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MASS BALANCE RESULTS FOR PRICETOWN 1 UNDERGROUND COAL GASIFICATION

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ABSTRACT

A mass balance model was applied to the Pricetown I test data. This model gave the values of various parameters such as water influx, percent devolatilization, percent gasification, amount of coal affected, thermal efficiency, etc., for the various phases of the test. Both hourly and daily values of the test data were used. At certain times, there was air loss to the coal seam or air gain from the coal seam as related to the underground reactor. Mass balances are modified accordingly. Realistic pyrolysis temperatures have been chosen for the different phases of the test based on the thermocouple responses. The nitrogen and argon balances gave similar results.

The mass balance results showed that approximately 702 tons of coal was affected during the test. Approximately 232 tons of coal was completely gasified. The reverse combustion linkage through the virgin coal seam was dominated by the devolatilization and accounted for approximately 80% devolatilization whereas the same accounted for only 26% devolatilization during the gasification phase. During the enhanced linkage phase, the percent devolatilization ranged between that observed for the RCL and gasification phase. There was net influx of water and amounted to 0.59 barrels per ton of coal affected. The percent energy recovery for the gasification phase was 72% based on gas chromatographic data, and accounting the sensible heat of the gas and the latent heat of the water vapor in the gas.

INTRODUCTION

During an underground gasification (UCG) test, the air injected, the amount and composition of gas produced and the amount and composition of tars produced can be measured. However, the amount of coal consumed and the amount of water which entered the in-situ reactor cannot be determined directly. During the test both devolitization and gasification processes are operating. To determine the amount of coal gasified, the amount carbonized and the amount of water influx, material balances must be performed. The most ideal situation is to perform the balances in real time during the test so that process changes can be effected to optimize the process. If the balances cannot be performed in real time, they are performed following the test to provide a more complete analysis of the process. In this paper the results of the material balances for the Pricetown Field Test are presented.

The results presented below have been acquired during post-test analysis. During the test, material balance algorithums were present on the data acquisition system but because of the size of the data acquisition system as test data density increased, the material balance routines were placed in low priority and not utilized after the first few days of the test. However, if the data acquisition system at the field site had more capacity, material balances could have been performed in real time for better process control.

BACKGROUND

Elder, et al (1), as well as others have described a material balance based on a carbon, hydrogen, and an oxygen balance and has been designated as an oxygen balance method. Schrider, et al (2), also applied the same method for the Hanna I test. Recently, Cena (3) also published a material balance analysis of the Hanna 2 UCG tests using LLL's version of the oxygen balance method. Cena used nine equations to solve for nine unknowns. Only three equations were independent and six of the

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equations were redundant as pointed out by Gunn (4). Lawrence Livermore Lab also used another form of the material balance, called a Tiger Code (5). Unfortunately, the Tiger Code does not have predictive capability. The Tiger Code can back calculate the gas composition if the amount of coal consumed and the amount of water entering the process is known. Recently Gunn (4) pointed out that only the carbon and hydrogen balances should be used for the mass balance as the oxygen balance may lead to error. However, he was addressing a gasification process. For the Pricetown I field test, the oxygen balance method has been used. The predominance of devolatilization (6) during the different phases of the test necessitated the use of the oxygen balance method and it provided reasonably good results.

COAL, CHAR AND DEVOLATILIZATION PRODUCT ANALYSIS

The coal seam at the Pricetown I field site was a high swelling bituminous coal. Because coal is not homogeneous material, its composition will depend upon the location from which the sample is extracted. Consequently, several coal analyses (1, 7, 8, 9, 10, 11), including 48 samples from Pricetown, were used to estimate a composition representative of the Pittsburgh coal seam near Pricetown and to access the sensitivity of the mass balance results to compositional changes of the volatile matter. Average weight percent factors (1) from the Bruceton and Warden mines were used to construct elemental weight percents for the char and the volatile matter produced at various carbonizing temperatures. These factors were applied to the average ultimate analysis (MAF) determined from the samples (7, 12) taken from the core wells at Pricetown. The elemental values thus obtained for the char at 800°C are in good agreement with those reported by Forrester (8) and Solomon (13) for Pittsburgh coal. The appropriate values are shown in Table 1. As can be seen from this Table the volatile matter yield increases with the carbonization temperature. In addition, results from a devolatilization study (14) of the bituminous coal were also used to carry out the sensitivity analysis. The elemental values for the volatile matter from this study and those determined at Mound and by the Bruceton Warden factors for the Pricetown coal are listed in Table 2. The presented mass balance results are based upon the Mound analysis with the other analyses being used to show the sensitivity of these mass balances to the volatile matter analysis.

The yield of volatiles (16) under given conditions can deviate from the ASTM values. Also, it is known that secondary reactions can alter the distribution of devolatilized products and lower the volatile yield when pyrolysis is performed in the presence of surfaces such as bed of coal. This is due to polymerization or condensation reactions occurring within the coke bed. Cracking of simple hydrocarbons can produce carbon and hydrogen and in the limit condensation and polymerization reactions can produce a graphitic deposit.

MASS BLANCE RESULTS

The Pricetown I test was divided into eight phases: Preignition flow testing; RCL-1 (P/I-2 to P/I-3); RCL-2 (P/I-3 to P/I-2); RCL-3 (P/I-2 to P/I-1); LE-1 (P/I-1 to P/I-2); LE-2 (P/I-1 to P/I-2); Gasification (P/I-1 to P/I-2); and Post Test Monitoring. The Preignition phase was designed to establish gas flow characteristics and instrument response times. The RCL (Reverse Combustion Linkage) phases were designed to establish a devolatilized permeable path between the wells. The LE (Link Enhancement) phases were utilized to enhance the conductivity of the linkage path. The gasification phase was a high flow period in which a major portion of the coal seam was gasified. The Post Test Monitoring Phase was conducted to verify that the coal seam returned to its ambient temperature. The duration of each phase is listed in Table 3.

Mass balances equations have been applied to the hourly averages of the Pricetown data. Two models have been considered in quantifying the stoichiometry of the process. The first model assumes char gasification while the second assumes only the carbonization of coal at 800°C. Use of the 800°C temperature is based on actual Pricetown data. The model that actually addresses the process will lie somewhere between these two models. In reality, coal carbonization will precede char gasification. The oxygen balance has been used to combine these models.

Balances were completed on carbon, nitrogen, argon, hydrogen, oxygen, and sulfur. These balances provided information regarding the unknown variables in the process. The carbon balance provided the ratios of standard cubic feet of gas produced to pounds of coal consumed in each of the models. The percentage energy recovery was calculated by using these ratios for each of the models. The nitrogen balance provided the information regarding the air leakage or gain in the system. The argon balance provided a check on the nitrogen balance as both of the gases are inert. The hydrogen balance provided information on the groundwater influx into the reactor zone. The oxygen balance is a check on the previous mass balance calculations. The value of oxygen unaccounted for will have opposite signs in these two models and this indicates that a more accurate model lies somewhere between the gasification and devolatilization models. The oxygen balance has been used to combine these models.

The mass balances have been derived by assuming a 6% water vapor in the produced gas whenever real water data were not available. during the gasification phase, water averaged approximately 6% in the produced gas. During the other phases of the test, the measured water was not the true water as the piping was not at the temperature required to avoid condensation of the water and some of the water stream condensed before the gas stream reached the analytical sampling system.

Figure 1 depicts the typical injection and production rates for the nitrogen for the RCL-1 phase. The nitrogen balance provided insight for interpreting the data. During the RCL-1 phase there was loss of nitrogen during the initial phase of this test and it was followed by a gain towards the end of the phase. This occurred on June 12, and this has been attributed to the process (6).

Figure 3 depicts the computation of water vapor produced by using the argon and nitrogen balances for the gasification phase. As shown, the agreement was good which confirms that the gas analysis, as performed by the analytical system, was consistent.

Figure 4 shows the typical oxygen not accounted for, for the gasification and the devolatilization models and this unaccounted oxygen has been used to combine these two models. Oxygen not accounted for is positive for the gasification model and negative for the devolatilization model, as would be expected. Some of the injected oxygen might have been consumed in the formation of coal tars (discounted as negligible), in reaction with minerals contained in the coal, and in low temperature oxidation of coal yielding no gaseous products but being neglected in these computations. Figures 5, 6, and 7 show the combination of the two models for the RCL-1, LE-1 and the gasification phases, respectively. As illustrated, the percent gasification is much lower during the reverse combustion linkage phase and the percent devolatilization is much higher as expected. During the gasification phase, percent gasification is much higher than the devolatilization phase as would be expected. Values for the Linkage Enhancement phase lie between the valyes for the reverse combustion linkage phase and the gasification phase.

Figure 8 is a typical plot of the net water into the system for the gasification phase. The devolatilization model leads to the outflow of water from the reactor and the gasification model leads to an influx of water. A combination of these two models leads to a net influx of water into the reactor zone. Figure 9 shows the water vapor produced for the September 24-25 period. The computed water vapor produced was more than 30%. This is in agreement with the test operations log book which noted steam flowing from piping leaks. This water could not be measured by the Gas Chromatograph as it exceeded the operational 20% limit for the Gas Chromatograph, which was in use at that time. The Gas Chromatograph could have measured up to 40% water by utilizing an auxiliary system, however, for most of the Pricetown test up to this time, water was below 20% except for some spikes, hence, the auxiliary system was not operating at this time.

Figure 10 is a typical plot of carbon produced during the gasification phase. These plots have been generated for all the phases of the test. All of the carbon has been produced from the coal. Figure 11 is a plot of coal affected during the test. This coal affected has been computed as the maximum of two values i.e., percent devolatilization multiplied by coal affected from the devolatilization model (X1) or percent gasification multiplied by coal affected from the gasification model (X2). During the reverse combustion linkage and the linkage enhancement phases, this value is always X1, as is expected. For the gasification phase, this value is X1 for most of the period. During the beginning of the gasification phase, this value is X1 and a gradual change takes place towards X2. During the end of the gasification phase, the process again changes mode and X1 again becomes the amount of coal affected. When evaluating data on an hourly or daily basis, X1 or X2, whichever is higher, should be taken as the amount of coal affected.

Figure 12 is a typical plot of scf of dry gas produced per lb of coal. For the gasification model, this averaged approximately 64 scf/lb of day coal (Mineral Matter free) and for the devolatilization model, the average was approximately 16 scf/lb of dry coal (Mineral Matter free). These data are consistent with the surface gasifiers. Figure 13 depicts the percent energy recovery for the gasification phase. For the gasification phase, this value ranged from 44.3 to 72.0 percent based on mass spectrometer data. For the Reverse Combustion Linkage and the Link Enhancement Phases, this value was much lower which is to be expected.

Figure 14 shows the sulfur produced during the gasification phase as computed by the sulfur mass balances. Sulfur production was approximately 60 lb/hr for the gasification phase and was much lower for the other phases. The total sulfur production was within EPA limits (17).

Table 4 and Table 5 depict the mass balance results for the coal gasification and the devolatilization models. The values of oxygen unaccounted for in Tables 4 and 5 show opposite signs and that indicates that a more accurate model exists somewhere between pure gasification and pure devolatilization. The amount of coal affected is higher for the devolatilization model as compared to the gasification model by a factor of approximately 4.0. This is also reflected in the scf of dry gas produced per lb of coal where this figure is higher for the gasification model as compared to the devolatilization model by a factor of 4.0. The percent energy recovery for the gasification model is higher by a factor of 4.0 as compared to the devolatilization model. The net water into the system is again positive for the gasification model and is negative for the devolatilization model, as expected.

Table 6 presents the mass balance results for the different phases of the test. The percent devolatilization during the RCL-1 phase was 80.3% and it dropped to 60.0% during the RCL-2 phase. This is expected as the coal seam during the RCL-1 phase was virgin. The percent devolatilization during the RCL-3 phase was 80.1% as the link was being formed in the virgin coal seam. During the LE-1 and LE-2 phases, the percent devolatilization was 48.1 and 57.7%, respectively. During the gasification phase, the percent devolatilization was 25.8%, whereas the percent gasification was 74.2%. The percent energy recovery ranged from 29.8 to 59.3% for the different phases of the test. For the gasification phase, the percent energy recovery was 59.3% based on mass spectrometer data. The gas chromatograph data will lead to a 15% higher thermal efficiency. It should be noted that the sensible heat of the gas and the latent heat of the water vapor has not been taken into account in the energy balances. Inclusion of these numbers will result in an increase in energy recovery by another 5%.

The total amount of coal (MAF) affected were 611.4 tons for all the phases of the test which is equivalent to 701.8 tons of coal. The moisture and ash accounted for 12.4% of the coal content and this means a multiplication factor of 1.147 has to be used to convert coal (MAF) values to absolute coal values. Most of the coal was affected during the LE-2 and gasification phases. These results also indicated an influx of ground water. The total amount of water influx was 414.7 barrels for the test. This amounts to 0.59 barrel of water per ton of coal affected or 9% water in the coal seam, which is not unreasonable.

Table 7 shows the summary of the coal carbonized and gasified during each phase of the test. During the P/I-2 to P/I-3 linkage which consisted of RCL-1 and RCL-2 phases, a total of 39.6 tons of coal (MAF) were carbonized, out of which 5.6 tons of coal (MAF) were completely gasified and 34.1 tons of coal (MAF) were only carbonized. During the P/I-2 to P/I-1 linkage which consisted of RCL-3, LE-1, and LE-2 phases, a total of 333.0 tons of coal (MAF) were carbonized, out of which 58.5 tons of coal (MAF) were completely gasified and 274.5 tons of coal (MAF) were only carbonized. Part of this 274.5 tons of carbonized coal (MAF), all of which was in the P/I-2 to P/I-1 linkage path, took part in the gasification which was carried out from P/I-1 to P/I-2.

During the gasification phase, a total of 239.2 tons of coal (MAF) was carbonized whereas the amount of gasified coal was 167.7 tons (MAF). Part of the coal carbonized during the gasification was probably not gasified and the balance came from the previously carbonized coal.

The computation of 701.8 tons of coal affected is based on the 100% char or the devolatilized matter removal efficiency. But in reality, it may not be true. As a reasonable number, based on post core analysis, a 90% removal efficiency will result in 779.2 tons of coal affected.

SENSITIVITY OF RESULTS TO VOLATILE MATTER COMPOSITION

For comparative purposes, material balances were computed for three volatile matter compositions determined at a carbonizing temperature of 800°C. The elemental weight percents are found in Table 2. The average of the char values found in Table 1 and the char values given in Reference 8 for 800°C were used for these computations. As indicated before, the water vapor in the produced gas was set at 6 mole % for all phases except for the gasification phase where the gas chromatograph values were used whenever they were available. For those instances when the sampling system was not operable, a default value of 6 mole % was used.

Figure 15 and 16 indicate the percent devolatilization for the RCL-1 and gasification phases respectively, for the three different devolatilized matter compositions. Not unexpectedly, the higher carbon content Bruceton-Warden composition leads to higher devolatilization percentages while the hydrogen-oxygen rich Mentser composition (under rapid devolatilization conditions) shows the lowest devolatilization values. For the RCL-1 phase, the Bruceton-Warden composition generates devolatilization values greater than 100%, indicating that the hydrogen and oxygen found in the produced gas cannot be totally accounted for using that composition. The results suggest that the volatile matter composition generated during this phase is actually richer in hydrogen and oxygen, and supports the use of compositions as obtained by Mentser (14).

Figure 17 indicates the tons of coal affected per day for each of the volatile matter compositions. As shown there, the Mentser composition produces the largest numbers for the amount of coal (MAF) affected. The totals for the gasification phase are 239.3, 271.7, and 267.7 tons for the Mound, Mentser, and Bruceton-Warden compositions, respectively.

Comparative plots for the net water into the reactor system for the devolatilization model is shown in Figure 18. With purely devolatilization model, the outflux of water decreases as the relative hydrogen and oxygen content of the volatile matter decreases. As depicted in Figure 18, the Mentser composition indicates approximately twice the water outflux as the Bruceton-Warden composition.

A comparison of the effect of composition, the percent of volatile matter, and the carbonizing temperature on the amount of coal gasified and coal affected is presented in Table 8. Examination of the values shows an increasing trend for coal affected as the carbonizing temperature decreases. Gunn has commented on this previously.(4) A decrease in the percent of volatile matter is reflected in an increase in the coal affected. During this LE-2 phase and during the other phases, computations based on a carbonizing temperature of 800°C produced reasonable results. Calculations based on the assumption of no char formation, according to Gunn's Model (4), produced values about one-third of the value for coal affected as shown in the first Table entry. The assumption of no char formation could lead to erroneous results when the devolatilization is predominant, as was the case during the RCL-1, RCL-2, RCL-3, LE-1, and LE-2 phases. Hence, Gunn's model should be used with discretion when gasification is not the dominating process.

CONCLUSIONS

The Pricetown I Field Test proved the viability of gasifying thin seam, swelling bituminous coal. The mass balance results showed that approximately 702 tons of (611 tons MAF) of coal was affected during the test. Approximately 266 tons (232 tons MAF) of coal was completely gasified. A 90% char or the devolatilized matter removal efficiency will lead to 779 tons (679 tons MAF) of coal affected. The percent gasification and the percent devolatilization varied during the test depending on the test phase. The percent gasification during the gasification phase accounted for the 74% gasification contribution whereas the same during the reverse combustion linkage, through the virgin seam, accounted for only 20% gasification contribution. There was a net influx of water which amounted to 415 barrels for the test. The percent energy recovery ranged from 30 to 59 percent. The percent energy recovery during the gasification phase was 59 percent based on Mass Spectrometer data, and not accounting sensible heat and the latent heat of water vapor. Based on Gas Chromatographic data and accounting the above mentioned contributions, the percent energy recovery for the gasification phase was 72 percent. A sensitivity analysis was done to see the effects of changes in the volatile matter composition on the computed parameters.

The mass balance equations provided reasonable and consistent results. The percent energy recovery for this UCG test was high and this warrants further research and development work to commercialize this technology.

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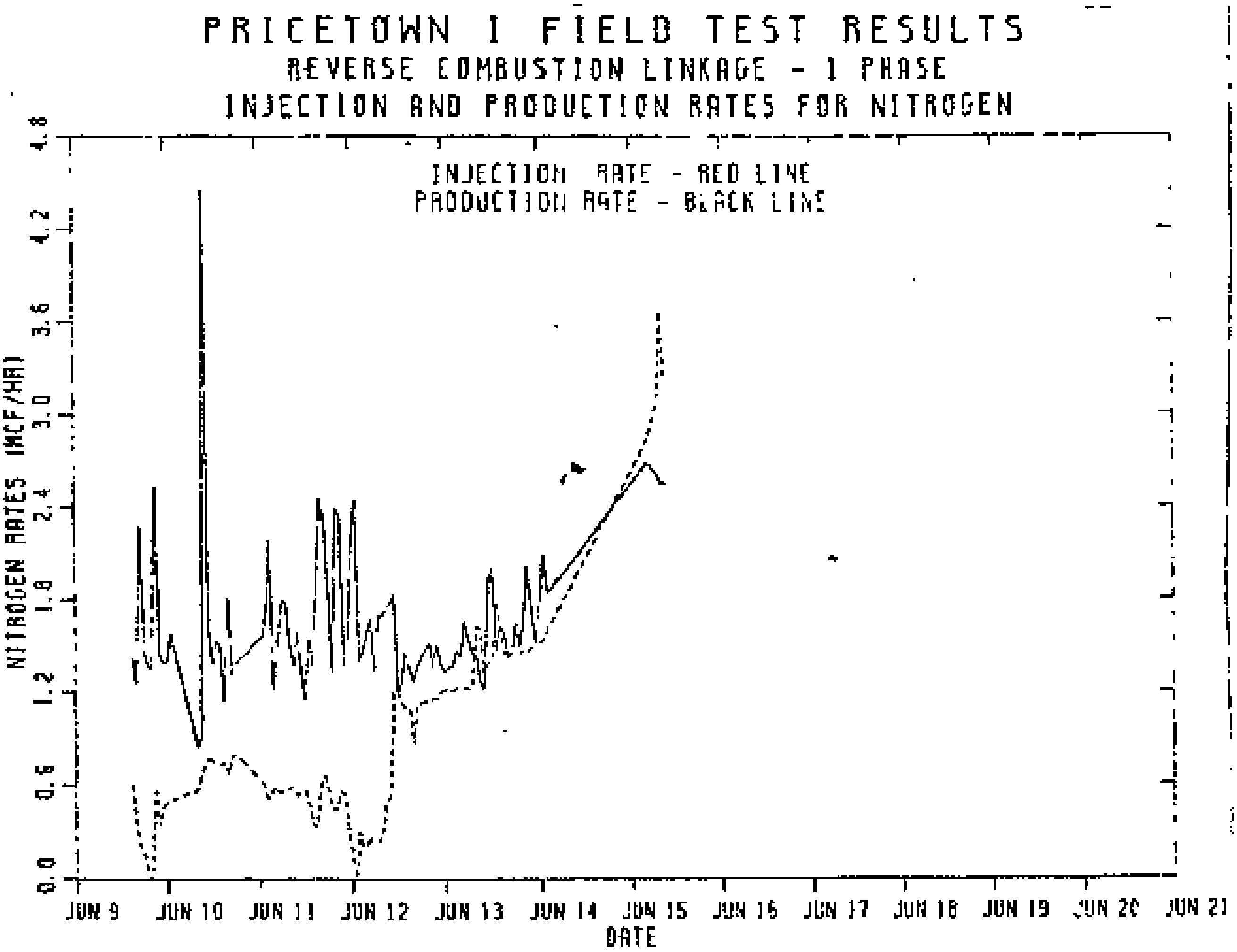


FIGURE 1

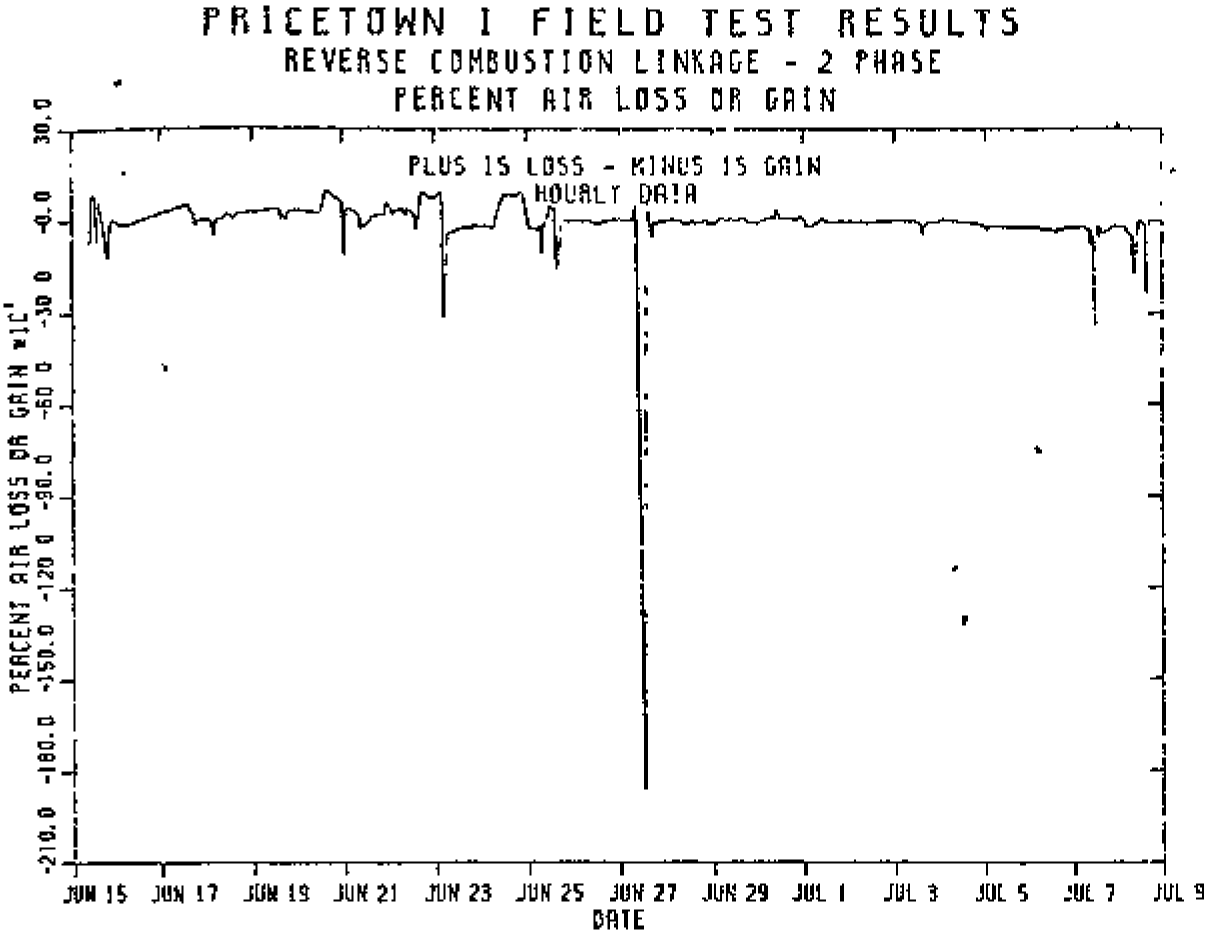

PRICETOWN I FIELD TEST RESULTS
REVERSE COMBUSTION LINKAGE - 2 PHASE
PERCENT AIR LOSS OR GAIN

FIGURE 2

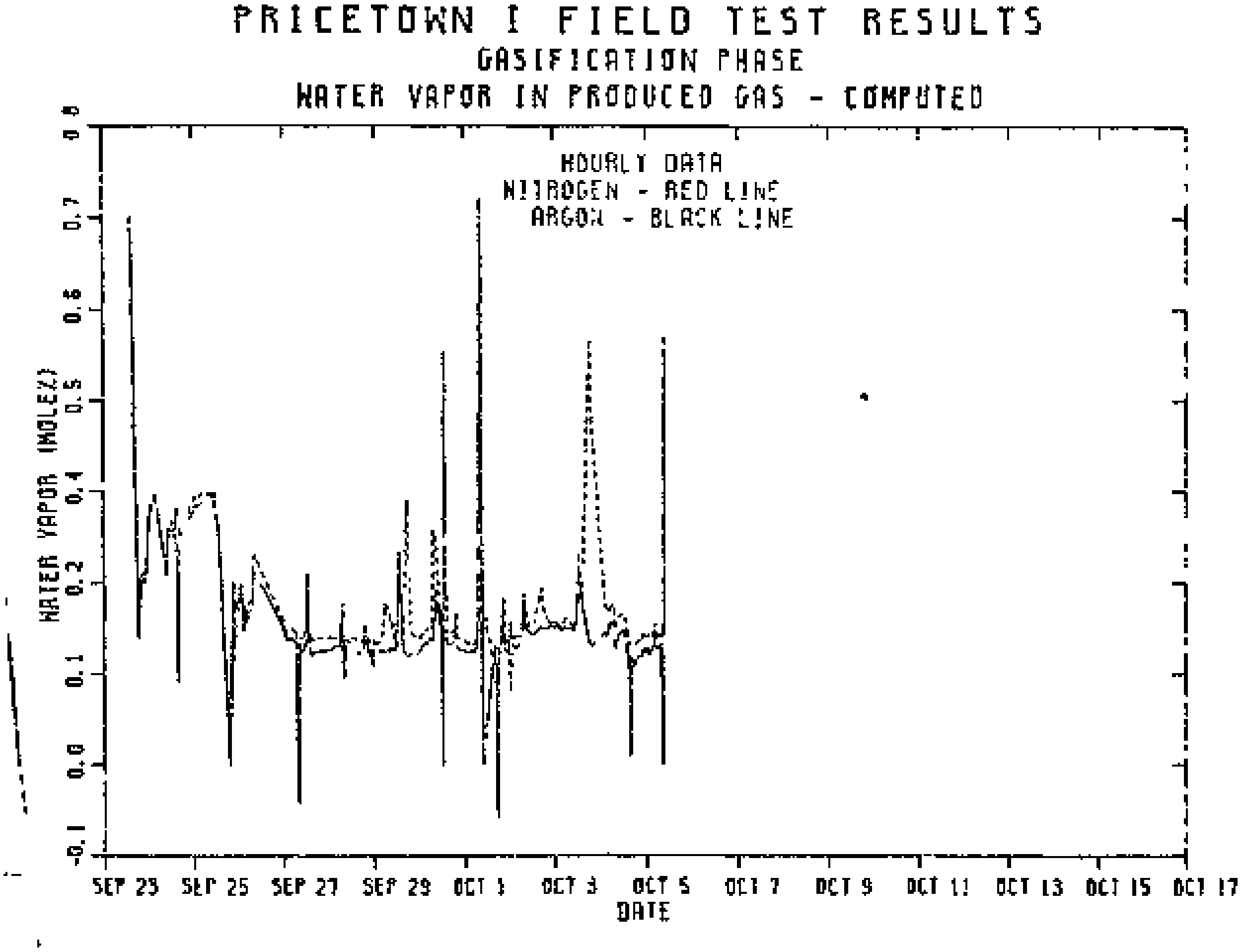

PRICETOWN I FIELD TEST RESULTS
GASIFICATION PHASE
WATER VAPOR IN PRODUCED GAS - COMPUTED

FIGURE 3

PRICETOWN I FIELD TEST RESULTS
ENHANCED LINKAGE - 2 PHASE
OXYGEN NOT ACCOUNTED FOR

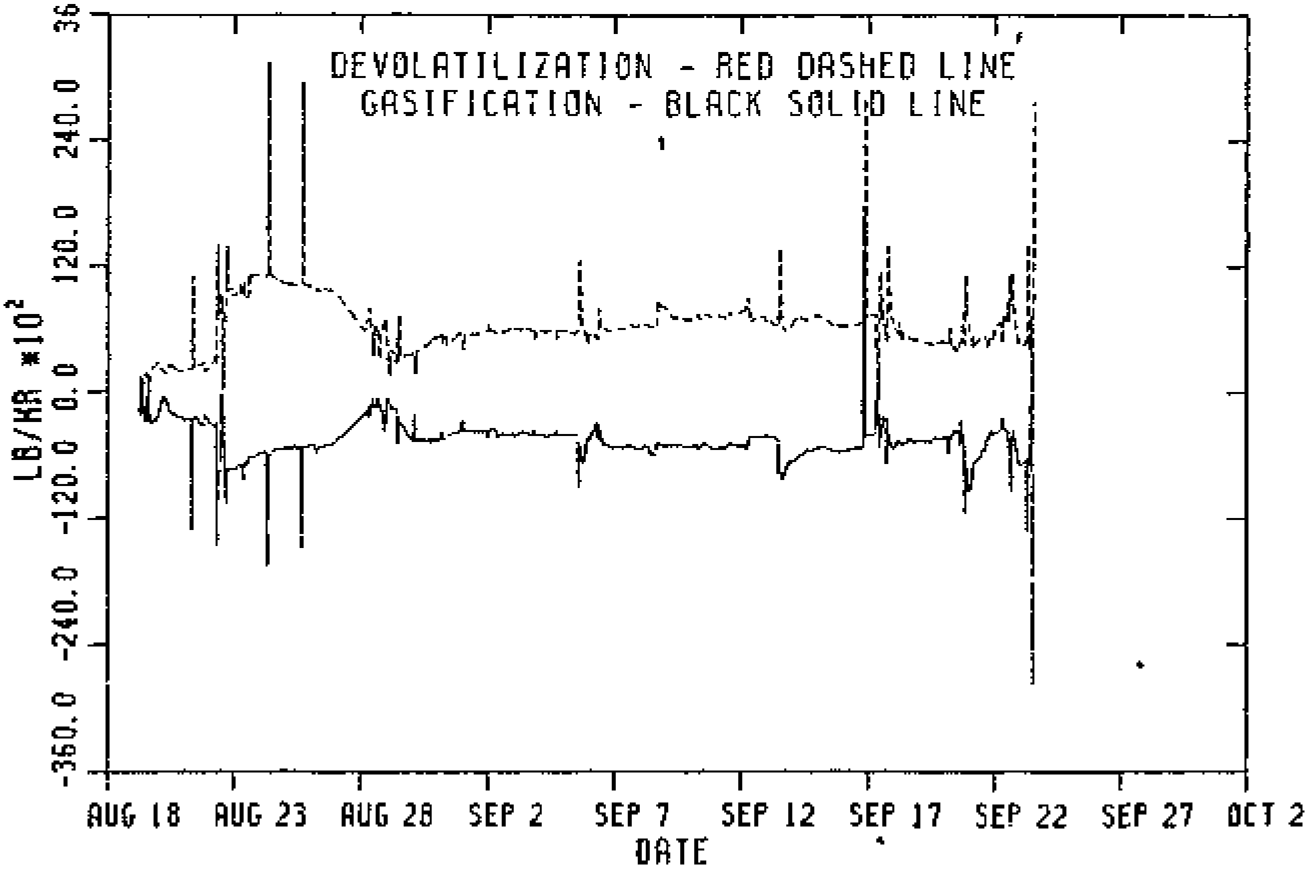
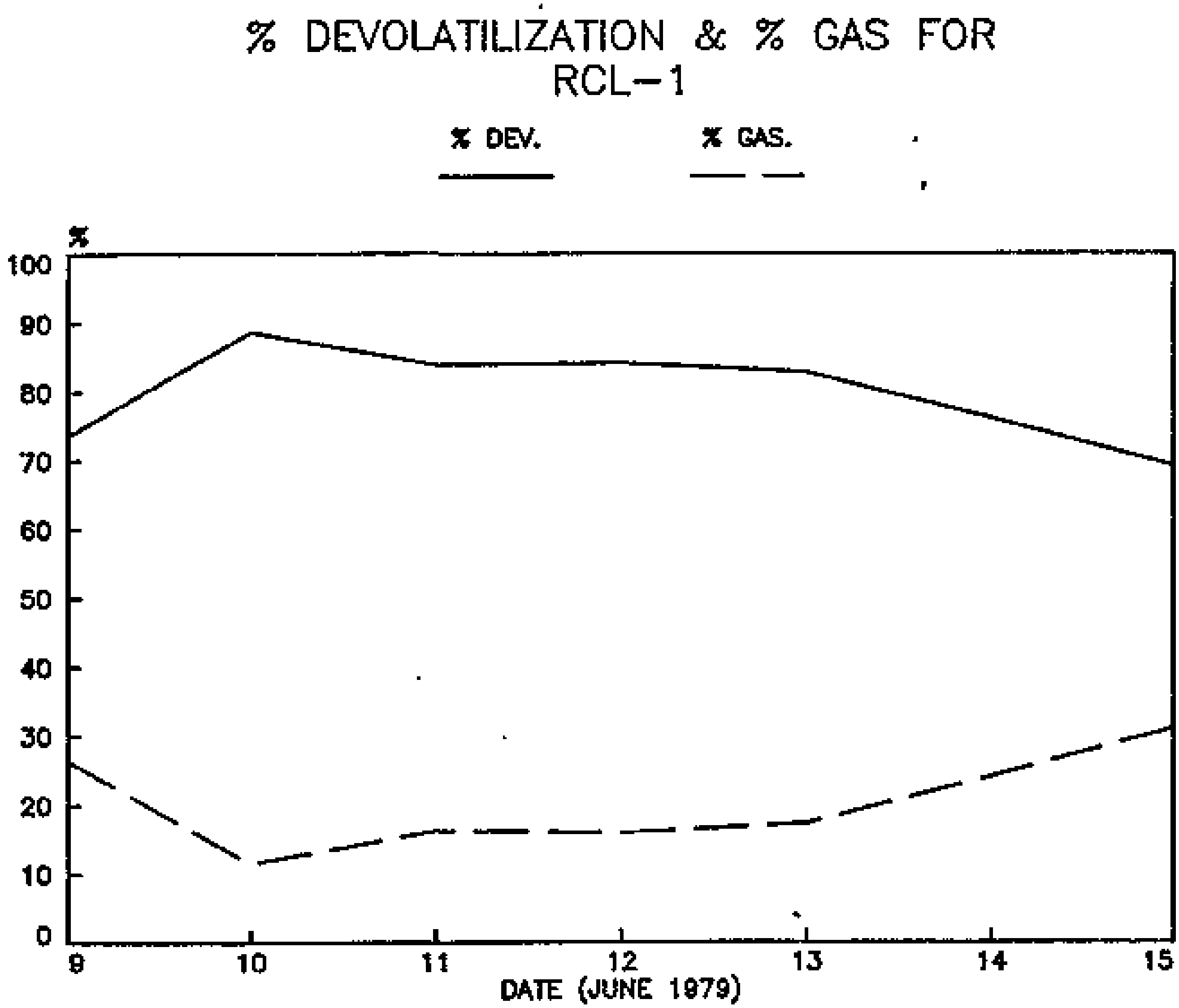


FIGURE 4



% DEVOLATILIZATION & % GAS FOR RCL-1

FIGURE 5

% DEVOLATILIZATION & % GASIFICATION FOR LINK ENHANCEMENT-1

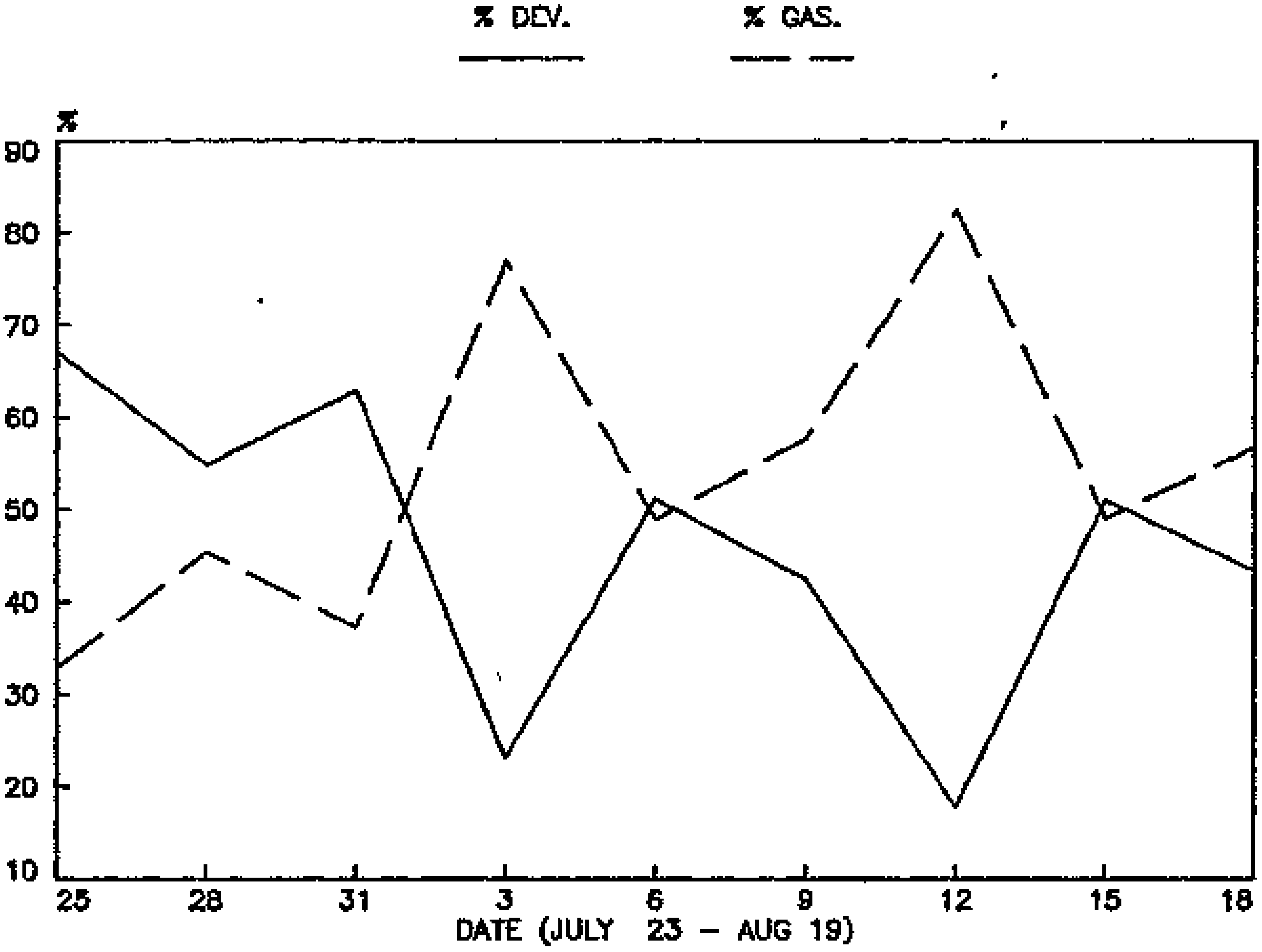


FIGURE 6

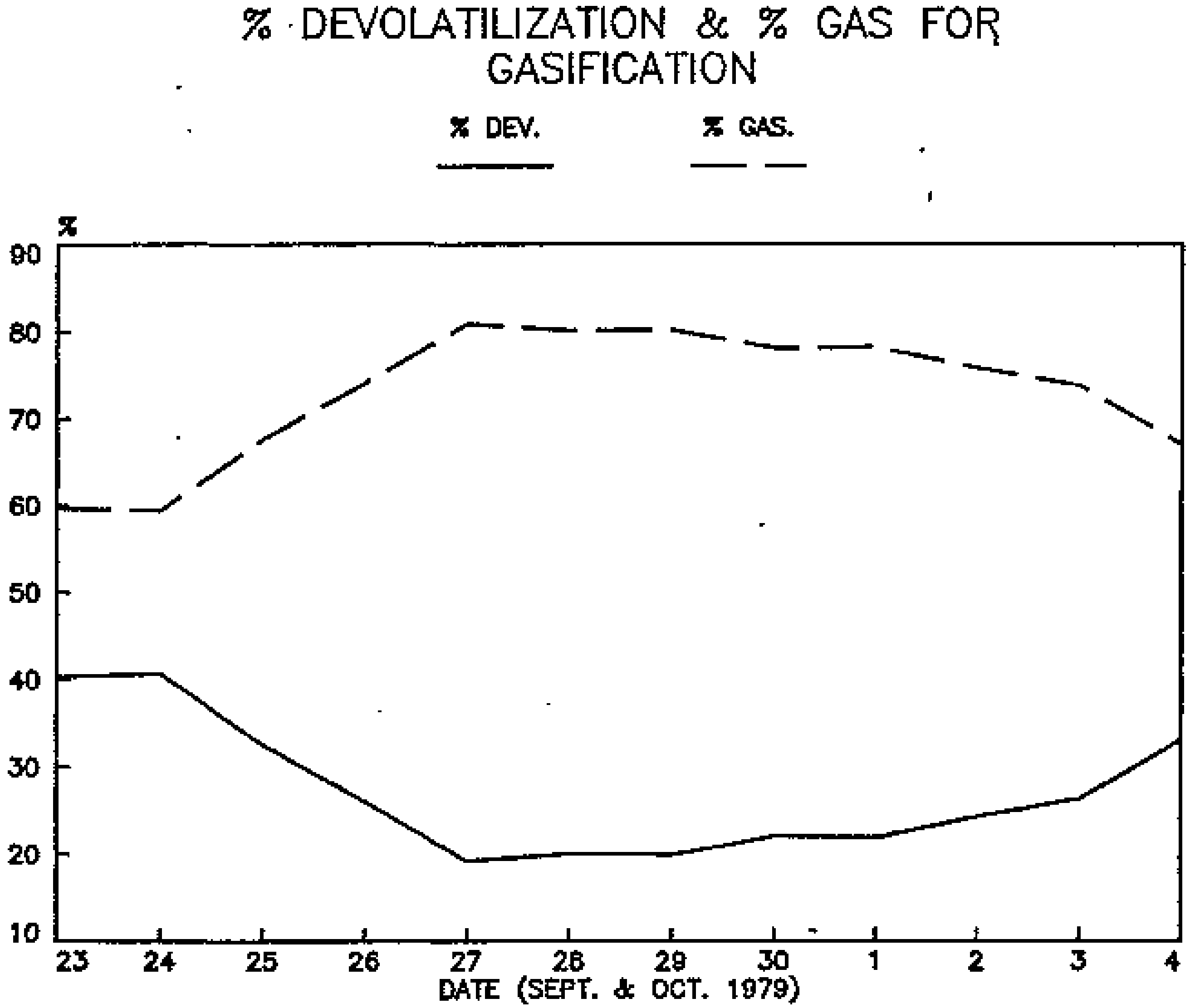

% DEVOLATILIZATION & % GAS FOR GASIFICATION
% DEV.
% GAS.
%
90
80
70
60
50
40
30
20
10
23
24
25
26
27
28
29
30
1
2
3
4
DATE (SEPT. & OCT. 1979)

FIGURE 7

PRICETOWN I FIELD TEST RESULTS

GASIFICATION PHASE

NET WATER INTO PROCESS

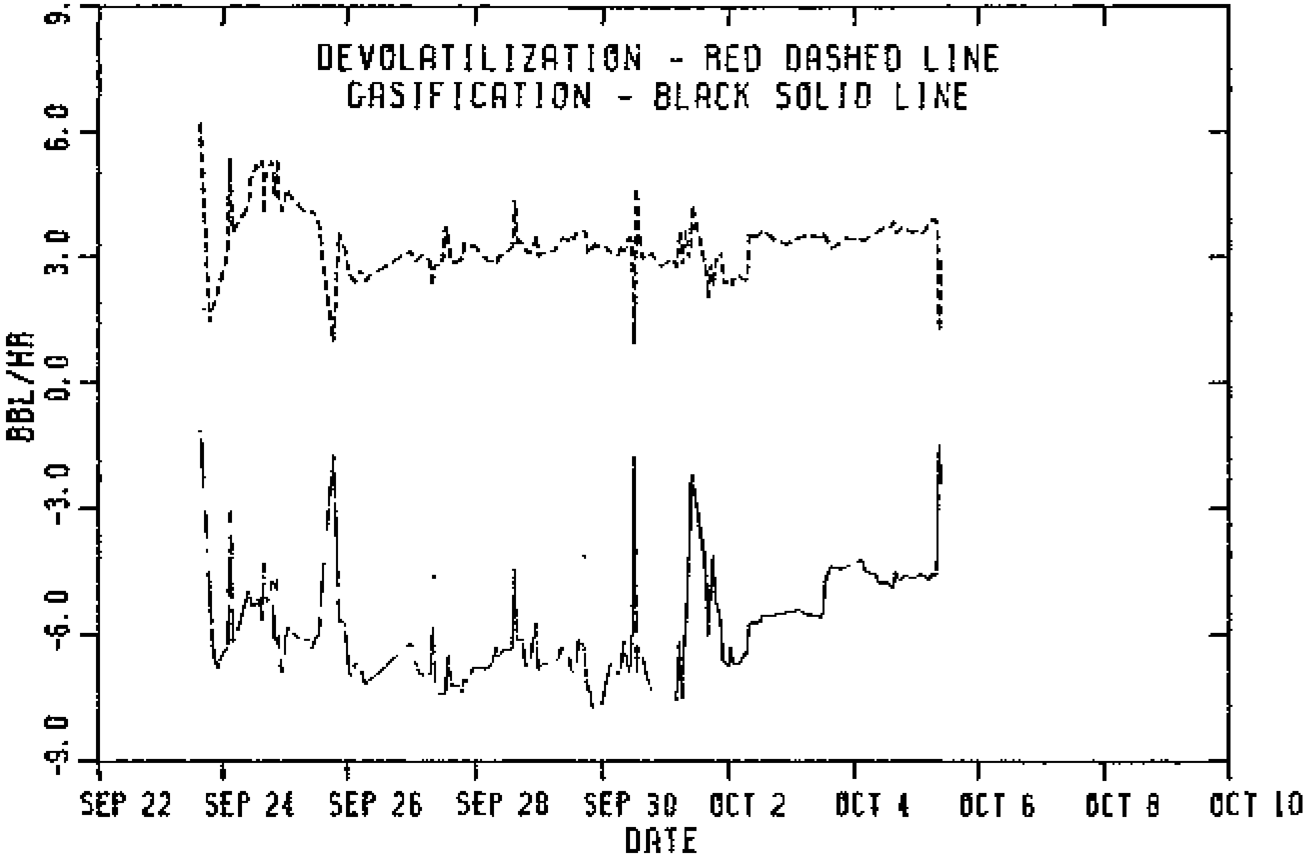
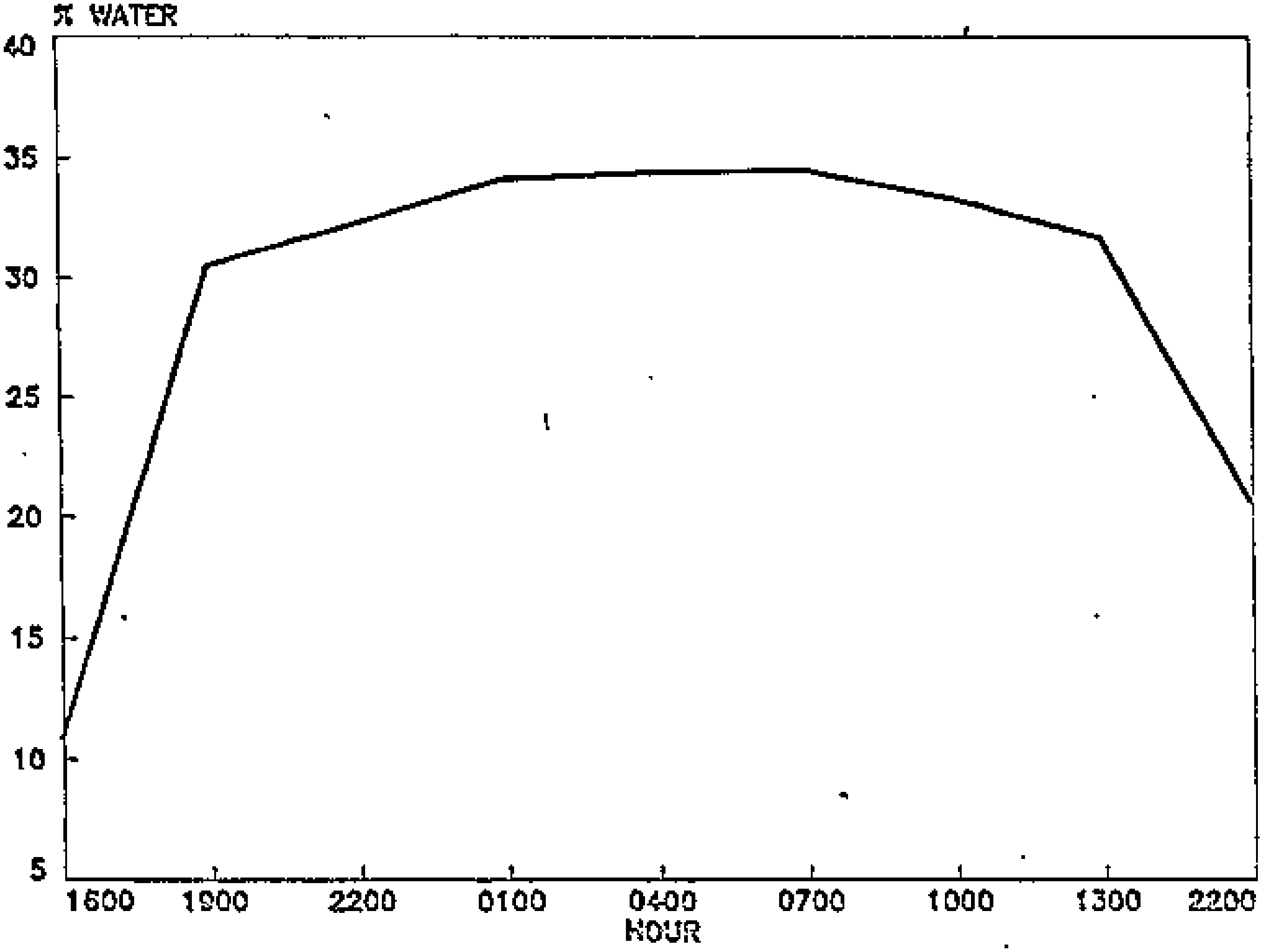


FIGURE 8



DATA UNCORRECTED FOR WATER
SEPT. 24 (1600 HR) TO SEPT. 25 (0800 HR)

FIGURE 9

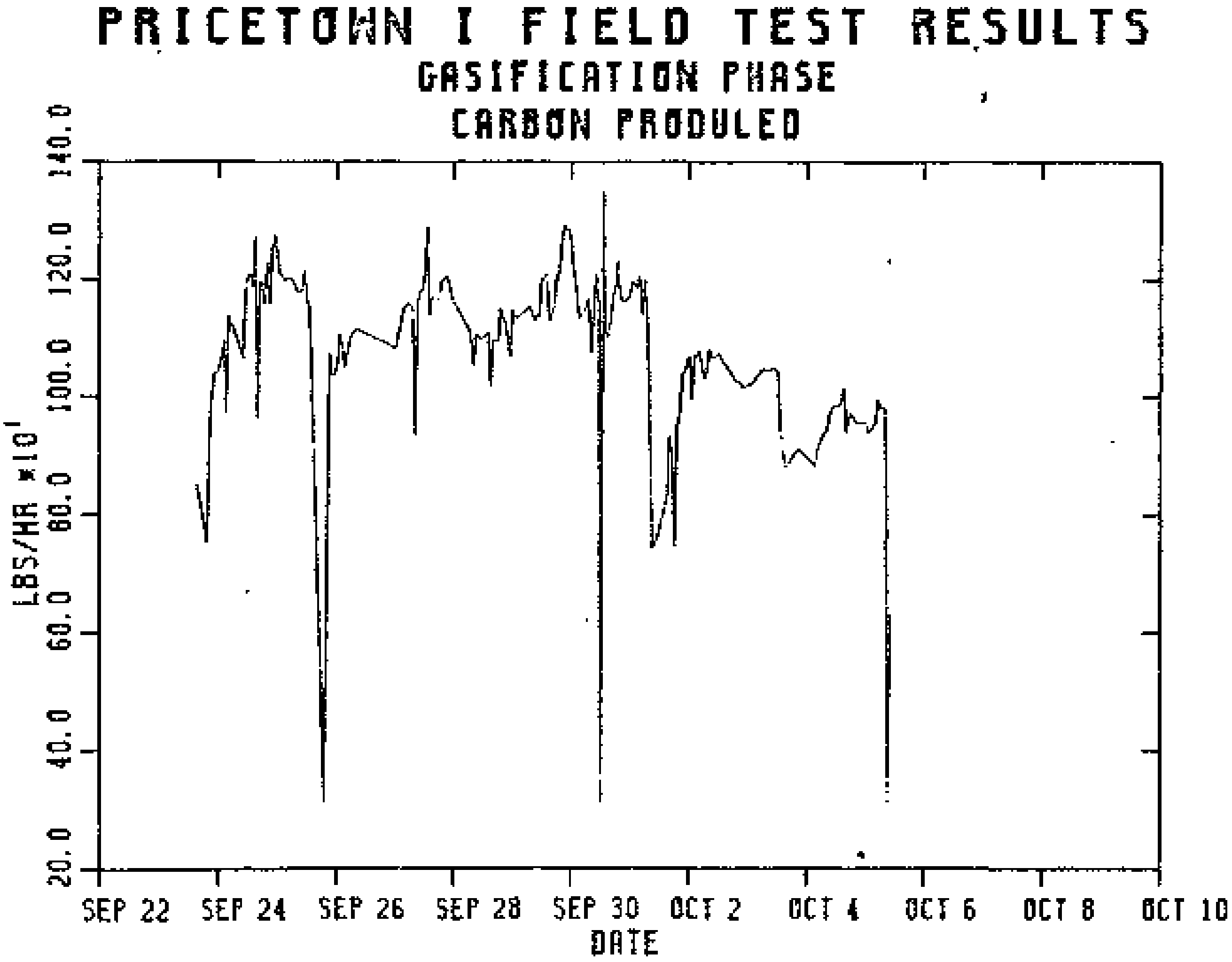

PRICETOWN I FIELD TEST RESULTS
GASIFICATION PHASE
CARBON PRODUCED
LBS/HR ×10^1
20.0
40.0
60.0
80.0
100.0
120.0
140.0
SEP 22
SEP 24
SEP 26
SEP 28
SEP 30
OCT 2
OCT 4
OCT 6
OCT 8
OCT 10
DATE

FIGURE 10

AMOUNT OF COAL AFFECTED – GASIFICATION PHASE

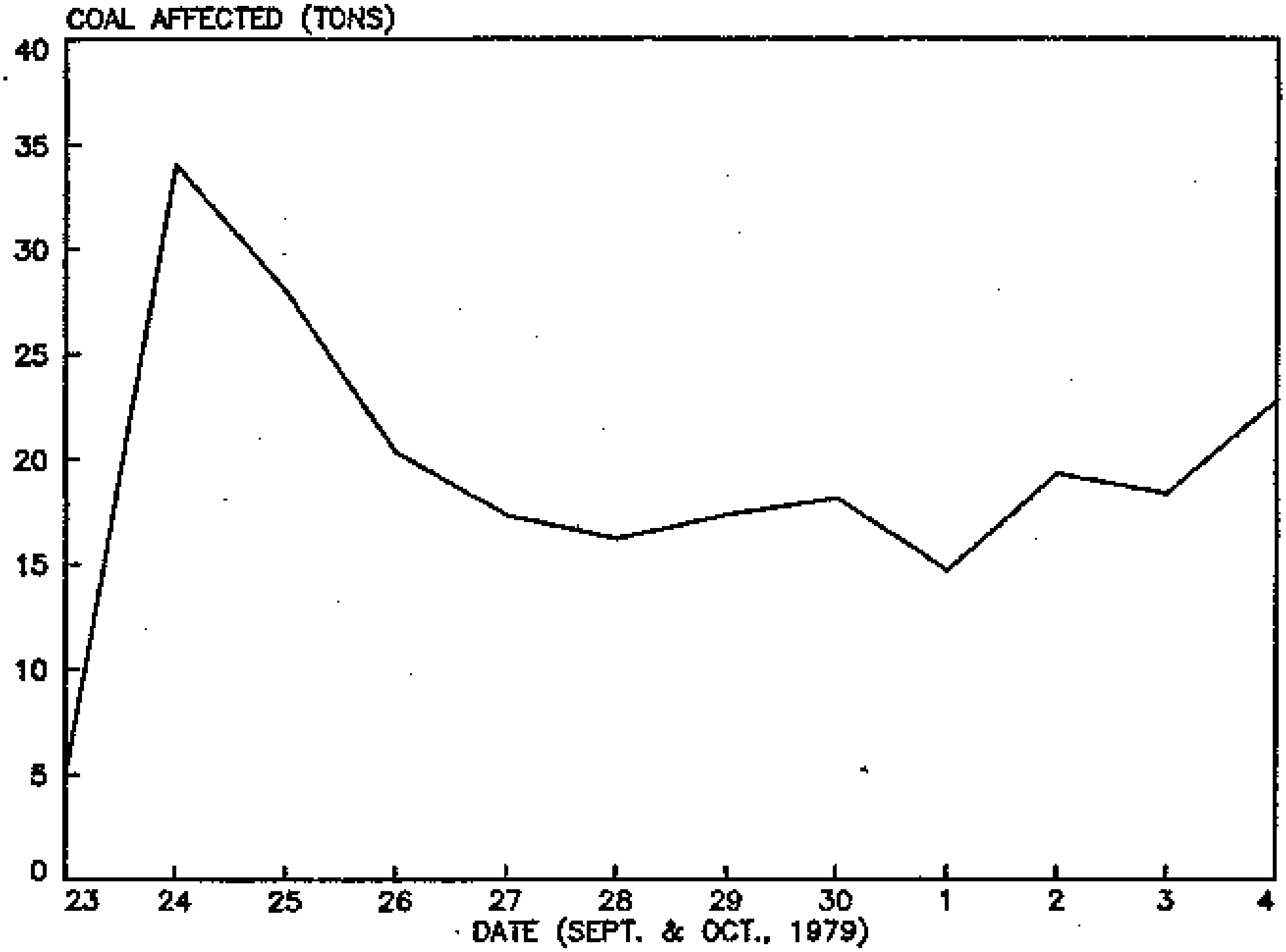


FIGURE 11

PRICETOWN I FIELD TEST RESULTS

GASIFICATION PHASE

SCF DRY GAS PRODUCED PER LB OF COAL

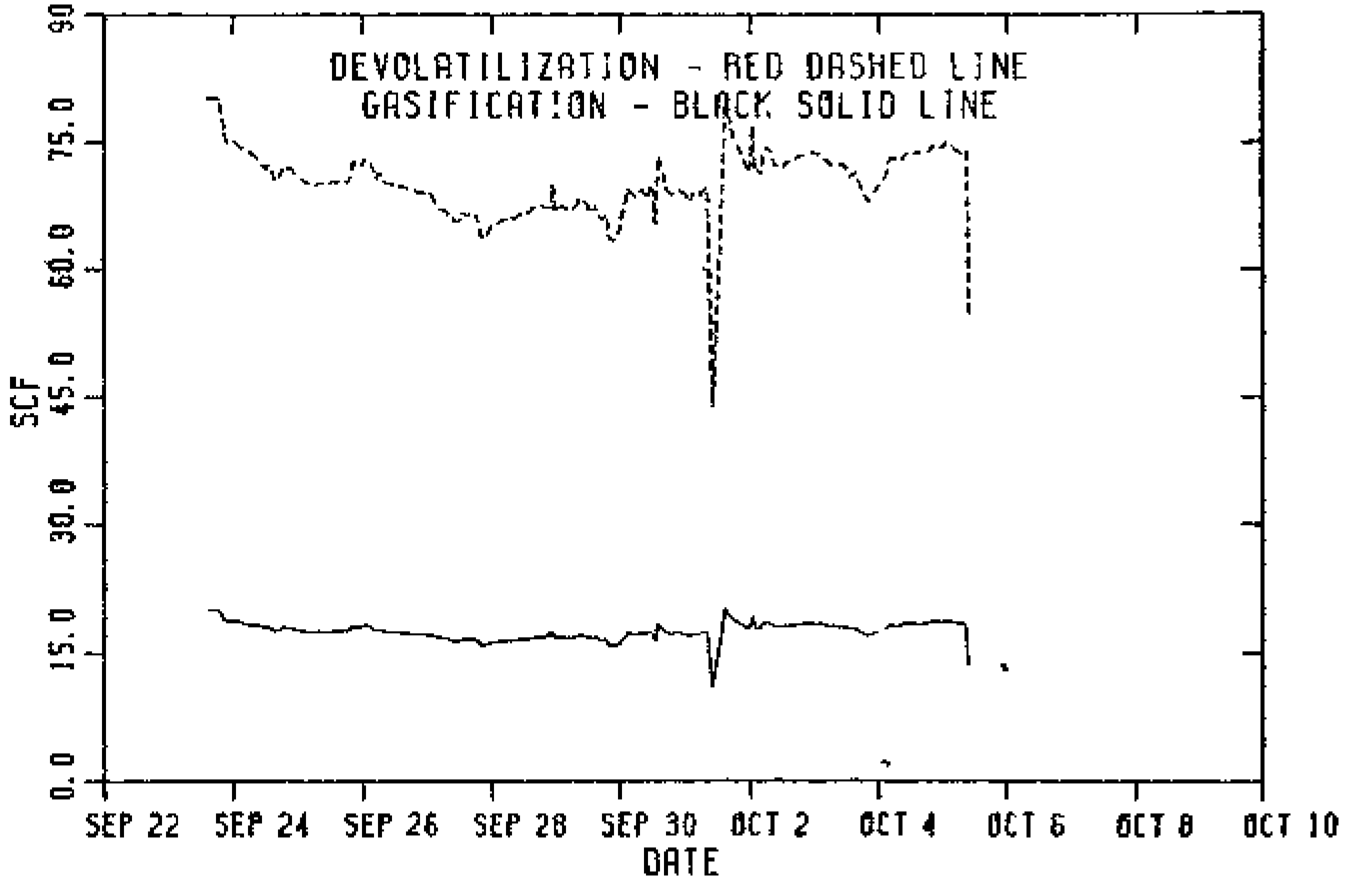
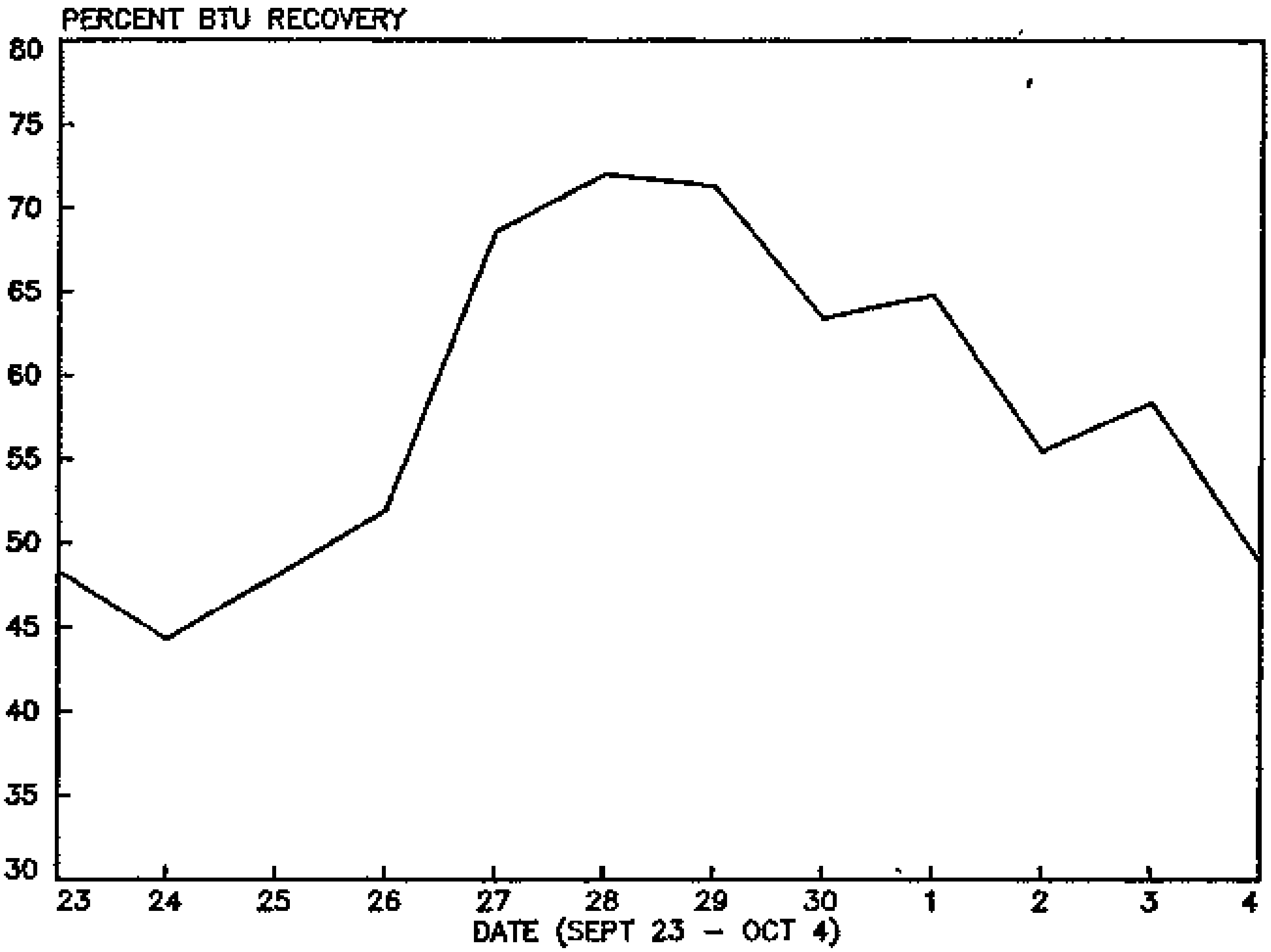


FIGURE 12



PRICETOWN I FIELD TEST RESULTS

GASIFICATION PHASE

% BTU RECOVERED FROM LB OF COAL

FIGURE 13

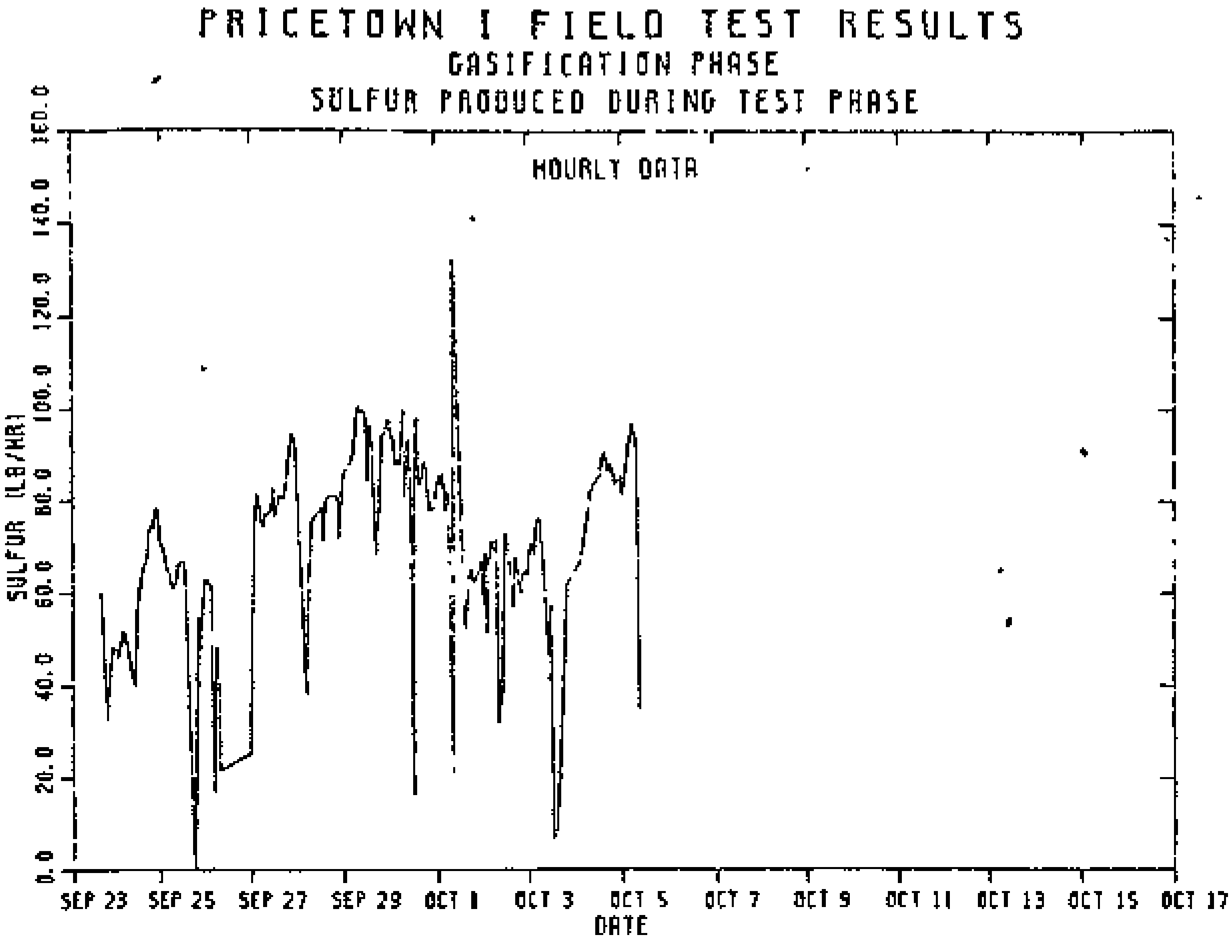

PRICETOWN I FIELD TEST RESULTS
GASIFICATION PHASE
SULFUR PRODUCED DURING TEST PHASE

FIGURE 14

RESULTS USING THREE VOLATILE MATTER COMPOSITIONS
FROM A CARBONIZING TEMPERATURE OF 800°C

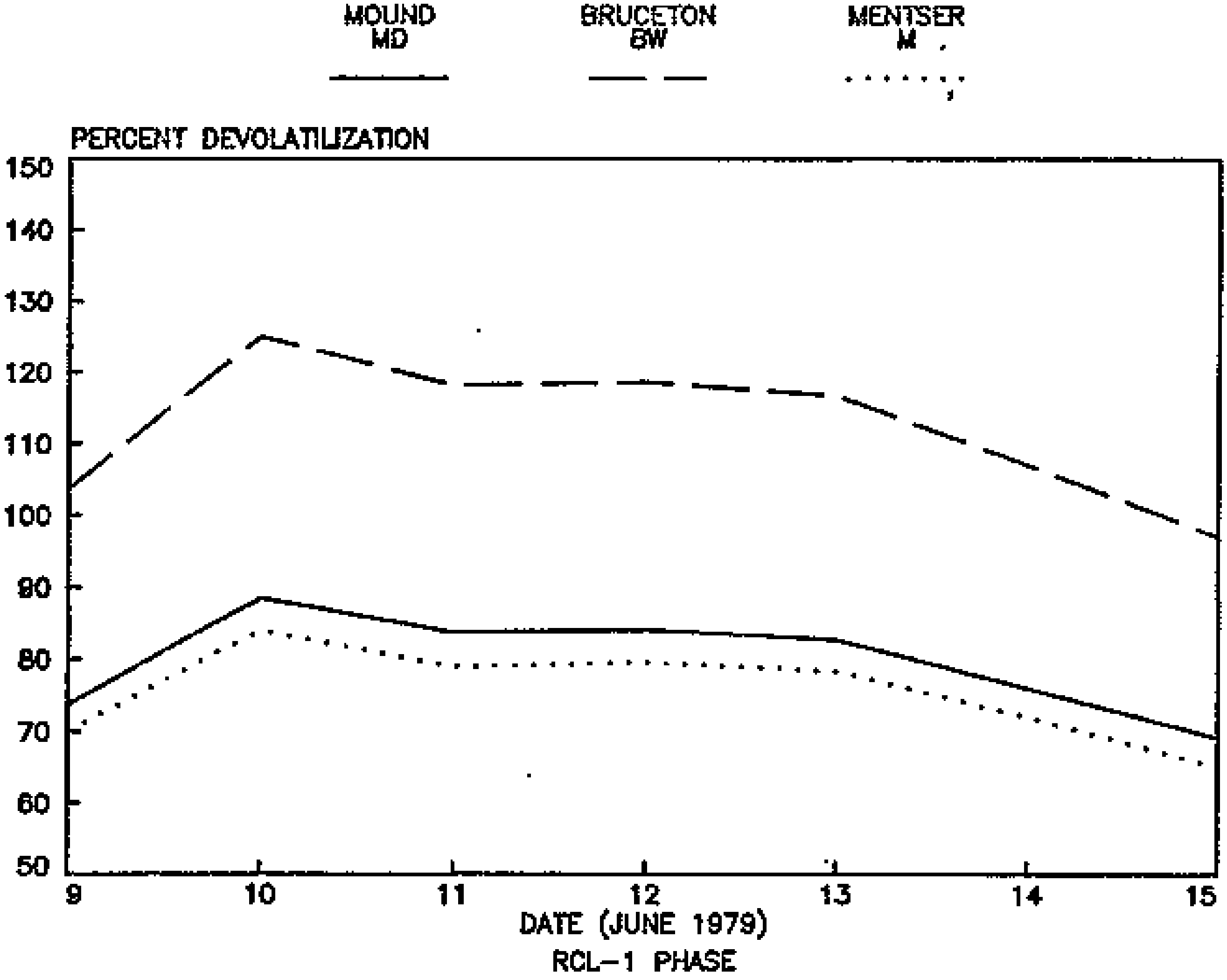


FIGURE 15

RESULTS USING THREE VOLATILE MATTER COMPOSITIONS FROM A CARBONIZING TEMPERATURE OF 800°C

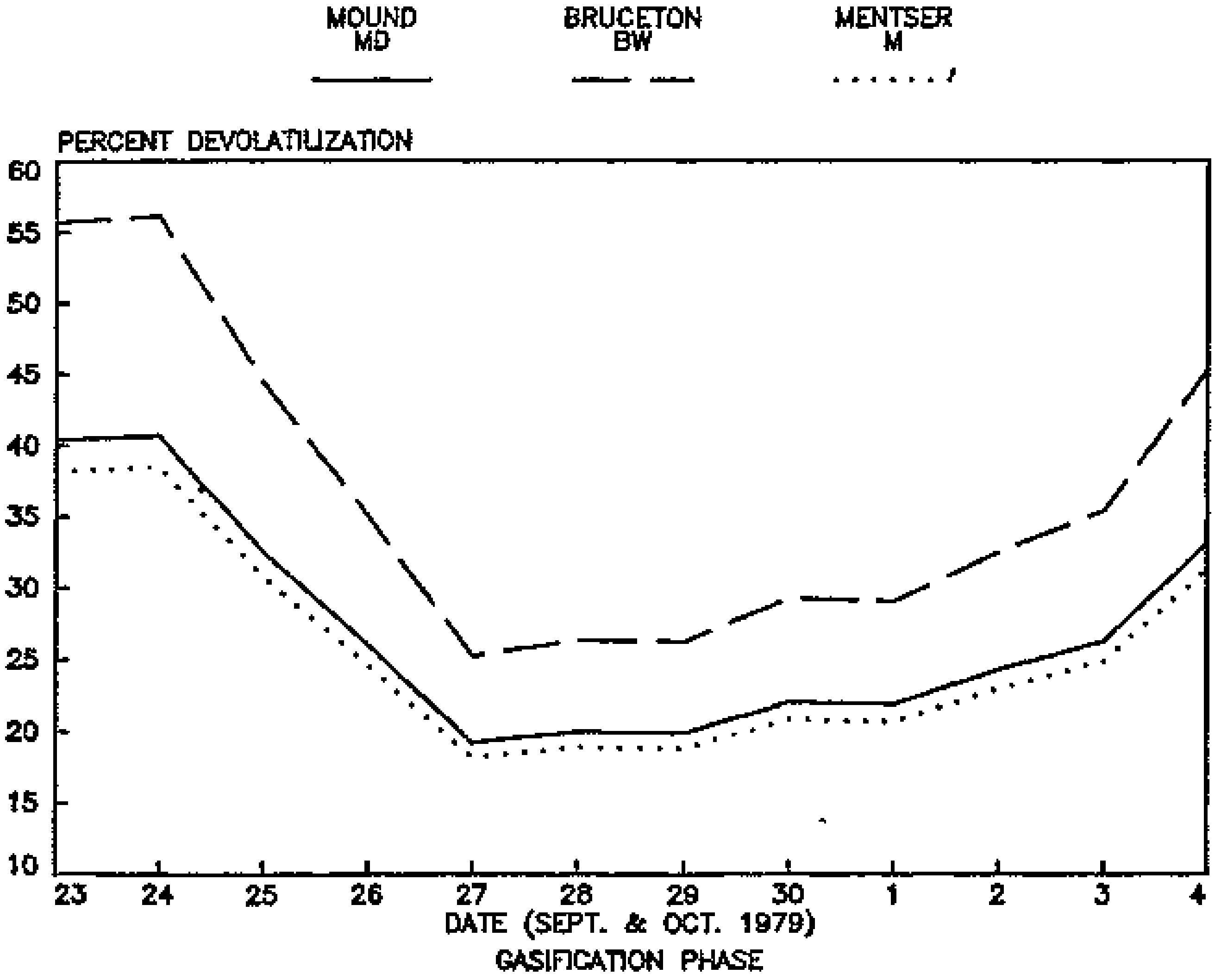
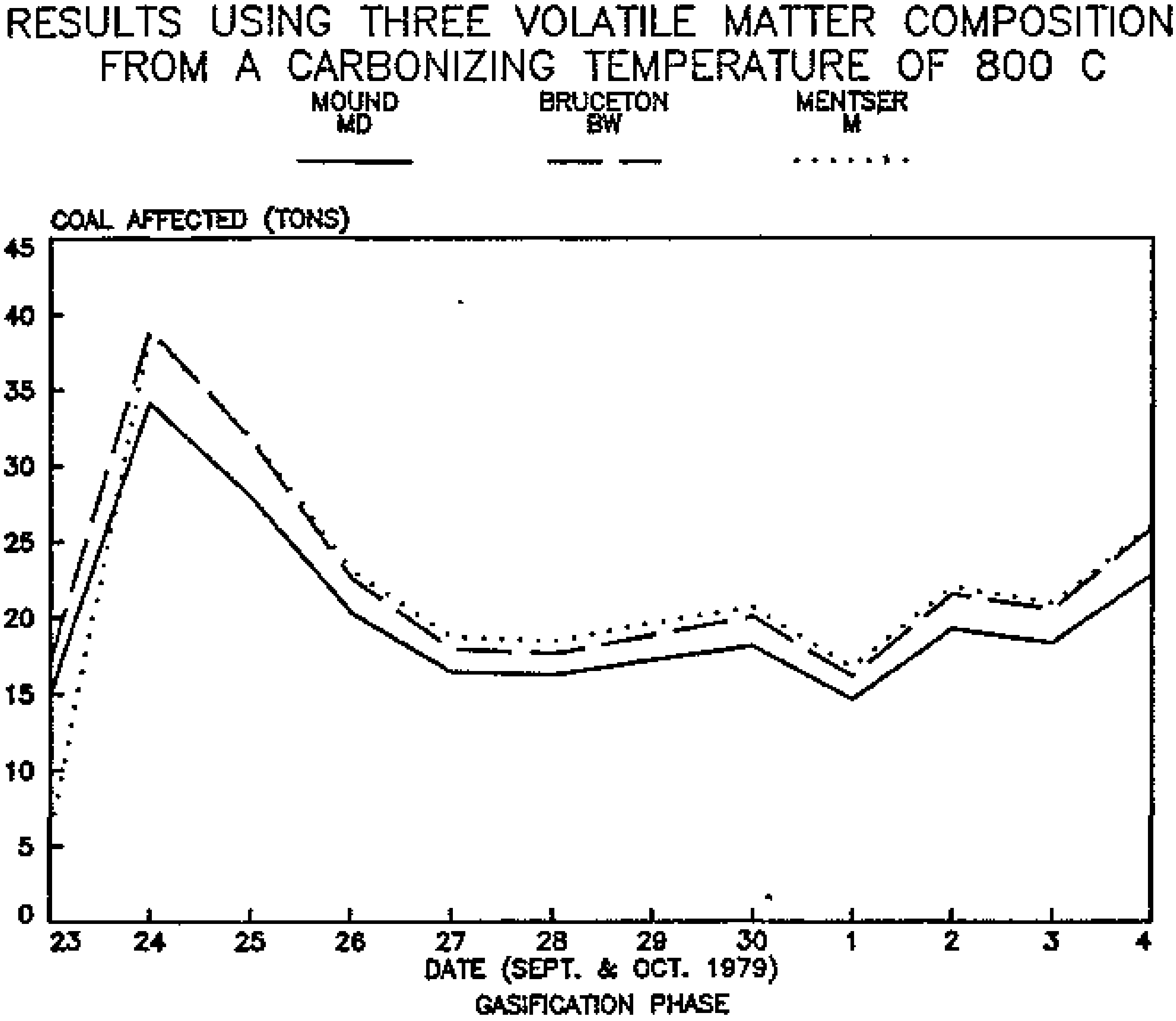
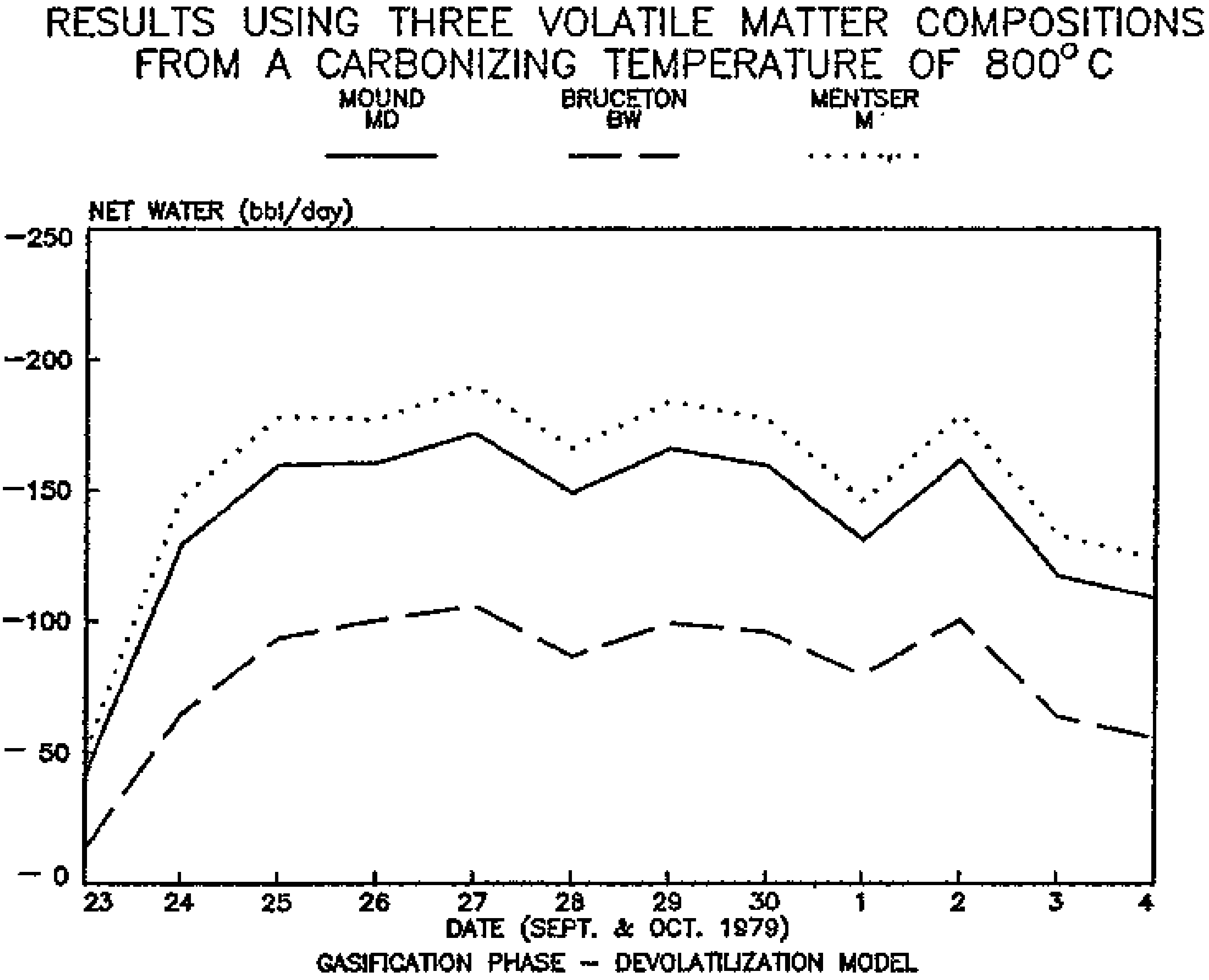


FIGURE 16



RESULTS USING THREE VOLATILE MATTER COMPOSITIONS FROM A CARBONIZING TEMPERATURE OF 800 C

FIGURE 17



RESULTS USING THREE VOLATILE MATTER COMPOSITIONS FROM A CARBONIZING TEMPERATURE OF 800° C

FIGURE 18

TABLE 1

Elemental Weight Percent for Char and Volatile Matter for Pricetown Coal at 600°C, 700°C and 800°C Using Bruceton Warden Factor (10)

ELEMENT	COAL (MAF)	CHAR (MAF) 600°	CHAR (MAF) 700°	CHAR (MAF) 800°	VOLATILE MATTER 600°	VOLATILE MATTER 700°	VOLATILE MATTER 800°
CARBON	82.1	89.8	91.8	92.5	63.6	61.2	60.6
HYDROGEN	5.8	2.8	1.6	1.2	13.0	14.7	15.2
OXYGEN	6.0	1.9	1.1	0.7	15.7	16.5	16.9
NITROGEN	1.4	1.6	1.4	1.4	0.8	1.2	1.2
SULFUR	4.8	3.9	4.0	4.2	7.0	6.4	6.0
PERCENT VOLATILE MATTER					29.3	31.7	32.6

TABLE 2

Elemental Weight Percent for Volatile Matter as Determined at 800°C Carbonizing Temperature by Different Studies

ELEMENT	MENTSER (14)	MOUND	BRUCETON-WARDEN FACTORS (10)
CARBON	53.8	55.2	60.6
HYDROGEN	22.2	18.9	15.2
OXYGEN	22.7	18.2	16.9
NITROGEN	1.0	1.9	1.2
SULFUR	0.3	5.8	6.0
PERCENT VOLATILE MATTER	25.0	29.7	32.6

TABLE 3

Phases of the Pricetown I Field Test

TEST PHASE	DURATION (DAYS)	PRINCIPLE BURN FRONT PATTERN
AIR ACCEPTANCE		
RCL-1	5.9	P/I-2→P/I-3
RCL-2	24.2	P/I-3→P/I-2*
RCL-3	14.1	P/I-2→P/I-1
LE-1	28.6	P/I-1→P/I-2
LE-2	35.3	P/I-1→P/I-2
GASIFICATION	11.8	P/I-1→P/I-2

*RCL-2 did not link wells P/I-3 and P/I-2, the link zone was transferred to P/I-1.

TABLE 4

Mass Balance Results - Gasification Model

PHASE	AMOUNT OF COAL (MAF) AFFECTED (TONS/DAY)	SCF DRY GAS/ LB OF COAL	% ENERGY RECOVERY	MET WATER INTO SYSTEM (BBL/DAY)	OXYGEN NOT ACCOUNTED FOR (LB/DAY)
RCL-1	0.28	79.99	76.06	2.31	672.88
RCL-2	0.58	54.99	86.99	4.56	1087.30
RCL-3	0.28	57.18	91.62	2.49	697.89
LE-1	0.52	66.32	69.60	3.81	841.89
LE-2	3.51	57.27	81.42	26.86	6212.44
GASIFICATION	19.19	69.58	55.36	77.66	15562.66

TABLE 5

Mass Balance Results - Devolatilization Model

PHASE	AMOUNT OF COAL (MAF) AFFECTED (TONS/DAY)	SCF DRY GAS/ LB OF COAL	% ENERGY RECOVERY	NET WATER INTO SYSTEM (BBL/DAY)	OXYGEN NOT ACCOUNTED FOR (LB/DAY)
RCL-1	1.11	20.01	20.48	−0.84	−188.09
RCL-2	2.30	14.08	21.99	−1.85	−669.38
RCL-3	1.12	14.30	27.75	−0.68	−167.84
LE-1	2.05	16.53	17.71	−2.34	−843.58
LE-2	14.03	14.33	20.63	−13.08	−4602.98
GASIFICATION	76.72	17.41	14.85	−138.98	−43684.02

TABLE 6

Summary of the Mass Balance Results

PHASE	% DEV.	% GAS.	% ENERGY RECOVERY	AMOUNT OF COAL (MAF) AFFECTED (TONS/DAY)	NET WATER INTO SYSTEM (BBL/DAY)
RCL-1	80.33	19.67	30.2	5.18	−0.54
RCL-2	60.01	39.99	44.2	34.38	10.43
RCL-3	80.05	19.95	31.7	13.32	2.71
LE-1	48.13	51.87	29.8	27.68	11.46
LE-2	57.71	42.29	40.2	292.02	145.15
GASIFICATION	25.81	74.19	59.3	239.25	245.51
TOTAL	—	—	47.2	611.38	414.72

TABLE 7

Summary of the Coal Carbonized and Gasified

PHASE	AMOUNT OF COAL (MAF) CARBONIZED (TONS)	AMOUNT OF COAL (MAF) GASIFIED (TONS)	AMOUNT OF COAL (MAF) CARBONIZED ONLY (TONS)
RCL-1	5.18	0.36	4.82
RCL-2	34.38	5.15	29.23
RCL-3	13.32	0.76	12.56
LE-1	27.68	6.92	20.76
LE-2	292.02	50.82	241.20
GASIFICATION	239.25	167.71	71.54
TOTAL	611.83	231.72	380.11

TABLE 8

Comparison of Coal Affected, Gasified and Carbonized for Different Volatile Matter Compositions (September 13, 1979, 2400 Hours)

	COAL CONSUMED	COAL CARBONIZED ONLY	COAL AFFECTED
800°C MOUND (2=0.297)*	1.83	7.20	9.03
800°C MENTSER (2=0.260)	2.06	7.21	9.27
800°C BRUCETON-WARDEN (2=0.326)	0.98	9.49	10.47
700°C BRUCETON-WARDEN (2=0.317)	0.84	10.29	11.13
600°C BRUCETON-WARDEN (2=0.293)	0.10	13.97	14.07

*Gunn Partial Solution Gives 3.27 Tons Consumed for This Case.