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SOLVENT REFINED COAL (SRC) PROCESS

Flashing of SRC-II Slurry in the Vacuum Column on Process Development Unit P-99

Interim Report for the Period February—June 1980

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By
J. A. Gray
S. T. Mathias

October 1980

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Gulf Research & Development Company
Chemical and Minerals Division
Pittsburgh, Pennsylvania

U. S. DEPARTMENT OF ENERGY

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INTERIM REPORT FOR THE PERIOD
FEBRUARY to JUNE 1980

J. A. Gray
S. T. Mathias

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Gulf Research & Development Company
Chemical and Minerals Division
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ABSTRACT

This report presents the results of 73 tests on the vacuum flash system of Process Development Unit P-99 performed during processing of three different coals; the second batch, fourth shipment (low ash batch) of Powhatan #5 Mine (LR-27383), Powhatan #6 Mine (LR-27596) and Ireland Mine (LR-27987). The objective of this work was to obtain experimental data for use in confirming and improving the design of the vacuum distillation column for the 6000 ton/day SRC-II Demonstration Plant. The 900°F$^-$ distillate content of the bottoms and the percent of feed flashed overhead were correlated with flash zone operating conditions for each coal, and the observed differences in performance were attributed to differences in the feed compositions. Retrogressive reactions appeared to be occurring in the 900°F+ pyridine soluble material leading to an increase in the quantity of pyridine insoluble organic matter. Stream physical properties determined include specific gravity, viscosity and melting point. Elemental, distillation and solvent analyses were used to calculate component material balances. The Technology and Materials Department has used these results in a separate study comparing experimental K-values and vapor/liquid split with CHAMP computer program design predictions.

I. SUMMARY

This report discusses the results of a test program (Table I) on the vacuum flash system of Process Development Unit P-99 located at the Gulf Research Center, Harmarville, PA. The objective of this work was to obtain experimental data on a single-stage, equilibrium vacuum flash of an SRC-II atmospheric flash tower bottoms stream. This information is being used to confirm and improve the design of the vacuum distillation column for the 6000 ton/day SRC-II Demonstration Plant.

The P-99 vacuum flash column is designed and operated as a single-stage, isothermal, equilibrium flash with flash zone dimensions of 13.5 in. i.d. x 24 in. long and vapor velocities in the range of 0.48-2.30 ft/s. The range of experimental conditions in this work are summarized in Table I. The maximum practical operating temperature in the P-99 vacuum column was the temperature at which essentially complete 900°F^{-} distillate separation from the bottoms occurred or 375°C (707°F), whichever came first.

Essentially complete separation of 900°F^{-} distillate from the vacuum column bottoms was achieved under certain operating conditions, but the vacuum column feed produced from the second batch, fourth shipment (a low reactivity batch) of Powhatan #5 Mine (LR-27383) coal required much more severe conditions to obtain the same level of separation as the feed from Powhatan #6 Mine (LR-27596) coal. The vacuum column feed produced from Ireland Mine (LR-27987) coal gave separations intermediate to those with the Powhatan coals. The fraction of vacuum column feed flashed overhead in these experiments was in the range of 17-38% by weight and was influenced by the source coal in the same manner as the distillate content of the bottoms. The 900°F^{-} distillate content of the vacuum bottoms and the percent of feed vaporized were correlated with flash zone operating conditions for each coal. Correlation of the data with an equivalent flash zone temperature at 760 mm Hg using a Watson characterization factor of 10 proved to be very satisfactory. The differences in the separation achieved for the three different coals can be explained by the differences in the contents of 900°F^{-} distillate, 900°F+ pyridine solubles low enough in molecular weight to be vaporized, and insoluble organic matter in the vacuum column feeds. The latter material may be exhibiting colligative effects.

Retrogressive reactions during preheating and flashing occur causing as much as a 15% increase in the pyridine insolubles fraction (30% increase of insoluble organic matter) for Powhatan #5 coal and a 6.3% increase (22.4% increase in insoluble organic matter) for Powhatan #6 coal at the highest flash zone temperature. No trend toward retrogressive reactions was observed in the Ireland Mine coal experiments. The 900°F^{-} distillate balance indicated negligible cracking and that the degradation reactions probably were occurring primarily in the 900°F+ pyridine soluble material leading to additional insoluble organic matter.

Physical property information, such as viscosity, melting point and specific gravity, was also determined. Overhead product specific gravity correlated the same with equivalent flash zone temperature at 760 mm Hg regardless of the source coal. The ash content of the overhead product was 5 ppm by weight or less, and no single trace metal exceeded 1.5 ppm.

A separate study[2] was performed by the Technology and Materials Department in which K-values were calculated for the major 50°F pseudocomponents using the experimental data in this report and were shown to be in reasonable agreement with the K-values predicted by the CHAMP computer design program. CHAMP predictions of the fraction of feed vaporized were, on the average, within 3% of the experimental values.

II. INTRODUCTION

This report discusses the results of a test program on the vacuum flash system of Process Development Unit P-99 located at the Gulf Research Center, Harmarville, PA. SRC-II processing of coal is performed on P-99 at a rate of 20 kg/h (0.5 ton/day) under conditions that closely approximate the flowsheet of the 6000 ton/day SRC-II Demonstration Plant which is now being designed. Confirmatory experimental data are being obtained on process areas of P-99 that are of key importance to the demonstration plant design, in addition to the conduct of process variable/yield studies and process improvement studies. The vacuum flash column is one of these key areas and is used in the SRC-II Process as the final means of separating heavy distillate (550-900°F) from the insoluble organic bottoms, mineral matter and 900°F+ pyridine solubles prior to their removal from the dissolver area of the process. The latter comprise the vacuum column bottoms and will be used as feedstock for gasification and hydrogen manufacture in the commercial process.

The P-99 vacuum flash column is designed and operated as a single-stage, isothermal, equilibrium flash. An earlier vacuum column test program[1] determined the general effect of flash zone temperature on the recovery of 900°F$^-$ distillate and the viscosity of the bottoms product at a flash zone pressure of approximately 15-18 mm Hg. As the flash zone temperature was increased in 5-10°C increments from 320 to 375°C, the distillate in the bottoms decreased from about 6 wt% to 3 wt% and the bottoms viscosity increased. The vacuum bottoms product was observed to be a non-Newtonian pseudoplastic with thixotropic behavior over the shear rate range of the viscosity measurements. In subsequent tests (Appendix C), the distillate contents predicted by the previous study were found to be high. It was found important to keep the bottoms receiver at a temperature at least as high as the flash zone temperature in order to prevent internal refluxing in the receiver, which is normally open to the flash zone except during bottoms discharge. This precaution had not been taken in the previous study, and consequently bottoms receiver temperatures were typically 40-50°C below the flash zone temperature.

Most recently, during Runs 63 to 71, a very extensive test program was completed with the following objectives:

- Determine the 900°F$^-$ distillate content of the vacuum column bottoms as a function of flash zone temperature and pressure, overhead product recycle rate and source coal.
- Determine the amount of net vacuum column feed that is flashed overhead as a function of flash zone temperature and pressure and source coal.
- Obtain stream composition and component balance data for use in design calculations.

- Relate certain feed and product stream physical properties to vacuum column operating conditions and source coal.
- Define trace metals in the overhead product.
- Estimate vapor velocity and note operating limitations.

This report deals solely with the experimental program. A separate study[2] has been performed by the Technology and Materials Department in which K-values (equilibrium flash vaporization ratio) were calculated for the major 50°F pseudocomponents, using the experimental results, and were shown to be in reasonable agreement with the K-values predicted by the CHAMP (Computer Heat and Material Balance Program) computer design program. When the experimental feed compositions were specified in CHAMP, the predicted fractions of feed vaporized were within an average error of 3% of the experimentally determined values.

III. EXPERIMENTAL

A. Process Development Unit P-99 Overview

Vacuum flashing is used as the final means of separating the residue in the dissolver effluent from any remaining heavy distillate (500-900°F) on Process Development Unit P-99. This is shown on the P-99 flowsheet in Figure 1. Details of the design and operation of P-99 have been discussed in Reference 3, and process yield results have been published in a series of topical reports. Typically, processing of 20 kg/h of feed coal with about 47 kg/h of recycle slurry in the dissolver results in approximately 73 kg/h of dissolver effluent. In the hot separator 52 kg/h of slurry is recovered from the dissolver effluent. The slurry pressure is reduced from 2000 psig to 50 psig through a system of let-down valves and a surge tank. The slurry is flashed at 50 psig and 300°C yielding 3 kg/h of distillate and 49 kg/h of slurry bottoms. The atmospheric flash tower bottoms is split into two streams, net vacuum column feed and recycle slurry. The recycle slurry portion amounts to approximately 37 kg/h (about 75%) and the 12 kg/h balance comprises the net feed to the vacuum column. The vacuum column bottoms is recovered directly as product and is weighed each hour in buckets. The vacuum column overhead stream is condensed and collected in a receiver. A portion of the overhead is recycled and mixed with the net feed in the stream splitter tank below the atmospheric flash column to yield the gross vacuum column feed. The net overhead product is transferred to the process solvent Tanks 8 & 9 and weighed along with the fractionator bottoms each hour. The fractionator bottoms product is weighed each hour in Tanks 6 & 7 enabling the calculation of the vacuum column overhead weight by difference between Tanks 8/9 and Tanks 6/7. The on-line data acquisition system calculates and prints the bottoms weight and the sum of the bottoms and overhead weights each hour along with the hourly average flash zone temperature and overhead receiver and bottoms receiver pressures.

B. Description of P-99 Vacuum Flash Column

A schematic of the vacuum flash column is shown in Figure 2. The column was constructed from a 23 3/4 inch length of 14 inch diameter, schedule 10, 304L stainless steel pipe, the corresponding pipe cap, and a custom-made, 1/4-inch thick, 50° angle cone section. A 4 inch schedule 10 pipe inclined at a 30° angle serves as the feed port and provides for discharge of the feed onto a 10 inch diameter, cone-shaped splash plate with a 110° angle at the apex. The upper section of the column contains a 4 inch thick, Style 326 York demister pad made of 304 stainless steel, and a 4 inch diameter (schedule 40 pipe) overhead vapor port. The bottoms outlet to the receiver is fabricated from 3/4 inch diameter, schedule 40 pipe, and discharges through a 3/4 inch Hills-McCanna ball valve packed with inconnel-wire-reinforced graphite.

The receiver is fabricated from a 14 inch diameter, schedule 10S weld cap, a 2 1/2 inch length of 14 inch diameter, 1/8 inch wall tubing and a custom-made, 1/8 inch wall, 90° cone section, all 304L or 304 stainless steel. The inlet and outlet ports are 3/4 inch 316 stainless steel pipe couplings. Bottoms discharge from the receiver is performed manually with either a 3/4 inch or 1 inch Hills-McCanna ball valve of the same construction as the computer actuated inlet valve.

Both the vacuum column and receiver are wound with rod-type heaters to maintain isothermal operation. The connecting piping and valves are wound with nichrome wire heaters. Appropriate wall thermocouples are used for monitoring and control. The temperature of the flash zone is monitored by two internal thermocouples in a single sheath located beneath the center of the splash plate. The data acquisition system prints the average of 10 readings from one of these thermocouples each hour while the operator records the reading from the other thermocouple once every two hours.

The preheater is constructed from two sections of 1 1/2 inch diameter, schedule 40 pipe 8 ft-6 1/4 inch long and 8 ft-11/16 inch long, respectively, connected by a U-type turn having a 10° included angle. Five heated zones are provided by strapping twelve 2000 watt and one 1250 watt rod-type heaters on the outside of the pipe as well as appropriate skin thermocouples for control. There are also internal thermocouples located at the U-turn and near the outlet.

C. Vacuum Flash System Flowsheet

The flowsheet of the vacuum flash system is shown in Figure 3. The slurry feed from the splitter tank is composed of flash tower bottoms and recycled vacuum column overhead product, and enters the vacuum column preheater at a temperature of approximately 225°C. It is necessary to recycle overhead product to dampen the oscillatory nature of the flash tower bottoms flowrate and to maintain a flow to the vacuum column when the flash tower bottoms stream is stopped due to an upstream process upset. The flow pulsations are usually caused by the cyclic, on-off operation of the slurry pressure let-down valves and the timed cycling of the stream splitter (refer to Figure 1). The level in the vacuum column side of the splitter tank is measured using a differential pressure cell that in turn controls the vacuum column feed valve. Thus, flow surges into the splitter tank cause fluctuations in the level and hence fluctuations in the feed valve position. Despite the use of overhead recycle, significant vacuum column feed rate pulsation still occurs and can be observed by the pulsations of the pressures in the product receivers.

The gross slurry feed is heated to the flash zone temperature in the preheater and is directed onto the splash plate in the flash zone of the vacuum column. The vapor product passes through a demister pad to prevent transport of solids and liquid droplets overhead and is cooled in a two-stage, water-cooled Basco condenser assembly. The heavy distillate condensate is collected in the overhead receiver, while gases evolved from solution in the feed or cracking and any gas from leakage into the system are drawn out through the steam jet evacuation system. A surge tank and sight glass trap are located ahead of the vacuum control valve, and an absolute dP cell on the surge tank and a Foxboro Controller provide the necessary pressure control. Since the overhead receiver is vented to the surge tank, the absolute dP cell essentially measures the pressure in the receiver and at the outlet of the condenser.

A pump-around loop on the vacuum overhead receiver keeps the heavy distillate in circulation and provides enough discharge pressure to feed the recycle gear pump and to transport the net overhead product to the process solvent hold tank.

The bottoms product flows off of the vacuum column splash plate, down the wall of the cone-shaped section and is continuously discharged into the receiver. The receiver essentially functions as a lock-hopper to remove the bottoms from the system at atmospheric pressure. Once each hour at fifteen minutes past the hour, the data acquisition system actuates the closure of the ball valve between the receiver and the vacuum column. An operator places the five gallon bucket to be used for collecting the bottoms on a scale so that the data acquisition system records the tare weight. The bucket is then positioned under the receiver outlet valve. The receiver is pressured to atmospheric pressure using a nitrogen supply, and the receiver contents are dumped into the bucket by opening the outlet valve. The bucket is placed back on the scale for recording of the gross weight. The receiver outlet valve is then closed, the receiver is evacuated through a line connected to the steam-jet system and a trap upstream of the overhead column control valve, and the valve between the vacuum column and the receiver is opened. The entire sequence requires about 5 minutes. During this short period, bottoms product accumulates in the cone section of the vacuum column.

An absolute dP cell is connected to the receiver, and the data acquisition system records the pressures in both product receivers every 6 minutes and prints out an hourly average. Strip-chart recorders also indicate the receiver pressures on a continuous basis. The pressure in the flash zone is taken as the average of the overhead and bottoms pressures when all systems are functioning properly. However, the vacuum line to the bottoms receiver is susceptable to plugging because of its regular use for receiver evacuation in addition to its function as a pressure tap. When the receiver pressure is greatly different than the overhead pressure, it usually is a result of a receiver vacuum line plug. In such cases, the flash zone pressure is assumed to be the same as the overhead pressure until the plug is cleared. Both dP cell readings can be checked using a mercury manometer. Usually the average pressure in the bottoms receiver is no more than 1 mm Hg higher than the average pressure in the overhead receiver.

D. Data Acquisition

Each test period was twenty hours in duration, and the vacuum column operating conditions were changed during the remaining four hours of the day. The test period started at 0815 and concluded at 0415. Multiple data logger readings of the flash zone temperature, overhead receiver pressure and bottoms receiver pressure were averaged over a one-hour period and were printed every hour on the computer run sheet. Spot readings were recorded by the operator every two hours for the other pertinent temperatures and pressures from the digital temperature display panel and a mercury manometer, respectively. The operating conditions recorded during the hour prior to sampling of the vacuum column streams were taken to be the most representative for the spot samples.

The on-line computer mass balance program calculated the net vacuum column product rate every hour as the sum of the hourly weights of vacuum column bottoms and net vacuum column overhead, and printed both the product and bottoms weights. There is no direct measurement of the net feed rate to the vacuum column. Therefore, the net feed rate was assumed equal to the net product rate, and mass balance calculations were performed only on the individual components as a check. This approach was found to be quite adequate, since overall process mass balances were usually very good, and losses due to cracking, coking or inventory change were believed to be very small compared to the measured stream rates. A direct feed rate was calculated by the computer from the set point of the atmospheric flash tower bottoms stream splitter and the hourly weight changes in the recycle slurry tanks. However, the actual stream split only occasionally matched the set point because of the pulsating flow to the stream splitter as discussed in the previous section.

Except for the vacuum overhead recycle stream, the net overhead and bottoms flowrates are twenty hour average values. The overhead recycle rate was calculated from the speed of the recycle pump using a calibration curve, and the speed was obtained immediately after sampling. Twenty hour averages of the product rates are believed to be more representative for the spot samples than the hourly rate just before sampling because of the averaging effect introduced by the capacity of the overhead product reservoir and recycle stream.

E. Sampling and Analysis

Vacuum bottoms samples were obtained at the end of the twenty hour test period from the last hour of receiver discharge. These included the special test samples and the normal process control samples. A period sample was also obtained by melting and sampling the 55 gallon drum containing the entire 20 hours of accumulated vacuum bottoms. Analytical results for the period samples were generally used for backup purposes only, since reheating in an electric furnace to melt and sample the bottoms may have affected the distillate and pyridine insolubles content. The vacuum column overhead and atmospheric flash column bottoms were also sampled at the end of the test period.

A complete list of analyses for the various samples is tabulated in Appendix A, and Table II gives a brief summary. All analyses except viscosity were performed by the Analytical Technology Department.

1. Distillations

The distillate content of the net feed, bottoms and overhead samples was characterized using the Cushman distillation analysis. Total distillate content is usually defined as cummulative wt% distilled up to 900°F. This method is essentially a modified ASTM D-1160 distillation and is generally limited to a maximum stillpot temperature of 640°F for slurry samples due to thermal cracking of the sample above this temperature. The maximum stillpot temperature and the 3 mm Hg operating pressure constrain the atmospheric equivalent vapor temperature to slightly above 900°F for slurry samples. Atmospheric equivalent vapor temperatures as high as 1050°F have been obtained with vacuum column overhead samples because solids are not present. The bottoms special test samples were also analyzed by the Sarnia High Vacuum method which allowed deeper cuts than could be obtained by the Cushman method because of a lower pressure (<1 mm Hg). Even with the lower vacuum, distillation of bottoms samples was generally limited to an atmospheric equivalent vapor temperature of 1050-1075°F before the onset of thermal cracking. In either case, the initial boiling point and a single cut point were generally all that were available on the bottoms samples, so that a linear distribution was assumed for lack of a measured distribution. This was found to be a major difficulty because of the desire to estimate K-values for the various 50°F pseudocomponent fractions in the overhead vapor and the bottoms. In agreement with the previous vacuum column study, reproducibility of the Cushman distillations of the bottoms samples was found to be poor and generally required multiple analyses in order to average them or to select the most representative analysis.

The Cushman analysis is performed with 500 g of sample in a 1 liter glass distillation flask. For vacuum column net feed and bottoms samples the initial pressure was set at 3 mm Hg, and the distillation was controlled by gradually raising the stillpot temperature. A carousel receiver system, also under vacuum, was used to collect 25 g cuts. No packing was used in the neck of the stillpot as required for lower boiling samples. Usually the vacuum bottoms sample yielded only one cut at 535°F (900°F @ 760 mm Hg) vapor temperature, while the net feed yielded 5-6 cuts. Control Cushman analyses of the net feed were abreviated to half this number of cuts. For vacuum column overhead samples, the vacuum was initially set at 80 mm Hg and the distillation started by raising the stillpot temperature. The vaporization rate was maintained steady by gradually increasing the vacuum until 3 mm Hg was reached. At this point stillpot temperature was raised slowly to complete the distillation.

The Sarnia analysis is very similar to the Cushman technique. Again, 500-600 g of vacuum bottoms are charged to a 1 liter distillation flask. The pressure is lowered to best vacuum before heating, and the stillpot temperature is slowly raised. Distillation started at about 0.1 to 0.2 mm Hg pressure, and the pressure increased to at most 1 mm Hg at the completion. This apparatus is not yet capable of maintaining a constant pressure while changing the stillpot heat input.

2. Viscosity Measurements

Viscosity measurements were performed on selected samples using a Brookfield laboratory model LVT viscometer capable of shear rates ranging from 0.084 to 16.8 sec^{-1} and from 0.40 to 79.20 sec^{-1} for the smallest and largest spindle sizes, respectively. The accompanying Brookfield Thermosel unit and temperature controller were limited to a maximum measurement temperature of 597°F.

Vacuum column net feed and bottoms samples were prepared at room temperature while in solid form for convenience. These samples are difficult to handle otherwise because the melting points are typically 125-175°F for the net feed and 300-400°F for the bottoms, and the viscosities are quite high. A 12 g crushed sample was prepared using a mortar and pestle and charged to the sample cylinder. The sample cylinder was inserted into the Brookfield Thermosel unit and the temperature increased to melt the sample and attain the desired measurement temperature. Spindle #34 was inserted into the melted sample and connected to the viscometer drive. Initial warmup and equilibrium required about 45 minutes. Vacuum column overhead samples were very fluid at room temperature enabling the use of a graduate cylinder to obtain the necessary 8 ml charge, and spindle #18 was used. Viscometer readings were obtained after each revolution or several revolutions, depending upon the speed, until the last three readings indicated equilibrium at the set shear rate. This was simplified later to a standard 10 minute equilibration time after a shear rate change.

F. P-99 Run Conditions During Vacuum Column Tests

The vacuum column tests were performed during Runs P99-63 to 71, involving the use of three different Pittsburgh seam, West Virginia panhandle coals. Runs 63-66 were performed with an 9% ash, low reactivity batch of Powhatan #5 coal. Powhatan #6 coal containing 11% ash was used in Runs 67-69, and 16% ash Ireland Mine coal was processed in Runs 70-71.

Runs 63-66 were divided into two sets of experiments to determine the effect of dissolver length/diameter ratio and the combined effect of recycle gas rate and purity. A 4 1/4 inch ID x 20 ft dissolver was utilized in Runs 63 and 64 at the operating conditions shown in Table III. A 6 inch ID x 10 ft dissolver was evaluated in Runs 65 and 66, with operating conditions matching approximately those in Runs 63 and 64, respectively. As shown in Table III, the increase in gas purity resulted in a 0.5-1% decrease in hydrocarbon gas yield, a 2-3% decrease in IOM yield and a 3-4% increase in SRC (900°F+ pyridine soluble) yield. Distillate yield was unchanged, and dissolver L/D had no effect on yields. Gas purity exhibited similar effects on the atmospheric flash tower bottoms composition (net slurry feed to the vacuum flash column) as shown in Table IV. The 6 inch x 10 ft dissolver was used in the remaining experiments shown in Table III.

Dissolver temperature was investigated in Runs 67 and 68, and conditions in Run 69 were matched with Run 67, except for slurry residence time, in order to obtain product yields at a 1 hour slurry residence time taking into account coke deposition in the dissolver. The coke problem occurred when a pressure relief disk on the hot separator ruptured at the beginning of Run 67. A decrease in dissolver outlet temperature from 460°C in Run 67 to 455°C in Run 68 decreased the distillate yield and hydrogen consumption as shown in Table IV. The atmospheric flash tower bottoms contained 2.4% more distillate and 3% less SRC at the higher temperature. The pyridine insolubles content was a slight 0.6% higher at the higher temperature. It is significant that the IOM content was about half that of the atmospheric flash tower bottoms in Runs 63-66. Product yields and atmospheric flash tower bottoms composition in Run 69 reproduced those in Run 67 within the accuracy of the experimental data.

Ireland Mine coal was processed in Runs 70 and 71 at two different feed slurry solids levels. The feed slurry in Run 70 consisted of 16% recycle solids and 30% coal, while that in Run 71 contained an additional 2% recycle solids. As indicated in Table IV, distillate yields increased with increasing recycle solids concentration. The pyridine insolubles content of the atmospheric flash tower bottoms correspondingly increased at the expense of the SRC content and, to a lesser extent, the distillate content.

IV. RESULTS AND DISCUSSION

A. Distillate Content of Vacuum Column Bottoms as a Function of Flash Zone Temperature and Pressure

1. Powhatan #5 Coal - Runs 63-66

The vacuum column operating conditions used in Runs 63-66 are listed in Tables V to VII. Flash zone temperature was varied over the range 335-375°C (635-707°F) at pressures of 15 to 30 mm Hg. Atmospheric flash tower bottoms fed to the vacuum column were in the range 11.4-14.9 kg/h. The effect of overhead recycle rate in the range 6-18 kg/h on the vacuum bottoms distillate content was also investigated, although theoretically this should have no effect as long as the preheating capacity and demister capacity are not exceeded. The flash zone temperature was taken as the 1 hour computer average value just before sampling, although it was found important to maintain the receiver liquid and outlet line temperature as close as possible to the flash zone temperature presumably to avoid internal refluxing at a temperature lower than the flash zone temperature. Part of the poor correlation of vacuum bottoms distillate content with flash zone temperature obtained in earlier work is believed to be a result of the receiver temperature being significantly lower (as much as 50-60°C) than the flash zone temperature. The flash zone pressure was taken as the average of the computer average overhead receiver and bottoms receiver pressures.

The results for the Powhatan #5 coal tests are summarized in Figure 3, where the 900°F⁻ distillate content of the vacuum column bottoms is plotted versus flash zone temperature at three levels of pressure: 15, 21.5 and 30 mm Hg. Comparison of the data points in Figure 3 at the three overhead recycle flowrates indicates that this variable had little if any effect on the flash zone operation as expected. The distillate content of the bottoms decreases in a linear fashion with increasing flash zone temperature at the same rate for all three pressure levels. In order to check the consistency of all the data, the flash zone temperature was corrected to the equivalent temperature at atmospheric pressure using the vapor pressure charts in the API Data Book and a Watson characterization factor of 10. The result of this transformation is shown in Figure 4 and shows that the data are consistent and correlate well with equivalent flash zone temperature. Some moderate extrapolation of the results to conditions outside those used in the experiments (e.g., slightly higher pressures) should be fairly reliable provided the coal feedstock and the feed to the vacuum column are similar to those in these experiments.

The data in Figures 3 and 4 were correlated with the following linear parameters:

Pressure Level	Slope	Intercept
14-16	-0.1469 wt%/°C	53.42 wt%
21-22	-0.1285 wt%/°C	48.74 wt%
29-31	-0.1308 wt%/°C	50.39 wt%
760	-0.06456 wt%/°F	63.68 wt%

Data for Periods 63-7, 64-3 and 65-1 were omitted from the figures and the correlations because they were outliers. Scatter of the distillate content data may have been due primarily to three factors: the differences in vacuum column feed composition for each run as shown in Table IV, the use of a spot sample of the bottoms as representative of the flash zone conditions, and poor reproducibility of the Cushman distillation analysis. The correlations show that total 900°F⁻ distillate removal is possible at temperatures of 364, 379 and 385°C at pressure levels of 15, 21.5 and 30 mm Hg, respectively. From Figure 4, the equivalent temperature at atmospheric pressure where total distillate removal occurs is 986°F.

The Cushman and Sarnia distillation data used in the above correlations are summarized in Table VIII. These distillation samples were listed in Table II and discussed previously. In two-thirds of the cases, it was possible to simply use the average of the control and special test sample Cushman results. Since the period sample was obtained and handled in a different manner than the control and special test samples, the period sample Cushman analysis was simply used as a guide when the control and special test sample Cushman analyses were greatly different. Similarly, the Sarnia analysis was used as a check, and was only substituted in one case where the other values were thought to be low.

2. Powhatan No. 6 Mine Coal - Runs P99-67 to -69

The vacuum column operating conditions for Runs 67-69 are listed in Tables IX-XI. The overhead recycle rate was held constant at about 10 kg/h for all of these tests, and flash zone temperature and pressure were varied over the ranges 305-375°C (579-707°F) and 15-30 mm Hg, respectively. The feed rate of atmospheric flash tower bottoms to the vacuum column was in the range 10.7-13.3 kg/h. In several cases (e.g., 67-6, 69-7 and 69-8) the bottoms receiver pressure was substantially higher than the overhead receiver pressure due to plugging of the vacuum line as discussed in the flowsheet section of this report. The flash zone pressure was simply assumed equal to the overhead receiver pressure plus a small differential typical of the other tests.

The vacuum bottoms distillate content as a function of the flash zone temperature and pressure is shown in Figure 5, and exhibited the same behavior as observed in Runs 63-66. The latter results are represented in Figure 5 by the dashed lines. However, less severe flash zone conditions were required in the case of the Powhatan #6 coal runs to obtain the same level of distillate content in the bottoms. For example, at 16 mm Hg pressure, a 1% distillate content required a flash zone temperature of 342°C when the Powhatan #6 coal feedstock was used and 357°C with the low ash Powhatan #5 coal feedstock. At 30 mm Hg pressure, the differences are less, 371°C and 378°C, respectively.

The scatter in the 21 mm Hg pressure data in Figure 5, especially at temperatures near 305°C, is believed to be a result of the compositional differences in the net feed to the vacuum column in addition to other factors mentioned previously. This is illustrated by the following data:

	Vacuum Column Feed Composition, Wt%		
Period, P99-	PI	SRC	Dist
69-9	28.8	42.6	28.6
69-0	27.1	43.9	29.0
68-6	26.3	47.4	26.3
69-1	27.8	46.3	25.9
68-5	25.6	47.1	27.3
69-2	25.9	47.2	26.9

The vacuum column feed composition for periods 69-9 and 69-0 were very similar, and the corresponding data points in Figure 5 agree well. The same can also be said for periods 68-6 and 69-1. However, the agreement between the latter pairs of data points was not good, and was very likely related to the higher SRC content and lower distillate content of the feed in periods 68-6 and 69-1 compared to periods 69-9 and 69-0. At 30 mm Hg pressure, the feed compositions of periods 68-5 and 69-2 agree well and so do the distillate contents, adding further support to the above hypothesis.

In order to check the consistency of the data, the flash zone temperatures were corrected to an equivalent temperature at atmospheric pressure, using the API vapor pressure charts and a Watson characterization factor of 10, and were plotted in Figure 6. The distillate contents of the vacuum column bottoms samples agree reasonably well for the various pressures, although the scatter is more significant than that obtained in Figure 4 for the Powhatan #5 coal tests. Especially noticeable is the difference between the 30 mm Hg pressure data and the lower pressure results. Except for two 15 mm Hg data points at 842°F, two separate lines could possible by used to correlate the data. This discrepancy can be seen in Figure 5 also, where the 30 mm Hg line has a significantly larger negative slope than the other two isobars. As in Figure 5, compositional differences in the vacuum column feed are thought to be largely responsible for the variances. The dashed line in Figure 6 for the Powhatan #5 data indicates again the higher severity required for distillate removal from the low ash Powhatan #5 vacuum column feed compared to the Powhatan #6 vacuum column feed. Although the average pyridine insolubles level for Runs 63-66 and Runs 67-69 are identical, significant differences in the feed are apparent:

Average Vacuum Column Feed Composition, Wt%	Run Series 63-66	Run Series 67-69
900°F$^-$ Distillate	23.9	28.4
900°F+ Pyridine Soluble	49.8	45.3
Pyridine Insoluble	26.3	26.3
Ash	13.1	18.9
IOM	13.2	7.4

For example, the 13.2% IOM of Runs 63-66 was nearly twice as high as the 7.4% IOM in Runs 67-69 and could have significantly affected the flash equilibrium via interaction in the liquid phase. The molecular weights of species in the SRC fraction in the feed from Powhatan #5 coal may be distributed over higher values than in the feed from Powhatan #6 coal causing an interaction similar to the IOM.

The results in Figures 5 and 6 were correlated with the following linear parameters:

Pressure Level mm Hg	Slope	Intercept
15-16.5	-0.07601 wt%/°C	26.98 wt%
20.5-23	-0.08544 wt%/°C	31.58 wt%
29.5-32	-0.1184 wt%/°C	44.98 wt%
760	-0.05114 wt%/°F	49.37 wt%

These correlations extrapolate to zero distillate content at 355°C, 370°C, 380°C and 965°F, respectively.

The distillate contents of the vacuum bottoms samples are listed in Table XII along with the average or selected values used in Figures 5 and 6. As expected, reproducibility of the Cushman analyses was poor. About two-thirds of the final distillate values were averages, while the remainder were selected using the Sarnia analysis as a guide. Period sample distillate analyses were not performed in time to be used in evaluating the other distillation results.

3. Ireland Mine Coal - Runs P99-70 to -71

The vacuum column operating conditions for Runs 70-71 are compiled in Tables XIII and XIV. The overhead recycle rate was held constant at about 10 kg/h for all tests, and the flash zone temperature was varied over the range 305-344°C (581-651°F). The feed rate of atmospheric flash tower bottoms to the vacuum column was in the range 10.9-12.9 kg/h. Although the overhead receiver pressure was varied from 15 to 31 mm Hg, the actual flash zone pressures were in doubt because the indicated bottoms receiver pressure was consistently higher (by as much as 11 mm Hg in Run 70 and 25 mm Hg in Run 71), indicating either an erroneous pressure reading because of receiver vacuum line plugging or a significant pressure drop across the vacuum column. A large pressure drop could have been caused by leakage of air into the receiver through the ball valves or plugging of either the demister or piping on the Basco condensers. During Run 70, however, cleaning of the receiver vacuum line did not reduce the pressure differential. At the end of Run 70, the vacuum flash column was shut down for approximately eight hours to replace the vacuum bottoms receiver and the top and bottom receiver valves. In order to expedite changing the valves, Calrod heaters were mounted on the connecting and bottoms outlet lines of the receiver to eliminate the time-consuming task of wrapping the piping with nichrome wire. The latter technique is usually more desirable because it gives reasonably uniform heat distribution. When the vacuum column was restarted and operated during Run 71, there was still a large pressure differential between the bottoms receiver and the overhead system. It was tentatively concluded that a flow restriction in the demister pad or the overhead piping was causing at least part of the pressure differential.

The use of the Calrod heaters on the bottoms receiver inlet/outlet valves and piping created an additional problem during Run 71 that eventually required complete shutdown of the vacuum flash system midway through Period 71-3. The heat distribution on the valves and piping was sufficiently uneven to cause local overheating and coking, especially as the operating temperature was increased. Consequently, the valve balls and seats were damaged during the process of freeing them, and the valve stems were extremely difficult to rotate. Leakage of air through the stem and ball packing of the receiver valves became severe by the time Period 71-3 was started. Post shutdown inspection of the vacuum system revealed the following:

1) The inlet/outlet bottoms receiver valves were badly damaged as expected.

2) The 1 1/2 inch diameter pipe connecting the vacuum surge tank and the secondary Basco condenser was found to be at least half full of a black, sludgy material in the horizontal portion of the pipe run.

3) The wall of the vacuum column flash zone was covered with approximately 1/2 inch thick coke.

4) The bottom of the demister pad was completely covered by a thin layer of dry solid material and appeared severely plugged. The top of the demister pad and the top head wall were partially covered with a heavy, tarry residue.

5) The top section of the preheater was clean, but the bottom section had a tarry layer of sludge that increased from a thin film at the mid-section flange to a thick layer at the vacuum column inlet flange.

6) The impingement cone in the flash zone was covered with a 1/2 inch thick layer of heavy, tarry residue. A considerable amount of coke was found on top of the residue.

7) The piping between the vacuum column head and the primary condenser was clean.

8) The bottom cone section of the vacuum column was relatively clean in the lower area near the discharge port.

9) The bottoms receiver removed after Run 70 was very heavily coked on the inside wall, and the vacuum line port was plugged. The bottoms receiver removed after Run 71 was in good condition.

Based on the above information, the pressure differential is believed to have been caused by a combination of leaky receiver valves and a partially plugged demister pad. The actual flash zone pressure was probably at some value intermediate to the overhead and bottoms pressures.

The distillate content of the vacuum column bottoms is shown in Figure 7 as a function of the flash zone temperature and overhead pressure. Periods 71-0A and 71-0B appear to be outliers and thus were ignored in the data correlations. The data points in Figure 7 were consistent with isobars based on the overhead receiver pressure or the average of the overhead and bottoms pressure. For example, Periods 70-0, 70-1 and 71-1 all had an overhead pressure of 15 mm Hg, while the bottoms receiver pressures and calculated average pressures were 24, 26 and 40 mm Hg, and 19.5, 20.5 and 27 mm Hg, respectively. If the bottom pressures were correct, the isobar correlation in Figure 7 would be very poor. The isobar slope for Periods 70-4, 5, 6 and 7 is reasonably firm because the overhead and calculated average pressures were essentially constant, while the bottoms receiver pressure was in a narrow range (35-38 mm Hg).

The vacuum column feed composition varied slightly from Run 70 to 71 as shown in Table IV, but probably had little effect on the distillate content of the vacuum bottoms. The feed in Run 70 contained 2.8% less pyridine insolubles than in Run 71, and consequently had 1.3% more distillate and 1.5% more SRC. The pyridine insolubles in Run 70 consisted of 25.1% ash and 6.4% insoluble organic matter compared to 27.4% and 6.9%, respectively, for Run 71.

Figure 8 shows the result of plotting vacuum bottoms distillate content versus equivalent flash zone temperature at 760 mm Hg based on the overhead pressure. Although Periods 71-0A and 71-0B were outliers, the remaining data are very consistent yielding a correlation coefficient of 0.981. As an alternate check on the flash zone pressure, Figure 8 was replotted based on the bottoms receiver pressure and is shown in Figure 9. The data appear more scattered (correlation coefficient of 0.952) than in Figure 8, and the slope of a correlating line through the data is much steeper than was obtained previously for the Powhatan #5 and #6 coal tests. However, a good correlation (correlation coefficient of 0.986) can be obtained based on the calculated average pressure as shown in Figure 10. Use of the average pressure is not completely consistent with the isobars in Figure 7 because the average pressures for Periods 71-1 and 71-2 differ significantly from the other average pressures in their subsets. However, the highest correlation coefficient was obtained using the average pressure supporting its use as the flash zone pressure. Additional experiments are necessary to resolve this question. The average pressure levels were approximately 20, 25 and 33 mm Hg.

The results in Figures 7 and 8 were correlated with the following linear parameters:

Pressure Level mm Hg	Slope	Intercept
15	-0.1077 wt%/°C	40.05%
20-22	-0.1128 wt%/°C	42.66%
30-31	-0.1016 wt%/°C	39.88%
760	-0.05098 wt%/°F	50.97% (based on ovhd. pressure)
760	-0.06512 wt%/°F	62.24% (based on average pressure)

The distillate contents of the vacuum bottoms samples are listed in Table XV along with the average or selected values used in the above correlations. All the distillate values except for Periods 70-0 and 71-1 were based on the average of the control and special test samples. Period sample distillate analyses were not performed in time to be used as a check for the other sample analyses.

A comparison of the distillate content in the vacuum bottoms from Ireland Mine coal with the results obtained for the two Powhatan coals is shown in Figures 11 and 12.

At the 15 and 21 mm Hg pressure levels in Figure 11, the vacuum bottoms from Powhatan #6 coal contains significantly less distillate than the bottoms generated from the other two coals over the entire flash zone temperature range explored. At 30 mm Hg pressure the differences are not great, with the vacuum bottoms from Powhatan #6 coal containing less distillate than the bottoms from Powhatan #5 coal. Ireland Mine coal vacuum bottoms has a distillate content the same as Powhatan #6 bottoms at 305°C and the same as Powhatan #5 bottoms at 360°C. The isobars for Ireland Mine coal and Powhatan #5 coal are very similar and intersect in two cases.

When the distillate contents of the vacuum bottoms from the three coals are normalized and compared in Figure 12 using an equivalent flash zone temperature at 760 mm Hg, the results from the Ireland Mine coal based on the overhead pressure are observed to be within 1% of the Powhatan #5 correlation at 870°F, and within less than 0.5% at 960°F. The Ireland Mine coal vacuum bottoms distillate line parallels the Powhatan #6 correlating line with a constant offset of 1.74%. For example, at any given equivalent flash zone temperature, the distillate content of the Ireland Mine coal vacuum bottoms will be 1.74% more than that for the Powhatan #6 coal vacuum bottoms. If the average pressure is used for the Ireland Mine coal tests in Figure 12, the dashed line is obtained and parallels the Powhatan #5 line with a constant offset of -1.95% over the range 870-950°F. This correlation is much closer to the Powhatan #6 line.

The compositional differences of the vacuum column feeds from the three coals are great:

Average Vacuum Column Feed Composition, Wt%	Run Series 63-66	Run Series 67-69	Run Series 70-71
900°F⁻ Distillate	23.9	28.4	29.3
900°F+ Pyridine Soluble	49.8	45.3	37.8
Pyridine Insoluble	26.3	26.3	32.9
Ash	13.1	18.9	26.3
IOM	13.2	7.4	6.6

As discussed in the previous section, the large IOM content in the pyridine insoluble fraction of the feed from Powhatan #5 coal may be largely responsible for the differences in vacuum bottoms distillate content between the Powhatan #5 and Powhatan #6 coals in Figures 11 and 12. The vacuum column feed from Ireland Mine coal contains 6.6% more pyridine insolubles than the feed from Powhatan #6 coal possibly accounting for the offset in distillate content. Molecular weight distributions of the SRC fractions may also be of significant influence.

B. Quantity of Feed Flashed

1. Powhatan #5 and #6 Coals

The percent of net feed that was flashed overhead was calculated for each of the tests with Powhatan #5 and #6 coals by simply using the net feed and net overhead rates listed in Tables V-VII and IX-XI. For each operating pressure, Figures 13-15 show that the vacuum column feed generated from Powhatan #5 coal consistently required more severe conditions to flash the same quantity of feed even though the pyridine insolubles content was nearly the same for both cases. For example, Figure 13 indicates that 25% of the vacuum column feed produced from Powhatan #6 coal can be flashed overhead at a temperature of 302°C, while the feed produced from Powhatan #5 coal requires a temperature of 342°C to achieve the same result. The information in Figures 13-15 is summarized in Figure 16 without the data points and shows the effect of operating pressure and coal source.

Table XVI summarizes the average feed compositions for the two coals at the different vacuum column operating pressure levels and indicates why the feed generated from Powhatan #6 coal can be more deeply flashed than the feed produced from Powhatan #5 coal (low ash batch) at the same flash zone conditions. Approximately 8-10% more of the feed generated from Powhatan #6 coal can be flashed compared to the other case at the same operating conditions. About 4-5% of this increase can be accounted for by the difference in 900°F$^-$ distillate content. The pyridine insolubles content is about the same for both feeds, so that the feed from Powhatan #5 coal has about 4-5% more SRC than the feed from Powhatan #6 coal. The remaining 3-5% difference is accounted for by the larger amount of the SRC fraction that is flashed in the case of the feed from Powhatan #6 coal.

The differences become obvious when the maximum % feed flashed at each of the pressure levels is compared to the 900°F$^-$ distillate content of the feed. Under the maximum operating severity of the experiments, essentially all of the 900°F$^-$ distillate is vaporized, so that the data in Table XVI can be used to calculate that approximately 18% of the SRC in the feed from Powhatan #6 coal is flashed overhead compared to about 9% of the SRC in the feed from Powhatan #5 coal.

The actual quantities of SRC and distillate flashed overhead based on the overhead and bottoms distillation analyses and rates are illustrated in Figures 17-19 for the tests based on Powhatan #5 and Powhatan #6 coals. Under less severe operating conditions, the difference in SRC vaporized for the two coals is still significant. Usually the quantity of distillate flashed is about 90% or higher when the flash zone temperature corresponds to the arrows in Figures 13-15. The arrows mark the points at which the % of feed vaporized is numerically equal to the distillate content of the feed. Increasing feed vaporization beyond these points is primarily due to vaporizing SRC in the feed.

It is very probable that the molecular weights of the constituents in the SRC fraction of the Powhatan #6 vacuum column feed are distributed to much lower values compared to the same fraction for the Powhatan #5 coal. The large difference in the IOM contents of the vacuum column feeds (almost a 2/1 ratio) also supports the idea of a higher molecular weight distribution and may also be of significance in that the IOM concentration influences the equilibrium between the vapor and liquid phases. Some additional colloidal material may be precipitating as SRC and distillate are removed, and the colloidal material in the feed may be exhibiting adsorption effects.

2. Ireland Mine Coal

The percent of net vacuum column feed vaporized for the Ireland Mine coal tests (Runs 70 and 71) was calculated using the overhead product rate and feed rate data in Tables XIII and XIV and is shown in Figure 20 as a function of flash zone temperature and pressure. The results for the coals discussed in the previous section are also shown in Figure 20 for reference. The vaporization of vacuum column feed from Ireland Mine coal appears to be much less sensitive to flash zone temperature than the feed for Powhatan #5 and #6 coals. As discussed previously, there is some uncertainty in the Ireland Mine coal results because of the difficulties in accurately measuring the flash zone pressure due to the pressure differential across the vacuum column. However, the experiments at an overhead pressure of 30 mm Hg serve as an internal check for the rest of the data from Runs 70 and 71 because the average or the bottoms pressures were all about constant so that the response in Figure 20 is probably not a result of pressure variation.

The arrow in Figure 20 indicates the point at which the % feed vaporized equals the average 900°F$^-$ distillate content of the feed. It is clear that, with the Ireland Mine coal vacuum column feed, complete removal of the distillate is not attained and that the amount of SRC vaporized is low. For example, the lowest and highest quantities of distillate removed were 76.6% and 92.2%, respectively, while the corresponding quantities of SRC vaporized were 3.2 and 5.7%, respectively. These values were calculated using the stream rates and distillation analyses.

In order to correct the Ireland Mine coal results to a common basis with the Powhatan coals, the % of feed flashed overhead was calculated on a pyridine insolubles free basis for each test and replotted in Figures 21-24. The comparisons for the various coals are essentially the same as before except that the slopes of the correlating lines for the Ireland Mine coal tests are greater than before and more in agreement with the correlating lines for the other coals.

The percent distillate and SRC vaporized for the Ireland Mine coal tests are shown in Figure 25 and follow the same trends as exhibited in the Powhatan #5 and #6 experiments. In order to check the consistency of the data and compare the results for all three coals on a common basis, the percent distillate and SRC vaporized were plotted as a function of equivalent flash zone temperature at 760 mm Hg in Figures 26 and 27. The fraction of distillate flashed is observed to be the same for the vacuum column feed derived from Powhatan #6 coal and Ireland Mine coal at a given flash zone temperature as shown in Figure 26. Substantially less of the distillate in the feed from Powhatan #5 coal is vaporized at the same temperature. However, at 975°F, 100% of the distillate is vaporized for both the Powhatan #5 and Powhatan #6 vacuum column feeds. Complete distillate removal from the feed from Ireland Mine coal would also be expected at 975°F. The percent SRC vaporized is different for all three feedstocks as illustrated in Figure 27, except at temperatures below 850°F, where the data merge at values of 1% or less vaporized.

C. Mass Balances

1. Stream Compositions and Component Balances

Stream compositions and component balance data for each vacuum column experiment are tabulated in Appendix B. As discussed in the Experimental section, the net vacuum column feed rate was calculated by summing the 20-hour-average net overhead and bottoms rates. This was necessary because there was no direct method of measuring the feed rate. These rates are checked for each experiment by computing elemental balances using analytical data for the feed and product streams. Thus, the closure of the elemental balances should give an indication of the true overall mass balance. The balances for total distillate and pyridine insolubles were also checked to elucidate any unusual phenomena such as cracking or repolymerization reactions. Appendix B contains raw data that have not been forced to normalize analyses or balances, except in one or two cases that are so noted. Forced balances would probably further improve the correlations presented in this report.

The boiling point distributions, tabulated in Appendix B in 50°F increments for the feed, bottoms and overhead, are based on Cushman distillation analyses. The actual vapor temperatures were corrected to equivalent temperatures at atmospheric pressure using the API vapor pressure charts and a Watson characterization factor of 10. The raw analyses for the feed and overhead were graphed, and new values for cummulative weight percent distilled read from the smoothed data at the desired temperatures. In several cases it was necessary to plot the overhead product distillation data on probability graph paper in order to adequately smooth the data and interpolate the 900°F cut point. Except for Runs 70 and 71, the bottoms distillation analysis consisted of the initial boiling point and the 900°F cut point. The 900°F distillate in the vacuum bottoms was simply distributed in a linear manner down to the initial boiling point. Several distillate cuts were obtained for the vacuum bottoms in Runs 70 and 71, allowing distribution of the distillate in a more representative way. The product composite boiling point distribution is calculated by combining the compositions and rates of the overhead and bottoms streams. The composite distribution should closely approximate the measured net feed boiling point distribution unless reactions occur that redistribute the boiling range or some colligative phenomenon (related to the pyridine insolubles associating or in solution with very heavy distillate material) affect the boiling point.

The average recoveries for all the vacuum column tests are listed in Table XVII. Balances for carbon, nitrogen and ash were usually very good, giving the lowest standard deviations. This is a strong indication that the overall mass balances were reasonably accurate. Hydrogen and total oxygen balances were good on the average, but were subject to wider variation than the carbon, nitrogen and ash balances. Oxygen balances were much greater than 100% for Runs 70 and 71 probably as a result of air leaking into the vacuum column through the bottoms receiver valves. The air would tend to oxidize the bottoms. The pyridine insoluble balance was always above 100% for Runs 63-66 and frequently above 100% for Runs 67-69 and 70-71, suggesting that some retrogressive reactions were occurring in the non-distillable portion of the vacuum column feed upon preheating and flashing. This effect is especially pronounced with the Powhatan #5 coal experiments and is not unexpected considering the poor reactivity of this particular batch (low ash) of coal. The 900°F$^-$ distillate balance was reasonably good on the average, but was subject to wider deviations than some of the other balances and appeared to show a slightly positive bias of about 1% for the tests using the Powhatan coals.

2. Effect of Temperature on Pyridine Insolubles

The recoveries in Table XVII strongly suggest that some retrogressive reactions may have occurred during preheating and flashing causing the quantity of pyridine insolubles in the vacuum column bottoms to exceed the amount in the net feed from the atmospheric flash tower. This is illustrated in Figure 28 which shows a substantial increase of the pyridine insolubles fraction for the vacuum column tests using Powhatan #5 coal. The correlating line indicates a 15% pyridine insolubles increase at a flash zone temperature of 380°C and no increase at 320°C. On the average, the vacuum column feed from Powhatan #5 coal contained 26.3% pyridine insolubles of which 13.1% was ash and 13.2% IOM. Since the ash is unchanged, as verified by the ash balance, a 15% increase of pyridine insolubles would correspond to a 30% increase of the IOM.

A similar correlation of pyridine insolubles recovery with flash zone temperature for tests using Powhatan #6 coal was inconclusive, as indicated in Figure 29, because the data were extremely scattered. There appears to be a slight trend of increasing pyridine insolubles recovery with increasing flash zone temperature, especially when the data are segregated by run. A blind least squares fit of the data in Figure 29 to a straight line shows a pyridine solubles increase of 6.3% at 380°C. On the average, the vacuum column feed produced from Powhatan #6 coal contained 26.3% pyridine insolubles of which 18.9% was ash and 7.4% IOM. Therefore, a 6.3% increase of pyridine insolubles would correspond to a 22.4% increase of the IOM.

The pyridine insolubles fraction of the vacuum column feed produced from Ireland Mine coal showed no tendency to increase as flash zone temperature increased up to 344°C. As shown in Figure 30 and Table XVII, pyridine insolubles recoveries averaged very close to 100%.

3. Boiling Point Distribution Shift from Feed to Product Composite Feed

In order to check whether the boiling range of the vacuum column feed was shifted due to cracking reactions or some colligative phenomenon related to the pyridine insolubles, a feed boiling range distribution was computed using the distillation analyses and rates for the overhead and bottoms products. The composite feed analysis for each test is tabulated in Appendix B. Some typical results are shown in Figures 31-33 for the Powhatan #5 coal tests, in Figures 34-36 for the Powhatan #6 coal tests and in Figures 37-39 for the Ireland Mine coal tests. The nomenclature in these figures is as follows: the solid curve is the distillation analysis for the test sample of the feed; the circles are the routine control analysis of the feed; and the X's and dashed curve represent the calculated composite analysis. The inset graph shows the bottoms distillate analysis.

Comparison of the control and test sample distillation analyses of the vacuum column feed indicates that this distillation is subject to rather wide variation. In Figure 31 the control analysis agrees well with the composite distribution, while the test sample analysis does not agree well. Figure 32 shows how some of the feed distillation analyses give distribution curves of rather unusual shape, while Figure 33 shows a set of analyses that are very consistent with each other. Even though the composite and actual feed boiling range distributions were not always in agreement, the balances of 900°F distillate were usually reasonable and averaged close to 100% (see Table XVII). In general, it appears that chemical reaction of the distillate range material in the vacuum column is minimal, if occurring at all, and that the composite curve frequently gives a better representation of the feed than the direct analysis of the feed itself.

The bulk of the composite curve is defined by the overhead product analysis. The overhead product is liquid at room temperature, does not contain solids, and is much easier to distill; therefore, it should yield more reproducible results than those from distillation of samples containing solids. Despite the fluctuation in the control sample and test sample distillation analyses, there appears to be a consistent colligative effect of the solids (ash and IOM) on the distillation of vacuum column feed samples. The boiling point distribution is shifted to higher temperatures when solids are present.

For example, comparison of the distributions of the feed and calculated composite analysis for period 68-5 shows that the distribution reaches a maximum at about 700°F for the composite analysis versus 750°F for the actual feed analysis. The composite fractions below 700°F overestimate the actual fractions, while the composite fractions between 700 and 900°F underestimate the actual fractions. The composite analysis also displays a bimodal pattern, as would be expected because of the large amount of organic material boiling above 900°F, while the actual analysis does not. Although there are exceptions, the majority of the test results show the above trend. The initial boiling point of the composite, almost without exception, was below the initial boiling point of the actual feed, also a strong indication of boiling point elevation. The 1% average over balance in Table XVII for the 900°F$^-$ distillate is probably a result of the boiling point elevation of the feed.

4. K-Value Determination

As discussed previously, the distribution of distillate in the vacuum bottoms was assumed to be linear between the initial boiling point and the 900°F cut point, since these two data points were usually all that were available from the Cushman distillation. This was adequate for estimating a composite feed composition, since the overhead stream made up the bulk (greater than 75%) of the distillate in the feed, and the SRC fraction was unaffected by the assumed distribution. This method is not adequate for calculation of the vapor/liquid distribution coefficient (K-value or equilibrium flash vaporization ratio) because the distribution of distillate in the bottoms is unlikely to be linear, the measured initial boiling points of the bottoms samples are unreliable and a significant amount of distillate in the 900-1050°F boiling range is lumped with the SRC fraction. Although some of the overhead stream distillation data extend to 1050°F, thermal cracking of the bottoms samples during distillation generally precludes recovering this high boiling material. Some method of smoothing the data is needed that will use the 900°F cut point for the bottoms and distribute the distillate such that very small amounts of light fractions are taken into account, as well as fractions boiling up to 1050-1100°F. Also, a distillation technique should be developed that can recover 1100°F$^-$ material from the bottoms samples without causing cracking.

In a separate study,[2] the Technology and Materials Department developed a technique for redistributing the distillate in the vacuum bottoms and the 900°F+ distillate in the vacuum overhead. Briefly, this technique involves redistributing the bottoms fractions and 900°F+ overhead fractions in a geometric manner having one adjustable constant, the cut ratio. The K-values were calculated for the 800-850°F, 850-900°F and 900-950°F fractions for all the tests with a given coal, and the geometric parameter was adjusted to minimize the error in the K-value temperature correlation. K-values were corrected to a common basis at atmospheric pressure assuming ideal gas behavior at the low experimental pressure. These K-values compared very favorably to those predicted by the Computer Heat and Material Balance Program (CHAMP), although the experimental values gave a greater temperature slope indicating somewhat higher heat of vaporization than in the petroleum correlation. The quantity of feed flashed and the product compositions predicted by CHAMP compared favorably to the experimental results. The composite feed was found to give less error in the predictions than the actual feed composition. Reference 2 should be consulted for further details of the K-value study.

D. Feed and Product Stream Properties

1. Specific Gravity

The specific gravity of the net vacuum column feed (atmospheric flash tower bottoms) varied between 1.270 and 1.366 and averaged 1.3145 (± 0.0210) for the tests performed during Runs 63-66 using Powhatan #5 coal. The vacuum bottoms specific gravity did not correlate with flash zone conditions varying over the range 1.291-1.401, and averaged 1.3669 (± 0.0247). Vacuum column overhead specific gravity varied in a very predictable manner with flash zone conditions as shown in Figure 40. In fact, Figure 40 shows that the overhead specific gravity was essentially the same for all three coals for a given flash zone temperature at 760 mm Hg. Overhead product specific gravity varied over the range 1.081-1.110 for the Powhatan #5 coal tests.

The net vacuum column feed specific gravity varied between 1.357 and 1.389 and averaged 1.3709 (± 0.0094) for the tests performed during Runs 67-69 using Powhatan #6 coal. This average specific gravity is higher than the average for the Powhatan #5 coal tests because of the higher ash and lower IOM contents produced with Powhatan #6 coal. The vacuum bottoms specific gravity did not correlate with flash zone conditions, varying over the range 1.388-1.501, and averaged 1.4534 (± 0.0318). As expected, the average vacuum bottoms specific gravity is higher for Powhatan #6 coal than for Powhatan #5 coal because of the higher ash content of the vacuum bottoms produced from Powhatan #6 coal. The vacuum column overhead specific gravity again varied predictably with flash zone temperature and pressure, as illustrated in Figure 40, in the range 1.072-1.100 (neglecting outliers) for the tests based on Powhatan #6 coal.

The net vacuum column feed specific gravity varied between 1.392 and 1.448 and averaged 1.4189 (± 0.0214) for the tests performed during Runs 70 and 71 using Ireland Mine coal. This average specific gravity is the highest for the three coals tested because the ash content of the net vacuum column feed is the highest of the three. The vacuum bottoms specific gravity varied over the range 1.453-1.582 and averaged 1.5243 (± 0.0427). This bottoms specific gravity is also highest for the three coals used. The vacuum column overhead specific gravity correlated well with the data from the Powhatan coals (Figure 40) and varied over the range 1.057-1.085.

2. Melting Point

Melting point measurements were performed on all vacuum column feed and bottoms samples and are tabulated in Appendix B. The melting point of the net vacuum column feed (atmospheric flash tower bottoms) varied between 176°F and 212°F and average 188.5°F (± 9.3°F) for the tests performed during Runs 63-66 using Powhatan #5 coal. The vacuum bottoms melting point varied over the range 338-401°F and seemed to correlate to some degree with the 900°F$^-$ distillate content of the bottoms as demonstrated in Figure 41.

The net vacuum column feed melting point in the Powhatan #6 tests varied over the range 122-176°F and average 147.2°F (± 17.6°F). This wide variation in melting point is partially a result of Run 68 in which the dissolver temperature was lowered and affected the composition of the feed as indicated in Table IV. Thus, the vacuum column feed melting point is sensitive to changes in composition. It is interesting to note that the melting point of the feed was 131°F for all of the points in Run 67 except for 67-0 when it was 122°F. During Run 68 the melting point was in the range 154-176°F, while in Run 69 it fluctuated extensively between 131 and 167°F.

Vacuum bottoms melting point also appeared to be very sensitive to composition during Runs 67-69 as indicated in Figure 42. The correlation with 900°F$^-$ distillate content was very poor indicating other compositional parameters may also have to be accounted for in the correlation. The trend in Figure 42, however, is very similar for the Powhatan #5 and #6 coals, and the vacuum bottoms produced from Powhatan #5 coal had a 25-30°F higher melting point on the average compared to the vacuum bottoms produced from Powhatan #6 coal. This also agrees with the difference in feed melting point for the two coals.

The net vacuum column feed melting point in the Ireland Mine coal tests varied over the range 104-135°F and averaged 117.1°F (± 12.3°F). In Run 70, the vacuum column feed melting point was in the range 104-113°F, while in Run 71, the melting point was in the range 122-131°F. This again indicates a compositional effect on melting point and is expected since the recycle solids level was increased in Run 71. The vacuum bottoms melting points for Runs 70 and 71 are shown in Figure 43 to correlate to some extent with distillate content of the bottoms. The dashed line accounts for all the data points, while the solid line correlates only periods in Run 70 (except period 70-7). The results for Run 70 are in excellent agreement with the correlating line for Runs 67-69 in Figure 42, while the Run 71 data points are lower by 30-40°F for a given distillate content.

Comparison of the vacuum column feed and bottoms melting points indicates the trend Powhatan #5 > Powhatan #6 > Ireland Mine. The vacuum column feed compositions are in agreement with this trend as shown previously in which the distillate content increased and SRC and IOM decreased in the order Powhatan #5 → Powhatan #6 → Ireland Mine coal.

3. Viscosity

Extensive viscosity measurements have been recorded for the vacuum column bottoms of Runs 63 through 70. These measurements, taken with a model LVT series Brookfield viscometer, correspond to operating conditions between the temperatures of 305°C and 375°C and pressures between 15 and 30 mm Hg. Sample temperatures achieved by utilizing a Brookfield thermosel ranged from 500°F to 597°F, while shear rates varied between 0.084 and 16.80 sec-1. In addition, viscosity results for the flash tower bottoms and the vacuum column overhead were determined for Run 63. The flash tower bottoms, being less viscous than the vacuum column bottoms, were measured at sample temperatures ranging from 400°F to 550°F and identical shear rates as the vacuum column bottoms. The least viscous of the streams, the vacuum column overhead, necessitated the measurement of viscosity at lower temperatures (100-200°F) and higher shear rates (.40-79.2 sec^{-1}).

The vacuum column bottoms exhibits non-Newtonian behavior, since the viscosity is dependent on the shear rate. The viscosity of the material decreases as the shear rate increases at a constant temperature. For a particular shear rate, viscosity decreases as the sample temperature is raised. These trends are exemplified by the log-log plots of viscosity vs. RPM (linearly proportional to shear rate) displayed in Figures 44-53. The effect of the vacuum column operating conditions on the viscosity is graphically represented by Figure 54, a viscosity vs. reciprocal sample temperature semi-log plot at constant shear rate for Run 63. For constant pressure, higher operating temperatures yield a more viscous bottoms product due to the higher percentage of material flashed. At equivalent temperatures, the vacuum column bottoms from operation at greater pressures is less viscous, since more lower boiling range distillate is present.

Similar trends are evident for the vacuum column overhead stream. Figure 55, a log-log plot of viscosity vs. RPM, demonstrates the decrease in viscosity associated with either lower viscometer temperatures and/or higher shear rates. As the shear rate approaches the higher extreme, the viscosity effect becomes less pronounced, and the rheological behavior becomes closer to that of a Newtonian material.

Typical viscosity results for Powhatan #5 coal are displayed in Tables XVIII, XIX, and XX for the vacuum column bottoms, overhead, and flash tower bottoms, respectively. On the average, the feed to the vacuum column coming from the flash tower bottoms contained 23.87 wt% 900°F^{-} distillate, 26.40 wt% pyridine insolubles, and 49.73 wt% SRC. Operating the vacuum column at 335°C and 21 mm Hg caused the bottoms product to be 5 1/2 times more viscous than the feed. At the same pressure, an increase in temperature of 20°C resulted in a considerable decline in distillate content from 5.78 to 3.04 wt% with a subsequent twofold increase in the viscosity of the vacuum column bottoms. When the temperature was then kept constant and the pressure raised to 31 mm Hg, the distillate content of the bottoms increased to 4.71 wt% with a corresponding decrease in the viscosity.

A reasonably good correlation of the viscosity of the vacuum column bottoms with the weight percent distillate and IOM present was obtained by statistical analysis. A linear model was derived with a high probability of significance which explains approximately 81% of the deviation in the data at a shear rate of 0.168 sec^{-1}. A mathematical formula of this model can be expressed as:

$$\begin{aligned}\text{Viscosity (cP)} = {} & -114{,}952.95 + 23{,}995.78\ (\text{wt\% } 900^\circ\text{F}^{-}\ \text{distillate}) \\ & + 8{,}705.87\ (\text{wt\% IOM}) - 1{,}491.81\ (\text{wt\% distillate}) \\ & \times (\text{wt\% IOM}).\end{aligned}$$

A parity plot for the viscosity predictions, Figure 56, displays the observed viscosities on the ordinate in relation to those predicted by the model on the abscissa. Although the model is in close agreement with the experimental values, it is important to realize that its applicability is limited to the range of the independent variables on which it is based and to the single shear rate of .168 sec^{-1}. The values of distillate and IOM content used in the derivation are tabulated in Table XXI along with the observed and predicted viscosities.

The viscosity measurements for Runs 67-69 with Powhatan #6 coal are given in Table XXII for the vacuum column bottoms at a sample temperature of 550°F. Since the IOM content was relatively constant, a viscosity - wt% distillate correlation sufficed to explain 87% of the deviation in the observed values. The linear model took the form:

$$\begin{aligned}\text{Viscosity (cP)} = {} & 90{,}321.15 - 17{,}970.41\ (\text{wt\% } 900^\circ\text{F}^{-}\ \text{distillate}) \\ & + 1{,}230.95\ (\text{wt\% } 900^\circ\text{F}^{-}\ \text{distillate})^2\end{aligned}$$

The corresponding parity plot, Figure 51, exemplifies the statistical significance of this model. Distillate content and IOM values in addition to the observed and predicted viscosities are in Table XXIII.

The operating conditions of the vacuum column for Runs 67-69 are represented graphically in Figure 58, emphasizing the relationship between the 900°F^{-} distillate content in the vacuum tower bottoms and the flash zone temperature and pressure. Since there is both a direct relation between the viscosity and distillate content and between the viscosity and the operating conditions, the viscosity results were used as a guide in determining the reliability of the distillation cuts for the bottoms product. When the results from different distillation techniques were inconsistent, engineering judgement based on the viscosity results and the operating conditions was utilized to differentiate between non-reproducible results. Thus, Figure 58 illustrates how the data in Figure 5 can be modified somewhat based on the viscosity measurements.

Viscosity results from Ireland Mine coal were limited to Run 70 due to problems in minimizing the pressure differential between the overhead and bottoms receivers. The results obtained are displayed in

Table XXIV and provide a good correlation in terms of weight percent distillate and pyridine insolubles. For a shear rate of 8.4 sec^{-1} the linear model takes the form:

$$\text{Viscosity (cP)} = 2{,}231.31 - 1{,}107.44\ (\text{wt\% } 900°\text{F}^{-} \text{ distillate}) + 64.07\ (\text{wt\% } 900°\text{F}^{-} \text{ distillate})^2 + 82.91\ (\text{wt\% PI})$$

and explains about 90% of the deviation in the observed values. Although the model is based on a small sample population, a parity plot of viscosity vs. predicted viscosity in Figure 59 demonstrates the 98%+ significance of the model.

The individual correlations presented for the three coals, Powhatan #5, Powhatan #6, and Ireland Mine, vary in form based on the particular coal, the shear rate, and the sample temperature at which the viscosity was measured. A more general correlation independent of coal type was attempted on all the viscosity data from Runs 63-70 at the eight possible shear rates for a sample temperature of 550°F. The best linear correlation obtained was of the form:

$$\text{Viscosity (cP)} = \text{Intercept} + A(\text{wt\% distillate}) + B(\text{wt\% distillate})^2 + C(\text{wt\% PI})$$

Table XXV gives the corresponding coefficients for the various shear rates along with the R-Square statistic. The results become less reliable as the shear rate increases which is evident by comparing the scatter in the parity plots of Figures 60 to 67.

Since it was often difficult to obtain reproducible viscosity results due to the bubbling tendency of the material at high temperatures and the loss of volatile components, and since the absolute viscosity values are dependent on technique, equipment, and operating procedures, the results presented here should be considered in light of these limitations. The derived correlations are useful in presenting the observed data; however, care should be exercised not to apply these expressions beyond their extremely restrictive scope of significance.

E. Trace Metals in Product Streams

Samples of the vacuum column overhead and bottoms products were obtained at the end of Runs 65-70 and analyzed for metals content. Table XXVI shows that for all samples except one, the ash content of the overhead product was 5 ppm by weight or less. The principal metals components in the ash were aluminum, silicon, sodium and iron and lesser quantities of boron, calcium, magnesium, potassium, titanium and lead. No single metal was in a concentration above 1.5 ppm. These results are in agreement with previous analyses performed on samples from Run 55. The relative metal concentrations in the ash from the vacuum overhead samples are roughly consistent with the metals content of the ash in the vacuum bottoms samples (Table XXVII) and the source coals (Table XXVIII).

F. Flash Zone Vapor Velocity

The flash zone vapor velocity was estimated using the overhead vapor molar flowrates calculated for the vacuum column K-value study described in Reference 3 and the flash zone temperature and pressure. The ideal gas equation was used to calculate the volumetric rate, since it is applicable at the low pressures in the vacuum column. Molecular weight values, that were assigned to the various 50°F pseudocomponents, are listed in Table XXIX. The cross-sectional area of flow was calculated from the vacuum column ID to be 0.994 ft^2. Vapor velocities for typical test periods are listed in Table XXX and range from 0.48 to 2.30 ft/s.

V. CONCLUSIONS

A sufficiently large number of vacuum column experiments were completed on three different coals to permit the reliable use of these results in confirming and improving available computer vacuum distillation design models such as CHAMP. This should provide a sound basis for the design of the 6000 ton/day demonstration plant vacuum distillation column. The fact that three different coals were utilized in these experiments, including one that was very unreactive, gave a wide range of vacuum column feed compositions that will likely encompass most situations (but not startup) that may arise in the demonstration plant operation.

The significant findings of this experimental program are as follows:

1) Based on the bottoms distillation analyses, essentially complete separation of 900°F$^-$ distillate from the vacuum bottoms is possible, requiring an equivalent flash zone temperature (760 mm Hg, K = 10) of approximately 965°F for the vacuum column feed from Powhatan #6 coal and 986°F for the feed from the unreactive batch of Powhatan #5 coal. More severe conditions were needed for the Powhatan #5 coal to achieve the same level of distillate removal as the Powhatan #6 coal. Extrapolation of Ireland Mine coal results to zero distillate content in the bottoms gives an equivalent flash zone temperature of 955°F, although there is some question about the flash zone pressure in the Ireland Mine coal experiments. Correlations have been developed for the vacuum bottoms distillate content under less severe operating conditions. At less severe conditions the distillate content of the vacuum bottoms from Ireland Mine coal was intermediate to the two Powhatan coals.

2) The maximum practical operating temperature in the P-99 vacuum column was the temperature at which total distillate removal occurred or 375°C (707°F), whichever came first. This was dictated by plugging and coking in the bottoms receiver and associated piping and valves.

3) Although the content of pyridine insolubles was the same for the vacuum column feed from both Powhatan coals, the Powhatan #5 coal yielded a feed material that contained 1.8 times more IOM than the feed from Powhatan #6 coal, corresponding to 50% of the pyridine insoluble material. This higher level of IOM shows that there is more high molecular weight material present that may be partially in solution before flashing. This colloidal or partially soluble material may be exerting colligative properties that cause more distillate to be retained by the Powhatan #5 vacuum bottoms than in the case of the Powhatan #6 coal. The intermediate behavior of vacuum column feed from Ireland Mine coal may be a result of the intermediate IOM content of this feed. The average IOM contents on total vacuum column feeds for the Powhatan #5, Powhatan #6 and Ireland Mine coals were 3.47, 2.17 and 1.95%, respectively.

4) The fraction of vacuum column feed flashed overhead was in the range 17-38% by weight and was influenced by the source coal in the same manner as the distillate content of the bottoms.

5) Based on the component balance data, the percent of the distillate in the feed that is vaporized converges to 100% at an equivalent flash zone temperature of 975°F for all three coals. This is in general agreement with the bottoms distillation results discussed above. At lower equivalent flash zone temperatures, the percent 900°F$^-$ distillate vaporized is essentially the same for the Powhatan #6 and Ireland Mine coals while it is much lower (by as much as 12%) for the Powhatan #5 coal. Percent distillated vaporized ranged from 73 to 100%.

6) The percent of 900°F+-pyridine soluble material (SRC) vaporized ranged from 0.5 to 15%. The quantity of SRC vaporized was highest for Powhatan #6 coal and lowest for the Powhatan #5 coal. At equivalent flash zone temperatures below 860°F, the values of percent SRC flashed converge for all three coals to about 1%.

7) The differences in the amount of feed flashed between the two Powhatan coals can be explained by the differences in contents of 900°F- distillate and of SRC that is of low enough molecular weight to be vaporized.

8) Material balance data on the pyridine insolubles fraction of the feed from Powhatan #5 coal shows that retrogressive reactions in the 900°F+-pyridine soluble material begin at a flash zone temperature of about 320°C (608°F) and generate as much as 15% more pyridine insolubles at a temperature of 380°C (716°F). This corresponds to a 30% increase in the IOM fraction since the ash level was constant. The distillate balances averaged close to 100% indicating that distillate material was unlikely involved in any of these reactions. A similar, but much less pronounced trend was exhibited in the tests with Powhatan #6 coal where the average pyridine insolubles increase was estimated to be 6.3% at 380°C, corresponding to a 22.4% increase in the IOM. No trend toward retrogressive reactions was observed for the Ireland Mine coal at temperatures up to 344°C.

9) The presence of pyridine insolubles during the Cushman distillation analysis of the vacuum column feed and bottoms samples apparently elevates the observed boiling point significantly as observed when the feed boiling curve is compared to the product composite boiling curve (primarily influenced by the solids-free overhead sample distillation). This appears to be a very minor if not insignificant influence on the 900°F cut point where the average distillate recovery is about 1% high based on a large data base, but does significantly affect the boiling point distribution of the 900°F$^-$ distillate.

10) The specific gravity of vacuum column overhead product increases with increasing equivalent flash zone temperature as would be expected, but is the same for all three coals for a given flash zone temperature. Specific gravity increased from 1.059 at 810°F to 1.107 at 985°F according to the linear correlation of the data.

11) The viscosity of the vacuum bottoms varied with shear rate and, to some extent, with time indicating the bottoms is a pseudoplastic and thixotropic fluid in the shear rate range of the measurements (0.084-16.80 $\sec^{-1}$ at 500-597°F). Vacuum bottoms viscosity data for all three coals were correlated with distillate and pyridine insolubles contents. The vacuum column overhead product also exhibits psuedoplastic behavior, but only at shear rates below 79.2 $\sec^{-1}$ at temperatures in the range 125-200°F.

12) Flash zone vapor velocities were typically in the range 0.48 to 2.30 ft/s based on a column cross-sectional area of 0.994 ft^2.

13) The ash content of the vacuum column overhead was 5 ppm by weight or less, and no single trace metal exceeded 1.5 ppm.

REFERENCES

1. Solvent Refined Coal (SRC) Process, Technical Progress Report for the Period July-September, 1979, The Pittsburg & Midway Coal Mining Company, FE/496-176, February, 1980.

2. Holder, G.D., "Vacuum Flash Tower, P-99 Analysis", September, 1980 (in press).

3. Solvent Refined Coal (SRC) Process, Annual Technical Progress Report for the Period January-December, 1978, The Pittsburg & Midway Coal Mining Company, FE/496-170, November, 1979.

Table I

VACUUM FLASH SYSTEM TEST PROGRAM ON PROCESS DEVELOPMENT UNIT P-99

1. Powhatan #5 Mine Coal (LR-27383), Runs 63-66

30 Tests

Flash Zone Temperature	335-375°C (635-707°F)
Flash Zone Pressure	13.5-30.5 mm Hg
Overhead Recycle Rate	6-18 kg/h

2. Powhatan #6 Mine Coal (LR-27596), Runs 67-69

31 Tests

Flash Zone Temperature	304-375°C (579-707°F)
Flash Zone Pressure	15-31.5 mm Hg
Overhead Recycle Rate	10 kg/h

3. Ireland Mine Coal (LR-27987), Runs 70-71

12 Tests

Flash Zone Temperature	305-345°C (579-653°F)
Flash Zone Pressure	19.5-34.5 mm Hg
Overhead Recycle Rate	10 kg/h

Net slurry feed rate ∿11-13 kg/h

Total feed rate including recycle ∿18-22 kg/h

Table II

SAMPLES AND ANALYSES FOR VACUUM COLUMN TESTS

	Atmospheric Flash Column Bottoms		Vacuum Column Bottoms			Vacuum Column Overhead	
	Special Test Sample	Control Sample	Special Test Sample	Control Sample	Period Sample	Special Test Sample	Control Sample
1. Cushman Distillation	X	X	X	X	X	X	
2. Sarnia High Vacuum Distillation			X				
3. ASTM D-1160 Distillation							X
4. Elemental Analysis (C,H,N,S,O)	X		X		X	X	
5. Ash	X	X	X		X	X^1	
6. Pyridine Insolubles	X	X	X		X		
7. Specific Gravity	X		X			X	X
8. Melting Point	X		X	X	X		
9. Ash/Trace Metals			X^1			X^1	
10. Viscosity	X^2		X			X^2	

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[1] Last period of several runs.
[2] Performed for Runs 63 and 64 only.

Table III

PDU P-99 OPERATING CONDITIONS AND PRODUCT YIELDS DURING THE VACUUM COLUMN TESTS

Run No., P99-	63	64	65	66	67	68	69	70	71
Dissolver Operating Conditions									
Average Temperature, °F	849	849	856	855	856	847	856	855	855
Pressure, psig	2000	2000	2000	2000	2000	2000	2000	2000	2000
Slurry Residence Time, hr	1.0	1.0	1.0	1.0	0.95	0.95	1.0	0.85	0.85
Coal in Feed Slurry, wt%	30	30	30	30	30	30	30	30	30
Recycle Solids, wt%	14	12	13	12	15	14	15	16	18
Gas Rate, MSCF/T	60.8	54.6	59.9	54.0	54.0	54.4	54.4	54.1	53.7
Hydrogen Purity, vol%	85	94	85	94	94	94	94	94	94
Yields, wt% Moisture Free Coal									
Hydrogen	-3.3	-3.3	-3.5	-3.3	-4.0	-3.8	-4.0	-3.9	-4.0
C_1-C_4	13.8	13.0	14.6	13.2	14.4	13.5	15.5	14.9	14.8
NH_3, H_2S, CO, CO_2, HCl	3.2	3.1	3.1	3.1	4.5	4.3	4.6	4.5	4.6
Water	5.7	6.0	5.9	5.7	4.9	5.4	4.8	4.6	4.8
C_5-380°F	6.4	7.2	7.3	6.8	9.0	7.8	9.0	8.4	7.9
380-550°F	11.5	10.8	12.4	12.8	16.2	13.2	15.2	14.3	15.2
550-900°F	12.9	13.1	10.2	10.8	15.4	17.2	15.5	13.2	16.0
Total C_5-900°F	30.8	31.1	29.9	30.4	40.5	38.2	39.6	35.9	39.2
900°F+ Pyridine Soluble	29.0	31.7	28.9	32.6	22.6	26.4	23.2	24.0	20.4
IOM	11.8	9.4	12.1	9.3	5.6	4.5	5.0	3.8	4.0
Ash	9.0	9.0	9.0	9.0	11.4	11.4	11.4	16.2	16.2
Total 900°F+	49.8	50.1	50.0	50.9	39.6	42.3	39.5	43.9	40.6

Table IV

AVERAGE ATMOSPHERIC FLASH TOWER BOTTOMS COMPOSITION[2] FOR RUNS 63-71 (NET FEED TO THE VACUUM FLASH COLUMN)

Run, P99-	63	64	65	66	67	68	69	70	71[4]
Slurry Composition, Wt%									
900°F⁻ Distillate	22.0	24.8	23.7	25.1	29.7	27.3	28.2	29.9	28.6
SRC[1]	50.6	52.1	46.9	49.8	44.2	47.2	44.4	38.6	37.1
Pyridine Insoluble	27.4	23.1	29.4	25.1	26.1	25.5	27.4	31.5	34.3
Ash	13.5	12.6	13.6	12.8	18.9	18.3	19.6	25.1	27.4
IOM[3]	13.9	10.5	15.8	12.3	7.2	7.2	7.8	6.4	6.9
Ash/IOM	0.97	1.20	0.86	1.04	2.62	2.54	2.51	3.92	3.97

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[1] 900°F+ Pyridine Soluble

[2] Based on special test sample analyses

[3] Pyridine insolubles less the ash content, "insoluble organic matter"

[4] Only includes periods through 71-2 when the vacuum flash column was functional

Table V

VACUUM COLUMN OPERATING CONDITIONS DURING RUNS P99-63 AND P99-64

Period No., P99-	63-1	63-2	63-3	63-4	63-5	63-6	63-7	63-8	64-1	64-2	64-3	64-4	64-5	64-6
TEMPERATURE, °C														
Preheater Inlet[a]	319	318	344	352	355	357	358	358	357	358	351	351	333	334
Preheater Elbow	221	222	215	230	222	248	247	247	246	245	239	241	231	228
Preheater Midpoint[a]	343	342	374	380	381	392	402	403	398	397	389	381	368	370
Preheater Outlet[a]	365	354	480	471	474	411	442	442	428	427	416	413	397	396
Flash Column Top[a]	357	357	380	381	383	363	384	387	390	390	367	366	345	344
Flash Column Btm[a]	345	354	374	373	373	358	379	379	383	381	359	360	342	341
Receiver[a]	345	352	368	367	374	368	389	395	392	393	391	394	357	357
Outlet Line[a]	337	339	349	352	352	354	373	377	378	377	376	371	337	340
Receiver	331	337	352	353	355	355	375	377	372	372	366	363	335	332
Flash Zone	336	340	361	354	358	358	376	377	376	377	356	353	337	337
Flash Zone, Comp. Avg.[b]	335	335	355	357	358	351	373	372	374	373	355	355	336	335
PRESSURE, mm Hg														
Ovhd Receiver, Man.	18.6	22.4	22.3	16.5	31.5	32.1	31.7	22.5	24.2	31.7	22.3	15.0	16.6	22.5
Ovhd Rec., Comp. Avg.[b]	15	22	22	15	31	31	31	21	21	31	21	14	15	21
Btm Receiver, Man.	16.5	22.0	22.3	16.4	31.8	32.4	30.4	22.7	22.1	30.6	22.8	15.5	16.8	23.2
Btm Rec., Comp. Avg.[b]	16	21	21	15	30	30	30	21	21	30	22	14	15	21
RATES, kg/h[c]														
Net Feed	11.367	12.192	12.208	13.096	12.448	12.882	14.138	14.342	14.147	13.669	13.850	13.923	13.534	12.904
Net Overhead	2.338	2.170	2.680	2.920	2.348	2.627	3.583	4.014	4.046	3.649	3.729	4.038	3.269	2.798
Bottoms	9.029	10.022	9.528	10.176	10.100	10.255	10.555	10.328	10.101	10.020	10.121	9.885	10.265	10.106
Overhead Recycle	18.62	17.87	17.87	18.40	18.10	6.43	5.75	5.34	6.02	5.81	5.60	6.02	6.02	6.02

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[a] Skin temperature

[b] One hour average by computer

[c] Based on 20 hour average

Table VI

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-65

Period No., P99-	65-1	65-2	65-3	65-4	65-5	65-6	65-7	65-8
TEMPERATURE, °C								
Preheater Inlet[1]	319	318	318	325	325	325	325	342
Preheater Elbow	221	221	220	223	223	222	222	232
Preheater Midpoint[1]	353	351	350	356	348	358	352	357
Preheater Outlet[1]	377	383	377	387	384	393	398	428
Flash Column Top[1]	347	346	346	365	365	365	375	396
Flash Column Btm[1]	343	344	341	350	357	361	370	392
Receiver[1]	375	358	359	373	375	369	370	413
Outlet Line[1]	342	347	347	353	354	355	354	371
Receiver	340	332	334	344	345	344	345	382
Flash Zone	338	336	335	348	350	346	355	373
Flash Zone, Comp. Avg.[2]	336	335	335	345	348	346	356	372
PRESSURE, mm Hg								
Ovhd Receiver, Man.	15.5	16.5	33.0	32.0	22.7	15.0	30.4	31.7
Ovhd Rec., Comp. Avg.[2]	14	14	30	30	21	15	30	30
Btm Receiver, Man.	16.1	16.9	33.4	32.5	23.4	15.3	31.2	32.3
Btm Rec., Comp. Avg.[2]	13	15	29	29	22	16	30	30
RATES, kg/h[3]								
Net Feed	11.630	13.304	13.404	13.560	13.260	13.216	12.938	13.178
Net Overhead	2.763	3.028	2.600	2.740	3.018	3.152	2.836	3.266
Bottoms	8.867	10.276	10.804	10.820	10.242	10.064	10.102	9.912
Overhead Recycle	9.709	9.709	9.709	9.709	9.709	9.709	9.709	9.709

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[1] Skin Temperatures

[2] One Hour Average by Computer

[3] Based on 20 Hour Average

Table VII

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-66

Period No., P99-	66-0	66-1	66-2	66-3	66-4	66-5	66-6	66-7
TEMPERATURE, °C								
Preheater Inlet[1]	345	345	345	346	345	347	344	344
Preheater Elbow	234	234	236	239	238	238	236	238
Preheater Midpoint[1]	368	360	360	368	363	374	364	360
Preheater Outlet[1]	432	429	422	408	401	400	407	407
Flash Column Top[1]	394	394	370	355	353	343	357	356
Flash Column Btm[1]	386	387	363	351	345	340	350	351
Receiver[1]	411	416	390	380	377	372	375	377
Outlet Line[1]	370	376	356	339	338	331	339	339
Receiver	371	373	355	351	345	340	345	347
Flash Zone	379	378	357	350	342	338	347	348
Flash Zone, Comp. Avg.[2]	372	375	355	350	340	335	344	343
PRESSURE, mm Hg								
Ovhd Receiver, Man.	30.3	31.8	30.8	15.9	17.3	32.8	17.4	17.1
Ovhd Rec., Comp. Avg.[2]	30	30	29	14	14	30	15	15
Btm Receiver, Man.	32.8	32.7	32.4	16.2	17.5	32.3	17.0	17.2
Btm Rec., Comp. Avg.[2]	31	30	29	14	14	29	16	16
RATES, Kg/h[3]								
Net Feed	13.585	14.853	14.600	14.407	14.677	14.303	13.794	13.913
Net Overhead	3.643	4.065	3.649	3.991	3.943	3.189	3.523	3.477
Bottoms	9.942	10.792	10.951	10.416	10.734	11.114	10.271	10.436
Overhead Recycle	9.709	9.709	9.709	9.709	9.709	9.709	9.709	9.709

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[1] Skin Temperatures

[2] One Hour Average by Computer

[3] Based on 20 Hour Average

Table VIII

DISTILLATE CONTENT OF VACUUM COLUMN BOTTOMS

Period No.	Wt% 900°F$^-$ Distillate By Cushman Analysis			Sarnia Analysis of Special Test Sample		Average or Selected Wt% 900°F$^-$ Distillate
	Control Sample	Special Test Sample	Run Period Sample	Wt% 900°F$^-$ Distillate	Wt% Total Distillate[1]	
63-1	4.5	4.6	1.2	4.2 (4.59)[4]	7.51	4.55
63-2	6.35	5.2	6.6	3.5 (5.67)	11.39	5.78
63-3	2.11	3.0	4.0	3.0 (3.68)	6.17	3.04
63-4	1.0	1.8	4.6	0.9 (2.50)	4.20	1.4
63-5	4.05	5.1	4.9	1.6 (4.49)	8.29	4.58
63-6	3.92	5.5	2.2	2.4 (4.70)	9.01	4.71
63-7	0.0	0.6	0.0	0.5 (1.30)	4.97	0.6
63-8	0.0	0.0	1.4	1.95[5]	3.72	0.7
64-1	1.0	1.8	0.8	0.71	3.66	0.9
64-2	1.6	1.5	1.6	0.3 (1.63)	7.66	1.55
64-3	0.4[2]	0.8	1.1	1.21	4.53	0.8
64-4	0.6	0.6	0.0	1.04	3.68	0.6
64-5	3.74[3]	2.72	3.0	2.1 (4.46)	9.65	3.74
64-6	6.1	5.0	4.1	2.3 (3.11)	10.53	5.55

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[1] Final cut point does not exceed 1000°F

[2] Reported cut temperature 820°F

[3] Extrapolated from reported cut temperature of 864°F

[4] Numbers in parentheses are based on linear interpolation between the initial boiling point and the final cut point.

[5] Numbers without parentheses are interpolated values based on a single cut point.

Table VIII (Continued)

DISTILLATE CONTENT OF VACUUM COLUMN BOTTOMS

Period No.	Wt% 900°F$^-$ Distillate By Cushman Analysis			Sarnia Analysis of Special Test Sample		Average or Selected Wt% 900°F$^-$ Distillate
	Control Sample	Special Test Sample	Run Period Sample	Wt% 900°F$^-$ Distillate	Wt% Total Distillate[1]	
65-1	1.6	1.8	--	2.36	6.30	1.7
65-2	5.0	4.9	4.64	4.54	7.02	4.95
65-3	7.3	5.6	4.32	6.46	7.70	6.45
65-4	5.0	3.28	3.99	4.71	7.97	5.0
65-5	4.2	2.6	1.84	4.11	6.22	4.2
65-6	1.2	4.2	1.65	3.68	5.44	2.7
65-7	0.6	3.5	3.52	4.43	9.18	3.5
65-8	1.5	1.9	1.76	1.25	5.08	1.7
66-0	1.4	0.0	--	3.11	4.87	1.4
66-1	1.4	1.5	1.4	2.39	6.46	1.45
66-2	3.8	4.0	4.64	4.07	6.64	3.9
66-3	1.98	3.0	1.7	2.50	7.09	2.5
66-4	0.0	2.2	1.9	2.04	6.56	2.2
66-5	4.83	5.57	4.16	6.64	10.7	6.64
66-6	1.04	3.65	1.6	3.04	3.5	3.65
66-7	2.3	0.72	2.7	2.33	6.31	2.3

Table IX

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-67

Period No., P99-	67-0	67-1	67-2	67-3	67-4	67-5	67-6	67-7	67-8	67-9	67-10	67-11
TEMPERATURE, °C												
Preheater Inlet[1]	319	318	320	328	328	329	330	333	332	333	332	334
Preheater Elbow	238	238	237	243	243	245	244	251	246	245	248	247
Preheater Midpoint[1]	355	351	357	361	361	365	363	362	360	361	351	357
Preheater Outlet[1]	334	335	335	339	352	354	358	371	363	362	347	346
Flash Column Top[1]	339	340	340	361	360	360	360	387	386	387	362	361
Flash Column Btm[1]	330	331	333	360	355	354	355	383	381	378	356	354
Receiver[1]	344	344	349	369	369	373	370	389	397	393	427	428
Outlet Line[1]	317	317	319	340	338	340	340	361	365	368	378	383
Receiver	319	327	330	352	344	345	352	371	373	356	358	372
Flash Zone	331	330	332	355	351	352	354	378	378	375	353	352
Flash Zone,Comp.Avg.[2]	331	331	331	351	350	350	349	375	373	373	352	351
PRESSURE, mm Hg												
Ovhd Receiver, Man.	19.1	19.1	24.0	23.4	24.0	31.1	31.7	35.3	23.0	23.0	23.0	27.4
Ovhd Rec.,Comp.Avg.[2]	15	15	21	21	15	31	30	30	21	19	21	20
Btm Receiver, Man.	18.5	18.3	24.2	24.1	23.8	31.2	33.5	35.9	23.5	24.5	22.6	28.6
Btm Rec.,Comp.Avg.[2]	15	15	22	22	16	31	37	29	23	22	23	24
RATES, Kg/h[3]												
Net Feed	11.781	11.509	11.466	11.572	12.161	12.272	12.515	12.411	12.950	12.716	12.540	12.306
Net Overhead	3.827	3.775	3.238	3.734	3.764	3.785	3.961	4.465	4.726	4.742	4.491	4.296
Bottoms	7.954	7.734	8.228	7.838	8.397	8.487	8.554	7.946	8.224	7.974	8.049	8.010
Overhead Recycle	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975

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[1] Skin temperatures

[2] One hour average by computer

[3] Based on 20 hour average except for Periods; 67-1, 16 hr; 67-4, 14 hr; 67-8, 5 hr

Table X

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-68

Period No., P99-	68-0	68-1	68-2	68-3	68-4	68-5	68-6	68-7	68-8
TEMPERATURE, °C									
Preheater Inlet[1]	323	317	317	317	318	310	310	309	311
Preheater Elbow	245	234	235	237	235	230	229	230	232
Preheater Midpoint[1]	351	341	340	340	340	329	333	332	333
Preheater Outlet[1]	347	342	344	334	345	332	334	327	335
Flash Column Top[1]	360	339	338	338	338	310	310	310	311
Flash Column Btm[1]	356	335	334	335	335	307	307	306	308
Receiver[1]	406	380	381	375	374	354	354	353	353
Outlet Line[1]	378	347	346	336	336	327	326	326	327
Receiver	367	328	341	335	329	306	311	301	313
Flash Zone	352	332	332	338	332	306	306	303	307
Flash Zone, Comp. Avg.[2]	349	330	331	330	330	305	304	304	305
PRESSURE, mm Hg									
Ovhd Receiver, Man.	18.5	13.0	26.1	33.7	34.2	32.2	24.2	17.3	19.1
Ovhd Rec., Comp. Avg.[2]	15	14	20	30	30	30	21	15	15
Btm. Receiver, Man.	19.4	19.3	27.6	36.4	34.8	32.8	24.9	19.2	22.8
Btm. Rec., Comp. Avg.[2]	18	15	22	31	30	30	22	17	16
RATES, Kg/h[3]									
Net Feed	12.755	12.880	13.010	12.534	13.265	12.504	12.176	12.883	12.746
Net Overhead	4.425	3.952	3.364	2.998	3.343	2.762	2.794	3.225	3.236
Bottoms	8.330	8.928	9.646	9.536	9.922	9.742	9.382	9.658	9.510
Overhead Recycle	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975

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[1] Skin temperatures

[2] One hour average by computer

[3] Based on 20 hour average except for periods: 68-0, 6 hr; 68-7, 16 hr

Table XI

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-69

Period No., P99-	69-0	69-1	69-2	69-3	69-4	69-5	69-6	69-7	69-8	69-9
TEMPERATURE, °C										
Preheater Inlet[1]	310	310	312	312	312	324	325	327	327	312
Preheater Elbow	230	231	228	228	229	242	243	244	244	234
Preheater Midpoint[1]	328	328	333	350	351	352	356	359	360	361
Preheater Outlet[1]	331	323	333	363	357	358	364	364	353	325
Flash Column Top[1]	311	311	311	350	350	371	371	371	371	315
Flash Column Btm[1]	308	307	307	345	345	369	366	370	366	310
Receiver[1]	352	349	345	374	373	410	407	407	410	351
Outlet Line[1]	323	331	326	344	344	382	382	382	384	304
Receiver	318	309	307	342	338	359	348	359	354	316
Flash Zone	306	306	307	342	342	363	361	363	362	307
Flash Zone, Comp. Avg.[2]	304	305	305	340	339	361	360	359	360	306
PRESSURE, mm Hg										
Ovhd Receiver, Man.	23.4	22.2	33.9	32.5	36.4	31.0	34.5	29.2	24.3	25.0
Ovhd Rec., Comp. Avg.[2]	21	21	31	31	31	31	31	22	21	21
Btm. Receiver, Man.	22.9	22.5	34.4	33.0	36.9	32.9	34.9	29.4	39.7	24.6
Btm. Rec., Comp. Avg.[2]	22	23	32	31	33	32	32	27	37	23
RATES, Kg/h[3]										
Net Feed	12.076	11.195	10.784	10.724	10.926	12.083	11.657	11.682	10.808	11.224
Net Overhead	2.905	2.671	2.220	3.016	3.020	3.849	3.675	3.805	3.470	2.718
Bottoms	9.171	8.524	8.564	7.708	7.906	8.234	7.982	7.877	7.338	8.506
Overhead Recycle	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975

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[1] Skin temperatures

[2] One hour average by computer

[3] Based on 20 hour average except for Period 69-3, 16 hr

Table XII

DISTILLATE CONTENT OF VACUUM COLUMN BOTTOMS, RUNS P99-67 TO -69

Period No.	Wt% 900°F^{-} Distillate By Cushman Analysis: Control Sample	Wt% 900°F^{-} Distillate By Cushman Analysis: Special Test Sample	Wt% 900°F^{-} Distillate By Cushman Analysis: Run Period Sample	Sarnia Analysis of Special Test Sample: Wt% 900°F^{-} Distillate	Sarnia Analysis of Special Test Sample: Wt% Total[3] Distillate	Average or Selected Wt% 900°F^{-} Distillate
67-0	2.66	2.0, 0.84	--	--	--	1.83
67-1	2.15	1.8, 2.74	--	3.38	6.0	2.23
67-2	3.16	3.31[1], 3.1	--	5.27	7.68	3.17
67-3	0.0	0.0, 1.4	1.1	1.46	5.04	1.46
67-4	0.0	0.0, 0.0	3.2	0.12	3.40	0.0
67-5	0.0	1.24	2.1	3.53, 3.63	7.35, 3.89	3.53
67-6	3.4	2.16, 5.14	3.4	3.46	7.46	3.57
67-7	1.0	0.83[1]	--	1.80	2.20	0.92
67-8	0.0	0.0	0.9,1.6[2]	0.0	2.60	0.0
67-9	0.0	0.0	0.2	0.50	3.53	0.0
67-10	0.0	0.5	0.6	1.05	1.43	1.05
67-11	1.0	1.30[1]	0.9	0.93	1.77	1.15
68-0	0.6	0.0	--	1.03	5.07	0.6
68-1	2.5	1.18	--	4.04	5.60	1.84
68-2	3.0	2.46	--	2.62	5.33	2.73
68-3	3.6	6.3	4.7	5.93	7.27	6.12

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[1] Extrapolated to 900°F

[2] End of run sample

[3] Final cut point does not exceed 965°F except in Period 69-6 where it was 1055°F.

Table XII (Continued)

DISTILLATE CONTENT OF VACUUM COLUMN BOTTOMS , RUNS P99-67 TO -69

	Wt% 900°F$^-$ Distillate By Cushman Analysis			Sarnia Analysis of Special Test Sample		
Period No.	Control Sample	Special Test Sample	Run Period Sample	Wt% 900°F$^-$ Distillate	Wt% Total Distillate	Average or Selected Wt% 900°F$^-$ Distillate
68-4	3.6	5.34	9.7	6.96	10.62	6.15
68-5	7.9	8.8	9.2	9.0	9.9	8.8
68-6	3.5	4.88	6.7	5.22	5.34	5.05
68-7	3.6	3.44	6.12	4.57	4.90	3.52
68-8	4.4	3.58	6.4,3.7[2]	5.32	6.82	3.99
69-0	8.0	6.3	--	7.46	7.60	6.3
69-1	4.9	5.0	--	8.04	10.6	4.95
69-2	8.0	8.8	--	9.7[1]	--	8.8
69-3	3.0	3.6	4.3	4.59	5.0	4.59
69-4	5.4	4.5	5.3	5.68	6.2	4.95
69-5	1.9	1.52	2.8	1.63	1.8	1.71
69-6	2.4	2.3	1.7	2.65	5.1	2.35
69-7	1.2	1.0	0.0	2.28[1]	--	1.1
69-8	1.1	0.0	0.6	4.06[1]	--	1.1
69-9	6.2	6.9, 6.6[2]	4.8	6.22, 6.43[2]	7.9[2]	6.55

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[1] Extrapolated to 900°F

[2] End of run sample

Table XIII

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-70

Period No., P99-	70-0	70-1	70-2	70-3	70-4	70-5	70-6	70-7
TEMPERATURE, °C								
Preheater Inlet[1]	311	310	310	310	311	312	311	312
Preheater Elbow	230	228	227	231	231	232	230	229
Preheater Midpoint[1]	358	351	355	355	355	356	355	358
Preheater Outlet	315	307	312	316	312	315	320	324
Flash Column Top[1]	315	315	314	315	314	315	340	341
Flash Column Btm[1]	309	308	309	309	306	308	334	334
Receiver[1]	345	346	345	345	344	344	370	373
Outlet Line[1]	312	312	311	312	312	312	336	340
Receiver	309	302	307	311	305	310	324	328
Flash Zone	307	306	307	306	306	306	332	332
Flash Zone, Comp. Avg.[2]	305	305	305	305	305	305	330	330
PRESSURE, mm Hg								
Ovhd Receiver, Man.	27.4	22.4	26.0	26.8	26.8	33.7	34.4	34.7
Ovhd Rec., Comp. Avg.[2]	15	15	21	21	30	31	30	31
Btm. Receiver, Man.	29.6	23.0	28.3	28	37.1	35.1	36.7	36.3
Btm. Rec., Comp. Avg.[2]	24	26	30	29	35	35	36	38
RATES, Kg/h[3]								
Net Feed	12.829	12.954	12.932	12.630	12.682	12.500	12.710	12.826
Net Overhead	3.568	3.434	3.324	3.263	3.072	3.020	3.374	3.232
Bottoms	9.261	9.520	9.608	9.367	9.610	9.480	9.336	9.594
Overhead Recycle	9.975	9.975	9.975	9.975	9.975	9.975	9.975	9.975

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[1] Skin temperature

[2] One-hour average by computer

[3] Based on 20 hour average. The rates are shown to 3 decimal places for convenience in mass balance calculations only and should not be considered to be that accurate

Table XIV

VACUUM COLUMN OPERATING CONDITIONS DURING RUN P99-71

Period No., P99-	71-0A	71-0B	71-1	71-2
Temperature, °C		TEMPERATURE, °C		
Preheater Inlet[1]	312	313	312	313
Preheater Elbow	233	234	232	231
Preheater Midpoint[1]	340	342	340	340
Preheater Outlet[1]	324	323	328	323
Flash Column Top[1]	340	341	354	354
Flash Column Btm[1]	335	337	348	347
Receiver[1]	335	332	347	345
Outlet Line[1]	360	359	361	361
Receiver	326	328	341	341
Flash Zone	333	334	346	346
Flash Zone, Comp. Avg.[2]	332	332	344	344
Pressure, mm Hg		PRESSURE, mm Hg		
Ovhd Receiver, Man.	22	17.3	19.2	22
Ovhd Rec., Comp. Avg.[2]	20	15	15	22
Btm. Receiver, Man.	34.5	29.1	33.1	51.4
Btm. Rec., Comp. Avg.[2]	32	33	40	42
Feed/Prod. Rates,[3] Kg/h		RATES, Kg/h[3]		
Net Feed	10.932	11.760	11.658	11.278
Net Overhead	2.862	2.970	3.318	2.950
Bottoms	8.070	8.790	8.340	8.328
Overhead Recycle	9.975	9.975	9.975	9.975

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[1] Skin temperature

[2] One-hour average by computer

[3] Based on 20 hour average. The rates are shown to 3 decimal places for convenience in mass balance calculations only and should not be considered to be that accurate.

Table XV

DISTILLATE CONTENT OF VACUUM COLUMN BOTTOMS, RUNS P99-70 AND -71

Period No.	Wt% 900°F$^-$ Distillate By Cushman Analysis: Control Sample	Wt% 900°F$^-$ Distillate By Cushman Analysis: Special Test Sample	Wt% 900°F$^-$ Distillate By Cushman Analysis: Run Period Sample	Sarnia Analysis of Special Test Sample: Wt% 900°F$^-$ Distillate	Sarnia Analysis of Special Test Sample: Wt% Total Distillate[3]	Average or Selected Wt% 900°F$^-$ Distillate
70-0	7.0	4.5	--	(7.06)[2]	7.8	7.0
70-1	8.2	6.6	7.0	7.3 (8.88)	10.8	7.4
70-2	9.3	7.6	6.8	8.2 (9.39)	10.2	8.45
70-3	8.2	7.9	6.7	10.4 (10.0)[1]	--	8.05
70-4	8.89	9.5	8.7	9.0 (9.32)	10.2	9.2
70-5	8.46	8.7	5.3	(9.16)[1]	--	8.58
70-6	6.2	6.9	4.8	6.5 (7.45)	8.8	6.55
70-7	5.5	6.8	8.3, 5.26[6]	7.8 (8.16)	9.2	6.15
71-0A	3.0	2.9	--	(3.7)[1]	--	2.95
71-0B	2.6	3.0	4.5	(4.96)	5.5	2.8
71-1	3.0	1.6	4.1	3.0[4]	--	3.0
71-2	3.7	4.0	3.4	2.8[5]	--	3.85

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[1] Extrapolated to 900°F

[2] Number in parentheses based on linear interpolation between the initial boiling point and the final cut point

[3] Final cut points do not exceed 930°F

[4] Final cut point 800°F

[5] Final cut point 817°F

[6] End of run sample

Table XVI

VACUUM COLUMN FEED COMPOSITIONS AND MAXIMUM % OF FEED VAPORIZED FOR RUNS P99-63 TO -69

Flash Zone Pressure	15-16 mm Hg		21-22 mm Hg		29-31 mm Hg	
Coal	Powhatan #5[1]	Powhatan #6[2]	Powhatan #5	Powhatan #6	Powhatan #5	Powhatan #6
Wt% of Feed						
900°F⁻ Distillate	24.1	28.1	23.6	28.6	23.9	28.7
SRC	50.0	45.9	50.2	44.8	49.0	45.1
Pyridine Insolubles	25.9	26.0	26.2	26.6	27.1	26.2
Ash	13.3	18.6	13.2	19.1	13.0	19.2
IOM	12.6	7.4	13.0	7.5	14.1	7.0
Max. % Flashed	28.7	37.1	28.6	37.1	27.4	36.0
Flash Zone Temperature, °C	355		374		375	

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[1] Runs 63-66, Powhatan #5 Coal, Batch LR-27596 (low ash)

[2] Runs 67-69, Powhatan #6 Coal, Batch LR-29383

Table XVII

COMPONENT BALANCE STATISTICS FOR VACUUM COLUMN TESTS DURING RUNS P99-63 TO -71

	Mean Recovery (Std. Dev.)		
Component	Powhatan #5 Coal Runs 63-66	Powhatan #6 Coal Runs 67-69	Ireland Mine Coal Runs 70-71
900°F^{-} Distillate	101.2 (± 4.7)	101.0 (± 5.2)	99.8 (± 4.4)
Pyridine Insolubles	107.0 (± 4.5)	103.3 (± 5.6)	100.7 (± 2.1)
Carbon	100.5 (± 1.0)	100.4 (± 1.0)	100.0 (± 0.7)
Hydrogen	100.0 (± 3.5)	100.1 (± 2.8)[3]	100.2 (± 1.7)
Nitrogen	99.9 (± 1.7)	99.8 (± 2.2)[4]	99.5 (± 1.8)
Sulfur	97.8 (± 3.4)[1]	96.8 (± 5.0)	97.7 (± 5.2)
Oxygen (Total)	99.3 (± 4.8)[2]	99.3 (± 5.9)	111.9 (± 13.1)
Ash	100.0 (± 1.2)	100.2 (± 1.3)	101.2 (± 1.7)

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[1] Excluding Period 64-3

[2] Excluding Periods 65-5 and 7

[3] Excluding Periods 67-4 and 69-0

[4] Excluding Period 69-7

Table XVIII

P99-63 VACUUM TOWER BOTTOMS

Temp. °F	Shear Rate, sec^{-1}	Viscosity (cP)							
	Period, P99-	63-1	63-2	63-3	63-4	63-5	63-6	63-7	63-8
500	16.8								
	8.4								
	3.36								
	1.68		9,055						
	0.84		13,110						
	0.42	35,840	20,520				36,800		
	0.168	64,950	38,300				61,600		
	0.084	113,000	71,700				126,400		
525	16.8								
	8.4								
	3.36		4,150						
	1.68	9,390	6,190						
	0.84	14,160	9,890			19,000	15,810		
	0.42	22,820	16,460			28,040	24,420		
	0.168	43,700	34,600	88,000		55,500	45,750		
	0.084	84,700	64,000	170,900		104,200	78,200		
550	16.8								
	8.4		1,813						
	3.36	4,612	2,878						
	1.68	6,780	4,690			9,030	8,645		
	0.84	10,750	8,170			13,540	12,730		
	0.42	18,540	14,000	35,900		21,440	20,080		
	0.168	26,500	29,950	67,750		41,950	41,800		
	0.084	62,200	52,800	122,400	176,300	76,800	78,000	185,000	

Table XVIII (Continued)

P99-63 VACUUM TOWER BOTTOMS

		Viscosity (cP)							
	Period, P99-	63-1	63-2	63-3	63-4	63-5	63-6	63-7	63-8
Temp. °F	Shear Rate, sec^{-1}								
575	16.8		943						
	8.4	1,628	1,230						
	3.36	2,740	2,278			4,275	3,488		
	1.68	4,345	3,685			6,205	5,550		
	0.84	7,060	6,600	16,500		9,720	9,210		
	0.42	13,060	10,760	26,240	35,400	16,560	15,100		
	0.168	26,950	24,500	52,700	72,600	34,000	34,700	92,150	
	0.084	50,800	45,300	91,200	137,400	66,800	66,800	149,600	
597	16.8	878	995						
	8.4	1,264	1,260			1,705	1,520		
	3.36	2,408	2,295	4,865		2,650	2,515		
	1.68	3,880	3,515	7,200		4,130	3,980		
	0.84	6,850	5,950	11,210		6,860	6,420		
	0.42	12,220	10,460	19,180	27,200	11,880	11,320		35,160
	0.168	25,500	24,850	37,900	53,500	24,650	24,450		64,400
	0.084	48,100	42,000	70,200	88,600	53,000	51,300	178,300	106,200

Table XIX

P99-63 VACUUM TOWER OVERHEAD

		Viscosity (cP)							
	Period, P99-	63-1	63-2	63-3	63-4	63-5	63-6	63-7	63-8
Temp. °F	Shear Rate, sec^{-1}								
100	79.2								
	39.6		90						
	15.84	124	100	207		159	231		
	7.92	130	122	222	413	174	251	476	
	3.96	166	155	243	449	193	275	506	744
	1.98	282	266	336	556	296	374	588	848
	0.79	650	610	595	930	585	655	885	1,145
	0.40	1,275	1,080	1,050	1,220	740	1,140	1,235	1,630
125	79.2	43	36						
	39.6	44	36	64		53	69		
	15.84	47	43	68	109	58	72	122	163
	7.92	72	58	86	122	73	90	130	175
	3.96	124	84	105	154	100	116	150	204
	1.98	241	150	180	252	186	216	235	300
	0.79	610	355	385	580	475	525	475	495
	0.40	1,090	680	730	1,060	760	940	840	880

Table XIX (Continued)

P99-63 VACUUM TOWER OVERHEAD

		Viscosity (cP)							
Temp. °F	Period, P99- Shear Rate, sec^{-1}	63-1	63-2	63-3	63-4	63-5	63-6	63-7	63-8
150	79.2	20	18	28	40	24	29	44	
	39.5	22	18	29	40	25	30	46	55
	15.84	30	24	38	46	30	35	50	58
	7.92	55	41	62	72	42	58	67	77
	3.96	110	56	95	102	60	87	90	100
	1.98	249	106	182	190	114	156	164	156
	0.79	530	250	410	460	300	390	360	345
	0.40	935	470	740	810	550	772	830	660
200	79.2	8	7	10	12	9	10	12	14
	39.6	11	7	12	14	11	11	12	15
	15.84	24	12	20	22	19	16	19	22
	7.92	49	16	38	38	35	28	31	34
	3.96	115	21	69	40	56	75	47	56
	1.98	210	42	98	72	98	140	80	104
	0.79	482	105	230	175	240	315	195	260
	0.40	925	210	460	350	300	600	390	530

Table XX

P99-63 VACUUM TOWER BOTTOMS

	Period, P99-	Viscosity (cP)					
Temp. °F	Shear Rate, sec^{-1}	63-1	63-2	63-3	63-4	63-5	63-6
400	16.8	492	508	455	492	593	574
	8.4	683	633	602	642	716	752
	3.36	1,095	1,030	875	905	1,230	1,231
	1.68	1,660	1,697	1,300	1,490	1,750	1,810
	0.84	2,720	2,540	1,700	2,220	2,840	2,720
	0.42	4,640	4,520	3,960	2,800	4,760	4,360
	0.168	10,243	4,600	5,900	6,200	9,260	6,600
	0.084	21,000	5,200	--*	7,000	11,000	9,800
450	16.8	293	264	250	294	327	325
	8.4	456	369	400	439	533	578
	3.36	850	736	750	805	986	1,055
	1.68	1,449	1,306	1,210	1,330	1,600	1,745
	0.84	2,520	2,300	2,020	2,220	2,720	2,744
	0.42	4,360	4,340	3,440	3,560	5,000	4,280
	0.168	9,900	8,017	7,500	9,300	9,500	7,600
	0.084	15,800	14,800	11,200	9,000	12,600	7,600

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*Difficulties were encountered with viscometer reading.

Table XX (Continued)

P99-63 VACUUM TOWER BOTTOMS

Temp. °F	Period, P99- / Shear Rate, sec^{-1}	Viscosity (cP) 63-1	63-2	63-3	63-4	63-5	63-6
500	16.8	218	210	245	245	247	228
	8.4	344	328	398	415	429	350
	3.36	578	808	915	835	900	700
	1.68	1,328	1,600	1,450	1,445	1,610	1,250
	0.84	2,528	3,120	2,340	2,500	2,900	2,200
	0.42	4,307	5,287	3,800	4,200	4,640	4,400
	0.168	9,457	6,271	9,100	6,800	6,200	8,900
	0.084	22,800	11,400	17,267*	10,200	10,600	12,800
550	16.8	216	198	194	190	224	199
	8.4	307	287	290	264	350	326
	3.36	696	660	958	500	675	750
	1.68	1,500	1,020	1,800	860	1,190	1,350
	0.84	2,299	1,560	2,560	2,573	3,000	3,620
	0.42	3,897	2,640	6,200	4,840	5,000	6,600
	0.168	8,000	4,600	16,567	6,900	9,200*	11,500
	0.084	10,800	7,600	21,000*	12,400	16,700	10,200

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*Difficulties were encountered with viscometer reading.

Table XXI

CORRELATION OF POWHATAN #5 VACUUM BOTTOMS VISCOSITY DATA USING THE GS&TC STATISTICAL ANALYSIS SYSTEM

OBS	VISC	DIST	IOM	DIST2	IOM2	DI	PVISC
1	26500	4.55	18.54	20.7025	343.732	84.357	29790.1
2	21894	3.74	15.82	13.9876	250.272	59.167	24252.5
3	40386	1.70	20.72	2.8900	429.318	35.224	53678.0
4	28221	4.54	20.79	20.6116	432.224	94.387	34176.1
5	48714	2.70	22.98	7.2900	528.080	62.046	57335.7
6	33262	2.50	17.58	6.2500	309.056	43.950	32520.7
7	33988	2.20	18.00	4.8400	324.000	39.600	35467.8
8	27427	2.76	16.86	7.6176	284.260	46.534	28637.1
9	29950	5.78	18.02	33.4084	324.720	104.156	25242.1
10	67750	3.04	21.65	9.2416	468.722	65.816	48291.4
11	24650	5.55	15.95	30.8025	254.402	88.522	25023.5
12	37700	4.20	23.25	17.6400	540.563	97.650	42565.6
13	41950	4.05	20.98	16.4025	440.160	84.969	38121.5
14	41800	4.71	20.83	22.1841	433.889	98.109	33050.0
15	39300	1.55	16.76	2.4025	280.898	25.978	29396.7
16	24044	6.45	20.88	41.6025	435.974	134.676	20687.4
17	32683	5.00	22.79	25.0000	519.384	113.950	33441.0
18	32844	3.98	22.65	15.8404	513.022	90.147	43256.0
19	93492	1.70	26.26	2.8900	689.588	44.642	87858.7
20	80950	1.40	22.75	1.9600	517.563	31.850	69185.6
21	47767	1.45	21.50	2.1025	462.250	31.175	60510.0
22	31500	3.90	18.31	15.2100	335.256	71.409	31506.4
23	22429	6.64	15.98	44.0896	255.360	106.107	25207.0

Table XXII

VISCOSITY OF VACUUM TOWER BOTTOMS FOR POWHATAN #6 COAL

Shear Rate (sec^{-1}) \ Period, P99-	67-0	67-1	67-2	67-3	67-4	67-5	67-6	67-7	67-8	67-9	67-11
	Viscosity, cP (Sample Temperature of 550°F)										
16.8											
8.4	1,884		1,734								
3.36	3,838	3,934	3,475			4,141	3,714				
1.68	6,822	6,698	6,049	8,942		7,186	6,210				
0.84	12,047	12,200	10,850	16,058		12,320	10,840	17,141			
0.42	22,935	22,072	20,177	30,622	39,312	22,333	20,740	33,320			35,460
0.168	44,570	51,112	46,600	67,300	83,200	52,325	47,057	76,014	98,550	92,267	83,200
0.084	93,240	97,600	90,333	126,160	155,450	93,630	90,000	150,800	174,160	161,400	154,600

Note: Measurements for Period 69-10 were off-scale.

Shear Rate (sec^{-1}) \ Period, P99-	68-1	68-2	68-3	68-4	68-5	68-6	68-7	68-8
	Viscosity, cP (Sample Temperature of 550°F)							
16.8	979	929	687	682	528	625	735	775
8.4	1,532	1,485	1,096	1,109	850	1,048	1,166	1,219
3.36	2,580	2,681	2,100	2,165	1,730	2,030	2,180	2,332
1.68	4,830	4,610	3,660	3,770	2,960	3,560	3,760	4,060
0.84	8,420	8,060	6,500	6,660	5,549	6,380	6,813	7,200
0.42	15,360	14,600	12,840	12,040	10,370	11,800	12,640	13,040
0.168	34,614	33,700	29,100	23,400	22,550	25,583	27,400	32,100
0.084	66,960	63,200	59,000	59,000	47,200	55,000	52,800	60,280

Table XXII (Continued)

VISCOSITY OF VACUUM TOWER BOTTOMS FOR POWHATAN #6 COAL

	Viscosity, cP (Sample Temperature of 550°F)									
Period, P99- / Shear Rate (sec^{-1})	69-1	69-2	69-3	69-4	69-5	69-6	69-7	69-8	69-9	69-10
16.8	772	599		973					735	616
8.4	1,233	979		1,583					1,188	1,012
3.36	2,508	2,050	3,990	3,131		4,225			2,375	2,085
1.68	4,350	3,630	6,850	5,470	9,560	7,460	8,750	9,880	4,300	3,667
0.84	7,760	6,560	12,160	9,840	16,760	13,300	15,320	17,240	7,700	6,500
0.42	14,640	11,440	22,120	18,945	29,560	29,550	28,240	31,080	14,680	12,640
0.168	32,500	26,500	46,400	46,233	66,600	52,400	60,300	67,420	33,300	31,043
0.084	57,600	51,920	101,200	91,000	123,200	110,800	128,800	132,400	65,000	38,400

Table XXIII

CORRELATION OF POWHATAN #6 VACUUM BOTTOMS VISCOSITY DATA USING THE GS&TC STATISTICAL ANALYSIS SYSTEM

OBS	VISC	DIST	IOM	DIST2	IOM2	DI	PVISC
1	51112	2.23	12.23	4.9729	149.573	27.2729	56368.5
2	46600	3.17	11.95	10.0489	142.802	37.8815	45724.6
3	67300	1.46	11.50	2.1316	132.250	16.7900	66708.2
4	83200	0.00	12.25	0.0000	150.063	0.0000	90321.2
5	52325	3.53	11.69	12.4609	136.656	41.2657	42224.3
6	47057	3.57	11.84	12.7449	140.186	42.2688	41855.1
7	76014	0.92	18.13	0.8464	328.697	16.6796	74830.3
8	98550	0.00	12.68	0.0000	160.782	0.0000	90321.2
9	92267	0.00	13.61	0.0000	185.232	0.0000	90321.2
10	83200	1.15	10.60	1.3225	112.360	12.1900	71283.1
11	34614	2.50	10.98	6.2500	120.560	27.4500	53088.6
12	33700	2.73	11.10	7.4529	123.210	30.3030	50436.1
13	29100	6.12	9.19	37.4544	84.456	56.2428	26446.7
14	23400	6.15	11.10	37.8225	123.210	68.2650	26360.7
15	22550	8.40	9.75	70.5600	95.063	81.9000	26225.5
16	25583	5.05	11.31	25.5025	127.916	57.1155	30962.9
17	27400	4.57	10.97	20.8849	120.341	50.1329	33904.6
18	32100	4.40	10.83	19.3600	117.289	47.6520	35082.5
19	26500	8.40	5.53	70.5600	30.581	46.4520	26225.5
20	46400	4.59	11.01	21.0681	121.220	50.5359	33770.7
21	46233	4.95	10.93	24.5025	119.465	54.1035	31529.0
22	66600	1.71	12.57	2.9241	158.005	21.4947	63191.2
23	67420	1.10	12.62	1.2100	159.264	13.8820	72043.2

Table XXIV

VACUUM TOWER BOTTOMS' VISCOSITY RESULTS FOR RUN P99-70

	Viscosity (cP)							
Period No., P99-	70-0	70-1	70-2	70-3	70-4	70-5	70-6	70-7
Shear Rate (sec^{-1})								
16.80	706	610	592	598	646	692	884	774
8.40	1,180	1,000	971	997	1,040	1,040	1,419	1,264
3.36	2,325	2,025	2,030	2,175	2,204	2,401	2,912	2,602
1.68	4,060	3,560	3,490	3,940	3,900	4,405	5,010	4,570
0.84	7,180	6,500	6,420	6,800	7,120	8,220	9,080	8,000
0.42	12,862	12,200	12,320	13,320	13,680	14,640	17,040	14,900
0.168	29,800	29,300	29,400	27,400	31,000	34,000	37,600	36,083
0.084	56,200	56,000	53,200	47,000	61,800	48,300	58,280	53,080

Sample Temperature = 550°F

Table XXV

COEFFICIENTS FOR GENERAL VISCOSITY CORRELATION

Shear Rate (sec^{-1})	Intercept	A	B	C	R^2
0.084	62407.48	-30462.64	2109.89	2525.39	.7602
0.168	10997.28	-14555.83	990.40	1805.88	.7861
0.420	4908.52	-4619.90	253.50	725.53	.7575
0.840	2589.58	-1791.41	72.78	356.72	.7187
1.680	3584.11	-866.89	21.75	148.58	.6307
3.360	3189.20	-378.33	4.66	44.12	.5086
8.40	1314.85	15.42	-9.04	5.62	.4732
16.80	854.45	-36.64	-0.95	3.97	.5036

Viscosity (cP) = Intercept + A (wt% distillate) + B (wt% distillate)^2 + C (wt% PI).

Table XXVI

ASH AND TRACE METALS IN VACUUM COLUMN OVERHEAD

Period No., P99-	65-8	66-7	67-11	68-8	69-9[1]	70-7
Ash, Wt%	0.0005	0.0005	0.0002	0.0002		0.08[2]
Spectral Ash Analysis Metals, Wt% of Ash						
Al	15	6	20	9		4
Sb	--	--	--	--		--
Ba	Tr	Tr	0.4	Tr		Tr
B	2	2	0.2	4		1
Cd	--	--	--	--		--
Ca	1	0.6	2	15		0.4
Cr	0.5	0.3	0.3	0.6		0.3
Co	--	--	--	--		--
Cu	0.02	0.03	0.09	0.1		1
Fe	10	9	5	15		3
Pb	0.6	--	0.3	2		3
Li	--	--	--	--		--
Mg	1	0.6	1	1		0.5
Mn	0.3	0.2	0.1	0.4		0.1
Mo	0.05	0.06	0.09	0.2		0.03
Ni	0.1	0.2	0.3	0.6		0.2
P	--	--	--	--		--
K	2.3	0.7	--	--		1.0
Si	20	30	3	15		40
Ay	--	--	--	--		0.006
Na	1.5	0.6	10	--		0.2
Sr	0.2	0.09	0.2	--		0.02
Sn	0.4	0.7	0.2	0.6		1
Ti	3	0.7	0.2	0.8		0.5
W	--	--	--	--		--
V	0.1	--	--	--		0.1
Zn	--	--	--	--		1
Ge	Tr	Tr	--	--		Tr

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[1] Ash too low to measure with 1 liter of sample

[2] Ash value believed to be erroneous by analytical lab, value should be much lower.

Table XXVII

ASH AND TRACE METALS IN VACUUM COLUMN BOTTOMS

Period No., P99-	65-8	66-7	67-11	68-8	69-9[1]	70-7[1]
Ash, Wt%	17.8	17.0	28.7	25.11	26.96	34.7
Spectral Ash Analysis Metals, Wt% of Ash						
Al	15	15	10	15	15	10
Sb	--	--	--	--	--	--
Ba	Tr	Tr	1	Tr	Tr	Tr
B	0.1	0.1	0.1	0.1	0.1	0.09
Cd	--	--	--	--	--	--
Ca	0.7	0.6	1	1	0.9	1
Cr	0.1	0.2	0.08	0.04	0.04	0.05
Co	--	--	--	--	--	--
Cu	0.008	0.004	0.03	0.007	0.005	0.009
Fe	10	10	15	15	15	15
Pb	--	--	0.1	--	--	--
Li	--	--	--	--	--	--
Mg	1	1	1	1	0.005	1
Mn	0.1	0.1	0.2	0.1	--	0.1
Mo	--	--	--	--	--	--
Ni	0.03	0.04	0.03	0.03	0.03	0.02
P	--	--	--	--	0.2	--
K	1.0	1.2	0.9	0.9	0.9	1.1
Si	25	20	20	20	20	20
Ag	--	--	--	--	--	--
Na	0.2	0.3	0.2	0.2	0.2	0.2
Sr	0.09	0.1	0.09	0.09	0.05	0.08
Sn	--	--	--	--	--	--
Ti	1	1	1	1	0.7	1
W	--	--	--	--	--	--
V	0.09	--	--	--	--	--
Zn	--	--	--	--	0.2	0.5
Ge	--	--	--	--	--	--

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[1] Period sample

Table XXVIII

ANALYSIS OF COAL

Coal Sample	Powhatan #5 LR-27383	Powhatan #6 LR-27596	Ireland LR-27987
Elemental Analyses, Wt% of Moisture-Free Coal			
Carbon	74.26	71.42	66.36
Hydrogen	5.17	5.04	4.83
Nitrogen	1.40	1.24	1.15
Sulfur	2.54	4.31	4.65
Oxygen	11.64	11.7	13.34
Chlorine	0.07	0.05	0.05
Metals	4.91	6.25	8.62
Ash, Wt% of Moisture-Free Coal	9.1	11.5	16.3
Sulfur, Wt% of Ash	0.34	0.85	1.00
Oxygen, Wt% of Ash	45.8	44.4	45.6
Moisture, Wt% of As-Received Coal	0.72	0.96	1.00
Spectral Ash Analysis			
Metals, Wt% of Ash			
Al	13.2	11.0	11.3
Ba	Tr	Tr	Tr
B	0.1	0.2	0.08
Ca	1.3	2.2	1.8
Cr	0.09	0.04	0.06
Cu	0.01	0.005	0.02
Fe	13.4	18.3	14.6
Mg	0.5	0.4	0.4
Mn	0.09	0.1	0.09
Ni	0.03	0.03	0.02
P	--	--	--
K	1.5	1.3	1.6
Si	22.5	20.5	22.6
Na	0.08	0.2	0.3
Sr	0.1	0.07	0.1
Ti	0.3	0.6	0.6
V	--	--	--
Zn	--	--	--
Proximate Analysis, Wt% of As-Received Coal			
Moisture	0.72	0.96	0.57
Ash	9.12	11.9	15.7
Volatile	39.2	39.4	32.9
Sulfur Types, Wt% of Moisture-Free Coal			
Pyritic Sulfur	1.00	2.12	2.44
Sulfate Sulfur	0.04	<0.2	0.04
Inorganic Sulfur	1.04	2.12	2.48
Organic Sulfur	1.50	2.30	2.52
Total Sulfur	2.54	4.42	5.00
Particle Size Distribution,			
on 80 Mesh	0.0	0.0	0.0
thru 80 on 200	3.8	4.0	6.3
thru 200 on 325	20.7	24.0	21.1
thru 325 on 625	39.8	36.3	35.2
thru 625 mesh	35.5	35.7	37.4
Iron, Wt% of Moisture-Free Coal	0.94	2.11	2.38

Table XXIX

MOLECULAR WEIGHTS FOR 50°F PSEUDOCOMPONENTS

Pseudocomponent Boiling Range, °F	Molecular Weight
<500	155
500-550	173
550-600	185
600-650	203
650-700	220
700-750	241
750-800	260
800-850	282
850-900	300
900-950	318
950-1000	338
1000-1100	368
>1100	410

Table XXX

FLASH ZONE VAPOR VELOCITY ESTIMATES

Period, P99-	Flash Zone Temp., °C	Flash Zone Press., mm Hg	Overhead Vapor Rate kg/h	Overhead Vapor Rate g-moles/h	Overhead Vapor Recycle Rate kg/h	Flash Zone Vapor Velocity
63-1	335	15.5	2.338	10.11	18.62	2.19
63-4	357	15.0	2.920	12.19	18.40	2.30
63-6	351	30.5	2.627	11.10	6.43	0.48
64-1	374	21.0	4.046	16.47	6.02	0.78
64-6	355	21.0	2.798	12.00	6.02	0.67
65-2	335	14.5	3.028	13.17	9.71	1.43
65-5	348	21.5	3.018	12.69	9.71	0.95
65-8	372	30.0	3.266	13.76	9.71	0.72
66-1	375	30.0	4.066	17.47	9.71	0.77
66-7	343	15.5	3.477	14.31	9.71	1.33
67-1	331	15.0	3.775	16.37	9.98	1.48
67-5	350	31.0	3.785	15.79	9.98	0.71
67-9	373	21.0	4.742	19.59	9.98	1.18
68-1	330	15.0	3.952	16.40	9.98	1.43
68-7	304	16.0	3.225	14.08	9.98	1.28
69-1	305	22.0	2.671	11.90	9.98	0.91
69-5	361	31.5	3.849	16.01	9.98	0.71
69-9	306	22.0	2.718	12.04	9.98	0.91

Figure 1. PROCESS DEVELOPMENT UNIT P-99

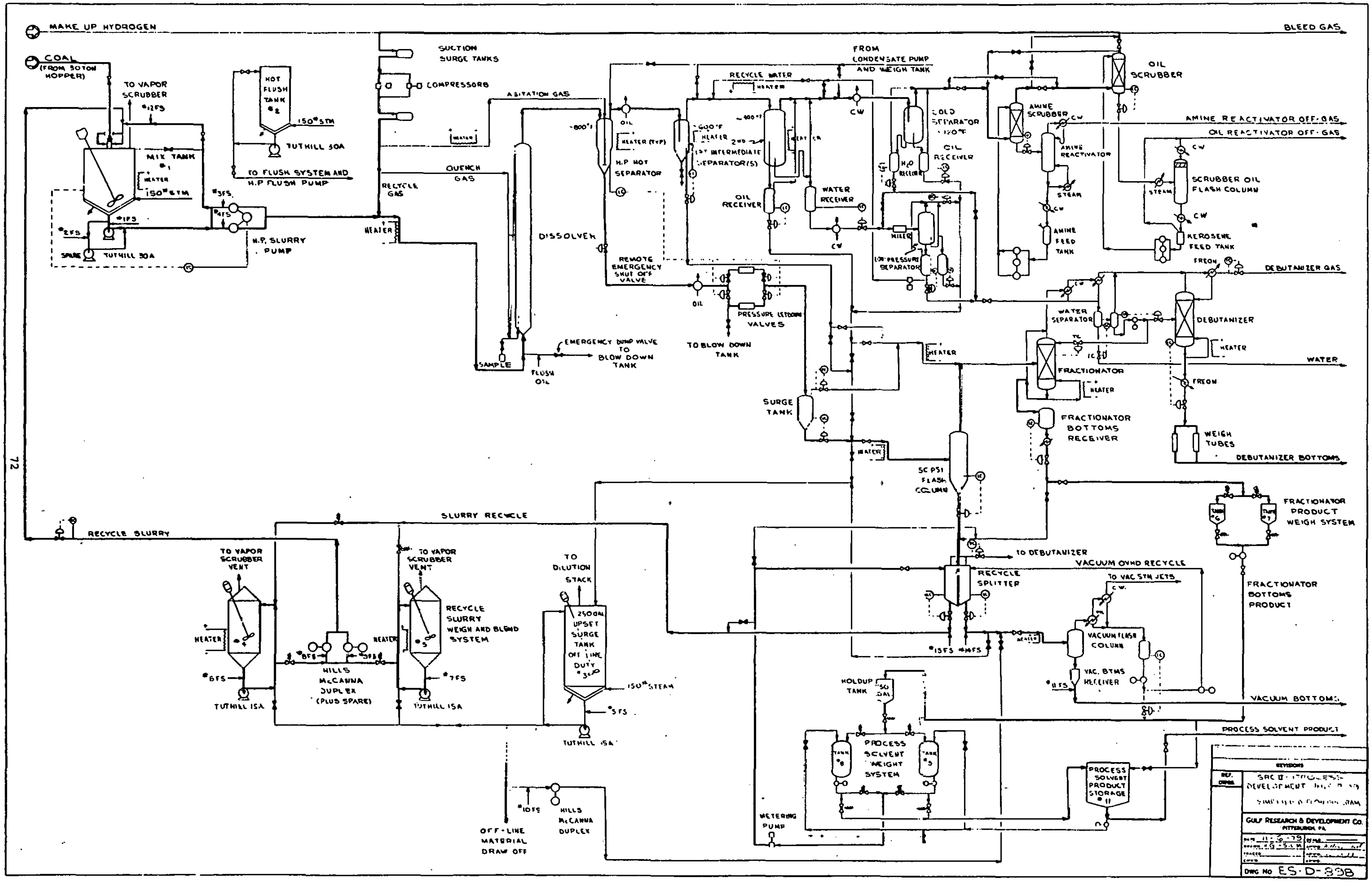


Figure 2. P-99 VACUUM FLASH SYSTEM

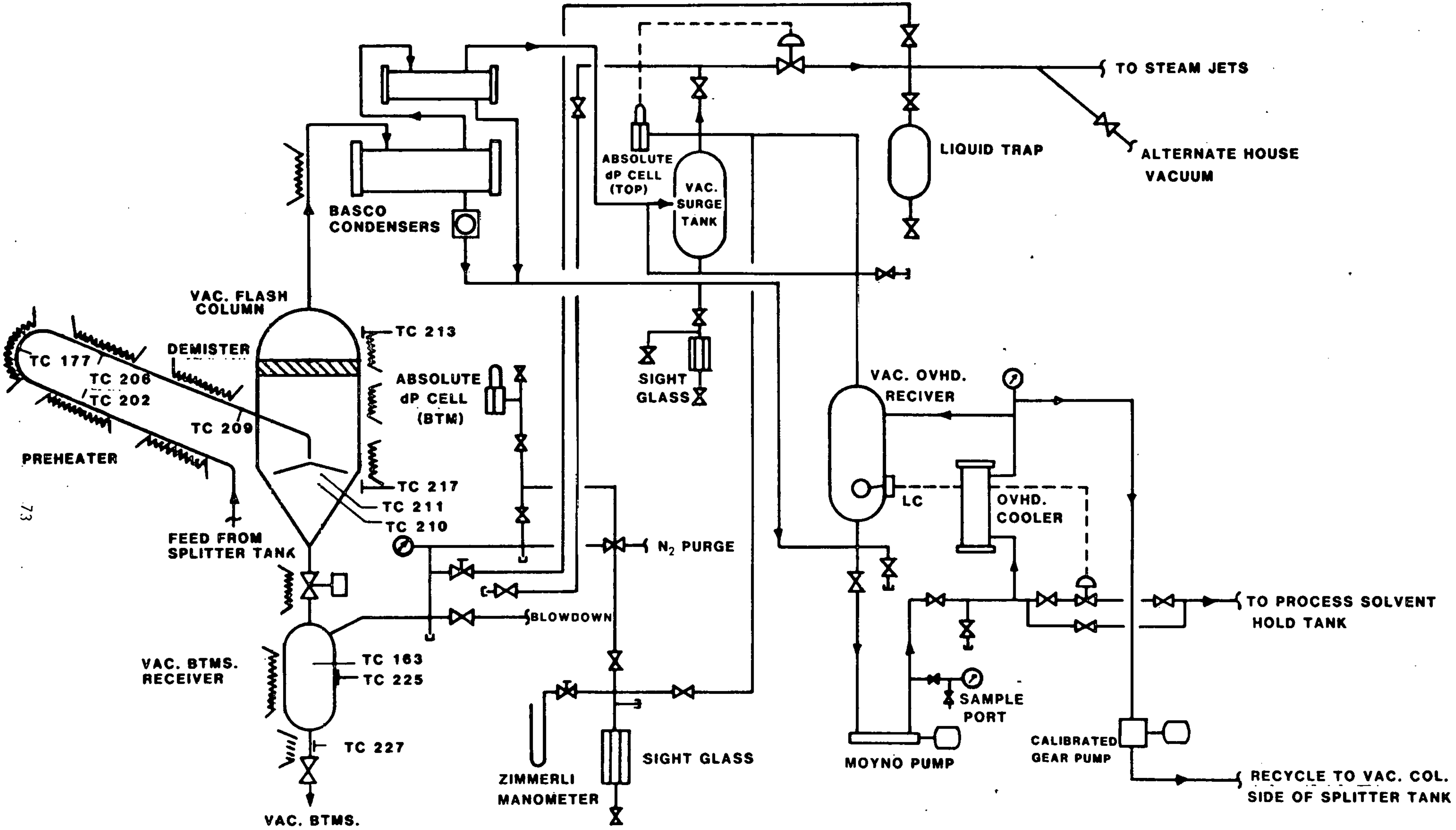


Figure 3

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION OF FLASH ZONE TEMPERATURE AND PRESSURE, RUNS 63-66

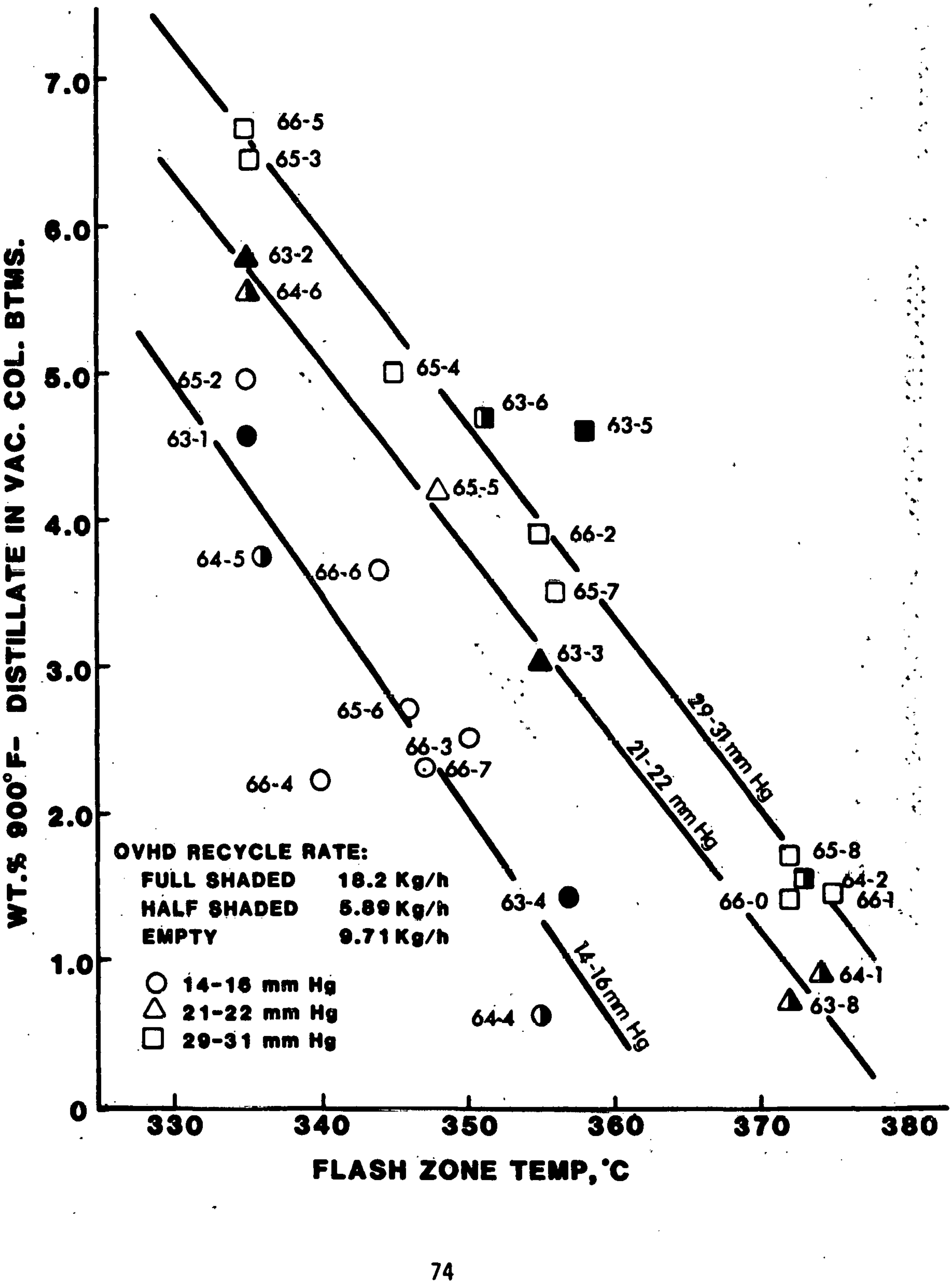


Figure 4

DISTILLATE REMAINING IN VACUUM BOTTOMS AS A FUNCTION OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg, RUNS 63-66

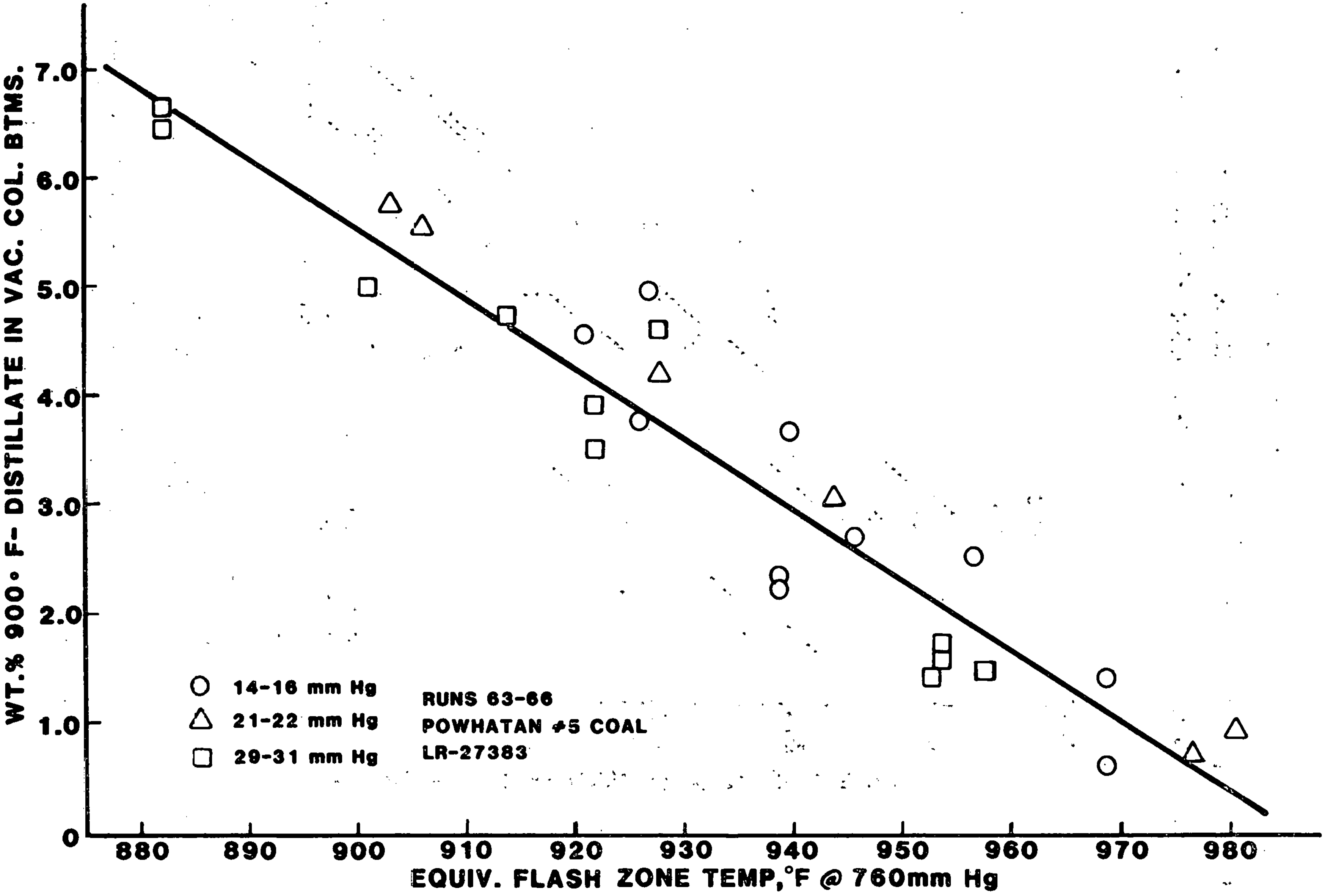


Figure 5

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION OF FLASH ZONE TEMPERATURE AND PRESSURE, RUNS 67-69

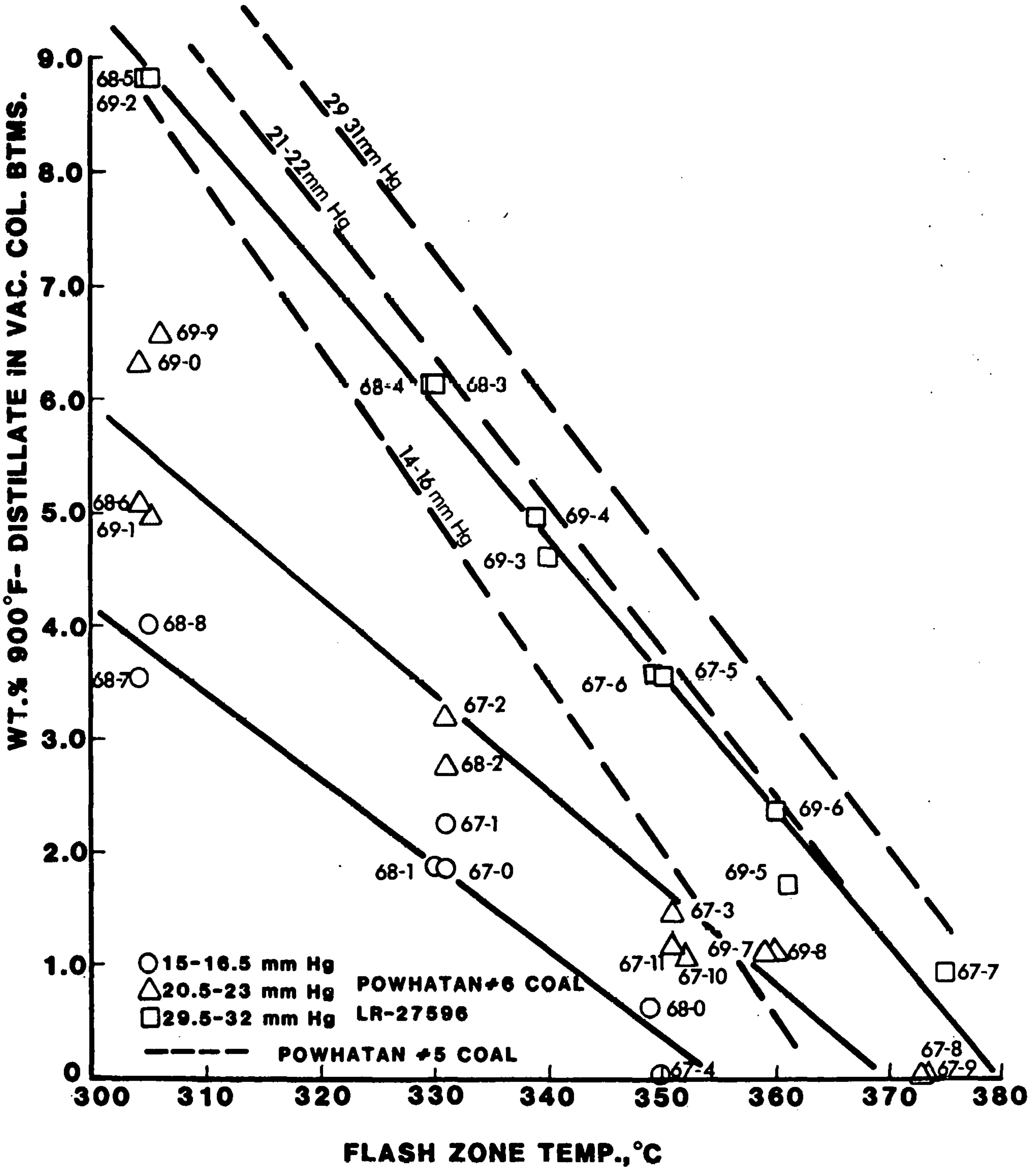


Figure 6

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg, RUNS 67-69

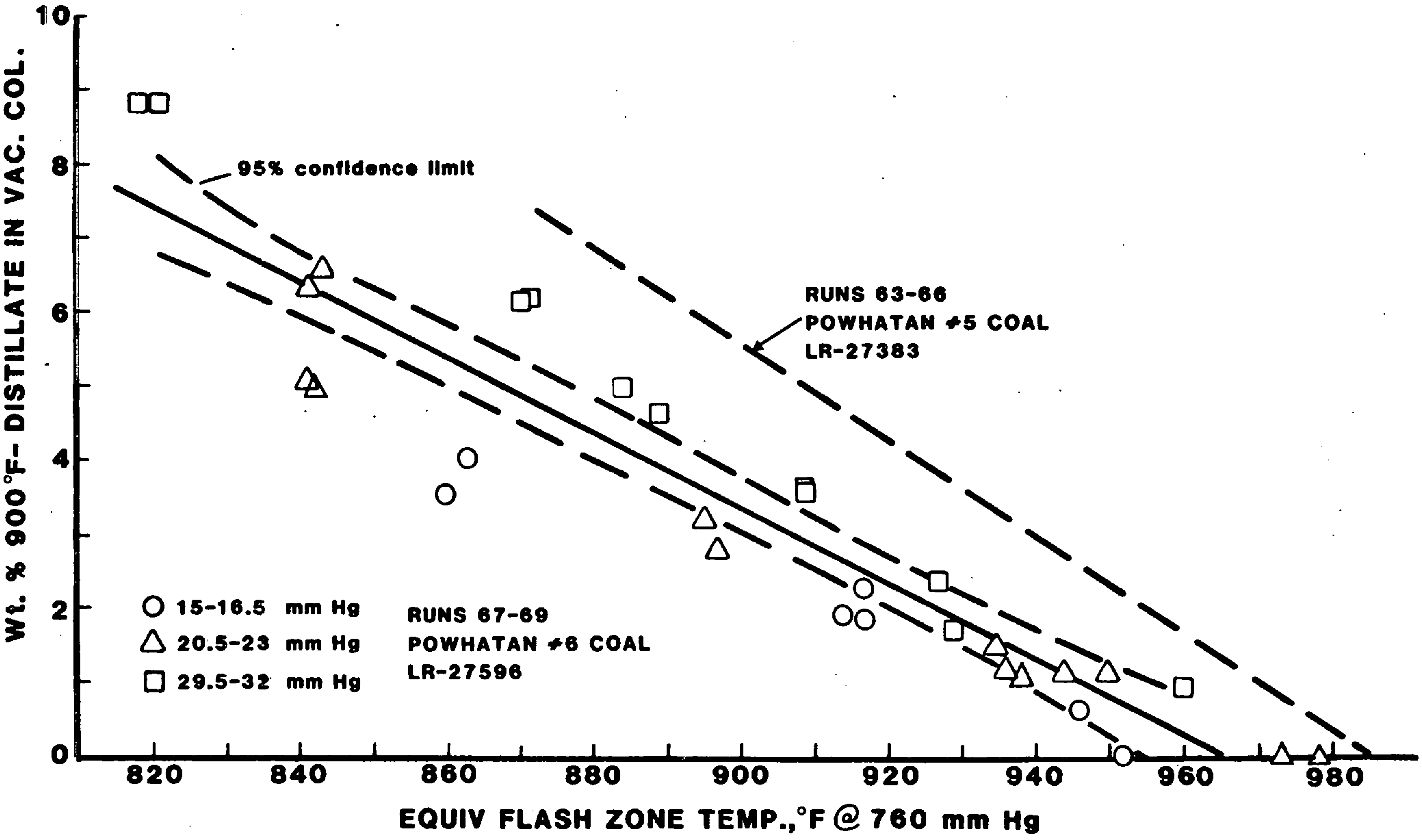


Figure 7

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION OF FLASH ZONE TEMPERATURE AND PRESSURE, RUNS 70-71

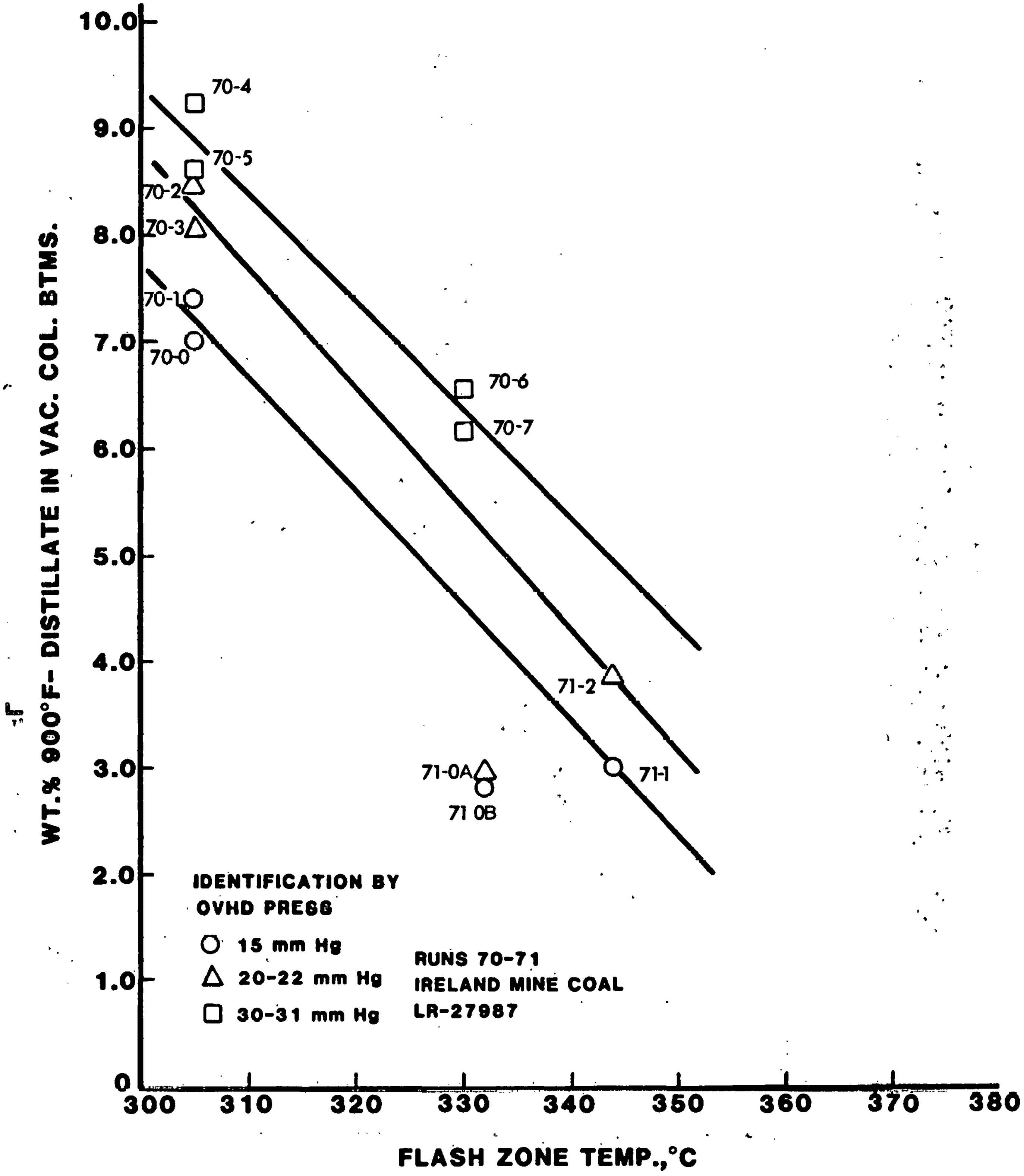


Figure 8

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg BASED ON THE OVERHEAD PRESSURE, RUNS 70-71

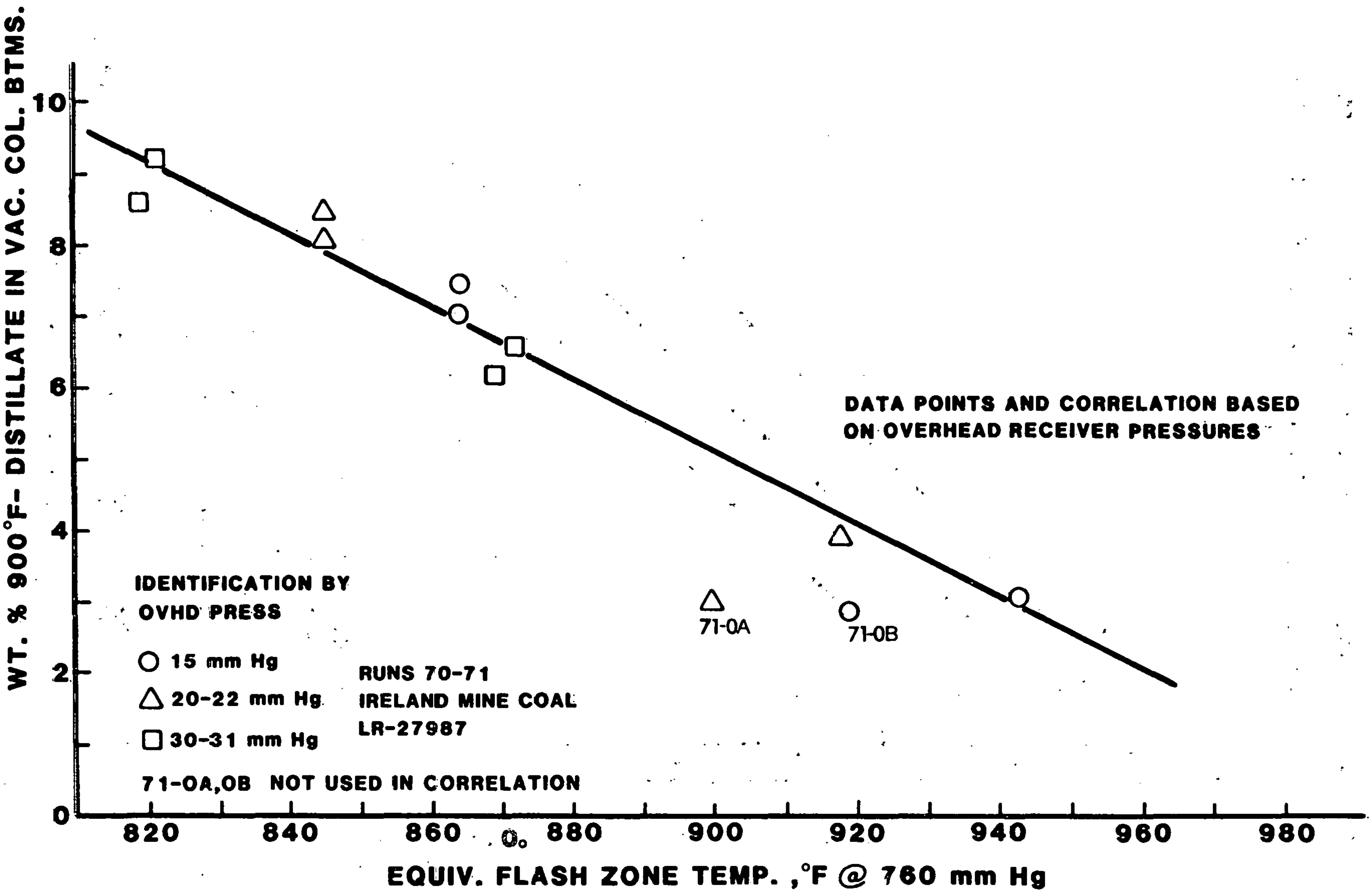


Figure 9

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg BASED ON THE BOTTOMS PRESSURE, RUNS 70-71

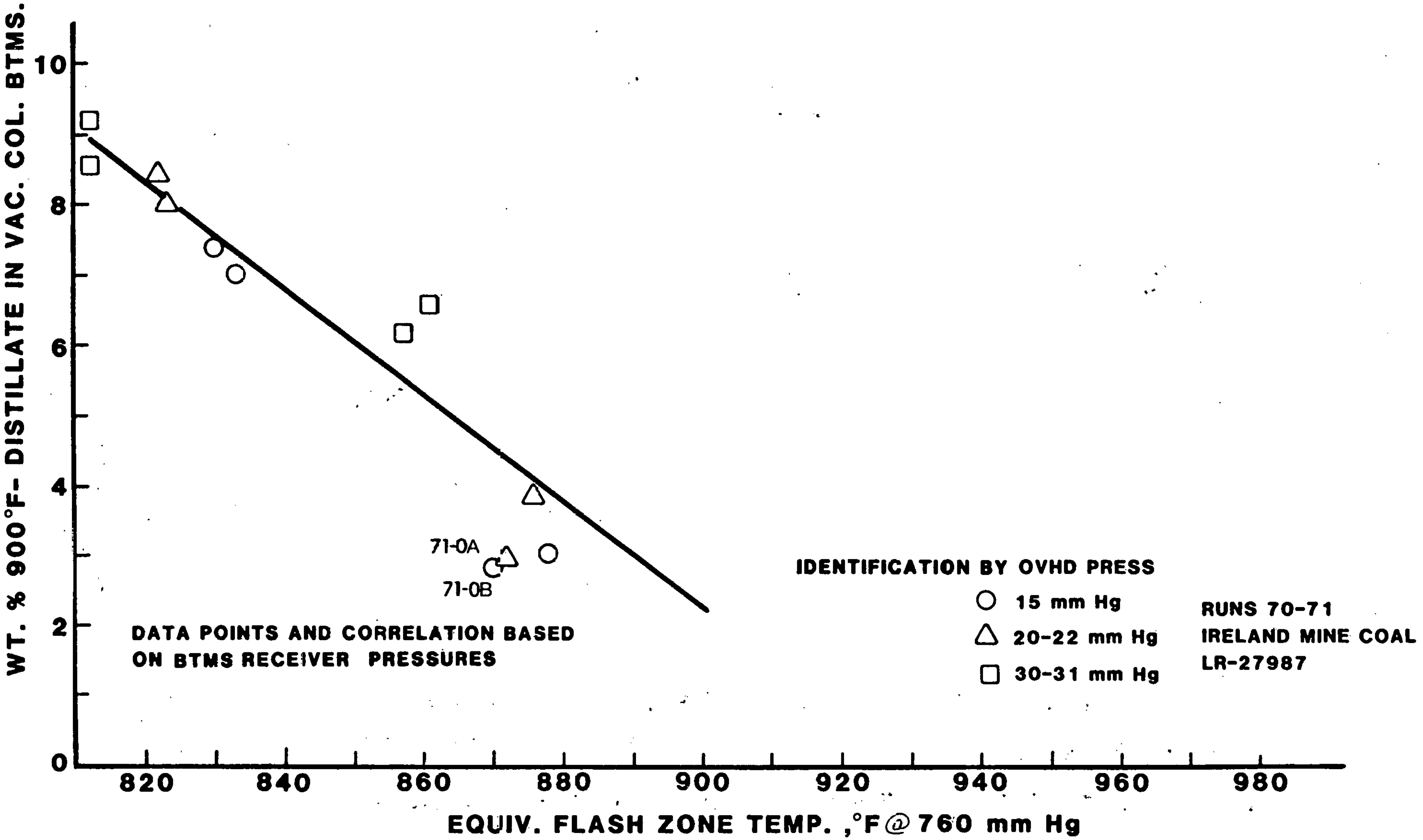


Figure 10

DISTILLATE REMAINING IN VACUUM COLUMN BOTTOMS AS A FUNCTION
OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg
BASED ON THE AVERAGE PRESSURE, RUNS 70-71

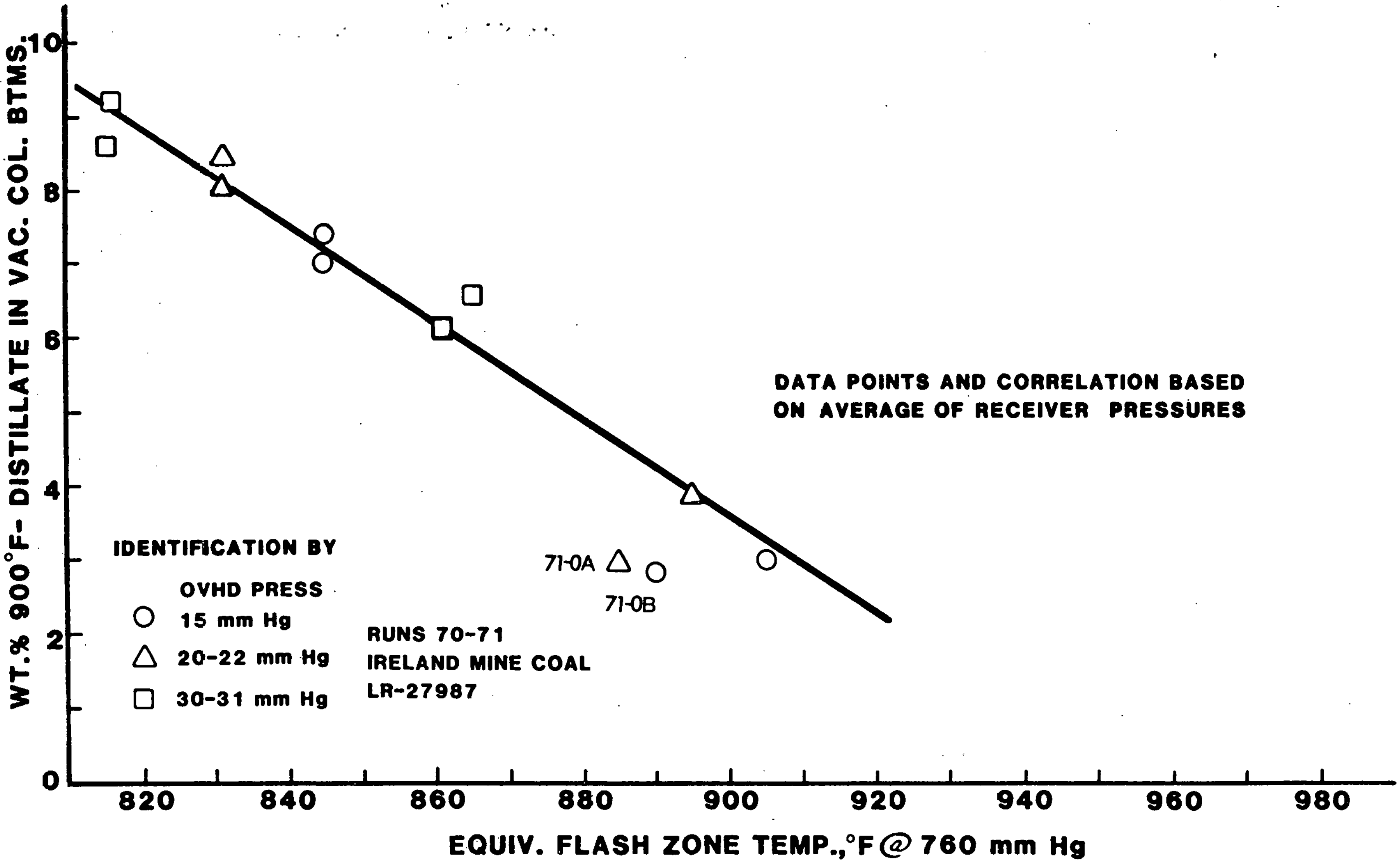


Figure 11
COMPARISON VACUUM BOTTOMS DISTILLATE CONTENT FOR THREE DIFFERENT COAL FEEDSTOCKS AS A FUNCTION OF FLASH ZONE TEMPERATURE AND PRESSURE

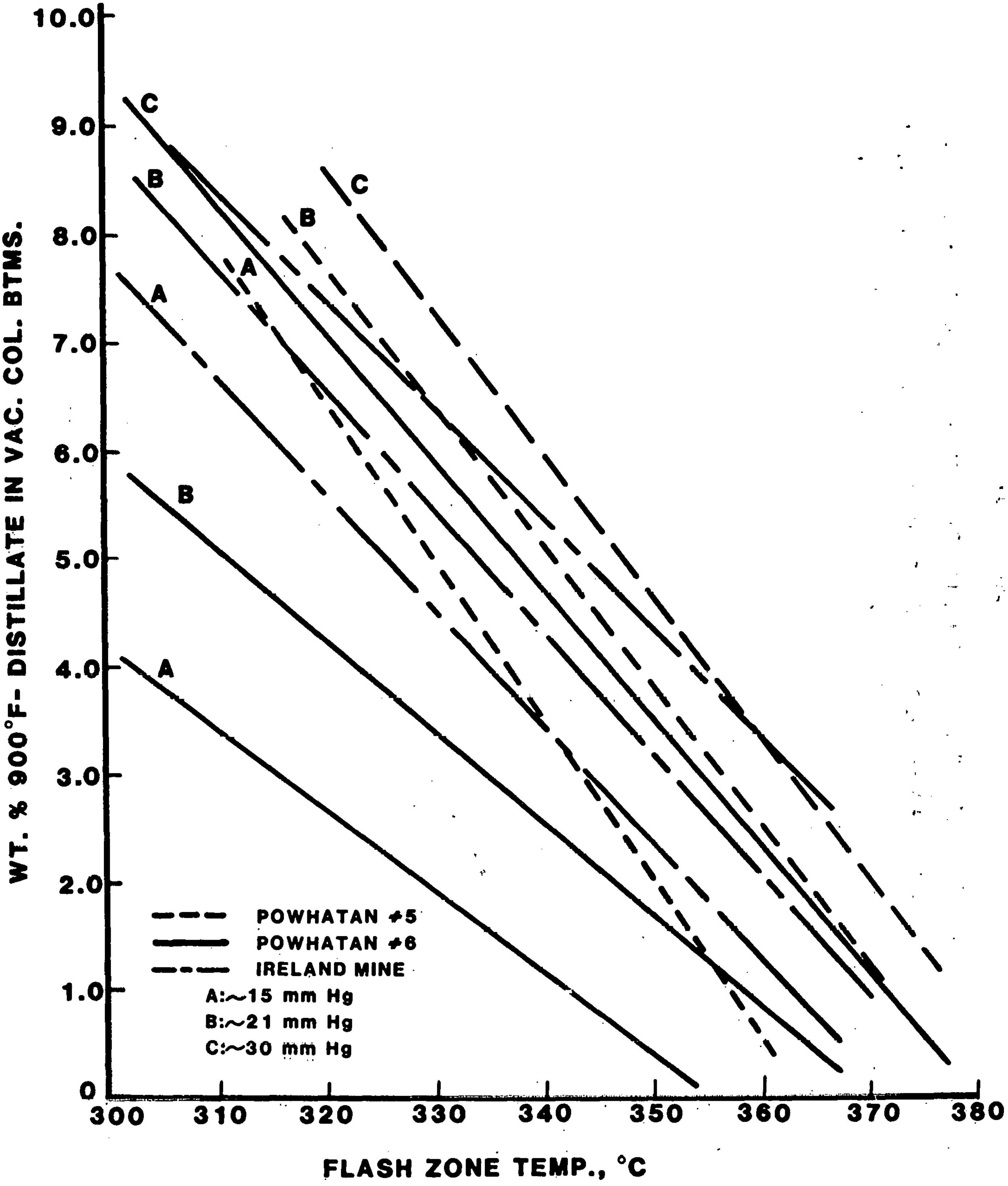


Figure 12

COMPARISON VACUUM BOTTOMS DISTILLATE CONTENT FOR THREE DIFFERENT COAL FEEDSTOCKS AS A FUNCTION OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg

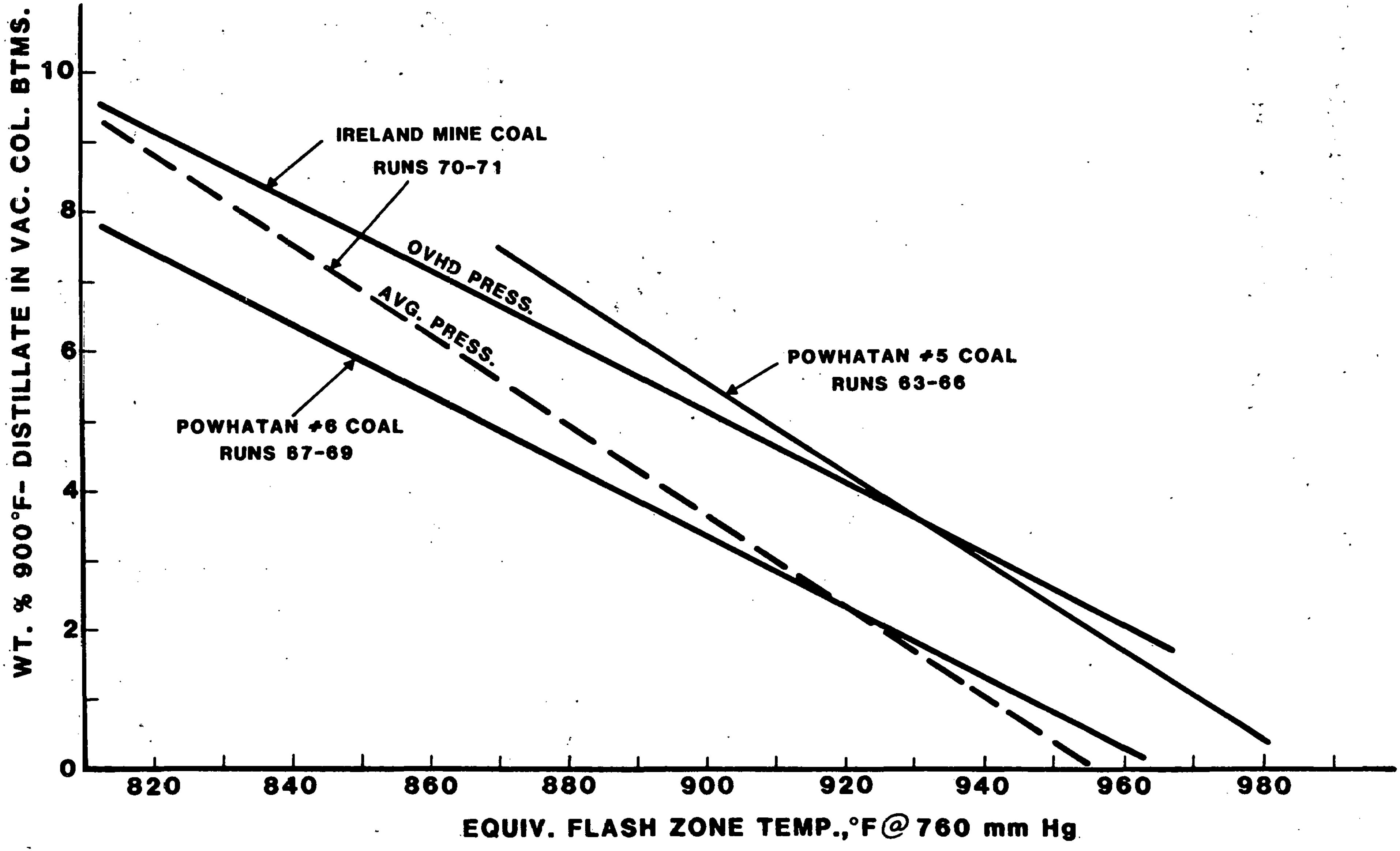


Figure 13

FRACTION OF VACUUM COLUMN FEED VAPORIZED
VS. FLASH ZONE TEMPERATURE, 14-17 mm Hg

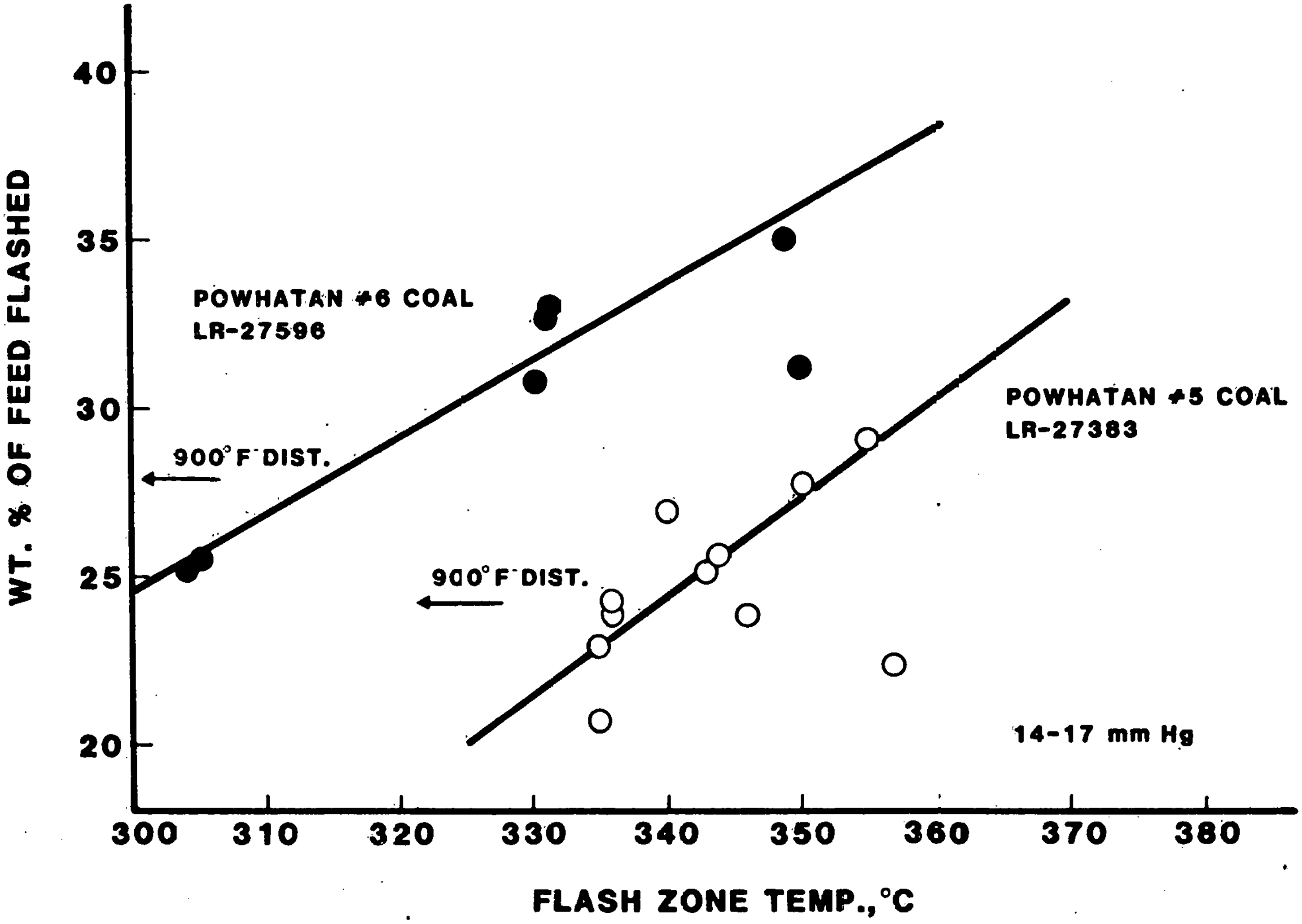


Figure 14

FRACTION OF VACUUM COLUMN FEED VAPORIZED
VS. FLASH ZONE TEMPERATURE, 21-33 mm Hg

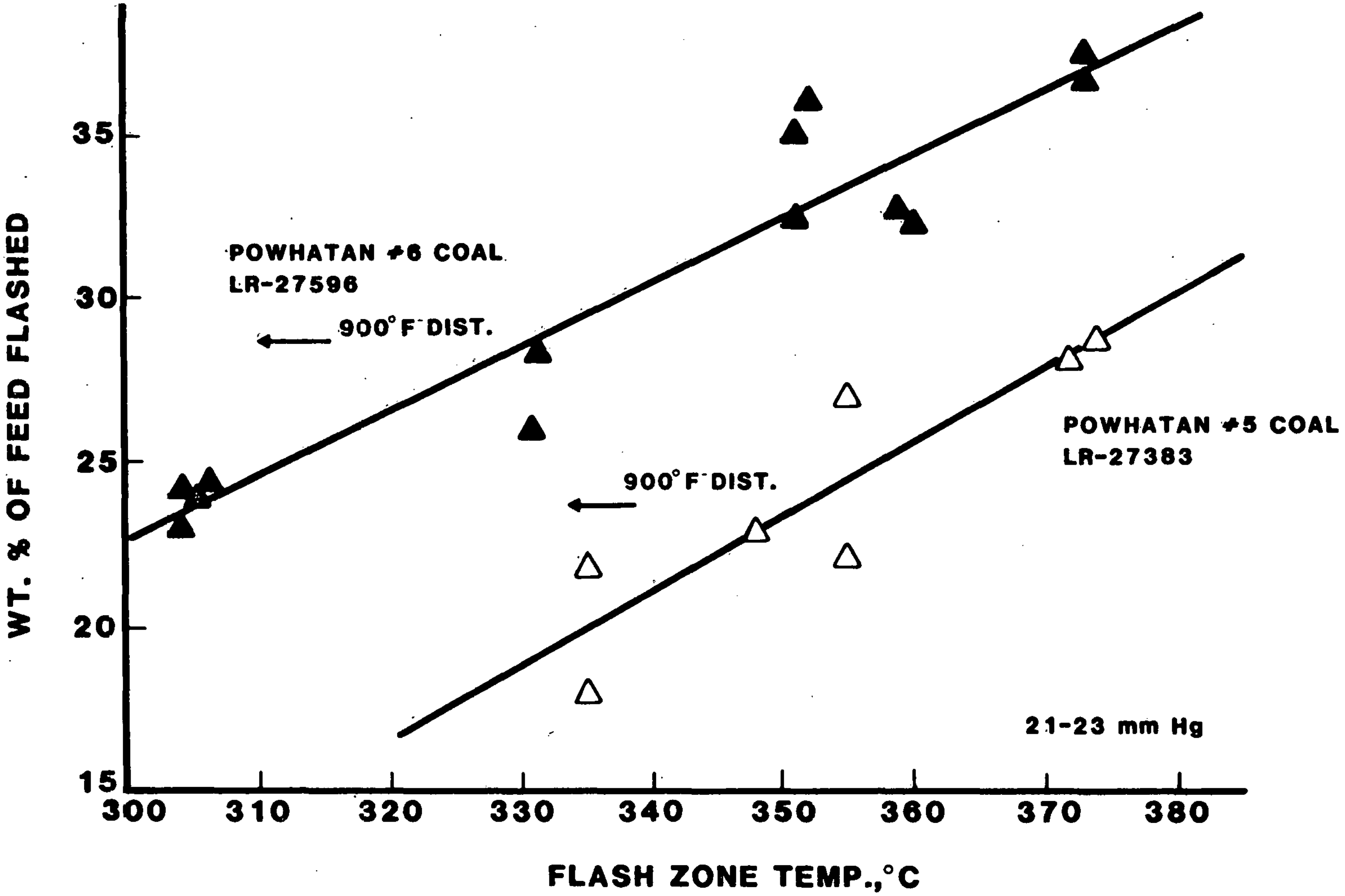


Figure 15

FRACTION OF VACUUM COLUMN FEED VAPORIZED VS. FLASH ZONE TEMPERATURE, 29-32 mm Hg

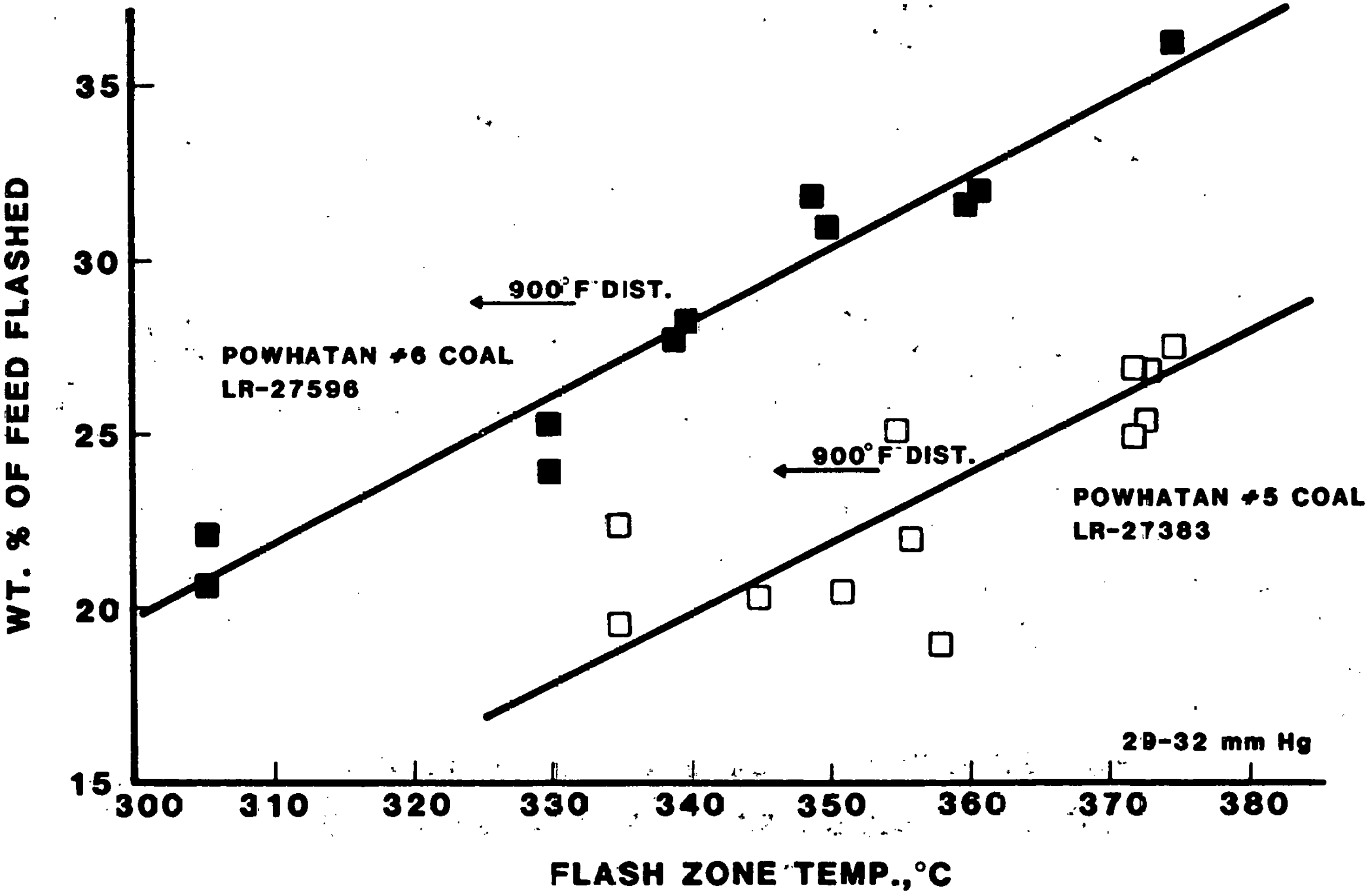


Figure 16

FRACTION OF VACUUM COLUMN FEED VAPORIZED
VS. FLASH ZONE TEMPERATURE, AND PRESSURE

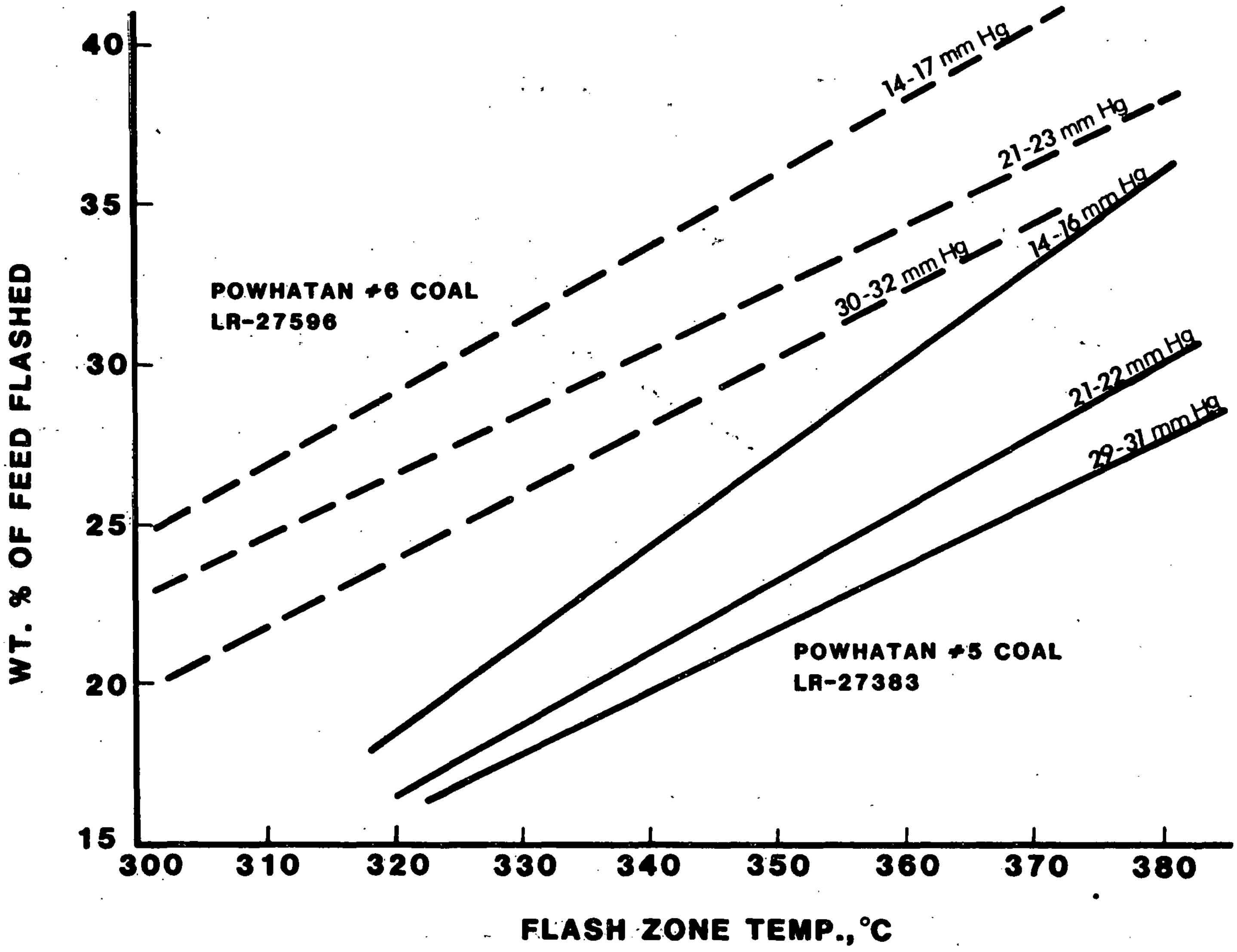


Figure 17

PERCENT OF 900°F- DISTILLATE AND 900°F+-PYRIDINE SOLUBLES FLASHED VERSUS FLASH ZONE TEMPERATURE, 15 mm Hg

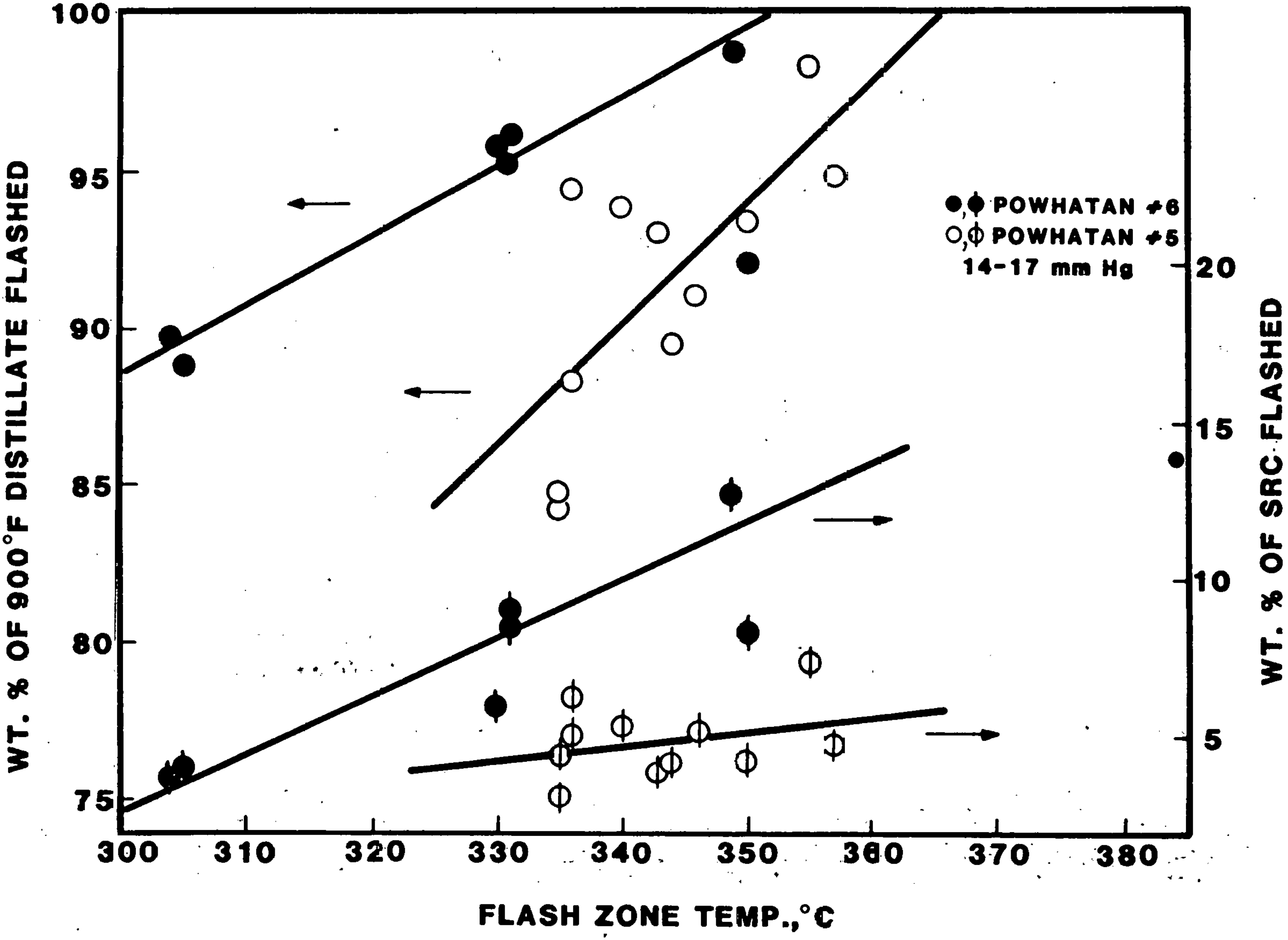


Figure 18

PERCENT OF 900°F- DISTILLATE AND 900°F+-PYRIDINE SOLUBLES FLASHED VERSUS FLASH ZONE TEMPERATURE, 21 mm Hg

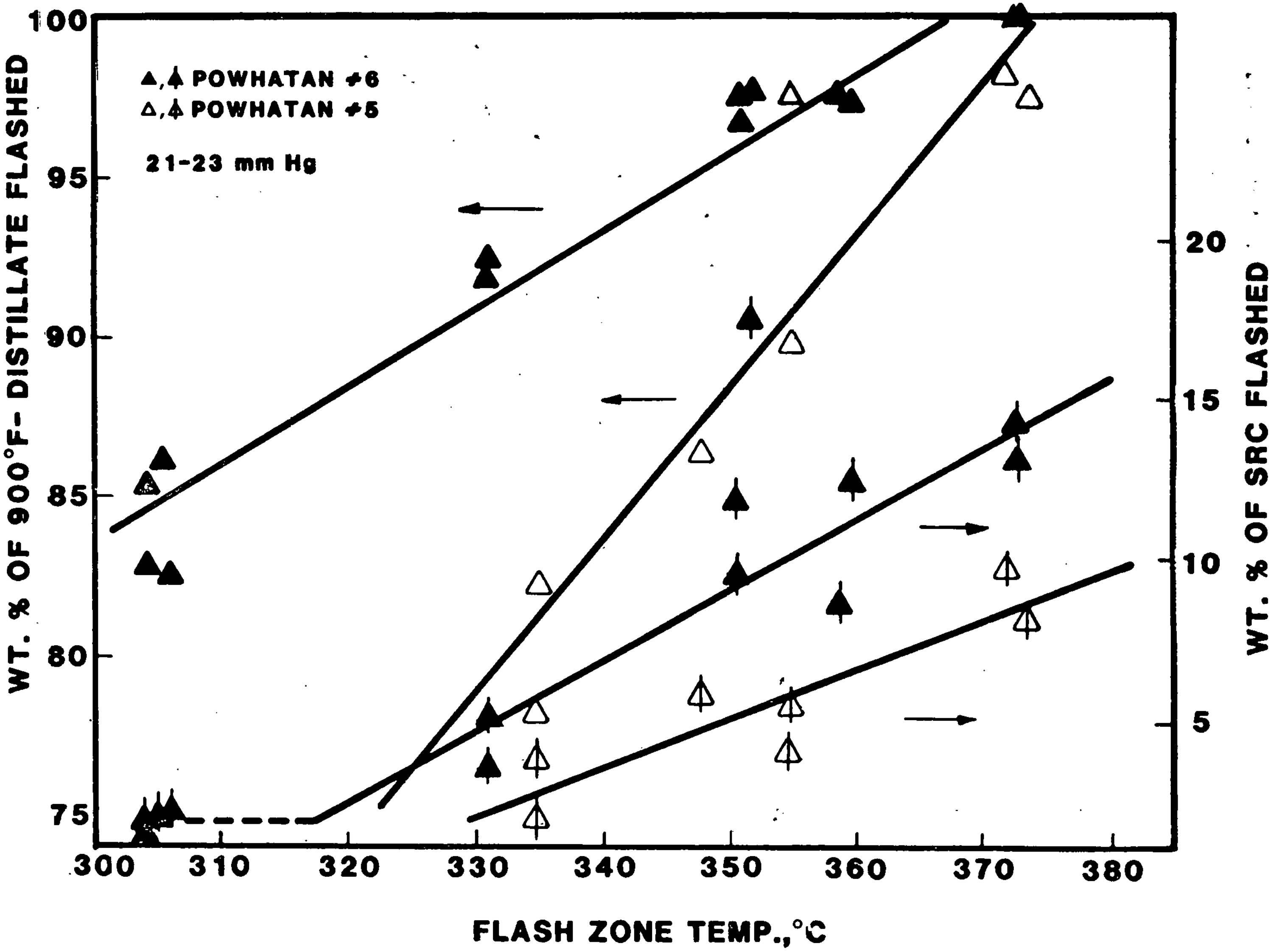


Figure 19

PERCENT OF 900°F- DISTILLATE AND 900°F+-PYRIDINE SOLUBLES FLASHED VERSUS FLASH ZONE TEMPERATURE,30 mm Hg

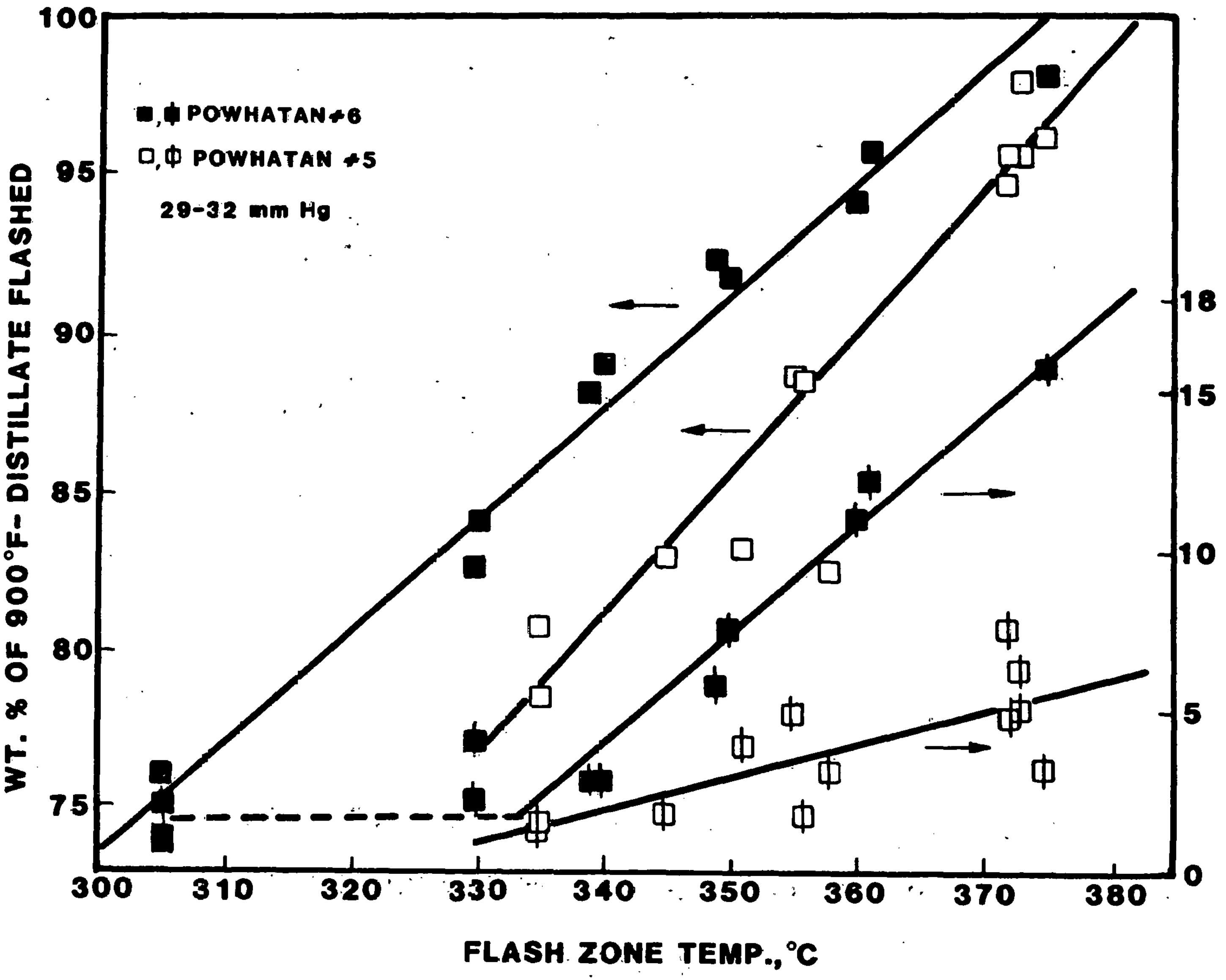


Figure 20

FRACTION OF VACUUM COLUMN FEED VAPORIZED VS. FLASH ZONE TEMPERATURE, PRESSURE AND SOURCE COAL

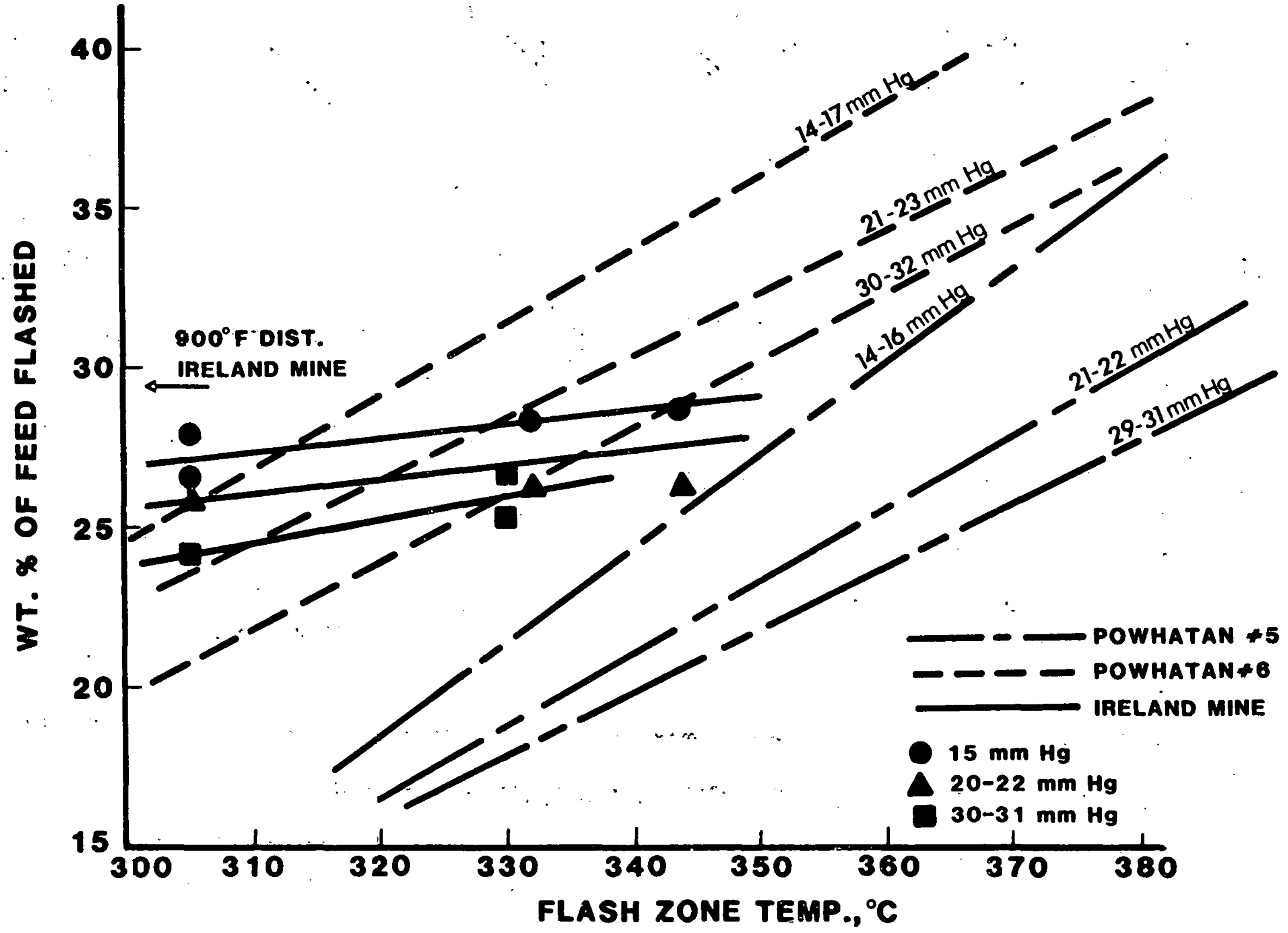


Figure 21

% PYRIDINE SOLUBLE FEED VAPORIZED VERSUS FLASH ZONE TEMPERATURE , 15 mm Hg

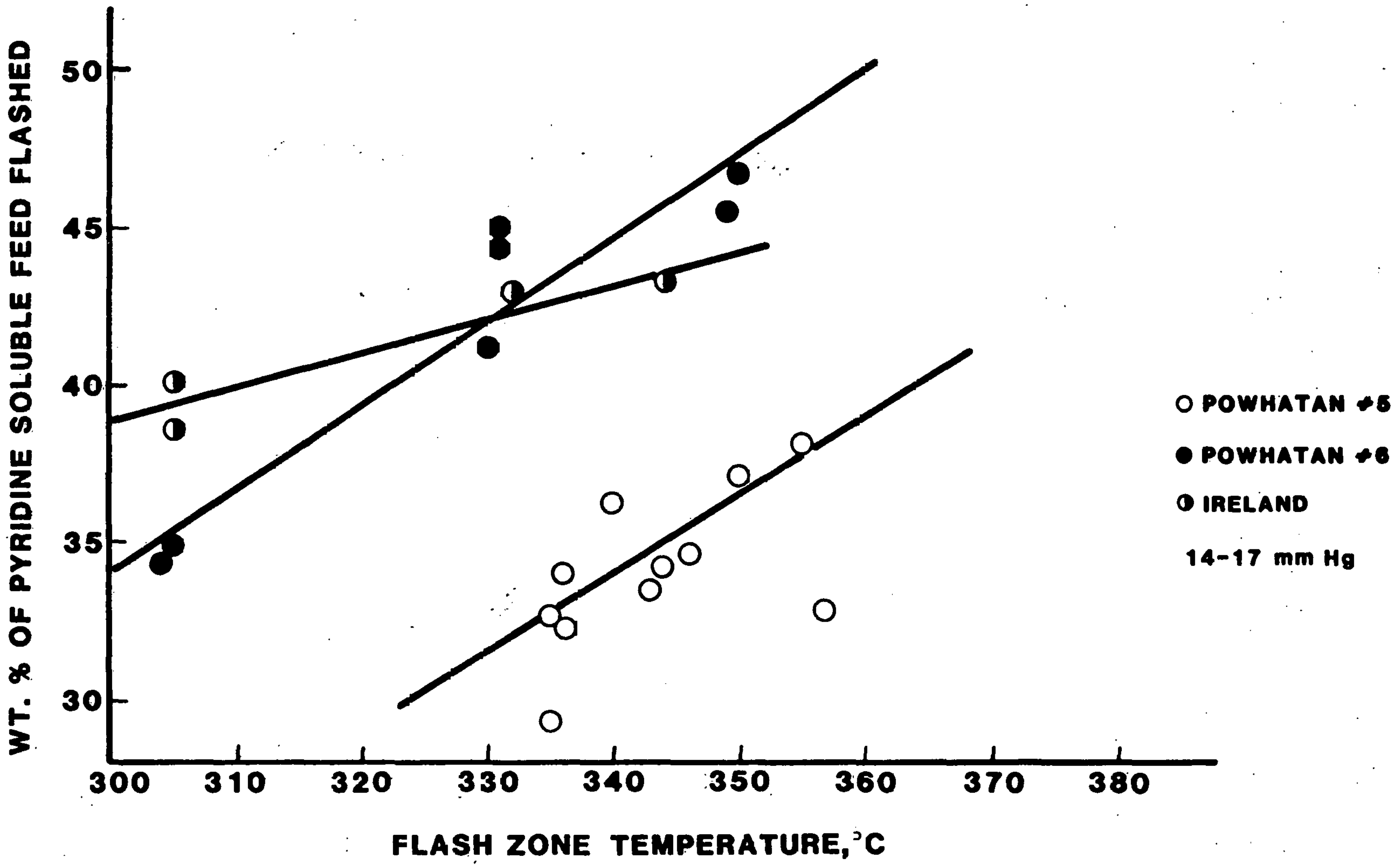


Figure 22
% PYRIDINE SOLUBLE FEED VAPORIZED VERSUS

FLASH ZONE TEMPERATURE , 21 mm Hg

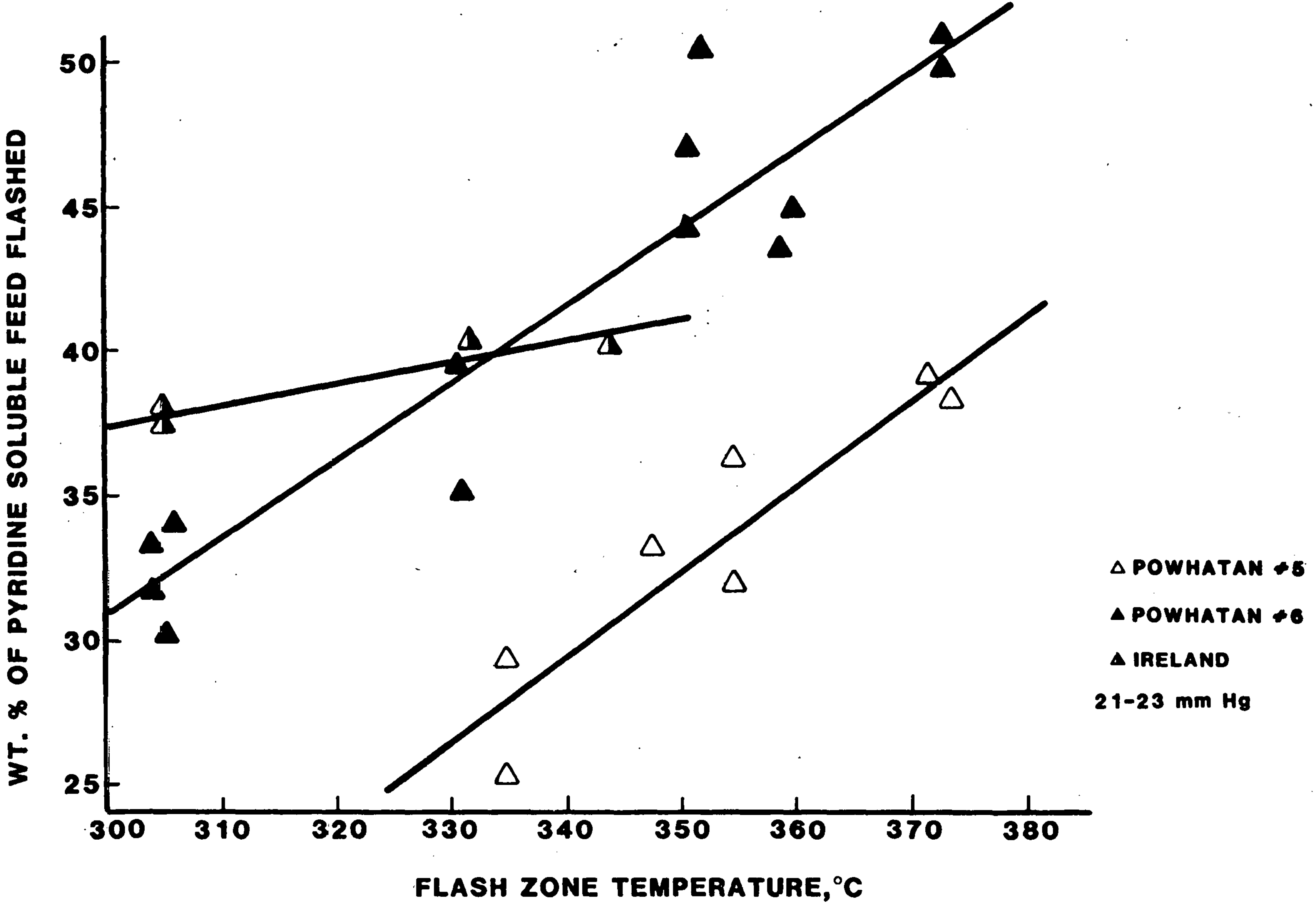


Figure 23

% PYRIDINE SOLUBLE FEED VAPORIZED VERSUS

FLASH ZONE TEMPERATURE 30 mm Hg

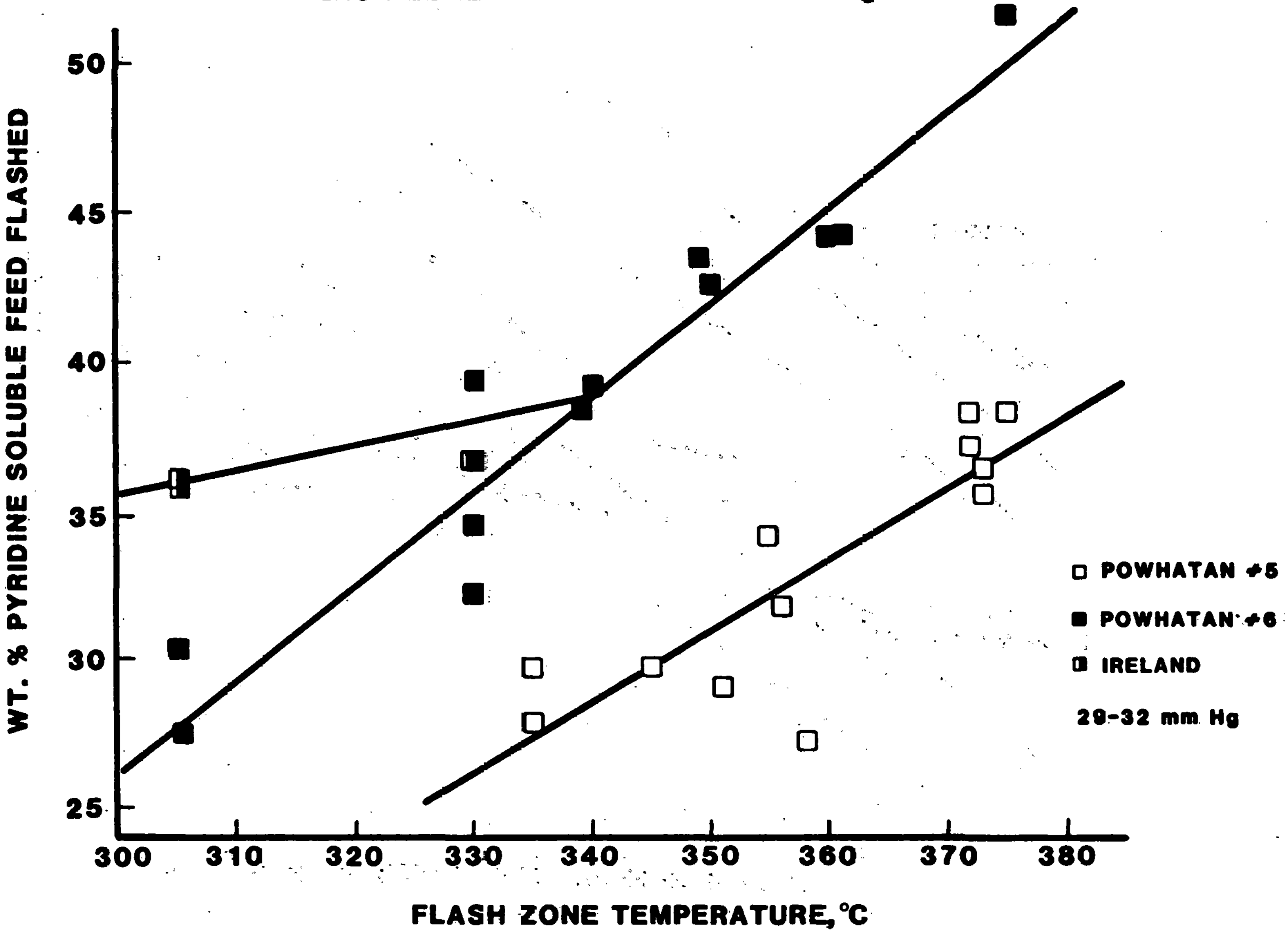


Figure 24
% PYRIDINE SOLUBLE FEED VAPORIZED VERSUS FLASH ZONE TEMPERATURE, AND PRESSURE

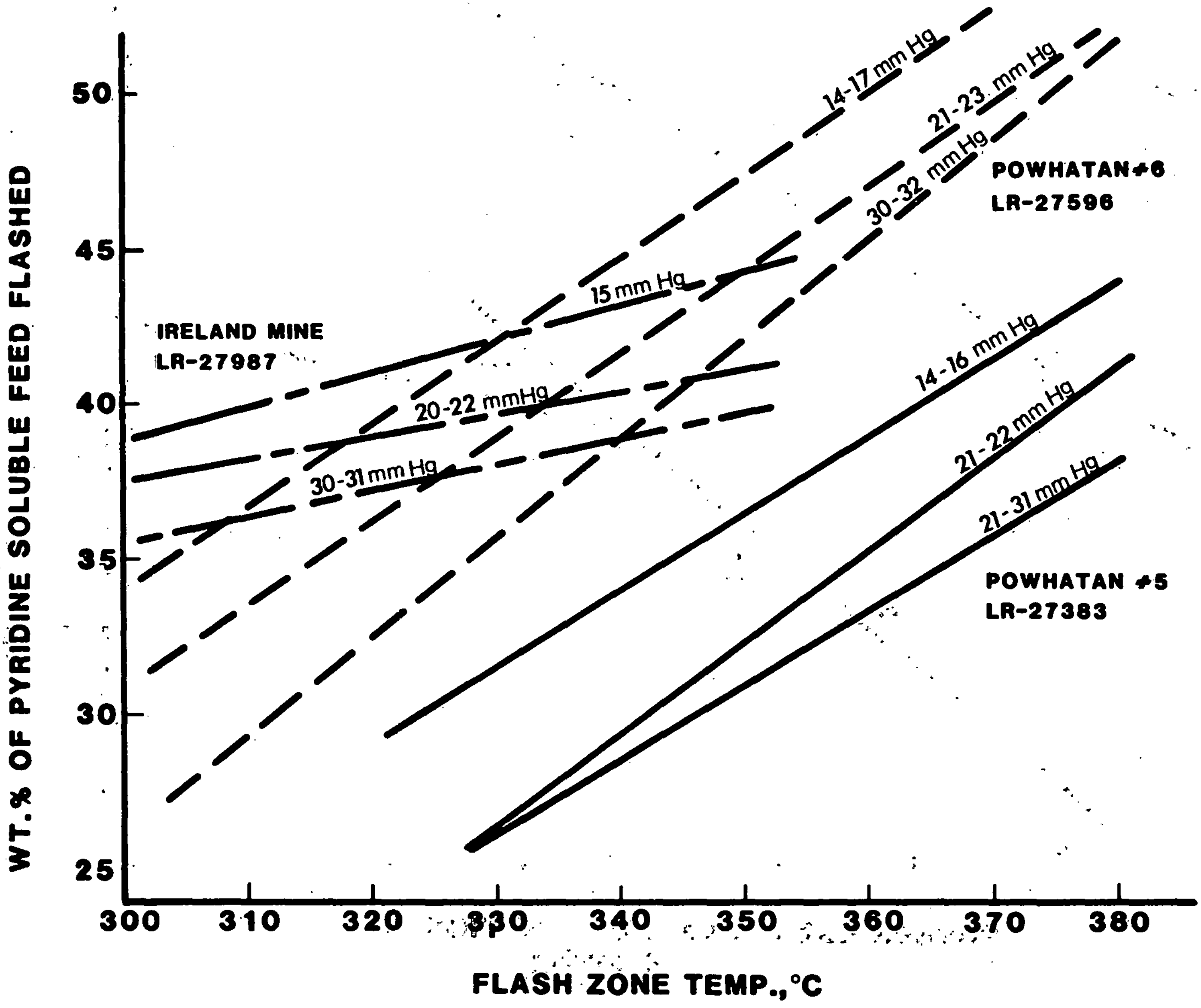


Figure 25

%900°F- DISTILLATE AND 900°F+-PYRIDINE SOLUBLES FLASHED VERSUS FLASH ZONE TEMPERATURE AND PRESSURE, IRELAND MINE COAL

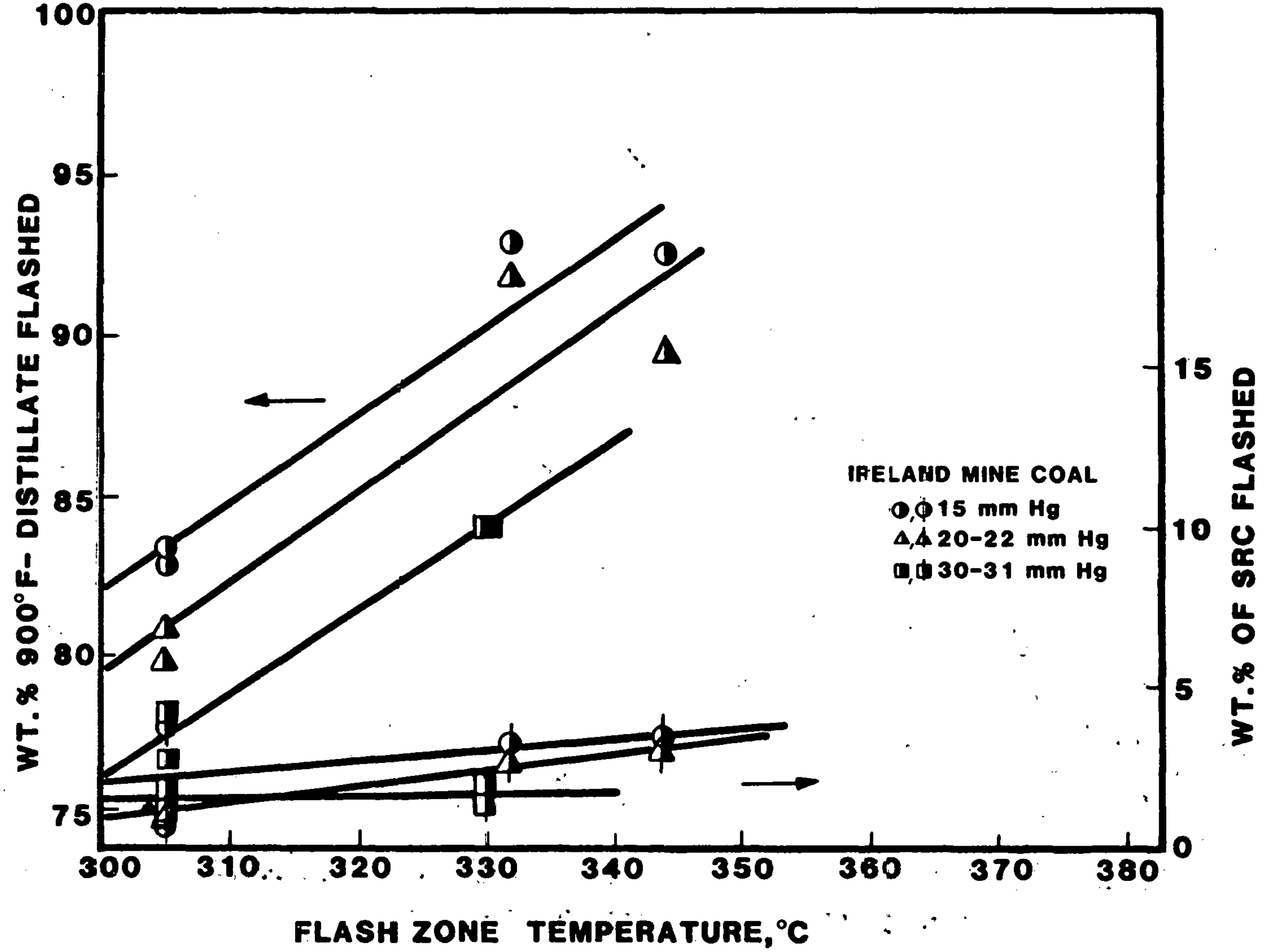


Figure 26
% 900 F- DISTILLATE FLASHED AS A FUNCTION
OF EQUIVALENT FLASH ZONE TEMPERATURE AT 760 mm Hg and COAL SOURCE

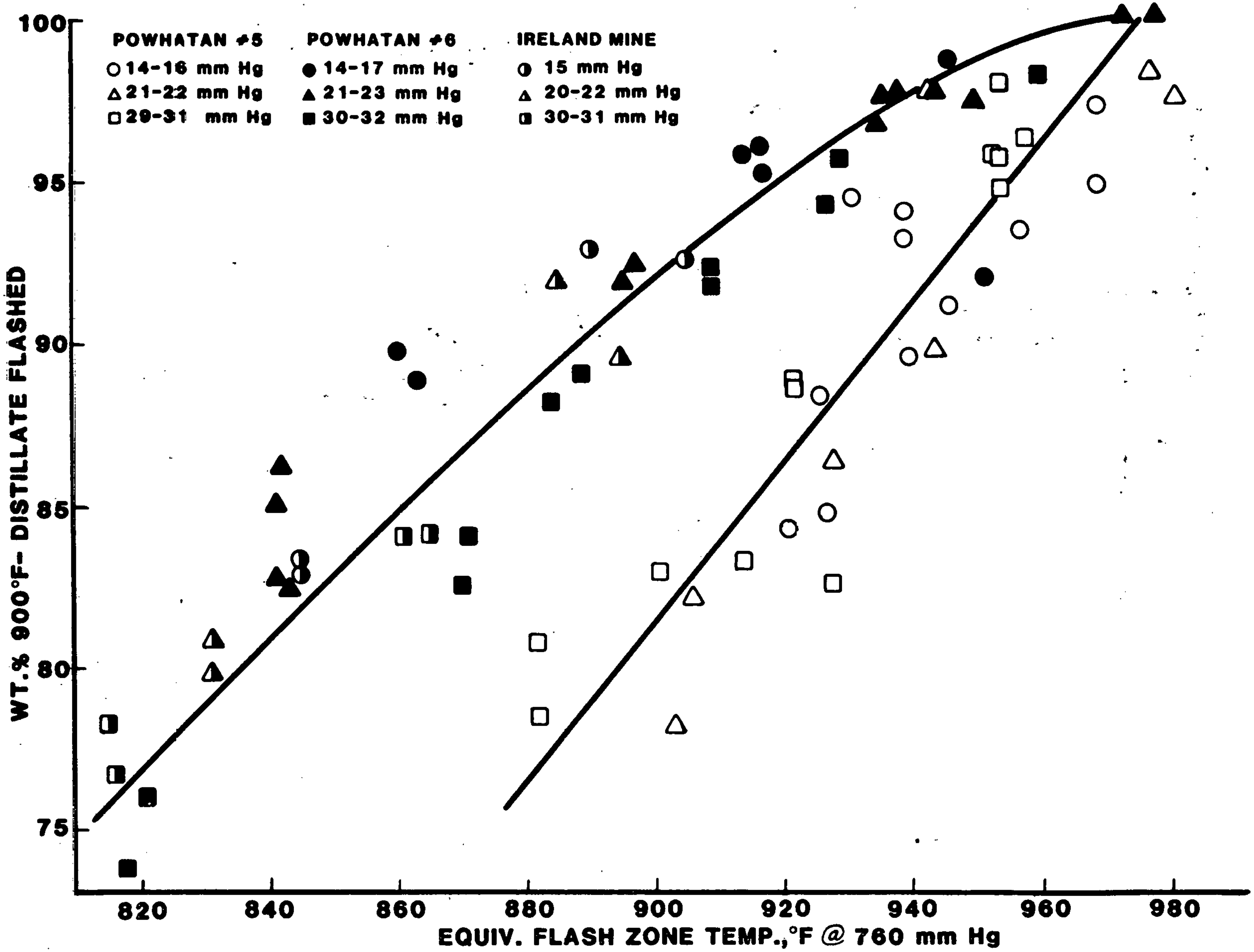
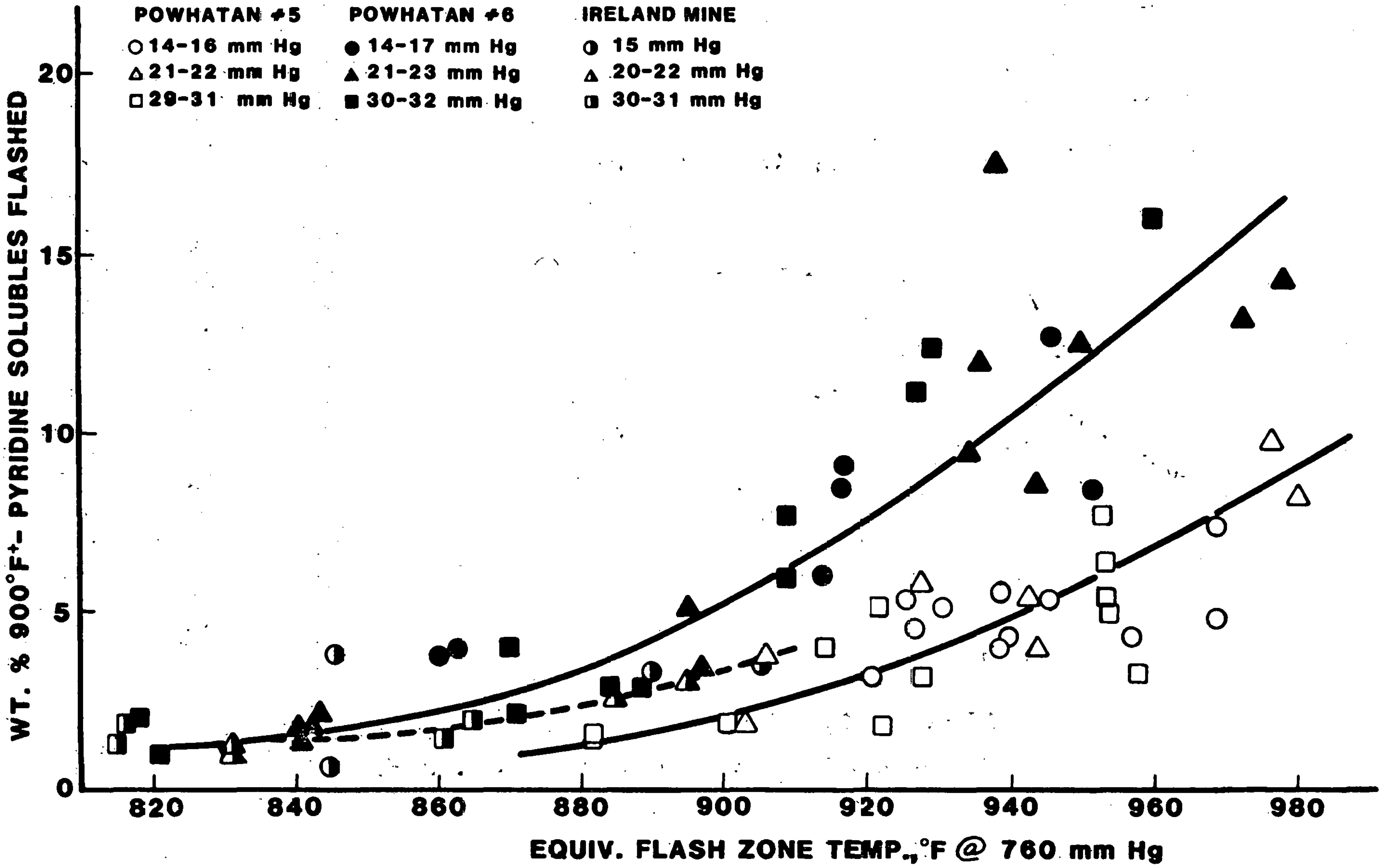


Figure 27

% 900 F+-PYRIDINE SOLUBLES FLASHED AS A FUNCTION
OF FLASH ZONE TEMPERATURE AT 760 mm Hg AND COAL SOURCE



Figur 28

EFFECT OF FLASH ZONE TEMPERATURE ON PYRIDINE INSOLUBLES, POWHATAN #5 COAL

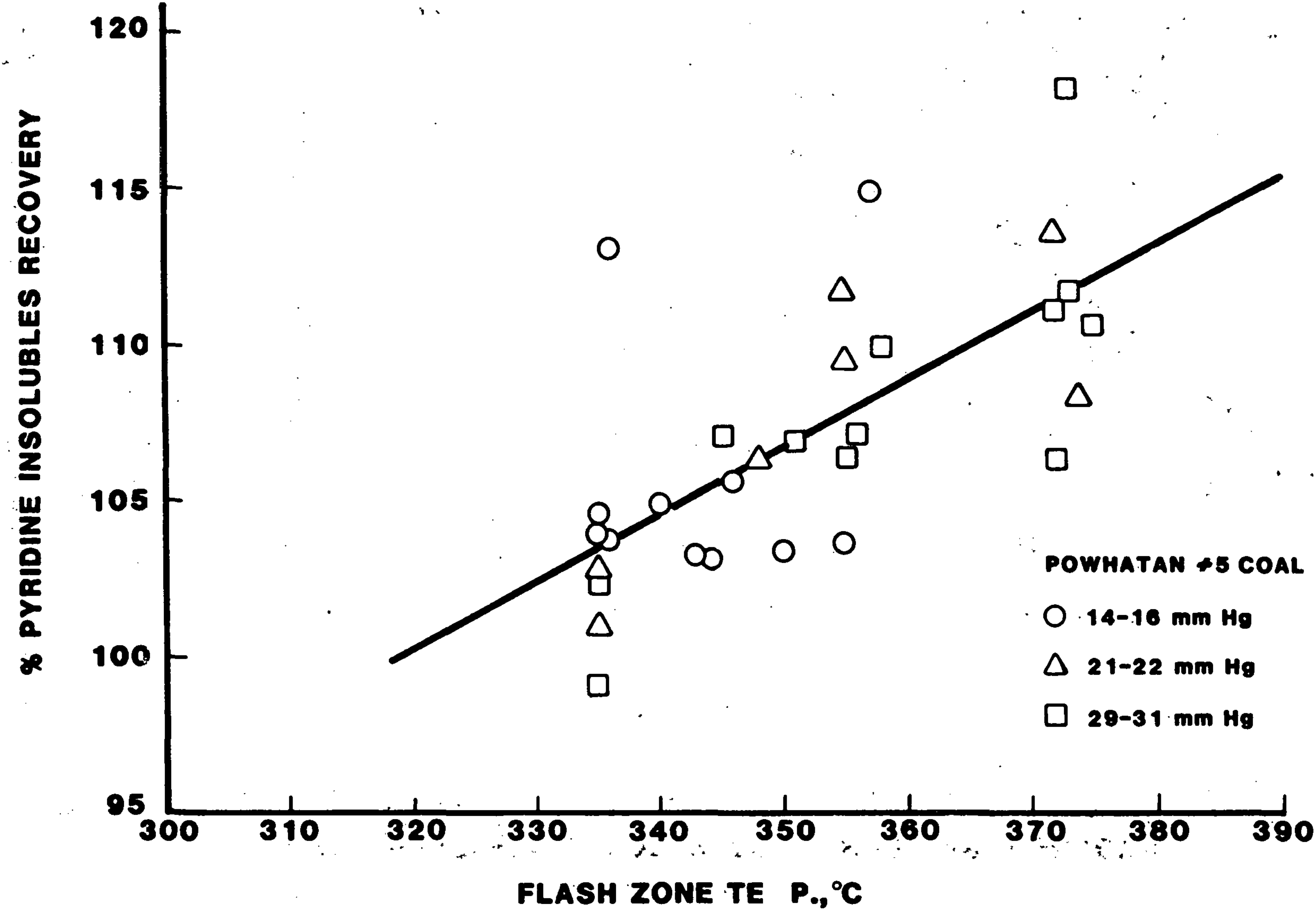


Figure 29

EFFECT OF FLASH ZONE TEMPERATURE ON PYRIDINE INSOLUBLES, POWHATAN #6 COAL

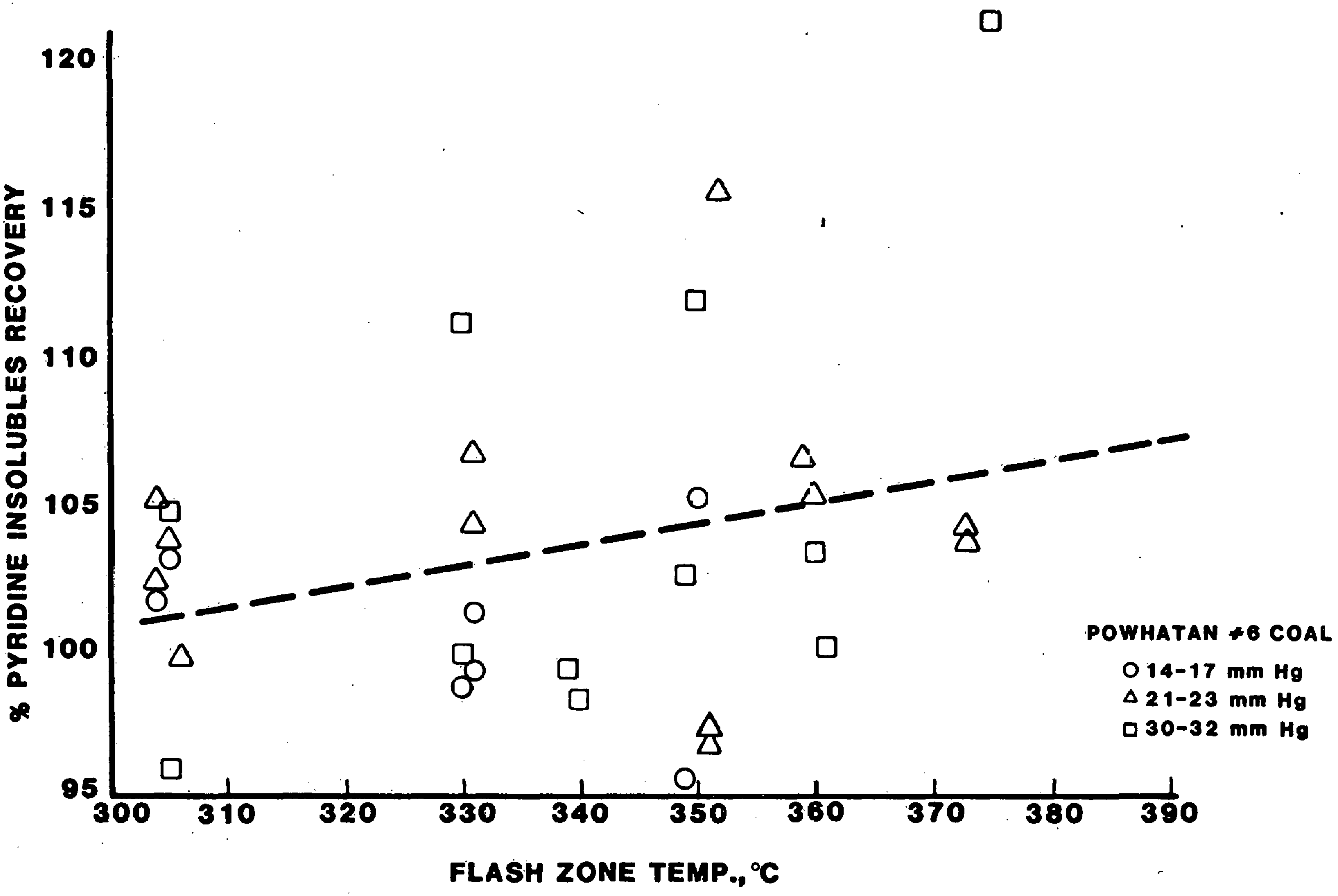


Figure 30

EFFECT OF FLASH ZONE TEMPERATURE ON PYRIDINE INSOLUBLES, IRELAND MINE COAL

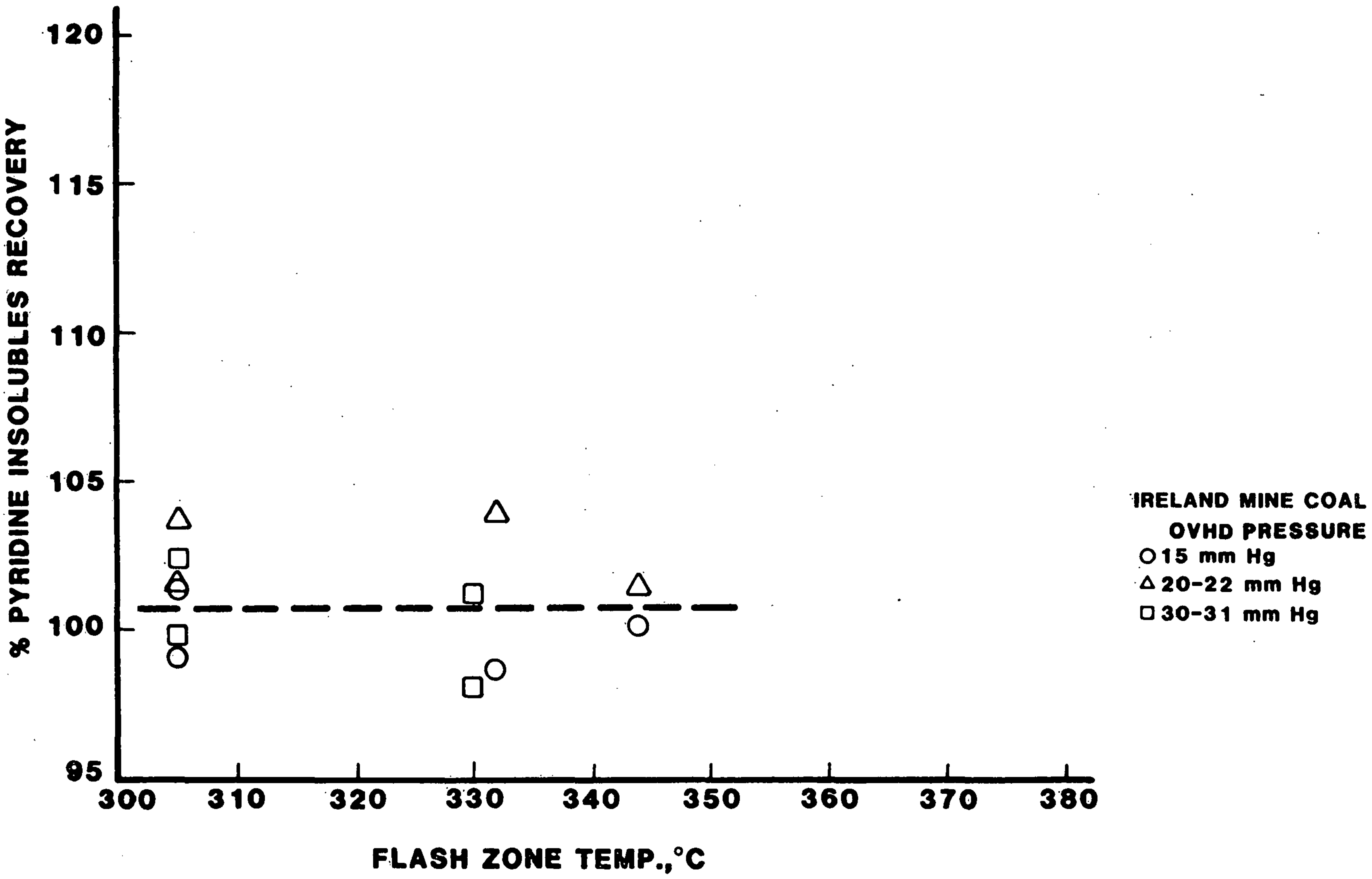


Figure 31

VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 63-4

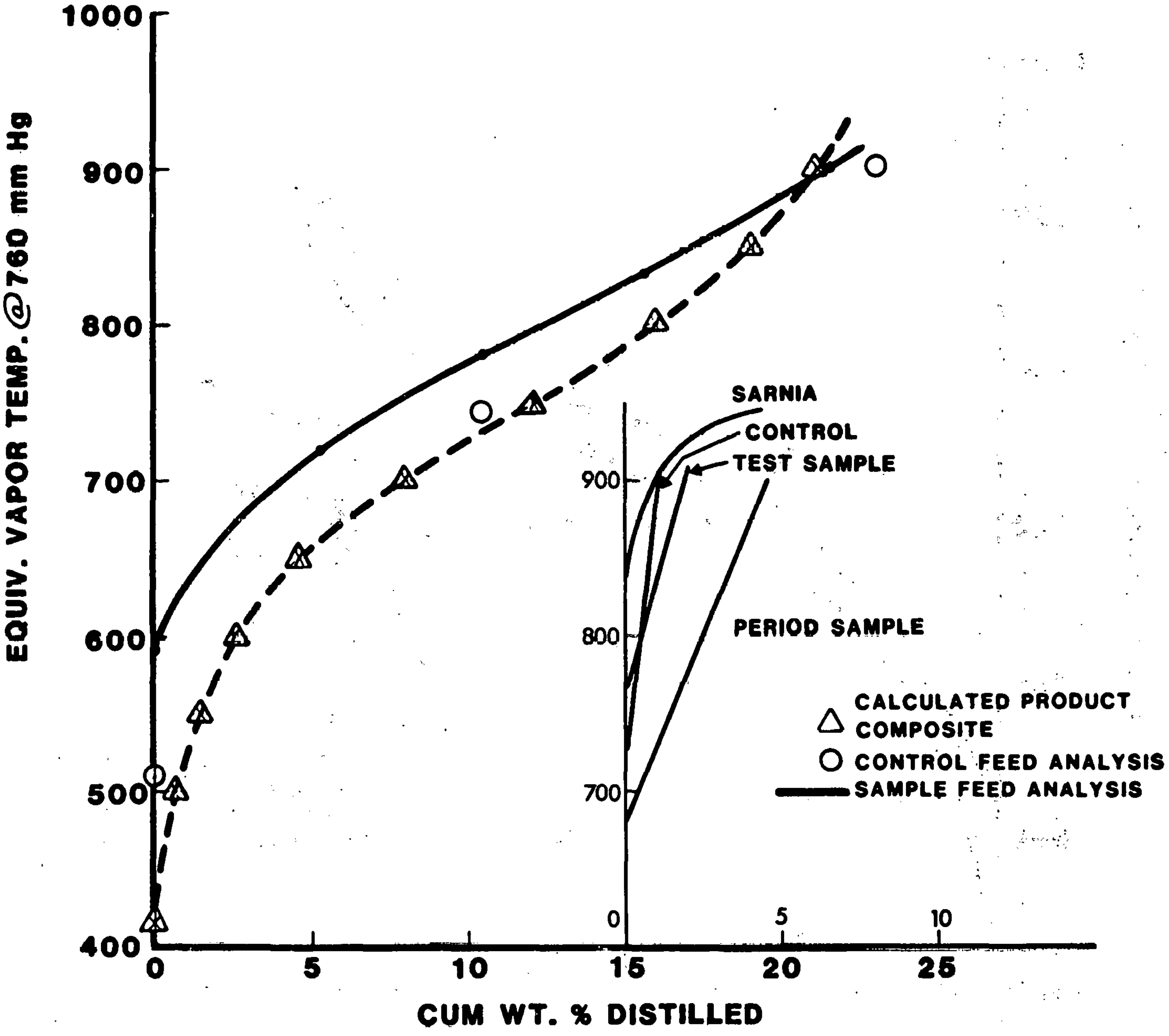


Figure 32
VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 63-2

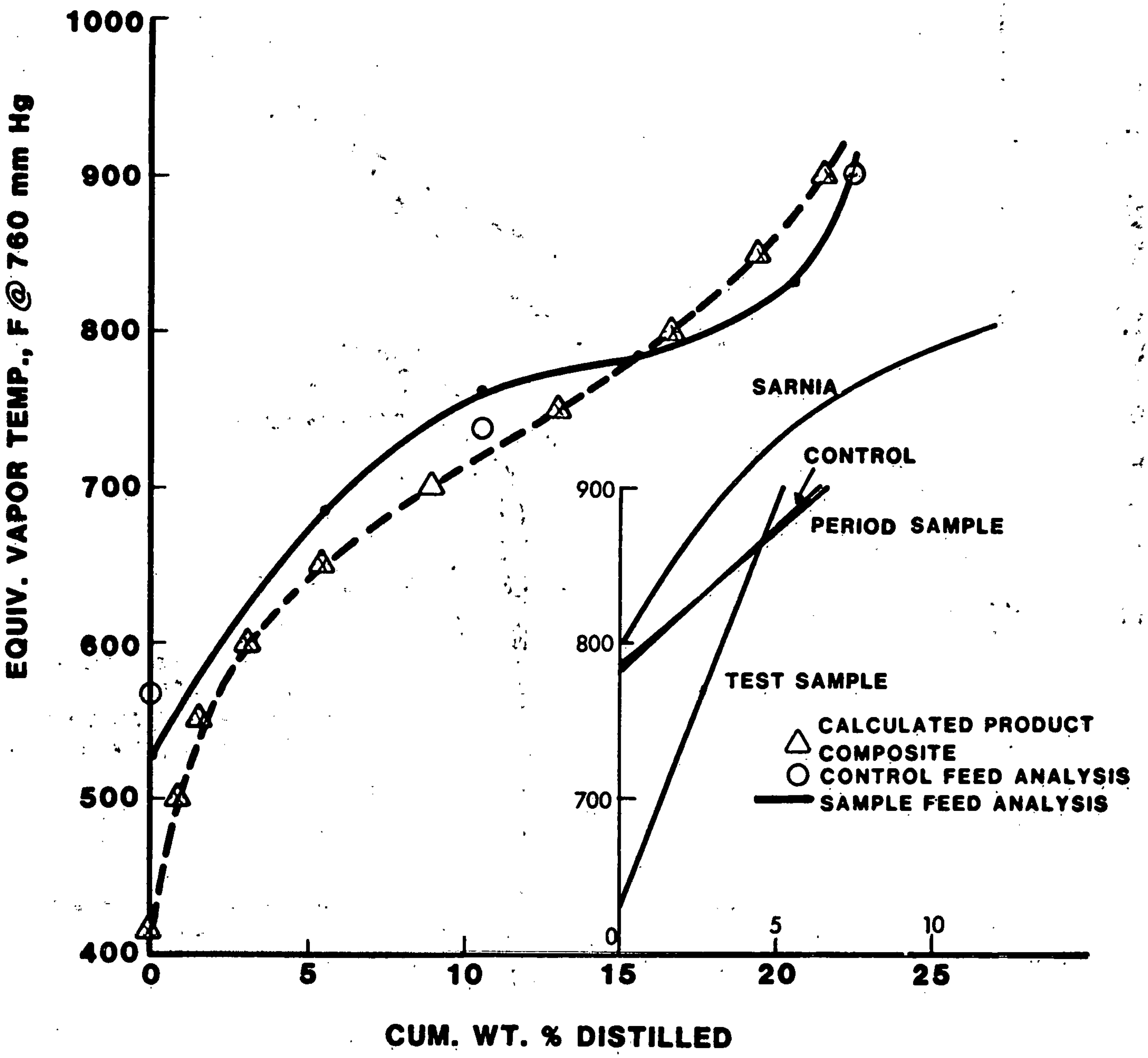


Figure 33
VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 63-6

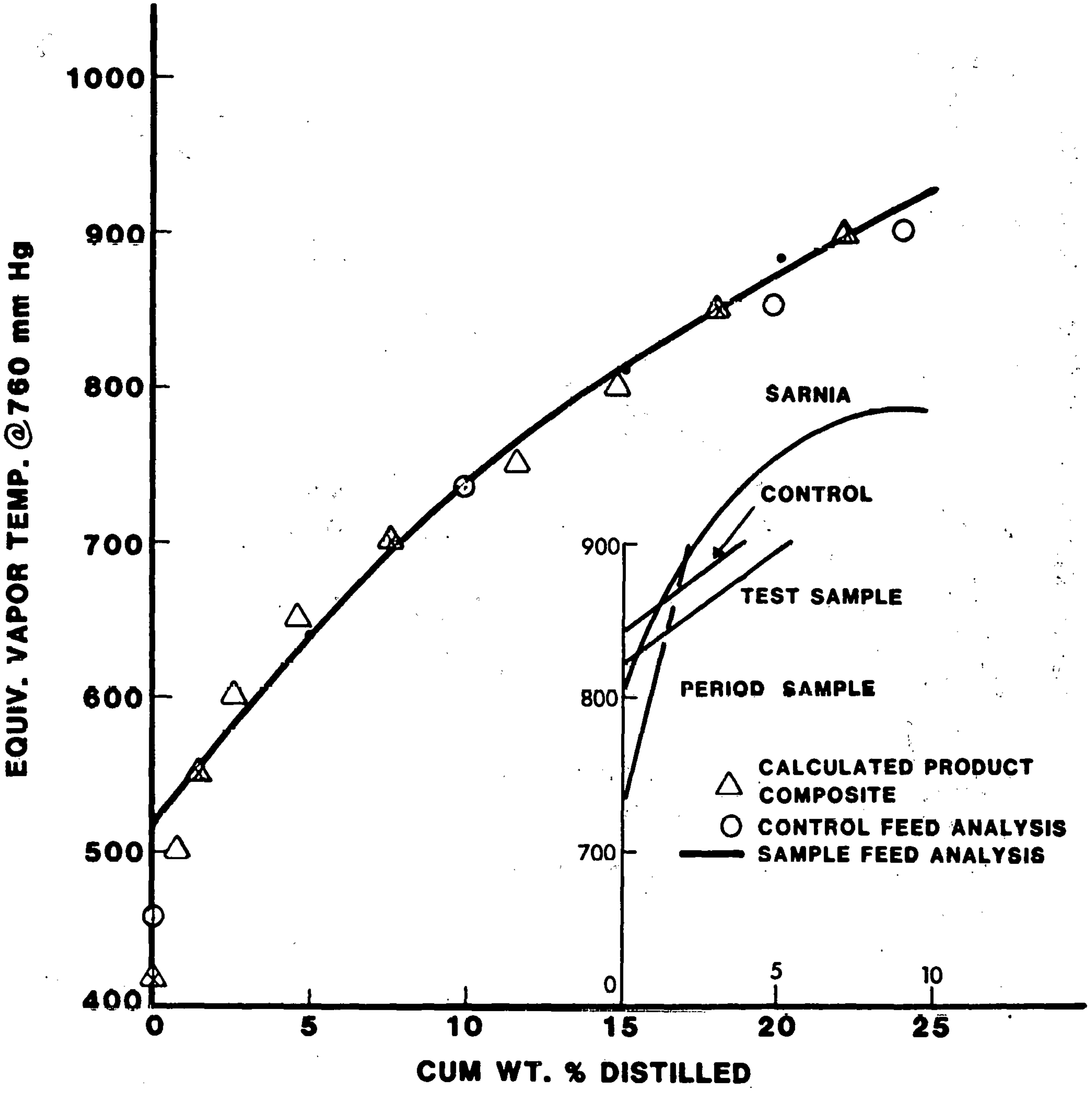


Figure 34
VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 67-0

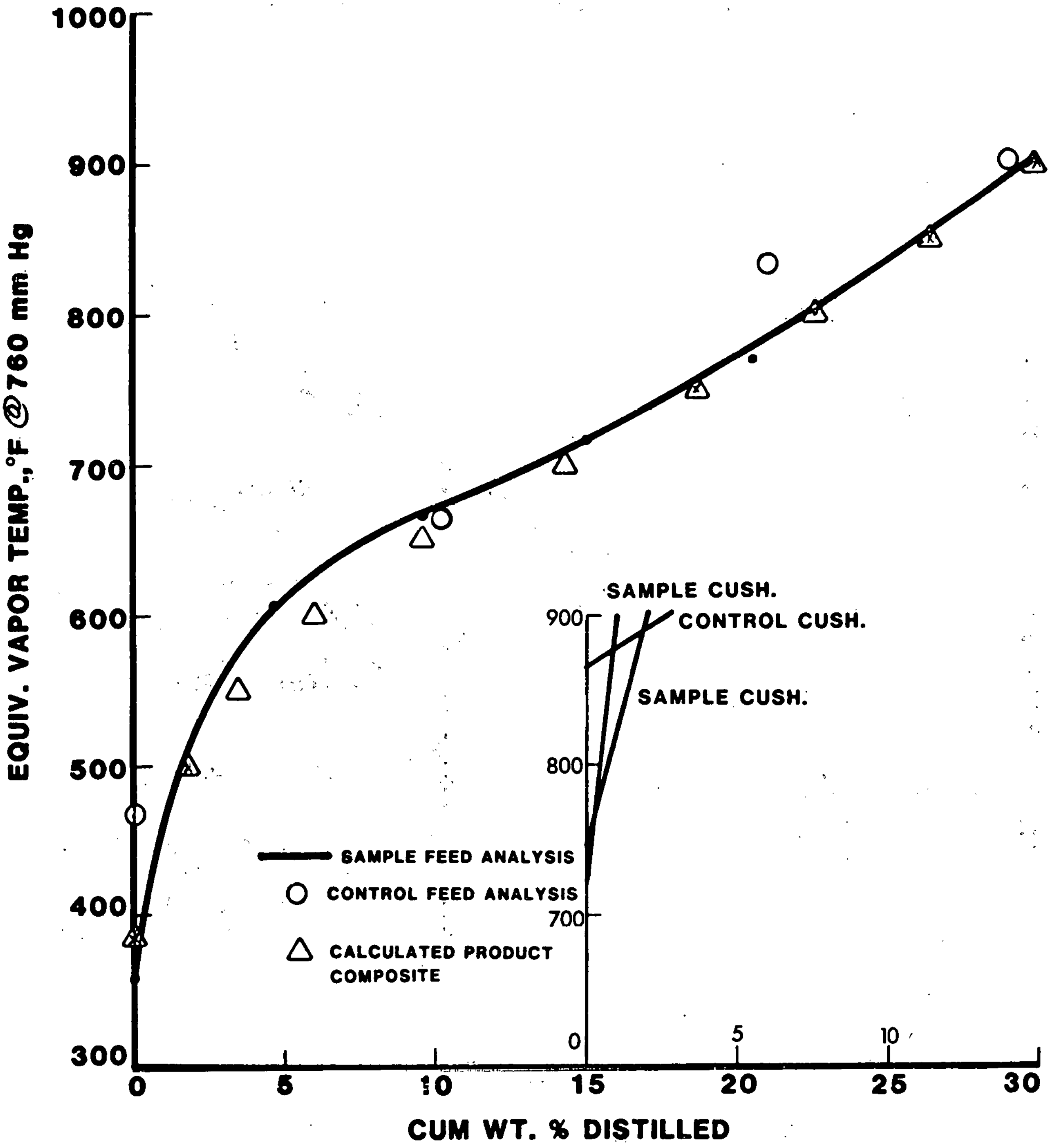


Figure 35
VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 68-5

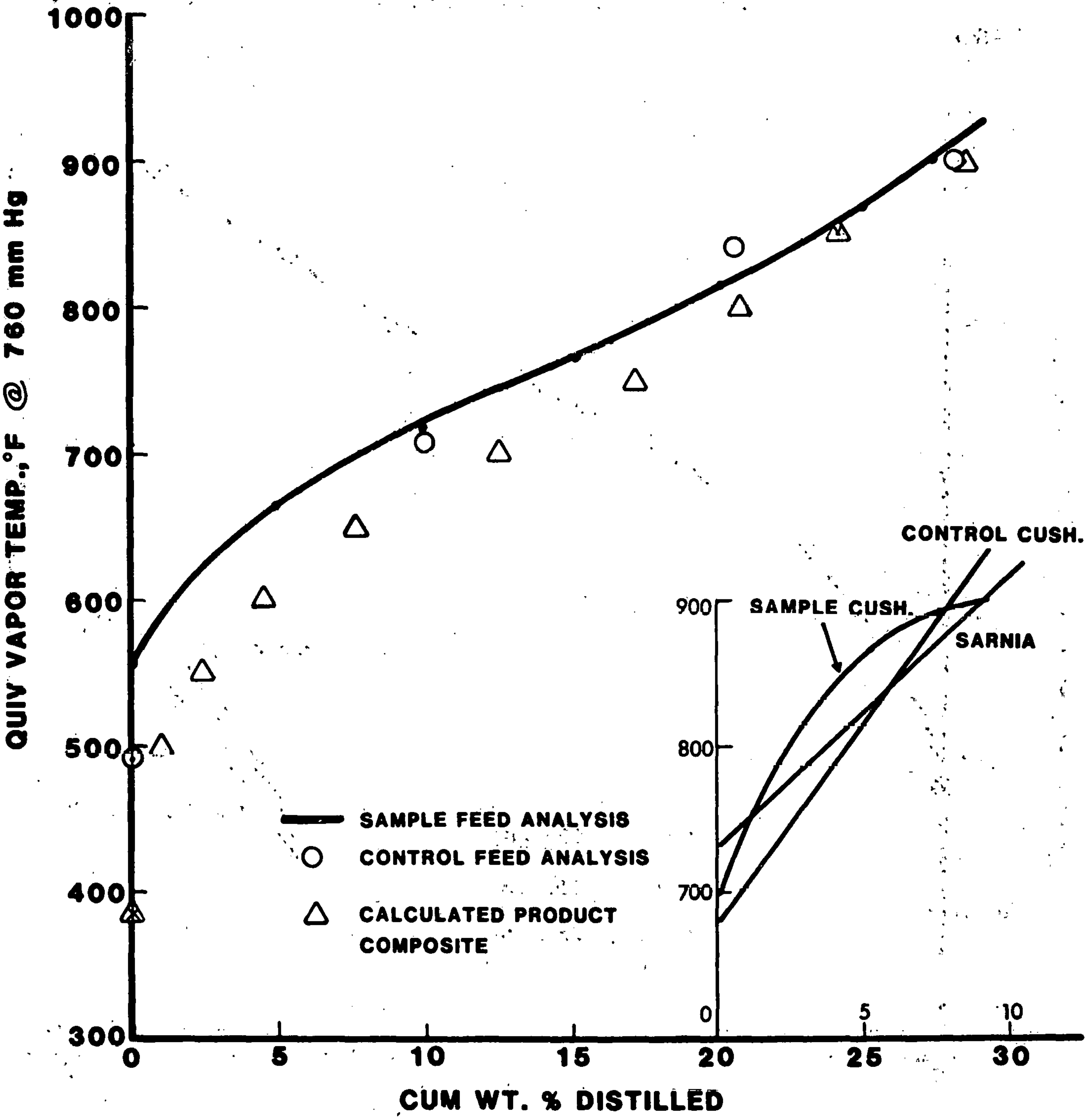


Figure 36

VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 69-2

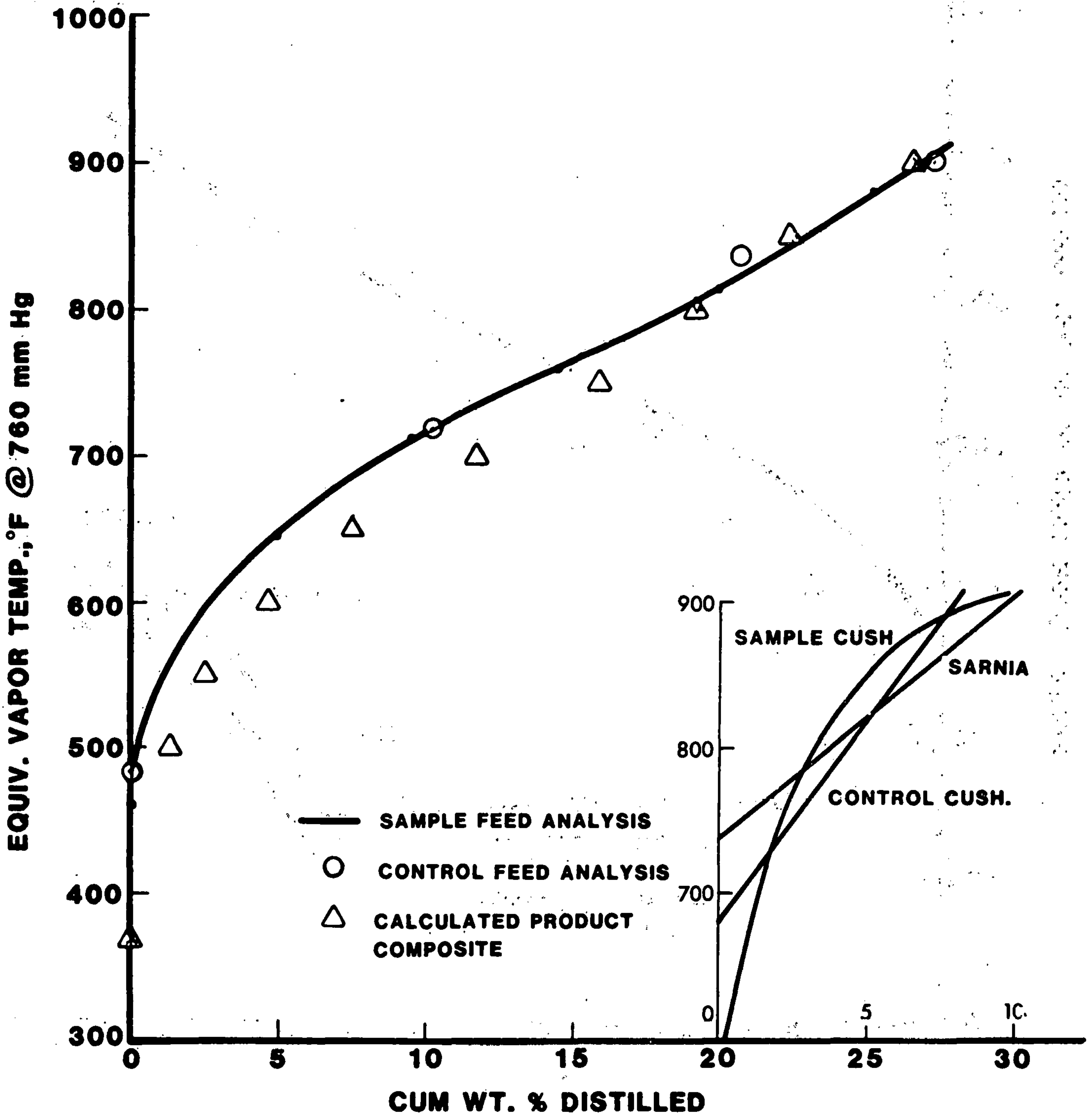


Figure 37

VACUUM COLUMN FEED AND BOTTOMS DISTILLATION ANALYSES, PERIOD 70-1

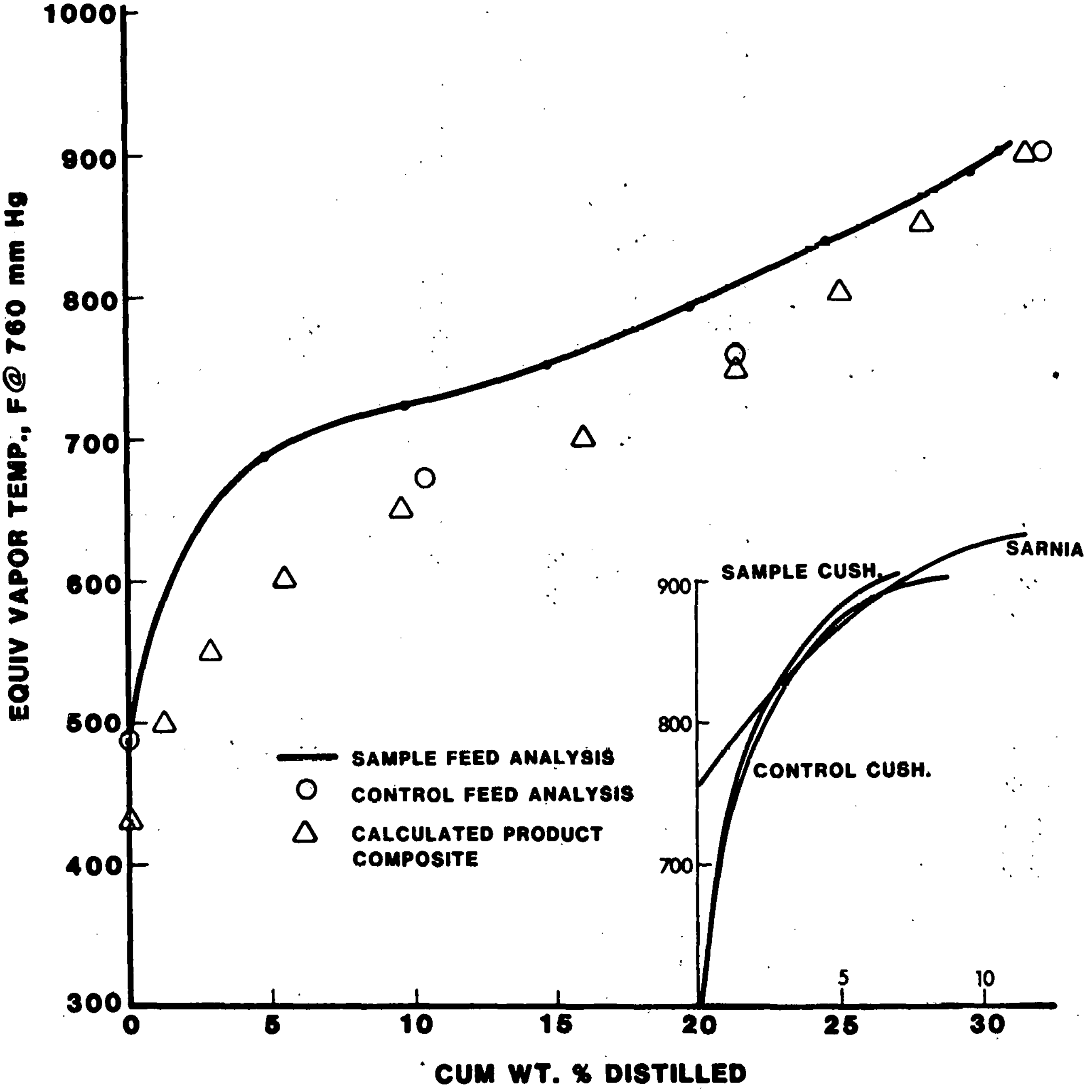


Figure 38
VACUUM COLUMN FEED AND BOTTOMS
DISTILLATION ANALYSES, PERIOD 70-6

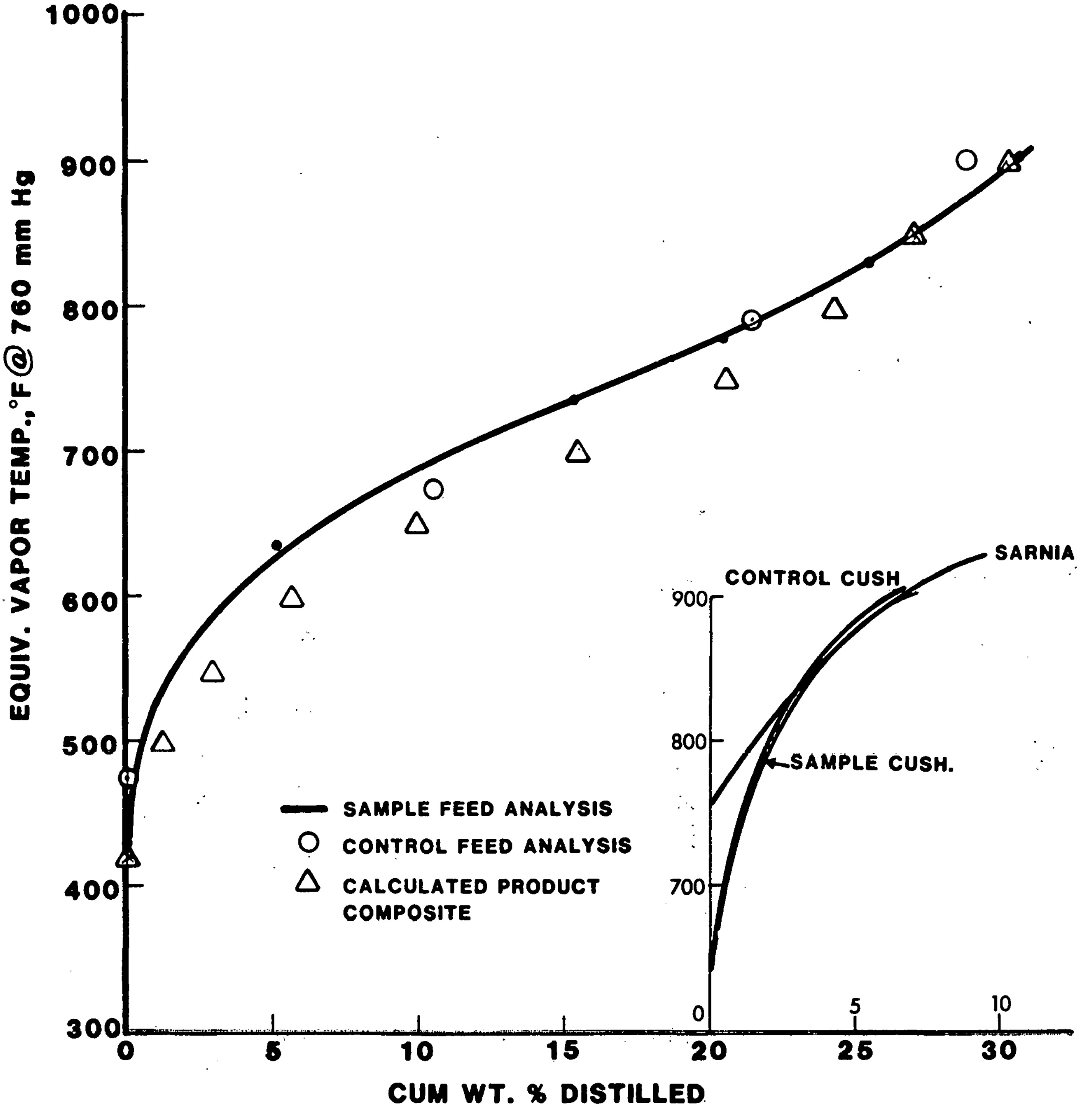


Figure 39

VACUUM COLUMN FEED AND BOTTOMS

DISTILLATION ANALYSES, PERIOD 71-2

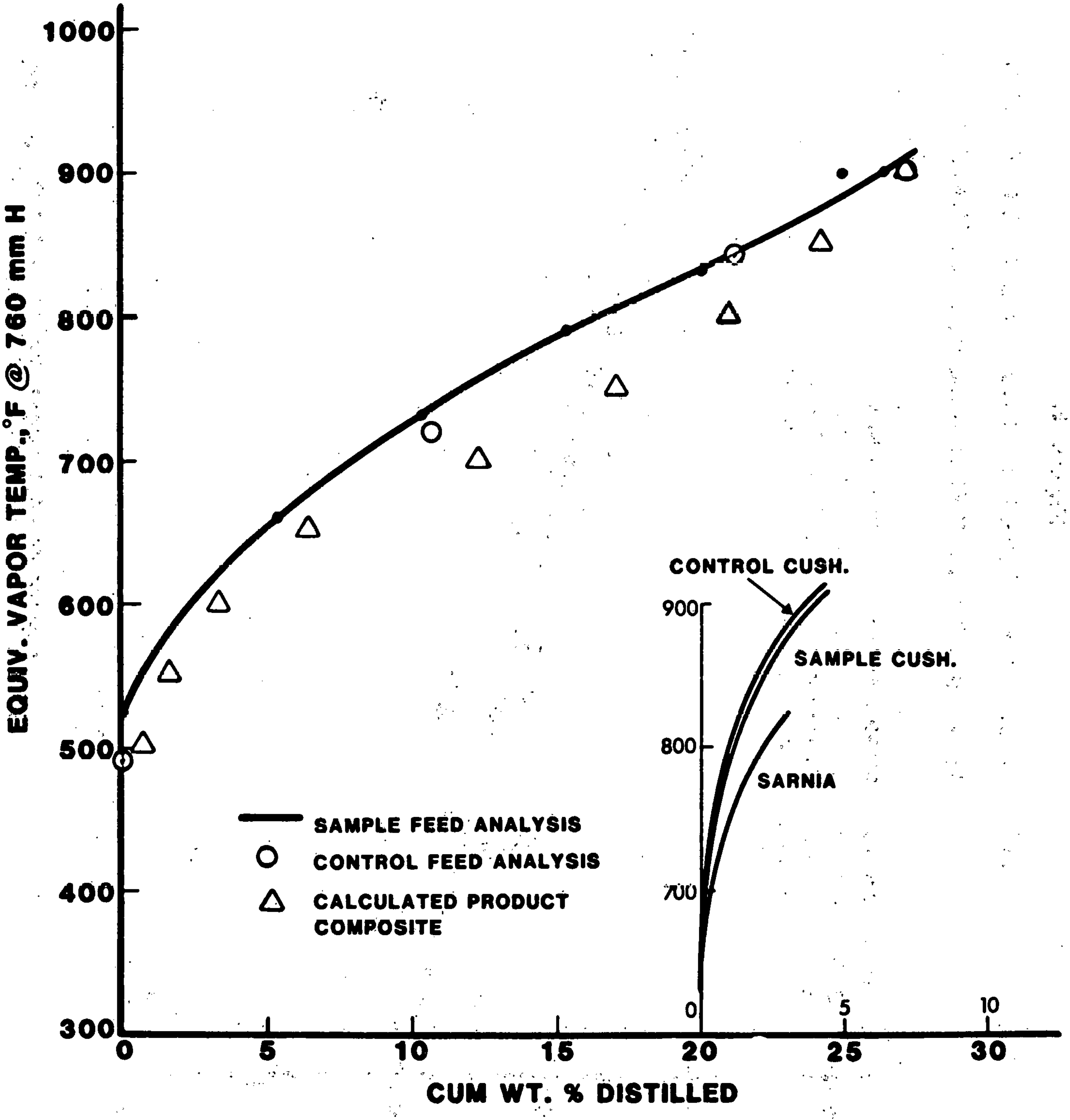


Figure 40

VACUUM COLU OVERHEAD PRODUCT SPECIFIC GRAVITY AS A FUNCTION OF FLASH ZONE TEMPERATURE

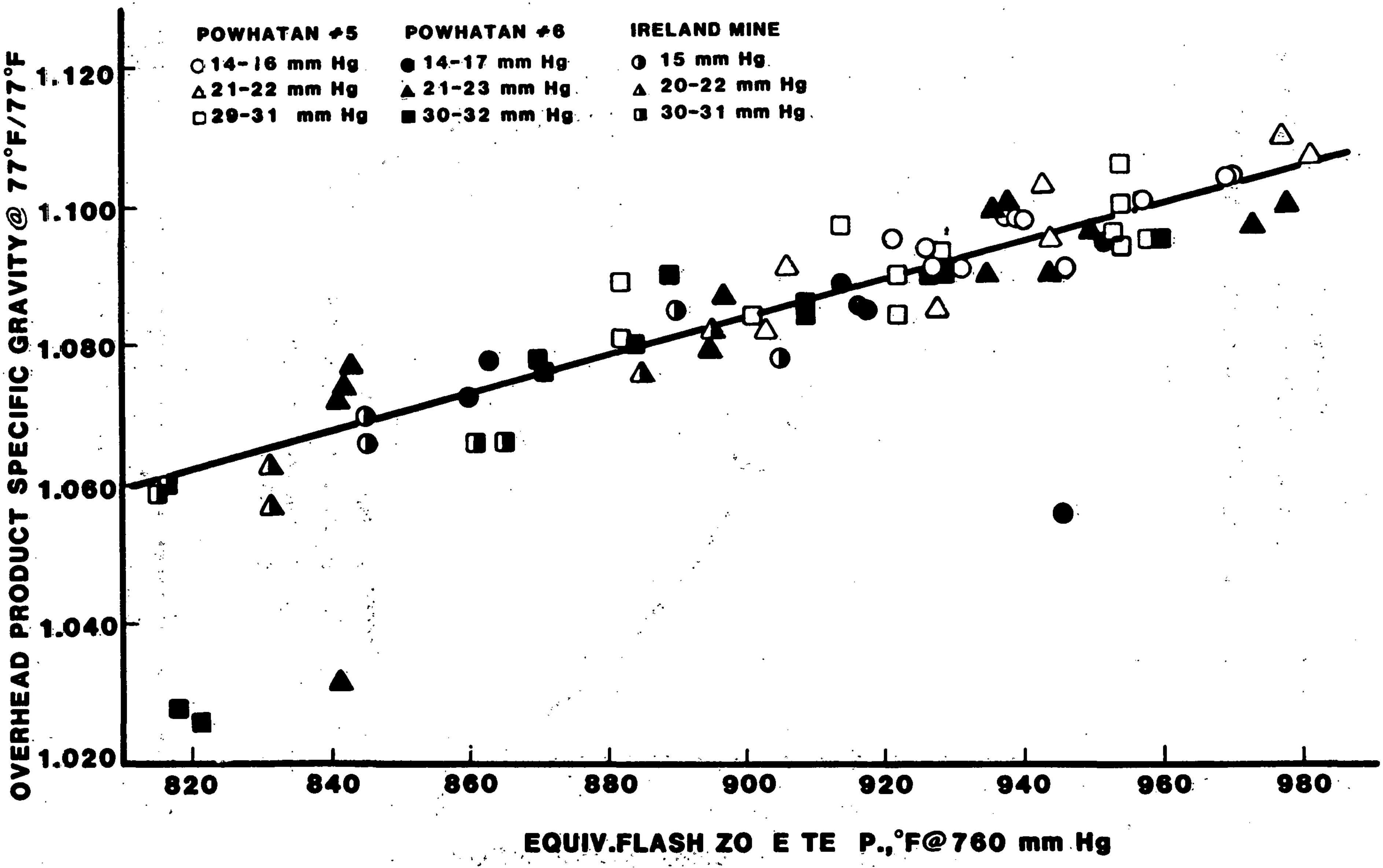


Figure 41

EFFECT OF DISTILLATE CONTENT ON VACUUM COLUMN BOTTOMS FUSION TEMPERATURE, POWHATAN #5 COAL

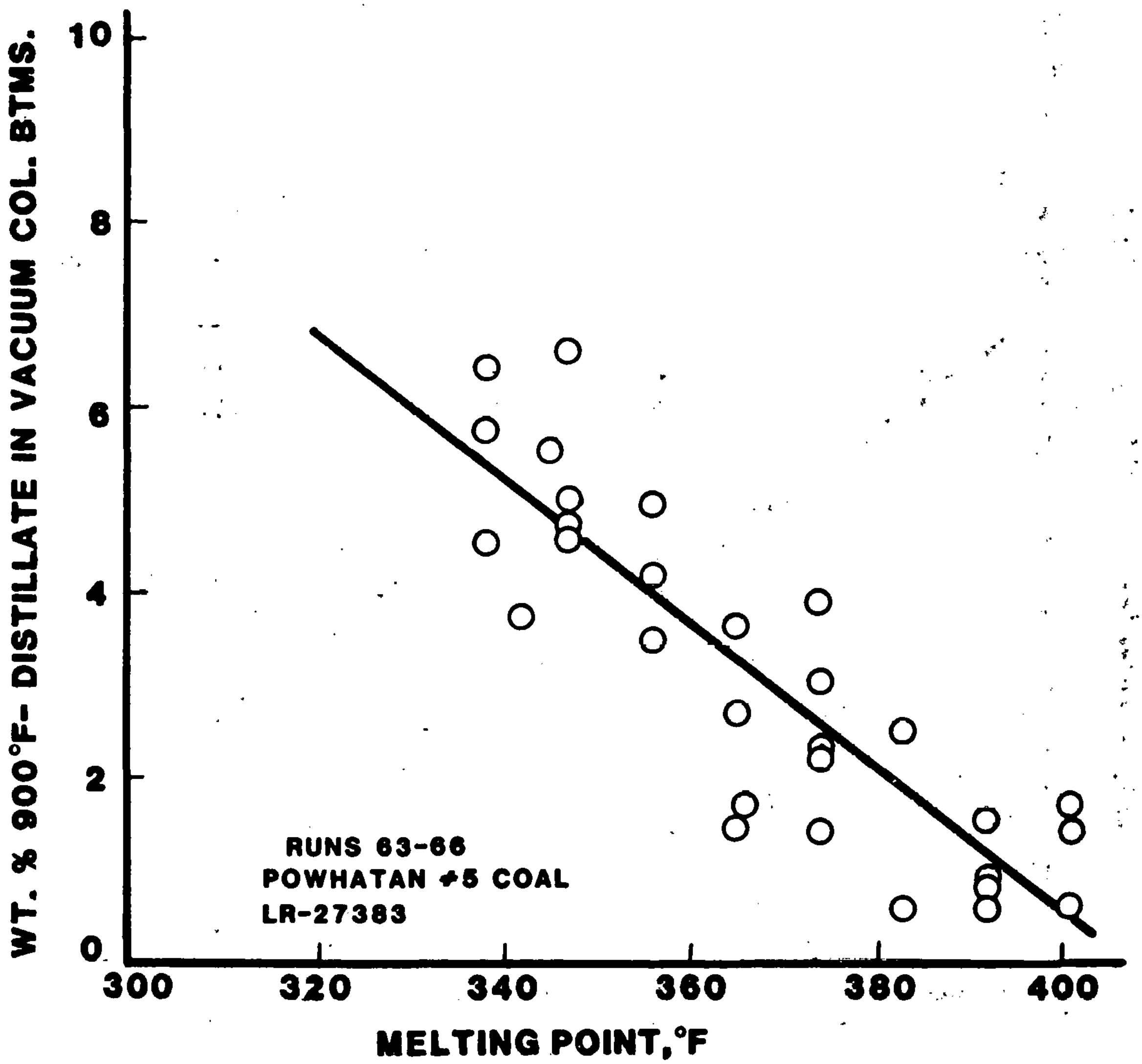


Figure 42

EFFECT OF DISTILLATE CONTENT ON VACUUM COLUMN BOTTOMS FUSION TEMPERATURE, POWHATAN #6 COAL

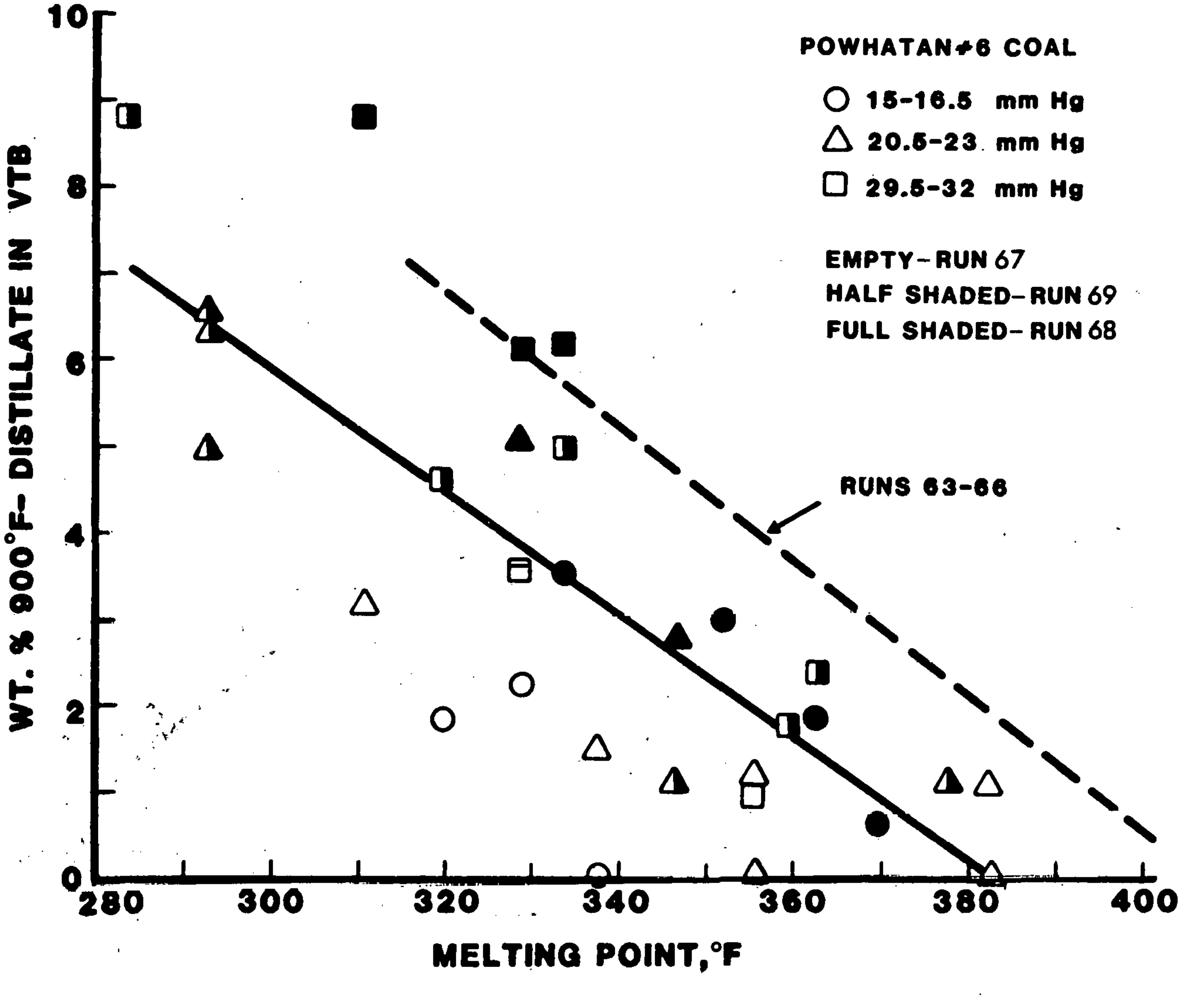


Figure 43

EFFECT OF DISTILLATE CONTENT ON VACUUM BOTTOMS FUSION TEMPERATURE, IRELAND MINE COAL

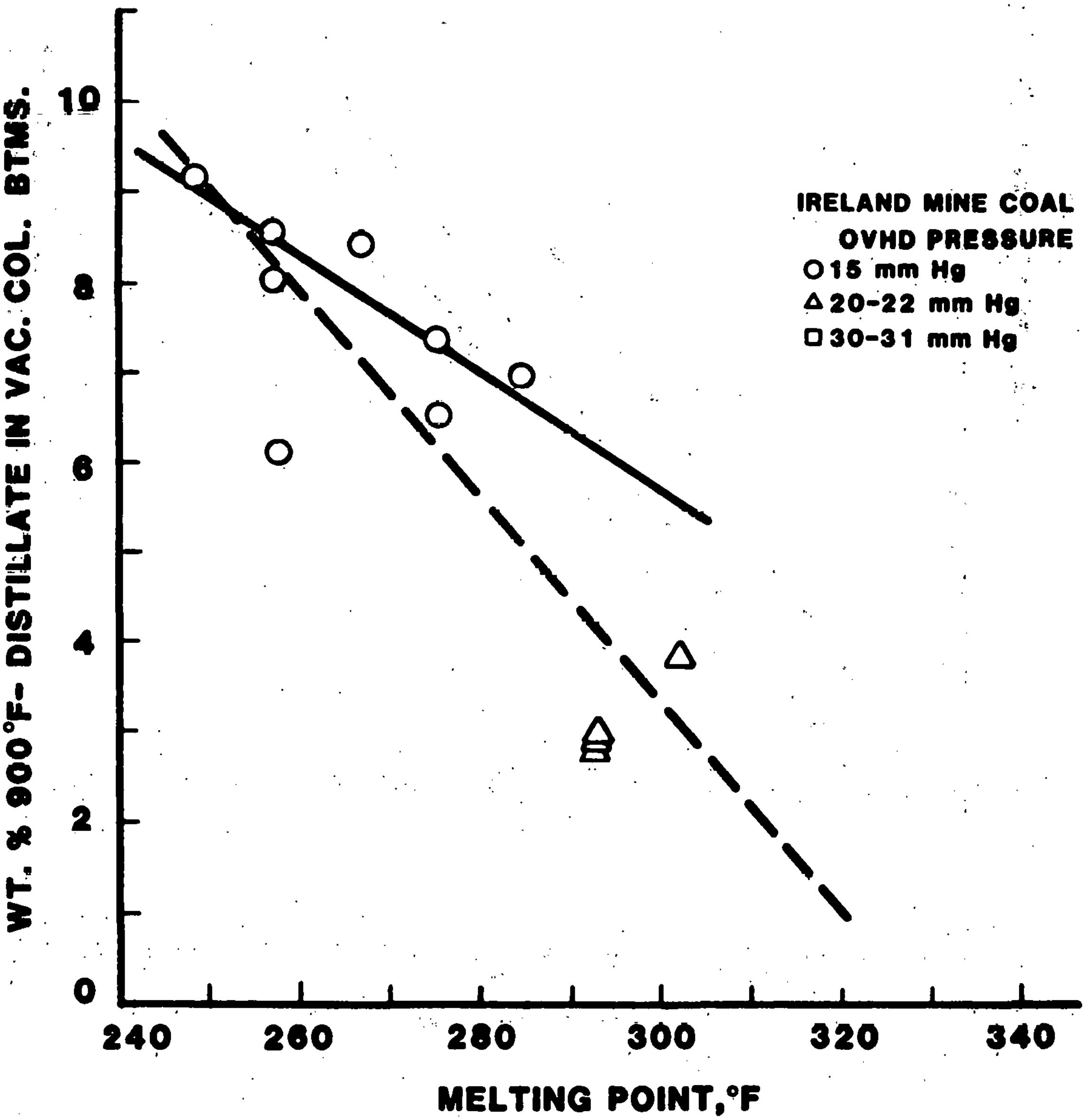


FIGURE 44

P99 - 63-2 VACUUM TOWER BOTTOMS

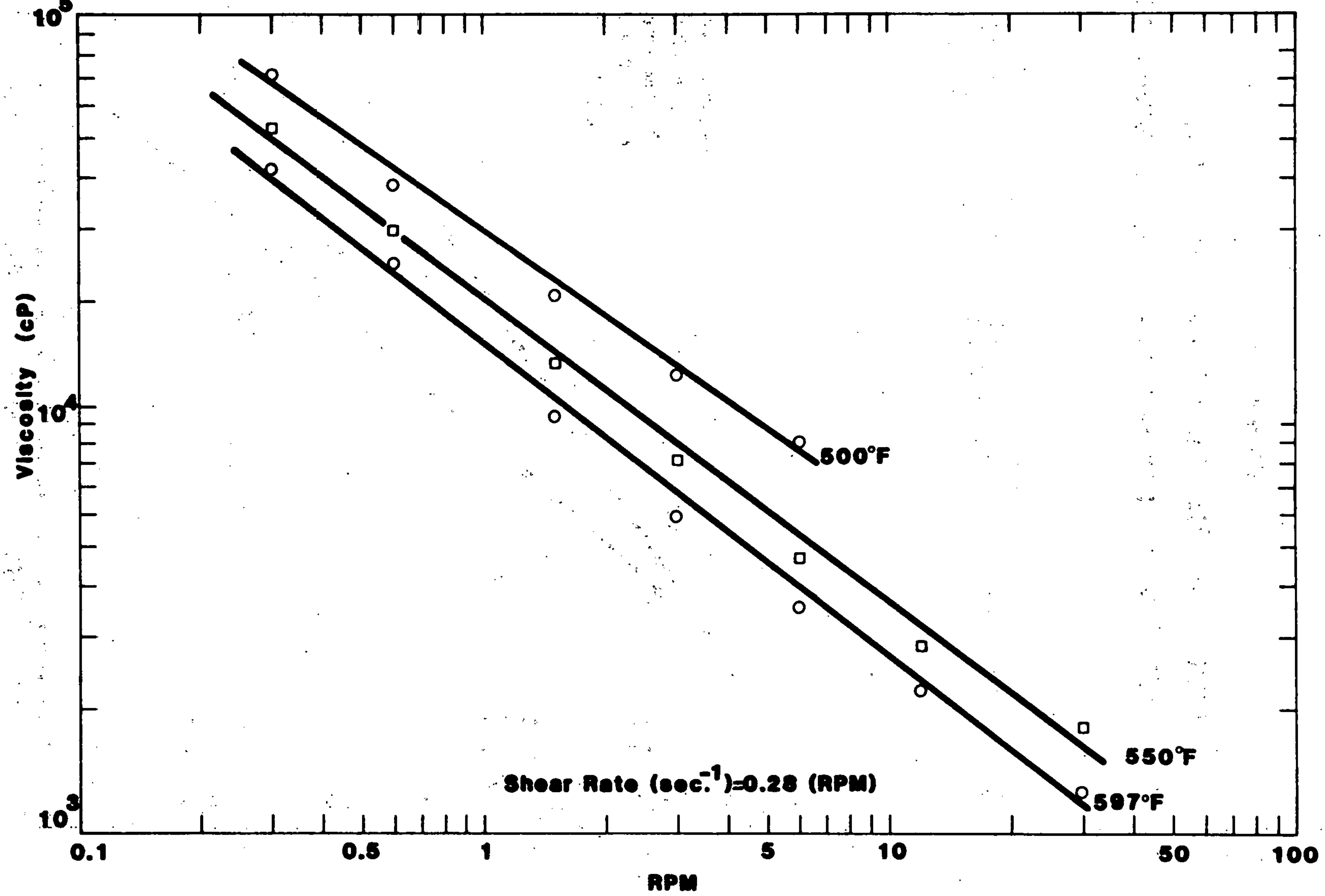
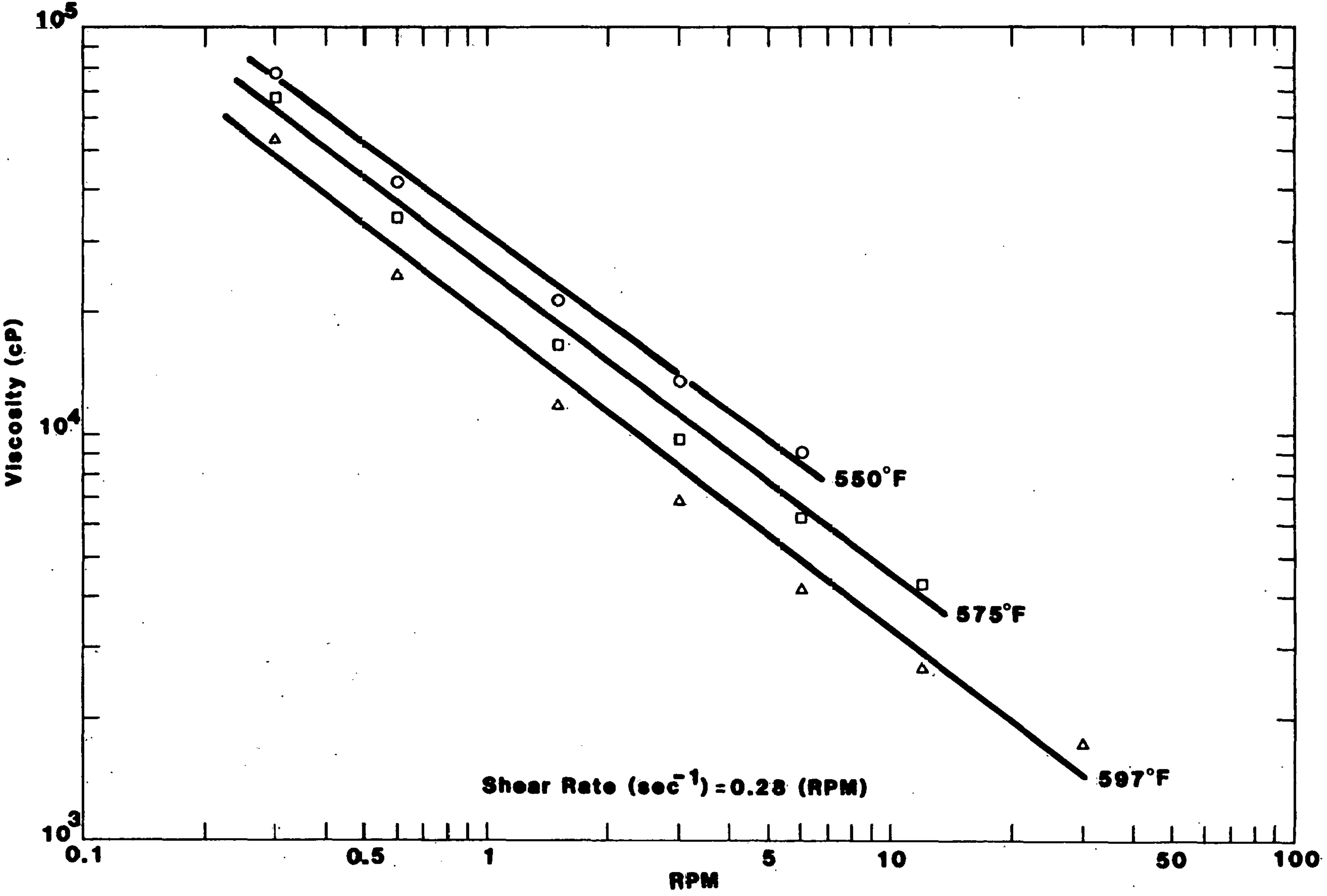


FIGURE 45

P99-63-5 VACUUM TOWER BOTTOMS



Shear Rate (sec^{-1}) = 0.28 (RPM)

FIGURE 46

P99-64-2 VACUUM TOWER BOTTOMS

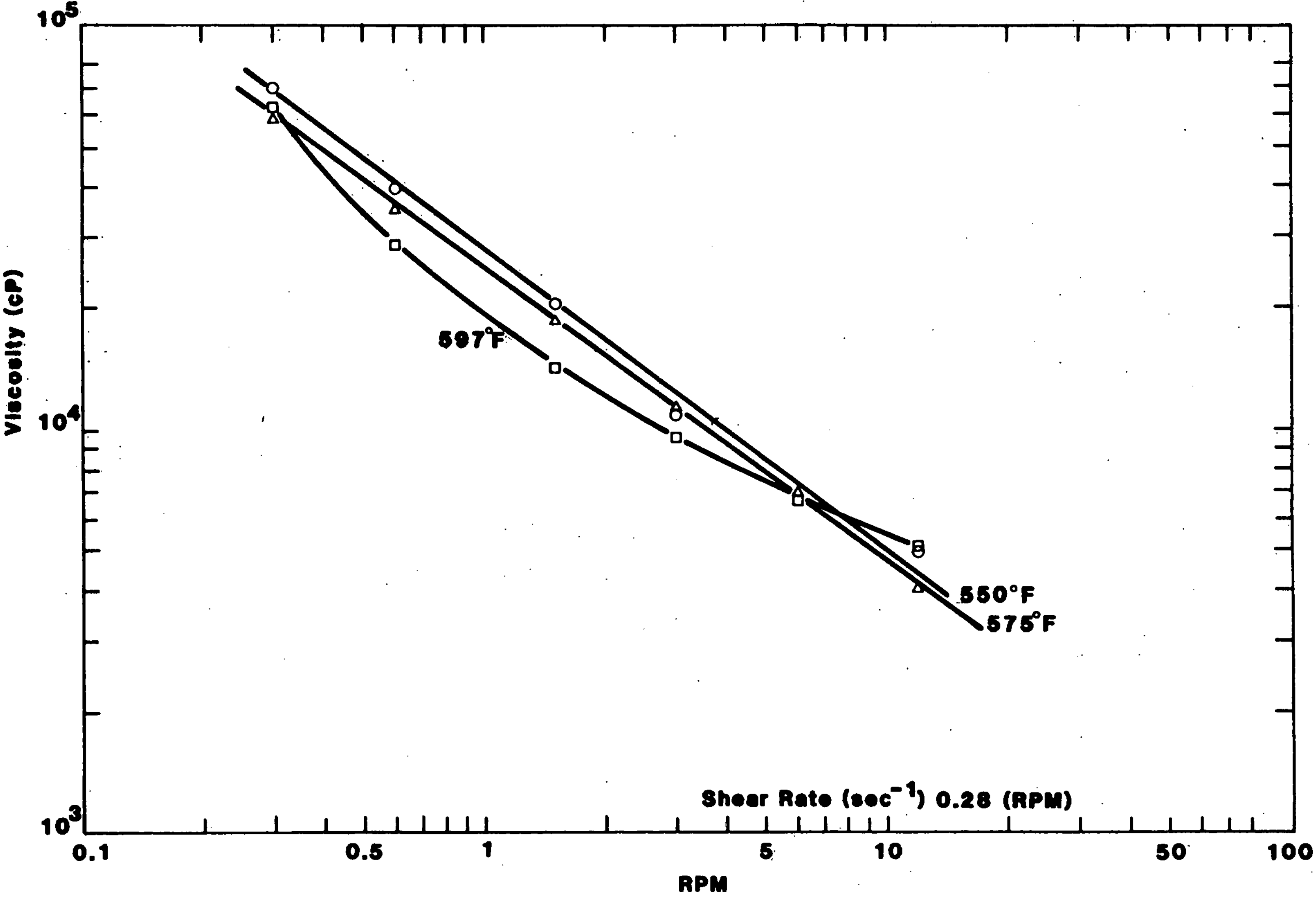


FIGURE 47

F99-64-5 VACUUM TOWER BOTTOMS

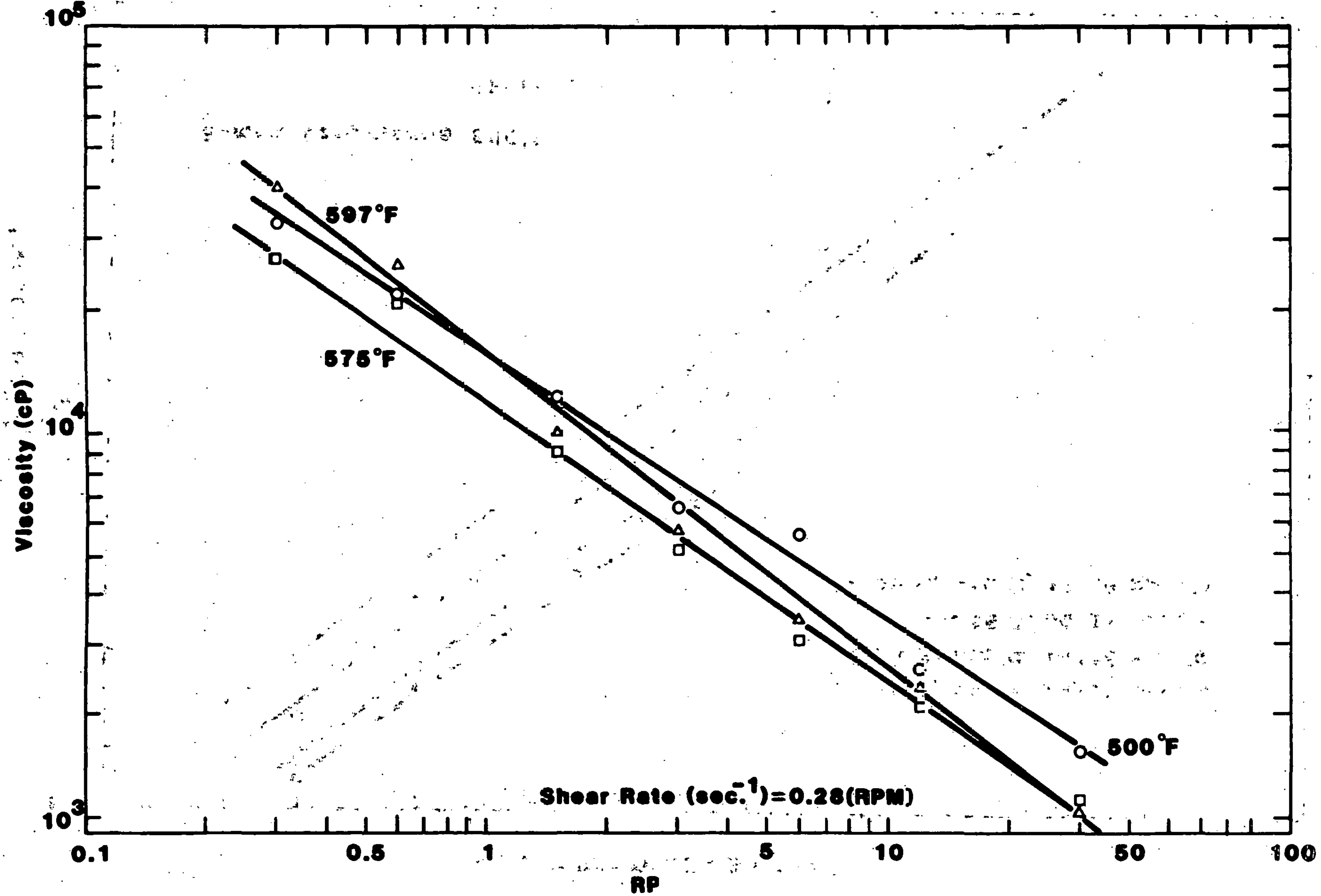


FIGURE 48

P-65 VACUUM TOWER BOTTOMS

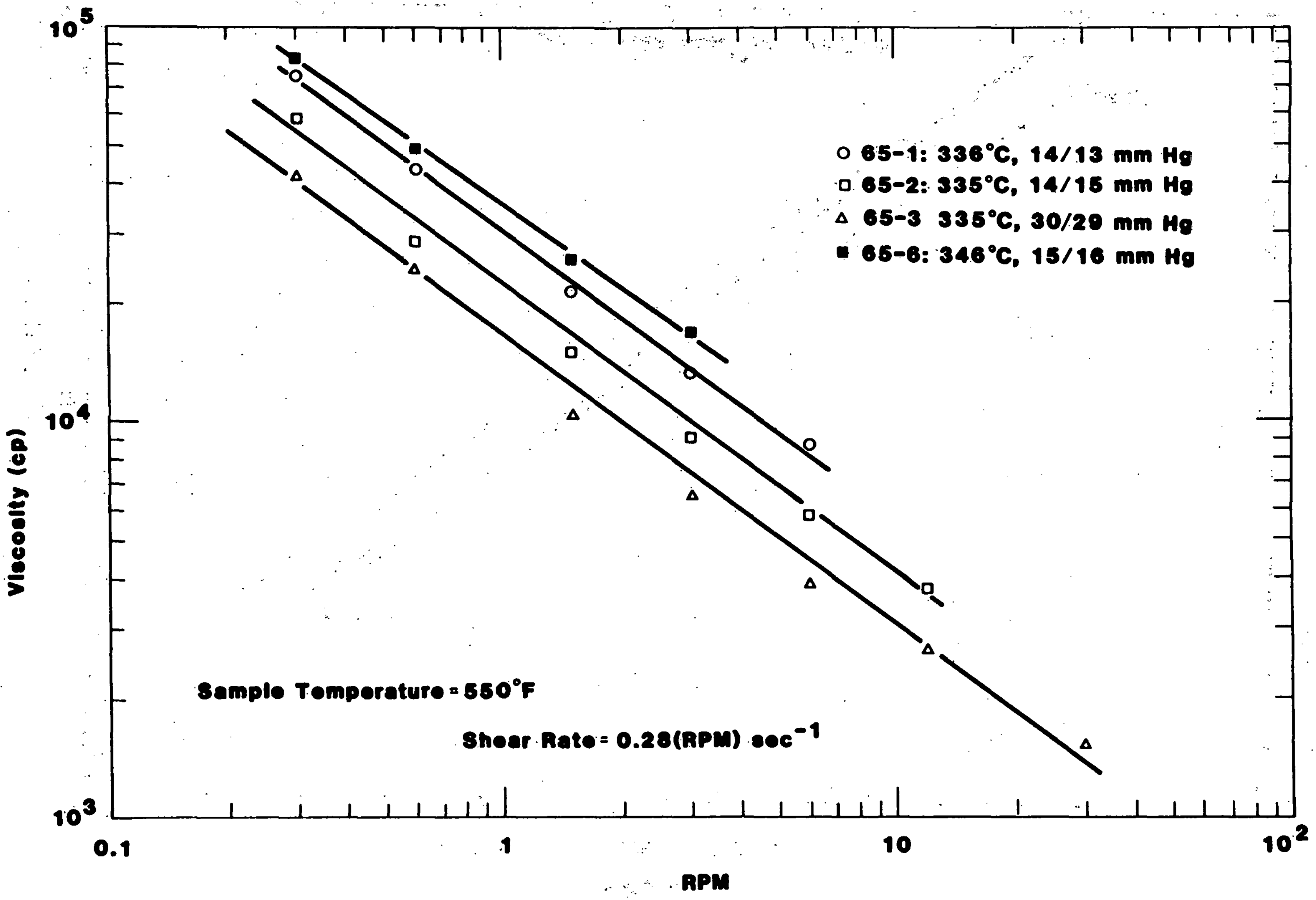


FIGURE 49

P-66 VACUUM TOWER BOTTOMS

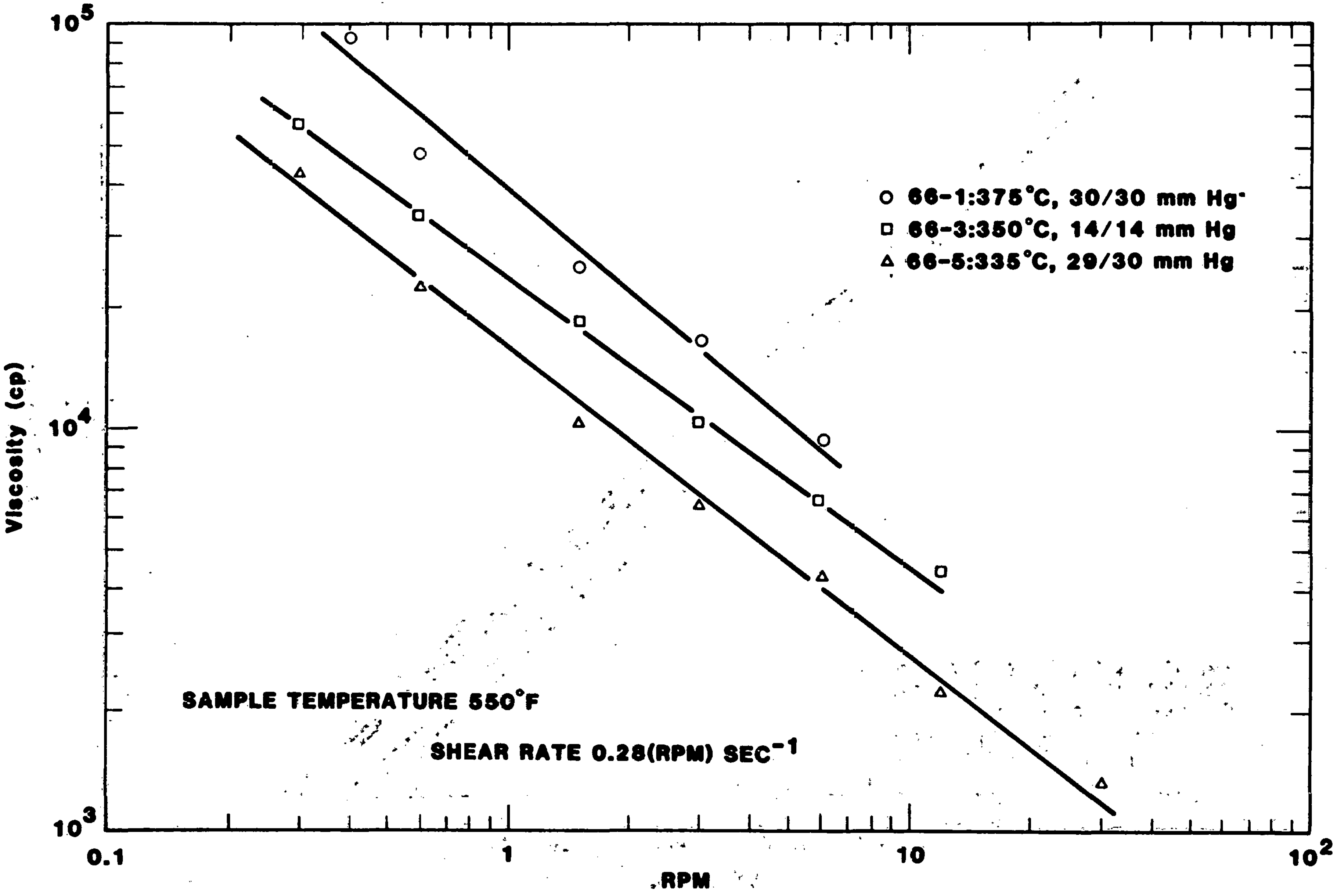


FIGURE 50

P99-67 VACUUM TOWER BOTTOMS

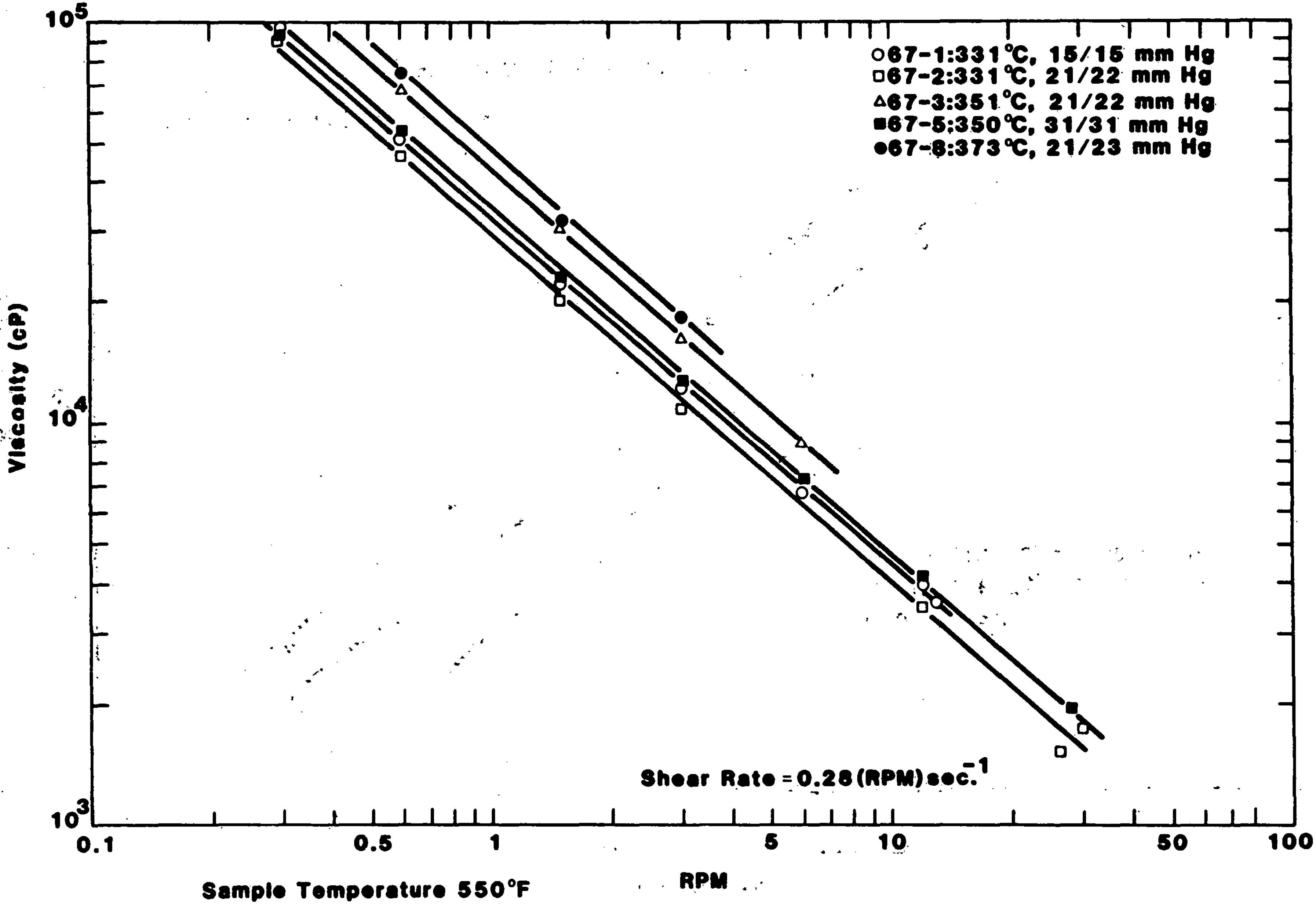
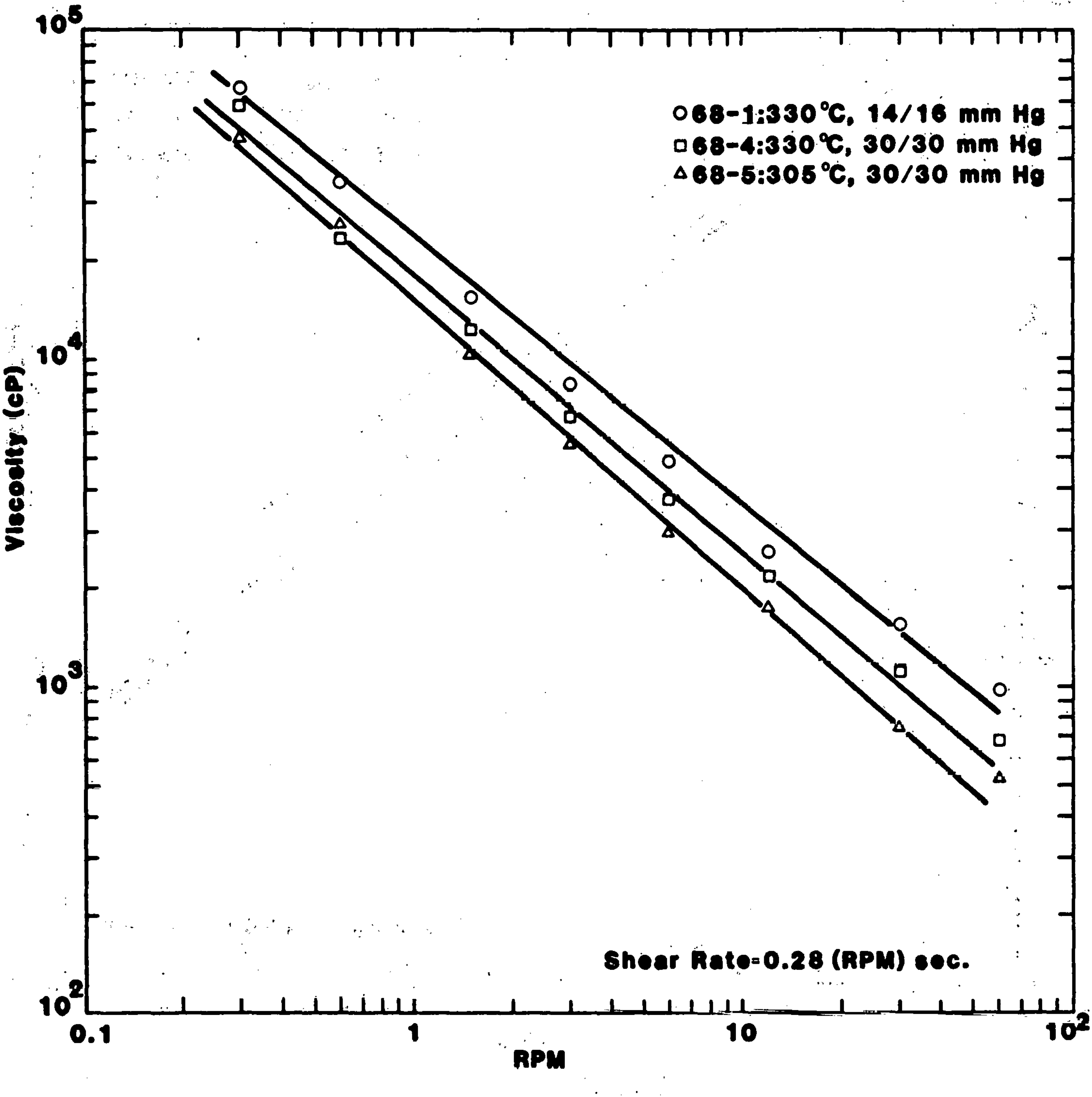


FIGURE 51

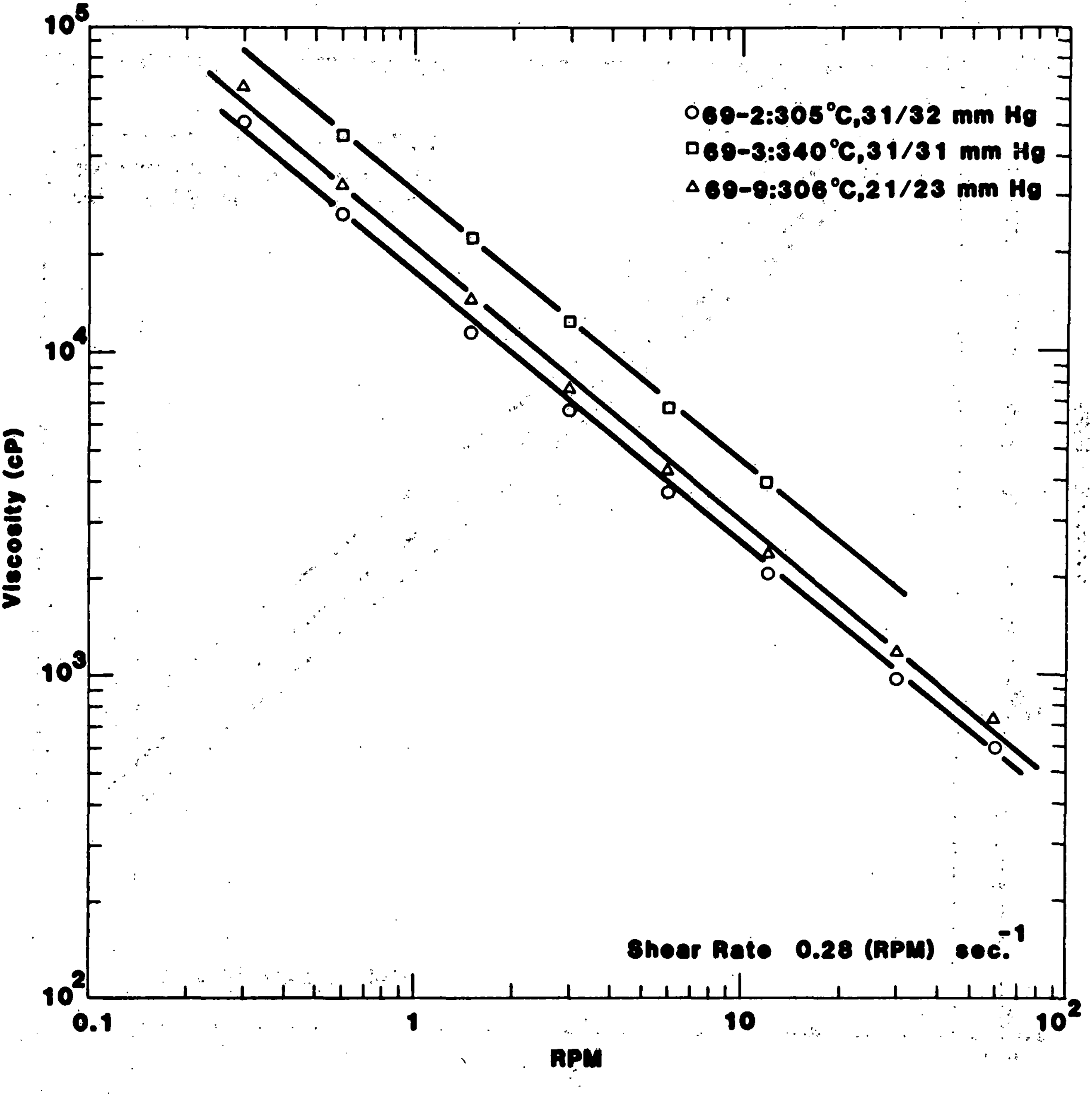
P99-68 VACUUM TOWER BOTTOMS



Sample Temperature 550 F

FIGURE 52

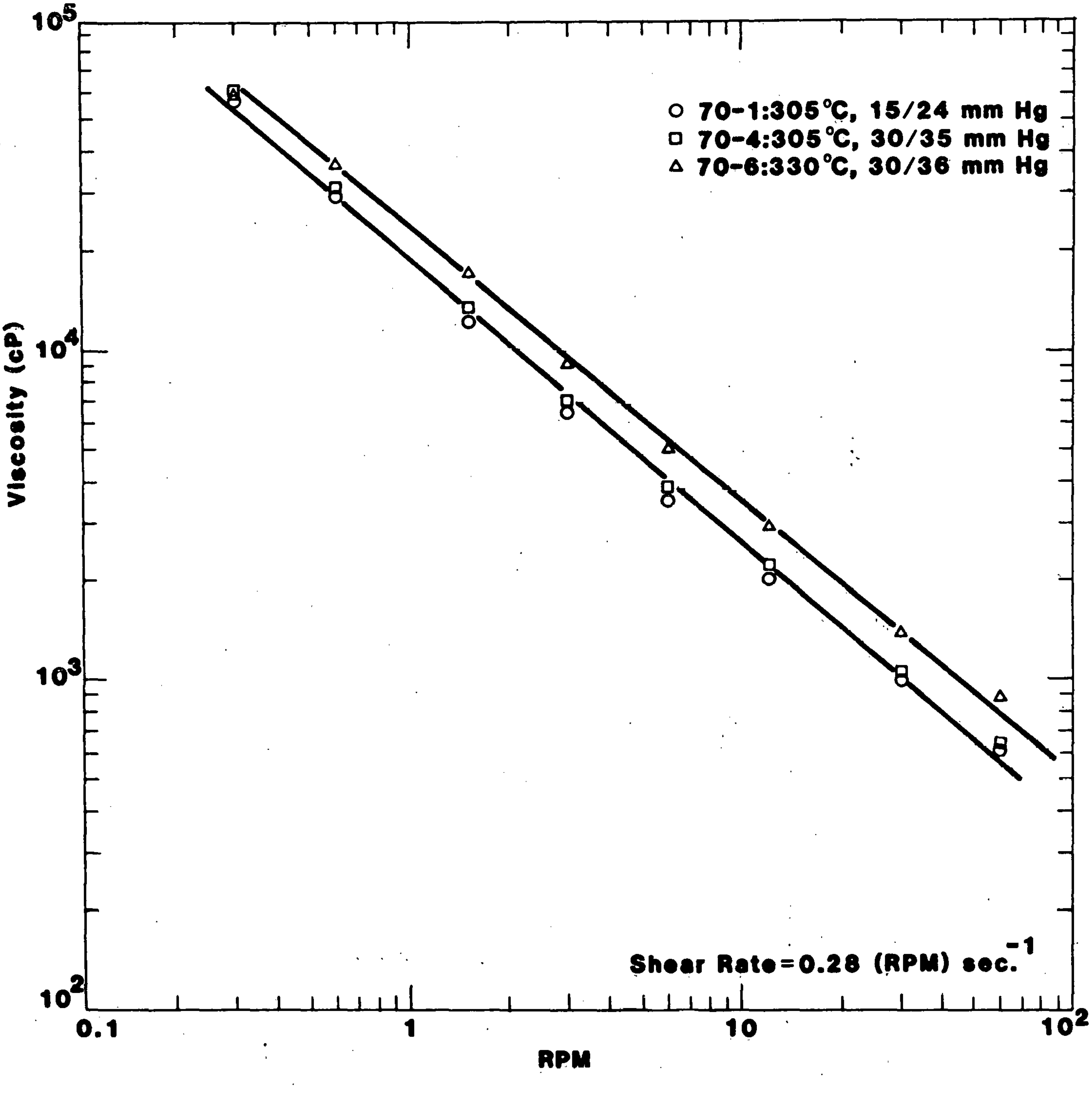
P99-69 VACUUM TOWER BOTTOMS



Sample Temperature 550°F

FIGURE 53

P99-70 VACCUM TOWER BOTTOMS



Sample Temperature 550 F

FIGURE 54 P99-63

VACUUM TOWER BOTTOMS (CONSTANT SHEAR RATE 0.168 sec^{-1})

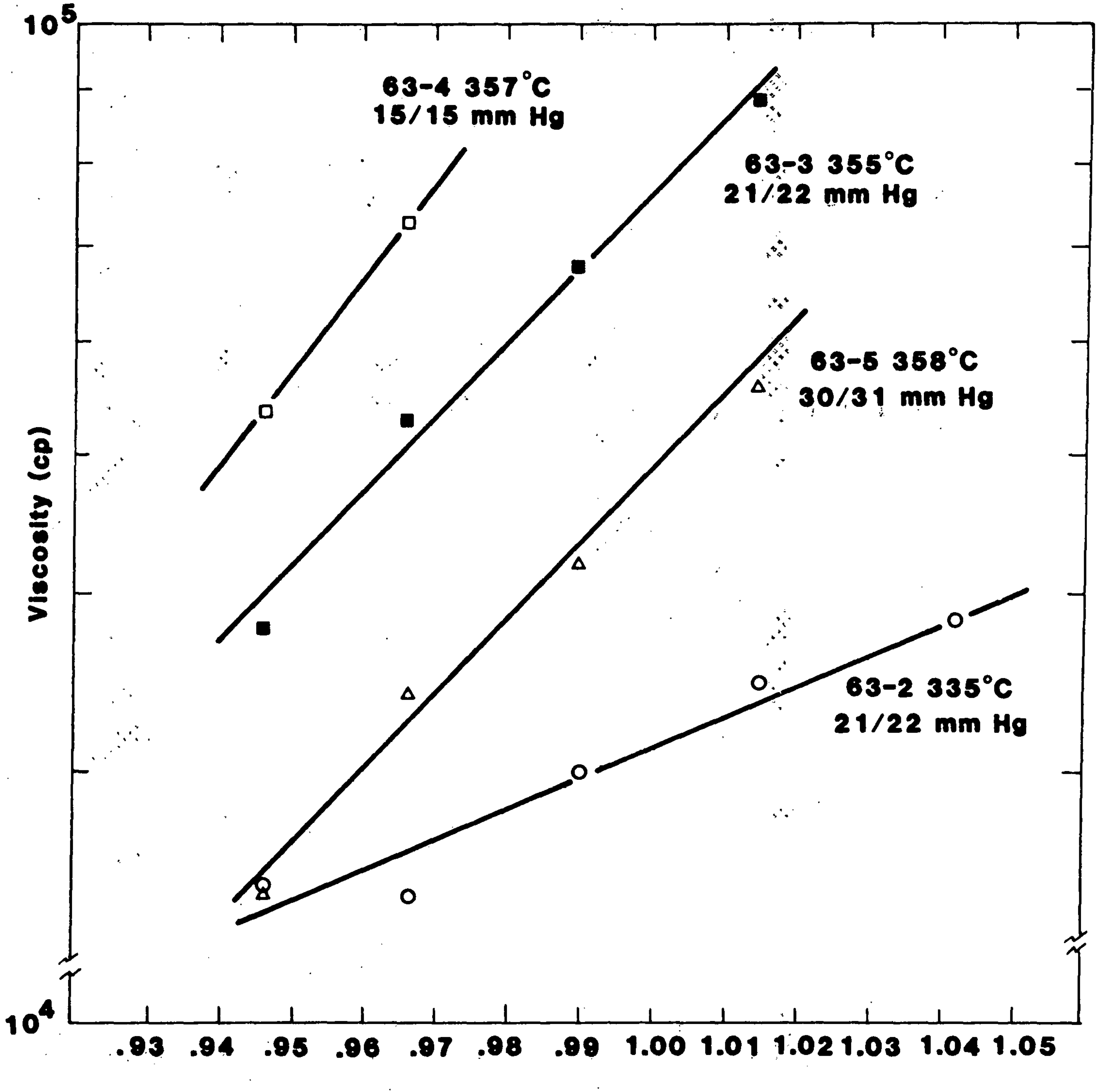


FIGURE 55

P99-63-2 VACUUM TOWER OVERHEAD

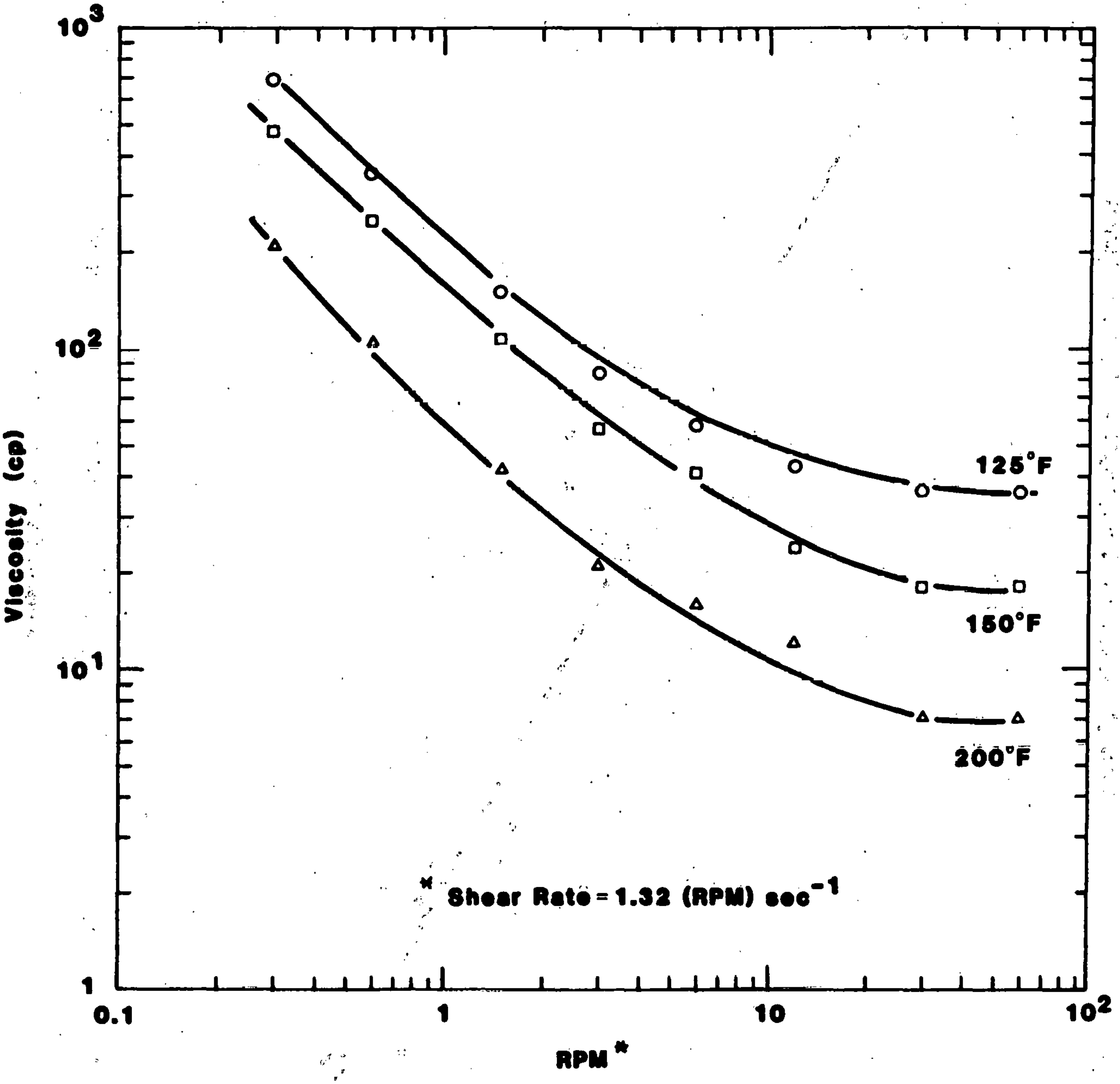


FIGURE 56

PARITY PLOT FOR VISCOSITY PREDICTIONS

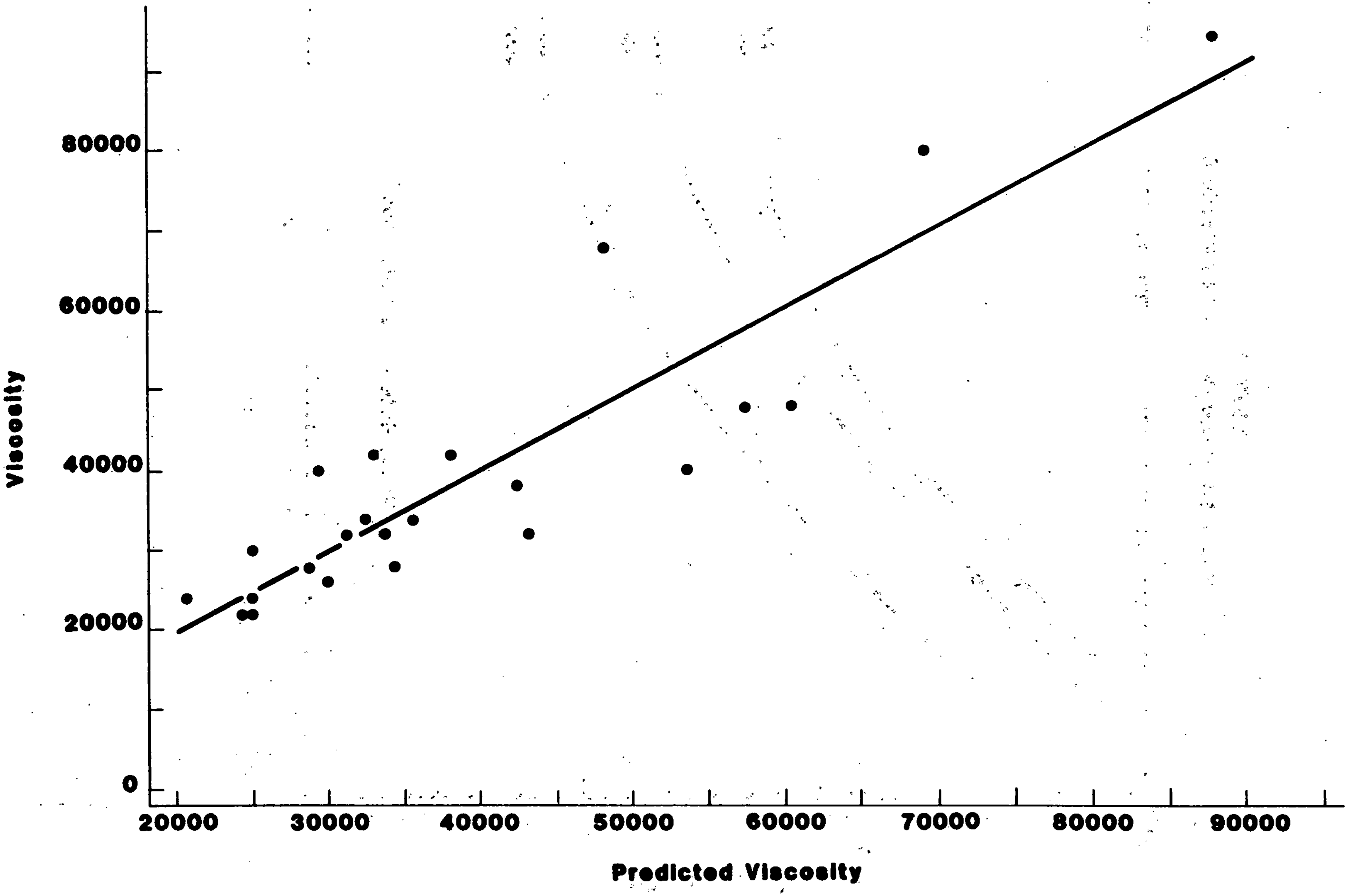


FIGURE 57

PARITY PLOT FOR VISCOSITY PREDICTIONS

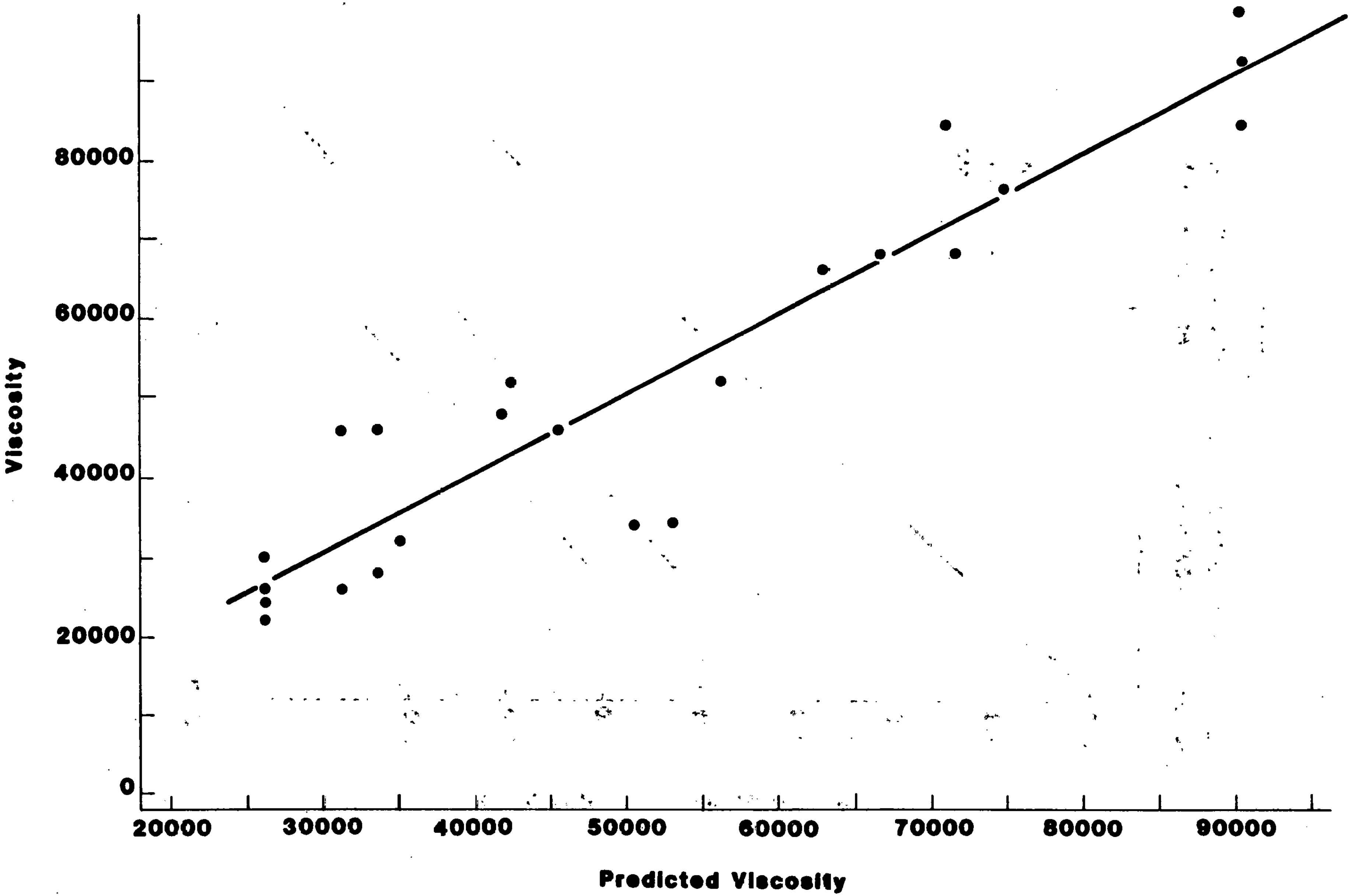


FIGURE 58

VISCOSITY CORRECTED VACUUM BOTTOMS DISTILLATE CONTENT VS. FLASH ZONE TEMPERATUQE AND PRESSURE, POWHATAN #6 COAL

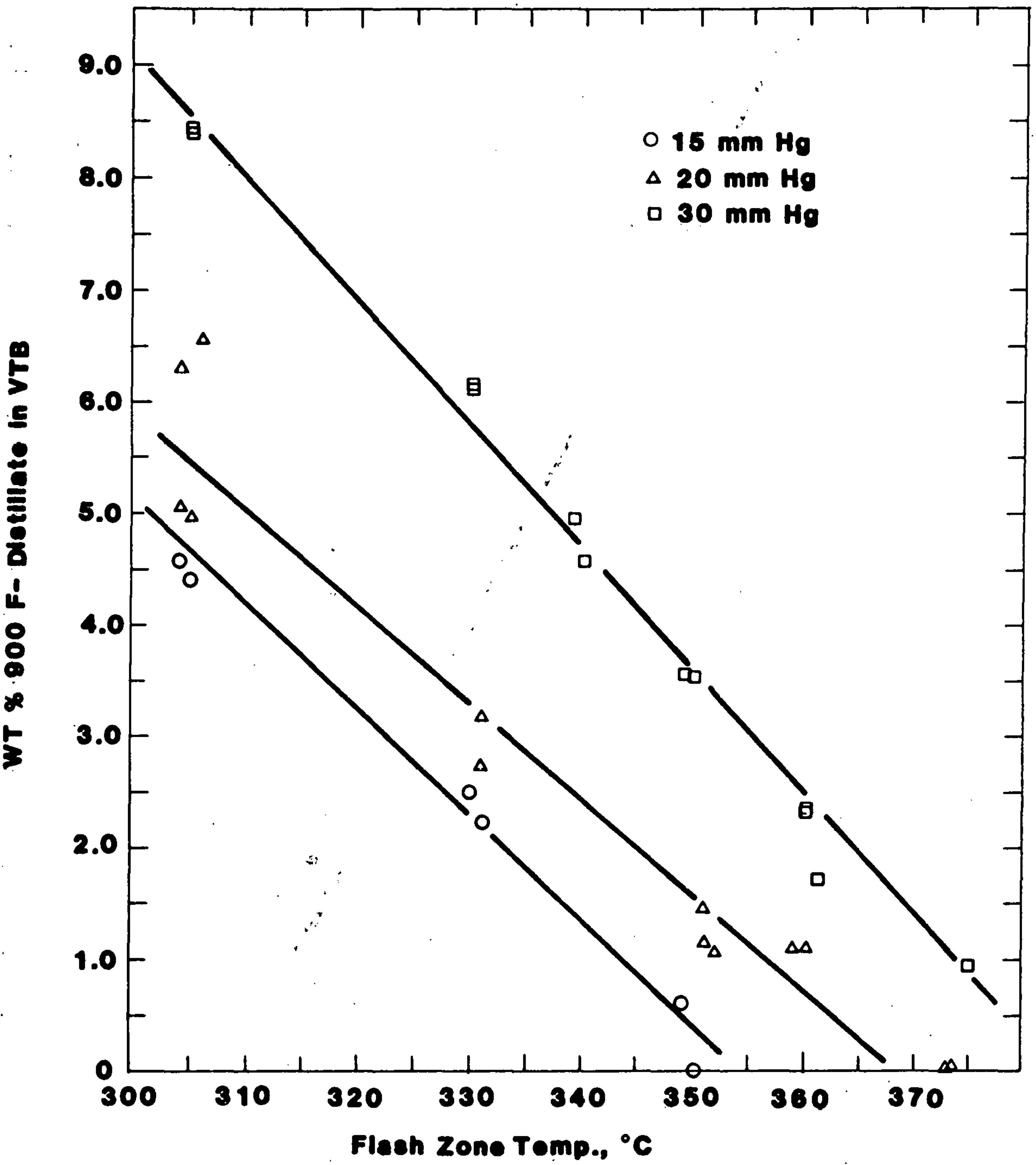


FIGURE 59

PARITY PLOT FOR VISCOSITY PREDICTION

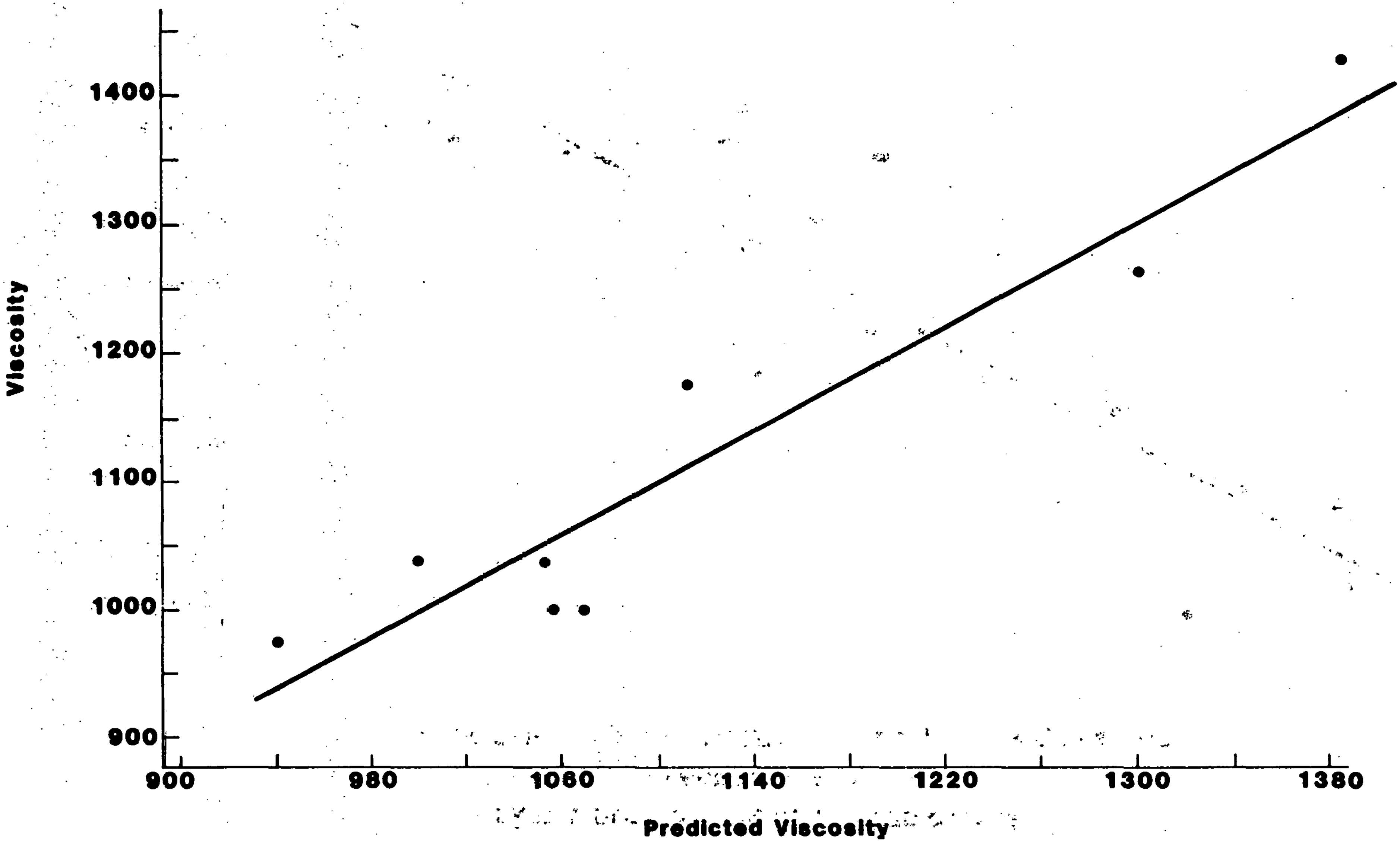


FIGURE 60

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 0.084

PLOT OF RESULT* VPRED LEGEND: ● = 1 OBS, ○ = 2 OBS, △ = 3 OBS

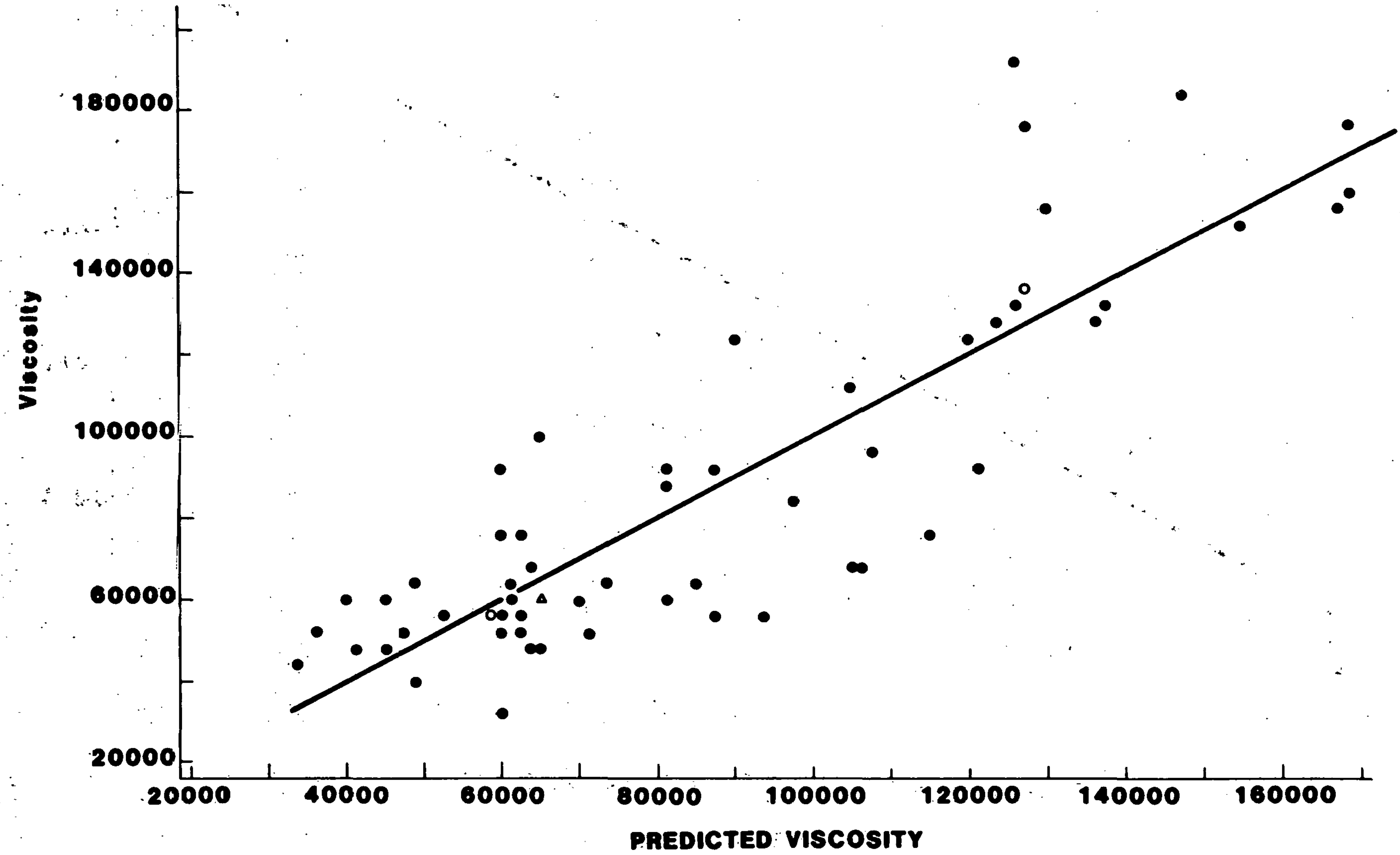
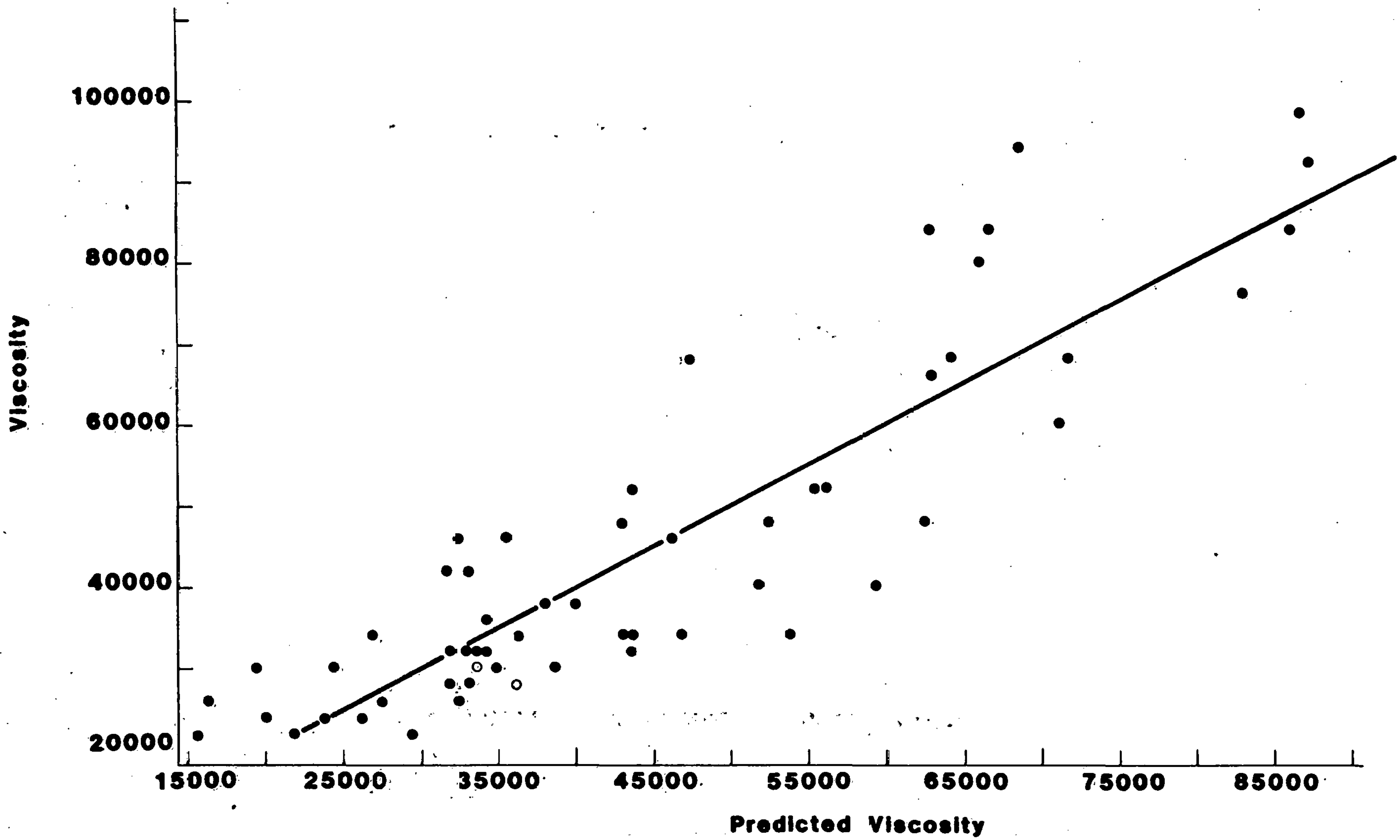


FIGURE 61

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 0.168

PLOT OF RESULT✱VPRED LEGEND: ●=1 OBS, ○=2 OBS



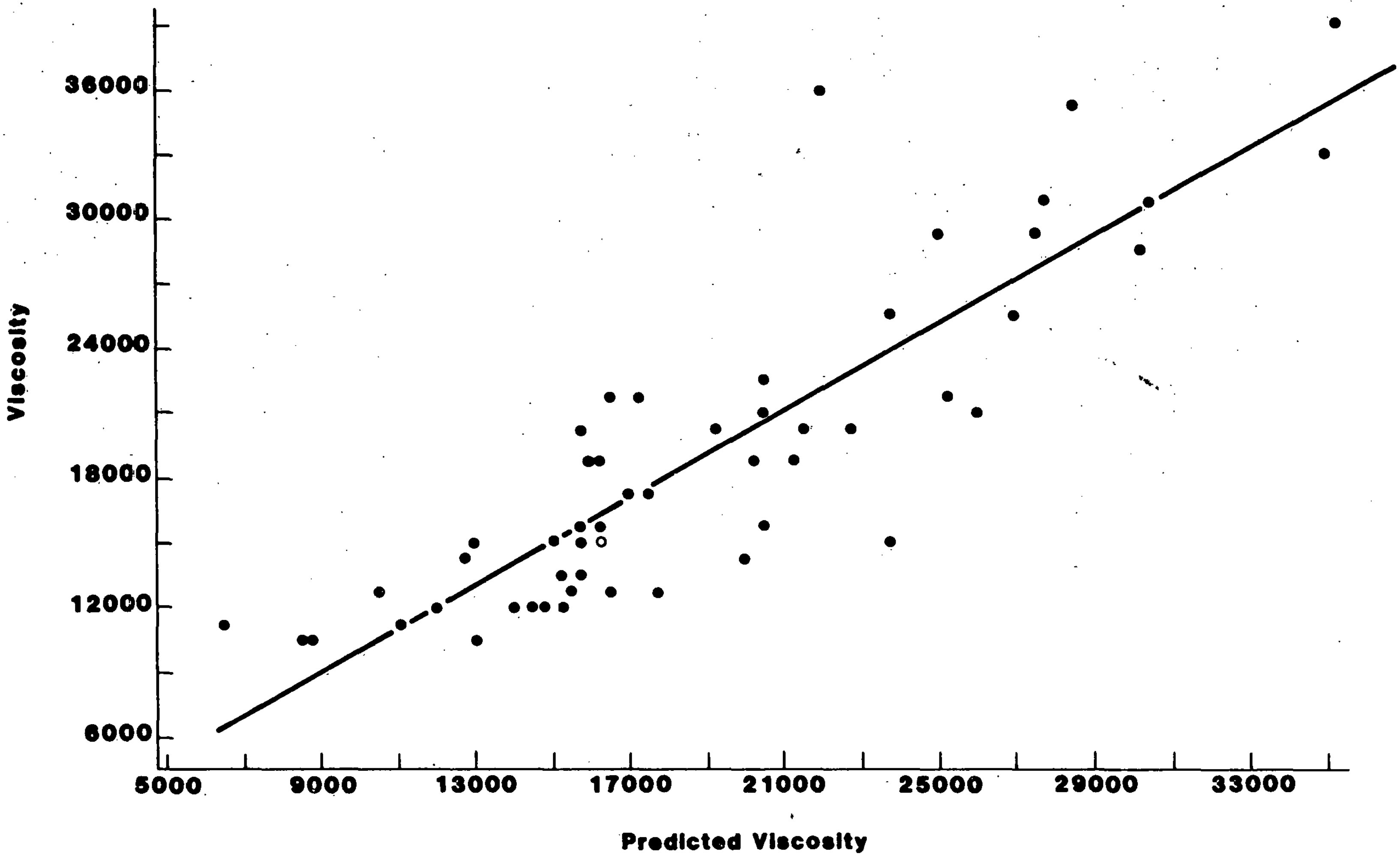
NOTE: 3 OBS HAD MISSING VALUES

FIGURE 62

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 0.42

PLOT OF RESULT*VPRED LEGEND: ●=1 OBS, ○=2 OBS



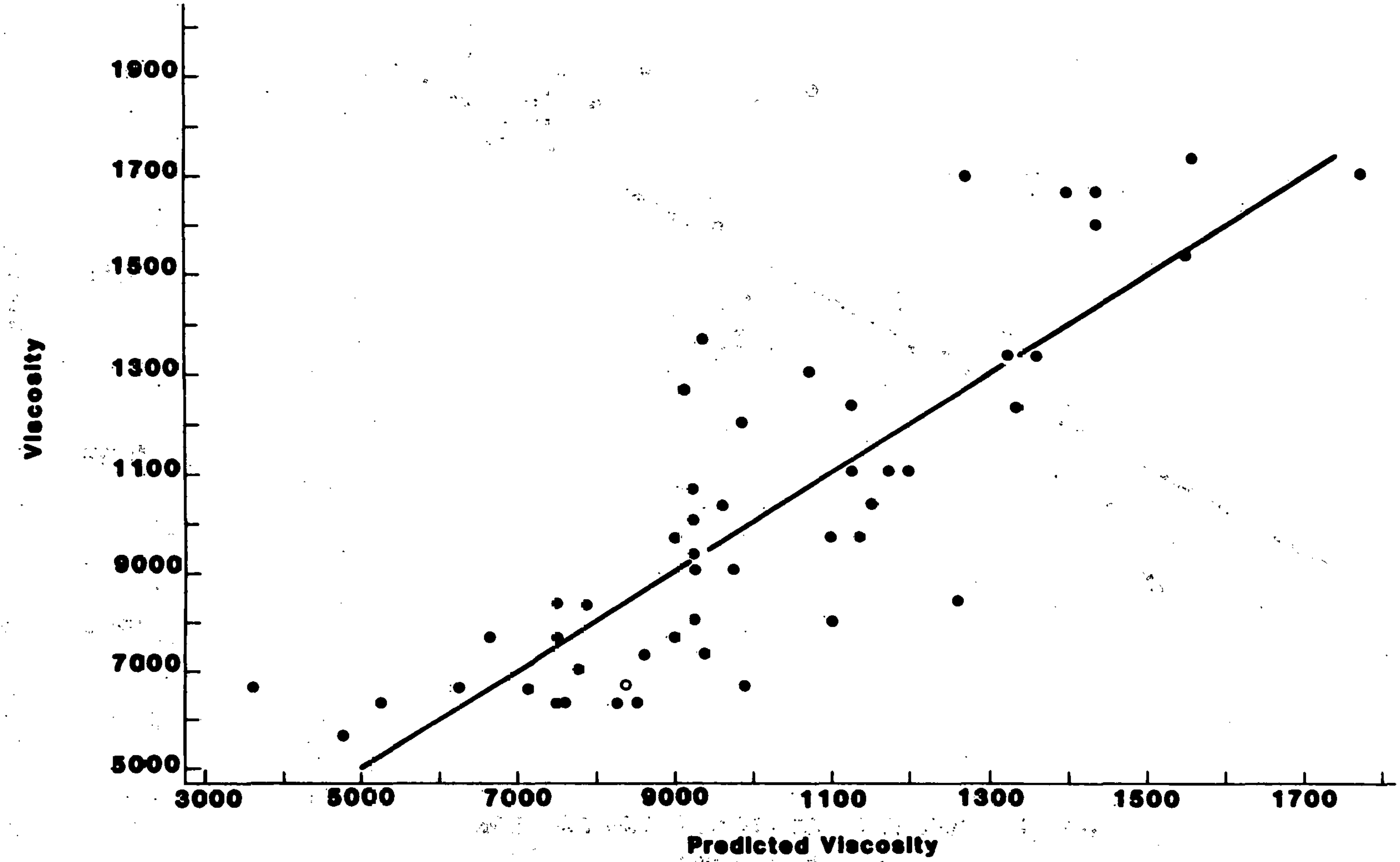
NOTE: 8 OBS HAD MISSING VALUES

FIGURE 63

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 0.84

PLOT OF RESULT*VPRED LEGEND: ●=1 OBS, ○=2 OBS



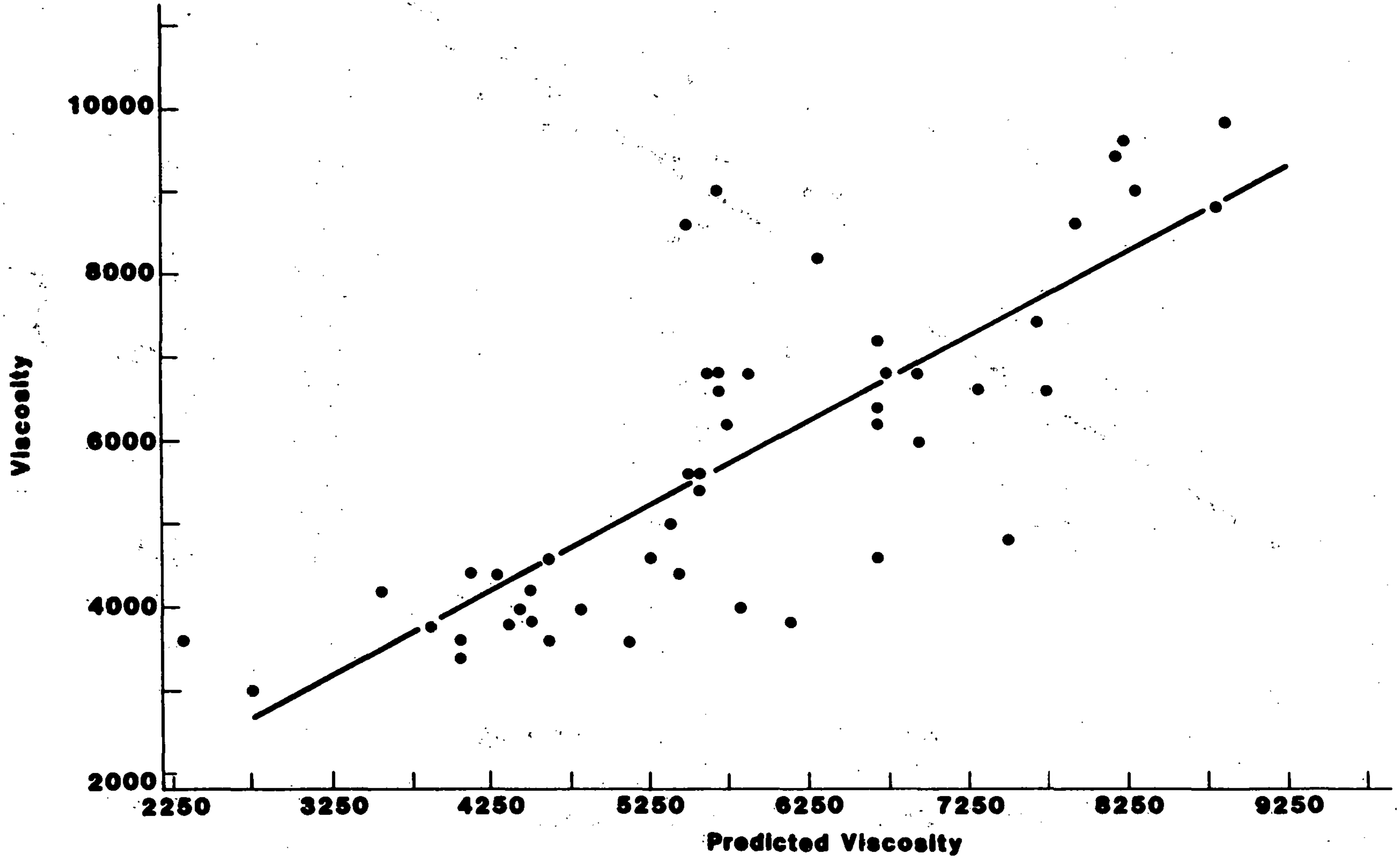
NOTE: 11 OBS HAD MISSING VALUES

Figure 64

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 1.68

PLOT OF RESULT*VPRED LEGEND: ● 1 OBS



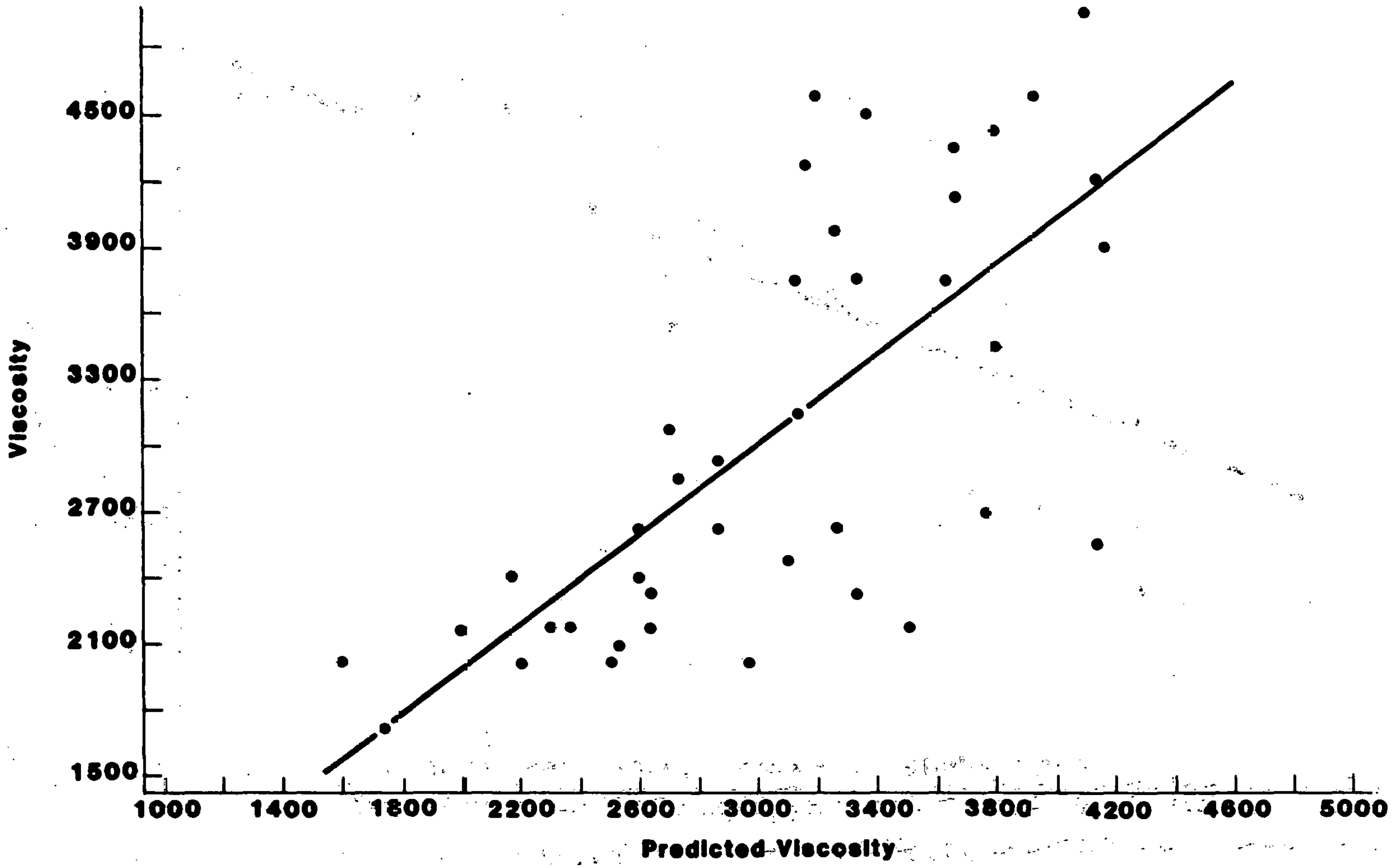
NOTE: 13 OBS HAD MISSING VALUES

FIGURE 65

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 3.36

PLOT OF RESULT*VPRED LEGEND: ● = 1 OBS, ○ = 2 OBS



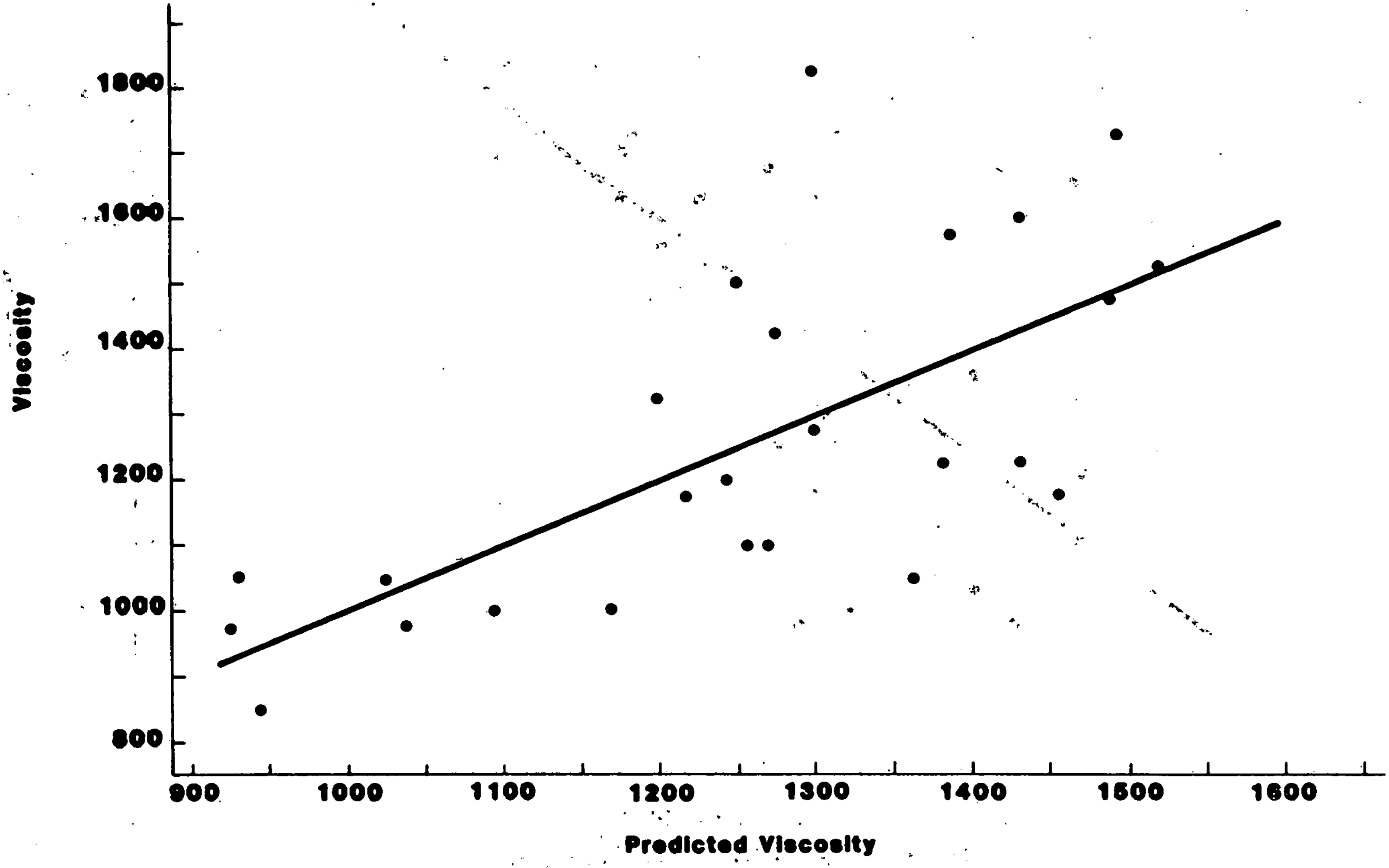
NOTE: 22 OBS HAD MISSING VALUES

FIGURE 66

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 8.4

PLOT OF RESULT*VPRED LEGEND: ●=1 OBS, ○=2 OBS



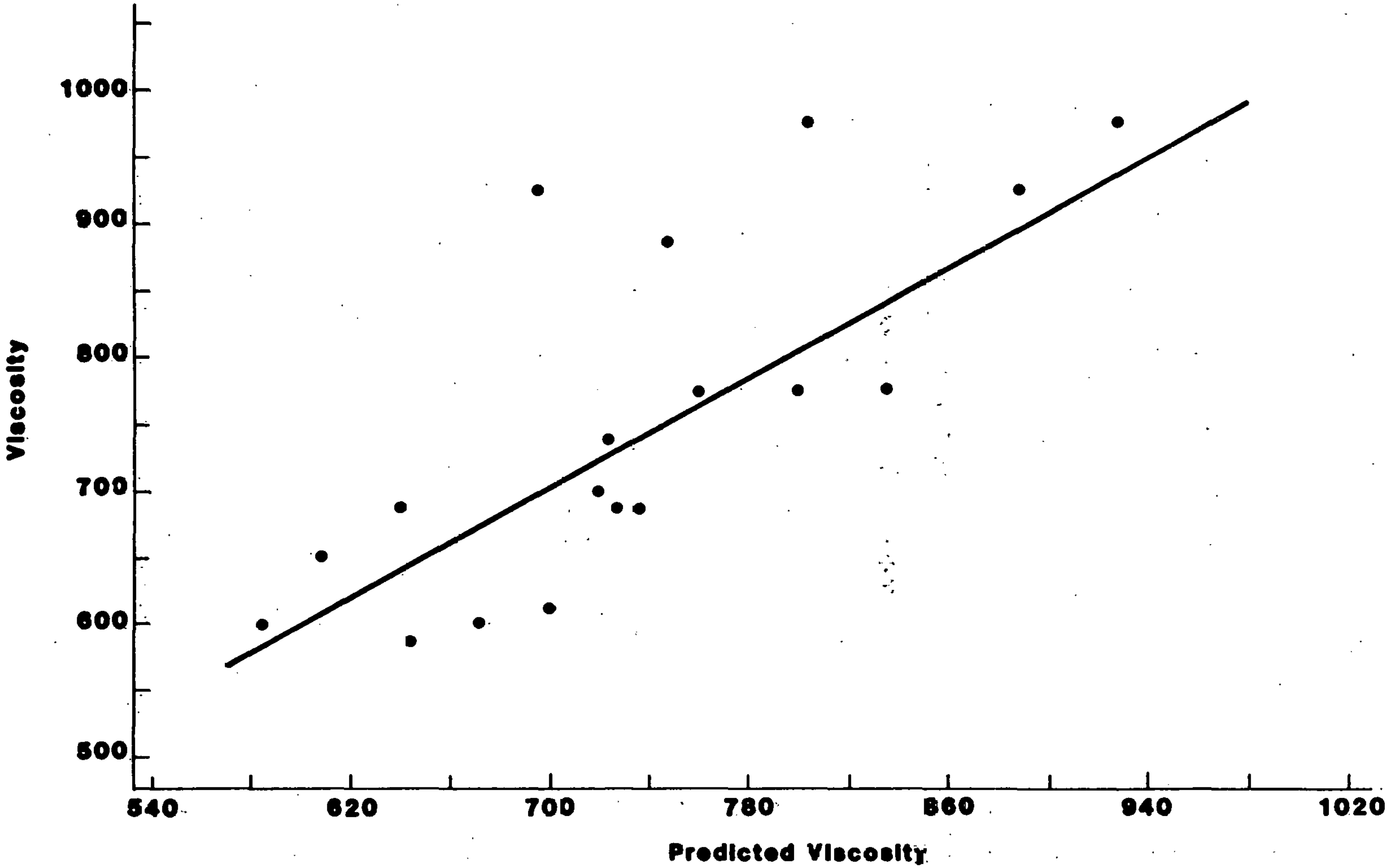
NOTE: 37 OBS HAD MISS G VALUES

FIGURE 67

PARITY PLOT OF VISCOSITY PREDICTIONS

SHEARATE 16.8

PLOT OF RESULT *VPRED LEGEND: ● = 1 OBS, ○ = 2 OBS



NOTE: 41 OBS HAD MISSING VALUES

APPENDIX A

Tabulation of Analyses

Appendix A

VACUUM COLUMN STUDY SAMPLE ANALYSES

	Analysis	Test No.	ATD Area No.	Gulf/ASTM No.
1.	Cushman Distillation	9402	63	--
2.	Sarnia High Vacuum Distillation	9246	63	--
3.	ASTM D-1160	9305	01	D-1160
4.	Elemental Analysis			
	Carbon and Hydrogen	2335	26	--
	Nitrogen	2594	29	G-811
	Sulfur	2747	02	D-1552
	Oxygen	2610	30	G-1432
5.	Ash	7095	02	G-599
6.	Pyridine Insolubles	3016	63	--
7.	Specific Gravity	0185	22	D-70
8.	Melting Point	0530	22	G-898
9.	Spectrographic Ash	7162	14	G-905

APPENDIX B

Vacuum Column Stream Compositions and Component Balances for Runs 63 and 71

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-1

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F -	0.4	0.4	--	--	5.0	5.0	1.03	1.03
500-550°F	0.8	1.2	--	--	5.0	10.0	1.03	2.06
550-600°F	1.0	2.2	--	--	7.0	17.0	1.44	3.50
600-650°F	1.2	3.4	--	0.0	10.5	27.5	2.16	5.66
650-700°F	2.2	5.6	0.15	0.15	13.5	41.0	2.90	8.56
700-750°F	3.1	8.7	1.10	1.25	17.5	58.5	4.47	13.03
750-800°F	3.5	12.2	1.10	2.35	18.5	77.0	4.68	17.71
800-850°F	4.2	16.4	1.10	3.45	10.5	87.5	3.03	20.74
850-900°F	4.7	21.1	1.10	4.55	5.2	92.7	1.94	22.68
900°F+, Pyr. Sol.	50.44	71.54	58.26	62.81	7.3	100.0	47.78	70.46
IOM	13.66	85.2	18.54	81.35	--	--	14.73	85.19
Ash	14.8	100.0	18.65	100.0	--	--	14.81	100.0

				% Recovery
900°F-	21.1	4.55	92.7	107.5
Pyr. Insol.	28.46	37.19	--	103.8
C	76.82	72.62	89.18	99.0
H	4.03	3.84	7.26	94.1
N	1.55	1.59	1.31	98.9
S	1.35	1.53	0.42	96.4
O (Total)	6.9	8.6	1.7	99.9
Ash	14.8	18.65	--	100.1
Net Stream Rate, Kg/h	11.367	9.029	2.338	
Sp. Gr. 77/77°F	1.350	1.389	1.095	
Melting Point, °F	212	338		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-2

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	--	0.0	--	--	4.5	4.5	0.80	0.80
500-550°F	0.7	0.7	--	--	4.5	9.0	0.80	1.60
550-600°F	1.55	2.25	--	--	8.0	17.0	1.42	3.02
600-650°F	1.75	4.0	--	--	13.2	30.2	2.35	5.37
650-700°F	2.25	6.25	--	0.0	20.3	50.5	3.61	8.98
700-750°F	3.25	9.5	1.31	1.31	16.5	67.0	4.01	12.99
750-800°F	8.2	17.7	1.49	2.80	14.0	81.0	3.72	16.71
800-850°F	3.5	21.2	1.49	4.29	8.5	89.5	2.74	19.45
850-900°F	1.1	22.3	1.49	5.78	5.5	95.0	2.20	21.65
900°F+, Pyr. Sol.	48.53	70.83	58.40	64.18	5.0	100.0	48.90	70.55
IOM	14.57	85.4	18.02	82.2	--	--	14.81	85.36
Ash	14.6	100.0	17.8	100.0	--	--	14.63	99.99

				% Recovery
900°F-	22.3	5.78	95.0	97.1
Pyr. Insol.	29.17	35.82	--	100.9
C	76.60	73.70	89.39	99.8
H	4.60	3.94	7.34	98.8
N	1.54	1.51	1.30	95.6
S	7.1	8.0	1.7	96.9
O (Total)	1.47	1.65	0.49	98.2
Ash	14.6	17.8	--	100.2
Net Stream Rate, Kg/h	12.192	10.022	2.170	
Sp. Gr. 77/77°F	1.331	1.383	1.082	
Melting Point, °F	194	338		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-3

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0.25	0.25	--	--	4.0	4.0	0.88	0.88
500-550°F	1.50	1.75	--	--	3.5	7.5	0.77	1.65
550-600°F	1.55	3.3	--	--	6.0	13.5	1.32	2.97
600-650°F	1.95	5.25	--	--	10.0	23.5	2.20	5.17
650-700°F	2.55	7.8	--	--	14.5	38.0	3.18	8.35
700-750°F	6.7	14.5	--	--	19.5	57.5	4.28	12.63
750-800°F	4.9	19.4	--	--	17.7	75.2	3.88	16.51
800-850°F	2.1	21.5	--	0.0	10.5	85.7	2.30	18.81
850-900°F	1.6	23.1	3.04	3.04	6.0	91.7	3.69	22.5
900°F+, Pyr. Sol.	49.17	72.27	57.31	60.35	8.3	100.0	46.55	69.05
IOM	13.83	86.1	21.65	82.0	--	--	16.90	85.95
Ash	13.9	100.0	18.0	100.0	--	--	14.05	100.0

				% Recovery
900°F-	23.1	3.04	91.7	97.4
Pyr. Insol.	27.73	39.65	--	111.6
C	78.30	73.89	88.40	98.4
H	4.80	3.99	7.23	97.9
N	1.58	1.62	1.37	99.0
S	1.40	1.60	0.47	96.6
O (Total)	6.7	8.3	1.7	102.2
Ash	13.9	18.0	--	101.1
Net Stream Rate, Kg/h	12.208	9.528	2.680	
Sp. Gr. 77/77°F	1.366	1.363	1.095	
Melting Point, °F	212	374		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-4

	Feed		Bottoms		Overhead		Prod. Composite	
Component	**Frac.**	**Cum.**	**Frac.**	**Cum.**	**Frac.**	**Cum.**	**Frac.**	**Cum.**
500°F-	--	--	--	--	3.3	3.3	0.74	0.74
500-550°F	--	0.0	--	--	3.4	6.7	0.76	1.5
550-600°F	0.2	0.2	--	--	5.1	11.8	1.14	2.64
600-650°F	1.4	1.6	--	--	9.0	20.8	2.01	4.65
650-700°F	2.4	4.0	--	0.0	14.7	35.5	3.28	7.93
700-750°F	3.6	7.6	0.1	0.1	18.3	53.8	4.16	12.09
750-800°F	4.8	12.4	0.4	0.5	15.7	69.5	3.81	15.9
800-850°F	4.8	17.2	0.5	1.0	12.2	81.7	3.11	19.01
850-900°F	4.3	21.5	0.4	1.4	8.3	90.0	2.16	21.17
900°F+, Pyr. Sol.	50.74	72.24	57.6	59.0	10.0	100.0	46.99	68.16
IOM	14.06	86.3	23.2	82.2	--	--	18.03	86.19
Ash	13.7	100	17.8	100	--	--	13.83	100.02

				% Recovery
900°F-	21.5	1.4	90.0	98.4
Pyr. Insol.	27.76	41.00	--	114.8
C	77.42	75.06	88.97	101.0
H	4.95	4.05	7.09	95.5
N	1.59	1.65	1.42	100.5
S	1.40	1.57	0.51	95.3
O (Total)	6.5	8.0	1.7	101.5
Ash	13.7	17.8	--	101.0
Net Stream Rate, Kg/h	13.096	10.176	2.920	
Sp. Gr. 77/77°F	1.305	1.366	1.104	
Melting Point, °F	203	374		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-5

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0.2	0.2	--	--	3.5	3.5	0.66	0.66
500-550°F	0.6	0.8	--	--	3.5	7.0	0.66	1.32
550-600°F	0.9	1.7	--	--	5.7	12.7	1.08	2.40
600-650°F	1.0	2.7	--	--	10.0	22.7	1.89	4.29
650-700°F	1.7	4.4	--	--	14.8	37.5	2.79	7.08
700-750°F	3.2	7.6	--	0.0	25.0	62.5	4.72	11.8
750-800°F	4.2	11.8	0.76	0.76	17.0	79.5	3.82	15.62
800-850°F	4.2	16.0	1.91	2.67	8.7	88.2	3.19	18.81
850-900°F	4.0	20.0	1.91	4.58	3.8	92.0	2.27	21.08
900°F+, Pyr. Sol.	52.07	72.07	57.64	62.22	8.0	100.0	48.28	69.36
IOM	14.43	86.5	20.98	83.2	--	--	17.02	86.38
Ash	13.5	100.0	16.8	100.0	--	--	13.63	100.01

				% Recovery
900°F-	20.0	4.58	92.0	105.3
Pyr. Insol.	27.93	37.78	--	109.8
C	77.19	75.83	88.58	101.4
H	4.60	4.21	7.31	104.2
N	1.61	1.68	1.35	100.5
S	1.37	1.60	0.50	101.6
O (Total)	6.5	7.7	1.7	101.0
Ash	13.5	16.8	--	101.0
Net Stream Rate, Kg/h	12.448	10.100	2.348	
Sp. Gr. 77/77°F	1.294	1.338	1.093	
Melting Point, °F	194	347		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-6

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0.0	0.0	--	--	3.7	3.7	0.75	0.75
500-550°F	1.2	1.2	--	--	3.6	7.3	0.73	1.48
550-600°F	2.1	3.3	--	--	5.7	13.0	1.16	2.64
600-650°F	2.1	5.4	--	--	10.0	23.0	2.04	4.68
650-700°F	2.4	7.8	--	--	14.5	37.5	2.96	7.64
700-750°F	2.9	10.7	--	--	19.8	57.3	4.04	11.68
750-800°F	3.5	14.2	--	0.0	15.5	72.8	3.16	14.84
800-850°F	3.7	17.9	1.25	1.25	10.9	83.7	3.22	18.06
850-900°F	4.4	22.3	3.46	4.71	7.0	90.7	4.18	22.24
900°F+, Pyr. Sol.	49.87	72.17	57.96	62.67	9.3	100.0	48.04	70.28
IOM	14.63	86.8	20.83	83.5	--	--	16.58	86.86
Ash	13.2	100.0	16.5	100.0	--	--	13.14	100.0

				% Recovery
900°F-	22.3	4.71	90.7	99.8
Pyr. Insol.	27.83	37.33	--	106.8
C	77.68	75.63	88.57	100.8
H	4.72	4.05	7.17	99.3
N	1.62	1.69	1.40	100.7
S	1.34	1.56	0.51	100.4
O (Total)	6.2	7.5	1.8	102.2
Ash	13.2	16.5	--	99.5
Net Stream Rate, Kg/h	12.882	10.255	2.627	
Sp. Gr. 77/77°F	1.316	1.356	1.097	
Melting Point, °F	194	347		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-7

Component	Feed		Bottoms		Overhead		Prod. Composite	
	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0	0	0	0	5.2	5.2	1.32	1.32
500-550°F	0.8	0.8	0	0	4.0	9.2	1.01	2.33
550-600°F	1.3	2.1	0	0	4.8	14.0	1.22	3.55
600-650°F	1.9	4.0	0	0	7.7	21.7	1.95	5.50
650-700°F	2.7	6.7	0	0	12.3	34.0	3.12	8.62
700-750°F	3.2	9.9	0.14	0.14	15.0	49.0	3.90	12.52
750-800°F	3.8	13.7	0.15	0.29	20.2	69.2	5.23	17.75
800-850°F	4.3	18.0	0.15	0.44	10.7	79.9	2.82	20.57
850-900°F	4.8	22.8	0.16	0.6	8.4	88.3	2.25	22.82
900°F+, Pyr. Sol.	51.4	74.2	58.6	59.2	11.7	100.0	46.71	69.53
IOM	13.3	87.5	23.8	83.0	--	--	17.77	87.3
Ash	12.5	100.0	17.0	100.0	--	--	12.69	99.99

				% Recovery
900°F-	22.8	0.6	88.3	100.1
Pyr. Insol.	25.80	40.80	--	118.1
C	78.19	75.38	88.69	100.7
H	4.86	4.00	7.15	98.7
N	1.61	1.68	1.44	100.6
S	1.25	1.52	0.55	101.9
O (Total)	6.4	7.5	1.8	94.6
Ash	12.5	17.0	--	101.5
Net Stream Rate, Kg/h	14.138	10.555	3.583	
Sp. Gr. 77/77°F	1.300	1.362	1.106	
Melting Point, °F	185	383		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-63-8

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0.9	0.9	--	--	2.7	2.7	0.76	0.76
500-550°F	0.8	1.7	--	--	2.7	5.4	0.76	1.52
550-600°F	1.0	2.7	--	--	4.6	10.0	1.29	2.81
600-650°F	1.6	4.3	--	--	9.5	19.5	2.66	5.47
650-700°F	3.0	7.3	--	--	11.0	30.5	3.08	8.55
700-750°F	3.5	10.8	--	--	14.7	45.2	4.11	12.66
750-800°F	3.9	14.7	--	0.0	16.0	61.2	4.48	17.14
800-850°F	4.1	18.8	0.22	0.22	12.8	74.0	3.74	20.88
850-900°F	4.4	23.2	0.38	0.60	9.3	83.3	2.88	23.76
900°F+, Pyr. Sol.	51.93	75.13	60.25	60.85	16.7	100.0	48.06	71.82
IOM	12.77	87.9	22.35	83.2	--	--	16.09	87.91
Ash	12.1	100.0	16.8	100.0	--	--	12.10	100.01

				% Recovery
900°F-	23.2	0.6	83.3	102.4
Pyr. Insol.	24.87	39.15	--	113.4
C	79.10	75.82	88.24	100.2
H	4.93	3.97	7.00	97.7
N	1.61	1.70	1.46	101.4
S	1.23	1.50	0.51	99.4
O (Total)	6.0	7.4	1.7	96.7
Ash	12.1	16.8	--	100.0
Net Stream Rate, Kg/h	14.342	10.328	4.014	
Sp. Gr. 77/77°F	1.301	1.338	1.110	
Melting Point, °F	189	401		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-64-1

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0	0	--	--	2.7	2.7	0.77	0.77
500-550°F	0.5	0.5		--	3.5	6.2	1.00	1.77
550-600°F	1.8	2.3	--	--	4.6	10.8	1.32	3.09
600-650°F	1.9	4.2	--	--	8.0	18.8	2.29	5.38
650-700°F	2.2	6.4	--	--	12.1	30.9	3.46	8.84
700-750°F	2.8	9.2	--	0.0	16.9	47.8	4.83	13.67
750-800°F	4.0	13.2	0.17	0.17	17.7	65.5	5.18	18.85
800-850°F	8.6	21.8	0.37	0.54	12.3	77.8	3.78	22.63
850-900°F	3.0	24.8	0.36	0.90	8.2	86.0	2.60	25.23
900°F+, Pyr. Sol.	51.89	76.69	63.76	64.66	14.0	100.0	49.53	74.76
IOM	11.21	87.9	18.14	82.8	--	--	12.95	87.71
Ash	12.1	100.0	17.2	100.0	--	--	12.28	99.99

				% Recovery
900°F-	24.8	0.90	86.0	101.8
Pyr. Insol.	23.31	35.34	--	108.2
C	78.81	73.87	88.76	99.1
H	4.87	4.03	7.20	101.4
N	1.63	1.66	1.44	98.0
S	1.14	1.36	0.42	95.7
O (Total)	7.1	9.1	1.7	98.4
Ash	12.1	17.2	--	101.5
Net Stream Rate, Kg/h	14.147	10.101	4.046	
Sp. Gr. 77/77°F	1.318	1.382	1.107	
Melting Point, °F	194	392		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-64-2

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F -	0	0	0	0	3.3	3.3	0.88	0.88
500-550°F	0.2	0.2	0	0	3.2	6.5	0.85	1.73
550-600°F	1.55	1.75	0	0	5.6	12.1	1.49	3.22
600-650°F	2.25	4.0	0	0	9.7	21.8	2.59	5.81
650-700°F	2.9	6.9	0	0	14.9	36.7	3.98	9.79
700-750°F	3.7	10.6	0.10	0.10	15.1	51.8	4.10	13.89
750-800°F	4.2	14.8	0.48	0.58	15.2	67.0	4.41	18.30
800-850°F	4.9	19.7	0.48	1.06	14.5	81.5	4.22	22.52
850-900°F	5.3	25.0	0.49	1.55	9.0	90.5	2.76	25.28
900°F+, Pyr. Sol.	52.82	77.82	64.69	66.24	9.5	100.0	49.96	75.24
IOM	9.98	87.8	16.76	83.0	--	--	12.28	87.52
Ash	12.2	100.0	17.0	100.0	--	--	12.46	99.98

				% Recovery
900°F-	25.0	1.55	90.5	101.2
Pyr. Insol.	22.18	33.76	--	111.6
C	78.02	74.51	88.58	100.3
H	4.84	4.07	7.25	101.6
N	1.59	1.63	1.39	98.5
S	1.14	1.35	0.46	97.6
O (Total)	7.0	9.3	1.8	104.2
Ash	12.2	17.0	--	102.1
Net Stream Rate, Kg/h	13.669	10.020	3.649	
Sp. Gr. 77/77°F	1.304	1.336	1.100	
Melting Point, °F	194	392		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-64-3

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0	0	0	0	3.4	3.4	0.92	0.92
500-550°F	0.4	0.4	0	0	2.9	6.3	0.78	1.70
550-600°F	1.1	1.5	0	0	4.5	10.8	1.21	2.91
600-650°F	1.8	3.3	0	0	8.4	19.2	2.26	5.17
650-700°F	4.0	7.3	0	0	13.6	32.8	3.66	8.83
700-750°F	4.4	11.7	0	0	22.7	55.5	6.11	14.94
750-800°F	4.1	15.8	0.24	0.24	18.3	73.8	5.10	20.04
800-850°F	4.0	19.8	0.28	0.52	9.9	83.7	2.87	22.91
850-900°F	4.2	24.0	0.28	0.8	6.5	90.2	1.95	24.86
900°F+, Pyr. Sol.	52.65	76.65	64.24	65.04	9.8	100.0	49.58	74.44
IOM	10.85	87.5	17.66	82.7	--	--	12.90	87.34
Ash	12.5	100.0	17.3	100.0	--	--	12.64	99.98

				% Recovery
900°F-	24.0	0.8	90.2	103.6
Pyr. Insol.	23.35	34.96	--	109.4
C	77.53	75.30	89.52	102.1
H	5.18	3.92	7.38	93.6
N	1.54	1.65	1.42	103.1
S	0.98	1.60	0.42	130.8
O (Total)	7.3	9.0	1.7	96.4
Ash	12.5	17.3	--	101.1
Net Stream Rate, Kg/h	13.850	10.121	3.729	
Sp. Gr. 77/77°F	1.298	1.330	1.103	
Melting Point, °F	185	392		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-64-4

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	--	0.0	--	--	3.0	3.0	0.87	0.87
500-550°F	0.7	0.7	--	--	3.3	6.3	0.96	1.83
550-600°F	1.8	2.5	--	--	5.1	11.4	1.48	3.31
600-650°F	2.1	4.6	--	--	8.9	20.3	2.58	5.89
650-700°F	2.5	7.1	--	0.0	12.2	32.5	3.54	9.43
700-750°F	3.4	10.5	0.01	0.01	16.8	49.3	4.88	14.31
750-800°F	8.5	19.0	0.20	0.21	16.0	65.3	4.78	19.09
800-850°F	4.3	23.3	0.19	0.40	12.6	77.9	3.79	22.88
850-900°F	3.0	26.3	0.20	0.6	9.4	87.3	2.87	25.75
900°F+, Pyr. Sol.	50.86	77.16	66.07	66.67	12.7	100.0	50.59	76.34
IOM	10.54	87.7	15.63	82.3	--	--	11.10	87.44
Ash	12.3	100.0	17.7	100.0	--	--	12.57	100.01

				% Recovery
900°F-	26.3	0.6	87.3	97.9
Pyr. Insol.	22.84	33.33	--	103.6
C	78.78	74.49	88.99	99.9
H	5.10	4.23	7.18	99.7
N	1.58	1.68	1.40	101.2
S	1.13	1.57	0.38	108.4
O (Total)	7.1	9.9	1.7	105.9
Ash	12.3	17.7	--	102.2
Net Stream Rate, Kg/h	13.923	9.885	4.038	
Sp. Gr. 77/77°F	1.281	1.377	1.104	
Melting Point, °F	185	392		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-64-5

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0	0	0	0	4.8	4.8	1.16	1.16
500-550°F	1.2	1.2	0	0	3.9	8.7	0.94	2.10
550-600°F	1.7	2.9	0	0	5.6	14.3	1.35	3.45
600-650°F	2.4	5.3	0	0	10.3	24.6	2.49	5.94
650-700°F	3.5	8.8	0	0	18.4	43.0	4.44	10.38
700-750°F	5.2	14.0	0	0	13.6	56.6	3.28	13.66
750-800°F	4.1	18.1	0.37	0.37	11.1	67.7	2.96	16.62
800-850°F	3.8	21.9	1.69	2.06	9.8	77.5	3.65	20.27
850-900°F	3.8	25.7	1.68	3.74	9.3	86.8	3.52	23.79
900°F+, Pyr. Sol.	52.48	78.18	63.74	67.48	13.2	100.0	51.53	75.32
IOM	8.92	87.1	15.82	83.3	--	--	12.00	87.32
Ash	12.9	100.0	16.7	100.0	--	--	12.67	99.99

				% Recovery
900°F-	25.7	3.74	86.8	92.6
Pyr. Insol.	21.82	32.52	--	113.0
C	76.93	75.20	88.97	102.1
H	4.90	4.37	7.26	103.4
N	1.59	1.68	1.39	101.2
S	1.31	1.53	0.36	95.2
O (Total)	7.5	9.7	1.7	103.6
Ash	12.9	16.7	--	98.2
Net Stream Rate, Kg/h	13.534	10.265	3.269	
Sp. Gr. 77/77°F	1.270	1.371	1.094	
Melting Point, °F	185	342		

VACUUM COLUMN STREAM COMPOSITIONS, WT %

PERIOD P99-64-6

	Feed		Bottoms		Overhead		Prod. Composite	
Component	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.	Frac.	Cum.
500°F-	0	0	0	0	4.5	4.5	0.98	0.98
500-550°F	0.75	0.75	0	0	3.9	8.4	0.84	1.82
550-600°F	1.75	2.5	0	0	5.6	14.0	1.21	3.03
600-650°F	2.0	4.5	0	0	9.8	23.8	2.12	5.15
650-700°F	2.7	7.2	0.05	0.05	17.1	40.9	3.75	8.90
700-750°F	3.5	10.7	1.38	1.43	22.3	63.2	5.92	14.82
750-800°F	3.9	14.6	1.37	2.80	14.1	77.3	4.13	18.95
800-850°F	4.1	18.7	1.38	4.18	8.7	86.0	2.97	21.92
850-900°F	4.1	22.8	1.37	5.55	5.4	91.4	2.24	24.16
900°F+, Pyr. Sol.	52.04	74.84	61.5	67.05	8.6	100.0	50.03	74.19
IOM	11.86	86.7	15.95	83.0	--	--	12.49	86.68
Ash	13.3	100.0	17.0	100.0	--	--	13.31	99.99

				% Recovery
900°F-	22.8	5.55	91.4	106.0
Pyr. Insol.	25.16	32.95	--	102.6
C	77.58	73.77	89.15	99.4
H	4.95	4.09	7.41	97.2
N	1.58	1.67	1.37	101.6
S	1.31	1.53	0.44	98.8
O (Total)	7.8	9.5	1.7	100.1
Ash	13.3	17.0	--	100.1
Net Stream Rate, Kg/h	12.904	10.106	2.798	
Sp. Gr. 77/77°F	1.336	1.344	1.091	
Melting Point, °F	189	345		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-1

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F⁻	0.8	0.8	--	--	2.3	2.3	0.55	0.55
500-550°F	1.4	2.2	--	--	5.0	7.3	1.19	1.74
550-600°F	1.3	3.5	--	--	7.8	15.1	1.85	3.59
600-650°F	1.6	5.1	--	--	11.6	26.7	2.76	6.35
650-700°F	1.9	7.0	--	--	16.5	43.2	3.92	10.27
700-750°F	2.7	9.7	--	--	18.1	61.3	4.30	14.57
750-800°F	3.6	13.3	--	0.0	13.0	74.3	3.09	17.66
800-850°F	4.1	17.4	0.28	0.28	9.5	83.8	2.47	20.13
850-900°F	5.1	22.5	1.42	1.70	6.2	90.0	2.56	22.69
900°F⁺, Pyr.Sol.	48.89	71.39	59.38	61.08	10.0	100.0	47.65	70.34
IOM	14.61	86.0	20.72	81.8	--	--	15.80	86.14
Ash	14.0	100.0	18.2	100.0	--	--	13.88	100.02

	FEED	BOTTOMS	OVERHEAD	% RECOVERY
900°F⁻	22.5	1.70	90.0	100.8
Pyr. Insol.	28.61	38.92	--	103.7
C	76.62	73.10	89.57	100.5
H	4.73	3.89	7.03	98.0
N	1.51	1.63	1.30	102.8
S	1.39	1.54	0.45	92.2
O(Total)	7.9	9.3	1.7	94.9
Ash	14.0	18.2	--	99.1
Net Stream Rate, kg/h	11.630	8.867	2.763	
Sp.Gr. 77/77°F	1.301	1.384	1.091	
Melting Pt., °F	194	365		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-2

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	0.4	0.4	--	--	3.3	3.3	0.75	0.75
500-550°F	1.1	1.5	--	--	6.1	9.4	1.39	2.14
550-600°F	1.3	2.8	--	--	8.8	18.2	2.00	4.14
600-650°F	2.5	5.3	--	--	11.6	29.8	2.64	6.78
650-700°F	3.5	8.8	--	--	15.4	45.2	3.50	10.28
700-750°F	3.7	12.5	--	--	19.0	64.2	4.32	14.60
750-800°F	3.7	16.2	--	0.0	15.6	79.8	3.55	18.15
800-850°F	3.7	19.9	1.97	1.97	7.0	86.8	3.11	21.26
850-900°F	3.9	23.8	2.98	4.95	4.5	91.3	3.32	24.58
900°F$^+$, Pyr.Sol	47.58	71.38	56.36	61.31	8.7	100.0	45.51	70.09
IOM	14.85	86.23	20.79	82.1	--	--	16.06	86.15
Ash	13.77	100.0	17.9	100.0	--	--	13.83	99.98

				% RECOVERY
900°F$^-$	23.8	4.95	91.3	103.4
Pyr. Insol	28.62	38.69	--	104.4
C	76.28	74.63	88.64	102.0
H	4.46	4.00	7.24	106.2
N	1.57	1.63	1.30	99.0
S	1.25	1.47	0.45	99.0
O(Total)	7.4	8.0	1.8	89.0
Ash	13.77	17.9*	--	100.4
Net Stream Rate, kg/h	13.304	10.276	3.028	
Sp.Gr. 77/77°F	1.316	1.373	1.091	
Melting Pt., °F	194	356		

*Value from period samples.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-3

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	1.0	1.0	--	--	2.6	2.6	0.50	0.50
500-550°F	1.4	2.4	--	--	5.1	7.7	0.99	1.49
550-600°F	1.7	4.1	--	--	9.0	16.7	1.74	3.23
600-650°F	1.8	5.9	--	--	14.8	31.5	2.87	6.10
650-700°F	2.4	8.3	--	--	21.8	53.3	4.23	10.33
700-750°F	3.0	11.3	--	0.0	17.3	70.6	3.36	13.69
750-800°F	3.4	14.7	0.84	0.84	12.1	82.7	3.02	16.71
800-850°F	3.6	18.3	2.80	3.64	8.5	91.2	3.90	20.61
850-900°F	4.3	22.6	2.81	6.45	5.5	96.7	3.33	23.94
900°F$^+$, Pyr.Sol	46.82	69.42	55.97	62.42	3.3	100.0	45.75	69.69
IOM	17.14	86.56	20.88	83.3	--	--	16.83	86.52
Ash	13.44	100.0	16.7	100.0	--	--	13.46	99.98

				% RECOVERY
900°F$^-$	22.6	6.45	96.7	106.0
Pyr. Insol	30.58	37.58*	--	99.0
C	76.66	75.73	89.18	102.2
H	4.67	4.10	7.30	101.1
N	1.55	1.61	1.25	99.4
S	1.25	1.45	0.48	100.9
O(Total)	7.7	9.2	1.8	100.8
Ash	13.44**	16.7	--	100.2
Net Stream Rate, kg/h	13.404	10.804	2.600	
Sp.Gr. 77/77°F	1.305	1.393	1.081	
Melting Pt., °F	194	338		

*Value from period sample.
**Avg. of control sample and special sample ash values.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-4

COMPONENT	FEED		BOTTOMS		OVERHEAD*		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	1.2	1.2	--	--	3.0	3.0	0.61	0.61
500-550°F	1.5	2.7	--	--	5.7	8.7	1.15	1.76
550-600°F	1.7	4.4	--	--	10.3	19.0	2.08	3.84
600-650°F	2.1	6.5	--	--	14.3	33.3	2.89	6.73
650-700°F	2.8	9.3	--	0.0	18.6	51.9	3.76	10.49
700-750°F	3.4	12.7	0.25	0.25	17.1	69.0	3.65	14.14
750-800°F	3.9	16.6	1.59	1.84	15.4	84.4	4.38	18.52
800-850°F	4.4	21.0	1.58	3.42	7.4	91.8	2.76	21.28
850-900°F	4.8	25.8	1.58	5.0	4.2	96.0	2.11	23.39
900°F⁺, Pyr.Sol	44.6	70.4	55.31	60.31	4.0	100.0	44.94	68.33
IOM	16.2	86.6	22.79	83.1	--	--	18.18	86.51
Ash	13.4	100.0	16.9	100.0	--	--	13.48	99.99

				% RECOVERY
900°F⁻	25.8	5.0	96.0	90.6
Pyr. Insol	29.60	39.69**	--	107.0
C	77.27	74.84	89.67	100.6
H	4.83	4.13	7.27	98.6
N	1.57	1.65	1.31	100.7
S	1.25	1.43	0.50	99.4
O(Total)	7.7	9.5	1.7	102.9
Ash	13.4	16.9	--	100.6
Net Stream Rate, kg/h	13.560	10.820	2.740	
Sp.Gr. 77/77°F	1.332	1.381	1.084	
Melting Pt., °F	185	347		

*Corrected data using D-1160 results.
**Value from period sample.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-5

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	1.5	1.5	--	--	1.6	1.6	0.36	0.36
500-550°F	1.0	2.5	--	--	3.9	5.5	0.89	1.25
550-600°F	1.2	3.7	--	--	6.5	12.0	1.48	2.73
600-650°F	1.5	5.2	--	--	10.5	22.5	2.39	5.12
650-700°F	2.3	7.5	--	--	15.8	38.3	3.60	8.72
700-750°F	3.2	10.7	--	0.0	23.4	61.7	5.32	14.04
750-800°F	4.0	14.7	1.11	1.11	15.0	76.7	4.27	18.31
800-850°F	4.7	19.4	1.55	2.66	7.8	84.5	2.97	21.28
850-900°F	5.6	25.0	1.54	4.20	4.1	88.6	2.12	23.4
900°F$^+$, Pyr.Sol	45.63	70.63	55.45	59.65	11.4	100.0	45.42	68.82
IOM	16.07	86.7	23.25	82.9	--	--	17.96	86.78
Ash	13.3	100.0	17.1	100.0	--	--	13.21	99.99

				% RECOVERY
900°F⁻	25.0	4.20	88.6	93.6
Pyr. Insol	29.37	40.35	--	106.2
C	77.49	73.97	88.69	99.8
H	4.59	3.97	7.18	102.4
N	1.58	1.62	1.34	98.5
S	1.35	1.59	0.45	98.6
O(Total)	5.8	8.9	1.9	126.0
Ash	13.3	17.1	--	99.3
Net Stream Rate, kg/h	13.260	10.242	3.018	
Sp.Gr. 77/77°F	1.323	1.374	1.085	
Melting Pt., °F	176	356		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-6

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.3	0.3	--	--	8.1	8.1	1.93	1.93
500-550°F	1.2	1.5	--	--	6.6	14.7	1.57	3.50
550-600°F	1.8	3.3	--	--	8.7	23.4	2.07	5.57
600-650°F	2.3	5.6	--	--	11.3	34.7	2.70	8.27
650-700°F	2.8	8.4	--	--	13.6	48.3	3.24	11.51
700-750°F	3.3	11.7	--	0.0	12.5	60.8	2.98	14.49
750-800°F	3.8	15.5	0.85	0.85	11.2	72.0	3.32	17.81
800-850°F	4.1	19.6	0.93	1.78	10.3	82.3	3.16	20.97
850-900°F	4.4	24.0	0.92	2.70	7.7	90.0	2.54	23.51
900°F$^+$, Pyr.Sol	46.71	70.71	56.72	59.42	10.0	100.0	45.58	69.09
IOM	15.79	86.5	22.98	82.4	--	--	17.50	86.59
Ash	13.5	100.0	17.6	100.0	--	--	13.40	99.99

				% RECOVERY
900°F$^-$	24.0	2.70	90.0	98.0
Pyr. Insol	29.29	40.58*	--	105.5
C	77.25	73.85	88.58	100.1
H	4.89	3.93	7.16	96.1
N	1.56	1.62	1.35	99.7
S	1.37	1.58	0.33	93.6
O(Total)	7.8	9.3	1.7	96.0
Ash	13.5	17.6	--	99.3
Net Stream Rate, kg/h	13.216	10.064	3.152	
Sp.Gr. 77/77°F	1.350	1.401	1.091	
Melting Pt., °F	176	365		

*Value from period sample.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-7

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	0.5	0.5	--	--	4.4	4.4	0.96	0.96
500-550°F	1.2	1.7	--	--	6.9	11.3	1.51	2.47
550-600°F	1.8	3.5	--	--	9.5	20.8	2.08	4.55
600-650°F	2.3	5.8	--	--	12.0	32.8	2.63	7.18
650-700°F	2.9	8.7	--	--	15.5	48.3	3.40	10.58
700-750°F	3.3	12.0	--	0.0	14.5	62.8	3.18	13.76
750-800°F	3.7	15.7	0.87	0.87	12.1	74.9	3.33	17.09
800-850°F	4.0	19.7	1.31	2.18	11.1	86.0	3.46	20.55
850-900°F	4.3	24.0	1.32	3.50	10.5	96.5	3.33	23.88
900°F$^+$, Pyr.Sol	47.13	71.13	56.95	60.45	3.5	100.0	45.23	69.11
IOM	15.57	86.7	22.65	83.1	--	--	17.68	86.79
Ash	13.3	100.0	16.9	100.0	--	--	13.20	99.99
							% RECOVERY	
900°F$^-$	24.0		3.5		96.5		99.5	
Pyr. Insol	28.87		39.55		--		107.0	
C	76.94		74.65		89.01		101.1	
H	4.59		4.30		7.12		107.1	
N	1.57		1.61		1.32		98.5	
S	1.37		1.56		0.55		97.7	
O(Total)	5.8		8.7		1.8		123.9	
Ash	13.3		16.9		--		99.2	
Net Stream Rate, kg/h	12.938		10.102		2.836			
Sp.Gr. 77/77°F	1.341		1.371		1.084			
Melting Pt., °F	176		356					

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-65-8

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	1.1	1.1	--	--	2.2	2.2	0.54	0.54
500-550°F	1.1	2.2	--	--	4.2	6.4	1.04	1.58
550-600°F	1.4	3.6	--	--	6.9	13.3	1.71	3.29
600-650°F	1.6	5.2	--	--	10.7	24.0	2.65	5.94
650-700°F	2.1	7.3	--	--	15.5	39.5	3.84	9.78
700-750°F	2.7	10.0	--	--	16.3	55.8	4.04	13.82
750-800°F	3.5	13.5	--	--	12.9	68.7	3.20	17.02
800-850°F	4.2	17.7	--	0.0	11.7	80.4	2.90	19.92
850-900°F	4.9	22.6	1.7	1.7	11.1	91.5	4.03	23.95
900°F$^+$, Pyr.Sol	47.56	70.16	54.24	55.94	8.5	100.0	42.90	66.85
IOM	16.44	86.6	26.26	82.2	--	--	19.75	86.60
Ash	13.4	100.0	17.8	100.0	--	--	13.39	99.99

				% RECOVERY
900°F⁻	22.6	1.7	91.5	106.0
Pyr. Insol	29.84	44.06	--	111.1
C	77.14	74.76	88.37	101.3
H	4.45	3.91	7.06	105.4
N	1.59	1.64	1.37	98.9
S	1.37	1.58	0.60	97.6
O(Total)	6.2	7.8	1.9	102.2
Ash	13.4	17.8	0.0005	99.9
Net Stream Rate, kg/h	13.178	9.912	3.266	
Sp.Gr. 77/77°F	1.334	1.398	1.094	
Melting Pt., °F	183	401		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-0

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	0.3	0.3	--	--	2.9	2.9	0.78	0.78
500-550°F	1.1	1.4	--	--	3.1	6.0	0.83	1.61
550-600°F	1.4	2.8	--	--	6.1	12.1	1.64	3.25
600-650°F	1.9	4.7	--	--	10.1	22.2	2.71	5.96
650-700°F	2.8	7.5	--	--	12.1	34.3	3.24	9.20
700-750°F	3.5	11.0	--	--	14.5	48.8	3.89	13.09
750-800°F	4.0	15.0	--	0.0	15.5	64.3	4.16	17.25
800-850°F	4.7	19.7	0.54	0.54	12.9	77.2	3.85	21.10
850-900°F	5.0	24.7	0.86	1.4	9.7	86.9	3.23	24.33
900°F$^+$, Pyr.Sol	47.23	71.93	57.85	59.25	13.1	100.0	45.85	70.18
IOM	14.87	86.8	22.75	82.0	--	--	16.65	86.83
Ash	13.2	100.0	18.0	100.0	--	--	13.17	100.0

				% RECOVERY
900°F⁻	24.7	1.4	86.9	98.5
Pyr. Insol	28.07	40.75	--	106.2
C	77.38	73.82	89.02	100.7
H	4.58	4.10	6.85	105.6
N	1.59	1.62*	1.45	99.0
S	1.32	1.57	0.55	98.2
O(Total)	7.3	9.8	1.8	104.8
Ash	13.2	18.0	--	99.8
Net Stream Rate, kg/h	13.585	9.942	3.643	
Sp.Gr. 77/77°F	1.298	1.403	1.096	
Melting Pt., °F	176	401		

*Value from 66-1 period sample.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-1

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	0.6	0.6	--	--	4.9	4.9	1.34	1.34
500-550°F	1.1	1.7	--	--	4.3	9.2	1.18	2.52
550-600°F	1.1	2.8	--	--	7.5	16.7	2.05	4.57
600-650°F	1.5	4.3	--	--	10.0	26.7	2.74	7.31
650-700°F	2.4	6.7	--	--	13.2	39.9	3.61	10.92
700-750°F	4.0	10.7	--	--	16.5	56.4	4.52	15.44
750-800°F	6.1	16.8	--	0.0	15.4	71.8	4.21	19.65
800-850°F	5.0	21.8	0.56	0.56	12.2	84.0	3.74	23.39
850-900°F	4.2	26.0	0.89	1.45	10.7	94.7	3.57	26.96
900°F$^+$, Pyr.Sol	48.36	74.36	59.55	61.0	5.3	100.0	44.70	71.66
IOM	12.74	87.1	21.5	82.5	--	--	15.62	87.28
Ash	12.90	100.0	17.5	100.0	--	--	12.71	99.99

				% RECOVERY
900°F⁻	26.0	1.45	94.7	103.7
Pyr. Insol	25.64	39.00	--	110.5
C	78.04	74.32	87.87	100.0
H	5.07	4.08	7.35	98.1
N	1.59	1.64	1.39	98.8
S	1.38	1.56	0.56	93.2
O(Total)	6.5	8.1	1.9	98.5
Ash	12.90	17.5	--	98.5
Net Stream Rate, kg/h	14.858	10.792	4.066	
Sp.Gr. 77/77°F	1.310	1.387	1.095	
Melting Pt., °F	185	365		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-2

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0	0	--	--	1.5	1.5	0.37	0.37
500-550°F	1.1	1.1	--	--	3.8	5.3	0.95	1.32
550-600°F	2.1	3.2	--	--	6.8	12.1	1.70	3.02
600-650°F	2.5	5.7	--	--	10.7	22.8	2.67	5.69
650-700°F	3.1	8.8	--	--	17.1	39.9	4.27	9.96
700-750°F	3.7	12.5	--	--	21.4	61.3	5.35	15.31
750-800°F	4.0	16.5	--	0.0	11.7	73.0	2.92	18.23
800-850°F	4.3	20.8	0.42	0.42	9.3	82.3	2.66	20.89
850-900°F	4.7	25.5	3.48	3.90	8.1	90.4	4.63	25.52
900°F$^+$, Pyr.Sol	49.57	75.07	60.79	64.69	9.6	100.0	48.00	73.52
IOM	12.33	87.4	18.31	83.0	--	--	13.73	87.25
Ash	12.6	100.0	17.0	100.0	--	--	12.75	100.00

				% RECOVERY
900°F$^-$	25.5	3.90	90.4	100.1
Pyr. Insol	24.93	35.31	--	106.2
C	77.55	74.58	89.11	100.8
H	4.77	3.97	7.18	100.0
N	1.59	1.65	1.39	99.7
S	1.32	1.59	0.48	99.4
O(Total)	8.4	9.7	2.1	92.9
Ash	12.6	17.0	--	101.2
Net Stream Rate, kg/h	14.600	10.951	3.649	
Sp.Gr. 77/77°F	1.311	1.381	1.090	
Melting Pt., °F	176	374		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-3

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	0.3	0.3	--	--	3.0	3.0	0.83	0.83
500-550°F	1.0	1.3	--	--	5.3	8.3	1.47	2.30
550-600°F	1.7	3.0	--	--	7.4	15.7	2.05	4.35
600-650°F	2.3	5.3	--	--	9.8	25.5	2.71	7.06
650-700°F	2.9	8.2	--	--	12.3	37.8	3.41	10.47
700-750°F	3.4	11.6	--	--	14.4	52.2	3.99	14.46
750-800°F	3.8	15.4	--	--	13.5	65.7	3.74	18.20
800-850°F	4.3	19.7	--	0.0	13.7	79.4	3.80	22.00
850-900°F	4.6	24.3	2.50	2.50	13.4	92.8	5.52	27.52
900°F$^+$, Pyr.Sol	51.29	75.59	62.62	65.12	7.2	100.0	47.27	74.79
IOM	11.61	87.2	17.58	82.7	--	--	12.71	87.50
Ash	12.8	100.0	17.3	100.0	--	--	12.51	100.01

				% RECOVERY
900°F$^-$	24.3	2.50	92.8	113.2
Pyr. Insol	24.41	34.88	--	103.3
C	77.72	74.08	89.50	100.8
H	4.91	4.00	7.20	99.5
N	1.58	1.66	1.43	101.0
S	1.32	1.61	0.48	98.3
O(Total)	7.4	10.6*	2.2	111.8
Ash	12.8	17.3	--	97.7
Net Stream Rate, kg/h	14.407	10.416	3.991	
Sp.Gr. 77/77°F	1.310	1.351	1.101	
Melting Pt., °F	185	383		

*Value from period sample.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-4

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	0.4	0.4	--	--	1.8	1.8	0.48	0.48
500-550°F	1.5	1.9	--	--	4.2	6.0	1.13	1.61
550-600°F	1.8	3.7	--	--	6.7	12.7	1.80	3.41
600-650°F	1.9	5.6	--	--	10.0	22.7	2.69	6.10
650-700°F	2.4	8.0	--	--	14.1	36.8	3.79	9.89
700-750°F	3.8	11.8	--	--	18.1	54.9	4.86	14.75
750-800°F	4.6	16.4	--	--	13.9	68.8	3.73	18.48
800-850°F	4.4	20.8	--	0.0	11.2	80.0	3.01	21.49
850-900°F	4.1	24.9	2.20	2.20	10.3	90.3	4.38	25.87
900°F^{+}, Pyr.Sol	50.74	75.64	62.9	65.1	9.7	100.0	48.61	74.48
IOM	11.86	87.5	18.0	83.1	--	--	13.16	87.64
Ash	12.5	100.0	16.9	100.0	--	--	12.36	100.0
							% RECOVERY	
900°F^{-}	24.9		2.20		90.3		103.9	
Pyr. Insol	24.36		34.90		--		104.8	
C	78.37		73.57		88.51		99.0	
H	4.98		3.94		7.22		96.8	
N	1.61		1.68		1.36		99.0	
S	1.33		1.56		0.50		95.9	
O(Total)	8.4		10.2		2.2		95.8	
Ash	12.5		16.9		--		98.9	
Net Stream Rate, kg/h	14.677		10.734		3.943			
Sp.Gr. 77/77°F	1.317		1.291		1.098			
Melting Pt., °F	185		374					

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-5

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.4	0.4	--	--	3.7	3.7	0.82	0.82
500-550°F	1.2	1.6	--	--	5.1	8.8	1.14	1.96
550-600°F	1.4	3.0	--	--	8.0	16.8	1.78	3.74
600-650°F	1.8	4.8	--	--	11.4	28.2	2.54	6.28
650-700°F	3.0	7.8	--	--	16.1	44.3	3.59	9.87
700-750°F	6.9	14.7	--	0.0	19.2	63.5	4.28	14.15
750-800°F	4.1	18.8	1.15	1.15	14.7	78.2	4.17	18.32
800-850°F	3.3	22.1	2.75	3.90	10.7	88.9	4.52	22.84
850-900°F	3.1	25.2	2.74	6.64	7.8	96.7	3.87	26.71
900°F$^+$, Pyr.Sol	50.52	75.72	61.38	68.02	3.3	100.0	48.43	75.14
IOM	11.58	87.3	15.98	84.0	--	--	12.42	87.56
Ash	12.7	100.0	16.0	100.0	--	--	12.43	99.99

				% RECOVERY
900°F$^-$	25.2	6.64	96.7	106.0
Pyr. Insol	24.28	31.98	--	102.3
C	78.23	76.12	88.49	100.8
H	4.78	4.22	7.46	103.4
N	1.53	1.66	1.33	103.7
S	1.31	1.54	0.50	99.8
O(Total)	7.5	9.1	2.2	100.8
Ash	12.7	16.0	--	97.9
Net Stream Rate, kg/h	14.303	11.114	3.189	
Sp.Gr. 77/77°F	1.314	1.344	1.089	
Melting Pt., °F	185	347		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-6

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	0.0	--	--	1.8	1.8	0.46	0.46
500-550°F	0.7	0.7	--	--	4.0	5.8	1.02	1.48
550-600°F	1.7	2.4	--	--	6.5	12.3	1.66	3.14
600-650°F	2.4	4.8	--	--	9.4	21.7	2.40	5.54
650-700°F	3.1	7.9	--	--	13.1	34.8	3.34	8.88
700-750°F	3.7	11.6	--	--	18.2	53.0	4.65	13.53
750-800°F	4.1	15.7	--	--	17.3	70.3	4.42	17.95
800-850°F	4.7	20.4	--	0.0	12.5	82.8	3.19	21.14
850-900°F	5.2	25.6	3.65	3.65	9.1	91.9	5.04	26.18
900°F$^+$, Pyr.Sol	50.09	75.69	62.69	66.34	8.1	100.0	48.75	74.93
IOM	11.61	87.3	16.86	83.2	--	--	12.55	87.48
Ash	12.7	100.0	16.8	100.0	--	--	12.51	99.99

				% RECOVERY
900°F$^-$	25.6	3.65	91.9	102.3
Pyr. Insol	24.31	33.66	--	103.1
C	78.26	74.89	89.46	100.4
H	5.06	4.17	7.34	98.4
N	1.59	1.65	1.38	99.4
S	1.33	1.58	0.56	99.2
O(Total)	7.7	8.8	2.3	92.7
Ash	12.7	16.8	--	98.5
Net Stream Rate, kg/h	13.794	10.271	3.523	
Sp.Gr. 77/77°F	1.302	1.377	1.098	
Melting Pt., °F	185	365		

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
RUN P99-66-7

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	0.2	0.2	--	--	1.2	1.2	0.30	0.30
500-550°F	1.0	1.2	--	-	3.3	4.5	0.82	1.12
550-600°F	1.9	3.1	--	--	5.5	10.0	1.37	2.49
600-650°F	2.5	5.6	--	--	8.5	18.5	2.12	4.61
650-700°F	3.2	8.8	--	--	13.2	31.7	3.30	7.91
700-750°F	3.7	12.5	--	-	18.8	50.5	4.70	12.61
750-800°F	4.0	16.5	--	--	17.0	67.5	4.25	16.86
800-850°F	4.2	20.7	--	0.0	15.3	82.8	3.82	20.68
850-900°F	4.3	25.0	2.30	2.30	9.4	92.2	4.07	24.75
900°F⁺, Pyr.Sol	50.52	75.52	64.03	66.33	7.8	100.0	49.98	74.73
IOM	11.48	87.0	16.67	83.0	--	--	12.50	87.23
Ash	13.0	100.0	17.0	100.0	--	--	12.75	99.98

				% RECOVERY
900°F⁻	25.0	2.30	92.2	99.1
Pyr. Insol	24.48	33.67	--	103.2
C	77.71	74.83	88.38	100.6
H	4.91	4.22	7.26	101.4
N	1.59	1.60	1.40	97.5
S	1.39	1.52	0.48	90.6
O(Total)	7.8	9.1*	1.7	93.0
Ash	13.0	17.0	0.0005	98.1
Net Stream Rate, kg/h	13.913	10.436	3.477	
Sp.Gr. 77/77°F	1.300	1.362	1.098	
Melting Pt., °F	185	374		

*Value from period sample.

HGM:WPC/7-28-80/251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-0

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	1.7	1.7	--	--	5.4	5.4	1.75	1.75
500-550°F	1.0	2.7	--	--	5.1	10.5	1.66	3.41
550-600°F	1.7	4.4	--	--	7.7	18.2	2.50	5.91
600-650°F	3.2	7.6	--	--	11.1	29.3	3.60	9.51
650-700°F	5.7	13.3	--	--	14.7	44.0	4.78	14.29
700-750°F	4.9	18.2	--	0.0	13.5	57.5	4.38	18.67
750-800°F	4.1	22.3	0.33	0.33	11.2	68.7	3.86	22.53
800-850°F	3.8	26.1	0.75	1.08	10.0	78.7	3.75	26.28
850-900°F	3.5	29.6	0.75	1.83	9.2	87.9	3.49	29.77
900°F^{+}, Pyr.Sol.	43.69	73.29	58.87	60.7	12.1	100.0	43.68	73.45
IOM	7.41	80.7	10.9	71.6	--	--	7.36	80.81
Ash	19.3	100.0	28.4	100.0	--	--	19.17	99.98

				% RECOVERY
900°F^{-}	29.6	1.83	87.9	100.6
Pyr. Insol.	26.71	39.30	--	99.3
C	71.07	63.63	88.23	100.8
H	5.01	3.77	7.40	98.8
N	1.29	1.29	1.32	100.8
S	2.62	3.57	0.68	100.4
O(Total)	9.6	12.6	2.0	95.4
Ash	19.3	28.4	--	99.3
Net Stream Rate, kg/h	11.781	7.954	3.827	
Sp.Gr. 77/77°F	1.372	1.488	1.085	
Melting Pt., °F	122	320		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-1

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	0.0	--	--	6.2	6.2	2.03	2.03
500-550°F	1.2	1.2	--	--	5.5	11.7	1.80	3.83
550-600°F	2.1	3.3	--	--	8.0	19.7	2.62	6.45
600-650°F	3.4	6.7	--	--	10.6	30.3	3.48	9.93
650-700°F	5.1	11.8	--	--	14.0	44.3	4.59	14.52
700-750°F	5.7	17.5	--	0.0	15.2	59.5	4.98	19.50
750-800°F	4.3	21.8	0.45	0.45	11.3	70.8	4.01	23.51
800-850°F	3.8	25.6	0.89	1.34	9.8	80.6	3.81	27.32
850-900°F	3.41	29.01	0.89	2.23	8.6	89.2	3.42	30.74
900°F$^+$, Pyr.Sol.	44.15	73.16	57.34	59.57	10.8	100.0	42.07	72.81
IOM	7.44	80.6	12.23	71.8	--	--	8.22	81.03
Ash	19.4	100.0	28.2	100.0	--	--	18.95	99.98

				% RECOVERY
900°F$^-$	29.01	2.23	89.2	106.0
Pyr. Insol.	26.84	40.43	--	101.2
C	70.92	63.80	88.81	101.5
H	4.88	3.60	7.66	101.0
N	1.27	1.28	1.30	101.3
S	2.65	3.49	0.68	96.9
O(Total)	9.7	13.1	2.1	97.8
Ash	19.4	28.2	--	97.7
Net Stream Rate, kg/h	11.509	7.734	3.775	
Sp.Gr. 77/77°F	1.375	1.501	1.085	
Melting Pt., °F	131	329		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-2

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.7	0.7	--	--	2.1	2.1	0.59	0.59
500-550°F	0.9	1.6	--	--	5.4	7.5	1.52	2.11
550-600°F	1.2	2.8	--	--	7.8	15.3	2.20	4.31
600-650°F	3.0	5.8	--	--	10.8	26.1	3.05	7.36
650-700°F	4.0	9.8	--	0.0	13.7	39.8	3.87	11.23
700-750°F	4.6	14.4	0.20	0.20	18.4	58.2	5.34	16.57
750-800°F	5.4	19.8	0.99	1.19	16.0	74.2	5.23	21.80
800-850°F	5.4	25.2	0.99	2.18	11.0	85.2	3.82	25.62
850-900°F	4.1	29.3	0.99	3.17	7.1	92.3	2.72	28.34
900°F$^+$, Pyr.Sol.	44.0	73.3	57.18	60.35	7.7	100.0	43.21	71.55
IOM	7.2	80.5	11.95	72.3	--	--	8.58	80.13
Ash	19.5	100.0	27.7	100.0	--	--	19.88	100.01

				% RECOVERY
900°F$^-$	29.3	3.17	92.3	96.7
Pyr. Insol.	26.70	39.65	--	106.6
C	70.95	64.23	88.32	100.1
H	4.95	3.77	7.55	97.7
N	1.36	1.27	1.31	94.2
S	2.66	3.39	0.65	98.4
O(Total)	9.8	12.4	2.1	96.8
Ash	19.5	27.7	--	101.9
Net Stream Rate, kg/h	11.466	8.228	3.238	
Sp.Gr. 77/77°F	1.376	1.473	1.079	
Melting Pt., °F	131	311		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-3

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.5	0.5	--	--	2.3	2.3	0.74	0.74
500-550°F	0.8	1.3	--	--	3.8	6.1	1.23	1.97
550-600°F	1.5	2.8	--	--	5.7	11.8	1.84	3.81
600-650°F	2.5	5.3	--	--	8.6	20.4	2.78	6.59
650-700°F	3.8	9.1	--	--	12.4	32.8	4.00	10.59
700-750°F	5.6	14.7	--	--	17.2	50.0	5.55	16.14
750-800°F	5.5	20.2	--	--	16.3	66.3	5.26	21.40
800-850°F	4.6	24.8	--	0.0	12.0	78.3	3.87	25.27
850-900°F	4.3	29.1	1.46	1.46	8.9	87.2	3.86	29.13
900°F$^+$, Pyr.Sol.	43.05	72.15	58.54	60.0	12.8	100.0	43.78	72.91
IOM	8.35	80.5	11.5	71.5	--	--	7.79	80.70
Ash	19.5	100.0	28.5	100.0	--	--	19.30	100.00

				% RECOVERY
900°F$^-$	29.1	1.46	87.2	100.1
Pyr. Insol.	27.85	40.00	--	97.3
C	71.04	62.95	88.49	100.2
H	4.85	3.53	7.45	98.9
N	1.25	1.28	1.34	103.9
S	2.62	3.51	0.69	99.2
O(Total)	9.5	13.0	2.0	99.5
Ash	19.5	28.5	--	99.0
Net Stream Rate, kg/h	11.572	7.838	3.734	
Sp.Gr. 77/77°F	1.379	1.495	1.090	
Melting Pt., °F	131	338		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-4

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	0.6	0.6	--	--	3.5	3.5	1.18	1.18
500-550°F	1.1	1.7	--	--	4.2	7.7	1.42	2.60
550-600°F	1.7	3.4	--	--	6.5	14.2	2.19	4.79
600-650°F	3.1	6.5	--	--	9.8	24.0	3.30	8.09
650-700°F	3.9	10.4	--	--	13.8	37.8	4.65	12.74
700-750°F	4.5	14.9	--	--	17.9	55.7	6.03	18.77
750-800°F	4.6	19.5	--	--	13.6	69.3	4.58	23.35
800-850°F	4.5	24.0	--	--	10.9	80.2	3.67	27.02
850-900°F	4.58	28.58	--	0.0	8.4	88.6	2.83	29.85
900°F^{+}, Pyr.Sol.	45.15	73.73	58.35	58.35	11.4	100.0	42.53	72.38
IOM	7.27	81.0	12.25	70.6	--	--	8.12	80.5
Ash	19.0	100.0	29.4	100.0	--	--	19.49	99.99

				% RECOVERY
900°F^{-}	28.58	0.0	88.6	104.5
Pyr. Insol.	26.27	41.65	--	105.1
C	71.83	63.39	88.50	100.0
H	4.90	5.71*	7.29	127.4
N	1.26	1.09*	1.33	92.9
S	2.41	3.46	0.7	105.0
O(Total)	9.2	13.7	1.9	105.7
Ash	19.0	29.4	--	102.6
Net Stream Rate, kg/h	12.562	8.329	4.233	
Sp.Gr. 77/77°F	1.370	1.497	1.095	
Melting Pt., °F	131	338		

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* These analyses appear erroneous.

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-5

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	0.5	0.5	--	--	3.3	3.3	1.02	1.02
500-550°F	0.8	1.3	--	--	3.7	7.0	1.14	2.16
550-600°F	1.5	2.8	--	--	6.6	13.6	2.04	4.20
600-650°F	2.7	5.5	--	--	9.9	23.5	3.05	7.25
650-700°F	5.0	10.5	--	--	12.5	36.0	3.86	11.11
700-750°F	6.8	17.3	--	--	15.0	51.0	4.63	15.74
750-800°F	5.9	23.2	--	0.0	17.3	68.3	5.34	21.08
800-850°F	4.2	27.4	0.64	0.64	15.2	83.5	5.13	26.21
850-900°F	4.16	31.56	2.89	3.53	6.0	89.5	3.85	30.06
900°F^{+}, Pyr.Sol.	43.92	75.48	56.88	60.41	10.5	100.0	42.58	72.64
IOM	5.42	80.9	11.69	72.1	--	--	8.08	80.72
Ash	19.1	100.0	27.9	100.0	--	--	19.29	100.01

				% RECOVERY
900°F^{-}	31.56	3.53	89.5	95.2
Pyr. Insol.	24.52	39.59	--	111.7
C	71.07	63.73	88.42	100.4
H	4.97	3.69	7.21	96.1
N	1.32	1.30	1.30	98.5
S	2.55	3.47	0.64	101.8
O(Total)	9.7	12.8	1.9	97.3
Ash	19.1	27.9	--	101.0
Net Stream Rate, kg/h	12.272	8.487	3.785	
Sp.Gr. 77/77°F	1.372	1.468	1.086	
Melting Pt., °F	131	329		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-6

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**
500°F^{-}	0.8	0.8	--	--	5.7	5.7	1.80	1.80
500-550°F	0.9	1.7	--	--	4.0	9.7	1.27	3.07
550-600°F	1.0	2.7	--	--	6.5	16.2	2.06	5.13
600-650°F	1.9	4.6	--	--	10.3	26.5	3.26	8.39
650-700°F	3.6	8.2	--	--	16.0	42.5	5.06	13.45
700-750°F	9.8	18.0	--	0.0	20.0	62.5	6.33	19.78
750-800°F	6.7	24.7	1.19	1.19	13.8	76.3	5.18	24.96
800-850°F	3.1	27.8	1.19	2.38	9.7	86.0	3.88	28.84
850-900°F	1.9	29.7	1.19	3.57	6.3	92.3	2.81	31.65
900°F^{+}, Pyr.Sol.	43.84	73.54	56.79	60.36	7.7	100.0	41.25	72.90
IOM	7.56	81.1	11.84	72.2	--	--	8.09	80.99
Ash	18.9	100.0	27.8	100.0	--	--	19.00	99.99

				% RECOVERY
900°F^{-}	29.7	3.57	92.3	106.6
Pyr. Insol.	26.46	39.64	--	102.4
C	71.49	64.35	88.14	100.5
H	4.95	3.73	7.49	99.4
N	1.31	1.28	1.31	98.4
S	2.53	3.36	0.58	98.0
O(Total)	9.1	12.7	2.0	102.3
Ash	18.9	27.8	--	100.5
Net Stream Rate, kg/h	12.515	8.554	3.961	
Sp.Gr. 77/77°F	1.368	1.435	1.084	
Melting Pt., °F	131	329		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-7

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.8	0.8	--	--	2.7	2.7	0.97	0.97
500-550°F	0.9	1.7	--	--	4.5	7.2	1.62	2.59
550-600°F	1.5	3.2	--	--	7.2	14.4	2.59	5.18
600-650°F	2.6	5.8	--	--	9.4	23.8	3.38	8.56
650-700°F	4.4	10.2	--	--	11.0	34.8	3.96	12.52
700-750°F	5.5	15.7	--	0.0	12.5	47.3	4.50	17.02
750-800°F	5.1	20.8	0.03	0.03	13.5	60.8	4.88	21.90
800-850°F	4.4	25.2	0.44	0.47	11.9	72.7	4.56	26.46
850-900°F	3.64	28.84	0.45	0.92	9.8	82.5	3.81	30.27
900°F$^+$, Pyr.Sol.	46.29	75.13	52.05	52.97	17.5	100.0	39.62	69.89
IOM	6.37	81.5	18.13	71.1	--	--	11.61	81.50
Ash	18.5	100.0	28.9	100.0	--	--	18.50	100.00

				% RECOVERY
900°F$^-$	28.84	0.92	82.5	105.0
Pyr. Insol.	24.87	47.03	--	121.1
C	71.38	63.14	88.19	101.1
H	4.87	3.51	7.40	100.8
N	1.30	1.29	1.35	100.9
S	2.54	3.49	0.63	96.9
O(Total)	9.5	13.7	2.0	99.9
Ash	18.5	28.9	--	100.0
Net Stream Rate, kg/h	12.411	7.946	4.465	
Sp.Gr. 77/77°F	1.364	1.484	1.095	
Melting Pt., °F	131	356		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-8

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.5	0.5	--	--	2.4	2.4	0.88	0.88
500-550°F	1.0	1.5	--	--	3.9	6.3	1.42	2.30
550-600°F	1.5	3.0	--	--	6.0	12.3	2.19	4.49
600-650°F	2.9	5.9	--	--	8.0	20.3	2.92	7.41
650-700°F	4.5	10.4	--	--	10.2	30.5	3.72	11.13
700-750°F	5.3	15.7	--	--	12.7	43.2	4.63	15.76
750-800°F	5.6	21.3	--	--	15.1	58.3	5.51	21.27
800-850°F	4.4	25.7	--	--	15.5	73.8	5.66	26.93
850-900°F	4.03	29.73	--	0.0	10.9	84.7	3.98	30.91
900°F$^+$, Pyr.Sol.	44.61	74.34	58.12	58.12	15.3	100.0	42.49	73.40
IOM	7.26	81.6	12.68	70.8	--	--	8.05	81.45
Ash	18.4	100.0	29.2	100.0	--	--	18.54	99.99

				% RECOVERY
900°F$^-$	29.73	0.0	84.7	104.0
Pyr. Insol.	25.66	41.88	--	103.6
C	72.07	62.68	88.64	100.1
H	4.66	3.45	7.29	104.1
N	1.29	1.30	1.35	102.2
S	2.60	3.67	0.68	99.2
O(Total)	9.3	13.6	2.0	100.7
Ash	18.4	29.2	--	100.8
Net Stream Rate, kg/h	12.950	8.224	4.726	
Sp.Gr. 77/77°F	1.364	1.476	1.097	
Melting Pt., °F	131	356		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-9

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.5	0.5	--	--	5.5	5.5	2.05	2.05
500-550°F	0.9	1.4	--	--	4.2	9.7	1.57	3.62
550-600°F	1.5	2.9	--	--	5.6	15.3	2.09	5.71
600-650°F	2.4	5.3	--	--	8.1	23.4	3.02	8.73
650-700°F	4.0	9.3	--	--	10.6	34.0	3.95	12.68
700-750°F	5.2	14.5	--	--	13.7	47.7	5.11	17.79
750-800°F	6.2	20.7	--	--	14.3	62.0	5.33	23.12
800-850°F	4.8	25.5	--	--	12.2	74.2	4.55	27.67
850-900°F	4.1	29.6	--	00	9.7	83.9	3.62	31.29
900°F$^+$, Pyr.Sol.	44.92	74.52	57.69	57.69	16.1	100.0	42.18	73.47
IOM	7.38	81.9	13.61	71.3	--	--	8.53	82.00
Ash	18.1	100.0	28.7	100.0	--	--	18.00	100.00

				% RECOVERY
900°F$^-$	29.6	0.0	83.9	105.7
Pyr. Insol.	25.48	42.31	--	104.1
C	72.10	63.18	88.39	100.7
H	4.90	3.58	7.13	100.1
N	1.32	1.28	1.38	99.8
S	2.64	3.67	0.75	97.8
O(Total)	9.1	13.2	2.0	99.2
Ash	18.1	28.7	--	99.4
Net Stream Rate, kg/h	12.716	7.974	4.742	
Sp.Gr. 77/77°F	1.359	1.482	1.100	
Melting Pt., °F	131	383		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-10

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F^{-}	0.6	0.6	--	--	1.4	1.4	0.50	0.50
500-550°F	0.8	1.4	--	--	3.4	4.8	1.22	1.72
550-600°F	1.3	2.7	--	--	5.5	10.3	1.97	3.69
600-650°F	2.5	5.2	--	--	8.0	18.3	2.86	6.55
650-700°F	5.4	10.6	--	--	10.7	29.0	3.83	10.38
700-750°F	7.1	17.7	--	--	14.0	43.0	5.01	15.39
750-800°F	6.0	23.7	--	0.0	15.7	58.7	5.62	21.01
800-850°F	4.2	27.9	0.42	0.42	12.5	71.2	4.75	25.76
850-900°F	2.98	30.88	0.63	1.05	8.5	79.7	3.45	29.21
900°F^{+}, Pyr.Sol.	43.98	74.86	53.77	54.82	20.3	100	41.78	70.99
IOM	6.74	81.6	15.88	70.7	--	--	10.19	81.18
Ash	18.4	100.0	29.3	100.0	--	--	18.81	99.99

				% RECOVERY
900°F^{-}	30.88	1.05	79.7	94.6
Pyr. Insol.	25.14	45.18	--	115.4
C	72.49	63.29	89.00	100.0
H	4.89	3.51	7.36	100.0
N	1.29	1.25	1.37	100.2
S	2.58	3.57	0.67	98.1
O(Total)	9.0	13.0	2.0	100.7
Ash	18.4	29.3	--	102.2
Net Stream Rate, kg/h	12.540	8.049	4.491	
Sp.Gr. 77/77°F	1.362	1.478	1.100	
Melting Pt., °F	131	383		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-67-11

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**
500°F$^-$	--	0.0	--	--	2.0	2.0	0.70	0.70
500-550°F	0.6	0.6	--	--	3.7	5.7	1.29	1.99
550-600°F	1.2	1.8	--	--	5.7	11.4	1.99	3.98
600-650°F	1.9	3.7	--	--	8.1	19.5	2.83	6.81
650-700°F	4.0	7.7	--	--	10.4	29.9	3.63	10.44
700-750°F	5.1	12.8	--	0.0	13.4	43.3	4.68	15.12
750-800°F	6.4	19.2	0.32	0.32	16.4	59.7	5.93	21.05
800-850°F	5.8	25.0	0.41	0.73	14.5	74.2	5.33	26.38
850-900°F	5.6	30.6	0.42	1.15	11.0	85.2	4.11	30.49
900°F$^+$, Pyr.Sol.	42.89	73.49	59.45	60.6	14.8	100.0	43.86	74.35
IOM	7.61	81.1	10.6	71.2	--	--	6.90	81.25
Ash	18.9	100.0	28.8	100.0	--	--	18.74	99.99

				% RECOVERY
900°F$^-$	30.6	1.15	85.2	99.6
Pyr. Insol.	26.51	39.40	--	96.7
C	73.51	63.21	88.69	98.1
H	4.95	3.59	7.31	98.8
N	1.33	1.30	1.37	99.6
S	2.68	3.68	0.66	98.0
O(Total)	9.3	13.3	2.0	100.6
Ash	18.9	28.8	0.001	99.2
Net Stream Rate, kg/h	12.306	8.010	4.296	
Sp.Gr. 77/77°F	1.369	1.458	1.099	
Melting Pt., °F	131	356		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-0

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	--	--	--	3.4	3.4	1.18	1.18
500-550°F	--	0.0	--	--	4.6	8.0	1.60	2.78
550-600°F	1.4	1.4	--	--	6.3	14.3	2.18	4.96
600-650°F	2.6	4.0	--	--	8.4	22.7	2.91	7.87
650-700°F	3.8	7.8	--	--	10.5	33.2	3.64	11.51
700-750°F	5.4	13.2	--	--	12.5	45.7	4.34	15.85
750-800°F	5.6	18.8	--	0.0	14.5	60.2	5.03	20.88
800-850°F	5.4	24.2	0.24	0.24	13.0	73.2	4.67	25.55
850-900°F	5.0	29.2	0.36	0.6	9.5	82.7	3.53	29.08
900°F$^+$, Pyr.Sol.	46.24	75.44	63.44	64.04	17.3	100.0	47.43	76.51
IOM	7.00	82.44	8.96	73.0	--	--	5.85	82.36
Ash	17.56	100.0	27.0	100.0	--	--	17.63	99.99

				% RECOVERY
900°F$^-$	29.2	0.6	82.7	99.6
Pyr. Insol.	24.56	35.96	--	95.6
C	73.72	64.68	87.72	98.6
H	5.05	3.82	7.37	100.0
N	1.34	1.34	1.35	100.2
S	2.64	3.61	0.69	98.4
O(Total)	8.4	11.5	2.3	98.9
Ash	17.56	27.00	--	100.4
Net Stream Rate, kg/h	12.755	8.330	4.425	
Sp.Gr. 77/77°F	1.357	1.439	1.056	
Melting Pt., °F	158	370		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-1

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.6	0.6	--	--	2.6	2.6	0.80	0.80
500-550°F	0.9	1.5	--	--	4.2	6.8	1.29	2.09
550-600°F	1.3	2.8	--	--	6.3	13.1	1.93	4.02
600-650°F	2.4	5.2	--	--	8.8	21.9	2.70	6.72
650-700°F	3.3	8.5	--	0.0	11.6	33.5	3.56	10.28
700-750°F	4.2	12.7	0.46	0.46	15.0	48.5	4.92	15.20
750-800°F	4.6	17.3	0.46	0.92	16.8	65.3	5.47	20.67
800-850°F	4.5	21.8	0.46	1.38	14.5	79.8	4.77	25.44
850-900°F	3.98	25.78	0.46	1.84	11.4	91.2	3.82	29.26
900°F$^+$, Pyr.Sol.	48.59	74.37	61.65	63.49	8.8	100.0	45.43	74.69
IOM	7.79	82.16	10.98	74.47	--	--	7.61	82.30
Ash	17.84	100.0	25.53	100.0	--	--	17.70	100.00

				% RECOVERY
900°F$^-$	25.78	1.84	91.2	113.5
Pyr. Insol.	25.63	36.51	--	98.7
C	72.94	66.08	88.59	100.1
H	4.80	3.97	7.38	104.5
N	1.33	1.35	1.32	100.8
S	2.70	3.38	0.76	95.4
O(Total)	8.3	11.4	2.2	103.3
Ash	17.84	25.53	--	99.2
Net Stream Rate, kg/h	12.880	8.928	3.952	
Sp.Gr. 77/77°F	1.362	1.414	1.089	
Melting Pt., °F	158	363		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-2

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.7	0.7	--	--	4.1	4.1	1.06	1.06
500-550°F	0.6	1.3	--	--	4.7	8.8	1.22	2.28
550-600°F	1.0	2.3	--	--	7.2	16.0	1.86	4.14
600-650°F	2.0	4.3	--	--	10.3	26.3	2.66	6.80
650-700°F	3.8	8.1	--	0.0	14.6	40.9	3.78	10.58
700-750°F	6.1	14.2	0.55	0.55	19.8	60.7	5.53	16.11
750-800°F	4.6	18.8	0.73	1.28	16.3	77.0	4.76	20.87
800-850°F	3.8	22.6	0.72	2.00	10.3	87.3	3.20	24.07
850-900°F	3.5	26.1	0.73	2.73	6.4	93.7	2.20	26.27
900°F$^+$, Pyr.Sol.	48.57	74.67	61.67	64.4	6.3	100.0	47.35	73.62
IOM	6.87	81.54	11.1	75.5	--	--	8.23	81.85
Ash	18.46	100.0	24.5	100.0	--	--	18.16	100.01

				% RECOVERY
900°F$^-$	26.1	2.73	93.7	100.6
Pyr. Insol.	25.33	35.60	--	104.2
C	72.46	66.99	87.33	99.7
H	4.80	3.88	7.53	100.5
N	1.34	1.39	1.27	101.4
S	2.71	3.28	0.69	96.3
O(Total)	9.3	10.5	2.3	90.1
Ash	18.46	24.50	--	98.4
Net Stream Rate, kg/h	13.010	9.646	3.364	
Sp.Gr. 77/77°F	1.366	1.436	1.087	
Melting Pt., °F	171	347		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-3

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.7	0.7	0.41	0.41	4.7	4.7	1.44	1.44
500-550°F	1.0	1.7	0.72	1.13	5.5	10.2	1.86	3.30
550-600°F	1.5	3.2	0.71	1.84	8.0	18.2	2.45	5.75
600-650°F	2.0	5.2	0.71	2.55	11.1	29.3	3.20	8.95
650-700°F	3.6	8.8	0.72	3.27	14.7	44.0	4.06	13.01
700-750°F	5.9	14.7	0.71	3.98	18.5	62.5	4.97	17.98
750-800°F	5.3	20.0	0.71	4.69	17.7	80.2	4.77	22.75
800-850°F	4.0	24.0	0.72	5.41	7.6	87.8	2.36	25.11
850-900°F	3.68	27.68	0.71	6.12	4.1	91.9	1.52	26.63
900°F$^+$, Pyr.Sol.	46.78	74.46	60.37	66.49	8.1	100.0	47.87	74.50
IOM	7.23	81.69	9.19	75.68	--	--	6.99	81.49
Ash	18.31	100.00	24.32	100.0	--	--	18.50	99.99

				% RECOVERY
900°F$^-$	27.68	6.12	91.9	96.2
Pyr. Insol.	25.54	33.51	--	99.8
C	72.46*	67.15	88.81	99.8
H	5.00	4.08	7.60	98.4
N	1.33	1.37	1.27	101.2
S	2.68	3.28	0.65	98.9
O(Total)	9.4	10.6	2.3	91.6
Ash	18.31	24.32	--	101.0
Net Stream Rate, kg/h	12.534	9.536	2.998	
Sp.Gr. 77/77°F	1.358	1.417	1.078	
Melting Pt., °F	165	329		

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*Value from test 68-2.

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-4

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	0.7	0.7	--	--	5.2	5.2	1.31	1.31
500-550°F	0.9	1.8	--	--	5.8	11.0	1.46	2.77
550-600°F	1.5	3.3	--	--	8.4	19.4	2.12	4.89
600-650°F	2.9	6.2	--	--	11.5	30.9	2.90	7.79
650-700°F	4.3	10.5	--	--	15.6	46.5	3.93	11.72
700-750°F	5.2	15.7	--	0.0	19.8	66.3	4.99	16.71
750-800°F	6.1	21.8	2.02	2.02	17.0	83.3	5.80	22.51
800-850°F	4.5	26.3	2.07	4.09	8.5	91.8	3.69	26.20
850-900°F	2.9	29.20	2.06	6.15	4.5	96.3	2.67	28.87
900°F⁺, Pyr.Sol.	46.68	75.88	58.05	64.2	3,7	100.0	44.35	73.22
IOM	6.18	82.06	11.1	75.3	--	--	8.30	81.52
Ash	17.94	100.0	24.7	100.0	--	--	18.48	100.00

				% RECOVERY
900°F⁻	29.20	6.15	96.3	98.9
Pyr. Insol.	24.12	35.80	--	111.0
C	73.10	71.09	88.45	103.2
H	5.14	3.99	7.58	95.2
N	1.33	1.36	1.24	100.0
S	2.71	3.31	0.66	97.5
O(Total)	8.5	11.1	2.3	104.5
Ash	17.94	24.7	--	103.0
Net Stream Rate, kg/h	13.265	9.922	3.343	
Sp.Gr. 77/77°F	1.359	1.421	1.076	
Melting Pt., °F	154	334		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-5

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	--	--	--	4.8	4.8	1.06	1.06
500-550°F	--	0.0	--	--	6.0	10.8	1.32	2.38
550-600°F	1.4	1.4	--	--	9.5	20.3	2.10	4.48
600-650°F	2.6	4.0	--	0.0	14.5	34.8	3.20	7.68
650-700°F	3.7	7.7	0.1	0.1	21.4	56.2	4.80	12.48
700-750°F	5.5	13.2	1.0	1.1	17.6	73.8	4.67	17.15
750-800°F	5.5	18.7	1.3	2.4	11.5	85.3	3.55	20.70
800-850°F	4.6	23.3	1.9	4.3	8.4	93.7	3.34	24.04
850-900°F	4.0	27.3	4.5	8.8	4.3	98.0	4.46	28.50
900°F$^+$, Pyr.Sol.	47.13	74.43	56.86	65.66	2.0	100.0	44.74	73.24
IOM	6.59	81.02	9.75	75.41	--	--	7.60	80.84
Ash	18.98	100.0	24.59	100.0	--	--	19.16	100.00

				% RECOVERY
900°F$^-$	27.3	8.8	98.0	104.4
Pyr. Insol.	25.57	34.34	--	104.6
C	70.78	66.77	86.45	100.5
H	4.86	4.00	7.65	98.9
N	1.35	1.36	1.24	98.8
S	2.79	3.19	0.63	94.1
O(Total)	8.8	10.8	2.4	101.6
Ash	18.98	24.59	--	100.9
Net Stream Rate, kg/h	12.504	9.742	2.762	
Sp.Gr. 77/77°F	1.373	1.412	1.026	
Melting Pt., °F	167	311		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-6

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	0.2	0.2	--	--	5.2	5.2	1.19	1.19
500-550°F	1.1	1.3	--	--	6.0	11.2	1.38	2.57
550-600°F	1.9	3.2	--	--	8.8	20.0	2.02	4.59
600-650°F	2.6	5.8	--	--	12.3	32.3	2.82	7.41
650-700°F	3.5	9.3	--	0.0	17.2	49.5	3.95	11.36
700-750°F	4.4	13.7	1.14	1.14	19.8	69.3	5.42	16.78
750-800°F	4.5	18.2	1.31	2.45	13.5	82.8	4.11	20.89
800-850°F	4.1	22.3	1.30	3.75	9.0	91.8	3.07	23.96
850-900°F	3.98	26.28	1.30	5.05	5.6	97.4	2.29	26.25
900°F^{+}, Pyr.Sol.	47.36	73.64	59.04	64.09	2.6	100.0	46.09	72.34
IOM	7.36	81.0	11.31	75.4	--	--	8.71	81.05
Ash	19.0	100.0	24.6	100.0	--	--	18.96	100.01

				% RECOVERY
900°F^{-}	26.28	5.05	97.4	99.8
Pyr. Insol.	26.36	35.91	--	105.0
C	70.13	66.28	87.50	101.4
H	4.93	3.90	7.59	96.3
N	1.33	1.37	1.23	100.6
S	2.69	3.33	0.64	100.8
O(Total)	9.1	11.4	2.4	102.6
Ash	19.0	24.6	--	99.8
Net Stream Rate, kg/h	12.176	9.382	2.794	
Sp.Gr. 77/77°F	1.385	1.428	1.032	
Melting Pt., °F	176	329		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-7

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.2	0.2	--	--	5.0	5.0	1.25	1.25
500-550°F	1.1	1.3	--	--	5.7	10.7	1.43	2.68
550-600°F	2.0	3.3	--	--	7.9	18.6	1.98	4.66
600-650°F	3.1	6.4	--	--	10.9	29.5	2.73	7.39
650-700°F	4.4	10.8	--	0.0	14.2	43.7	3.55	10.94
700-750°F	5.4	16.2	0.50	0.50	18.1	61.8	4.90	15.84
750-800°F	4.5	20.7	1.01	1.51	14.7	76.5	4.44	20.28
800-850°F	3.7	24.4	1.00	2.51	10.0	86.5	3.25	23.53
850-900°F	3.0	27.4	1.01	3.52	6.5	93.0	2.38	25.91
900°F$^+$, Pyr.Sol.	46.31	73.71	60.85	64.37	7.0	100.0	47.37	73.28
IOM	7.75	81.46	10.97	75.34	--	--	8.22	81.50
Ash	18.54	100.0	24.66	100.0	--	--	18.49	99.99

				% RECOVERY
900°F$^-$	27.4	3.52	93.0	94.6
Pyr. Insol.	26.29	35.63	--	101.6
C	71.18	65.95	88.34	100.5
H	4.98	3.87	7.61	96.5
N	1.33	1.35	1.24	99.4
S	2.80	3.43	0.65	97.6
O(Total)	9.0	10.7	2.4	95.8
Ash	18.54	24.66	--	99.7
Net Stream Rate, kg/h	12.883	9.658	3.225	
Sp.Gr. 77/77°F	1.369	1.421	1.073	
Melting Pt., °F	171	334		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-68-8

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.6	0.6	--	--	5.7	5.7	1.45	1.45
500-550°F	0.8	1.4	--	--	5.9	11.6	1.50	2.95
550-600°F	1.3	2.7	--	0.0	8.4	20.0	2.13	5.08
600-650°F	2.5	5.2	0.38	0.38	11.2	31.2	3.13	8.21
650-700°F	5.1	10.3	0.72	1.10	14.6	45.8	4.24	12.45
700-750°F	6.5	16.8	0.72	1.82	17.0	62.8	4.85	17.30
750-800°F	4.0	20.8	0.72	2.54	13.5	76.3	3.96	21.26
800-850°F	3.3	24.1	0.73	3.27	9.8	86.1	3.03	24.29
850-900°F	2.84	26.94	0.72	3.99	6.7	92.8	2.24	26.53
900°F$^+$, Pyr.Sol.	47.02	73.96	60.07	64.06	7.2	100.0	46.65	73.18
IOM	7.47	81.43	10.83	74.89	--	--	8.08	81.26
Ash	18.57	100.0	25.11	100.00	--	--	18.73	99.99

				% RECOVERY
900°F$^-$	26.94	3.99	92.8	98.5
Pyr. Insol.	26.04	35.94	--	103.0
C	71.87	66.67	88.34	100.4
H	5.00	3.95	7.57	97.4
N	1.34	1.37	1.25	100.0
S	2.70	3.32	0.64	97.8
O(Total)	8.9	10.6	2.3	95.4
Ash	18.57	25.11	0.0002	100.9
Net Stream Rate, kg/h	12.746	9.510	3.236	
Sp.Gr. 77/77°F	1.357	1.405	1.078	
Melting Pt., °F	167	352		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-0

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	0.0	--	--	4.4	4.4	1.06	1.06
500-550°F	0.9	0.9	--	--	5.6	10.0	1.35	2.41
550-600°F	2.1	3.0	--	--	8.5	18.5	2.04	4.45
600-650°F	3.3	6.3	--	0.0	12.2	30.7	2.93	7.38
650-700°F	4.9	11.2	0.3	0.3	17.1	47.8	4.34	11.72
700-750°F	6.6	17.8	0.8	1.1	20.5	68.3	5.54	17.26
750-800°F	5.2	23.0	1.0	2.1	14.0	82.3	4.13	21.39
800-850°F	3.7	26.7	1.5	3.6	8.9	91.2	3.28	24.67
850-900°F	2.32	29.02	2.7	6.3	5.6	96.8	3.40	28.07
900°F$^+$, Pyr.Sol.	43.88	72.9	57.2	63.5	3.2	100.0	44.21	72.28
IOM	8.26	81.16	11.36	74.86	--	--	8.63	80.91
Ash	18.84	100.0	25.14	100.0	--	--	19.09	100.00

	FEED	BOTTOMS	OVERHEAD	% RECOVERY
900°F$^-$	29.02	6.3	96.8	96.7
Pyr. Insol.	27.10	36.50	--	102.3
C	71.24	66.40	88.70	100.7
H	4.86	3.98	4.67	85.3
N	1.32	1.35	1.26	100.6
S	3.11	3.15	0.56	81.2
O(Total)	9.9	13.7	2.5	111.2
Ash	18.84	25.14	--	101.3
Net Stream Rate, kg/h	12.076	9.171	2.905	
Sp.Gr. 77/77°F	1.376	1.480	1.072	
Melting Pt., °F	149	293		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-1

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.1	0.1	--	--	4.7	4.7	1.12	1.12
500-550°F	0.4	0.5	--	--	5.7	10.4	1.36	2.48
550-600°F	1.3	1.8	--	--	8.8	19.2	2.10	4.58
600-650°F	2.3	4.1	--	0.0	12.6	31.8	3.01	7.59
650-700°F	3.2	7.3	0.74	0.74	18.0	49.8	4.86	12.45
700-750°F	4.2	11.5	1.05	1.79	18.9	68.7	5.31	17.76
750-800°F	5.1	16.6	1.05	2.84	13.1	81.8	3.92	21.68
800-850°F	4.7	21.3	1.06	3.90	9.0	90.8	2.95	24.63
850-900°F	4.6	25.9	1.05	4.95	6.0	96.8	2.23	26.86
900°F$^+$, Pyr.Sol.	46.26	72.16	57.13	62.08	3.2	100.0	44.26	71.12
IOM	8.17	80.33	12.25	74.33	--	--	9.33	80.45
Ash	19.67	100.0	25.67	100.0	--	--	19.54	99.99

				% RECOVERY
900°F$^-$	25.9	4.95	96.8	103.7
Pyr. Insol.	27.84	37.92	--	103.7
C	70.71	66.09	87.52	100.7
H	4.67	3.86	7.45	101.0
N	1.32	1.33	1.13	97.1
S	2.64	2.59	0.60	80.1
O(Total)	10.6	13.0	2.3	98.6
Ash	19.67	25.67	--	99.4
Net Stream Rate, kg/h	11.195	8.524	2.671	
Sp.Gr. 77/77°F	1.378	1.430	1.074	
Melting Pt., °F	162	293		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-2

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	0.2	0.2	--	--	6.1	6.1	1.26	1.26
500-550°F	1.0	1.2	--	0.0	6.2	12.3	1.28	2.54
550-600°F	1.5	2.7	0.2	0.2	9.4	21.7	2.09	4.63
600-650°F	2.5	5.2	0.5	0.7	12.7	34.4	3.01	7.64
650-700°F	3.5	8.7	0.6	1.3	17.5	51.9	4.08	11.72
700-750°F	4.7	13.4	0.9	2.2	16.5	68.4	4.11	15.83
750-800°F	5.3	18.7	1.1	3.3	12.1	80.5	3.36	19.19
800-850°F	4.2	22.9	1.7	5.0	8.7	89.2	3.14	22.33
850-900°F	4.0	26.9	3.8	8.8	6.0	95.2	4.25	26.58
900°F$^+$, Pyr.Sol.	47.19	74.09	59.9	68.7	4.8	100.0	48.56	75.14
IOM	5.59	79.68	5.53	74.23	--	--	4.39	79.53
Ash	20.32	100.0	25.77	100.0	--	--	20.46	99.99

				% RECOVERY
900°F$^-$	26.9	8.8	95.2	98.8
Pyr. Insol.	25.91	31.30	--	95.9
C	70.68	66.31	87.97	100.1
H	4.70	3.95	7.53	99.7
N	1.30	1.32	1.25	100.4
S	2.73	3.18	0.57	96.8
O(Total)	12.6	14.6	2.1	95.4
Ash	20.32	25.77	--	100.7
Net Stream Rate, kg/h	10.784	8.564	2.220	
Sp.Gr. 77/77°F	1.389	1.438	1.028	
Melting Pt., °F	149	284		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-3

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	--	0.0	--	--	4.3	4.3	1.21	1.21
500-550°F	0.5	0.5	--	--	5.2	9.5	1.46	2.67
550-600°F	1.2	1.7	--	--	7.5	17.0	2.11	4.78
600-650°F	1.7	3.4	--	--	10.3	27.3	2.90	7.68
650-700°F	3.3	6.7	--	0.0	13.6	40.9	3.82	11.50
700-750°F	5.3	12.0	0.15	0.15	17.1	58.0	4.92	16.42
750-800°F	5.5	17.5	1.48	1.63	19.0	77.0	6.41	22.83
800-850°F	5.1	22.6	1.48	3.11	11.8	88.8	4.38	27.21
850-900°F	4.9	27.5	1.48	4.59	7.1	95.9	3.06	30.27
900°F$^+$, Pyr.Sol.	43.96	71.46	56.4	60.99	4.1	100.0	41.69	71.96
IOM	8.34	79.8	11.01	72.0	--	--	7.91	79.87
Ash	20.2	100.0	28.0	100.0	--	--	20.12	99.99

	FEED	BOTTOMS	OVERHEAD	% RECOVERY
900°F$^-$	27.5	4.59	95.9	110.1
Pyr. Insol.	28.54*	39.01	--	98.2
C	70.59	63.82	88.40	100.2
H	4.60	3.65	7.50	102.9
N	1.29	1.30	1.31	101.0
S	2.75	3.44	0.56	95.6
O(Total)	10.7	13.8	2.0	98.0
Ash	20.2	28.0	--	99.6
Net Stream Rate, kg/h	10.724	7.708	3.016	
Sp.Gr. 77/77°F	1.383	1.388	1.090	
Melting Pt., °F	131	320		

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*Value from control sample analysis.
P.I. for special test sample was 22.80%.

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-4

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.6	0.6	--	--	3.8	3.8	1.05	1.05
500-550°F	0.9	1.5	--	--	5.0	8.8	1.38	2.43
550-600°F	1.4	2.9	--	--	7.4	16.2	2.04	4.47
600-650°F	2.7	5.6	--	0.0	10.5	26.7	2.90	7.37
650-700°F	4.1	9.7	0.24	0.24	14.0	40.7	4.04	11.41
700-750°F	5.3	15.0	1.17	1.41	18.0	58.7	5.82	17.23
750-800°F	5.3	20.3	1.18	2.59	19.1	77.8	6.13	23.36
800-850°F	4.0	24.3	1.18	3.77	11.5	89.3	4.03	27.39
850-900°F	3.1	27.4	1.18	4.95	6.5	95.8	2.65	30.04
900°F$^+$, Pyr.Sol.	44.58	71.98	56.62	61.57	4.2	100.0	42.13	72.17
IOM	7.72	79.7	10.93	72.5	--	--	7.91	80.08
Ash	20.3	100.0	27.5	100.0	--	--	19.90	99.98

	FEED	BOTTOMS	OVERHEAD	% RECOVERY
900°F$^-$	27.4	4.95	95.8	109.7
Pyr. Insol.	28.02	38.43	--	99.2
C	70.15	64.19	88.07	100.9
H	4.68	3.82	7.57	103.8
N	1.30	1.28	1.30	98.9
S	2.77	3.35	0.57	93.2
O(Total)	10.5	16.5	2.1	119.2
Ash	20.3	27.5	--	98.0
Net Stream Rate, kg/h	10.926	7.906	3.020	
Sp.Gr. 77/77°F	1.379	1.452	1.080	
Melting Pt., °F	176	334		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-5

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.75	0.75	--	--	5.2	5.2	1.66	1.66
500-550°F	0.95	1.7	--	--	5.0	10.2	1.59	3.25
550-600°F	1.2	2.9	--	--	7.1	17.3	2.26	5.51
600-650°F	1.8	4.7	--	--	9.0	26.3	2.87	8.38
650-700°F	3.05	7.75	--	0.0	11.0	37.3	3.50	11.88
700-750°F	4.85	12.6	0.34	0.34	13.1	50.4	4.40	16.28
750-800°F	6.3	18.9	0.46	0.80	12.9	63.3	4.42	20.70
800-850°F	5.8	24.7	0.46	1.26	10.9	74.2	3.78	24.48
850-900°F	4.9	29.6	0.45	1.71	8.6	82.8	3.05	27.53
900°F$^+$, Pyr.Sol.	42.41	72.01	57.22	58.93	17.2	100.0	44.47	72.00
IOM	8.39	80.4	12.57	71.5	--	--	8.56	80.56
Ash	19.6	100.0	28.5	100.0	--	--	19.42	99.98

				% RECOVERY
900°F$^-$	29.6	1.71	82.8	93.0
Pyr. Insol.	27.99	41.07	--	100.0
C	70.56	63.59	90.6	102.3
H	4.77	3.67	7.87	105.0
N	1.28	1.29	1.32	101.5
S	2.61	3.45	0.56	96.9
O(Total)	11.0	13.2	1.9	87.3
Ash	19.6	28.5	--	99.1
Net Stream Rate, kg/h	12.083	8.234	3.849	
Sp.Gr. 77/77°F	1.362	1.495	1.090	
Melting Pt., °F	158	360		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-6

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	1.1	1.1	--	--	4.7	4.7	1.48	1.48
500-550°F	1.3	2.4	--	--	5.0	9.7	1.58	3.06
550-600°F	1.7	4.1	--	--	6.7	16.4	2.11	5.17
600-650°F	2.6	6.7	--	0.0	8.8	25.2	2.77	7.94
650-700°F	3.8	10.5	0.21	0.21	10.8	36.0	3.55	11.49
700-750°F	5.6	16.1	0.54	0.75	13.0	49.0	4.47	15.96
750-800°F	6.7	22.8	0.53	1.28	14.3	63.3	4.87	20.83
800-850°F	4.5	27.3	0.54	1.82	12.1	75.4	4.18	25.01
850-900°F	2.68	29.98	0.53	2.35	9.1	84.5	3.23	28.24
900°F$^+$, Pyr.Sol.	43.08	73.06	57.05	59.4	15.5	100.0	43.95	72.19
IOM	7.74	80.0	12.7	72.1	--	--	8.70	80.89
Ash	19.2	100.0	27.9	100.0	--	--	19.10	99.99

				% RECOVERY
900°F$^-$	29.98	2.35	84.5	94.2
Pyr. Insol.	26.94	40.60	--	103.2
C	71.81	63.53	89.54	99.9
H	4.97	3.86	7.71	102.1
N	1.32	1.28	1.35	98.6
S	2.63	3.53	0.63	99.4
O(Total)	10.4	13.9	2.0	97.6
Ash	19.2	27.9	--	99.5
Net Stream Rate, kg/h	11.657	7.982	3.675	
Sp.Gr. 77/77°F	1.510	1.451	1.09	
Melting Pt., °F	167	363		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-7

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.2	0.2	--	--	2.2	2.2	0.72	0.72
500-550°F	1.1	1.3	--	--	3.8	6.0	1.24	1.96
550-600°F	1.5	2.8	--	--	6.0	12.0	1.95	3.91
600-650°F	2.7	5.5	--	--	8.7	20.7	2.83	6.74
650-700°F	4.3	9.8	--	0.0	11.3	32.0	3.68	10.42
700-750°F	5.1	14.9	0.01	0.01	14.8	46.8	4.83	15.25
750-800°F	5.7	20.6	0.37	0.38	18.1	64.9	6.14	21.39
800-850°F	4.7	25.3	0.36	0.74	14.7	79.6	5.03	26.42
850-900°F	3.18	28.48	0.36	1.10	9.4	89.0	3.30	29.72
900°F$^+$, Pyr.Sol.	45.21	73.69	57.34	58.44	11.0	100.0	42.25	71.97
IOM	7.01	80.7	12.76	71.2	--	--	8.60	80.57
Ash	19.3	100.0	28.8	100.0	--	--	19.42	99.99

				% RECOVERY
900°F$^-$	28.48	1.10	89.0	104.4
Pyr. Insol.	26.31	41.56	--	106.5
C	71.68	61.65	89.29	98.6
H	4.93	3.42	7.50	96.3
N	1.29	1.29*	1.37	102.0
S	2.58	3.61	0.68	102.9
O(Total)	10.3	13.7	2.0	96.0
Ash	19.3	28.8	--	100.6
Net Stream Rate, kg/h	11.682	7.877	3.805	
Sp.Gr. 77/77°F	1.388	1.487	1.090	
Melting Pt., °F	158	378		

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*Value from period sample analysis.

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-8

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**	**FRAC.**	**CUM.**
500°F$^-$	0.75	0.75	--	--	3.0	3.0	0.96	0.96
500-550°F	0.85	1.6	--	--	4.2	7.2	1.35	2.31
550-600°F	1.1	2.7	--	--	6.2	13.4	1.99	4.30
600-650°F	1.8	4.5	--	0.0	8.4	21.8	2.70	7.00
650-700°F	3.4	7.9	0.14	0.14	10.9	32.7	3.59	10.59
700-750°F	4.8	12.7	0.24	0.38	13.5	46.2	4.50	15.09
750-800°F	5.6	18.3	0.24	0.62	14.8	61.0	4.91	20.00
800-850°F	5.4	23.7	0.24	0.86	12.3	73.3	4.11	24.11
850-900°F	5.0	28.7	0.24	1.10	9.7	83.0	3.28	27.39
900°F$^+$, Pyr.Sol.	44.24	72.94	56.98	58.08	17.0	100.0	44.14	71.53
IOM	7.26	80.2	12.62	70.7	--	--	8.57	80.10
Ash	19.8	100.0	29.3	100.0	--	--	19.89	99.99

				% RECOVERY
900°F$^-$	28.7	1.10	83.0	95.4
Pyr. Insol.	27.06	41.92	--	105.2
C	71.07	64.17	89.36	101.7
H	4.86	3.96	7.43	104.4
N	1.27	1.27	1.33	101.5
S	2.77	3.45	0.63	91.9
O(Total)	10.2	13.5	2.0	96.2
Ash	19.8	29.3	--	100.5
Net Stream Rate, kg/h	10.808	7.338	3.470	
Sp.Gr. 77/77°F	1.380	1.472	1.096	
Melting Pt., °F	131	347		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-69-9

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	0.0	--	--	4.4	4.4	1.06	1.06
500-550°F	0.4	0.4	--	--	4.0	8.4	0.97	2.03
550-600°F	1.7	2.1	--	--	8.3	16.7	2.01	4.04
600-650°F	3.2	5.3	--	--	12.7	29.4	3.08	7.12
650-700°F	4.7	10.0	--	--	19.9	49.3	4.82	11.94
700-750°F	5.7	15.7	--	0.0	20.9	70.2	5.06	17.00
750-800°F	5.9	21.6	2.06	2.06	13.0	83.2	4.71	21.71
800-850°F	4.2	25.8	2.25	4.31	8.1	91.3	3.67	25.38
850-900°F	2.76	28.56	2.24	6.55	5.0	96.3	2.91	28.29
900°F$^+$, Pyr.Sol.	42.59	71.15	55.51	62.06	3.7	100.0	42.96	71.25
IOM	8.95	80.1	11.04	73.1	--	--	8.37	79.62
Ash	19.9	100.0	26.9	100.0	--	--	20.38	100.00

				% RECOVERY
900°F$^-$	28.56	6.55	96.3	99.0
Pyr. Insol.	28.85	37.94	--	99.7
C	70.88	64.90	89.52	100.0
H	4.60	3.79	7.87	103.9
N	1.29	1.31	1.27	100.8
S	2.79	3.35	0.71	97.2
O(Total)	9.8	12.2	2.5	100.5
Ash	19.9	26.9	--	102.4
Net Stream Rate, kg/h	11.224	8.506	2.718	
Sp.Gr. 77/77°F	1.377	1.436	1.077	
Melting Pt., °F	131	293		

HGM:WPC
8-14-80
251-8370

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-0

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.2	0.2	--	--	4.3	4.3	1.20	1.20
500-550°F	1.7	1.9	--	0.0	5.8	10.1	1.61	2.81
550-600°F	2.6	4.5	0.79	0.79	8.9	19.0	3.04	5.85
600-650°F	3.3	7.8	1.04	1.82	12.8	31.8	4.31	10.16
650-700°F	4.0	11.8	1.04	2.86	19.0	50.8	6.04	16.20
700-750°F	4.7	16.5	1.03	3.89	20.8	71.6	6.53	22.73
750-800°F	4.7	21.2	1.04	4.93	10.1	81.7	3.56	26.29
800-850°F	4.6	25.8	1.03	5.96	5.1	86.8	2.16	28.45
850-900°F	4.5	30.3	1.04	7.0	3.9	90.7	1.84	30.29
900°F$^+$, Pyr.Sol.	39.0	69.3	50.87	57.87	9.3	100.0	39.31	69.60
IOM	7.0	76.3	9.13	67.0	--	--	6.59	76.19
ASH	23.7	100.0	33.0	100.0	--	--	23.82	100.01

				% RECOVERY
900°F$^-$	30.3	7.0	90.7	99.9
Pyr. Insol.	30.70	42.13	--	99.1
C	67.25	59.42	88.59	100.4
H	4.85	3.71	7.64	99.0
N	1.18	1.16	1.21	99.5
S	2.53	3.25	0.48	98.0
O (Total)	11.6	16.5	2.5	108.7
Ash	23.7	33.0	--	100.5
Net Stream Rate, kg/h	12.829	9.261	3.568	
Sp.Gr. 77/77°F	1.392	1.478	1.070	
Melting Pt., °F	131	284		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-1

COMPONENT	FEED FRAC.	FEED CUM.	BOTTOMS FRAC.	BOTTOMS CUM.	OVERHEAD FRAC.	OVERHEAD CUM.	PROD. COMPOSITE FRAC.	PROD. COMPOSITE CUM.
500°F$^-$	0.1	0.1	--	--	4.6	4.6	1.22	1.22
500-550°F	0.6	0.7	--	0.0	6.2	10.8	1.64	2.86
550-600°F	0.8	1.5	0.10	0.10	9.7	20.5	2.64	5.50
600-650°F	1.4	2.9	0.20	0.30	15.0	35.5	4.12	9.62
650-700°F	3.1	6.0	0.40	0.70	23.0	58.5	6.39	16.01
700-750°F	8.4	14.4	0.60	1.30	18.8	77.3	5.42	21.43
750-800°F	6.2	20.6	0.90	2.20	11.0	88.3	3.58	25.01
800-850°F	5.1	25.7	1.48	3.68	6.5	94.8	2.81	27.82
850-900°F	4.9	30.6	3.72	7.40	3.7	98.5	3.71	31.53
900°F$^+$, Pyr.Sol.	38.7	69.3	50.27	57.67	1.5	100.0	37.34	68.87
IOM	6.3	75.6	8.73	66.4	--	--	6.42	75.29
ASH	24.4	100.0	33.6	100.0	--	--	24.69	99.98

	FEED	BOTTOMS	OVERHEAD	% RECOVERY
900°F$^-$	30.6	7.40	98.5	103.1
Pyr. Insol.	30.70	42.33	--	101.3
C	66.07	58.57	89.10	100.9
H	4.61	3.73	7.57	103.0
N	1.19	1.17	1.21	99.2
S	2.67	3.31	0.71	98.2
O (Total)	13.0	16.1	2.5	96.1
Ash	24.4	33.6	--	101.2
Net Stream Rate, kg/h	12.954	9.520	3.434	
Sp.Gr. 77/77°F	1.401	1.453	1.066	
Melting Pt., °F	113	275		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-2

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	1.2	1.2	--	--	9.3	9.3	2.39	2.39
500-550°F	0.7	1.9	--	--	4.9	14.2	1.26	3.65
550-600°F	1.3	3.2	--	0.0	8.8	23.0	2.26	5.91
600-650°F	2.1	5.3	0.60	0.60	18.5	41.5	5.20	11.11
650-700°F	4.5	9.8	0.70	1.30	21.3	62.8	5.99	17.10
700-750°F	6.0	15.8	0.90	2.20	11.6	74.4	3.65	20.75
750-800°F	6.4	22.2	1.25	3.45	9.8	84.2	3.45	24.20
800-850°F	5.0	27.2	1.75	5.20	8.8	93.0	3.56	27.76
850-900°F	2.2	29.4	3.25	8.45	3.7	96.7	3.36	31.12
900°F^{+}, Pyr.Sol.	39.75	69.15	49.43	57.88	3.3	100.0	37.57	68.69
IOM	6.05	75.2	8.02	65.9	--	--	5.96	74.65
ASH	24.8	100.0	34.1	100.0	--	--	25.34	99.99

				% RECOVERY
900°F^{-}	29.4	8.45	96.7	105.9
Pyr. Insol.	30.85	42.12	--	101.4
C	66.01	57.74	88.95	99.6
H	4.71	3.66	7.69	99.7
N	1.18	1.17	1.19	99.6
S	2.66	3.41	0.64	101.4
O (Total)	12.0	16.5	2.5	107.5
Ash	24.8	34.1	--	102.2
Net Stream Rate, kg/h	12.932	9.608	3.324	
Sp.Gr. 77/77°F	1.403	1.513	1.057	
Melting Pt., °F	113	266		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-3

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.8	0.8	--	--	6.2	6.2	1.60	1.60
500-550°F	1.3	2.1	--	--	6.3	12.5	1.63	3.23
550-600°F	1.6	3.7	--	--	9.7	22.2	2.51	5.74
600-650°F	2.4	6.1	--	0.0	15.6	37.8	4.03	9.77
650-700°F	4.3	10.4	0.75	0.75	22.0	59.8	6.24	16.01
700-750°F	7.4	17.8	0.95	1.70	17.8	77.6	5.30	21.31
750-800°F	5.9	23.7	1.25	2.95	10.6	88.2	3.66	24.97
800-850°F	3.6	27.3	1.75	4.70	6.0	94.2	2.85	27.82
850-900°F	2.2	29.5	3.35	8.05	3.1	97.3	3.28	31.10
900°F$^+$, Pyr.Sol.	39.46	68.96	48.55	56.6	2.7	100.0	36.70	67.80
IOM	6.64	75.6	9.4	66.0	--	--	6.97	74.77
ASH	24.4	100.0	34.0	100.0	--	--	25.22	99.99

				% RECOVERY
900°F$^-$	29.5	8.05	97.3	105.5
Pyr. Insol.	31.04	43.40	--	103.7
C	66.42	57.60	88.25	98.6
H	4.79	3.56	7.82	97.3
N	1.18	1.16	1.18	98.7
S	2.57	3.45	0.65	106.1
O (Total)	11.4	16.7	2.6	114.5
Ash	24.4	34.0	--	103.3
Net Stream Rate, kg/h	12.630	9.367	3.263	
Sp.Gr. 77/77°F	1.394	1.497	1.063	
Melting Pt., °F	104	257		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-4

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	0.0	--	--	5.2	5.2	1.26	1.26
500-550°F	0.4	0.4	--	--	8.0	13.2	1.94	3.20
550-600°F	1.7	2.1	--	--	11.6	24.8	2.81	6.01
600-650°F	2.9	5.0	--	0.0	15.4	40.2	3.73	9.74
650-700°F	5.2	10.2	0.04	0.04	19.8	60.0	4.83	14.57
700-750°F	6.5	16.7	1.91	1.95	19.7	79.7	6.22	20.79
750-800°F	5.6	22.3	1.93	3.88	7.6	87.3	3.30	24.09
800-850°F	4.4	26.7	2.32	6.20	4.4	91.7	2.82	26.91
850-900°F	3.3	30.0	3.00	9.20	3.2	94.9	3.05	29.96
900°F$^+$, Pyr.Sol.	38.0	68.0	47.55	56.75	5.1	100.0	37.27	67.23
IOM	6.8	74.8	8.65	65.4	--	--	6.55	73.78
ASH	25.2	100.0	34.6	100.0	--	--	26.22	100.00

				% RECOVERY
900°F$^-$	30.0	9.20	94.9	99.9
Pyr. Insol.	32.00*	43.25	--	102.4
C	65.59	57.76	87.97	99.2
H	4.70	3.64	7.66	98.2
N	1.17	1.14	1.17	98.0
S	2.59	3.47	0.65	107.6
O (Total)	11.8	15.9	2.4	107.0
Ash	25.2	34.6	--	104.0
Net Stream Rate, kg/h	12.682	9.610	3.072	
Sp.Gr. 77/77°F	1.404	1.476	1.060	
Melting Pt., °F	104	248		

* Value from control analysis.

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-5

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F^{-}	--	--	--	--	4.3	4.3	1.04	1.04
500-550°F	--	0.0	--	--	7.9	12.2	1.91	2.95
550-600°F	1.8	1.8	--	0.0	11.9	24.1	2.88	5.83
600-650°F	3.6	5.4	0.38	0.38	16.5	40.6	4.27	10.10
650-700°F	4.8	10.2	0.52	0.90	20.0	60.6	5.23	15.33
700-750°F	5.8	16.0	0.80	1.70	17.6	78.2	4.86	20.19
750-800°F	5.6	21.6	1.05	2.75	10.5	88.7	3.33	23.52
800-850°F	4.5	26.1	1.65	4.40	5.0	93.7	2.46	25.98
850-900°F	3.5	29.6	4.18	8.58	2.7	96.4	3.82	29.80
900°F^{+}, Pyr.Sol.	37.82	67.42	48.56	57.14	3.6	100.0	37.70	67.50
IOM	6.58	74.0	8.16	65.3	--	--	6.19	73.69
ASH	26.0	100.0	34.7	100.0	--	--	26.32	100.01

				% RECOVERY
900°F^{-}	29.6	8.58	96.4	100.7
Pyr. Insol.	32.58	42.86*	--	99.8
C	64.31	57.24	88.93	100.9
H	4.46	3.50	7.84	102.0
N	1.13	1.16	1.19	103.3
S	2.82	3.41	0.67	97.4
O (Total)	11.9	14.7	2.6	99.0
Ash	26.0	34.7	--	101.2
Net Stream Rate, kg/h	12.500	9.480	3.020	
Sp.Gr. 77/77°F	1.418	1.511	1.059	
Melting Pt., °F	104	257		

* Value from period sample.

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-6

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.6	0.6	--	--	4.7	4.7	1.25	1.25
500-550°F	1.0	1.6	--	--	6.3	11.0	1.67	2.92
550-600°F	2.0	3.6	--	0.0	10.2	21.2	2.71	5.63
600-650°F	3.1	6.7	0.15	0.15	15.7	36.9	4.28	9.91
650-700°F	4.5	11.2	0.40	0.55	19.9	56.8	5.58	15.49
700-750°F	6.0	17.2	0.57	1.12	17.4	74.2	5.04	20.53
750-800°F	5.4	22.6	0.98	2.10	11.3	85.5	3.72	24.25
800-850°F	4.4	27.0	1.40	3.50	6.3	91.8	2.70	26.95
850-900°F	3.6	30.6	3.05	6.55	3.3	95.1	3.12	30.07
900°F$^+$, Pyr.Sol.	37.39	67.99	49.33	55.88	4.9	100.0	37.54	67.61
IOM	5.81	73.8	8.42	64.3	--	--	6.18	73.79
ASH	26.2	100.0	35.7	100.0	--	--	26.22	100.01

				% RECOVERY
900°F$^-$	30.6	6.55	95.1	98.2
Pyr. Insol.	32.01	44.12	--	101.2
C	65.27	57.06	88.05	100.0
H	4.66	3.56	7.52	99.0
N	1.16	1.14	1.22	100.1
S	2.86	3.47	0.77	96.3
O (Total)	11.6	16.1	2.5	107.7
Ash	26.2	35.7	--	100.1
Net Stream Rate, kg/h	12.710	9.336	3.374	
Sp.Gr. 77/77°F	1.418	1.533	1.066	
Melting Pt., °F	113	275		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-70-7

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	0.3	0.3	--	0.0	5.3	5.3	1.34	1.34
500-550°F	0.8	1.1	0.08	0.08	6.4	11.7	1.67	3.01
550-600°F	1.7	2.8	0.12	0.20	9.6	21.3	2.51	5.52
600-650°F	2.8	5.6	0.20	0.40	14.0	35.3	3.68	9.20
650-700°F	4.3	9.9	0.40	0.80	19.8	55.1	5.29	14.49
700-750°F	6.3	16.2	0.58	1.38	16.5	71.6	4.59	19.08
750-800°F	6.1	22.3	0.87	2.25	11.2	82.0	3.47	22.55
800-850°F	4.2	26.5	1.36	3.60	8.0	90.8	3.03	25.58
850-900°F	2.8	29.3	2.55	6.15	5.4	96.2	3.27	28.85
900°F$^+$, Pyr.Sol.	38.55	67.85	52.17	58.32	3.72	99.92	39.96	68.81
IOM	6.25	74.1	6.58	64.9	--	99.92	4.92	73.73
ASH	25.9	100.0	35.1	100.0	0.08	100.0	26.28	100.01

				% RECOVERY
900°F⁻	29.3	6.15	96.2	98.4
Pyr. Insol.	32.15	41.68	--	97.0
C	64.91	57.08	88.12	100.0
H	4.41	3.53	7.43	102.3
N	1.16	1.15	1.21	100.4
S	2.82	3.43	0.71	97.3
O (Total)	11.5	16.1	2.5	110.2
Ash	25.9	35.1	0.08	101.4
Net Stream Rate, kg/h	12.826	9.594	3.232	
Sp.Gr. 77/77°F	1.414	1.554	1.066	
Melting Pt., °F	104	257		

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-71-OA

COMPONENT	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	0.7	0.7	--	--	4.3	4.3	1.12	1.12
500-550°F	1.0	1.7	--	--	5.7	10.0	1.49	2.61
550-600°F	1.55	3.25	--	0.0	8.7	18.7	2.28	4.89
600-650°F	2.95	6.2	0.06	0.06	12.6	31.3	3.34	8.23
650-700°F	4.1	10.3	0.14	0.20	18.4	49.7	4.92	13.15
700-750°F	5.1	15.4	0.30	0.50	17.9	67.6	4.91	18.06
750-800°F	5.8	21.2	0.50	1.00	12.6	80.2	3.67	21.73
800-850°F	4.55	25.75	0.75	1.75	8.2	88.4	2.70	24.43
850-900°F	3.65	29.4	1.20	2.95	5.1	93.5	2.22	26.65
900°F$^+$, Pyr.Sol.	36.93	66.33	49.67	52.62	6.5	100.0	38.37	65.02
IOM	6.67	73.0	9.48	62.1	--	--	7.00	72.02
ASH	27.0	100.0	37.9	100.0	--	--	27.98	100.00

				% RECOVERY
900°F$^-$	29.4	2.95	93.5	90.7
Pyr. Insol.	33.67	47.38*	--	103.9
C	63.24	54.77	88.13	100.4
H	4.52	3.43	7.51	99.5
N	1.16	1.06	1.26	95.9
S	3.01	3.58	0.48	92.0
O (Total)	13.0	19.8	2.0	116.5
Ash	27.0	37.9	--	103.6
Net Stream Rate, kg/h	10.932	8.070	2.862	
Sp.Gr. 77/77°F	1.448	1.582	1.076	
Melting Pt., °F	135	293		

* Estimated assuming a PI/ash ratio of 1.25 based on 10 other tests.

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-71-OB

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F⁻	0.3	0.3	--	--	3.8	3.8	1.07	1.07
500-550°F	0.7	1.0	--	--	5.0	8.8	1.41	2.48
550-600°F	1.2	2.2	--	--	7.5	16.3	2.11	4.59
600-650°F	2.5	4.7	--	--	10.2	26.5	2.88	7.47
650-700°F	4.2	8.9	--	--	13.8	40.3	3.89	11.36
700-750°F	5.2	14.1	--	0.0	17.5	57.8	4.93	16.29
750-800°F	5.3	19.4	0.1	0.1	16.9	74.7	4.84	21.13
800-850°F	4.8	24.2	0.7	0.8	10.8	85.5	3.55	24.68
850-900°F	4.1	28.3	2.0	2.80	7.1	92.6	3.44	28.12
900°F⁺, Pyr.Sol.	36.75	65.05	49.7	52.5	7.4	100.0	37.77	65.89
IOM	7.45	72.5	9.5	62.0	--	--	6.82	72.71
ASH	27.5	100.0	38.0	100.0	--	--	27.29	100.00

				% RECOVERY
900°F⁻	28.3	2.80	92.6	99.4
Pyr. Insol.	34.95***	47.50*	--	97.6
C	63.50	53.99	87.72	100.0
H	4.54	3.50	7.42	101.4
N	1.14	1.09	1.28	100.3
S	2.99	3.59	0.52	91.1
O (Total)	12.6	19.6	2.1	116.4
Ash	27.5	38.0	--	99.2
Net Stream Rate, kg/h	10.534**	7.564**	2.970	
Sp.Gr. 77/77°F	1.444	1.568	1.078	
Melting Pt., °F	131	293		

* Estimated assuming a PI/Ash ratio of 1.25 based on 10 other tests.

** Calculated from forced balance on carbon because of error in vacuum bottoms weight data.

*** PI value from control sample was 33.29.

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-71-1

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	1.8	1.8	--	--	2.9	2.9	0.82	0.82
500-550°F	1.1	2.9	--	--	4.3	7.2	1.22	2.04
550-600°F	1.8	4.7	--	--	7.0	14.2	1.99	4.03
600-650°F	2.8	7.5	--	--	10.8	25.0	3.07	7.10
650-700°F	3.8	11.3	--	0.0	14.9	39.9	4.24	11.34
700-750°F	4.9	16.2	0.10	0.10	16.1	56.0	4.65	15.99
750-800°F	6.0	22.2	0.45	0.55	15.8	71.8	4.82	20.81
800-850°F	5.1	27.3	0.80	1.35	11.9	83.7	3.96	24.77
850-900°F	3.0	30.3	1.65	3.0	8.3	92.0	3.54	28.31
900°F$^+$, Pyr.Sol.	35.75	66.03	49.46	52.46	8.0	100.0	37.66	65.97
IOM	6.57	72.6	9.64	62.1	--	--	6.90	72.87
ASH	27.4	100.0	37.9	100.0	--	--	27.11	99.98

				% RECOVERY
900°F$^-$	30.3*	3.0	92.0	93.5
Pyr. Insol.	33.97	47.54	--	100.1
C	63.91	54.05	88.17	99.8
H	4.53	3.39	7.48	100.5
N	1.15	1.10	1.29	100.4
S	2.96	3.61	0.50	92.0
O (Total)	10.0	20.0	1.9	148.5
Ash	27.4	37.9	--	99.0
Net Stream Rate, kg/h	11.658	8.340	3.318	
Sp.Gr. 77/77°F	1.444	1.573	1.085	
Melting Pt., °F	131	293		

* Control sample value was 27.5%.

VACUUM COLUMN STREAM COMPOSITIONS, WT%
PERIOD P99-71-2

	FEED		BOTTOMS		OVERHEAD		PROD. COMPOSITE	
COMPONENT	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.	FRAC.	CUM.
500°F$^-$	--	0.0	--	--	2.7	2.7	0.71	0.71
500-550°F	0.7	0.7	--	--	3.4	6.1	0.89	1.60
550-600°F	1.6	2.3	--	0.0	6.4	12.5	1.67	3.27
600-650°F	2.5	4.8	0.01	0.01	11.8	24.3	3.09	6.36
650-700°F	3.2	8.0	0.19	0.20	22.2	46.5	5.95	12.31
700-750°F	3.7	11.7	0.30	0.50	17.2	63.7	4.72	17.03
750-800°F	4.6	16.3	0.62	1.12	13.1	76.8	3.88	20.91
800-850°F	5.5	21.8	1.00	2.12	9.5	86.3	3.22	24.13
850-900°F	4.6	26.4	1.73	3.85	6.2	92.5	2.90	27.03
900°F$^+$, Pyr.Sol.	39.08	65.48	48.75	52.6	7.5	100.0	37.96	64.99
IOM	6.82	72.3	10.2	62.8	--	--	7.53	72.52
ASH	27.7	100.0	37.2	100.0	--	--	27.47	99.99

				% RECOVERY
900°F$^-$	26.4	3.85	92.5	102.4
Pyr. Insol.	34.52	47.40	--	101.4
C	63.80	54.69	88.58	99.6
H	4.51	3.45	7.49	99.9
N	1.15	1.08	1.28	98.5
S	2.84	3.45	0.54	94.7
O (Total)	12.4	17.9	1.9	110.6
Ash	27.7	37.2	--	99.2
Net Stream Rate, kg/h	11.278	8.328	2.950	
Sp.Gr. 77/77°F	1.447	1.554	1.082	
Melting Pt., °F	122	302		

HGM:WPC/10-9-80/251-8370

APPENDIX C

Vacuum Column Operation During Run P99-56-11

Appendix C

VACUUM COLUMN OPERATION DURING RUN P99-56-11

During Run 56, the vacuum column bottoms stream contained no distillate boiling below 900°F, in contrast to the incomplete distillate recovery obtained in previous runs. The flash zone was operated at 342°C and 15-18 mm Hg, typical conditions, but a new column had been installed before the run. In this and subsequent runs[1], it was observed that the temperature of the bottoms receiver must be held at the same temperature as the flash zone in order to maintain complete recovery. Apparently, vapor can reflux in the receiver if it is somewhat cooler than the flash zone causing recombination of distillate with the bottoms. Additional heaters were installed on the receiver and connecting line to improve temperature control.

A material balance calculation was made on Run Period P99-56-11. The flow rates, bottoms analysis, temperature profile, and column pressures are given in Table C-1. The vapor velocity in the vacuum flash column was determined to be about 0.98 ft/sec. This takes into account the portion of the vacuum tower overhead that is recycled back into the vacuum tower feed stream. This recycle distillate is pumped by a Northern metering pump into the vacuum column feed side of the splitter vessel. It insures a continuous feed to the vacuum column to prevent coking in the preheater.

A material balance of the distillate in the feed versus the distillate in the products is given in Table C-2. The calculated composite feed and measured feed distillation analyses agree fairly well indicating little or no polymerization or cracking occurs at these temperatures.

Table C-1

VACUUM COLUMN RESULTS FOR RUN P99-56-11

I. Vacuum Column Stream Rates

Feed Rate kg/hr	Distillate in Feed, Wt %	VTB kg/hr	Distillate in VTB, Wt %	VTO kg/hr	Recycle VTO kg/hr
12.20	32.6	7.58	0	4.62	6.8

II. Temperature Profile of Preheater and Vacuum Column Temperatures, °C

Preheater				Column		Bottoms	Outlet	Flash
Inlet	Elbow	Middle	Outlet	Top	Bottom	Receiver	Line	Zone
304	244	356	332	360	350	360	374	342

III. Column Pressures, mm Hg

Top of Overheads Surge Tank		Bottoms Receiver (Flash Zone)
Zimmerli Gauge	Absolute D/P Cell	Absolute D/P Cell
11.6	10	17.5

IV. Vacuum Column Bottoms Analyses

Specific Gravity 77/77°F	Melting Point °F	Pyridine Insolubles Wt %	Ash on Pyr. Insol. Wt %
1.497	417	42.69	66.3

V. Vapor Velocity

Vapor Flow Rate, kg/hr	Average Molecular Weight	Vapor Velocity, ft/sec
11.42	243	0.98

Table C-2

MATERIAL BALANCE FOR VACUUM COLUMN P99-56-11

Stream Rates:		
	Flash Tower Bottoms	12.20 kg/hr
	Vacuum Tower Overhead	4.62 "
	Vacuum Tower Bottoms	7.58 "

	Temperature, °F				
	600	700	800	900	990
% Dist in Flash Tower Bottoms	2.8	10.8	21.2	32.6	--
% Dist in Vac Tower Overhead	8.0	32.0	62.0	86.5	100
% Dist in Vac Tower Bottoms	0	0	0	0	0
Kg Dist in VTO	0.37	1.48	2.86	4.00	4.62
Kg Dist in VTB	0	0	0	0	0
Total Dist Out, kg	0.37	1.48	2.86	4.00	4.62
Total Dist In, kg	0.34	1.32	2.59	3.98	--

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