig	
Total N2	10951.1	g	
Total Liquid In	3002.0	g	
Feed Rate	1.0	kg/hr	
Run Duration	3.0	hr	
Initial Tank Pressure	0.0	psig	
Final Tank Pressure	0.0	psig	
Final Product Gas Meter Reading	322.1	SCFH	
Mass of Liquid in Traps	3431.0	g	
Mass of Cyclone Char	87.0	g	
Mass of Bottom Char	385.0	g	

Defaults:

Temperature at Gas Meter	15.56	C
Pressure at Gas Meter	0.0	psig

Char Analysis

Run # M538

	As Recvd Bottom	As Recvd Cyclone
Proximate Analysis (%)		
Moisture	0.60	2.40
Volatile Matter	15.11	18.31
Fixed Carbon	76.89	70.27
Ash	7.40	9.02
	100.00	100.00
Ultimate Analysis (%)		
Hydrogen	0.00	0.00
Carbon	0.00	0.00
Nitrogen	0.00	0.00
Sulfur	0.00	0.00
Oxygen (Diff)	0.00	0.00
Sulfur	0.00	0.00
	0.00	0.00
Sulfur (%)		
Organic Chlorine	0.00	0.00
Inorganic Chlorine	0.00	0.00

		Run #	M538			
Air Free Analysis		Yes				
		Gas Analysis		AIR/HELIUM FREE		
		Gas Bag 1	Gas Bag 2	Gas Bag 1	Gas Bag 2	Average
He	Helium	0.02	0.03			
H2	Hydrogen	5.13	5.31	5.14	5.32	5.23
CO2	Carbon Dioxide	2.19	2.33	2.20	2.34	2.27
C3H8	Propane			0.00	0.00	0.00
C3H6	Propylene	0.06	0.08	0.06	0.08	0.07
C2H2	Acetylene			0.00	0.00	0.00
i-C4H10	iso-Butane			0.00	0.00	0.00
COS	Carbonyl Sulfide			0.00	0.00	0.00
n-C4H10	n-Butane			0.00	0.00	0.00
H2S	Hydrogen Sulfide	0.05	0.04	0.05	0.04	0.05
1-C4H8	1-Butene			0.00	0.00	0.00
i-C4H8	iso-Butylene			0.00	0.00	0.00
t-2-C4H8	t-2-Butene			0.00	0.00	0.00
i-C5H12	iso-Pentane			0.00	0.00	0.00
c-2-C4H8	c-2-Butene			0.00	0.00	0.00
n-C5H12	n-Pentane			0.00	0.00	0.00
1,3-C4H6	1,3-Butadiene			0.00	0.00	0.00
C2H4	Ethylene	0.13	0.14	0.13	0.14	0.14
C2H6	Ethane	0.05	0.05	0.05	0.05	0.05
O2	Oxygen	0.05	0.04			0.00
N2	Nitrogen	90.93	90.44	90.98	90.50	90.74
CH4	Methane	1.05	1.17	1.05	1.17	1.11
CO	Carbon Monoxide	0.34	0.36	0.34	0.36	0.35
NH3	Ammonia			0.00	0.00	0.00
Total						
Avg. Mole Wt		26.9002	26.8580			26.8820

APPENDIX G

GASIFICATION TEST M539

Material Balance Sheet Summary

3-14-96

	Gms In	Gms Out	Yields	N Yields
Feed In/Residuals Out	951.4	193.4	20.3	88.4
H2O in Feed/Residual	377.0	10.4	-38.5	-38.2
H2O in H2O/Cond.	2028.0	2173.0	15.2	15.2
Ash	57.7	25.2	-3.4	3.6

Run #	M539
Thailand Lignite	
Temp	694.2 C
Pressure	29.8 psig
% H2O	30.1
% N2	69.9
kg H2O / kg Feed	2.53

	Gms In	Gms Out	Yields	N Yields	SCF
Gas Total	7335.2	7089.1	-25.9	31.0	18.9
H2		24.0	2.5	2.7	11.1
CO2		136.9	14.4	15.5	2.9
C3H8		0.0	0.0	0.0	0.0
C3H6		6.0	0.6	0.7	0.1
C2H2		0.0	0.0	0.0	0.0
i-C4H10		0.0	0.0	0.0	0.0
COS		0.0	0.0	0.0	0.0
n-C4H10		0.0	0.0	0.0	0.0
H2S		5.5	0.6	0.6	0.2
1-C4H8		0.0	0.0	0.0	0.0
i-C4H8		0.0	0.0	0.0	0.0
t-2-C4H8		0.0	0.0	0.0	0.0
i-C5H12		0.0	0.0	0.0	0.0
c-2-C4H8		0.0	0.0	0.0	0.0
n-C5H12		0.0	0.0	0.0	0.0
1,3-C4H6		0.0	0.0	0.0	0.0
C2H4		6.3	0.7	0.7	0.2
C2H6		1.8	0.2	0.2	0.1
O2	0.0	0.0	0.0	0.0	0.0
N2	7335.2	6820.5	-54.1	0.6	0.2
CH4		49.8	5.2	5.6	2.9
CO		38.2	4.0	4.3	1.3
NH3		0.0	0.0	0.0	0.0
Total	10749.2	9491.0	-32.3	100.0	
Mat. Balance		88.3			
% Cyclone	0				
% Main Char Leg	57				
% loss to liq	0				
% loss to gas	43				

06/12/96
08:15

Material Balance Data

Run Number	M539	Date 3-14-96
Fluidization Velocity	0.72	ft/s
Run Temperature	694.2	C
Run Pressure	29.8	psig
Total N2	7335.2	g
Total Liquid In	2028.0	g
Feed Rate	0.7	kg/hr
Run Duration	2.0	hr
Initial Tank Pressure	0.0	psig
Final Tank Pressure	0.0	psig
Final Product Gas Meter Reading	220.6	SCFH
Mass of Liquid in Traps	2173.0	g
Mass of Cyclone Char	132.0	g
Mass of Bottom Char	93.0	g

Defaults:

Temperature at Gas Meter	15.56	C
Pressure at Gas Meter	0.0	psig

Char Analysis

Run # M539

	As Recvd	
	Bottom	Cyclone
Proximate Analysis (%)		
Moisture	0.40	4.60
Volatile Matter	10.11	17.61
Fixed Carbon	79.86	65.31
Ash	9.36	12.49
	99.73	100.01
Ultimate Analysis (%)		
Hydrogen	0.00	0.00
Carbon	0.00	0.00
Nitrogen	0.00	0.00
Sulfur	0.00	0.00
Oxygen (Diff)	0.00	0.00
Sulfur	0.00	0.00
	0.00	0.00
Sulfur (%)		
Organic Chlorine	0.00	0.00
Inorganic Chlorine	0.00	0.00

		Run #	M539			
Air Free Analysis		Yes				
		Gas Analysis		AIR/HELIUM FREE		
		Gas Bag 1	Gas Bag 2	Gas Bag 1	Gas Bag 2	Average
He	Helium	0.03	0.03			
H2	Hydrogen	2.65	3.24	4.10	4.98	4.54
CO2	Carbon Dioxide	0.67	0.86	1.04	1.32	1.18
C3H8	Propane			0.00	0.00	0.00
C3H6	Propylene	0.04	0.03	0.06	0.05	0.05
C2H2	Acetylene			0.00	0.00	0.00
i-C4H10	iso-Butane			0.00	0.00	0.00
COS	Carbonyl Sulfide			0.00	0.00	0.00
n-C4H10	n-Butane			0.00	0.00	0.00
H2S	Hydrogen Sulfide	0.03	0.05	0.05	0.08	0.06
1-C4H8	1-Butene			0.00	0.00	0.00
i-C4H8	iso-Butylene			0.00	0.00	0.00
t-2-C4H8	t-2-Butene			0.00	0.00	0.00
i-C5H12	iso-Pentane			0.00	0.00	0.00
c-2-C4H8	c-2-Butene			0.00	0.00	0.00
n-C5H12	n-Pentane			0.00	0.00	0.00
1,3-C4H6	1,3-Butadiene			0.00	0.00	0.00
C2H4	Ethylene	0.07	0.04	0.11	0.06	0.08
C2H6	Ethane	0.03		0.05	0.00	0.02
O2	Oxygen	0.04	0.04			0.00
N2	Nitrogen	60.00	60.00	92.69	92.02	92.36
CH4	Methane	0.87	0.66	1.35	1.01	1.18
CO	Carbon Monoxide	0.36	0.31	0.56	0.48	0.52
NH3	Ammonia			0.00	0.00	0.00
Total						
Avg. Mole Wt		17.4574	17.4904			26.8777