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SOLVENT REFINED COAL (SRC) PROCESS OPERATION OF SOLVENT REFINED COAL PILOT PLANT

Quarterly Technical Progress Report for the Period January—March 1980

February 1981
Date Published

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Catalytic, Inc.
Wilsonville, Alabama

U. S. DEPARTMENT OF ENERGY

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OPERATION OF SOLVENT REFINED COAL PILOT PLANT
Wilsonville, Alabama

QUARTERLY TECHNICAL PROGRESS REPORT
for the period

January - March 1980

Prepared by

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NOMENCLATURE

ABBREVIATIONS

avg	average
AWS	acetone-washed solids
BP	boiling point
BR	boiling range
btm(s)	bottom(s)
Btu	British thermal unit(s)
cc	cubic centimeter(s)
CF	capacity factor
CI	cresol insoluble(s)
cm/sec^2	centimeters per second per second
col	column
comp	composite
conc	concentrate, concentrated, concentration
cons	consumed
conv	conversion
corr	corrected
cp	centipoise
CSD	Critical Solvent Deashing (Kerr-McGee proprietary system)
cum	cumulative
cfm	cubic feet per minute
cyc	cycle(s)
dia	diameter
DAS	deashing solvent
DOE	United States Department of Energy
EP	end point
EPRI	Electric Power Research Institute
est	estimated
Eq	equation
filt	filtered, filtrate, filtration
fps	feet per second
Frac	fractionation
ft	foot (feet)
ft^{-1}	reciprocal foot (feet)
ft/lb_m	foot (feet) per pound mass
ft/sec^2	feet per second per second
ft^2	square foot (feet)
ft^3	cubic foot (feet)
ft-lb	foot-pound(s)
g	acceleration due to gravity (32.2 ft/sec^2)
gal	gallon(s)
gm	gram(s)
gph	gallons per hour
gpm	gallons per minute
H/C	hydrogen-to-carbon atomic ratio
HP	high pressure
hp	horsepower

hr	hour(s)
hr^{-1}	reciprocal hour(s)
HVB	High Volatile Bituminous
IBP	initial boiling point
ID	inside diameter
IF	Industrial Filter and Pump Manufacturing Company
in.	inch(es)
K	vapor-liquid equilibrium constant
KM	Kerr-McGee Corporation
lab	laboratory
L/D	length-to-diameter ratio
lb	pound(s)
lb-ft	pound feet (of torque)
$lb/hr\text{-}ft^2$	pounds per hour per square foot
$lb/hr\text{-}ft^3$	pounds per hour per cubic foot
LFSFE	Lab-filtered solvent-free extract
LP	low pressure
LSRC	light Solvent Refined Coal
lt	light
LOL	light organic liquid
M	thousand(s)
mA	milliampere(s)
MAF	moisture and ash-free
MASF	moisture, ash, and solvent-free
max	maximum
MB	material balance
MCIF	moisture and cresol-insolubles-free
MF	moisture-free
mg/gm	milligrams per gram
mg/l	milligrams per liter
mid	middle
min	minimum, minutes
ml	milliliter(s)
mm	millimeter(s)
MM	million(s)
moist	moisture
mol	mole
MP	melting point
MW	molecular weight
NA	not available
ND	not detected
NMR	nuclear magnetic resonance
no.	number
OD	outside diameter
OF	overflow
OH	overhead
OR	oxygen removed
org	organic(s)
OSR	organic sulfur removal
ovhd	overhead
P	pressure
PA	preasphaltene(s)
$p(H_2)$	hydrogen partial pressure
ppm	parts per million
prod	product, produced

psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
qtr	quarter
r	correlation coefficient
ref.	reference
R_m	filter medium resistance
rpm	revolutions per minute
scf	standard cubic foot (feet) at 525°R and one atmosphere pressure
scfh	standard cubic feet per hour
scfm	standard cubic feet per minute
sec	second
sec^{-1}	reciprocal seconds
SG	specific gravity
SLS	solid-liquid separation
SN	sample number
solv	solvent
sp gr	specific gravity
spec	specification
SRC	solvent refined coal
SRT	short residence time
SS	stainless steel
std	standard
TBP	true boiling point
temp	temperature
THF	tetrahydrofuran
TI	terphenyl insoluble(s)
tpd	tons per day
tr	trace
UC	unreacted coal
UCC	undissolved carbon compounds
USF	United States Filter Corporation
vac	vacuum
visc	viscosity
vol	volume
wt	weight

SYMBOLS

α	average specific cake resistance
°C	temperature, degrees Celsius (Centigrade)
°F	temperature, degrees Fahrenheit
°R	absolute temperature, degrees Rankine
ΔH_R	heat of reaction
Δt	temperature differential
ΔP	pressure differential
$<$	less than
$>$	greater than
$\approx$	about, approximately equal to
Σ	the sum of

EQUIPMENT DESIGNATIONS

B	boiler, heater
C	compressor
D	dryer
DE	density element
DIT	density indicator transmitter
DPCV	differential pressure control valve
DPSH	differential pressure switch
DPT	differential pressure transmitter
E	exchanger
F	filter
FIC	flow indicator and controller
FR	flow recorder
FV	flow valve
GC	gas chromatograph
GLC	gas/liquid chromatograph
HV	hand valve
LSH	high level switch
LSL	low level switch
K	product cooler or flare
LV	letdown valve
LS	level switch
P	pump
PSH	high pressure switch
PSV	pressure safety valve
PV	pressure valve
R	reactor
SV	safety valve
T	tower; timer
TC	thermocouple
TR	temperature recorder
V	vessel
XV	filter cycle program operated valve

COAL IDENTIFICATION

o Period: 1 January to 26 February 1980

Company:	Lafayette Coal Company
State:	Kentucky
Mine:	Lafayette
Seam:	No. 9
Nomenclature:	Ky 9 (Lafayette)

o Period: 26 February through 30 March 1980

Company:	Mapco Coal Company
State:	Kentucky
Mine:	Dotiki
Seam:	No. 9
Nomenclature:	Ky 9 (Dotiki)

ABSTRACT

This report presents operating conditions and test results at the Solvent Refined Coal (SRC-I) pilot plant in Wilsonville, Alabama for the first quarter of 1980. Two coals from the Kentucky 9 seam (Lafayette mine and Dotiki mine) were processed. Hydrogen consumption, coal conversion and SRC yield were comparable when these coals were tested under similar conditions. Process solvent quality improved after the feed was switched from Lafayette to Dotiki coal.

A vertical-leaf filter, manufactured by the United States Filter Corporation (USF), was used for solids separation during most of the Lafayette coal operations. The Kerr-McGee Critical Solvent Deashing (CSD) unit, which had been shut down for modifications since late 1979, was returned to service near the end of the Lafayette coal tests and remained on-stream during Dotiki coal processing.

Using solution-annealed screens in the USF filter has eliminated the corrosion-related screen failures previously encountered. Cresol-insoluble material was very low, but ash in the filtered SRC product consistently exceeded the 0.16 wt % specification. The high-ash SRC product appears to have resulted from the presence of sodium carbonate, which was added to the coal slurry to prevent corrosion in the solvent recovery system.

Recovery of SRC in the CSD unit ranged from 78 to 82 wt %. Deashing solvent losses averaged 4.9 wt % of the CSD feed.

I. INTRODUCTION

In March 1972, the Southern Company System and the Edison Electric Institute (EEI) jointly began an investigation of the solvent refining process for making low-sulfur and low-ash solid fuel from coal. A six-ton-per-day solvent refined coal (SRC) pilot plant was designed and constructed at Wilsonville, Alabama by Catalytic, Inc. Catalytic also operates the facility under the management of Southern Company Services, Inc., a unit of the Southern Company.

Since April 1973, the Electric Power Research Institute (EPRI) has performed the functions of utility industry project supervision initiated by EEI. The United States Energy Research and Development Administration (ERDA), now Department of Energy (DOE), has been a co-sponsor since 1976.

Operation with coal began in January 1974. Since that time, activities have been documented in a series of monthly, quarterly and annual Technical Progress Reports. This report summarizes work during the first calendar quarter of 1980.

Objectives of the Wilsonville SRC program were:

- To evaluate state-of-the-art solid-liquid separation processes.
- To provide technical support for a large-scale SRC-I demonstration plant, currently in the design phase.
- To evaluate SRC process improvements.

Several solid-liquid separation projects are presently underway, namely:

- United States Filter Corporation (USF) vertical-leaf filter.

  Testing initiated in the fourth quarter of 1979 was concluded with emphasis on operation without precoat and cycle optimization.

- Industrial Filter & Pump Manufacturing Company (IF) candle filter.

  Studies were initiated with a skid-mounted unit.

- Critical Solvent Deashing.

  The CSD unit was restarted after modifications to the first stage separator and deashing solvent processing system were complete. Emphasis was placed on establishing a new baseline for CSD performance, on reducing deashing solvent losses, and on providing scale-up data for the demonstration plant design.

Other operating priorities for the first quarter were:

- To study the effects of sodium carbonate addition as a corrosion inhibitor.
- To analyze the effects of increasing the dissolver outlet operating temperature from 825 to 840°F.

II. SUMMARY

In the Solvent Refined Coal (SRC-I) process, pulverized coal is slurried with a process-derived recirculating solvent. Hydrogen is added to the slurry which is heated and fed to a dissolver. Effluent from the dissolver is flashed and the gas is separated and scrubbed to remove hydrogen sulfide and carbon dioxide. Makeup hydrogen is added and the scrubbed gas is recycled.

Effective solids separation is critical to the product quality. In one operating mode, solids are filtered from the SRC solution, and the filtrate is distilled to separate the solvent and SRC fractions. In an alternate operating mode, the unfiltered SRC slurry is distilled to separate the solvent, and the ash-containing SRC fraction is extracted with a deashing solvent in the Kerr-McGee Critical Solvent Deashing (CSD) unit at conditions near the critical temperature and pressure of that solvent. The SRC and light SRC (LSRC) are removed from the heavy ash concentrate as separate phases. The deashing solvent is recovered from each phase and recycled. A portion of the LSRC may be used for coal slurry preparation.

The SRC pilot plant was operated for about 72% of the first quarter. Kentucky 9 coal from the Lafayette mine was processed during Runs 195 through 201 (1 January to 26 February); and Kentucky 9 coal from the Dotiki mine was processed during Runs 202 through 204 (26 February through31 March). The United States Filter Corporation (USF) vertical-leaf filter was used until 23 February to remove insoluble materials from the reaction products. The Kerr-McGee Critical Solvent Deashing (CSD) unit, which had been out of service since late 1979, was restarted during the quarter. On 25 February, the CSD unit began to accept feed directly from the SRC plant.

In Run 195, sodium carbonate was added to the coal slurry feed (to prevent corrosion in the solvent recovery system) at a rate of 1.1 wt % of coal feed (40 lb per batch of slurry). This run was terminated by a power failure after only 12.3 hours.

The conditions for Runs 196 and 197 were the same as for Run 195. For these two runs, coal conversion averaged 93.8 % of MAF coal and hydrogen consumption was 2.2 wt % of MAF coal. Solvent quality was 67.4% by the short microautoclave test and 58.3% by the long microautoclave test. In Run 196, the filter screens leaked and high ash was present in the filtrate. New leaves with solution-annealed, 2-ply laminated outer screens were installed for Run 197. The new leaves performed much better than those used in the fourth quarter of 1979. However, there was still too much ash in the SRC product, so Run 197 was terminated and the V120 Vacuum Preheater Surge Drum was cleaned.

Run 198 was made at the same conditions as Runs 196 and 197, except that no sodium carbonate was added to the system. The filter performed very well mechanically during this 5-day run, yielding an SRC product which contained an average of 0.20 wt % ash and an average of 0.92 wt % sulfur. The hydrogen consumption for this run was 1.7 wt % of MAF coal, and the coal conversion was 93.2% at the reaction section effluent flash tank, V110.

In Run 199, sodium carbonate addition to the slurry feed tank was resumed at a rate of 1.1 wt % of coal feed, or 40 lb per batch of slurry. After adding the sodium carbonate, evidence of an exothermic reaction was noted in the slurry preheater and in the dissolver. For this 8-day run, the hydrogen consumption averaged 1.7% of MAF coal and the conversion was 92.9% at V110. The SRC product averaged 0.3 wt % ash and 0.93 wt % sulfur. For part of the run, the filter was operated with a precoat loading of 0.07 lb/ft^2 of filter area between sluicings, and 0.35 lb/ft^2 immediately after sluicing. Run 199 was terminated as a result of a broken cake cut-off blade in the filter.

Run 200 was made at the same conditions as Run 199. The filter performed well during most of the run, although there was some internal binding when the leaf shaft was rotated. Cake compressibility tests were completed during the run, and the specific cake resistances were higher than those previously measured. The run was terminated after 9 days to repair an internal leak in T102 Vacuum Column.

The conditions for Run 201 were identical to those of Run 200. Coal conversion to cresol-soluble material was 92.4% of MAF coal, and sulfur removal was 0.80 wt % in the V110 SRC. A 48-hour material balance was completed, and filter cake compressibility tests were performed. Six filter cycles, made without precoat, produced SRC with high ash content and extended the filtration times. In subsequent cycles, either Dicalite Perlite 436 or Johns-Manville Hyflo Super-Cel precoat was used. Run 201 ended on 26 February when the supply of Lafayette coal was exhausted. The USF filter test program was concluded during this run and the CSD unit was brought on-stream for the first time since October 1979.

Run 202 was begun with Kentucky 9 coal from the Dotiki mine. No sodium carbonate was added to the system during this run in order to establish baseline corrosion data for this coal. The dissolver was operated at 825°F and 1,700 psig, and solids were withdrawn from the dissolver bottom at a rate equivalent to about 6 wt % of slurry feed. The coal conversion to cresol soluble organics averaged 92.4 wt % of MAF coal, the hydrogen consumption was 2.1% of MAF coal, and the yield of SRC from the vacuum distillation column was 56 wt % of MAF coal. The average SRC recovery in the CSD unit was 78.9% based on a forced ash balance. Run 202 was terminated when corrosion probe measurements in the T105 Fractionation Column indicated a large increase in the corrosion rate.

Run 203 was made at the same conditions as Run 202, except that sodium carbonate was added to the coal slurry at a rate of 40 lb per batch (1.1 wt % of the coal feed). Coal conversion, hydrogen consumption, and SRC yield for this run were similar to those for Run 202. Solvent quality increased, however, from an average of 66% conversion by the microautoclave short test for Run 202 to 72% conversion for Run 203. CSD recovery of SRC averaged 81% during Run 203 based on a forced ash balance. The ratio of benzene-soluble to benzene-insoluble fractions in the CSD feed was much higher for Run 203DE MB than for Run 202A MB.

Conditions for Run 204 were identical to those of Run 203 except that the dissolver temperature was increased from 825°F to 840°F. Coal conversion was about the same, while the hydrogen consumption increased to 2.5 wt % of MAF coal. The increase in hydrogen consumption caused a reduction in dissolver hydrogen partial pressure, which was restored by raising the total dissolver pressure during Run 204 to 1,800 psig. The sulfur in the V110 Flash Tank SRC was 0.82 wt % in Run 204, and it averaged 0.93 wt % in Runs 202 and 203. The SRC yield from T102 Vacuum Column was 50 wt % of MAF coal in Run 204, and it averaged 54 wt % average for Runs 202 and 203. The CSD recovery of SRC was 79% by forced ash balance for the MB period on 31 March.

Recovery of SRC in the modified CSD unit (operated during Runs 201 through 204) was not markedly different from typical CSD performance before modifications were made. Total deashing solvent loss during the quarter averaged 17.8 lb/hr. Of this amount, about 12% was product-related and, therefore, measureable. A quantitative account of the balance of the lost DAS could not be made.

III. PROCESS DESCRIPTION

A. COAL SLURRY PREPARATION

The Wilsonville SRC-I pilot plant is pictured schematically in Figure 1. Pulverized coal, 95% of which is smaller than 200 mesh (74 x 74 microns), is mixed with a process-derived solvent in V101A Slurry Blend Tank. The boiling range of this solvent is 450 to 900°F. The resulting slurry is transferred to V101B Slurry Feed Tank where it is agitated and recirculated to maintain a uniform suspension. P102B Slurry Circulating Pump recirculates the slurry and also feeds P103A or B Slurry Preheater Feed Pump.

Feed gas, which consists of scrubbed recycle gas plus makeup hydrogen, is normally added to the coal slurry upstream of the preheater inlet. (Its composition is usually 85% hydrogen by volume.)

The mixture of coal slurry and feed gas flows upward in B102 Slurry Preheater through a 600-ft long helical coil of 1.25-in. schedule 160, 316 SS pipe. The coil is heated by a burner located in the bottom of the preheater.

B. COAL DISSOLUTION

The coal slurry-and-gas mixture leaving the preheater flows upward through R101 Dissolver. The dissolver is 24 ft high and one foot in diameter, centrifugally cast of high-chrome stainless steel. It can be operated at 800 to 875°F, 1,400 to 2,500 psig, and can provide residence times of 15 to 60 minutes. Outlets are located at the 25, 50, 75, and 100% volume levels to permit changes in residence time. Effluent from the dissolver is cooled to 600-650°F by E102 Dissolver Product Cooler.

Improvements made to the original dissolver include the installation of a distributor plate in the bottom (September 1977); a solids density monitoring system (November 1977); and a solids withdrawal system (February 1978). The solids withdrawal system may be operated continuously or intermittently to control solids accumulation. The solids are conveyed to V103 through a 3/4-in. line.

C. HIGH PRESSURE GAS AND SLURRY SEPARATION

The vapor and slurry phases are separated in V103 High Pressure Separator. Vapor from the separator is cooled to about 150°F by E103 High Pressure Cooler and is then passed into V104 High Pressure Vent Separator. Water and organic compounds condensed in E103 are fed through LV430 Letdown Valve to V105 Solvent Decanter. Vapor from V104 contains unreacted hydrogen, light hydrocarbon gases, hydrogen sulfide and carbon oxides.

D. FILTER FEED PREPARATION

Slurry from V103 is flashed through LV415A or B High Pressure Letdown Valve to V110 Flash Tank. The 115 psig vapor goes to E107 Flash Condenser. The V110 liquid phase flows to V111 Reclaim Tank which serves as a feed reservoir for the batch filtration system. Noncondensed vapors from E107 and vapors from V104 are vented from V105 to K110 Flare. Organic liquids from E107 and V104 are separated from the water phase in V105.

E. FILTRATION

The F125 United States Filter Corporation (USF) Pressure-Leaf Filter was used during the first quarter for product deashing. (A Funda Pressure-Leaf Filter had been used earlier.) Filtration can be used as an alternate to the Critical Solvent Deashing (CSD) system described later in this chapter. A schematic flow diagram of the USF filtration system is shown in Figure 2. The unit will accommodate four vertical, circular filter leaves with metal wire screens having a total effective filtration area of 87.2 ft^2. The filter operates at 480 to 580°F and 150 to 200 psig, with a maximum pressure drop of 100 psi between the slurry inlet and filtrate outlet. The leaves are cleaned by sluicing with wash solvent at high pressure.

The following batch filtration operations are automatically controlled by a programmer:

- precoating or no precoating
- filtration
- washing with sluice wash solvent
- cake blowing
- depressurization
- vacuum flash drying
- cake discharging
- repressurization
- sluicing (2,000 psig max)

High-boiling "process" solvent is used in precoat makeup and deposition. The washing step uses low boiling range (350 to 450°F) "wash" solvent. Nitrogen is used for cake blowing and repressurization.

During the first quarter, an Industrial Filter and Pump Manufacturing Company (IF) skid-mounted filter (Fig. 3) was installed. The unit has three tubular elements with a total area of 5.5 ft^2. All filtration operations are done manually. The sequence of operations is essentially the same as for previous filters. The major exceptions are that body feed is added to the filter feed (the elements are not precoated); the filter cake is blown dry with nitrogen rather than being vacuum-dried and the cake is discharged from the tubular elements by vibration. Testing of the IF filter will begin in April.

F. MINERAL RESIDUE PROCESSING

After depressurization, the pressure in the filter is reduced to 1-2 psia for 10 minutes. Most of the residual wash solvent in the filter cake flashes to K115 Dryer Vent Gas Scrubber where it is condensed by a circulating stream of cold solvent. The cake, now containing less than 5% residual solvent, is cooled and discharged into storage drums. The recovered solvent is pumped to V111 Reclaim Tank.

G. VACUUM FLASH SYSTEM

Filtered SRC solution flows to V120 Vacuum Preheater Surge Drum. P116A or B pumps the solution through B103 Vacuum Preheater to T102 Vacuum Column where it flashes as it enters. The primary function of T102 is to separate SRC from organic liquid boiling at temperatures up to 900°F. The following streams are removed from T102: liquid SRC (from the bottom), solvent fractions (from trays 3 to 8), and vapors (from the overhead). The overhead vapor then passes through a vacuum-jet precondenser and light organic condensate is pumped to V164 Feed Tank and then to T104.

Column T102, three feet in diameter, contains valve trays, tunnel cap trapout trays, and Koch-Sulzer packing. Overhead pressure is maintained at 0.3 to 1.5 psia by a two-stage jet, K111 (with pre- and after-condensers). The column feed is heated in B103 to maintain a bottom temperature of approximately 600°F. A portion of the liquid SRC is recirculated and mixed with the material from V102.

H. PRODUCT SOLIDIFICATION

Liquid SRC from T102 is fed to the vibrating water-cooled trays of K125 Product Cooler. Two trays provide a total surface area of 30 ft^2. The SRC solidifies into brittle sheets which shatter into small fragments. The fragmented SRC is conveyed to storage.

I. CRITICAL SOLVENT DEASHING (CSD)

A schematic flow diagram of the CSD unit is shown in Figure 4. A modified three stage CSD unit is shown in Figure 5. When this system is used as an alternative to filtration, the V111 material is diverted through B103 to T102. The bottoms concentrate from T102 is transferred to the CSD system, which separates the feed into ash concentrate (first stage), deashed SRC (second stage), and light SRC (LSRC), which can be added to the recycle solvent (third stage). The separations are made using a proprietary deashing solvent operating in the region of its critical temperature and pressure. Under these conditions, 65 to 85% of the SRC is dissolved. Deashing is accomplished in two steps. The ash-containing feed mixed with deashing solvent, flows to the first-stage settler where the mineral matter and undissolved coal separate as a heavy phase which is withdrawn from the bottom of the settler. Solvent is stripped from the mass and the solids (ash) become a free-flowing powder which is discharged. The density of the overhead is reduced and it is fed to the second stage. The ash-free SRC (heavy phase material) settles and is removed as the underflow. Solvent is stripped for recycle. The second stage overhead undergoes a third stage separation into deashing solvent for recycle (overhead) and LSRC (underflow).

When the CSD unit is in operation, V131B becomes the process solvent surge tank, receiving the third-stage LSRC and the T105 bottoms fraction. V131A tank and the filter surge vessels are by-passed. In-process solvent inventory is approximately 50% less in the CSD operating mode than in the filtration mode.

J. GAS RECOVERY AND RECOMPRESSION

Vapor from V104 High Pressure Vent Separator contains 60 to 80% hydrogen by volume, plus hydrocarbon gases, hydrogen sulfide, and carbon dioxide. The hydrogen sulfide and carbon dioxide are removed by a dilute solution of caustic soda in T101 Hyrogen Scrubber. The exit gas from T101 is scrubbed with water in V106 Recycle Hydrogen Water Scrubber to remove entrained caustic. Excess scrubbed gas is vented to K110 Flare. C104 Fresh Hydrogen Compressor brings pure hydrogen from storage to C102 Hydrogen Recycle Compressor which boosts the feed gas stream to the inlet pressure of B102 Slurry Preheater.

K. LIGHT ORGANICS RECOVERY

Organic liquid from V105 Solvent Decanter and the condensed overhead from T102 are combined in V164 and fed to T104 Light Organic Recovery Column. Components boiling below 350°F are collected in V170 Light Organics Storage Tank. Liquids boiling at 350°F or higher are combined in V160 with material withdrawn from T102 trays 3 and 8.

T104, six inches in diamter, contains two 5-ft sections. The top section contains 1/4-in. "Pro-Pak" packing, and the bottom section is packed with 5/8-in. SS Pall rings. The bottom contains an internal reboiler coil which is heated by Dowtherm.

Reboiler duty is 104,000 Btu/hr, and overhead condenser duty is 30,000 Btu/hr.

L. SOLVENT FRACTIONATION

The material from V160 is heated to 220°F by the T105 bottom product stream and is then fed to T105 Fractionation Column. It may enter at tray 10, 12, 14, or 16, depending upon the feed composition.

The T105 bottoms, having a boiling range of 450 to 900°F, is sent to V131 for use as a recycle process solvent. The overhead has a boiling range of 350 to 450°F and is recycled to the filter section for use in filter cake washing.

T105 contains 20 valve trays. Heat is supplied by a Dowtherm reboiler, E173. The overhead vapor is condensed by a fan cooler, E170. The reboiler design duty is 3.3 MM Btu/hr and the overhead condenser duty is 2.9 MM Btu/hr.

M. SOLVENT STORAGE

The following solvent storage is provided:

- V123 Process Solvent Storage (15,000 gal), startup and makeup;
- V131A Recovered Solvent Tank (4,750 gal), recycle process solvent (boiling range 450 to 900°F);
- V131B Process Solvent Surge Tank (1,250 gal), recycle process solvent plus CSD third stage (LSRC);
- V124B Wash Solvent Storage Tank (10,000 gal), filtration wash solvent (boiling range 350 to 450°F); and
- V124A Light Organic Liquid Tank (10,000 gal), light organic liquid and excess wash solvent as total organic liquid by-product (boiling range normally below 350°F).

IV. OPERATIONS AND RESULTS

A. RUN SUMMARY

During the first quarter of 1980, coal was fed to the SRC pilot plant for 1,571 hours, an on-stream factor of 72%. Runs 195 through 201 were made with Kentucky 9 coal from the Lafayette mine, and Runs 202 through 204 were made with Kentucky 9 coal from the Dotiki mine.

Runs 195 through 197 were made primarily to supply feed to the USF filter. Run conditions were: Kentucky 9 coal, 38.5% slurry concentration, 515 lb/hr feed rate, 11,500 scfh of recycle gas at 85 mole % hydrogen purity, 1,700 psig dissolver pressure, 825°F dissolver outlet temperature with 75% of the dissolver (38 lb/hr-ft^3) in use. The dissolver solids withdrawal system was in service. Sodium carbonate, a corrosion inhibitor, was added to V101A at the rate of 40 lb/batch of coal slurry.

The only change in Run 198 was the elimination of sodium carbonate in the coal slurry feed. The purpose of this run was to monitor the effects of sodium carbonate on filter operations. After 117 hours of coal feed, the corrosion probes indicated an increase in corrosion, and Run 198 was terminated.

Run 199 marked a return to sodium carbonate addition at 40 lb/batch of coal slurry, and also a reduction in the recycle gas flow from 11,500 to 10,000 scfh. Runs 200 and 201 were made at the same conditions as Run 199.

Run 202 was the first to process Kentucky 9 coal from the Dotiki mine. Light SRC (LSRC) was added to the slurry feed, but no sodium carbonate was added. The three purposes of this run were to provide feed to the CSD unit, to compare operations with and without sodium carbonate, and to establish baseline performance guides for Kentucky 9 coal from the Dotiki mine. After 215 hours of coal feed, the corrosion probes indicated an increase in corrosion, and Run 202 was terminated. The conditions for Run 203 were the same as for Run 202, except that carbonate addition was resumed at 40 lb/batch of coal slurry. In Run 204, the dissolver outlet temperature and pressure were increased to 840°F and 1,800 psig, respectively.

1. Filtration

The United States Filter Corporation (USF) filter was in operation from the beginning of the quarter until 23 February. During this period, 325 filter cycles were completed.

2. Distillation

For most of the quarter, the distillation section produced specification products. During Run 200, however, solvent separation in T102 Vacuum Column was poor due to a gasket failure at tray 8. In order to provide a liquid seal, tray 8 was welded into place.

3. Critical Solvent Deashing (CSD)

After modifications, the unit was tested with deashing solvent, deashed SRC, and remelted high-ash SRC. The CSD unit was on-stream 64% of the time from 25 February until the end of the quarter. Specification SRC was produced.

B. COAL COMPOSITION AND SLURRY PREPARATION

Coal is received at the pilot plant pulverized to 95% smaller than 200 mesh in tote bins averaging 3,600 lb each. Coal slurries were made to a nominal 38.5% MF concentration for all runs. Forty pounds of sodium carbonate was added to each slurry batch (made from one tote bin of coal) except during Runs 198 and 202, when none was added. Beginning on 28 February, 180 lb of light SRC (LSRC) was also added to each batch.

Coal slurry physical data, based on samples of coal from the Lafayette and Dotiki mines, are summarized below. Analyses of the coals are presented in Table 11. Typical chlorine contents of the coals tested were: 0.24 wt % (Lafayette coal) and 0.27 wt % (Dotiki coal).

(1) Specific gravity

Concentration, wt %	38.5			
Mine	Lafayette		Dotiki	
Temp, °F	60	150	60	150
Sp gr	1.116	1.080	1.151	1.085

(2) Viscosity

Temp, °F	Shear Rate, sec^{-1}	Viscosity, cp Lafayette	Viscosity, cp Dotiki
80	20.4	175	160
	10.2	180	165
150	20.4	57.5	60
	10.2	65	70
200	20.4	50	52.5
	10.2	55	60
250	20.4	37.5	35
	10.2	40	40

Microautoclave coal quality (coal reactivity) data are given in Table 5. The quality is expressed as the percent conversion of coal to THF-soluble products at standard extraction conditions using a synthetic solvent consisting of 25% tetralin and 75% 1-methylnaphthalene.

C. SLURRY PREHEATING AND DISSOLVING

During the first quarter, all of the hydrogen feed gas was introduced into B102 Slurry Preheater with the slurry feed. No dissolver by-pass runs were attempted.

The operation of this unit was generally stable throughout the quarter. B102 was decoked on 6 February. Prior to decoking, a test was conducted in which the feed consisted of 1,400 lb/hr of solvent, 10,000 scfh of hydrogen gas, and no coal or LSRC. After decoking, but prior to charging coal to B102, the test was repeated. Coil skin/fluid temperatures were measured except at turns 27 and 33. The data indicated that there was not much coke in the coil.

Typical slurry preheater and dissolver data are shown in Table 14.

D. REACTION

1. Stability

Reaction stability is affected by several dissolver operating parameters, including temperature, pressure, solids accumulation rate, solvent properties and coal composition. Dissolver temperature is generally controlled by adjusting the firing rate to B102 Slurry Preheater. Total pressure is controlled by venting, and hydrogen partial pressure is controlled by adjusting the rate of hydrogen make-up. Solids accumulate in the dissolver unless they are removed periodically. The solids withdrawal system is shown in Figure 6. Nuclear density gauges are normally used to monitor the relative changes in reaction mass density, but these gauges were inoperable during the first quarter. Solvent composition is determined by chromatography and elemental analyses. Solvent quality and changes in feed coal reactivity are measured with a laboratory microautoclave.

a. Temperature

Table 14 shows the slurry preheater and dissolver temperature profiles for selected 24-hour periods during the quarter. Normally, a slight temperature increase due to exothermic chemical reactions occurs as the mass flows up through the dissolver. These reactions yield both gas and distillate from the liquefied coal.

Significant changes in B102 Slurry Preheater and R101 Dissolver temperatures occurred on 14 January when, at 1030 hr, the V101B Slurry Feed Tank was charged with 30 lb of Na_2CO_3. The data are given below:

Run	Time, hr	B102 Fuel Feed Rate, gph	B102 Coil Outlet, °F	R101 Δt, °F	R101 Outlet, °F
198	0900	11.4	813	46	824
199	1100	11.4	816	46	825
199	1130	-	812	57	827
199	1200	-	805	60	831
199	1300	10.8	799	62	831
199	1500	10.6	800	57	819
199	2100	11.4	798	56	817

The following transient effects were observed:

- o B102 and R101 inlet temperatures decreased gradually after 1100 hr.
- o The R101 outlet temperature increased gradually after 1100 hr, indicating a significant increase in exothermic reactions occurring in the dissolver.
- o Between 1200 and 1300 hr, the B102 firing rate was reduced to compensate for the high dissolver temperature. The adjustment was too severe and the dissolver temperature fell below 820°F by 1430 hr.
- o The B102 firing rate was returned to normal by 2100 hr. A small but significant long-term exothermic effect was noted across R101.
- o A shift in the viscosity peak of material in B102 was noted.

Except for the addition of Na_2CO_3, no other known changes were made which could have accounted for the observed phenomena.

The dissolver temperature was increased from 825 to 840°F for Run 204. Predictably, the hydrogen consumption increased and the sulfur content of the V110 SRC decreased. There was a decrease in SRC yield and a slight decrease in solvent quality. The plant was not in solvent balance during this run as a result of losses in the T105 overhead.

b. Pressure

The dissolver pressure was maintained at 1,700 psig from 1 January until 25 March, when it was increased to 1,800 psig. This was done to control the hydrogen partial pressure.

c. Solids Accumulation

The solids withdrawal system was in operation for the entire quarter, but the nuclear density gauges on the dissolver were out of service. The target withdrawal rate was equivalent to 6 wt % of the total slurry feed. Table 14 presents a typical analysis of the withdrawn material. Table 15 shows the analyses of blowdown solids from the dissolver. There were 19 lb of solids recovered in the blowdown of 6 February. Blowdown of the dissolver means to discharge its content into V144 vessel. A sample of it is analyzed for solids content. Therefore, the solids content of the dissolver does not include the accumulated solids on the internals of the dissolver. There were 14 lb of solids removed when the dissolver was inspected.

d. Solvent Characteristics

The process solvent boiling range did not change significantly during the quarter, although the solvent quality did increase during Run 203 (as shown by both the long and short microautoclave tests). The solvent quality decreased slightly during Run 204. The hydrogen content of the solvent was 8.77% during Run 203 and 8.84% during Run 204.

e. Coal Composition

On 26 February, the feed coal was switched from Lafayette to Dotiki mine. After a few days of operation, changes in the reaction section performance were noted as a result of the change in coal composition, especially an increase in solvent quality, and an increase in SRC yield.

2. Yields

Yield data for organic and acid gases, water, organic liquids, SRC, ash, and unreacted coal for the material balance periods are given in Table 6. These data, along with those obtained earlier, show the increase in the process solvent yield at the expense of SRC when LSRC from the CSD unit replaced part of the process solvent that was added to the coal feed.

Typical gas chromatographic analyses of the various products are given in Tables 18 through 20. Analyses of the flare header gases are given in Table 21. Table 22 shows analyses of reaction products from the laboratory workup of the V110 Flash Tank composition for the material balance periods.

3. Heteroatom Removal

Oxygen, nitrogen, and sulfur removal can be calculated from elemental analyses of feed coal and SRC as follows:

$$\text{Heteroatom removal, \%} = 100\ (A-B)/A \qquad \text{(Equation 1)}$$

where

A = heteroatom-to-carbon ratio in feed coal

B = heteroatom-to-carbon ratio in SRC

Heteroatom removal calcuations for the runs made during the quarter are summarized in Table 17.

Total sulfur removal (TSR) can be calculated by the following equation based on the heating value of coal and SRC:

$$\text{TSR, \%} = \left[(A/C - B/D) \div A/C\right] 100 \qquad \text{(Equation 2)}$$

where

A = Total sulfur in feed coal, wt %

B = Total sulfur in SRC, wt %

C = Heating value of coal, Btu/lb

D = Heating value of SRC, Btu/lb

Total sulfur removal calculations are summarized in Table 17. Sulfur forms in feed coals and in SRC products are summarized below:

		Sulfur Forms, wt %			
Sample	Run	Pyritic	Sulfate	Sulfide	Organic
Feed Coal	201ABC MB	0.68	0.01	<0.01	1.75
	202A MB	1.18	0.03	<0.01	2.04
	203DE MB	1.34	0.03	<0.01	2.21
K125 SRC	201ABC MB	<0.01	<0.01	0.02	1.24
CSD SRC	202A MB	0.01	<0.01	<0.01	0.79
	203DE MB	0.01	<0.01	<0.01	0.91

Hydrodesulfurization results for the quarter were as follows:

Run	201ABC MB	202A MB	203DE MB
Total sulfur removal, %			
by equation (1)			
V110 SRC	63.6	76.6	79.6
K125 SRC	57.6	-	-
CSD SRC	-	80.9	79.6
by equation (2)			
V110 SRC	60.5	74.5	79.2
K125 SRC	56.8	-	-
CSD SRC	-	79.5	78.9
Organic sulfur in MF coal, %	1.75	2.04	2.21
Pyritic sulfur in MF coal, %	0.68	1.18	1.34
H_2S production, % of MF coal	0.91	1.07	1.51
Organic sulfur in SRC, %			
V110	1.07	0.95	0.91
K125	1.24	-	-
CSD	-	0.79	0.91

The sulfur removal was greater in Runs 202 and 203 (Dotiki mine coal) than in Run 201 (Lafayette mine coal). The Dotiki coal contains more pyritic sulfur than the Lafayette coal.

E. FILTRATION

The United States Filter Corporation (USF) filter was used to deash reaction product during Janaury and February. Three filter leaves, having a total screen area of 65.2 ft^2, were used. Figure 2 is a schematic of the filtration system and Figure 27 presents a cutaway view of a USF Michigan Dynamics leaf, showing its component parts. The leaves were made from a 2-ply, diffusion-bonded laminate (calendered 24 x 110 mesh on calendered 6 mesh) which was solution-annealed. The laminates were not spot-welded to the metal rods in the tubular slit screen as originally planned because a secure mechanical fit was obtained. Screen failures due to corrosion of the wire were eliminated by solution-annealing the diffusion-bonded laminates.

The following table summarizes filtration operations for the first quarter:

Period, 1980	Run No.	Cycle No.	Loading, lb/ft² Precoat	Wet Cake	Filtration Rate[a], gph/ft² Second day	Last day	Filtrate Ash Range, wt %	Average SRC Ash, wt %
5-8 Jan	197	1-24	0.35	3.6	3.1	3.6	0.01-0.09	0.30
8-13 Jan	198[b]	25-46	0.35	3.8	3.2	7.0	0.01-0.08	0.21
14-17 Jan	199[c]	14-30	0.07	3.8	4.1	3.2	0.02-0.14	0.26
17 Jan	199	31-33	0.35	3.4	3.1	-	0.07-0.14	-
17-22 Jan	199[d]	37-AMB7	0.07	3.4	3.7	2.8	0.03-0.14	0.30
22-23 Jan	199[d]	AMB8-BMB7	0.35	3.5	2.8	3.1	0.06-0.11	0.26
26 Jan-1 Feb	200[c]	1-41	0.07	3.6	3.8	2.3	0.04-0.11	0.26
3-5 Feb	200[c, f]	43-69	0.07	3.7	5.1	4.5	0.05-0.7	0.35
11-14 Feb	201[c,f]	1-24	0.07	3.7	4.0	3.7	0.03-0.13	0.41
14-15 Feb	201[e]	25-30	0	3.0	2.5	-	0.07-0.20	-
17-22 Feb	201[c,f,g]	38-CMB12	0.07	3.7	2.7	3.2	0.06-0.15	0.33

(a) Rate during filtration. Does not include downtime.
(b) Run made without sodium carbonate addition. Other runs made with sodium carbonate as 1.1% of coal.
(c) Precoat addition reduced.
(d) Filtrate recirculated to feed tank for one minute before forward filtration.
(e) No precoat added.
(f) Cake wash reduced from 737 to 344 lb/cycle.
(g) Johns-Manville Hyflo Super-Cel used as precoat. Dicalite Perlite 436 was precoat in other tests.

In all but one of the runs, sodium carbonate was present in the dissolver feed. An attempt was made to determine the effects of sodium carbonate addition on the filtration rate and the ash content of SRC during Run 198. During the run, one of the XV654 ball valves (between V141 and V112 tanks) leaked. This allowed wash solvent to transfer from V141 to V112. Consequently, large amounts of cake were dumped. The cut-off blade for one screen broke, and the leaves would not rotate.

Filtration rates were high on cycles 198-10 to 198-32 (See Figure 7) due to viscosity and feed solids concentration. After the XV654 valve was repaired and the plant was returned to operation, corrosion in T105 was detected and sodium carbonate addition was resumed.

Precoat addition was reduced for filtration cycles 199-14 to 199-30, 199-35 to 199-A MB-7 and 200-1 to 201-C MB-12. After each sluicing, 0.35 lb/ft² of precoat was placed on the clean screens. The sluicing times are shown in Figures 7 and 8. Between sluicings, the precoat was reduced to 0.07 lb/ft². Results of operation at the reduced precoat loading were similar to results obtained at 0.35 lb/ft² precoat loading.

The amount of wash solvent used to wash the cake was reduced from 737 lb per cycle to 344 lb per cycle between 3 and 23 February. With the wash solvent reduced to 1.4 lb of solvent per lb of discharged filter cake, the amount of SRC in the filter cake did not increase significantly. Previous analyses for SRC in the wash solvent indicated removal of SRC from the filter cake at a level of 3 lb of wash solvent per lb of cake. However, the quantitative SRC analyses of filter cake may be inaccurate due to the low SRC content.

Spot analyses of the filtrate showed an ash content of 0.03 to 0.12%, and a CI content of 0.01 to 0.02 wt %. The ash in the SRC product ranged from 0.05 to 0.45 wt %. To reduce the occurrence of ash breakthrough, which can happen before the cake is fully established, the filtrate was recirculated to the feed tank for one minute before forward filtration, from cycles 199-37 to the end of Run 199. The ash in the SRC did not decrease.

Six cycles were made without precoat. The filter leaves were sluiced prior to the start of the no-precoat cycles and every other cycle of the test (See Figure 8). Poor clarity was obtained at the start of each cycle and increased filtration time was required.

Dicalite Perlite 436 was used in most precoat tests during the quarter. However, Johns-Manville Hyflo Super-Cel was tested for 6 days. The ash contents in the SRC products were about the same for both precoat materials.

Mineral analyses of filtrate from Run 198, without sodium carbonate, and from Run 199, with carbonate, were made. When sodium carbonate was present in the reactor feed, more Na_2O and SO_3 were present in filtrate ash samples subjected to analysis by ignition, but the amount of Fe_2O_3 was substantially less. The chloride content of the filtrate was high, as shown in the following table:

Filtrate Analyses

Minerals	Run 198 No Carbonate Wt % in Ignited Ash	Run 199 Na_2CO_3, 1.1% of Coal Wt % in Ignited Ash
P_2O_5	0.53	0.09
SiO_2	5.40	11.13
Fe_2O_3	32.46	1.09
Al_2O_3	12.38	2.25
TiO_2	46.17	39.98
CaO	1.22	4.95
MgO	0.57	0.96
SO_3	0.97	23.35
K_2O	0.11	1.91
Na_2O	0.34	12.61
Total	100.15	98.32
	Wt % of Filtrate	Wt % of Filtrate
Ash	0.084	0.05
Chloride	0.08	0.04

Filter inspections during the quarter are given below:

Item	Leaf Description	Run Days	Filter Inspection	Sluice[a]
1	Run 194-196 3-ply, numbered C1 2-ply w/perforated sheet non-bonded D2.	4	No precoat operation. Poor clarity. Silver solder on leaf no. D2 corroded/eroded away.	1,200 psig each cycle.
2	Run 197 2-ply w/perforated sheet diffusion-bonded, solution annealed screens. No spot welds.	2	Precoat operation. Screens intact. Some solids under screen where outer mesh is not bonded down.	1,200 psig two times,
3	Runs 197-99 2-ply w/perforated sheet, diffusion-bonded, solution annealed screens. No spot welds.	17	Front cut-off blade broken at weld. Leaves in good condition. One leaf with loose outer mesh changed out.	1,200 psig. Each 25 cycles.
4	Run 200 Same as above.	6	Leaf hub seal blown.	1,200 psig. Each 25 cycles.
5	Run 200-201 Same as above.	18	Shut down. Screens and seals were okay.	1,200 psig. Each 25 cycles.

(a) Spraying Systems Co. 4006 nozzles were in use.

Cake compressibility tests were performed at the end of January for Run 200 and during February for Run 201. The tests consisted of running three cycles at each of three differential pressure levels: 25, 50 and 90 psi. The filter leaves were sluiced prior to each group of three cycles. After the sluice, 0.35 lb/ft^2 of the filter aid was deposited as precoat. For the last two cycles at each pressure, 0.07 lb/ft^2 of filter aid was used.

The cake compressibility test results for Run 200 follow:

Cycle	ΔP, psi	Filter Temp, °F	$R_m \times 10^{-10}$ 1/ft	$\alpha \times 10^{-12}$ ft/lb_m
200-29	72	543	52	2.51
200-31	33	535	92	1.51
200-32	33	540	54	1.57
200-33	33	538	39	1.78
200-34	25	539	41	1.47
200-35	25	544	27	1.37
200-36	25	547	74	1.16

The filter feed contained 4.8 lb solids/ft^3 of filtrate, as calculated from the cake weights, cake analyses and feed throughput. Filtrate viscosity was 0.9 cp at 540°F. The filter area was 65.8 ft^2.

A regression analysis of α versus filtration differential pressure for Run 200 yielded the following empirical equation:

$$\alpha = 2.5 \times 10^{11} \Delta P^{0.54}, \text{ ft/lb}_m$$

where α is specific cake resistance and ΔP is filtration differential pressure in psi. Analysis of two filter feed samples showed that between 40% and 43% of the filter feed solids were UC. The balance of the samples consisted of ash.

The specific cake resistances obtained were higher than those previously obtained. (See Figure 12.)

The cake compressibility test results for Run 201 follow:

Cycle	ΔP, psi	Temp, °F	$R_m \times 10^{-10}$ 1/ft	$\alpha \times 10^{-12}$ ft/lb$_m$
201-11	25	550	27	1.26
201-12	25	556	16	1.33
201-13	25	554	8	1.46
201-14	50	554	21	2.00
201-15	50	554	31	1.79
201-16	50	557	30	1.84
201-17	90	559	151	2.13
201-18	90	562	47	2.61
201-19	90	558	121	2.37

The feed contained 5.0 lb solids/ft^3 of filtrate, as calculated from cake weights, cake analyses and quantity of filter feed. Filtrate viscosity at 550°F (estimated by extrapolation) was 0.88 cp.

Analyses of the filter feed showed that 41.7% of the filter feed solids was UC. The balance was ash. The relationship between α and ΔP for Run 201 was calculated by regression analysis to be:

$$\alpha = 3.3 \times 10^{11} \Delta P^{0.44}, \text{ ft/lb}_m$$

where α is specific cake resistance and ΔP is filtration differential pressure, psi.

The filtration rate data are plotted in Figures 7 and 8. The volume filtered from V112 and the filtration time were fitted to the empirical equation:

$$t/V = a_o + a_1 V$$

where t is time in seconds and V is the filtrate volume in cubic feet.

The times required to filter 4.4 gallons of filtrate per square foot of filter area are shown on Figures 7 and 8. Also presented is the ash content in the SRC.

The viscosities of various filtrate samples are presented in Figures 10 and 11.

Figure 13 shows the effect of filter feed composition on the filtration parameters.

Installation of the Industrial Filter and Pump Manufacturing Company (IF) skid-mounted filter unit was completed. The IF unit is shown schematically in Figure 28. A cold test was made by adding Perlite 436 to cold wash solvent. A 1-in. cake of the filter aid was formed and discharged.

F. SOLVENT RECOVERY

1. T102 Vacuum Column

T102 was operated in the following mode throughout the first quarter: The feed entered the column below tray 8. Refluxes were maintained on both tray 1 (overhead) and tray 3, and the tray 3 and 8 drawoffs were recombined and sent to T105 Solvent Fractionation Column. The overhead product was sent to T104 Light Organics Recovery Column via P171 (hot well), and the bottom product was sent either to K125 Product Solidifier or to the CSD unit and to B103 Vacuum Preheater (recycle). The system is illustrated in Figure 1.

Typical operating conditions are shown on the following page.

Run	201	202	203
Date, 1980	19 Feb	6 March	14-15 March
Inlet Feed			
Rate, lb/hr	1,449	1,189	1,152
Temp, °F	791	627	728
Pressure, psia	1.1	0.8	0.8
T102 Temperatures, °F			
Overhead			
Tray 2	218	213	200
Tray 3	230	240	232
Packing reflux	175	150	150
Tray 8	350	354	357
Bottoms	584	560	555
Flow Rates, lb/hr			
Overhead	112	108	-
Tray reflux	1,100	1,050	1,050
Tray 3 reflux	1,400	1,500	1,500
Bottom rate	337	401	400

The bottoms recirculation is combined with feed from V120 (filter mode) or V110 (CSD mode) and sent through B103. Profiles of B103 for three material balance periods are shown below:

Run	201	202	203
Date, 1980	19 Feb	6 March	14-15 March
Temperatures, B103, °F			
Feed	584	567	560
Turn 4	610	580	573
Outlet skin	600	579	580
Outlet process	573	553	550
Top	791	628	723
Stack	647	577	567
Flow rates, lb/hr			
Feed	1,449	1,189	1,152

The only major problems encountered with T102 during the first quarter were associated with tray 8. A high percentage of process solvent in the SRC was noted in early February. Increasing the bottom temperature did not reduce this high solvent rate. It was found that the tray 8 gaskets had deteriorated, allowing solvent to flow to the bottom of the column. The tray was welded into place to prevent leakage.

The corrosion probes in T102 indicated a low corrosion rate. Results from 1 January through 31 March were:

Sample Location	Material of Construction	Total Corrosion Mils	Total Corrosion Mils/year
Packing area	1010 CS	1.95	7.91
Tray 8	410 SS	0	0.00
Tray 8	316L SS	0	0.00
Tray 3	304 SS	0	0.00
Vapor space	1010 CS	0	0.00

2. T105 Solvent Fractionation Column

The T105 Fractionation Column operated continuously during the quarter. The feed to the column consisted of distillates from T102 (trays 3 and 8) and the bottoms of T104. The overhead product specification (5% <350°F, 5% >450°F) in the column was difficult to maintain at low reflux due to the small amount of material boiling below 350°F in the feed. The reflux ratio in the column was kept high to reduce process solvent entrainment in the overhead stream.

Table 26 presents the operating performance for the material balance periods during the quarter. Tables 27 and 28 show the column product analyses and compositions. Figures 14 through 19 show the ASTM D-86 and GC simulated boiling point MB curves for process and wash solvent from T105. Figures 20, 21 and 22 show the ASTM D-1160 MB curves for recovered process solvent.

3. T104 Light Organics Recovery Column

T104 operated continuously during the quarter, processing feed from V105 and T102 overhead. The bottom stream went to V160 (T105 feed drum) and the overhead to storage. The column operated throughout the period without reflux. The feed was heated to 300°F by a reboiler operating at approximately 500°F. Without reflux, the column operated as a basic flash column.

The overhead stream consisted of over 95% light organic liquid. The bottom product contained up to 6% light organic liquid. Table 31 summarizes T104 operation during material balance periods. Tables 32 and 33 show light organic product analyses and compositions. Figures 23, 24 and 25 show the GC and ASTM D-86 simulated boiling point curves of the light organic liquids for the MB periods.

4. Solvent Inventory

Total solvent inventory increased 42,600 lb during the quarter, as shown below:

Date, 1980	1 Jan	31 March	Change	Composition, wt % IBP-350°F	350-450°F	450°F-EP
Inventory, M lb						
Light organic liquid						
in tanks	2.5	1.6				
in drums	-	-				
shipment	-	15.8				
total	2.5	17.4	+14.9	95.5	0.8	3.7
Wash Solvent						
in tanks	68.2	99.6				
in drums	-	-				
shipment	-	0.6				
total	68.2	100.2	+32.0	8.5	77.0	14.5
Process Solvent						
in process	42.2	45.0				
in storage	39.8	21.3				
in drums	-	5.3				
shipment	-	6.0				
makeup	41.3	41.4				
total	123.3	119.0	-4.3	0	1.5	98.5

The preceding table shows that the light organic liquid and wash solvent inventories increased while the process solvent inventory decreased. However, the inventories of wash solvent were calculated directly from the contents of several storage tanks. These inventories are mainly from T105 overhead, which contains more than 10% process solvent (boiling above 450°F). If this factor is taken into account, the adjusted solvent inventory at the beginning and end of the first quarter would be:

Inventory, M lb	1 Jan	31 March	Net change
Light Organic Liquid	3.6	25.1	+21.5
Wash solvent	59.8	79.0	+19.2
Process solvent	130.6	132.5	+1.9
Total	194.0	236.6	+42.6

5. Process Solvent Composition

Typical process solvent compositions during the quarter were:

Coal source	Lafayette	Dotiki	Dotiki
Solvent source	V131B	V131B	V131B
Run	201	202	203
Date, 1980	19-20 Feb	6 March	24 March
Boiling fractions, wt %			
IBP, °F	451	449	404
IBP-450°F	0.2	0.6	1.6
450-550°F	48.0	46.8	46.5
550-650°F	23.9	25.5	24.2
650°F-EP	27.1	26.4	27.6
Residual	0.8	0.7	0
EP, °F	867	838	872
Carbon, %	87.77	87.40	87.27
Hydrogen, %	8.38	8.70	8.77
H/C atomic ratio	1.146	1.195	1.206
Specific gravity	1.019	1.013	1.012

LSRC from the CSD unit was added during Runs 202 and 203. Forty pounds of sodium carbonate was added per batch of slurry during Runs 201 and 203, but none was added during Run 202.

Process solvent balance would have been maintained during the quarter, except for the solvent which was lost to the wash solvent storage tanks. Yields based on the net solvent inventory changes were as follows:

		Actual Inventory	From Material Balance[(a)]
Light Organic Liquid			
Net change, lb	=	21,500	-
% MAF coal[(b)]	=	2.98	3.03
% MF coal[(c)]	=	2.70	2.93
Wash Solvent			
Net change, lb	=	19,200	-
% MAF coal[(b)]	=	2.65	3.77
% MF coal[(c)]	=	2.41	3.42
Process Solvent			
Net change, lb	=	1,900	-
% MAF coal[(b)]	=	0.26	3.05
% MF coal[(c)]	=	0.24	2.76

(a) Reaction section balance, average for Run 201, 202 and 203. The reaction section material balance is calculated by using the lab analyses and flow rates to determine the yields.

(b) Total MAF lb fed = 723,569.

(c) Total MF lb fed = 796,488.

G. KERR-McGEE CRITICAL SOLVENT DEASHING (CSD)

Extensive modifications to the CSD unit were completed between mid-October 1979 and mid-February 1980. These included the erection of steel structure, an increased capacity first stage vessel, a new heat exchanger, a high pressure solvent system, and instrumentation. The primary purposes of the modifications were to give the CSD unit sufficient capacity for deashing the total output of the SRC pilot plant, to improve the operability and heat recovery of the system, and to reduce deashing solvent (DAS) losses. Figure 4 shows the modified Three-Stage Critical Solvent Deashing System.

Two different modes of operation are possible with the modified unit. "Mode 1" utilizes a new high-pressure, high-temperature DAS storage system with an option for maximum heat recovery from the third stage overflow stream. "Mode 2" is essentially the same as before the modification, except that a partial heat recovery system from the third stage overflow stream was added. All of the runs during the first quarter were made in "mode 2".

After pressure-testing the modified unit, a test run (Run 40) was made with remelted feed to demonstrate that deashing could be achieved. The ash concentrate was fluffy and powdery.

Feed to the CSD unit on 25 February was derived from Lafayette coal. Beginning on 26 February, the coal source was the Dotiki mine. Run 202 gave 79% SRC recovery and Run 203 gave 84% SRC recovery.

1. Process Stability

During the first quarter, 104.3 tons of T102 bottoms were processed in the CSD unit under "mode 2" conditions. Operability of the modified CSD unit in "mode 2" was better than it had been before modifications were made.

Improving the heat control in the system eliminated troubles in the letdown system. Using LPG instead of fuel oil for the heat transfer medium heater in the CSD unit reduced both the cost of operation and the frequency of burner cleaning. Incidence of fouling of the heat exchanger equipment was low during the first quarter.

At present, the only major problem area is the continuous ash concentrate handling system. Temperature control is still lacking. The level control instruments perform erratically, and consequently cause increases in DAS loss.

The amount of LSRC produced was greater than the amount recirculated as a result of unadjusted second stage CSD conditions.

2. Feed Composition

The feed compositions for Runs 202, 203 and 204 were:

Run	202	203	204
Date, 1980	6 March	14-16 March	31 March
Source	CSD feed SRC	CSD feed SRC	CSD feed SRC
Composition, wt % on solvent-containing basis[(a)]			
Oil	23.3	24.9	22.4
Asphaltene	38.7	57.4	53.3
Preasphaltene[(b)]	38.0	17.7	24.3
SRC Benzene solubles/preasphaltene ratio	1.6	4.6	3.1
SRC Recovery in CSD unit, wt %			
By forced ash balance method	77.7	81.4	79.0
By normalized balance method	79.3	83.8	80.2
By average of above two	78.5	82.6	79.6
SRC Plant Conditions			
Coal space rate, $lb/hr\text{-}ft^3$	38	38	38
Dissolver volume, %	75	75	75
Coal type	Dotiki	Dotiki	Dotiki
Dissolver pressure, psig	1,700	1,700	1,800
Dissolver outlet temp, °F	825	825	840
Solvent THF conversion, %[(c)]	64.2	69.0	70.4
Na_2CO_3 addition	No	Yes	Yes

(a) Cresol solubles.
(b) Benzene insoluble, but cresol soluble.
(c) Microautoclave short method.

V110 SRC and CSD feed SRC compositions were:

Run	202		203		204	
Date, 1980	6 March		14-16 March		31 March	
Source	V110 SRC	CSD feed SRC	V110 SRC	CSD feed SRC	V110 SRC	CSD feed SRC
Composition, wt %, on solvent-free basis						
Oil	20.5	12.1	20.1	16.8	21.7	14.6
Asphaltene	46.0	44.3	50.7	63.6	59.4	58.7
Preasphaltene	33.5	43.6	29.2	19.6	18.9	26.7
SRC Plant Conditions						
V110 temp, °F	585		585		590	
T102 temp, °F	557		553		553	

3. Ash Separation

Ash concentrate from the first stage underflow of the CSD unit is continuously discharged from the ash processing systems as a light powder. The ash concentrate discharge and the ash content in the ash concentrate were:

Run	202A MB	203D-E MB
Ash concentrate, % of feed	37.3	35.1
Ash in ash concentrate, %	28.7	32.3

Difficulties in ash separation were caused by malfunctions of level control instrumentation on the continuous ash concentrate vessel. Ash concentrate analyses are presented in Table 34.

Particle size distributions were determined by dry screen analysis on the ash concentrate.

Screen mesh size	Particle size, microns	Average size, microns	Ash Concentrate: Individual fraction, %	Ash Concentrate: Accumulated fraction, %
14-25	1,168-710	939	0.16	0.16
25-50	710-297	504	4.99	5.15
50-100	297-149	223	13.37	18.52
100-200	149-74	112	19.00	37.52
200-270	74-53	64	17.07	54.59
270-325	53-44	49	33.98	88.57
>325	est. 38	est. 38	11.43	100.00

Only 11% of the particles in the ash concentrate were smaller than 44 microns. Figure 26 shows the terminal settling velocities as a function of particle sizes in the ash concentrate vessel.

The compositions of cresol-soluble ash concentrate were:

Run	202 MB	203 MB	204 MB
Composition, wt %			
Oil	13.9	39.7	25.0
Asphaltene	12.1	18.6	41.7
Preasphaltene	74.0	41.7	33.3

The compositions have varied widely.

4. Total SRC and LSRC Recovery

(a) On-stream Balance

The total SRC and LSRC recovery may be calculated by the forced ash balance as follows:

$$\text{SRC recovery, \%} = \left[100 - \frac{(\text{\% ash in feed})\ (100)}{\text{\% ash in ash concentrate}}\right] \div \left[\frac{100 - \text{\% CI in feed}}{100}\right]$$

Total SRC and LSRC recovery may also be calculated by the normalized material balance method as follows:

$$\text{SRC recovery, \%} = \left[(\text{SRC in lb/hr} + \text{LSRC in lb/hr})\ 100\right] \div \left[\frac{(\text{feed in lb/hr})\ (100 - \text{\% CI in feed})}{100}\right]$$

SRC recoveries in the CSD unit by the two methods were:

Run	202A		203DE	
Date, 1980	6 March		14-16 March	
SRC recovery, %	as-is	solv-free	as-is	solv-free
by forced ash balance	77.7	75.6	81.4	80.5
by normalized balance	77.7	80.0	83.6	84.4
by average of the two	77.7	77.8	82.5	82.5

(b) Component Balances

Total SRC and LSRC recoveries by computerized component balances are presented on the following page.

Run 202A MB
(25.7 lb/hr of Light SRC added to Feed to SRC Plant)

Component	Total Feed(a), lb/hr	Recovered SRC(b), lb/hr	Component Recovery, % of feed(c)	Recovered Ash Conc, lb/hr	Component Recovery, % of feed(d)
Deashing solvent		0.44		1.71	
Solvent	33.45	22.91		2.65	
Oil	27.60	17.09	61.89	3.73	86.49
Asphaltene	101.32	139.01	137.20	5.53	94.54
Preasphaltene	99.70	25.32	25.40	33.80	66.10
Ash	34.75	0.10		34.52	
Unreacted coal	27.93	0.03		40.06	
Total	324.75	204.89	79.35	122.00	75.86(e)

Run 203 D-E MB
(25.7 lb/hr of Light SRC added to Feed to SRC Plant)

Component	Total Feed(a), lb/hr	Recovered SRC(b), lb/hr	Component Recovery, % of feed(c)	Recovered Ash Conc, lb/hr	Component Recovery, % of feed(d)
Deashing solvent		0.36		1.47	
Solvent	28.72	22.02		2.90	
Oil	44.59	54.22	121.61	12.26	72.50
Asphaltene	169.29	135.93	80.30	7.12	95.79
Preasphaltene	52.15	32.91	63.11	15.95	69.41
Ash	44.59	0.17		42.58	
Unreacted coal	38.54	0.78		51.02	
Total	377.87	246.40	83.85	133.30	82.03(e)

(a) Total CSD feed.
(b) Includes Light SRC stream.
(c) Calculated using recovered SRC flow rates.
(d) Calculated using flow rates obtained by difference between feed and ash concentrate streams.
(e) Includes correction for formation of unreacted coal.

The solvent refined coal analyses are presented in Table 10. The elemental balances for each run were:

Run	Element, percent error					
	Sulfur	Carbon	Hydrogen	Nitrogen	Oxygen	Ash
202A MB	4.06	0.29	1.11	8.02	-38.58	0.37
203DE	13.02	-0.11	0.56	4.33	-17.49	3.70

The oxygen balance shows the highest error because the oxygen contents were calculated by difference:

$$\% \text{ oxygen} = 100 - \% \text{ S} - \% \text{ C} - \% \text{ H} - \% \text{ N} - \% \text{ Ash}$$

(c) Overall SRC Yields

The data are tabulated below:

Run	202A MB		203DE MB	
Date, 1980	6 March		14-16 March	
Coal	Dotiki		Dotiki	
Plant Conditions				
Coal feed rate, MF lb/hr	525		505	
Slurry conc, % MF coal	37.9		36.9	
Feed gas rate, scfh	10,035		9,660	
LSRC addition with feed, lb/hr	25.7		25.7	
Dissolver volume, %	75		75	
Dissolver solids withdrawal	Yes		Yes	
B103 Vacuum Column Preheater in use	Yes		Yes	
Na_2CO_3 addition, wt % of MF coal	None		1.1	
Temperature, °F				
B102 outlet	794		790	
R101 outlet	826		825	
V103	645		645	
V110	585		585	
T102 bottoms	557		553	
Solvent in CSD feed, %	10.3		7.6	
Benzene-solubles in CSD feed, %	50.0		64.2	
Solvent in CSD-SRC, %	6.0		5.1	
SRC yield (based on % MAF coal)	SRC including solvent	Solvent-free SRC	SRC including solvent	Solvent-free SRC
By unadjusted process method in the SRC unit	64.6	55.9	66.3	59.6
SRC recovery in the CSD unit	77.7	77.8	82.5	82.5
Overall	50.2	43.5	54.7	49.2

5. Light SRC (LSRC) Separation

The LSRC is a fraction of SRC which is obtained from the third stage of the CSD unit. Some of the LSRC has periodically been added to the feed coal slurry to improve the quality of the process solvent. The amounts of LSRC produced, LSRC recycled and product analyses were:

Run	CSD Feed, lb/hr	LSRC addition to front end, lb/hr	LSRC production, lb/hr	Distillable solvent in CSD feed, %	Distillable solvent in LSRC, %
202A MB	326.9	25.7	66.3	10.3	22.4
203DE	379.6	25.7	76.6	7.6	17.5

The LSRC recycle rate was less than the production rate due to unadjusted second stage CSD conditions.

6. Deashing Solvent Recovery

During the first quarter, total DAS losses averaged 17.8 lb/hr, 12% of which were measurable, or product-related, and the balance of which were not accounted for. During March, DAS losses in the solvent clean-up system averaged about 0.7 lb/hr. An extensive program is in progress to compare DAS losses using the continuous ash recovery system with the losses using the batch system.

H. PRODUCT ANALYSES AND PROPERTIES

Studies were directed towards improving the control of the qualities of SRC products and evaluating plant performance as functions of various process variables. In these studies, feed coal and SRC product samples were analyzed as follows:

- Soxhlet extraction: for composition of SRC products in terms of oil, asphaltene, and preasphaltene.
- Viscosity test: for flow properties of SRC products.
- Microautoclave conversion test and GC boiling point distribution determination: for monitoring recycled process solvent quality.
- Ultimate and proximate analyses: for carbon, hydrogen, nitrogen, sulfur, ash, and oxygen (by difference).

Other pertinent tests included; cresol-soluble and SRC yields, specific gravities, fusion points, GC analyses for gaseous and liquid samples, etc.

1. Compositions of SRC Products

Compositions of V110 SRC, CSD feed, CSD-deashed SRC, CSD-LSRC, and CSD ash concentrate were determined by conventional Soxhlet solvent extraction. The first step in this procedure is extraction of the sample with benzene in the presence of Celite to separate the oil-asphaltene mixture from the benzene-insoluble portion. After evaporating the benzene from the benzene-soluble fraction, the mixture of oil and asphaltene is precipitated with pentane to separate the oil from the pentane-insoluble asphaltene. Extraction with cresol is then done to determine the preasphaltene and cresol-insoluble organic material in the benzene-insoluble portion. Analyses of the feed coal samples and results from solvent extraction of the SRC products for the first quarter are shown in Tables 10 and 11.

Solvent extraction data for SRC products from V110, T102 bottoms, and from the CSD unit on a cresol-soluble basis are tabulated below:

Run	201 MB	
Date, 1980	19 Feb	
Sample location	V110[a]	K125
Material	lab-filt. SRC	SRC
Composition, wt %		
Oil	25.1	23.3
Asphaltene	38.1	43.7
Preasphaltene[b]	36.8	33.0
Solvent in SRC, %	-	6.17
Sulfur, wt %	1.07	1.07
Fusion point, °F	388	374

Run	202A MB		
Date, 1980	6 March		
Sample location	V110[a]	CSD	CSD
Material	Lab-filt. SRC	Feed SRC	Deashed SRC
Composition, wt %			
Oil	20.5 (20.5)	23.3 (12.0)	11.9 (6.2)
Asphaltene	45.9 (45.9)	38.7 (44.4)	69.8 (74.3)
Preasphaltene[b]	33.6 (33.6)	38.0 (43.6)	18.3 (19.5)
Solvent in SRC, %	-	12.8	6.1
Benzene soluble / Benzene insoluble, ratio	1.98	1.63	4.46
Sulfur, wt %	0.95	-	0.79
Fusion point, °F	385	-	270

Run	203DE MB		
Date, 1980	14-16 March		
Sample location	V110[a]	CSD	CSD
Material	Lab-filt. SRC	Feed SRC	Deashed SRC
Composition, wt %			
Oil	20.1 (20.1)	24.9 (16.8)	25.5 (21.5)
Asphaltene	50.7 (50.7)	57.4 (63.6)	55.1 (58.1)
Preasphaltene[b]	29.2 (29.2)	17.7 (19.6)	19.4 (20.4)
Solvent in SRC, %	-	9.7	5.1
Benzene soluble / Benzene insoluble, ratio	2.42	4.65	4.15
Sulfur, wt %	0.91	-	0.91
Fusion point, °F	316	-	311

(a) 600°F, 0.1 mm Hg.
(b) Cresol soluble, benzene insoluble.
Note: Values in parentheses are on a solvent-free basis.

The SRC products obtained from Run 203DE MB contain more oil and/or asphaltene than those from Run 202A MB. In addition, the ratio of benzene-soluble to benzene-insoluble material in the CSD feed SRC of Run 203DE MB was 4.65, much higher than that of Run 202A MB, which was 1.63.

2. Viscosity Changes in SRC Products

Viscosities of CSD-deashed SRC and V110 lab-filtered filtrate were obtained by using a Brookfield thermocell viscometer (Model 638) with a proportional temperature controller. The following results were obtained:

Sample Material: CSD Deashed SRC(Not Solvent-free)

Run	201 MB	202A MB	203DE MB
Date, 1980	19 Feb[(a)(b)]	6 March	14-16 March
Composition, wt %			
Oil	23.3	11.9	25.5
Asphaltene	43.7	69.8	55.1
Preasphaltene	33.0	18.3	19.4
Viscosity, cp			
at 500°F			
shear rate, sec^{-1}			
0.84	-	-	5,500
1.7	-	2,600	4,300
3.4	-	2,200	3,400
8.4	-	1,720	-
at 550°F			
shear rate, sec^{-1}			
0.84	5,600	-	4,200
1.7	4,600	1,700	3,200
3.4	4,100	1,450	2,475
8.4	-	1,180	-

(a) K125 SRC.
(b) Filter mode.

Sample Material: V110 lab-filtered filtrate.

Run	201 MB	202A MB	203DE MB
Date, 1980	19 Feb	6 March	14-16 March
Composition, wt %			
SRC in V110	29.8	30.8	28.6
Oil	7.5	6.3	5.7
Asphaltene	11.4	14.1	14.5
Preasphaltene	10.9	10.4	8.4
Viscosity, cp			
at 250°F	19.4	18.2	11.4
300°F	7.4	7.9	5.5
350°F	3.9	4.4	3.1
400°F	2.5	2.8	2.1

I. PRODUCT SOLIDIFICATION

About 160 tons of liquid SRC from T102 was sent to K125 Product Cooler for solidification. This was necessary because the CSD unit was down for modifications during part of the quarter.

J. EFFLUENT TREATMENT

The industrial and sanitary effluent treatment systems operated satisfactorily during the period and all discharge permit criteria were met with a significant margin except for total outfall flow. The outfall flow averaged 21,132 gallons per day. The phenol concentration of the industrial effluent ranged between 0.02 and 0.04 mg/l while the average BOD reduction for the period was over 98%.

V. MECHANICAL PERFORMANCE

During January and February 1980, about two-thirds of the maintenance hours were expended in completing the CSD modifications (Project 4144). This included installation of a crusher in the CSD unit.

Other major maintenance required during the first quarter included replacing a section of liquid coal piping on the T102 circulation loop, cleaning the Pall packing rings in the T101 Hydrogen Scrubber, and repairing the lubricator on the C102 Hydrogen Recycle Compressor.

An analysis of plant component problems is contained in Tables 35-37. Supplemental information is presented below.

A. AGITATORS

All agitators and mixers operated without major maintenance.

B. COMPRESSORS

C102 Hydrogen Recycle Compressor packing and piston lubricator failed on 17 March because of a broken spring in a drive ratchet and required a 12-hr outage to repair. In addition, on 31 March, a cooling water filter plugged causing C102 compressor packing to overheat.

Other plant compressors operated satisfactorily.

C. DRYERS

The D201A Kahn Instrument Air Dryer failed on two occasions to produce a -40°F dew point. In the first occurrence, an adjustment to the purge system was required. In the second, a microswitch failed and one segment of the dryer failed to regenerate.

D. EXCHANGERS

There were no major problems with heat exchangers.

E. FIRED HEATERS

B102 Slurry Preheater was decoked on 7 February. Coal feed was stopped three times due to problems with the preheater. Two outages were caused by wet atomizing steam. To eliminate this problem, the heater was modified to use air for fuel atomization. The third outage resulted from a clinker in the heater burner.

B103 Vacuum Column Preheater malfunctioned at the beginning of the quarter due to a faulty spring in a fuel control regulator. On 7 February, B103 was decoked and the regulator was repaired.

B203 Dowtherm Heater was operated manually until the fuel controller was repaired on 15 February. On 21 March, a low flow caused the heater to shut down. While relighting the unit, the ignition wire failed and was replaced. The fuel nozzle plugged on 31 March and was cleaned during the outage. Parts are on order to convert this heater to propane gas fuel.

Other plant heaters operated for the period without problems.

F. MINERAL RESIDUE SEPARATION

The United States Filter Corporation (USF) filter was shut down three times during the test program. On 12 January, the XV654 recycle control valve began leaking, allowing precoat to flow into the filter feed tank. This valve was replaced with a rebuilt unit. Two pinholes were found in one screen on 24 January and a cutoff blade had broken. (The broken blade did not damage the screen.) A new screen was installed. On 2 February, a blown spacer gasket was replaced. On 23 February, the filter was inspected and the screens were found to be in excellent condition.

At the end of the test program, the filter was cleaned and the spare parts were stored inside the unit. The door was closed with all nozzles blinded.

The Kerr-McGee Critical Solvent Deashing (CSD) unit was restarted in late February using remelted SRC. Most of the maintenance effort was on equipment checkout and startup problems.

The CSD unit ran very well in March with the major problem being the P180 Feed Pumps.

G. PUMPS

There were very few pump failures during the quarter. The Filter Feed Pump P111B (Lawrence Pump) had two seal failures, a deteriorated Kalrez O-ring, and a bad bearing. The pump was shut down in February after a total of 2,426 operating hours had been logged. P180A and B CSD Feed Pumps failed on 9 March. Repair parts were fabricated in the shop and the pumps were returned to service on 14 March. An automatic grease feeder was added to the pump packing. The new parts and the injection of approximately one-half pint of grease per day in the packing gland have eliminated a major portion of the P180 problems.

H. REACTION SECTION

The nuclear density meters were removed from the R101 Dissolver and sent to the manufacturer for the repair of faulty electronic circuits. When the repaired units were reinstalled, they did not function. They were again returned to the manufacturer.

The dissolver was inspected on 7 February during a plant shutdown and on 17 February because of a leak on the bottom head flange gasket. During a shutdown on 27 March, the bottom head on R101 Dissolver was removed for an inspection and the flange gasket was replaced.

I. COLUMNS

T102 Vacuum Column was shut down for inspection on 7 February. The gasket under tray 8 was leaking solvent into the bottom of the column. Tray 8 was replaced with a new 321 SS tray and the tray was welded to the tray support ring, thereby eliminating the gasket.

A jacketed section of liquid coal piping on the T102 circulation loop failed. The inner pipe, worn thin, collapsed from the Dowtherm pressure in the outer pipe. This piping was replaced and samples of the failed pipe were sent to Oak Ridge National Laboratory for analysis.

Both T101 Hydrogen Scrubber and V106 Recycle Hydrogen Water Scrubber were cleaned on 27 March. Material had built up on the Pall packing rings of both units.

T105 Fractionation Column operated for the quarter with no major mechanical problems.

J. VALVES

The XV4078 Solids Withdrawal Valve operated during the quarter without problems. High pressure letdown valves LV415 A and B also operated without problems. The TV329 Temperature Valve on B102 Slurry Preheater fuel oil malfunctioned. The valve was removed and cleaned. The FV997 on T102 Vacuum Column recirculation loop was replaced because of a worn valve body. The FV904 (T102 feed valve) plugged on 3 March. The valve was cleaned and the worn trim was replaced.

VI. PROJECTS

A. ACTIVE

1. Project 4143 - Hydrotreater Installation

This project provides for the installation of a hydrogenation unit at the Wilsonville pilot plant. It will permit operation in various short residence time modes while maintaining process solvent quality at low hydrogen consumption. It will also yield experimental data on production of liquid fuels from SRC-I using conventional hydro-processing catalysts. Target completion date is 24 November 1980.

2. Project 4146 - Laboratory, Warehouse and Locker Room

This project provides for the following:

- A controlled-atmosphere laboratory to house electronic equipment
- Increased warehouse and maintenance shop area
- Increased and improved locker room facilities

Construction of this facility began on 25 February. Target completion date is 15 May 1980.

3. Project 4151 - Replacement of T105 Fractionation Column

This project provides for the replacement of T105 Fractionation Column with one of identical size and physical configuration, but fabricated from carbon steel clad with type 316L stainless steel. The purchase of the column is the only part of this project currently authorized. The scheduled delivery date for the column is 15 September 1980.

B. COMPLETED

1. Project 4144 - Critical Solvent Deashing Modifications

This project was completed in February.

2. Project 4150 - Rocketdyne Pump Test Loop

This project provided for the replacement of components in the Rocketdyne pump test loop to return the loop to operation. This loop is used to test wear on material specimens that are mounted in the pump volute on a test ring. This project was completed in March.

C. <u>CANCELLED</u>

1. <u>Project 4142 - New V204 Flush Solvent Tank</u>

This project to provide a new V204 Flush Solvent Tank rated at 600°F and 200 psig has been included in Project 4143 for hydrotreater installation.

VII. CONCLUSIONS

The results of operations during the first quarter of 1980 suggest the following:

- A major effect of LSRC recycle was to produce a higher yield of process solvent at the expense of SRC.
- No significant effect on product yields resulted when sodium carbonate, a corrosion inhibitor, was added to the coal slurry.
- Process solvent produced from Dotiki coal had a higher quality than that produced from Lafayette coal.
- Increasing the dissolver temperature resulted in lower sulfur in the SRC product, higher hydrogen consumption, slightly increased solvent production, and lower solvent quality. There was very little effect on CSD recovery.
- Dotiki and Lafayette coals produce similar rates of corrosion.
- The ash content in filtered SRC when processing Lafayette coal with sodium carbonate addition did not meet the 0.16 wt % specification. Specification SRC was obtained without Na_2CO_3 addition.
- Titanium compounds comprised about 30 to 50 wt % of the filtered SRC ash.
- Adding sodium carbonate to the slurry feed produced larger than normal amounts of Na_2CO_3 and SO_3 in the filtered SRC ash.
- Cake resistances were higher for filter feed derived from Lafayette coal than for that derived from Indiana V coal.
- Solution-annealing of the USF filter screens seemed to prevent the screen failures encountered in the fourth quarter 1979 operations.

VIII. FUTURE PLANS

The Wilsonville pilot unit operating schedule for the second quarter of 1980 is as follows:

Date	Objectives and Conditions
1-15 April	Operation in the high-temperature flash mode, with the dissolver product cooler and vacuum preheater bypassed. SRC operating conditions will be 38 $lb/hr-ft^3$ coal space rate, 10,000 scfh feed gas at 85% hydrogen purity, 840°F dissolver outlet temperature and a dissolver hydrogen partial pressure of 1,170 psia.
16-30 April	Demonstration plant conditions verification run. Conditions will be the same as above except the dissolver hydrogen partial pressure will be changed to 1,270 psia.
1-15 May	Down for hydrotreater tie-in installation.
16-31 May	Mixed deashing solvent run in the CSD unit. The dissolver conditions will be the same as in early April.
1-15 June	Minimum dissolver severity run with Light SRC recycle. Conditions will be selected to simulate conditions that will be used during hydrotreater operation. These conditions will also be selected to maintain solvent balance.
16 June-15 July	Extended demonstration plant design conditions verification run. The coal and conditions for this run will be selected to match those for the demonstration plant design as closely as possible.

The skid-mounted Industrial Filter candle filter will be tested off-line with feed stored in the V111 Reclaim Tank. Filtrate will be stored in the V120 Vacuum Preheater Surge Drum and fed to the T102 Vacuum Column at convenient times so as not to upset CSD operations. The test schedule will be as follows:

Date	Objectives and Conditions
1-4 April	Fill V111 with fresh filter feed. Anticipated dissolver conditions are 825°F and 1,700 psig, 38 lb/hr-ft^3 space rate, and 1,100 psia hydrogen partial pressure.
7-11 April	Demonstrate with inert body feed at 0.5 lb of body feed per lb of solids in filter feed.
14-18 April	Demonstrate with carbonaceous body feed at 0.5 lb of body feed per lb of solids in filter feed.
21-25 April	Same as above, but change body feed addition rate to 0.2 lb of body feed per lb of solids in filter feed.
28 April-2 May	Demonstrate unit with no body feed.

In May and June, further testing of the candle filter is probable. The purpose of this testing will be to optimize washing and drying conditions, the quantity of body feed required, cake thickness, and other pertinent filtration variables.

REFERENCE

1. Annual Technical Progress Report (FE-2270-70) for the period January to December 1979, Southern Company Services, Inc., Project No. 43080/43480 (prepared by Catalytic, Inc.).

APPENDIX: Operating Log

January, 1980

1. Run 195 was started at 2015 hr on Lafayette (Ky 9) coal. The purpose of the run was to provide feed to the United States Filter Corporation (USF) vertical-leaf filter.

2. Coal feed was stopped between 0820 and 1837 hr because of a power failure. Run 196 began.

3. The filter system was cooled because of high solids in the filtrate.

4. Coal feed was stopped at 0130 hr. Inspection of the USF filter showed three small holes in areas of spot welds.

5. The USF filter was returned to service. Coal feed was started at 0635 hr, beginning Run 197.

6. The filter system was cooled for inspection of the USF filter. Coal feed was stopped at 1900 hr.

7. Inspection of the filter showed the screens to be in good condition. The filter was returned to service. An experimental trim was installed in LV415B. The trim failed when put into service.

8. Coal feed was started. Sodium carbonate was not added to the coal slurry. Specification SRC was produced.

9. Valve XV654 in the filter system began leaking, allowing wash solvent to leak into the filter feed tank. The wash solvent pump was shut off when not needed to minimize leaking.

10. The valve positioner on XV654 was adjusted, but the valve continued to leak. Specification SRC was produced.

11. Coal feed was stopped at 2400 hr. The filter system was cooled for replacement of XV654 Discharge Valve.

12. XV654 was replaced. Coal feed was started at 1910 hr.

13. In general, the plant ran well. Initial testing of the Critical Solvent Deashing (CSD) unit instrumentation was begun.

14. The corrosimeter indicated an increase in corrosion. Sodium carbonate addition was resumed at 40 lb/batch of coal slurry. The level in the Dowtherm surge tank was lost. The K125 loop was checked for leaks.

15. Specification SRC was produced. When the K125 loop was restored to service, the concentration of Dowtherm in the process solvent increased, so the K125 Dowtherm system was isolated.

16. The steam vacuum jets in the filter system were removed, cleaned, and inspected. In general, the plant ran well.

17. Electrical power was off for approximately one hour. Coal feed was stopped at 2000 hr.

18. Both LV415A and B were plugged. Solvent circulation was begun at 1205 hr. Coal feed was started at 1800 hr. Pressure testing of completed sections of the CSD unit was begun.

19. The plant ran well. Opening the Dowtherm system to K125 once per shift was initiated to prevent LV945 1 and 2 from plugging.

20. The plant ran well except for problems with LV945 1 and 2.

21. The USF filter was put on hold while repairs were made to P147. It was then returned to service.

22. A 24-hr material balance was completed.

23. Another 24-hr material balance was started. It was terminated because the coal slurry was accidentally diluted. When Dowtherm was put on the K125 loop, the V206 level dropped and the amount of Dowtherm in the process solvent increased to 17.6%. Coal feed was stopped at 1340 hr.

24. V120 was cleaned and 2,475 lb of solids was removed. The USF filter was inspected. The Dowtherm system was drained and V206 was cleaned.

25. Two sections of the K125 loop were found to be leaking Dowtherm into the process. Both sections of the jacketed pipe were isolated from the Dowtherm system.

26. The USF filter was returned to service. While returning the T102 system to service, flow in the loop which circulates the vacuum column bottoms through B103 Preheater stopped.

27. The bottoms circulation was inspected. A section of jacketed pipe had collapsed. The collapsed section of line was replaced with a traced line.

28. Circulation in the T102 bottoms loop was restarted. Coal feed was started at 0850 hr. The T102 Vacuum Column bottom temperature was erratic.

29. T102 Vacuum Column bottom temperature remained low.

30. Reflux to tray 8 was stopped. B103 Vacuum Column Preheater was at maximum firing rate.

31. The Lawrence pump stopped. A bearing failed.

February 1980

1. Run 200 was in progress. The purpose of the run was to provide feed to the United States Filter Corporation (USF) vertical-leaf filter. Coal feed was stopped at 2045 hr. The USF filter leaves would not rotate. The filter was cooled for inspection.

2. A failed gasket between leaves was repaired and the filter system was returned to service.

3. Coal feed was started at 0910 hr.

4. Coal feed was stopped at between 1017 and 1900 hr because of a power outage.

5. Coal feed was stopped at 1515 hr. The reaction section was depressured for repairs to the distillation section.

6. Decoking of B102 Slurry Preheater was started. The dissolver was inspected and cleaned.

7. Decoking of B102 Slurry Preheater was completed and the decoking of B103 Vacuum Column Preheater was started.

8. Decoking of B103 was completed. The E102 Dissolver Product Cooler bypass was installed. Tray 8 in T102 Vacuum Column was repaired.

9-10. The SRC plant was pressure-checked. Dowtherm circulation was started. Process equipment heatup was begun.

11. A B102 Slurry Preheater "clean coil" test was completed. Coal feed was started at 1908 hr, beginning Run 201.

12. The level indication in T102 Vacuum Column was wrong. The line to V177 from tray 8 had become plugged with SRC.

13. A compressibility test was started on the USF filter.

14. B102 Slurry Preheater shut down several times. At 1640 hr, coal feed was stopped because B102 would not relight. Coal feed was restarted at 1934 hr, but was stopped at 2100 hr due to the recurring problems with B102.

15. Problems with B102 continued. The dissolver temperature dropped, causing the bottom flange to leak. The front end was depressured so that the bottom gasket on the dissolver could be replaced.

16. Coal feed was started at 1105 hr after repairs to the dissolver were completed. At 1930 hr, coal feed was stopped because of problems with B102.

17. After repairs to a safety switch on B102, coal feed was started at 0845 hr.

18-19. Run 201 proceeded smoothly.

20. A 24-hr material balance was completed. Testing of the CSD unit on solvent was begun.

21. A second 24-hr material balance was completed.

22. A third 24-hr material balance was completed. Deashed SRC was fed to the CSD unit.

23. Coal feed was stopped at 0545 hr because of problems with B102. Remelted high-ash SRC was fed to the CSD unit. The USF filter operation was discontinued.

24. Coal feed was started at 0925 hr.

25. Feed from the SRC plant was started to the CSD unit.

26. All of the Kentucky 9 coal from the Lafayette mine on hand was fed to the SRC plant by 0130 hr. At the beginning of Run 202, coal feed was then changed to Kentucky 9 from the Dotiki mine. No sodium carbonate was added to monitor the rate of corrosion for the new coal. LSRC from the CSD unit was added to the coal slurry feed to maintain solvent balance. The USF filter was inspected before isolating the unit.

27. Run 202 proceeded smoothly.

28. The temperature in V101A Slurry Blend Tank was increased by approximately 100°F to increase LSRC solubility.

29. The filter system was cleaned with a cleaning solution.

March 1980

1. Run 202 was in progress providing feed to the CSD unit.

2. Coal feed was stopped at 0655 hr because of vacuum problems in T102 Vacuum Column.

3. Coal feed was started at 1730 hr.

4. T105 Fractionation Column was put on "standby" due to pump problems.

5. T105 Fractionation Column was returned to service. T101 Hydrogen Scrubber (packed section) plugged. After back-flushing, the scrubber was returned to service.

6. A 24-hr material balance was completed.

7. The corrosion indicator probes indicated an increase in corrosion, so sodium carbonate addition was resumed. Run 203 began.

8. Run 203 proceeded smoothly.

9. A 24-hr material balance was started, but was terminated because of level problems in T101 Hydrogen Scrubber and V106 Recycle Hydrogen Water Scrubber. A second material balance was attempted, but it was terminated because of CSD problems.

10. Problems with B201 Steam Generator caused an upset in T102 Vacuum Column.

11-12. Run 203 was in progress.

13. A 24-hr material balance was started.

14. The material balance was completed. The caustic booster pump to the hydrogen scrubber failed. Later, a second material balance was started.

15. The 24-hr material balance was completed. A third 24-hr material balance was started.

16. The 24-hr material balance was completed. The temperature of the dissolver outlet was increased to 840°F.

17. Coal feed was stopped at 1002 hr. The lubricator on C102 Hydrogen Recycle Compressor was repaired. Coal feed was started at 1709 hr.

18. FT-1199 Vent Gas Flow Recorder was recalibrated to record increased flow.

19. V147, A107 and P147 were prepared for transfer to the hydrotreater area.

20. A voltage drop caused B102 Slurry Preheater and B204 Dowtherm Heater to stop. Both heaters were returned to service without problems.

21. A Dowtherm leak developed on T102 Vacuum Column feed line. Isolation valves failed so the complete Dowtherm system was shut down to repair the leak.

22-23. Gas loss from the C102 packing section increased.

24. To increase the hydrogen partial pressure in the dissolver, the dissolver pressure was increased to 1,800 psig.

25. A 24-hr material balance was completed.

26. A 24-hr material balance was terminated because of problems at the CSD unit.

27. Coal feed was stopped at 001 hr. The dissolver, hydrogen scrubber, and the recycle hydrogen water scrubber were inspected and cleaned. The recycle vent gas system was repaired.

28. Upon completion of repairs to the recycle vent system, coal feed was started at 1942 hr.

29. B203 Dowtherm Heater developed a plugged fuel nozzle. When the nozzle was cleaned, the fuel oil filter was replaced.

30. C102 Hydrogen Recycle Compressor packing had an increased gas flow.

31. A 24-hr material balance was completed.

Table 1
SRC Pilot Plant Operating Hours and Filter Cycles

Run	w/solv & H_2 hr(a)	5-20%(b)	25%(b)	27-35%(b)	38.5%(b)	40%(b)	Filtration section cycles	Vacuum Flash section, hr	KM-CSD section, hr
195	18				12		8(e)	16	-
196	38				31		9	42	-
197	54				46		24	50	-
198	122				119		46	119	-
199	212				197		82	217	-
200	196				153		67	183	-
201	309				261		89	305	11
202	218				215		0	218	180
203	223				223		0	223	170
204(d)	328				313		0	320	255
CSD 40	-				-		-	-	5
Report period	1,719	0	0	0	1,571	0	325	1,692	621
Prior 1980	0	0	0	0	0	0	0	0	0
Total 1980	1,719	0	0	0	1,571	0	325	1,692	621
Total 1979	6,837	26	37	71	6,188	0	605	6,530	2,882
Total 1978	7,207	0	0	0	6,697	0	1,102	7,002	1,495
Total 1974-1977	21,446	1,389	6,732	3,222	6,672	300	7,995	22,001	0
Overall total to date	37,209	1,415	6,769	3,293	21,128	300	10,027	37,225	4,998

(a) On-stream hours with solvent and hydrogen through B102 Slurry Preheater and R101 Dissolver.
(b) Coal slurry concentration, MF basis.
(c) On-stream hours with coal slurry and hydrogen through B102 Slurry Preheater and R101 Dissolver.
(d) March portion of run.
(e) Includes three carryover cycles from Run 194.

Table 2
Operating Data Summary for January 1980
Kentucky 9 Coal

Date Jan 1980	Coal Feed, MF lb/hr	Coal Feed, hr	Slurry conc, MF coal, %	Feed Gas H_2 %	Feed Gas to B102, scfh	Feed Gas total scfh	Proc solv[(a)], % conv	B102 Preheater inlet press, psig	B102 Preheater ΔP btm, psi	B102 Preheater ΔP mid, psi	B102 Preheater ΔP top, psi	B102 Preheater outlet temp, °F	R101 Dissolver Temperature btm, °F	R101 Dissolver Temperature outlet, °F	R101 Dissolver Density (b) btm, %	R101 Dissolver Density (b) mid, %	R101 Dissolver Density (b) top, %
								- Run 195 (Lafayette) Coal -									
1	449	2.8	37.7														
2	478	9.5	37.5	84	10,920	10,920		1,735	-	-	13	798	820	825	Instruments not operating		
								- Run 196 (Lafayette) Coal -									
2	474	4.4	38.0	82	10,100	10,100		1,710	10	20	7	786	820	826			
3	454	24	36.1	85	11,270	11,270		1,763	16	20	11	806	819	824			
4	447	2.5	35.5	85	11,400	11,400		1,760	25	26	2	808	819	824			
								- Run 197 (Lafayette) Coal -									
5	488	16.4	37.9	84	10,810	10,810		1,766	26	10	7	805	819	825			
6	483	20	38.0	84	11,210	11,210	69.5	1,770	22	24	8	810	819	824			
7		0															
8	509	9.5	38.3	84	10,290	10,290	67.8	1,757	30	12	10	806	819	824			
								- Run 198 (Lafayette) Coal -									
8	493	6.8	37.6	84	11,390	11,390	67.8	1,760	30	15	5	806	819	824			
9	502	24	38.0	85	11,280	11,280	70.6	1,770	30	12	8	813	819	823			
10	499	24	37.8	85	11,220	11,220	64.6	1,770	15	15	11	812	819	824			
11	509	24	37.5	84	10,790	10,790	68.9	1,760	13	19	11	808	821	824			
12	517	4.8	38.0	86	10,620	10,620		1,775	14	24	6	819	817	822			
13	534	24	38.1	85	10,200	10,200		1,760	15	20	11	810	818	823			
14	520	11.3	37.6	84	10,130	10,130	61.8	1,767	18	18	11	807	818	823			
								- Run 199 (Lafayette) Coal -									
14	520	12.7	37.6	84	10,130	10,130	61.8	1,765	17	13	17	807	818	823			
15	521	24	37.6	85	10,150	10,150	65.0	1,770	14	19	15	804	819	825			
16	533	24	37.7	85	10,240	10,240	62.2	1,760	18	19	15	804	818	824			
17	478	21	37.5	84	10,110	10,110	71.0	1,760	16	19	13	804	819	825			
18		5															
19	500	24	37.0	85	10,170	10,170		1,732	17	21	13	803	818	824			
20	492	24	37.2	85	10,180	10,180		1,732	18	19	15	810	818	823			
21	491	24	38.1	85	10,240	10,240	69.1	1,740	18	16	12	807	819	824			

(Table continued)

Table 2 (continued)
Operating Data Summary for January 1980
Kentucky 9 Coal

Date Jan 1980	Coal Feed, MF lb/hr	Coal Feed, hr	Slurry conc, MF coal, %	Feed Gas H_2 %	Feed Gas to B102, scfh	Feed Gas total scfh	Proc solv[a], % conv	B102 Preheater inlet press, psig	B102 Preheater ΔP btm, psi	B102 Preheater ΔP mid, psi	B102 Preheater ΔP top, psi	B102 Preheater outlet temp, °F	R101 Dissolver Temperature btm, °F	R101 Dissolver Temperature outlet, °F	R101 Dissolver Density[b] btm, %	R101 Dissolver Density[b] mid, %	R101 Dissolver Density[b] top, %
22	502	24	37.3	85	10,130	10,130		1,740	19	16	13	806	818	823	Instrument not operating		
23	529	14.7	37.1	85	10,160	10,160		1,740	12	17	15	805	820	825			
- Run 200 (Lafayette) Coal -																	
28	396	14.2	31.6	84	10,100	10,100	70.2	1,734	12	10	10	802	815	820			
29	518	24	37.6	84	10,100	10,100	63.0	1,760	17	13	18	803	816	822			
30	501	24	38.1	85	10,290	10,290	68.2	1,760	15	13	22	807	818	823			
31	473	24	38.5	84	10,270	10,270	66.4	1,760	16	19	12	810	815	820			

(Table continued)

Table 2 - (continued)
Operating Data Summary for January 1980
Kentucky 9 Coal

Date Jan 1980	Performance: Coal conv, % MAF	SRC yield(c), % MAF coal	SRC yield(d), % MAF coal	SRC sulfur(e), %	H_2 consumed, % MAF	T102 Vacuum Column Temperature btm, °F	T102 Vacuum Column Temperature top, °F	T102 Press top, psia	T104(f) lt org +350°F, wt%	T105 Frac Column(f) btm -450°F, wt %	T105 wash solvent -350°F wt %	T105 wash solvent +450°F, wt %
					- Run 195 (Lafayette) Coal -							
1												
2	92.3				2.7	606	189	0.5	1.7	5.7	3.6	8.2
					- Run 196 (Lafayette) Coal -							
2					2.6	600	190	0.4	1.7	5.7	3.6	8.2
3	94.2				2.2	592	188	0.6	4.7	0.3	3.3	11.2
4					2.3	596	197	0.6				
					- Run 197 (Lafayette) Coal -							
5					1.9	602	197	0.7	0.6	2.1	10.4	9.2
6	93.4		62.6		2.1	596	191	0.7	3.4	2.4	12.7	6.4
7												
8					1.7	586	197	0.5	4.7	0.4	1.9	5.3
					- Run 198 (Lafayette) Coal -							
8					1.8	585	199	0.4	4.7	0.4	1.9	5.3
9	93.5		52.3	0.92	1.7	589	195	0.4		2.8	3.6	4.6
10	95.4	[60.4]		1.10	1.8	591	185	0.4	6.3	1.0	5.3	4.3
11	94.1			0.76	1.8	592	180	0.4	0	8.0	5.1	4.7
12					1.5	580	180	0.4		3.3	3.0	2.2
13	91.3				1.6	584	179	0.4	0.4	0.4	5.9	1.8
14	91.5		78.0	0.89	1.8	568	180	0.3	0	2.7	5.5	6.0
					- Run 199 (Lafayette) Coal -							
14	91.5		78.0		1.8	591	180	0.3	0	2.7	5.5	6.0
15	92.3	[52.8]	75.7	0.90	1.9	595	180	0.4	0.7	3.4	4.4	2.7
16	92.6		74.1		1.9	593	180	0.4	0	3.4	2.9	2.7
17	91.8		77.8	0.86	2.1	595	177	0.4	0.2	4.0	3.1	5.9
18												
19	93.0		78.9	0.97	1.6	599	180	0.8	5.3	5.1	3.7	7.6
20	92.5		70.4	1.03	1.4	597	181	1.0	2.9	4.2	4.5	5.6
21	92.4	[56.7]	68.6	0.91	1.5	594	180	1.0	0	4.4	4.9	5.3
22	92.3		64.5		1.5	594	180	1.1	0.3	2.9	4.5	6.5
23	92.7		70.2		1.4	594	179	1.3	-	3.4	4.4	7.0

(Table continued)

Table 2 - (continued)
Operating Data Summary for January 1980
Kentucky 9 Coal

Date Jan 1980	Performance: Coal conv, % MAF	Performance: SRC yield(c), % MAF coal	Performance: SRC yield(d), % MAF coal	Performance: SRC sulfur(e), %	H_2 consumed, % MAF	T102 Vacuum Column: Temperature btm, °F	T102 Vacuum Column: Temperature top, °F	T102 Vacuum Column: Press top, psia	T104(f) lt org +350°F, wt%	T105 Frac Column(f): btm -450°F, wt %	T105 Frac Column(f): wash solvent -350°F wt %	T105 Frac Column(f): wash solvent +450°F, wt %
- Run 200 (Lafayette) Coal -												
28					3.0	524	180	0.9				
29	92.1		71.4	0.93	2.5	588	180	0.5	0.1	1.0	6.2	12.2
30	91.6	[71.4]	65.6	1.00	2.4	597	174	0.5	1.1	1.5	5.1	9.7
31	91.8		66.0	0.94	2.3	589	183	0.7	0.3	2.8	5.2	8.6

(a) From V131B, microautoclave conversion, short method.
(b) Density gauges not operating properly.
(c) Cresol-soluble, solvent-free T102 btms.
(d) V110 lab analysis and forced ash balance method, adjusted for LSRC added to coal feed slurry.
(e) From laboratory workup of V110 Flash Tank sample, distilled at 600°F, 0.1 mm Hg.
(f) By gas chromatography.

Table 3
Operating Data Summary for February 1980
Kentucky 9 Coal

Date Feb 1980	Coal Feed MF lb/hr	Coal Feed hr	Slurry conc, MF coal, %	Feed Gas H_2 %	Feed Gas to B102, scfh	Feed Gas total scfh	Process solv[a], % conv	B102 Preheater inlet press, psig	B102 Preheater ΔP btm, psi	B102 Preheater ΔP mid, psi	B102 Preheater ΔP top, psi	B102 Preheater outlet temp, °F	R101 Dissolver Temperature btm, °F	R101 Dissolver Temperature outlet, °F	R101 Dissolver Density[b] btm, %	R101 Dissolver Density[b] mid, %	R101 Dissolver Density[b] top, %
							Run 200 (Lafayette) Coal - continued										
1	502	21.8	38.4	84	10,290	10,290	67.3	1,771	16	15	7	813	818	823	Instruments not operating		
2		0.0															
3	531	13.8	38.2	84	10,010	10,010		1,760	21	-	-	800	820	826			
4	526	15.3	38.6	85	10,420	10,420	63.1	1,760	14	13	-	806	823	828			
5	532	16.3	38.5	84	10,260	10,260	67.7	1,751	13	10	14	804	820	825			
							Run 201 (Lafayette) Coal										
11		4.0						1,725	11	17	18	816	808	811			
12	509	24.0	38.0	84	10,240	10,240		1,732	14	20	14	807	822	825			
13	538	24.0	37.7	85	10,440	10,440	66.0	1,760	18	18	9	806	817	824			
14	536	19.2	37.3	85	10,400	10,400	64.0	1,754	17	22	4	804	817	824			
15		0.0															
16	507	8.4	37.4	84	10,060	10,060	65.6	1,789	-	18	2	806	-	817			
17	511	14.3	37.5	87	11,050	11,050		1,757	23	20	6	803	813	817			
18	492	24.0	36.7	85	10,470	10,470	68.6	1,741	23	21	3	800	818	824			
19	498	24.0	36.8	85	10,360	10,360	68.8	1,737	26	19	5	794	817	823			
20	529	24.0	37.5	85	10,260	10,260	68.4	1,731	23	14	8	797	819	825			
21	519	24.0	36.9	85	10,430	10,430	71.9	1,730	26	19	3	799	818	824			
22	517	24.0	36.7	85	10,310	10,310	65.7	1,718	22	21	4	794	819	826			
23	497	6.8	36.7	84				1,714	24	17	4	794	815	821			
24	500	13.4	36.7					1,710	25	17	5	791	815	821			
25	470	24.0	37.8	85	10,270	10,270	69.7	1,721	24	15	6	798	816	822			
26	462	2.5	35.4	85	10,470	10,470	70.2	1,720	-	18	4	802	819	824			
							Run 202 (Dotiki) Coal										
26	516	21.5	37.2	84	10,470	10,470	70.2	1,740	25	14	8	797	819	825			
27	510	24.0	36.3	84	10,400	10,400	64.3	1,740	22	13	9	794	818	824			
28	494	24.0	36.3	84	10,050	10,050	63.3	1,738	23	13	10	792	817	824			
29	496	24.0	35.1	84	9,530	9,530		1,735	23	12	10	794	819	825			

(Table continued)

Table 3 (continued)
Operating Data Summary for February 1980
Kentucky 9 Coal

Date	Performance				H_2	T102 Vacuum Column			T104[f]	T105 Frac Column[f]		
	Coal	SRC			con-	Temperature		Press,	lt org	btm	wash solvent	
Feb 1980	conv, % MAF	yield[c], % MAF coal	yield[d], % MAF coal	sulfur[e], %	sumed, % MAF	btm, °F	top, °F	top, psia	+350°F, wt %	-450°F, wt %	-350°F, wt %	+450°F, wt %
					Run 200 (Lafayette) Coal - continued							
1	90.5	57.4	66.2	0.96	2.0	603	185	0.7	3.0	0.2	4.2	10.1
2												
3	91.1		75.9	0.88	2.1	603	196	0.7	0.0	0.4	4.7	8.3
4	91.5	[55.3]	83.3	0.92	2.2	585	198	0.6	2.6	1.4	4.5	7.0
5	91.7		89.2	0.88	2.4	605	194	0.7	-	0.8	4.0	11.1
					Run 201 (Lafayette) Coal							
11												
12	91.1		79.6	0.81	2.6	589	195	0.5	8.3	0.1	2.6	10.8
13	92.4	54.9	70.0	0.89	2.2	586	194	0.9	0.0	0.2	2.3	14.0
14	92.9		60.0	0.84	2.3	608	195	1.1	0.0	5.0	4.0	6.8
15									-	4.2	5.2	9.9
16					2.3	604	193	1.1	-	-	-	-
17	92.3		65.0	1.00	2.1	573	196	2.0	0.6	1.4	2.9	14.2
18	92.2		70.8	0.90	2.6	585	196	1.1	6.3	2.8	4.8	2.8
19	92.9	64.6			2.6	584	195	1.1	0.0	1.8	4.7	5.2
20	92.9		66.1		2.5	579	195	1.0	-	2.0	6.3	5.5
21	92.6	[67.4]	71.4	[0.97]	2.3	574	195	1.0	0.0	2.5	4.2	14.7
22	92.7		66.2		2.6	575	196	1.0	0.0	2.1	4.8	10.1
23						576	195	1.0	0.0	2.5	4.3	7.2
24									3.3	5.3	4.0	3.5
25	92.4				2.6	559	196	0.8	0.0	1.5	4.1	6.0
26					2.5	558	196	0.9	-	-	-	-
					Run 202 (Dotiki) Coal							
26	92.7		66.2	0.92	2.5	560	195	0.9	-	-	-	-
27	92.8	50.6	73.6	1.21	2.1	557	195	0.8	0.0	0.9	14.5	4.3
28	92.8	[62.2]	65.9	0.88	2.7	556	195	0.8	0.0	0.5	6.8	2.9
29	92.6		68.3	0.85	2.7	556	195	0.8	0.0	2.6	9.2	7.1

(Table continued)

Table 3 (continued)
Operating Data Summary for February 1980
Critical Solvent Deashing Unit (Three-stage)

				Feed from T102 btms					Ash conc (DAS free basis)					SRC					
Date Feb 1980	Feed Rate, T102 btms, lb/hr	Feed Time, hr	(g) Run No.	Ash, %	UC, %	Solv, %	Sulfur, %	Softening-Fusion Points, °F	Ash, %	UC, %	(h) SRC, %	(h) Solv, %	DAS, %	Ash, %	Sulfur, %	(h) Solv, %	DAS, %	Softening-Fusion Points, °F	Recovery(i) (j) (k)
1-22	off due to insulation, instrumentation check, system check and pump calibrations																		
23	200	5.3	40-2	10.2	10.8	-	-	-	19.8	31.6			0.2						
24	off; pump problems - plugging																		
25	204.4	10.8	201-2	11.9	10.5				23.7	28.8	43.3	4.7	3.93						62.5/59.0
26	289.6	24.0	202-2	11.2	10.5	6.4	1.47	248/305	25.8	38.2	29.4	6.6	2.28	0.09	0.98	8.3	0.28	257/284	72.3/70.3
27	305.1	15.0	202-2	10.9	9.2	10.7	2.10	325/370	29.2	34.9	37.6	3.3	2.27	0.05	0.92	8.1	0.14	311/329	78.3/72.0
28	251.9	18.1	202-2	11.1	9.4	10.3	1.80	320/357	28.4	38.3	29.0	4.3	0.21	0.04	0.84	9.1	0.22	293/311	76.7/75.0
29	251.2	24.0	202-2	10.9	9.0	7.9	1.53	288/324	28.4	37.2	31.2	3.2	2.90	0.04	0.94	11.3	0.27	254/300	76.9/70.9

(a) From V131B, microautoclave conversion, short method.
(b) Density gauges not operating properly.
(c) Cresol-soluble, solvent-free T102 btms.
(d) V110 lab analysis and forced ash balance method, adjusted for LSRC added to coal feed slurry.
(e) From laboratory workup of V110 Flash Tank sample, distilled at 600°F, 0.1 mm Hg.
(f) By gas chromatography.
(g) Run No.-1 (mode 1 operation, by the use of high pressure recycle solvent system).
(h) 600°F, 0.1 mm Hg.
(i) Percent of cresol soluble feed from T102 btms.
(j) By forced ash balance.
(k) By normalized material balance.

Table 4
Operating Data Summary for March 1980
Kentucky 9 Coal

Date March 1980	Coal Feed MF lb/hr	Coal Feed hr	Slurry conc MF coal, %	LSRC added, lb/hr	Feed Gas H_2 %	Feed Gas to B102, scfh	Feed Gas total scfh	Process solv[a], % conv	B102 Preheater inlet press, psig	B102 Preheater ΔP btm, psi	B102 Preheater ΔP mid, psi	B102 Preheater ΔP top, psi	B102 Preheater outlet temp, °F	R101 Dissolver Temperature btm, °F	R101 Dissolver Temperature outlet, °F	R101 Dissolver Density[b] btm, %	R101 Dissolver Density[b] mid, %	R101 Dissolver Density[b] top, %
Run 202 (Dotiki) Coal - continued																		
1	524	24	37.2	26.1	85	10,360	10,360		1,735	23	9	10	794	819	826	No Data Recorded		
2	519	7.9	37.0	26.0				65.5	1.740			12	799	819	825			
3	510	5.5	37.3	25.2				65.4	1,740			12						
4	528	24	37.0	25.6	85	10,370	10,370	68.0	1,745			10	794	820	826			
5	473	24	34.1	22.7	84	10,110	10,110	63.1	1,727	20	11	9	799	821	826			
6	525	24	37.9	25.5	85	10,300	10,300	64.2	1,740	20	12	7	794	819	826			
7	537	12	37.8	26.6	85	10,310	10,310		1,743	24	15	15	794	820	826			
Run 203 (Dotiki) Coal																		
7	507	12	36.6	25.9	85	10,310	10,310		1,740		13		793	820	826			
8	533	24	37.1	26.3	86	10,370	10,370		1,740	26	14		794	819	825			
9	530	24	37.5	25.3	84	9,940	9,940	70.0	1,733	26	14	19	794	820	826			
10	518	24	38.1	25.8	85	10,290	10,290	73.3	1,730	26	15	14	787	819	826			
11	447	24	32.3	17.5	85	10,350	10,350	71.8	1,729	17	15	20	795	820	827			
12	496	24	37.1	24.3	85	10,460	10,460	69.9	1,736	18	13	14	793	820	826			
13	507	24	37.1	26.2	84	10,330	10,330		1,740	24	12	11	789	819	826			
14	503	24	37.0	27.8	85	10,400	10,400	72.4	1,740	22	15	11	786	818	824			
15	492	24	36.3	26.6	85	10,460	10,460		1,743	22	17	10	789	818	825			
16	501	19	36.3	26.1	84	10,090	10,090		1,740	24	13	8	792	822	828			
Run 204 (Dotiki) Coal																		
16	501	5	36.3	26.1	84	10,090	10,090		1,735	25	15	7	792	822	828			
17	517	16.9	36.5	26.0	84	10,230	10,230	68.6	1,738	23	16	9	796	832	839			
18	488	24	36.5	24.1	85	10,450	10,450	69.8	1,740	24	18		798	832	839			
19	510	24	36.2	26.1	85	10,380	10,380	69.0	1,743	23	12	19	793	832	837			
20	511	24	36.3	26.1	84	10,190	10,190	67.6	1,746	24	13	9	797	833	841			
21	506	24	36.9	21.7	86	10,510	10,510		1,747	25	18	9	798	828	835			
22	531	24	36.9	24.4	86	10,570	10,570		1,752	27	12	10	795	832	840			
23	514	24	36.6	25.0	86	10,600	10,600	67.5	1,747	26	15	12	792	833	841			
24	505	24	36.7	25.5	86	10,520	10,520	72.5	1,743	27	16	14	794	833	840			
25	497	24	36.2	24.7	84	10,560	10,560	71.4	1,852	25	20	13	792	832	840			
26	534	24	37.0	26.0	84	10,590	10,590	69.1	1,850	26	19	13	790	832	840			
27		0																
28	473	3.3		22.6														
29	507	24	36.8	25.0	85	10,640	10,640		1,860	24	17	7	822	834	840			
30	536	24	38.0	26.6	85	10,690	10,690	65.7	1,860		19	5	821	834	839			
31	537	24	37.4	26.3	86	10,810	10,810	70.4	1,860	26	20	11	802	834	841			

(Table continued)

Table 4 (continued)
Operating Data Summary for March 1980
Kentucky 9 Coal

Date March 1980	Performance: Coal conv, % MAF	Performance: SRC yield(c), % MAF coal	Performance: SRC yield(d), % MAF coal	Performance: SRC sulfur(e), %	H_2 consumed, % MAF	T102 Vacuum Column: Temperature btm, °F	T102 Vacuum Column: Temperature top, °F	T102 Vacuum Column: Press, top, psia	T104(f) lt org +350°F, wt %	T105 Frac Column(f): btm -450°F, wt %	T105 Frac Column(f): wash solvent -350°F, wt %	T105 Frac Column(f): wash solvent +450°F, wt %
Run 202 (Dotiki) Coal - continued												
1	92.8	52.3	67.2	0.92	2.0	555	196	0.8	0.0	2.2	7.6	7.5
2						552	196	0.8		0.9	9.6	13.4
3	91.7					552	196	0.9				
4	92.4		70.6	1.10	2.1	552	196	0.8	1.3	0.3	11.7	15.1
5		[58.3]			2.2	555	196	0.8		2.0	12.1	17.3
6	92.5		73.4		2.1	557	195	0.8		0.5	14.6	14.2
7	91.4		72.2	0.87	2.0	554	195	0.8	0.5	0.5	14.4	13.8
Run 203 (Dotiki) Coal												
7	91.4		72.2	0.87	2.1	549	195	0.8				
8	92.2		67.1	0.99	2.1	553	196	0.8	0.2	0.3	14.2	16.6
9	91.8	[52.9]	66.0	0.95	2.0	561	195	0.9		0.7	15.8	10.8
10	93.1	[46.2]	67.6	0.93	2.2	557	195	0.9	0.4	0.4	14.3	17.0
11	93.3		63.0	0.80	2.8	559	196	0.9	0.1	0.5	13.3	13.5
12	92.8	[54.7]	66.0	0.95	2.0	555	194	0.9		1.5	16.0	6.0
13	92.7		70.1	0.77	1.9	553	195	0.8	0.1	1.9	15.8	8.6
14					2.1	551	194	0.8		1.7	16.0	9.7
15	92.6	[57.9]	68.6	0.98	2.1	554	194	0.7		1.8	25.1	10.6
16	91.9		55.6	0.90	2.1	553	195	0.8		2.3	14.7	9.2
Run 204 (Dotiki) Coal												
16	91.9		55.6	0.90	2.1	552	194	0.9		2.3	14.7	9.2
17	92.3	53.1	74.4	0.83	2.5	552	195	0.8		1.3	16.4	9.5
18	92.7		67.1	0.81	2.5	553	196	0.8		2.1	17.1	7.8
19	92.4	52.3	61.6	0.81	2.5	552	196	0.6	1.5	2.0	18.2	6.0
20	93.3		65.3	0.72	2.7	553	194	0.6		2.3	20.3	5.3
21	92.4	41.2	63.7	0.71	2.4	556	194	0.6		2.5	19.5	5.3
22	93.5		61.0	0.94	2.5	558	196	0.5	0.0	2.4	33.5	5.6
23	93.1		60.2	0.89	2.5	560	195	0.5	0.0	2.1	29.9	7.1
24	92.7	50.9	59.9	0.76	2.7	561	195	0.4	0.3	1.9	12.4	12.5
25	93.2		58.3	0.71	2.0	560	195	0.4	0.2	2.2	6.1	20.9
26	92.9		60.6	0.81	2.6	560	194	0.4	0.1	1.6	8.9	8.2
27												
28												
29	91.9		64.3	0.73	2.6	560	195	0.4	0.0	1.8	16.2	13.9
30	92.2	[51.1]	68.5	0.68	2.6	555	195	0.5	0.1	1.3	14.6	13.4
31	92.6		65.1	1.05	2.7	553	195	0.6	-	1.3	14.3	13.3

(Table continued)

Table 4 (continued)
Operating Data Summary for March 1980
Critical Solvent Deashing Unit (Three-stage)

Date March 1980	Feed Rate, T102 btms, lb/hr	Feed Time, hr	(g) Run No.	Feed from T102 btms					Ash conc (DAS free basis)					SRC						
				Ash, %	UC, %	Solv, %	Sulfur, %	Softening-Fusion Points, °F	Ash, %	UC, %	(h) SRC, %	(h) Solv, %	DAS, %	Ash, %	Sulfur, %	(h) Solv, %	DAS, %	Softening-Fusion Points, °F	Recovery (i) %(j)	Recovery (i) %(k)
3-1	397.7	23.4	202-2	11.0	8.5	8.8	1.80	307-342	29.8	39.4	26.3	4.5	2.08	0.10	0.95	6.0	0.11	310-334	78.4	78.4
3-2	420.2	5.7	202-2	10.9	9.7	5.8	1.72	280-298	29.4	30.6	33.2	6.8	1.27	0.10	0.96	9.1	0.19	293-307	79.3	82.4
3-3								Down Due To Lack Of Feed												
3-4	396.8	21.3	202-2	10.1	8.35	9.1	1.78	293-311	28.8	43.5	24.1	3.6	0.82	0.04	0.94	9.0	0.26	320-329	79.7	75.7
3-5	351.2	21.1	202-2	10.8	9.2	9.2	1.27	271-325	30.1	40.7	26.3	2.9	0.81	0.12	1.01	5.7	0.03	257-280	80.1	73.9
3-6	326.9	24.0	202-2AMB	10.7	8.6	10.3	1.69	307-327	28.7	33.3	35.8	2.2	1.38	0.04	0.98	6.1	0.16	245-270	77.7	77.7
3-7	385.3	3.1	202-2BMB	10.8	8.8	11.4	1.66	329-347	28.7	30.2	27.1	14.0	7.89	0.07	0.90	6.6	ND	316-350	77.6	72.2
3-8	246.4	12.2	203-2AMB					Samples Not Available												
3-9	357.5	16.5	203-2BMB																	
3-10	359.6	21.0	203-2	11.6	7.9	12.8	1.70	293-307	32.4	34.8	25.7	7.1	0.10	0.10	0.83	5.3	0.02	302-329	79.8	83.1
3-11	377.5	10.3	203-2	11.7	8.0	13.9	1.70	307-334	32.3	31.8	20.5	15.4	0.97	0.10	0.93	6.6	0.08	293-311	79.4	82.8
3-12	332.5	20.7	203-2	11.8	8.1	13.3	1.66	311-329	33.3	32.5	28.1	6.1	1.1	0.15	0.81	5.4	ND	244-266	80.6	82.7
3-13(l)	366.7	12.0	203-2	11.6	8.6	8.4	1.9	289-329	35.3	35.4	24.4	4.9	0.12	0.07	0.95	5.8	0.6	271-318	84.1	82.3
3-13/14	373.2	24.0	203-2CMB					Samples Not Available												
3-14(m)	385.5	5.6	203-2																	
3-14/15	374.1	24.0	203-2DMB	11.8	10.25	7.6	1.45	338-356	32.3	38.7	26.9	2.2	1.11	0.09	1.03	5.1	0.10	293-311	81.6	83.2
3-15/16	385.1	24.0	203-2EMB	11.8	10.25	7.6	1.45	338-356	32.3	38.7	26.9	2.2	1.11	0.09	1.03	5.1	0.10	293-311	81.6	83.2
3-16(n)	345.1	6.0	204-2	11.6	9.35	7.2	1.72	334-363	29.1	34.6	34.2	2.1	2.10	0.05	0.91	5.5	0.10	296-334	76.1	78.9
3-17	376.2	10.1	204-2	12.0	9.6	8.0	1.64	324-342	31.8	35.2	28.1	4.9	0.83	0.01	0.84	2.4	0.17	287-322	79.4	79.5
3-18	344.9	17.2	204-2	12.0	8.85	8.2	1.89	311-343	29.4	41.3	27.1	2.2	0.02	0.18	0.78	6.2	0.22	302-341	74.8	75.8
3-19	367.5	24.0	204-2	12.4	8.7	7.9	1.72	329-347	33.6	35.2	26.3	4.9	0.42	0.12	0.80	5.0	0.01	288-306	80.0	80.9
3-20	340.9	7.3	204-2	12.7	8.6	7.4	1.64	313-349	31.6	32.7	30.2	5.5	0.21	0.07	0.75	11.6	0.14	293-320	76.0	82.0
3-21	273.6	8.7	204-2	12.5	9.3	7.0	1.63	298-334	32.7	43.7	19.6	4.0	0.70	0.11	1.00	4.5	0.13	306-324	79.0	82.1
3-22	365.0	24.0	204-2	12.5	8.80	9.9	1.68	275-302	34.0	34.9	27.2	3.9	0.12	0.13	0.90	6.5	0.05	284-311	80.3	82.5
3-23	390.6	21.7	204-2	12.5	9.10	7.9	1.61	293-322	33.6	36.3	27.0	3.1	0.08	0.12	0.85	5.2	0.24	302-320	80.1	80.1
3-24	375.3	24.0	204-2	12.5	9.60	7.6	1.73	293-324	34.0	37.2	25.4	5.2	3.43	0.17	0.77	4.1	0.07	302-320	81.2	80.2
3-25	379.7	24.0	204-2AMB	12.5	9.30	7.0	1.58	298-324	35.3	40.6	21.1	3.00	0.33	0.07	0.85	8.1	0.22	248-266	82.6	84.4
3-26	380.9	22.8	204-2BMB	12.3	8.90	8.5	1.57	288-302	35.6	38.6	23.0	2.8	0.32	0.05	0.68	7.5	0.19	293-311	83.1	80.7
3-27								Down Due To Lack Of Feed												
3-28																				
3-29	372.8	17.1	204-2	11.9	10.0	6.2	1.60	311-347	28.7	47.6	21.2	2.5	2.43	0.04	0.84	5.3	0.55	329-338	75.0	67.1
3-30	401.6	24.0	204-2	11.8	12.7	8.1	1.24	307-325	28.5	36.0	29.6	5.9	3.68	0.03	0.96	11.9	0.12	289-307	77.6	77.1
3-31	401.0	24.0	204-2CMB	12.4	8.1	7.3	1.76	289-315	33.3	42.7	21.0	3.0	0.62	0.05	0.84	13.3	0.02	311-329	79.0	80.2

(a) From V131B, microautoclave conversion, short method.
(b) Density gauges not operating properly.
(c) Cresol-soluble, solvent-free T102 btms.
(d) V110 lab analysis and forced ash balance method, adjusted for LSRC added to coal feed slurry.
(e) From laboratory workup of V110 Flash Tank sample, distilled at 600°F, 0.1 mm Hg.
(f) By gas chromatography.
(g) Run No.-1 (mode 1 operation, by the use of high pressure recycle solvent system).
(h) 600°F, 0.1 mm Hg.
(i) Percent of cresol soluble feed from T102 btms.
(j) By forced ash balance.
(k) By normalized material balance.
(l) Until MB started (203-2 CMB 12:00 on 3-13-80 until 12:00 on 3-14-80).
(m) Until MB started (203-2 DMB 12:00 on 3-14-80 until 12:00 on 3-15-80).
(n) After MB completed (12:00 on 3-16-80 until 24:00 on 3-16-80).

Table 5
Conditions and Results Summary
Kentucky 9 Coal

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Coal			
Volatile matter, (Dry basis), %	31.0	29.9	33.2
H/C atomic ratio	0.72	0.72	0.77
Microautoclave conversion, %			
short run	-	-	-
long run	78.2	80.2	80.2
Solvent			
IBP, °F	451	449	424
EP, °F	867	838	872
% minus 450°F/% plus 650°F	0.24/27.9	0.64/26.4	1.56/27.6
Specific gravity	1.019	1.013	
H/C atomic ratio	1.14	1.19	
Microautoclave conversion, %			
short run	68.3	64.2	69.0
long run	60.0	60.4	64.2
Operating conditions			
Feed			
Coal feed rate, MF lb/hr	518	525	505
Concentration, % MF coal	37.3	37.9	36.9
Feed gas, Mscf/ton MF coal to B102	40.6	38.2	38.3
Hydrogen purity, mol %	85.0	82.8	81.3
LSRC (from CSD) recycle, lb/hr	0	25.5	26.8
E102 Dissolver Product Cooler bypass	No	No	No
Dissolver solids withdrawal, % of feed[(a)]	6	6	6
Na_2CO_3, lb/TB of slurry makeup	40	0	40
Reaction			
Coal space rate, MF lb/hr-ft^3			
Cumulative[(b)]	31.1	31.5	30.3
Dissolver [(c)]	38.2	38.7	37.2
Temperature, °F			
Preheater outlet	797	794	789
Dissolver, °F			
Bottom	818	819	819
Middle	821	822	823
Outlet	824	826	826
Dissolver pressure, psig	1,700	1,700	1,700
Hydrogen pressure, psia[(d)]			
Preheater inlet	1,484	1,453	1,428
Preheater outlet	-	-	-
Dissolver outlet	1,201	1,132	1,138
Results			
Conversion, % MAF coal			
Preheater	-	-	-
Dissolver	92.5	93.8	93.0

(Table continued)

Table 5 (continued)
Conditions and Results Summary

Date, 1989 Run	19-21 Feb 201ABC MB	6 Mar 202A MB	14-16 Mar 203DE MB
Results (continued)			
Hydrogen consumption			
% MF coal[e]	2.2	1.9	1.8
Sulfur, %of SRC product	1.07	0.94	0.91
Yields, % MF coal[e]			
SRC	63.1	50.9	54.0
Organic liquid	15.5	26.1	21.4
Gases			
C_1-C_5	4.14	4.57	4.76
CO-CO_2	0.94	0.36	0.64
H_2S	0.91	1.07	1.51
NH_3	0.11	0.24	0.33
Water	2.77	4.82	4.58
Unreacted coal	6.82	5.66	6.34
Ash	7.94	8.17	8.29

(a) Nominal percentage of feed.

(b) Using 1.6 ft^3 as preheater volume, plus 1.5 ft^3 for full-dissolver transfer line, plus dissolver volume.

(c) Using 13.58 ft^3 as three-quarter dissolver volume.

(d) Dissolver outlet hydrogen pressure (psia) = $\left[\text{P at B102 inlet}\right] \times \left[\frac{\%\ H_2 \text{ in B102 feed}}{100}\right] \times \left[100 - \frac{H_2 \text{ consumed (lb/hr)}}{H_2 \text{ in B102 feed (lb/hr)}} \times 100\right] \times \frac{1}{100}$

(e) Based upon unadjusted yields, process method. SRC is on solvent-free basis.

Table 6
Conditions and Results Summary
Adjusted Yields
Kentucky 9 Coal

Date, 1980	19-21 February			
Run	201ABC MB			
Material Balance Method	Process Method		V110 Short Method	
Basis	Unadjusted	Elementally balanced	Unadjusted	Elementally balanced
Yields, % MF coal				
Gases				
H_2S	0.91	1.09	0.91	1.06
CO_2	0.86	1.11	0.86	1.07
CO	0.08	0.08	0.08	0.08
C_1	1.41	1.41	1.41	1.46
C_2	1.13	1.13	1.13	1.15
C_3	0.95	0.94	0.95	0.95
C_{4-5}	0.65	0.63	0.65	0.63
NH_3	0.11	0.15	0.11	0.15
Water	2.77	5.27	2.77	5.13
Distillates				
C_5-350°F	2.38	2.31	2.38	2.33
350-450°F	3.92	3.85	3.81	3.78
450°F-EP	9.18	5.89	0.61	0.74
SRC[a]				
Oil	14.58	14.37	17.39	16.93
Asphaltene	27.32	26.94	26.40	25.69
Benzene insoluble[b]	21.20	20.91	25.50	24.82
Ash	7.94	8.61	9.78	8.96
Unreacted coal	6.82	7.33	7.49	6.94
Hydrogen consumption, % MF coal	2.21	2.03	2.21	1.87
Organic liquid yield, % MF coal[c]				
IBP-350°F	15.40	19.18	34.99	34.03
350-450°F	25.31	31.92	56.07	55.21
450-550°F	-17.02	-36.82	-89.02	-91.31
550-650°F	20.97	20.64	3.41	4.16
650°F-EP	55.33	65.08	79.17	82.47

(Table continued)

Table 6 (continued)
Conditions and Results Summary
Adjusted Yields
Kentucky 9 Coal

Date, 1980	6 March			
Run	202A MB			
Material Balance Method	Process Method		V110 Short Method	
Basis	Unadjusted	Elementally balanced	Unadjusted	Elementally balanced
Yields, % MF coal				
Gases				
H_2S	1.07	1.77	1.07	1.71
CO_2	0.27	0.50	0.27	0.48
CO	0.09	0.09	0.09	0.09
C_1	1.67	1.70	1.67	1.73
C_2	1.23	1.22	1.23	1.25
C_3	1.02	0.99	1.02	1.02
C_{4-5}	0.65	0.61	0.65	0.63
NH_3	0.24	0.28	0.24	0.28
Water	4.82	4.19	4.82	3.90
Distillates				
C_5-350°F	2.02	1.88	2.02	1.96
350-450°F	3.29	3.20	3.04	2.99
450 °F-EP	20.80	19.24	3.26	4.02
SRC[a]				
Oil	12.09	11.70	13.66	13.35
Asphaltene	18.09	17.35	28.88	28.22
Benzene insoluble[b]	20.77	20.14	23.44	22.92
Ash	8.17	9.67	9.31	9.17
Unreacted coal	5.66	6.70	7.23	7.12
Hydrogen consumption, % MF coal	1.90	1.24	1.90	0.82
Organic liquid yield, % MF coal[c]				
IBP-350°F	7.73	7.74	24.25	21.79
350-450°F	12.59	13.13	36.50	33.32
450-550°F	-0.38	-5.12	-78.54	-70.29
550-650°F	12.15	11.64	-14.46	-10.86
650 °F-EP	67.91	72.62	132.26	126.04

(Table continued)

Table 6 (continued)
Conditions and Results Summary
Adjusted Yields
Kentucky 9 Coal

Date, 1980	14-16 March			
Run	203DE MB			
Material Balance Method	Process Method		V110 Short Method	
Basis	Unadjusted	Elementally balanced	Unadjusted	Elementally balanced
Yields, % MF coal				
Gases				
H_2S	1.51	1.83	1.51	1.81
CO_2	0.55	0.69	0.55	0.68
CO	0.09	0.09	0.09	0.09
C_1	1.63	1.63	1.63	1.64
C_2	1.21	1.21	1.21	1.21
C_3	1.04	1.04	1.04	1.02
C_{4-5}	0.88	0.88	0.88	0.86
NH_3	0.33	0.35	0.33	0.34
Water	4.58	4.16	4.58	3.98
Distillates				
C_5-350°F	4.41	4.35	4.40	4.43
350-450°F	3.64	3.59	3.42	3.39
450°F-EP	13.35	11.35	4.43	4.12
SRC(a)				
Oil	8.28	8.29	11.87	11.84
Asphaltene	34.29	34.37	30.46	30.38
Benzene insoluble(b)	11.43	11.47	19.43	19.38
Ash	8.29	9.50	8.84	9.18
Unreacted coal	6.34	7.16	7.18	7.44
Hydrogen consumption, % MF coal	1.83	1.96	1.83	1.70
Organic liquid yield, % MF coal(c)				
IBP-350°F	20.60	22.56	35.92	36.59
350-450°F	16.94	18.53	27.81	28.48
450-550°F	-14.12	-21.55	-51.86	-56.14
550-650°F	13.39	12.40	5.32	5.01
650°F-EP	63.18	68.06	82.81	86.06

(a) Solvent-free basis (distilled to 600°F and 0.1 mm Hg).
(b) Benzene insoluble, cresol soluble.
(c) Liquid fractions by GC determination. A negative value indicates that the amount of that fraction decreased because part of that fraction was consumed in the process.

Table 7
Conditions and Results Summary
CSD Yield Data
Dotiki Coal

Run	202A MB		203D-E MB	
Feed Rate, lb/hr	324.8		377.9	
Yields	% MF Coal[(a)]	% of Feed	% MF Coal[(a)]	% of Feed
SRC				
solvent	2.0	2.6	1.8	2.3
oil	1.9	2.5	7.3	9.1
asphaltene	22.7	29.7	19.8	24.7
preasphaltene	5.9	7.8	7.0	8.7
unreacted coal	0	0	0	0
ash	0	0	0	0
deashing solvent	0.1	0.1	0	0
Ash concentrate				
solvent	0.6	0.8	0.6	0.9
oil	0.9	1.1	2.6	3.2
asphaltene	1.3	1.7	1.5	1.9
preasphaltene	7.9	10.4	3.4	4.2
unreacted coal	9.4	12.3	10.9	13.5
ash	8.1	10.6	9.1	11.3
deashing solvent	0.4	0.5	0.3	0.4
SRC Recovery[(b)]	77.7		81.6	
Distillate[(c)]				
in SRC, wt %	6.1		5.1	
in Light SRC, wt %	22.4		17.5	
Deashing Solvent Loss, % of KM Feed				
total	8.7		5.7	
to products	0.6		0.6	

(a) Based upon adjusted coal feed and KM feed (from T102) rates.
(b) Based upon net SRC in feed (LSRC-free) and SRC product stream.
(c) @ 600°F and 0.1 mm Hg.

Table 8
Coal Feed Summary
Kentucky 9 Coal

Run	Mine	Feed Slurry Conc.		Coal Feed, Pounds			Weighted Average, %		
		MF lb/hr	% MF Coal	As-is	MF	MAF	Moist	Ash	Sulf
195	Lafayette	463	37.6	5,737	5,694	5,194	0.75	9.46	2.62
196	"	456	36.2	14,238	14,080	12,777	1.10	9.25	2.67
197	"	505	37.8	23,398	23,197	20,990	0.86	9.51	2.68
198	"	509	37.7	61,124	60,547	54,829	0.94	9.44	2.61
199	"	506	37.5	100,894	99,867	90,776	1.02	9.10	2.74
200	"	497	38.7	77,212	76,290	68,981	1.19	9.58	2.63
201	"	509	37.2	133,762	132,539	119,682	0.91	9.70	2.58
202	Dotiki	510	36.9	110,691	109,594	99,757	0.99	8.98	2.87
203	"	502	36.5	113,062	112,055	102,807	0.89	8.25	3.16
204(a)	"	519	36.7	164,339	162,625	147,776	1.04	9.13	3.13
Average		498	37.3				0.97	9.16	2.85
Total				804,457	796,488	723,569			

(a) March portion of run.

Table 9
SRC Production Summary
Kentucky 9 Coal

Run	Mine	MCIF, lb/hr		MCIF yield, % MAF coal	Analysis, wt %				MP °F	SRC Pounds					
										MF		MAF		MCIF	
		K125	KM		Solv	CI	Ash	S		K125	KM	K125	KM	K125	KM
195	Lafayette	272	0	64.5	3.8	4.4	1.37	1.05	520	3,505	0	3,457	0	3,350	0
196	"	272	0	65.9	3.8	4.4	3.24	1.03	520	8,808	0	8,523	0	8,419	0
197	"	290	0	63.4	4.3	1.8	0.70	0.87	460	13,542	0	13,447	0	13,302	0
198	"	241	0	52.3	4.7	2.9	0.21	0.88	414	29,509	0	29,447	0	28,662	0
199	"	305	0	66.2	4.6	1.9	0.28	0.94	448	61,271	0	61,099	0	60,131	0
200	"	332	0	73.8	6.4	2.6	0.51	0.88	382	52,139	0	51,874	0	50,904	0
201	"	289	8	64.5	6.4	8.0	3.68	0.96	373	81,369	2,642	78,588	2,330	75,189	2,053
202	Dotiki	91	210	64.9	9.0	20.7	11.2	1.59	312	25,907[b]	55,667[b]	22,977	49,425	19,487	45,217
203	"	98	201	64.9	11.4	21.4	12.2	1.68	322	27,623[b]	57,236[b]	24,294	50,223	21,863	44,829
204[a]	"	41	231	57.9	12.3	22.8	12.9	1.64	318	16,626[b]	94,004[b]	14,466	81,812	12,858	72,446
Average		187	105	63.4	8.9	13.4	7.15	1.30	359						
Total										320,299	209,549	308,172	183,790	294,165	164,545

(a) March portion of run.
(b) Reduced by proportioned amount of solvent-free LSRC added to coal feed.

Table 10
Solvent Refined Coal Analyses
Kentucky 9 Coal

Date, 1980	19 Feb		6 Mar				14-16 Mar			
Run	201 MB		202A MB				203DE MB			
Sample	K125	V110(a)	CSD-Feed	CSD-SRC	LSRC	V110(a)	CSD-Feed	CSD-SRC	LSRC	V110(a)
Proximate Analysis, wt %										
Volatile Matter	45.37	39.98	39.17	47.81		37.17	40.35	44.93		43.38
Fixed Carbon	54.37	59.18	50.13	52.04		62.54	47.90	54.96		56.34
Moisture	<0.01	0	<0.01	0.11		<0.01	<0.01	0.02		<0.01
Ash	0.26	0.84	10.70	0.04		0.29	11.75	0.09		0.38
Ultimate Analysis, wt %										
Carbon	87.38	86.80	77.08	87.60	86.69	87.23	76.68	87.41	87.13	87.19
Hydrogen	5.40	5.45	5.01	5.66	6.61	5.74	4.98	5.72	6.56	5.72
Nitrogen	1.30	1.34	1.50	1.68	1.36	1.78	1.61	1.77	1.61	1.63
Sulfur	1.26	1.07	1.69	0.79	0.94	0.95	1.45	0.91	0.76	0.91
Chlorine	-	-	0.10	0.05	-	0.08	0.29	0.03	-	0.05
Ash	0.26	0.43	10.70	0.04	0.06	0.29	11.75	0.09	0.03	0.38
Oxygen, by difference	4.40	4.91	3.92	4.18	4.34	3.93	3.24	4.07	3.91	4.12
Heating Value, Btu/lb	15,906	14,764	15,226	15,954		15,421	13,937	16,000		16,173
Sulfur Forms, wt %										
Pyritic	<0.01	-	0.09	<0.01		<0.01	0.05	<0.01		<0.01
Sulfate	<0.01	-	0.02	<0.01		<0.01	0.02	<0.01		<0.01
Sulfide	0.02	-	0.36	<0.01		<0.01	0.20	<0.01		<0.01
Organic	1.24	1.07	1.22	0.79		0.95	1.18	0.91		0.91
Fusion Point, °F	374	-	327	270		385	356	311		316
Distillate										
at 500°F, wt %	1.34	-	2.7	3.0	-	-	2.2	2.0	-	-
vacuum, mm Hg	0.1	-	0.1	0.05	-	-	0.01	0.05	-	-
at 600°F, wt %	6.17	-	10.3	6.1	22.40	-	7.6	5.1	17.50	-
vacuum, mm Hg	0.1	-	0.1	0.05	0.03	-	0.05	0.05	0.05	-
Solvent Fractionation Analysis, wt %										
Oil(b)	22.60	25.1	18.8	11.9		20.4	19.4	25.4		20.0
Asphaltene(c)	42.40	38.1	31.2	69.8		45.8	44.8	55.0		50.5
Benzene insoluble(d)	32.15	36.8	30.7	18.3		33.5	13.8	19.4		29.1
Cresol insoluble organic	2.59	-	8.6	0.01		-	10.25	0.10		-
Ash	0.26	0.43	10.7	0.04		0.29	11.75	0.09		0.38

(a) Laboratory filtered and vacuum distilled.
(b) Pentane soluble.
(c) Benzene soluble, pentane insoluble.
(d) Cresol soluble.

Table 11
Feed Coal Analyses
Kentucky 9 Coal

Date, 1980 Run Mine	19-21 Feb 201ABC MB Lafayette	6 Mar 202A MB Dotiki	14-16 Mar 203DE MB Dotiki
Proximate Analysis, wt %			
Moisture	1.23	0.95	1.40
Ash	9.33	8.95	9.17
Volatile Matter	31.36	30.15	33.68
Fixed Carbon	58.08	59.95	55.75
Ultimate Analysis, wt %			
Carbon	73.04	69.81	73.21
Hydrogen	4.39	4.22	4.75
Nitrogen	0.49	1.18	1.31
Chlorine	(a)	0.27	0.28
Sulfur	2.44	3.25	3.58
Ash	9.41	9.04	9.30
Oxygen (by difference)	10.23	12.23	7.57
Dry Heating Value, Btu/lb	13,311	13,441	13,254
Sulfur Forms, wt %			
Pyritic	0.66	1.18	1.34
Sulfate	0.01	0.03	0.03
Sulfide	<0.01	<0.01	<0.01
Organic	1.77	2.04	2.21
Mineral Analysis, wt %			
Phos. pentoxide, P_2O_5	0.09	0.08	0.08
Silica, SiO_2	59.70	49.35	50.53
Ferric Oxide, Fe_2O_3	13.06	20.85	20.13
Alumina, Al_2O_3	20.39	18.99	19.03
Titania, TiO_2	1.56	1.34	1.35
Lime, CaO	1.01	2.51	2.40
Magnesia, MgO	0.80	0.82	0.83
Sulfur Trioxide, SO_3	0.92	2.23	2.77
Potassium Oxide, K_2O	2.14	2.33	2.45
Sodium Oxide, Na_2O	0.41	0.49	0.55
Undetermined	-	1.01	-

(a) Chlorine data not available for Run 201ABC MB. Typical chlorine content of Ky 9 (Lafayette) coal (SN 517.54) was 0.24 wt %.

Table 12
Slurry Preheater Operating Data

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
B102 Feed, lb/hr			
gas	136	142	143
solvent (+LSRC)	871	859	860
coal (+ Na_2CO_3)	518	525	505
Total Feed	1,525	1,526	1,508
B102 Fuel, gph	9.0	9.4	8.9
stack, °F	895	927	917
B102 Inlet, psig	1,731	1,740	1,742
B102 Outlet, psig	1,686	1,701	1,694
Total ΔP, psi	45	39	48
ΔP btm	23	20	25
ΔP mid	16	12	15
ΔP top	6	7	8
B102 Inlet, °F	130	144	138
Turn 7, skin/fluid, °F	431/405	437/426	444/431
Δt	26	11	13
Turn 15, skin/fluid, °F	702/664	596/579	602/586
Δt	38	17	16
Turn 19, skin/fluid, °F	709/643	674/618	669/620
Δt	66	56	49
Turn 23, skin/fluid, °F	737/680	715/662	710/661
Δt	57	53	49
Turn 27, skin/fluid, °F	759/725	745/708	743/708
Δt	34	37	35
Turn 31, skin/fluid, °F	786/756	779/746	778/745
Δt	30	33	33
Turn 33, skin/fluid, °F	812/767	802/760	798/757
Δt	45	42	41
Turn 35, skin/fluid, °F	810/780	810/776	808/775
Δt	30	34	33
Turn 37, skin/fluid, °F	829/800	833/800	831/798
Δt	29	33	33
Coil outlet, °F	797	794	789

Table 13
Dissolver Operating Profile

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202	203
Volume in Use, %	75	75	75
Coal Space Rate, $lb/hr\text{-}ft^3$ (a)	38	38	37
B102 Feed, lb/hr			
Coal	512	525	499
Solvent (+LSRC)	871	859	862
Gas	136	142	143
Na_2CO_3	5.8	0	5.6
Gas Hydrogen Purity, mole %	85.0	82.8	81.3
R101 Bottoms Withdrawal Rate, lb/hr	80.2	83.0	83.5
Withdrawal Sample Analysis, wt %			
UC	9.0	NA	6.6
Ash	10.4	NA	9.9
SRC	38.6	NA	40.0
Solvent (by difference)	42.0	NA	43.5
V110 Analysis, wt %			
UC	3.2	3.2	3.1
Ash	4.7	4.1	4.3
SRC	29.8	30.8	28.6
Solvent (by difference)	62.3	61.9	64.0
R101 Temperature Profile, °F			
Inlet	771	758	744
5% from bottom	819	819	818
10% from bottom	821	821	821
15% from bottom	819	819	819
20% from bottom	821	821	820
25% from bottom	821	821	820
50% from bottom	823	824	823
75% from bottom	825	826	825
R101 Outlet Pressure, psig	1,700	1,700	1,700

(a) Based on no bottoms withdrawal.

Table 14
Slurry Preheater and Dissolver Data

Run	196	198	198	199	199	200
Date, 1980	3 Jan	10 Jan	13 Jan	15 Jan	20 Jan	30 Jan
B102 Feed, lb/hr						
coal	454	499	534	521	492	501
solvent	804	821	868	865	831	814
gas	11,270	11,220	10,200	10,150	10,180	10,290
Na_2CO_3	5.0	0	0	5.8	5.5	5.6
LSRC	0	0	0	0	0	0
Gas H_2 Purity, mole %	85	85	85	85	85	85
B102 Fuel Oil, gph	11.4	11.1	11.2	11.0	10.7	10.4
stack temp, °F	1,007	1,010	1,012	1,010	1,005	1,010
B102 Inlet temp, °F	780	773	775	763	777	772
B102 Coil temp, °F						
Turn 7, skin/fluid	365/327	363/329	366/329	360/327	360/327	355/321
Δt	38	34	37	33	33	34
Turn 15, skin/fluid	518/453	522/467	525/471	518/463	517/486	511/465
Δt	55	55	54	55	31	46
Turn 19, skin/fluid	618/537	638/543	637/546	619/537	636/538	609/529
Δt	81	95	91	82	98	80
Turn 23, skin/fluid	664/593	674/591	679/591	683/593	666/580	681/583
Δt	71	83	88	90	86	98
Turn 27, skin/fluid	696/667	706/674	702/676	700/672	696/670	699/671
Δt	29	42	48	46	48	46
Turn 31, skin/fluid	761/718	765/726	762/724	756/717	762/723	760/723
Δt	43	39	38	39	39	39
Turn 33, skin/fluid	793/756	794/755	791/758	785/751	798/761	789/752
Δt	37	39	33	34	37	37
Turn 35, skin/fluid	828/785	828/784	832/786	810/776	831/784	829/775
Δt	43	44	46	34	47	54
Turn 37, skin/fluid	871/814	877/829	878/829	872/821	878/828	883/825
Δt	57	48	49	51	50	58
B102 Outlet temp, °F	806	812	810	804	810	807
Pressure, psig	1,716	1,729	1,714	1,722	1,680	1,710
R101 Inlet temp, °F	780	773	775	763	777	772
R101 Dissolver temp, °F						
5% from btm	819	819	818	819	818	818
10% from btm	822	821	820	822	821	820
15% from btm	821	820	818	819	818	818
20% from btm	821	820	819	821	819	819
25% from btm	820	822	819	821	819	819
50% from btm	822	822	821	822	821	821
75% from btm	824	825	823	825	823	823
Estimated $p(H_2)$ in R101, psia	1,100	1,130	1,120	1,080	1,160	1,020

(Table continued)

Table 14 (continued)
Slurry Preheater and Dissolver Data

Run	200	(a)	(a)	201	201	201	202
Date, 1980	1 Feb	5 Feb	11 Feb	13 Feb	20 Feb	25 Feb	27 Feb
B102 Feed, lb/hr							
coal	502	0	0	538	529	470	510
solvent	805	1,400	1,400	889	882	773	869
gas	143	53	53	139	136	136	145
Na_2CO_3	5.5	0	0	5.9	5.8	5.2	0
LSRC	0	0	0	0	0	0	26
Gas H_2 Purity, mole %	84	100	100	85	85	85	84
B102 Fuel Oil, gph	11.7	10.5	10.9	9.3	9.0	8.8	9.6
stack temp, °F	1,020	1,002	1,048	981	895	910	926
B102 Inlet temp, °F	107	121	133	119	130	124	127
B102 Coil, temp, °F							
Turn 7, skin/fluid	357/317	374/329	322/289	369/344	431/405	418/406	418/405
Δt	40	45	33	25	26	12	13
Turn 15, skin/fluid	511/466	525/470	482/444	553/507	702/664	595/572	591/567
Δt	45	55	38	46	38	23	24
Turn 19, skin/fluid	646/546	599/538	547/522	658/579	709/643	664/615	665/608
Δt	100	61	25	80	66	49	57
Turn 23, skin/fluid	686/598	649/581	638/611	690/635	737/680	722/659	709/654
Δt	88	68	27	55	57	63	55
Turn 27, skin/fluid	701/677	694/669	700/670	736/696	759/725	754/708	743/702
Δt	24	25	30	40	34	46	41
Turn 31, skin/fluid	764/725	760/721	755/725	783/744	786/756	795/758	778/747
Δt	39	39	30	39	30	37	31
Turn 33, skin/fluid	793/761	782/749	782/748	804/761	812/767	814/767	803/760
Δt	32	33	34	43	45	47	43
Turn 35, skin/fluid	832/787	813/776	802/772	824/786	810/780	810/778	809/776
Δt	45	37	30	38	30	32	33
Turn 37, skin/fluid	886/834	874/819	825/790	853/808	829/800	833/799	833/796
Δt	52	55	35	45	29	34	37
B102 Outlet temp, °F	813	804	808	806	797	798	794
Pressure, psig	1,733	1,714	1,716	1,715	1,686	1,676	1,696
R101 Inlet temp, °F	770	763	789	772	771	765	761
R101 Dissolver temp, °F							
5% from btm	818	820	808	817	819	816	818
10% from btm	820	822	810	820	821	819	821
15% from btm	818	820	809	818	819	817	817
20% from btm	819	822	810	819	821	819	820
25% from btm	819	821	810	819	821	819	820
50% from btm	821	824	811	821	823	821	822
70% from btm	823	825	811	824	825	822	825
Estimated $p(H_2)$ in R101, psia	1,125			1,095	1,048	1,078	1,108

(Table continued)

Table 14 (continued)
Slurry Preheater and Dissolver Data

Run	203	203	204	204	204	204
Date, 1980	7 March	13 March	18 March	22 March	26 March	31 March
B102 Feed, lb/hr						
coal	522	507	488	531	534	537
solvent	881	860	849	908	909	899
gas	139	139	140	142	142	145
Na_2CO_3	5.8	5.6	5.4	5.9	5.9	6.0
LSRC	27	26	24	24	26	26
Gas H_2 Purity, mole %	85	84	85	86	84	86
B102 Fuel Oil, gph	9.4	9.0	9.2	9.6	9.5	10.9
stack temp, ^oF	920	920	914	923	923	932
B102 Inlet temp, ^oF	154	126	124	135	133	145
B102 Coil, temp, ^oF						
Turn 7, skin/fluid	437/428	427/415	437/429	450/438	444/435	426/439
Δt	9	12	8	12	9	13
Turn 15, skin/fluid	598/577	588/568	603/593	612/602	606/593	620/591
Δt	21	20	10	10	13	29
Turn 19, skin/fluid	668/618	664/613	668/624	667/624	666/618	661/609
Δt	50	51	44	43	48	52
Turn 23, skin/fluid	718/663	706/658	719/669	720/667	715/659	717/691
Δt	55	48	50	53	56	26
Turn 27, skin/fluid	745/709	740/705	752/715	751/715	746/711	753/736
Δt	36	35	37	36	35	17
Turn 31, skin/fluid	782/747	777/744	790/757	790/752	787/748	804/763
Δt	35	33	33	38	39	41
Turn 33, skin/fluid	807/762	800/757	814/767	816/767	815/766	824/776
Δt	45	43	47	49	49	48
Turn 35, skin/fluid	810/777	806/774	811/778	814/779	813/778	825/798
Δt	33	31	33	35	35	27
Turn 37, skin/fluid	833/800	826/795	837/803	840/804	839/802	852/815
Δt	33	31	34	36	37	37
B102 Outlet temp, ^oF	794	789	798	795	790	802
Pressure, psig	1,690	1,693	1,708	1,703	1,792	1,803
R101 Inlet temp, ^oF	755	732	765	757	732	770
R101 Dissolver temp, ^oF						
5% from btm	820	819	832	833	832	834
10% from btm	822	822	835	836	835	836
15% from btm	820	821	833	834	833	834
20% from btm	823	821	834	835	834	835
25% from btm	823	821	834	835	834	836
50% from btm	824	824	837	838	838	839
70% from btm	826	826	839	840	840	841
Estimated $p(H_2)$ in R101, psia	1,135	1,140	1,090	1,030	1,095	1,120

(a) Test run without coal, immediately prior to decoking.
(b) Test run without coal, clean coil.

Table 15
Reaction Solids Analyses (V144 Emergency Blowdown Tank)
Kentucky 9 Coal

Date, 1980	6 Feb	3-31 Mar
Mine	Lafayette	Dotiki
Run	201	204
Run Source	V144 AWS	V144 AWS
Proximate Analysis, wt %		
Moisture	0.67	3.99
Ash	42.80	56.60
Volatile Matter	14.95	10.72
Fixed carbon (by difference)	41.58	28.69
Ultimate Analysis, wt %		
Carbon	44.50	26.23
Hydrogen	2.55	1.32
Nitrogen	1.02	0.58
Sulfur	5.31	12.84
Chlorine	2.37	2.42
Ash	42.80	56.60
Oxygen (by difference)	1.45	0.01
Sulfur Forms, wt %		
Pyritic	0.34	1.05
Sulfate	0.29	0.45
Sulfide	3.33	7.63
Organic	1.35	3.71
Mineral Analysis of Ash, wt %		
Phos. Pentoxide, P_2O_5	NA	0.10
Silica, SiO_2	"	20.72
Ferric oxide, Fe_2O_3	"	45.07
Alumina, Al_2O_3	"	8.28
Titania, TiO_2	"	0.73
Lime, CaO	"	2.39
Magnesia, MgO	"	0.42
Sulfur Trioxide, SO_3	"	14.73
Potassium Oxide, K_2O	"	0.66
Sodium Oxide, Na_2O	"	4.12
Undetermined	"	2.78

Table 16
Reaction Section Operating Data
Kentucky 9 Coal

Mine	Lafayette	Dotiki	Dotiki
Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Flow rates, lb/hr			
MF coal to B102 (+Na CO)	518	525	505
Solvent to B102 (+LSRC)	871	859	862
Light organic liquid from V105	158	149	164
Water from V105	20	24	25
Gas flow rates, scfh			
Feed gas to B102	10,345	10,300	10,314
Makeup hydrogen	3,039	2,858	2,551
Recycle gas from V104	11,595	11,359	10,525
HP purge gas	912	1,002	765
LP vent gas from V105	295	340	369
Degas vent[(a)]	39	41	90
Gas removed by caustic scrubber	70	57	84
Temperature, °F			
B102 outlet	797	794	790
R101 bottom	819	819	818
R101 middle[(b)]	823	824	823
R101 top[(b)]	825	826	825
V105 HP flash			
V104 HP vent	84	84	83
V110 LP flash	591	581	585
Pressure, psig			
B102 inlet	1,731	1,740	1,742
B102 outlet	1,686	1,701	1,696
V110 outlet gas	136	101	101
V105 outlet gas	7	7	7
Hydrogen purity, vol %			
Feed gas to B102	85.0	82.8	81.3
Recycle gas from V104	81.0	79.2	77.4
Recycle gas from V106	81.5	79.0	77.4
LP vent gas from V105	31.6	34.1	33.9
Degas vent	61.8	62.7	68.3

(a) Includes compressor vents, plus on-line GC sample stream.
(b) Of liquid volume.

Table 17
Heteroatom Removal

		Weight Ratio of Heteroatom to Carbon					Heteroatom Removal, %			
			SRC				Equation (1) SRC			
Run	Heteroatom	Feed Coal	V110	CSD Feed	K125	CSD Product	V110	CSD Feed	K125	CSD Product
201ABC MB	Oxygen	0.140	0.057	-	0.050	-	59.3	-	64.3	-
	Nitrogen	0.007	0.015	-	0.015	-	-114.3	-	-114.3	-
	Sulfur	0.033	0.012	-	0.014	-	63.6	-	57.6	-
202A MB	Oxygen	0.177	0.045	0.051	-	0.048	74.6	71.2	-	72.9
	Nitrogen	0.017	0.020	0.019	-	0.019	-17.6	-11.8	-	-11.8
	Sulfur	0.047	0.011	0.022	-	0.009	76.6	53.2	-	80.9
203DE MB	Oxygen	0.103	0.047	0.042	-	0.047	54.4	59.2	-	54.4
	Nitrogen	0.018	0.019	0.021	-	0.020	-5.6	-16.7	-	-11.1
	Sulfur	0.049	0.010	0.019	-	0.010	79.6	61.2	-	79.6

	Heating Value, Btu/lb				Total Sulfur, wt %				Total Sulfur Removal, %		
		SRC				SRC			Equation (2) SRC		
Run	Coal	V110	K125	CSD Product	Coal	V110	K125	CSD Product	V110	K125	CSD Product
201ABC MB	13,311	14,764	15,906	-	2.44	1.07	1.26	-	60.5	56.8	-
202A MB	13,441	15,421	-	15,954	3.25	0.95	-	0.79	74.5	-	79.5
203DE MB	13,254	16,173	-	16,000	3.58	0.91	-	0.91	79.2	-	78.9

Table 18
High Pressure Vent Separator Gas Analyses (V104)
Kentucky 9 Coal

Date, 1980		20-22 Feb	6 Mar	14-16 Mar
Run		201ABC MB	202A MB	203DE MB
Component	Mol wt	Mole %	Mole %	Mole %
H_2	2.02	81.0	79.2	77.4
N_2	28.02	0.2	0.1	0.1
CO	28.00	0.5	0.5	0.6
CO_2	44.00	0.3	0.1	0.2
H_2S	34.08	0.3	0.4	0.6
CH_4	16.03	13.0	14.5	15.8
C_2H_2	26.02	0	0	0
C_2H_4	28.03	0	0	0
C_2H_6	30.05	3.3	3.7	3.8
C_3H_6	42.05	0	0	0
C_3H_8	44.06	1.1	1.3	1.3
iC_4H_{10}	58.08	0	0	0
nC_4H_{10}	58.08	0.3	0.2	0.2
iC_5H_{12}	72.15	0	0	0
nC_5H_{12}	72.15	0	0	0
C_6H_{14}	86.18	0	0	0

Table 19
Decanter Vent Gas Analyses (V105)
Kentucky 9 Coal

Date, 1980		20-22 Feb	6 Mar	14-16 Mar
Run		201ABC MB	202A MB	203DE MB
Component	Mol wt	Mole %	Mole %	Mole %
H_2	2.02	31.6	34.1	33.9
N_2	28.02	30.9	32.6	32.0
CO	28.00	0.2	0.2	0.2
CO_2	44.00	0.8	0.2	0.5
H_2S	34.08	4.0	3.5	4.0
CH_4	16.03	11.1	11.0	10.9
C_2H_2	26.02	0	0	0
C_2H_4	28.03	0	0	0
C_2H_6	30.05	9.4	7.9	7.5
C_3H_6	42.05	0	0	0
C_3H_8	44.06	7.5	6.5	6.3
iC_4H_{10}	58.08	0.6	0.6	0.6
nC_4H_{10}	58.08	2.3	2.2	2.4
iC_5H_{12}	72.15	0.4	0	0.4
nC_5H_{12}	72.15	0.9	1.2	0.7
C_6H_{14}	86.18	0.3	0	0.6

Table 20
Degas Vent Gas Analyses (V132)
Kentucky 9 Coal

Date, 1980		20-22 Feb	6 Mar	14-16 Mar
Run		201ABC MB	202A MB	203DE MB
Component	Mole wt	Mole %	Mole %	Mole %
H_2	2.02	61.8	62.7	68.3
N_2	28.02	20.9	19.5	11.3
CO	28.00	0.3	0.3	0.3
CO_2	44.00	0.2	0	0
H_2S	34.08	0	0	0
CH_4	16.03	12.0	13.0	14.7
C_2H_2	26.02	0	0	0
C_2H_4	28.03	0	0	0.2
C_2H_6	30.05	3.7	3.4	4.0
C_3H_6	42.05	0	0	0
C_3H_8	44.06	1.0	1.0	1.1
iC_4H_{10}	58.08	0	0	0
nC_4H_{10}	58.08	0.1	0.1	0.1
iC_5H_{12}	72.15	0	0	0
nC_5H_{12}	72.15	0	0	0
C_6H_{14}	86.18	0	0	0

Table 21
Flare Gas Analyses (K110)
Kentucky 9 Coal

Date, 1980		20-22 Feb	6 Mar	14-16 Mar
Run		201ABC MB	202A MB	203DE MB
Component	Mol wt	Mole %	Mole %	Mole %
H_2	2.02	23.9	37.3	30.9
N_2	28.02	70.3	51.9	56.8
CO	28.00	0.1	0.2	0.2
CO_2	44.00	0	0	0
H_2S	34.08	0	0	0
CH_4	16.03	3.8	6.4	7.2
C_2H_2	26.02	0	0	0
C_2H_4	28.03	0	0	0
C_2H_6	30.05	1.4	2.4	2.6
C_3H_6	42.05	0	0	0
C_3H_8	44.06	0.4	1.3	1.5
iC_4H_{10}	58.08	0	0.1	0.1
nC_4H_{10}	58.08	0.1	0.4	0.5
iC_5H_{12}	72.15	0	0	0.1
nC_5H_{12}	72.15	0	0	0.1
C_6H_{14}	86.18	0	0	0

Table 22
Low Pressure Flash (V110) Product Analyses

Date, 1980	20-22 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Composition, wt %			
Cresol Insoluble (CI)	7.9	7.3	7.4
Ash	4.7	4.1	4.3
SRC[(a)]	29.8	30.8	28.6
Distillate[(b)]	62.3	61.9	64.0
Distillate Composition, wt %			
IBP-350°F	0.1	0	0.1
350-450°F	1.3	1.4	2.4
450-550°F	39.2	36.2	36.4
550-650°F	24.7	24.5	24.2
650°F-EP	34.7	37.9	36.9
Distillate, lab Ultimate Analysis, wt %			
Carbon	87.55	87.23	87.04
Hydrogen	8.42	5.74	8.96
Nitrogen	0.33	1.78	0.69
Sulfur	0.48	0.95	0.53
Ash	0	0.29	0
Oxygen (by difference)	3.22	4.01	2.78
Cresol Insoluble, lab Ultimate Analysis, wt %			
Carbon	28.79	34.78	32.29
Hydrogen	1.17	1.54	1.31
Nitrogen	0.22	0.79	0.34
Sulfur	3.47	5.65	6.01
Ash	60.15	55.80	57.80
Oxygen (by difference)	6.20	1.44	2.25

(a) Distillation conditions: 600°F @ 0.1 mm Hg.
(b) Distillate = 100 - (CI + SRC).

Table 23
U. S. Filter
Filtration Data for January 1980

Date, Jan 1980	Run	No of cycles	Filtration time, min	Cycle time, min	Wash solv, lb/cyc	Filtration Volume: To V120, gal*	Filtration Volume: From V112, gal*	Filtration Rate: gpm	Filtration Rate: gph/ft²	Precoat, lb/cyc	ΔP, psi: Precoat range	ΔP, psi: Filtration range	ΔP, psi: Filtration avg
1	194-5	4	100	190	882	289	339	2.9	2.6	-	-	45-50	50
2	195-6	7	78	154	695	252	290	3.2	3.0	-	-	46-50	50
3	196	6	80	151	715	289	337	3.6	3.3	-	-	50-50	50
(a)													
5	197	8	80	152	757	289	340	3.6	3.3	23	5-19	30-50	46
6	197	6	85	152	737	289	342	3.4	3.1	23	8-15	30-50	47
(b)													
7	197	3	59	123	737	289	340	4.9	4.5	23	9-20	47-50	45
8	197-8	10	72.5	132	737	289	345	3.9	3.6	23	8-16	37-42	39
9	198	8	85	150	737	300	337	3.5	3.2	23	11-17	20-37	28.5
10	198	11	58	131	778	293	351	5.0	4.6	23	8-15	34-40	37
11	198	10	54	115	708	304	354	5.6	5.1	23	7-18	34-42	38
(c)													
12	198	4	24	75	737	308	356	12.8	11.7	23	12-17	50-51	50
13	198	10	38	96	735	291	328	7.7	7.0	23	10-15	50-50	50
14	199	6	60	115	737	289	327	4.8	4.4	23	9-14	50-50	50
15	199	10	65	138	737	288	326	4.4	4.1	23/5	8-13	30-50	50
16	199	10	74	146	737	290	320	3.9	3.6	5	9-19	30-50	50
17	199	8	83	158	737	290	322	3.5	3.2	5/23	12-22	30-50	50
18	199	6	70	147	737	289	322	4.1	3.7	5	11-19	50-50	50
19	199	10	80	142	737	289	321	3.6	3.3	5	10-20	49-50	50
20	199	9	86	166	766	280	311	3.2	3.0	5	10-20	48-50	50
21	199	7	82	151	737	289	320	3.5	3.2	5	10-22	50-50	50
22	199	9	94	173	737	289	322	3.0	2.8	11	5-28	50-52	50
23	199	7	84	162	744	289	326	3.4	3.1	23	6-14	50-51	50
(d)													
26	200	3	55	118	731	289	315	5.2	4.8	11	7-12	30-50	50
28	200	4	69	129	737	291	331	4.2	3.8	9	5-10	20-40	36
29	200	9	102	163	737	287	337	2.8	2.6	5	7-15	27-40	36
30	200	8	113	180	750	288	330	2.5	2.3	9	8-13	20-40	36
31	200	8	105	171	737	289	339	2.8	2.5	10	8-11	22-75	38

(Table continued)

Table 23 (continued)
U. S. Filter
Filtration Data for January 1980

Date, Jan 1980	Run	Filter Cake Solv, %	Filter Cake Ash, %	Filter Cake UC, %	Filter Cake SRC, %	Filter Cake wt, lb	Filtrate solids, wt %	V110 LFSFE Sulfur, wt %	Filter feed solids, wt %	Filter feed SRC, wt %	Filter Temperature Avg In, °F	Filter Temperature Avg Out, °F	Sluice, lb/cycle	Wash time, min
1	194-5	-	-	-	-	171	0.3-0.4	-	6.9	-	524	541	751	51
2	195-6	-	-	-	-	139	0.2-0.6	-	5.8	-	532	548	750	36
3	196	14.8	47.8	36.6	4.7	126	0.6-0.96	-	5.8	25.1	534	550	787	23
(a)														
5	197	6.6	60.0	31.4	1.0	232	0.04-0.09	-	6.6	28.3	544	556	101	22
6	197	13.1	56.8	34.7	4.1	260	0.07-0.08	-	6.8	26.9	554	555	135	16
(b)														
7	197	-	-	-	-	214	0.06-0.08	-	-	-	552	554	0	15
8	197-8	14.0	54.0	29.8	7.0	231	0.01-0.06	-	6.0	24.4	555	554	0	12
9	198	17.4	49.3	28.7	1.5	293	0.04-0.07	0.92	7.1	28.1	554	553	92	12
10	198	16.6	48.5	35.3	3.5	257	0.01-0.06	1.1	6.9	29.2	555	554	143	12
11	198	9.9	51.4	36.0	3.5	254	0.03-0.08	0.76	7.6	26.7	552	554	84	11
(c)														
12	198	-	-	-	-	215	0.02-0.06	-	5.2	-	546	545	0	5
13	198	15.4	47.4	38.4	3.0	251	0.04-0.08	-	6.3	27.7	552	552	0	14
14	199	9.0	48.0	37.2	4.4	311	0.06-0.27	0.89	7.1	27.9	550	544	0	17
15	199	19.6	44.6	31.8	4.2	256	0.02-0.08	0.90	6.9	30.0	537	551	167	27
16	199	-	-	-	-	206	0.07-0.11	0.86	6.9	31.0	536	552	0	29
17	199	7.0	52.4	37.8	2.4	220	0.03-0.14	0.86	5.5	28.5	537	550	107	30
18	199	17.8	45.8	30.6	4.0	297	0.07-0.11	-	6.2	27.8	539	555	107	28
19	199	4.1	56.4	39.6	1.4	193	0.05-0.14	0.97	6.0	26.5	548	554	0	27
20	199	6.8	54.3	38.3	0.40	209	0.05-0.12	1.03	6.2	27.8	540	552	82	33
21	199	-	-	-	-	207	0.05-0.09	0.91	6.4	27.9	539	551	0	27
22	199	-	-	-	-	219	0.06-0.11	-	6.4		528	544	169	31
23	199	-	-	-	-	246	0.07-0.11	-	6.6	27.3	537	547	0	31
(d)														
26	200	10.0	48.8	36.6	4.0	224	0.09-0.11	-	-	-	537	543	262	18
28	200	15.1	46.6	34.8	-	263	0.05-0.11	0.93	5.8	23.3	544	545	0	12
29	200	14.1	50.4	35.1	4.0	224	0.04-0.12	1.00	7.4	25.8	547	549	0	15
30	200	12.6	50.0	39.3	6.6	244	0.07-0.13	0.94	7.1	26.2	540	542	203	17
31	200	13.2	48.2	37.3	2.6	259	0.04-0.10	0.96	8.1	27.5	538	542	298	19

(Table continued)

Table 23 (continued)
U. S. Filter
Filtration Data for January 1980

Date, Jan 1980	Run	K125 SRC Analyses: Ash, %	CI, %	Solv, %	Melting Point, °F	GC Analysis of Solvent in Filter Cake: IBP-350°F, wt %	350-450°F, wt %	450-550°F, wt %	Cake Drying Conditions: Final Vacuum, In. Hg	Temp, °F
1	194-5	0.96	4.43	3.8	520	-	-	-	-	-
2	195-6	1.06	-	-	-	1.8	41.0	32.7	13	481-468
3	196	1.84	-	-	-	2.1	40.5	29.4	12	482-464
(a)						-	-	-	-	-
5	197	2.88	-	-	-	2.1	51.3	31.3	13	483-452
6	197	0.39	0.45	5.2	487	-	-	-	-	-
(b)										
7	197	0.26	-	-	-	-	-	-	-	-
8	197-8	0.33	-	1.43	432	0	60.1	27.3	13	476-447
9	198	0.15	-	-	-	0	56.5	26.2	13	471-439
10	198	0.25	2.0	7.0	500	0	54.7	30.8	13	473-439
11	198	0.21	4.5	3.7	371	0.2	58.3	30.8	13	469-436
(c)										
12	198	-	-	-	-	-	-	-	-	-
13	198	0.11	2.1	6.7	352	-	-	-	-	-
14	199	-	-	-	-	10.3	25.1	31.5	13	483-450
15	199	0.18	1.0	4.2	500	0.8	23.0	36.2	14-22	483-453
16		0.31	5.1	2.2	417	-	-	-	-	-
17		0.29	2.7	4.6	554	3.7	56.6	31.2	12	474-450
18		0.20	0.24	4.5	463	0.5	59.9	33.5	12.5	480-454
19		0.36	1.60	4.5	410	0.6	59.0	28.7	13	483-460
20		0.44	0.47	4.8	345	0	65.7	26.5	13	472-455
21		0.26	6.0	5.8	368	-	-	-	-	-
22		0.22	-	-	-	-	-	-	-	-
23	199	0.28	-	-	-	-	-	-	-	-
(d)		-	-	-	-	-				
26	200	-	-	-	-	0	53.5	31.4	11	476-458
28	200	-	-	-	-	0.4	63.3	25.1	11	475-447
29	200	0.15	0.55	12.2	419	0.5	59.1	24.8	11	478-449
30	200	0.34	-	8.3	332	0.9	59.8	25.7	11	480-447
31	200	0.29	1.9	5.6	404	-	-	-	-	-

*Converted from weight at 8.34 lb/gal.

(a) Leaf D2 had holes in silver-soldered areas; 2-ply with perforated sheet, no spot welds, solution annealed screens were installed.
(b) Screens inspected and replaced.
(c) XV654 valve leaking wash solvent from V141 to V112.
(d) Cut-off blade broken. One screen replaced.

Table 24
U. S. Filter
Filtration Data for February 1980

Date, Feb 1980	Run	No of cycles	Filtration time, min	Cycle time, min	Wash solv, lb/cyc	Filtration Volume: To V120, gal*	Filtration Volume: From V112, gal*	Filtration Rate: gpm	Filtration Rate: gph/ft^2	Precoat, lb/cyc	ΔP, psi: Precoat range	ΔP, psi: Filtration range	ΔP, psi: Filtration avg
1	200	8	91	157	571	230	272	2.6	2.3	7	6-32	20-40	31
(a)													
3	200	12	56	112	377	289	328	5.2	4.7	6	8-13	30-50	50
4	200	8	51	112	356	288	324	5.6	5.1	6.9	8-14	30-50	50
5	200	7	60	117	348	294	341	4.9	4.5	7.2	6-10	25-50	43
(b)													
11	201	2	35	86	344	289	337	8.3	7.5	12	5-9	30-50	50
12	201	9	66	126	334	289	328	4.4	4.0	5.5	7-10	25-50	47
13	201	9	79	149	334	289	329	3.6	3.3	7.1	5-9	25-90	58
14	201	4	70	135	344	288	324	4.1	3.7	4.8	5-10	20-72	50
14 (c)	201	5	99	165	737	273	330	2.8	2.5	0.0	-	20-80	50
15 (c)	201	1	97	157	786	273	361	2.8	2.8	0.0	-	45-48	47
15	201	2	63	137	596	289	337	4.6	4.2	9.5	5-17	30-48	47
16	201	3	60	117	344	289	353	4.8	4.4	4.8	4-11	20-48	48
(d)													
17	201	5	94	154	334	289	345	3.1	2.8	6.2	8-13	20-50	47
18	201	9	97	161	344	289	325	3.0	2.7	4.8	8-15	20-50	50
19	201	9	97	162	366	289	326	3.0	2.7	4.8	8-22	20-50	50
20	201AMB	9	89	158	344	289	325	3.2	3.0	5.5	8-22	20-50	50
21	201BMB	10	80	145	334	288	324	3.6	3.3	6.2	8-17	20-50	50
22	201CMB	10	79	143	346	276	318	3.5	3.2	5.5	8-18	20-50	50
23	201	2	93	161	344	289	329	3.1	2.8	4.8	9-26	20-50	50
(e)													

(Table continued)

Table 24 (continued)
U. S. Filter
Filtration Data for February 1980

Date, Feb 1980	Run	Filter Cake Solv, %	Filter Cake Ash, %	Filter Cake UC, %	Filter Cake SRC, %	wt, lb	Filtrate solids, wt %	V110 LFSFE sulfur, wt %	Filter feed solids, wt %	Filter feed SRC, wt %	Filter Temperature Avg In, °F	Filter Temperature Avg Out, °F	Sluice, lb/cycle	Wash time, min
1	200	15.1	36.5	48.1	3.3	194	0.05-1.4	0.92	7.9	28.7	533	542	316	11
(a)														
3	200	11.3	41.4	45.7	1.4	245	0.05-0.7	0.88	7.0	28.1	537	551	0	10
4	200	16.1	47.4	36.3	6.1	232	0.07-0.12	0.92	5.6	25.1	533	547	107	11
5	200	11.5	47.6	38.6	4.1	247	0.06-0.08	0.88	5.7	27.4	537	549	245	13
(b)														
11	201	-	-	-	-	218	0.04-0.06	-	-	-	541	543	0	7
12	201	12.9	47.2	32.7	7.2	249	0.03-0.10	0.81	6.8	29.7	534	546	95	14
13	201	13.7	47.6	34.8	5.2	254	0.05-0.13	0.89	7.3	27.7	545	559	286	21
14	201	14.5	40.7	39.5	3.9	239	0.05-0.09	0.84	7.5	25.7	532	559	0	18
14 (c)	201					190	0.07-0.20	-	-	-	523	531	582	29
15 (c)	201	-	-	-	-	241	0.08	-	-	-	538	540	906	16
15	201	-	-	-	-	231	0.08	-	-	-	549	554	882	14
16	201	-	-	-	-	236	0.03-0.10	-	-	-	550	550	0	7
(d)														
17	201	-	-	-	-	221	0.08-0.12	1.00	6.9	25.1	544	545	172	9
18	201	8.1	48.1	35.1	4.8	255	0.06-0.12	0.90	7.0	27.3	529	549	0	18
19	201					248	0.09-0.15		7.2		520	546	95	19
20	201AMB					239	0.08-0.11	0.98	8.2	30.7	525	548	196	21
21	201BMB	8.1	48.0	35.7	5.1	248	0.04-0.15	0.97	7.6	30.3	527	545	91	17
22	201CMB					237	0.06-0.12	0.96	7.5	30.0	530	548	186	16
23	201	-	-	-	-	256	0.09-0.10		-	-	522	548	0	19
(e)														

(Table continued)

Table 24 (continued)
U. S. Filter
Filtration Data for February 1980

Date, Feb 1980	Run	K125 SRC Analyses: Ash, %	CI, %	Solv, %	Melting Point, °F	GC Analysis of Solvent in Filter Cake: IBP-350°F, wt %	350-450°F, wt %	450-550°F, wt %	Cake Drying Conditions: Final Vacuum, In. Hg	Temp, °F
1	200	1.05	4.9	4.9	342	1.9	37.8	27.6	11	390-458
(a)										
3	200	0.45	2.0	4.4	427	-	-	-	-	-
4	200	0.47	3.05	4.7	365	0	39.3	29.4	11	484-463
5	200	0.14	-	-	-	0	33.3	30.3	11	499-474
(b)										
11	201		-	-						
12	201	0.34	0.95	10.7	266	0.1	37.6	35.3	10	499-473
13	201	0.34	1.1	11.2	375	0.9	26.2	29.4	11	500-478
14	201					2.2	41.8	32.0	10	491-470
14(c)	201	0.54	3.2	5.5	356					
15(c)	201			-						
15	201									
16	201	0.64	1.15	3.8	365					
(d)										
17	201	0.37	1.80	2.4	347					
18	201	0.36	3.50	7.7	>536	1.9	48.4	37.7	11	492-468
19	201	0.28								
20	201AMB									
21	201BMB	0.30	2.9	6.2	385					
22	201CMB									
23	201	0.37								
(e)										

*Converted from weight at 8.34 lb/gal.

(a) Seal between rear hub and retaining plate on 5-in. shaft blew, solution annealed; leaves replaced.
(b) Plant down.
(c) No precoat operation.
(d) Using Johns-Manville Hyflo Super-Cel as precoat.
(e) Filter leaves and cut-off blades in good condition.

Table 25
T102 Vacuum Column Operating Data

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Operating Conditions			
Pressure, psia	1.0	0.8	0.7
Flow rates, lb/hr			
Feed			
from V110	1,448	1,189	1,152
from T104 bottom	0	0	0
Overhead Light Solvent			
to T104 feed	112	108	-
Tray 1 reflux	1,100	1,050	1,000
Wash Solvent (Tray 3)			
To V178	To T105	To T105	To T105
Process Solvent (Tray 8)			
to V131B			
Bottoms (SRC)			
to K125/CSD	337	401	400
to B103	-	-	-
Temperature, °F			
Tray 1 (ovhd)	195	195	195
Tray 8	357	349	348
Packing reflux	363	361	369
B103 outlet	573	552	553
Bottom	830	628	723
Product Pump Power, amps	36	38	38
Compositions, wt %			
Tray 3			
IBP-350°F			
350-450°F			
450°F-EP	To T105	To T105	To T105
Tray 8			
IBP-350°F			
350-450°F			
450°F-EP			

Table 26
T105 Fractionation Column Operating Data

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Operating Conditions			
Pressure, psig	4.5	4.5	4.5
Rate, lb/hr			
Feed	1,270	935	904
Overhead product	427	117	56
Reflux	-	5,500	4,600
Vent	-	-	-
Reboiler	116,250	117,500	115,000
Temperature, °F			
Top	395	384	372
Reflux	391	380	366
Middle	-	-	-
Feed	302	310	300
Bottom	492	493	477
Reboiler	563	563	556
Composition, wt %			
Overhead			
Light organic liquid	4.9	6.3	13.1
Wash solvent	84.0	77.4	80.5
Bottom			
Light organic liquid	0	0	0
Wash solvent	1.4	0.5	1.4
Feed			
Light organic liquid	1.8	0.2	0.1
Wash solvent	15.0	10.2	3.4

Table 27
Recovered Solvent Analyses

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Recycle Solvent from T105 btm			
Boiling Fractions, wt %			
(IBP, °F)	(442)	(460)	(424)
IBP-350°F	0	0	0
350-450°F	1.4	0.5	1.4
450-550°F	42.9	44.8	45.0
550-650°F	23.1	23.9	23.7
650°F-EP	32.6	30.8	29.9
(EP, °F)	(910)	(878)	(888)
Specific Gravity	1.023	1.016	1.010
Ultimate Analysis, wt %			
Carbon	87.48	87.62	86.71
Hydrogen	8.29	8.60	8.92
Nitrogen	0.35	0.58	0.57
Chlorine	-	-	-
Sulfur	0.35	0.37	0.35
Ash	<0.01	<0.01	<0.01
Oxygen (by difference)	3.53	2.83	3.45
Wash Solvent from T105 ovhd			
Boiling Fractions			
(IBP, °F)	(231)	(210)	(194)
IBP-350°F	4.9	6.3	13.1
350-450°F	84.0	77.4	80.5
450-550°F	11.1	16.3	6.4
550-650°F	0	0	0
650°F-EP	0	0	0
(EP, °F)	(466)	(483)	(466)
Specific Gravity	0.951	0.928	0.917
Ultimate Analysis, wt %			
Carbon	83.98	83.80	83.88
Hydrogen	9.62	10.21	10.37
Nitrogen	0.84	1.39	1.78
Chlorine	-	-	-
Sulfur	0.12	0.23	0.27
Ash	<0.01	<0.01	<0.01
Oxygen (by difference)	5.44	4.37	3.70

Table 28
Organic Liquid Analyses
Kentucky 9 Coal

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Organic Liquid from V105			
Boiling fractions, wt %			
(IBP, °F)	(144)	(130)	(131)
IBP-200°F	3.9	4.4	8.4
200-350°F	3.4	4.2	4.8
350-450°F	7.4	6.3	7.9
450°F-EP	85.3	85.1	78.9
(EP, °F)	(763)	(713)	(808)
Specific Gravity	0.964	0.955	0.940
Ultimate Analysis, wt %			
Carbon	87.08	87.10	87.03
Hydrogen	9.02	9.36	9.76
Nitrogen	0.88	1.42	1.73
Sulfur	0.41	0.31	0.34
Ash	<0.01	<0.01	<0.01
Oxygen (by difference)	2.61	1.81	1.14
Organic liquid from T102 ovhd			
Boiling fractions, wt %			
(IBP, °F)	(231)	(210)	(231)
IBP-200°F	0	0.4	0.2
200-350°F	15.7	8.0	5.7
350-450°F	63.9	56.7	46.7
450°F-EP	20.4	34.9	47.4
(EP, °F)	(676)	(531)	(549)
Specific Gravity	0.925	0.923	0.934

Table 29
T104 Light Solvent Recovery Column Operating Data
Kentucky 9 Coal

Date, 1979	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Operating Conditions			
Pressure, psig	9.0	8.6	8.5
Flow rates, lb/hr			
Feed			
from V105	158	149	164
from T102	112	108	-
Overhead			
Product	0.2	2.3	12.5
Reflux	0	0	0
Vent	0	0	0
Temperature, °F			
Top	-	196	198
Bottom	-	545	546
Feed	~300	~300	~300
Composition, wt %			
Feed			
IBP-350°F	8.9	7.4	10.6
350-450°F	4.2	6.5	6.4
450°F-EP	86.9	86.1	83.0
Water in feed			
from V105	0.3[a]	0.4[a]	0.4[a]
from T102	1.2[a]	1.1[a]	1.0[a]
Overhead oil			
IBP-350°F	98.4	99.3	99.6
350-450°F	1.6	0.7	0.3
450°F-EP	0	0	0.1
Bottom			
IBP-350°F	5.6	2.0	6.7
350-450°F	9.5	8.7	11.1
450°F-EP	84.9	89.3	82.2
Specific Gravity			
Overhead	0.744	0.748	0.739
Bottom	0.978	0.972	0.963
Feed	0.966	0.956	0.950

(a) % water by Dean-Stark.

Table 30
Organic Liquid Product Analyses
Kentucky 9 Coal

Date, 1980	19-21 Feb	6 Mar	14-16 Mar
Run	201ABC MB	202A MB	203DE MB
Recycle solvent (V131B)			
Boiling fractions, wt %			
(IBP, °F)	(451)	(449)	(424)
IBP-350°F	0	0.2	0
350-450°F	0.2	0.4	1.6
450-550°F	47.9	46.8	46.5
550-650°F	23.9	25.5	24.1
650°F-EP	28.0	27.1	27.8
(EP, °F)	(867)	(838)	(872)
Specific Gravity	1.019	1.013	1.012
Ultimate Analysis, wt %			
Carbon	87.77	87.40	87.27
Hydrogen	8.39	8.70	8.77
Nitrogen	0.39	0.49	0.63
Chlorine	-	-	-
Sulfur	0.60	0.38	0.39
Ash	0	0.03	0
Oxygen (by difference)	2.85	3.00	2.94
Light Organic Liquid from T104 ovhd			
Boiling fractions, wt %			
(IBP, °F)	(153)	(130)	(131)
IBP-200°F	66.0	56.2	67.4
200-350°F	32.4	43.1	32.3
350-450°F	1.6	0.7	0.2
450°F- EP	0	0	0.1
(EP, °F)	(377)	(360)	(322)
Specific Gravity	0.744	0.748	0.739
Ultimate Analysis, wt %			
Carbon	85.21	84.79	85.00
Hydrogen	14.01	13.62	13.53
Nitrogen	0.46	1.08	1.07
Chlorine	-	-	-
Sulfur	0.32	0.30	0.40
Ash	<0.01	<0.01	0
Oxygen (by difference)	0	0.21	0

Table 31
Ash Concentrate Analyses KM-CSD Unit
DAS-free Basis
Dotiki Coal

Date, 1980	6 March	14-16 March
Run	202A MB	203D-E MB
Composition, wt %		
Ash	28.7	32.3
Unreacted coal	33.3	38.7
Solvent refined coal	34.43	25.74
Solvent	2.19	2.15
Deashing solvent	1.38	1.11
Solvent Extraction Analyses, wt %		
Oil	5.3	11.5
Asphaltenes	4.6	5.4
Benzene insoluble (cresol soluble)	28.1	12.1
Cresol insoluble	33.3	38.7
Ash	28.7	32.3
Ultimate Analyses, wt %		
Carbon	57.16	57.64
Hydrogen	2.59	2.69
Nitrogen	0.81	1.06
Ash	28.7	32.3
Sulfur	2.95	1.81
Chlorine	0.66	0.01
Oxygen	7.13	4.49

Table 32
Analysis of Plant Component Problems for January 1980

Item	Type of Failure	Cause	Process Conditions	Operating hours between failures	Priority Code (1)	Action	Future Action
F125 Vertical Leaf Filter	Holes in screens	Corrosion, poor screen fabrication process	535°F, 6.6% solids in feed	Less than 24	B	Replaced screens with solution-annealed type	None
XV-654 Filter Feed Recycle Valve	Galled seat	Unknown	80 gpm of filter feed at 550°F and 1.0 psi DP	18,000	B	Replaced valve	None
TV-239 B102 Slurry Preheater Fuel Control Valve	Loss of flow control	Valve fouled, hole in actuator air line	10 gph of No. 2 fuel oil at 80°F and 30 psi DP.	2,000	B	Replaced air line, clean valve	Clean valve on each shut-down
FV-997 SRC Recycle Control Valve	Leaking, hole eroded in body	Corrosion/ erosion	SRC at 600°F and 20-30 psi DP, with and without ash and undissolved coal	8,000	D	Replaced valve body	None
B103 Vacuum Column Preheater Fuel Gas Pressure Regulator	Balance spring in regulator	Unknown	LPG set pressure at 17 psig, 70°F	Less than 2,000	B	Removed and repaired	None
R101 Dissolver Nuclear Density Gauges	Electronic, in detector	Unknown	Dissolver wall at 700°F, atmospheric pressure	Has not worked correctly in six months	D	Returned unit to manufacturer for repair	None
B203 Dowtherm Heater Temperature Control Unit	Electronic component	Total plant power failure	Not applicable	50,000	D	None	Replace unit
P111-B Filter Feed Pump	Seal failure	O-ring failure	80 gpm at 550°F and 150 feet TDH	1,750	C	Replaced O-ring and seal	None
P111-B Filter Feed Pump	Seal failure	Bearing failure	80 gpm at 550°F and 150 feet TDH	250	C	Replaced bearing and seal	None

Table 33
Analysis of Plant Component Problems for February 1980

Item	Failure	Cause	Process Conditions	Operating hours between failures	Priority Code(1)	Action	Future Action
F125 Vertical Leaf Filter	Blown gaskets	Improper gasket compression	Process slurry at 550°F and 110 psig.	200	B	Replaced gasket	None
B102 Slurry Preheater	High coil film Δt's	Coke in coil	1,700 psig and 820°F at heater outlet, 38.5% slurry of Lafayette coal	1,500	A	Decoked heater	None
B102 Slurry Preheater	Flame out	Wet atomizing steam	Not applicable	175	A	Relit heater	None
B102 Slurry Preheater	"	"	"	72	A	Switched heater to air only	None
B102 Slurry Preheater	"	Clinker in burner	"	150	A	Cleaned burner	Check fuel/air ratio more often
B103 Vac Col Preheater	High coil film Δt's	Coke in coil	630°F outlet 20:1 vacuum column bottoms recycle to feed	3,000	A	Decoked heater	None
R101 Dissolver Nuclear Density Gauges	Unknown	Mfg did not repair units	Not applicable	0	D	Returned to manufacturer	Have mfg. rep. install gauges
R101 Dissolver Bottom Head Gasket	Leak	Dissolver cooled off	R101 temp: 823°F Pressure: 1,700 psig	800	A	Replaced gasket	None
T102 tray 8 Ring Gasket (Asbestos)	Leaking	Gasket binder dissolved	600°F, 2 psia, process solvent	3,000	A	Replaced tray weld in place	None
P180A	Packing leak	Packing being dissolved by solvent	1,000 psig discharge, 600°F inlet	20	C	Replaced packing	Order new type packing
P180B	"	"	"	60	C	"	"

Table 34
Analysis of Plant Component Problems for March 1980

Item	Type Failure	Cause	Process Conditions	Operating hours between failures	Priority Code[(1)]	Action	Future Action
P108A Water Scrubber Pumps	Bearings	Unknown	Process water at 1,200 psig, 100°F	Unknown	C	Replaced bearings	None
P106 Caustic Scrubber Pump	Bearings	Seal failed, allowing caustic to enter crankcase	4% caustic at 1,200 psig, 100°F	Unknown	C	Replaced bearings	Inspect seals more often
P180 A and B CSD Feed Pumps	Packing Crank Bearings	Heavy loading on bearings	SRC at 600°F and 20-30 psig with ash	P180-A (40) P180-B (2)	B	Rebuilt pumps	Install lubricator on packing and re-engineer suction piping. Look at alternate pumps
T101 Hydrogen Scrubber	Plugged	Solids carryover in gas stream	Acidic recycle gas, caustic at 1,200 psig	One year	A	Cleaned	None
B203 Dowtherm Heater	Plug wire burned	Unknown	Not applicable	Unknown	B	Replaced wire	None
B203 Dowtherm Heater	Burner nozzle plugged	Trash in fuel	No. 2 Fuel Oil at 80°F and 30 psig	Unknown	B	Cleaned nozzle	Change fuel filters weekly instead of bi-weekly
CSD Letdown System	Will not operate	Material buildup around stem	Not applicable	Unknown	C	Cleaned	None

(1) Priority Code:
(A) Requires immediate plant shutdown to repair.
(B) Plant operation is crippled, requires immediate attention.
(C) Operating spare is available. Jeopardy situation exists.
(D) Plant operation is not seriously impaired.

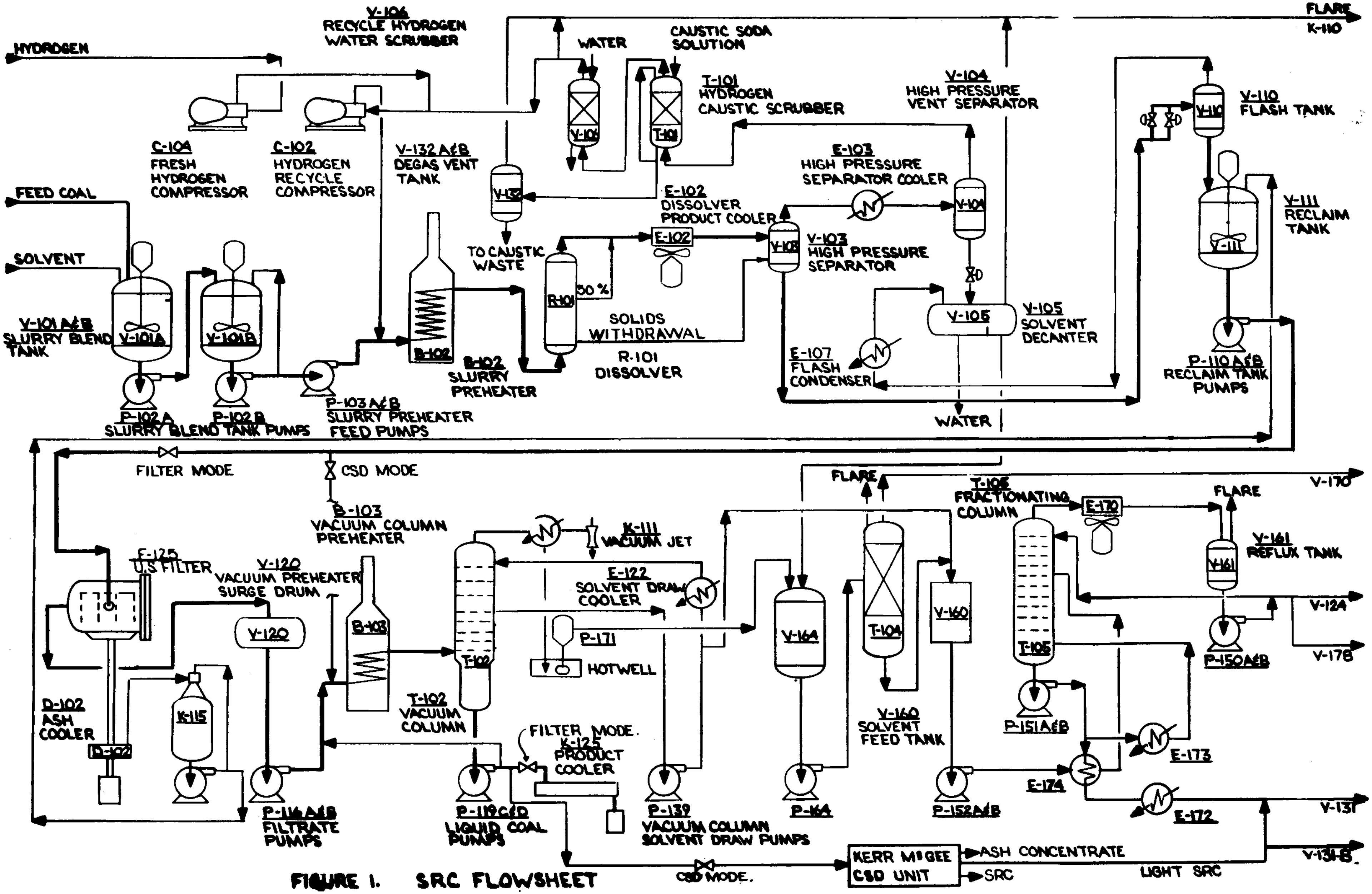

FIGURE 1. SRC FLOWSHEET

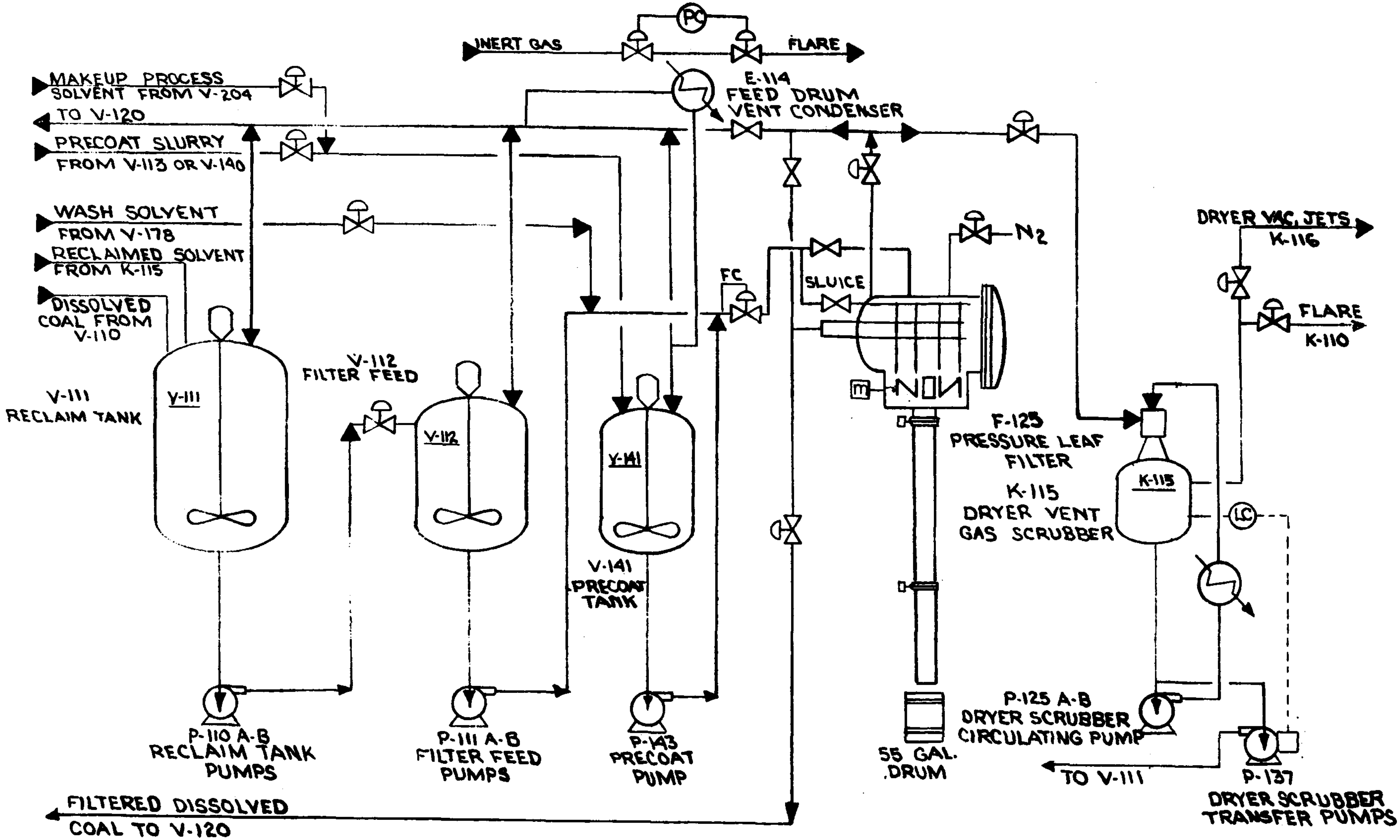

FIGURE 2. FILTRATION FLOWSHEET (U.S.F. FILTER)

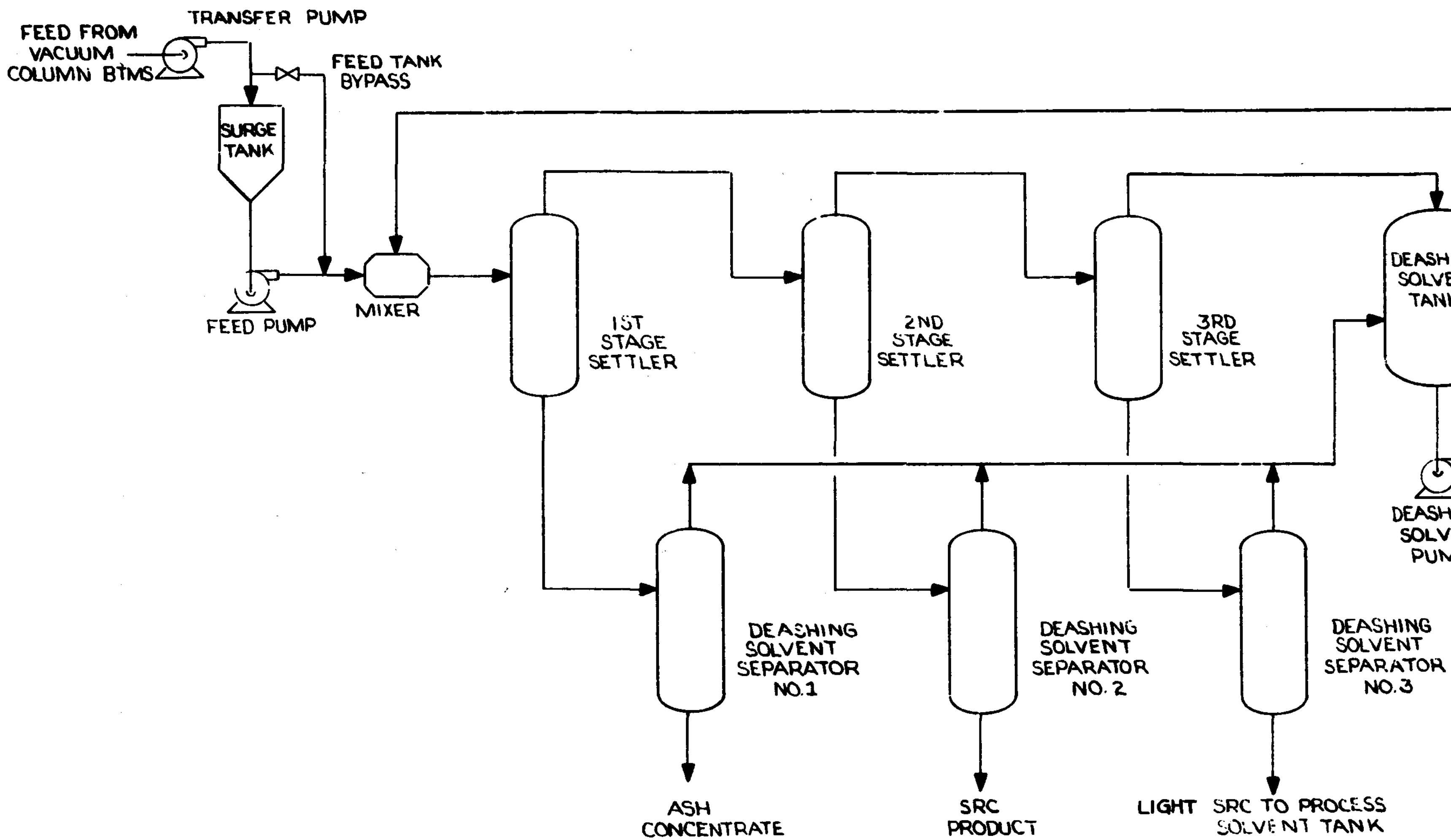

FIGURE 3. CRITICAL SOLVENT DEASHING PROCESS FLOW DIAGRAM

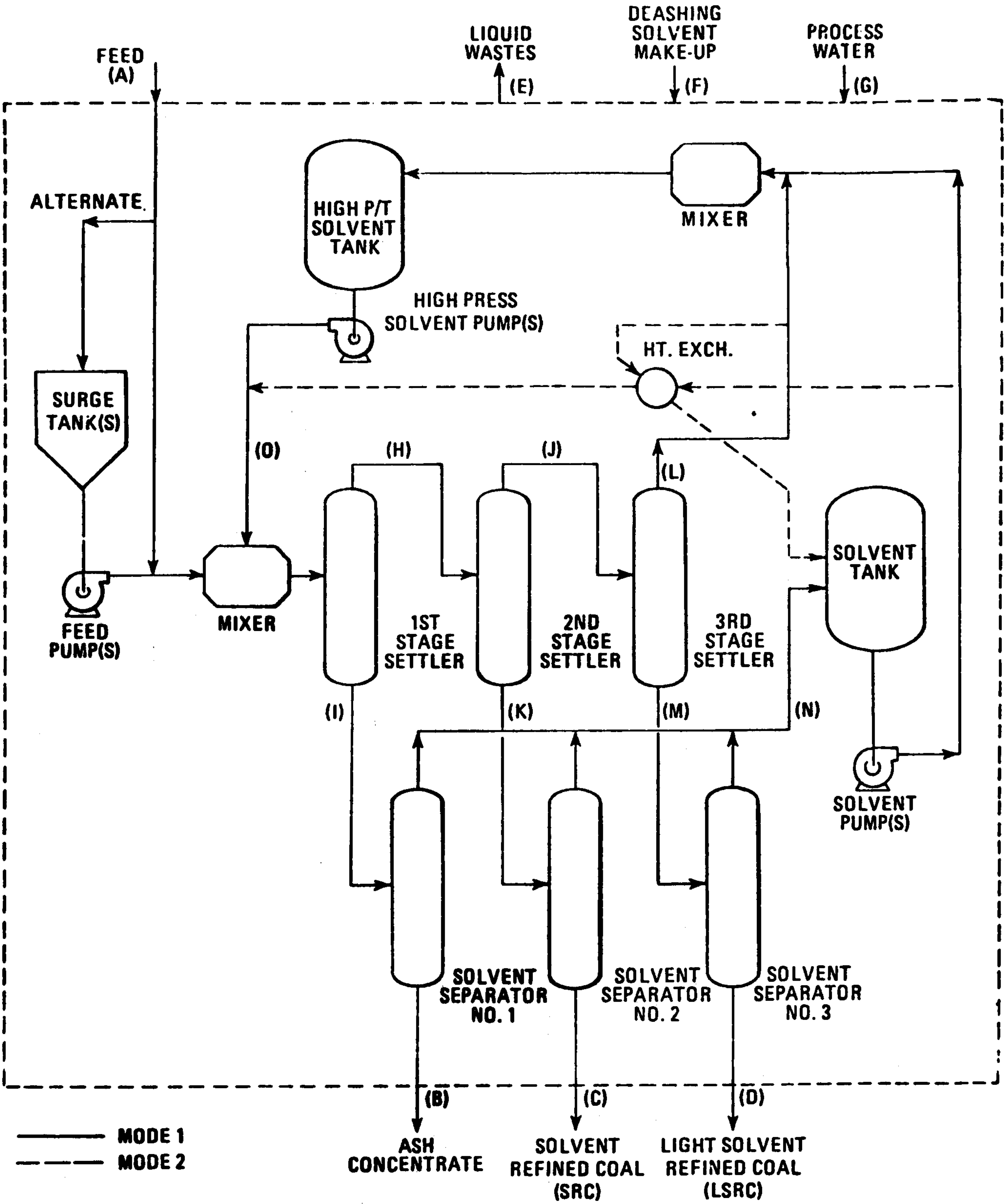

FIGURE 4. MODIFIED THREE-STAGE CRITICAL SOLVENT DEASHING UNIT

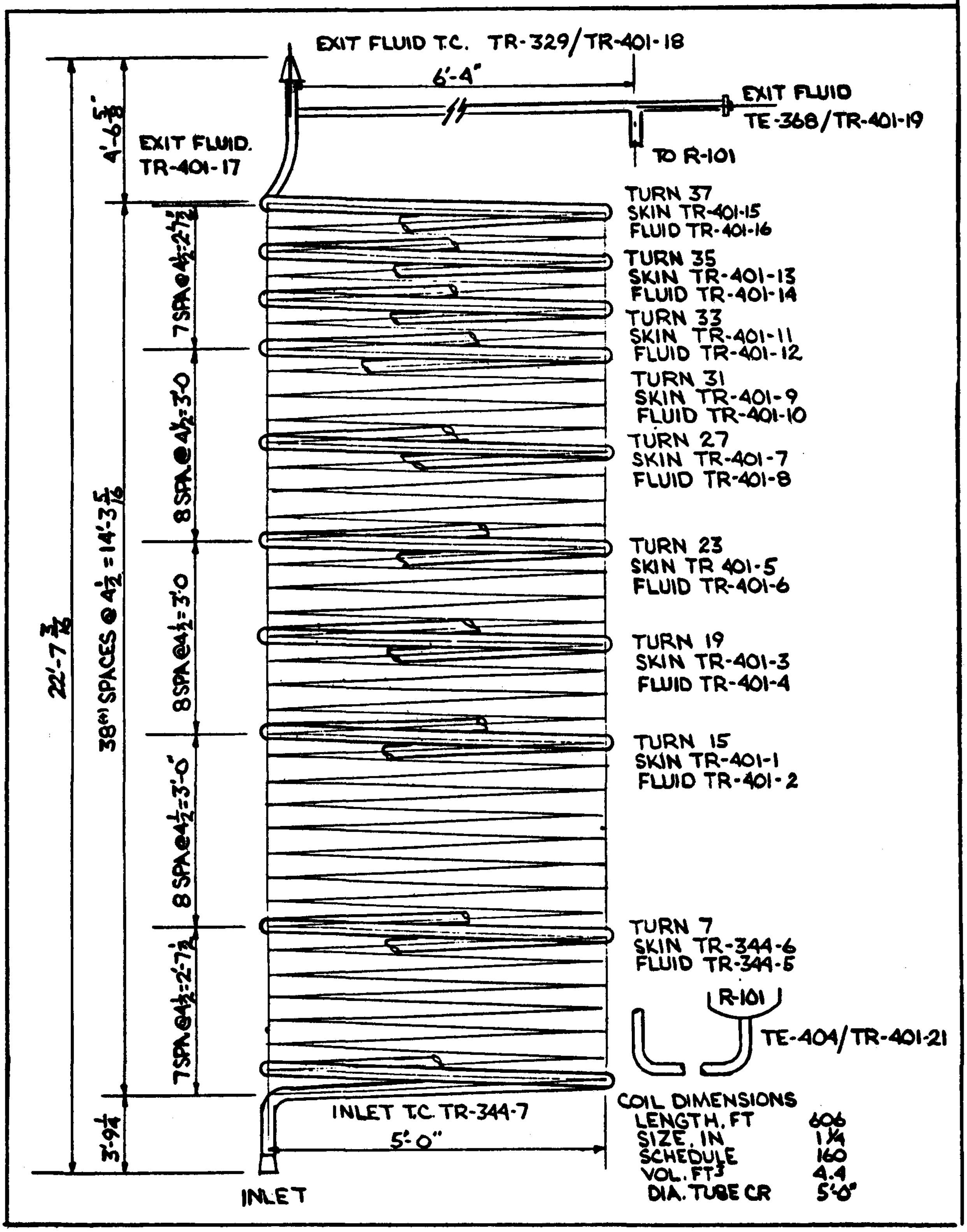

FIGURE 5. B-102 SLURRY PREHEATER THERMOCOUPLE LOCATIONS

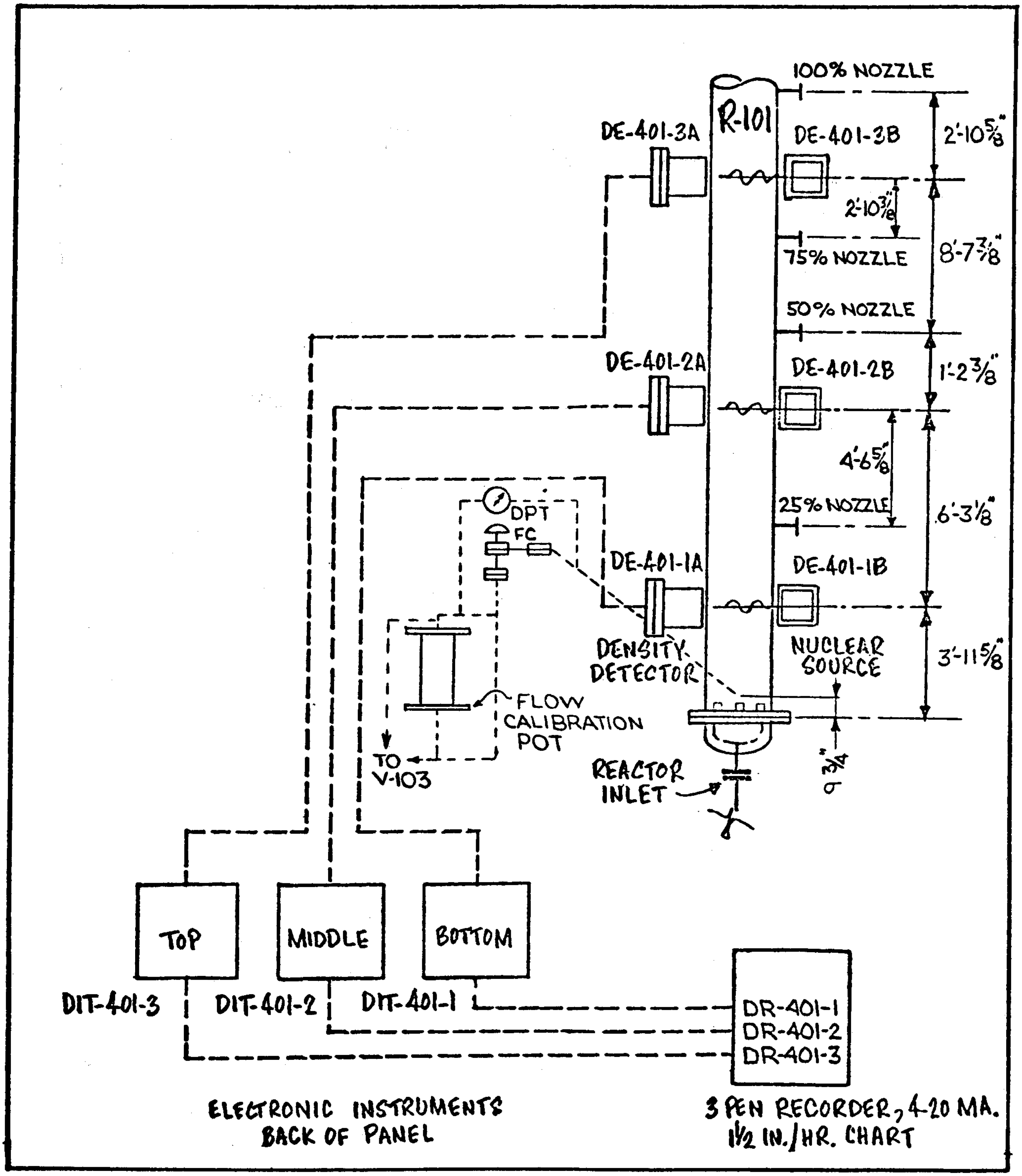

FIGURE 6. DISSOLVER SOLIDS MEASUREMENT AND CONTROL SYSTEM

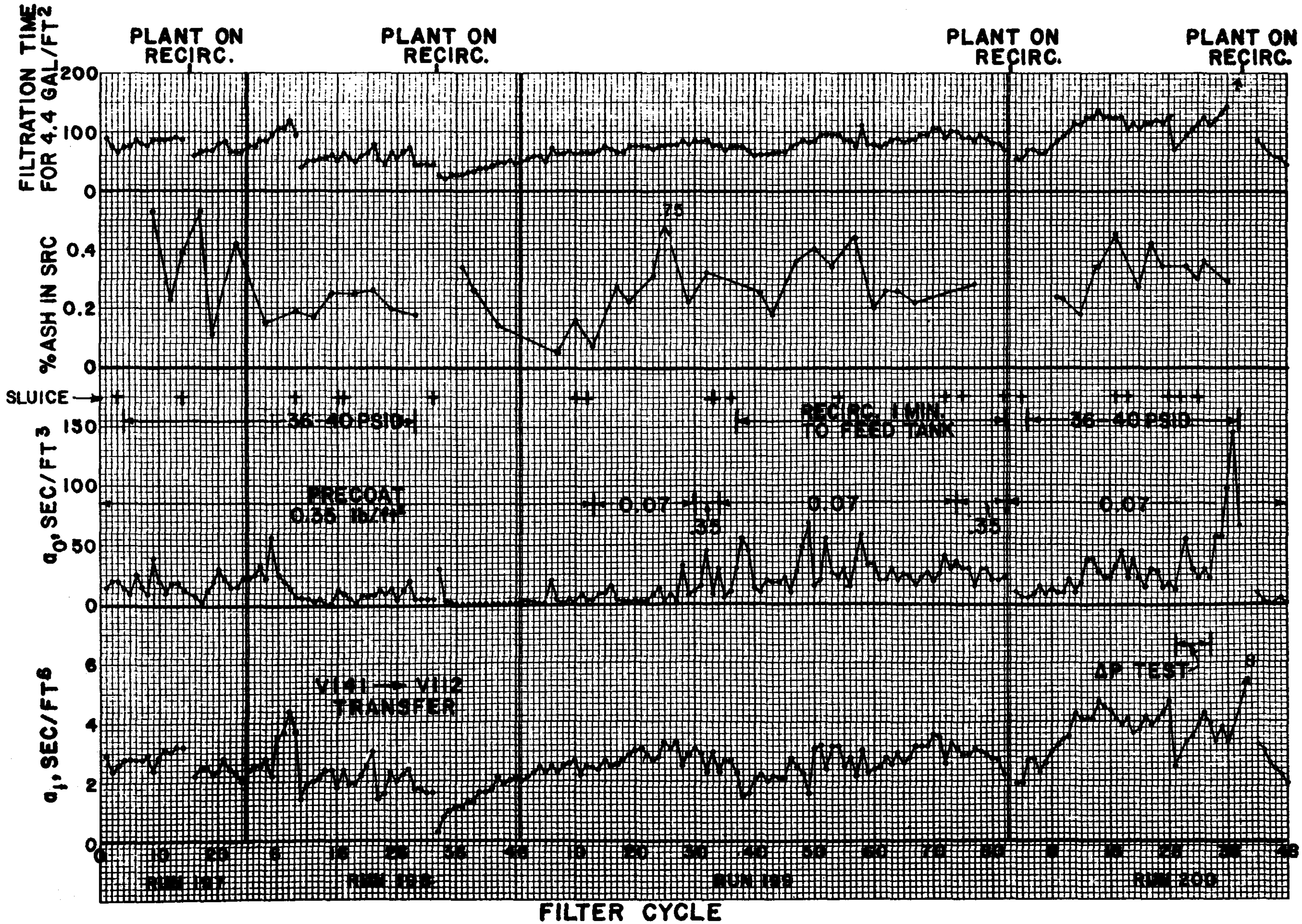

FIGURE 7. FILTER CYCLE DATA FOR JANUARY 1980

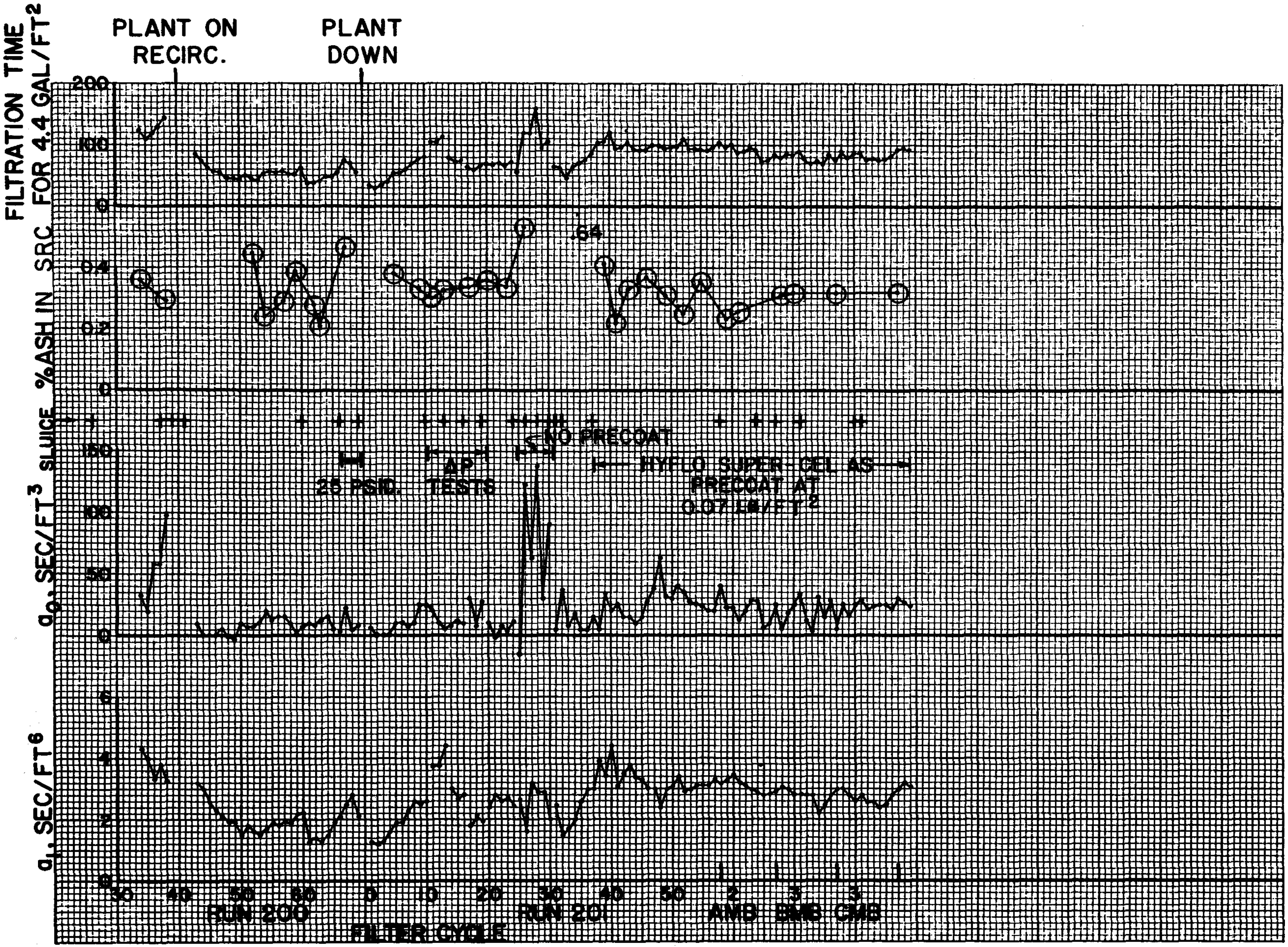

FIGURE 8. FILTER CYCLE DATA FOR FEBRUARY 1980

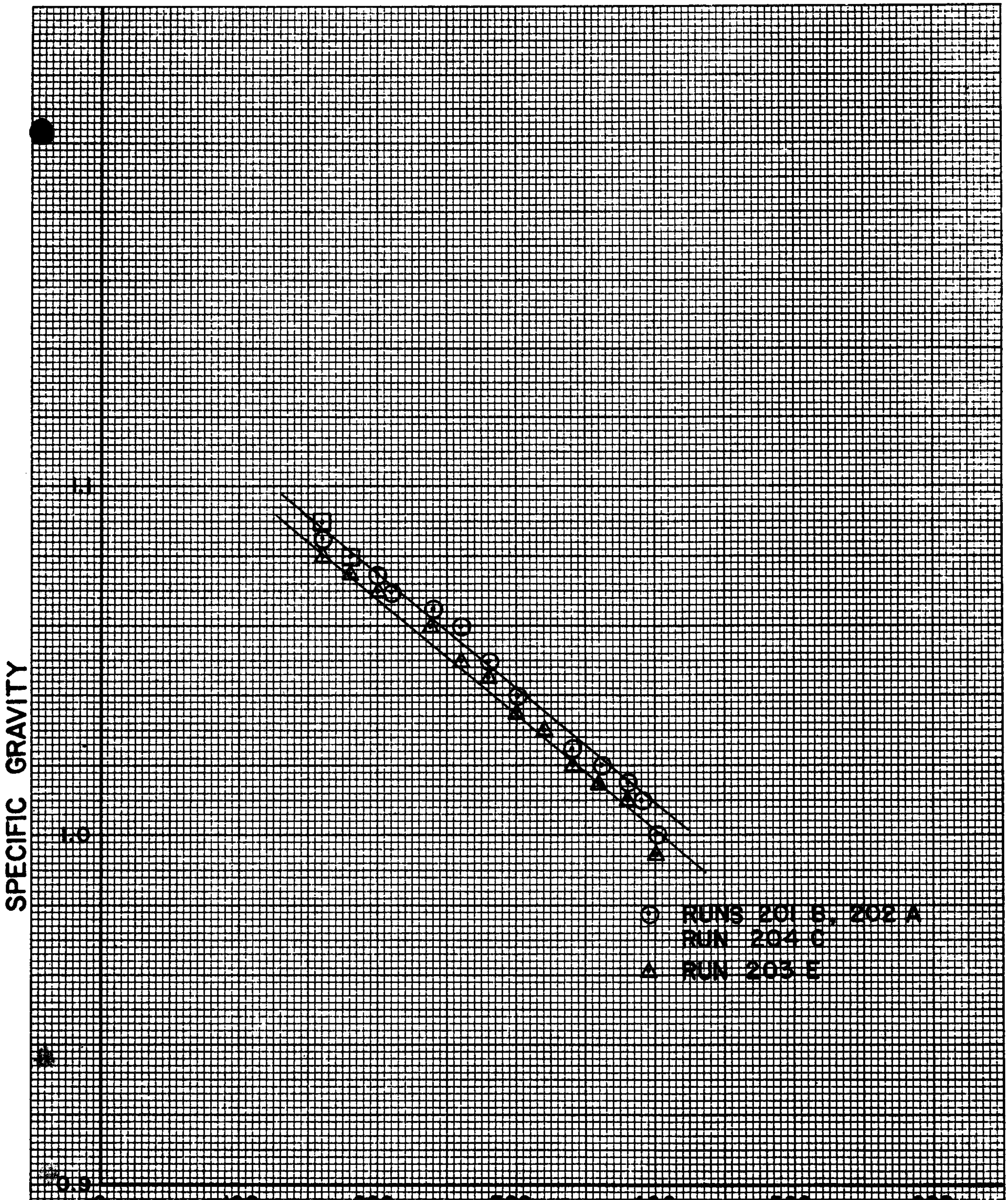

FIGURE 9. SPECIFIC GRAVITY VERSUS TEMPERATURE FOR REACTION PRODUCT FROM KENTUCKY 9 COAL

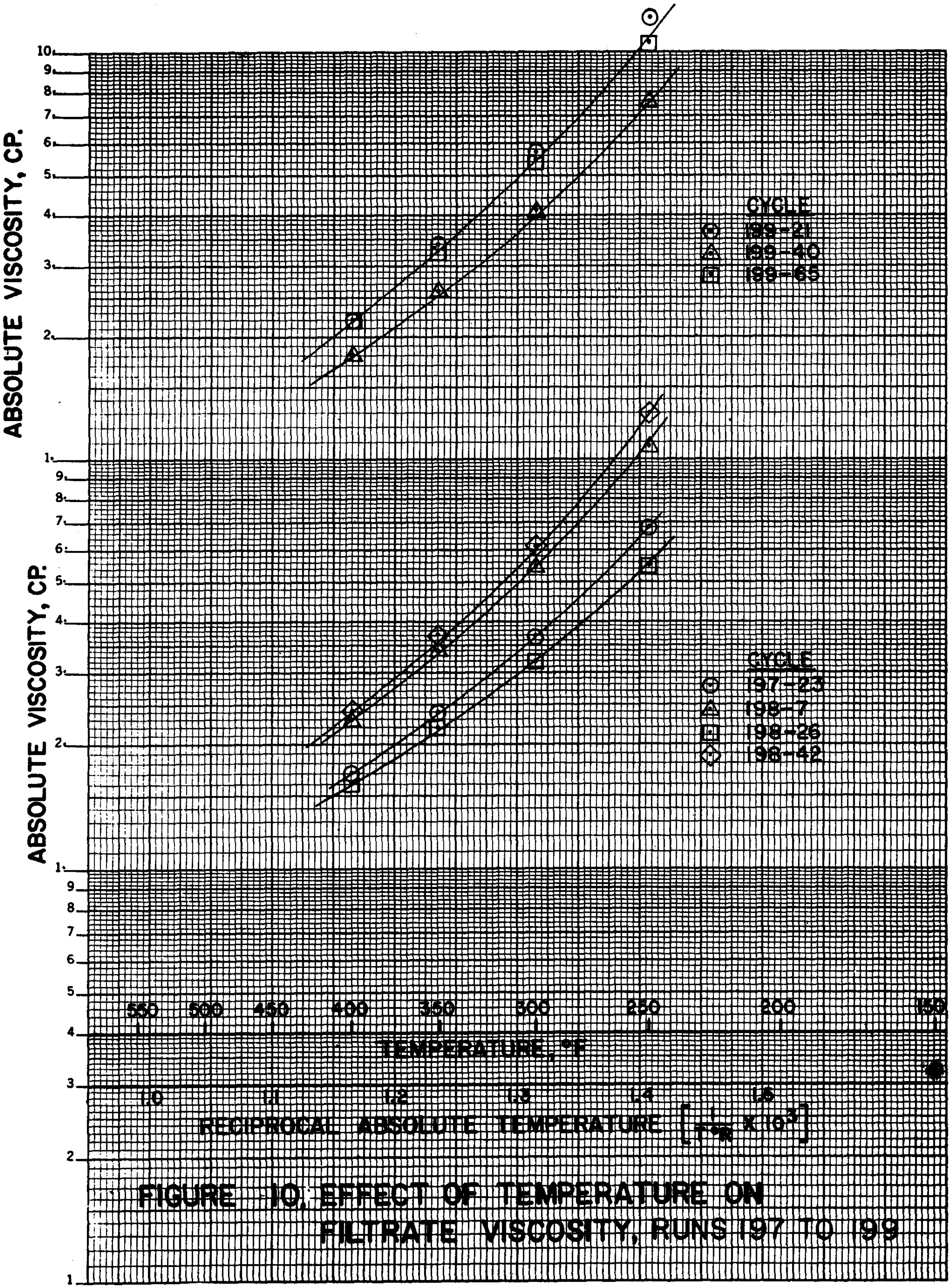

FIGURE 10. EFFECT OF TEMPERATURE ON FILTRATE VISCOSITY, RUNS 197 TO 199

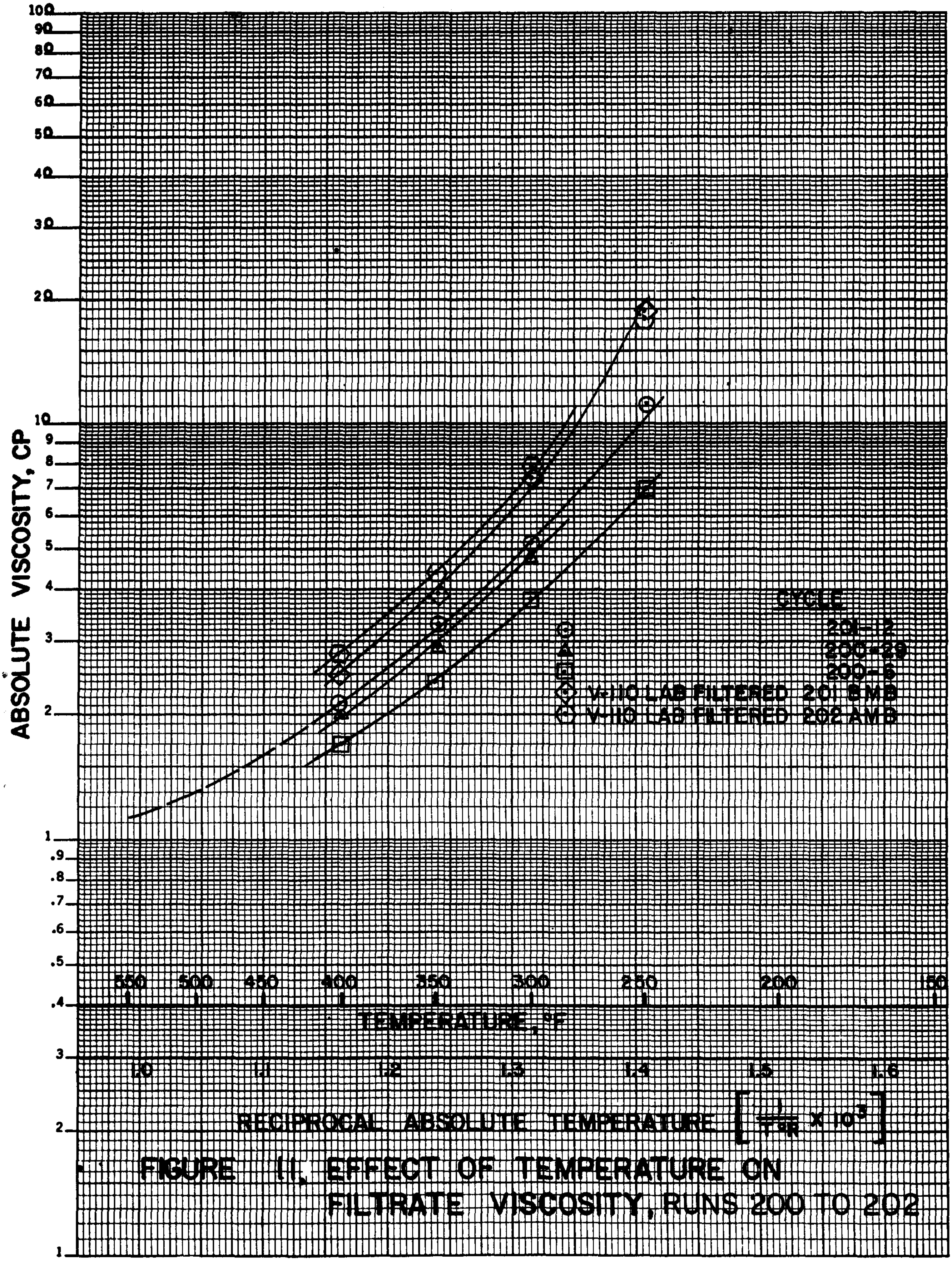

FIGURE 11. EFFECT OF TEMPERATURE ON FILTRATE VISCOSITY, RUNS 200 TO 202

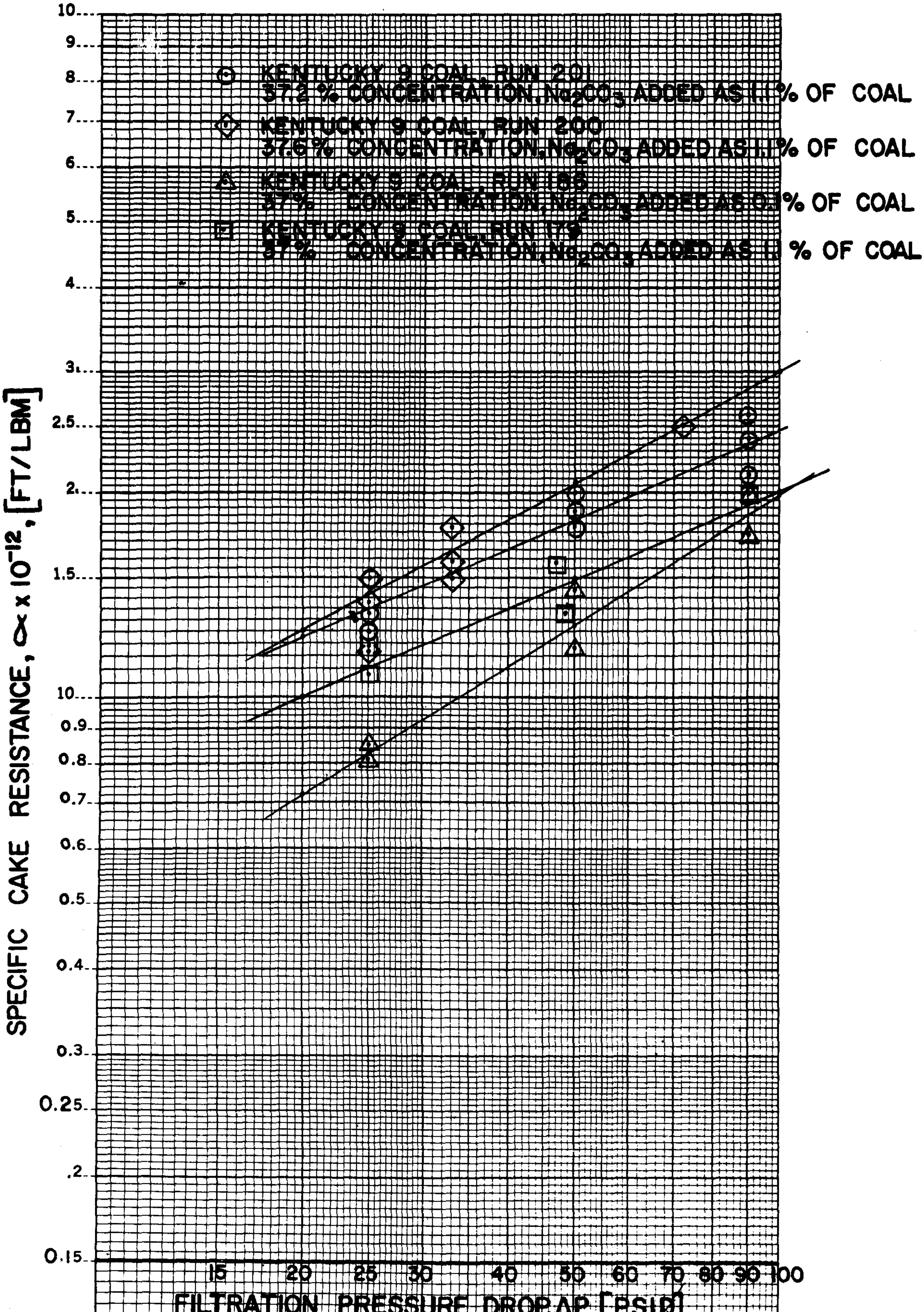

FIGURE 12. SPECIFIC CAKE RESISTANCE VERSUS FILTRATION PRESSURE DROP.

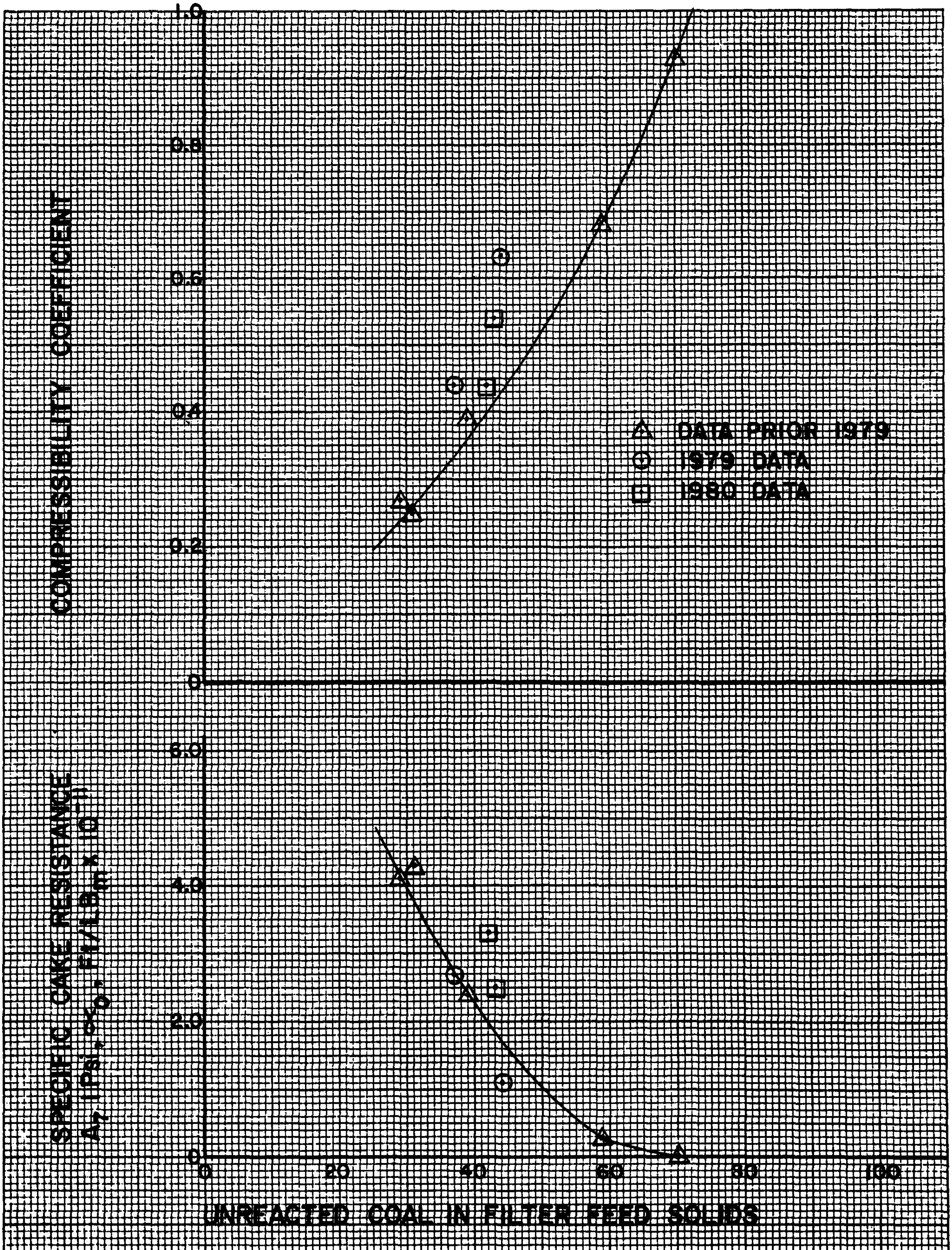

FIGURE 13. EFFECT OF FILTER FEED COMPOSITION ON FILTRATION MODEL PARAMETERS

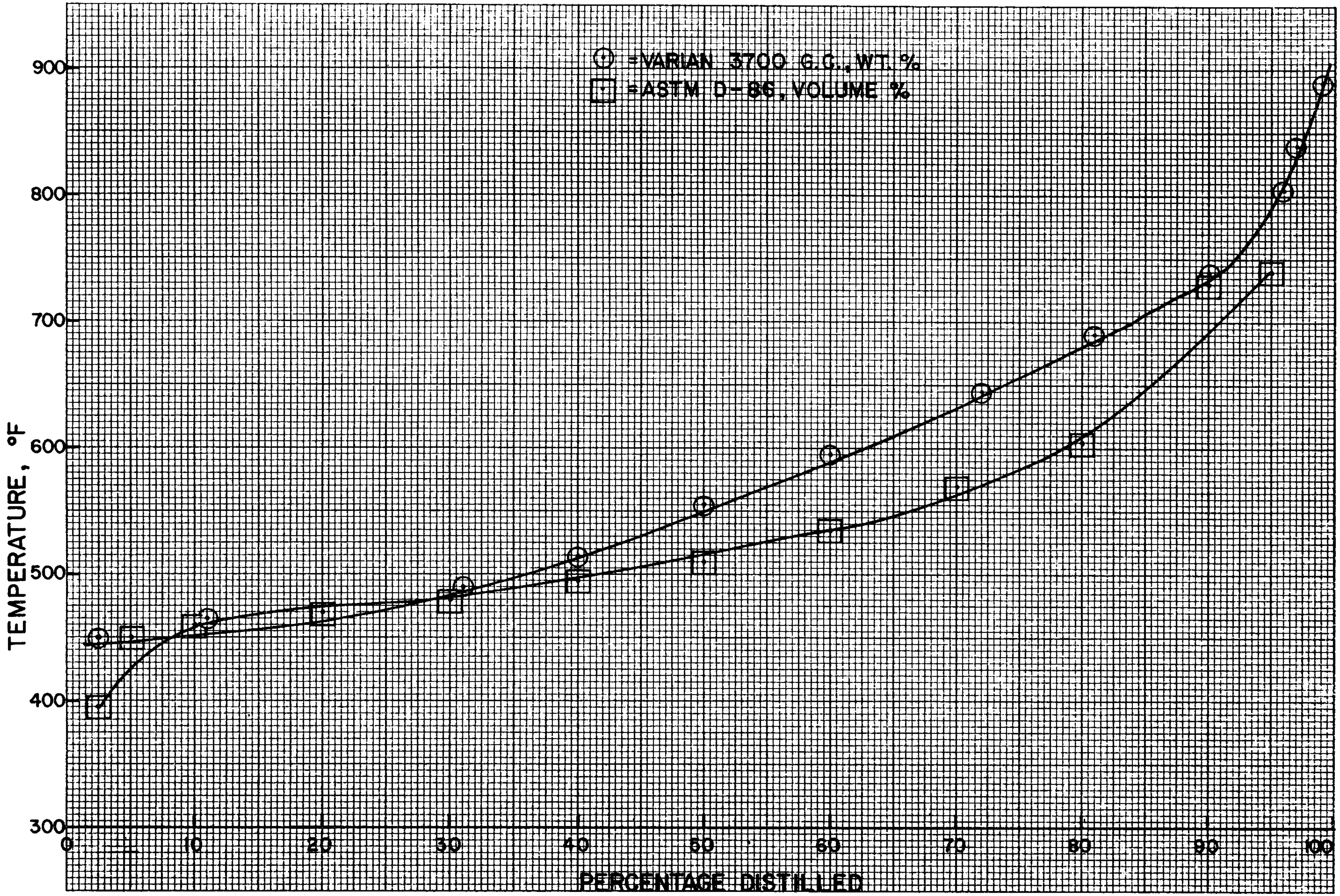

FIGURE 14. PROCESS SOLVENT DISTILLATION CURVES (RUN 201A MB)

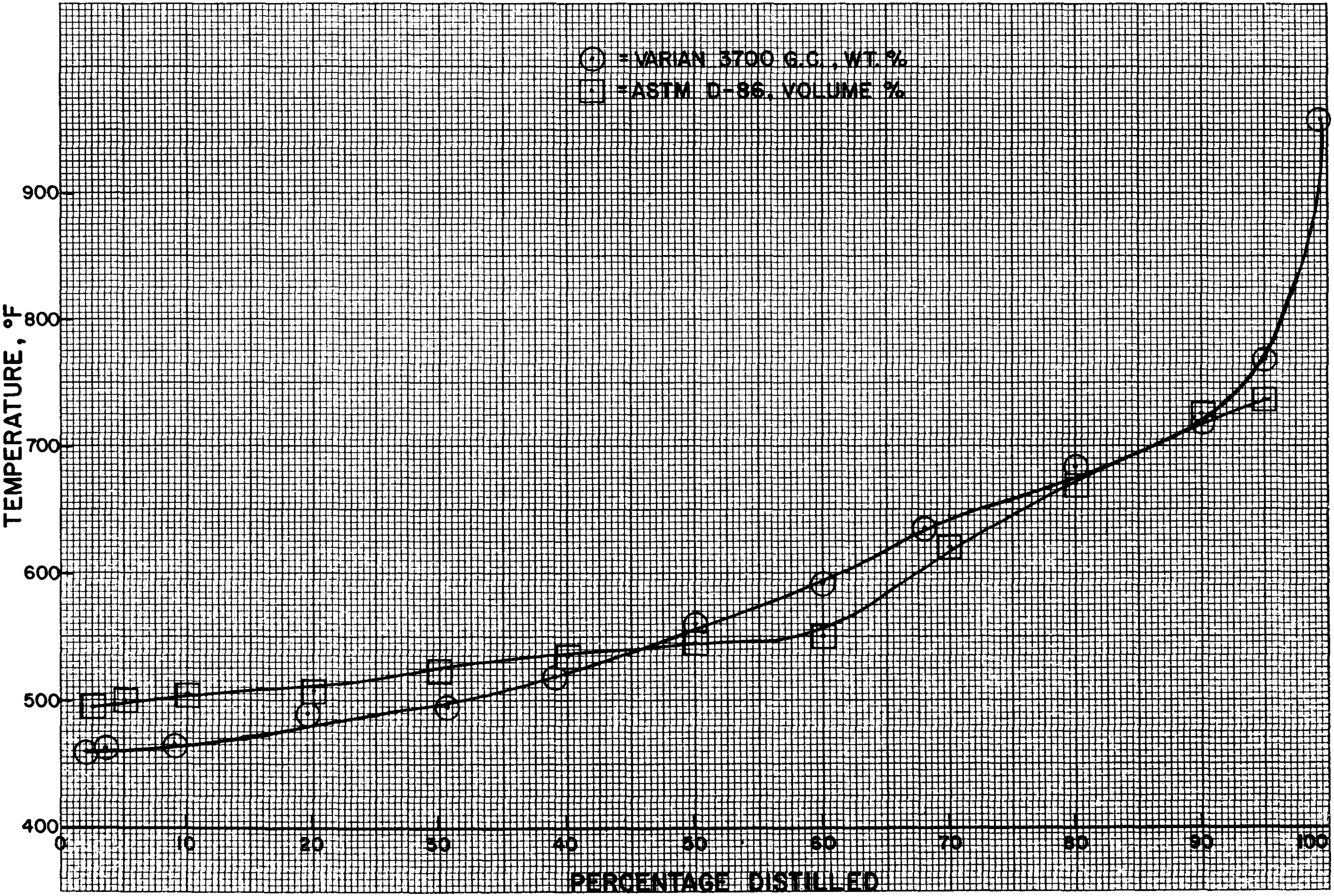

FIGURE 15. PROCESS SOLVENT DISTILLATION CURVES (RUN 202A MB)

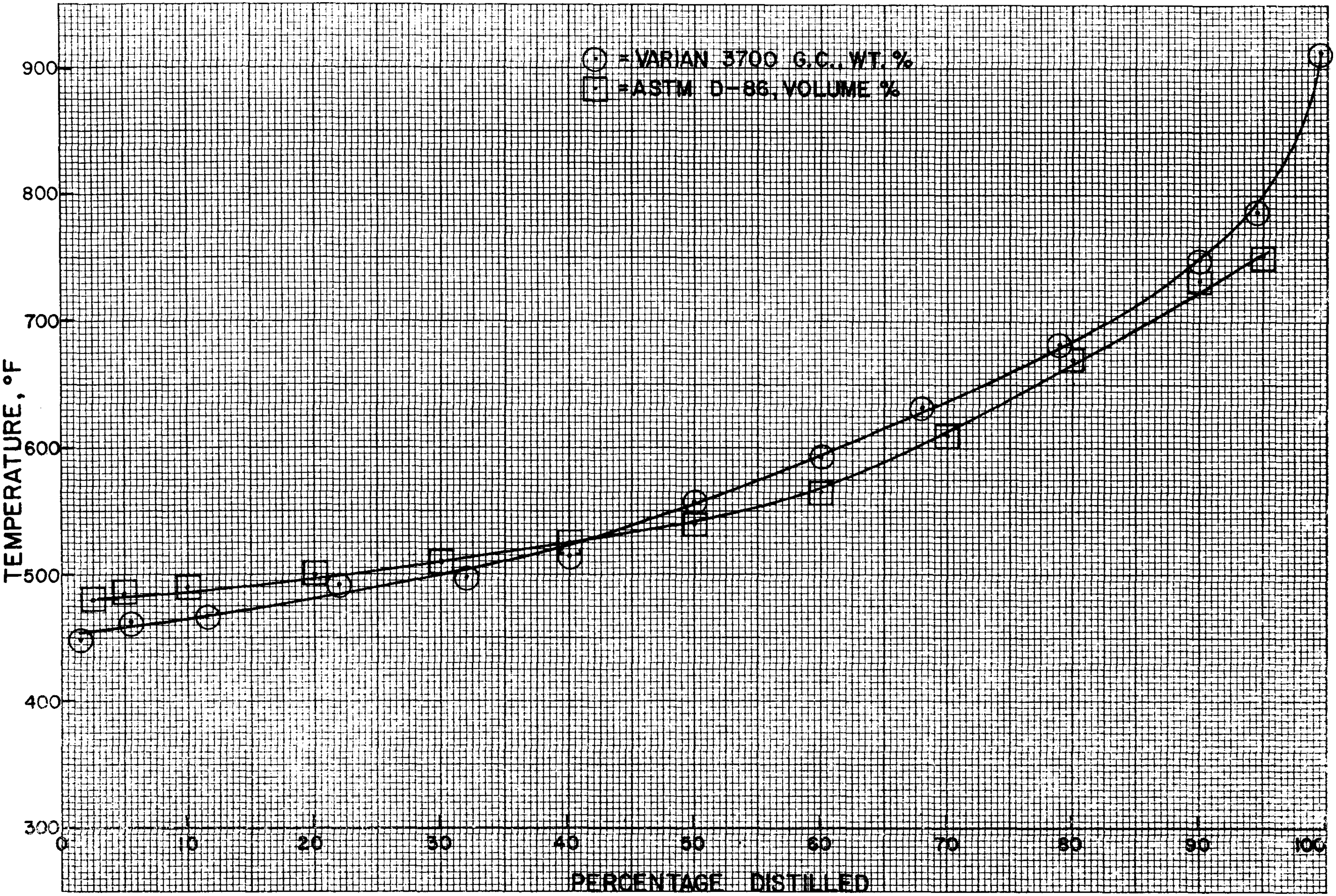

FIGURE 16. PROCESS SOLVENT DISTILLATION CURVES (RUN 203DE MB)

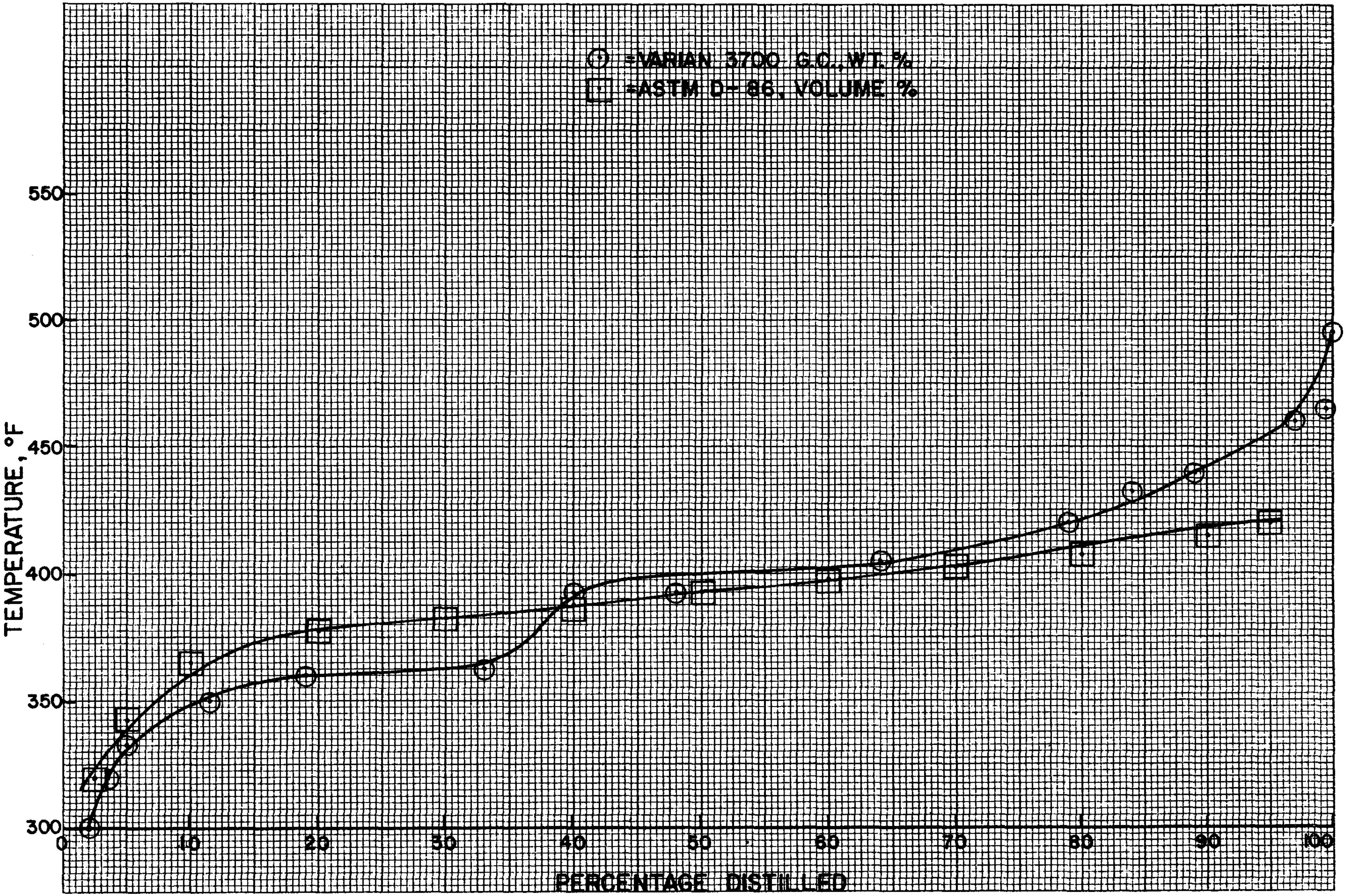

FIGURE 17. WASH SOLVENT DISTILLATION CURVES (RUN 201A MB)

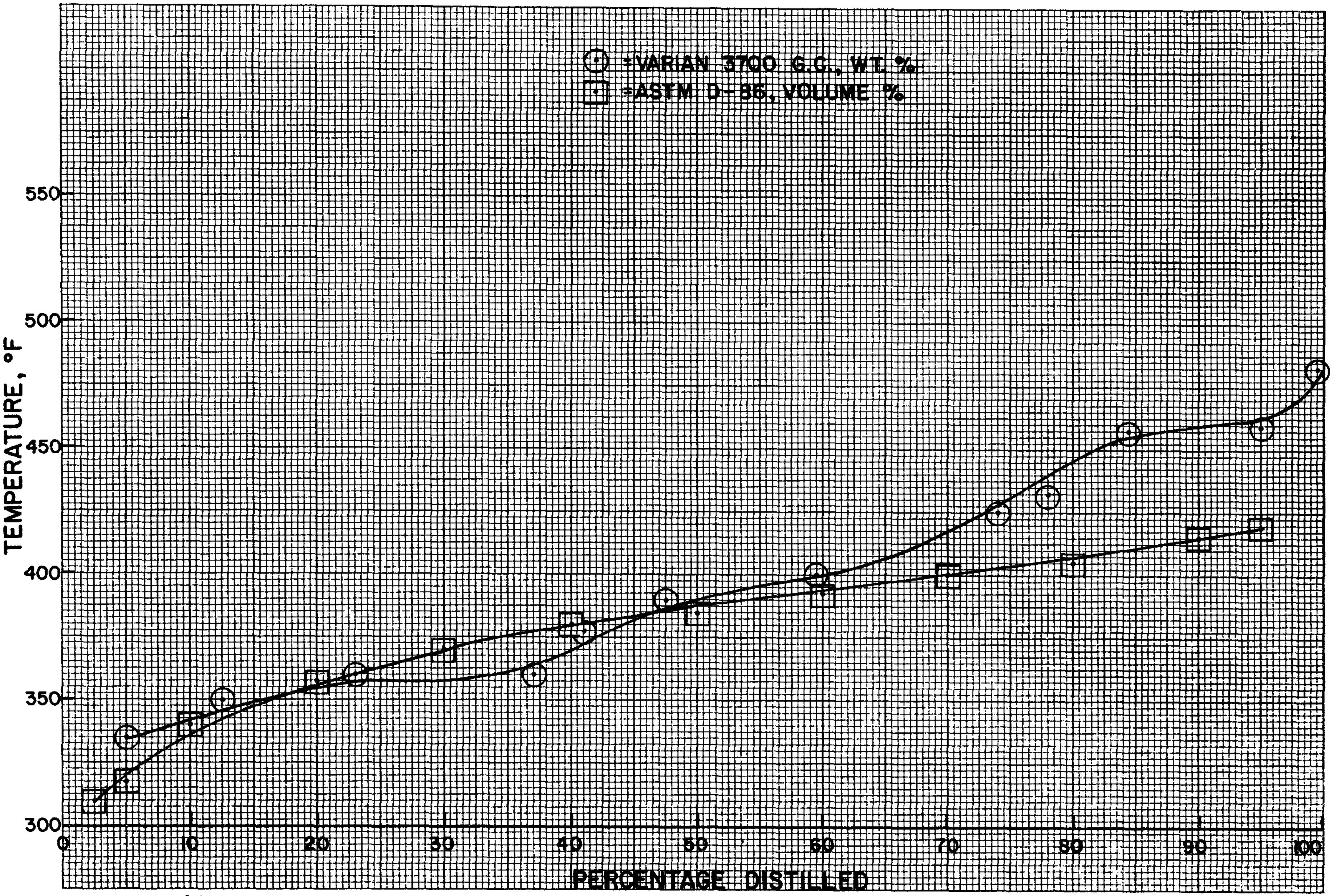

FIGURE 18. WASH SOLVENT DISTILLATION CURVES (RUN 202A MB)

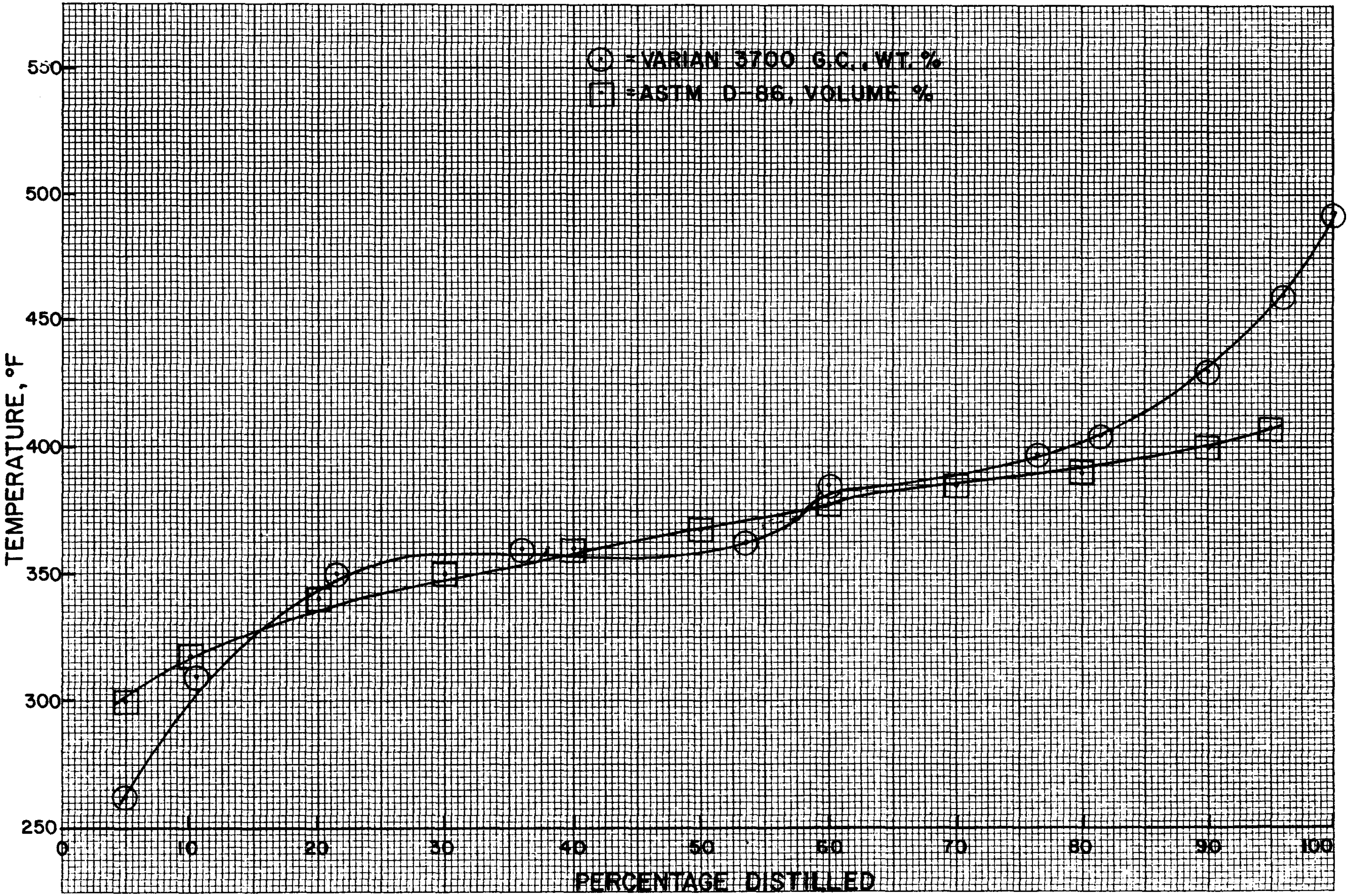

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FIGURE 19. WASH SOLVENT DISTILLATION CURVES (RUN 203DE MB)

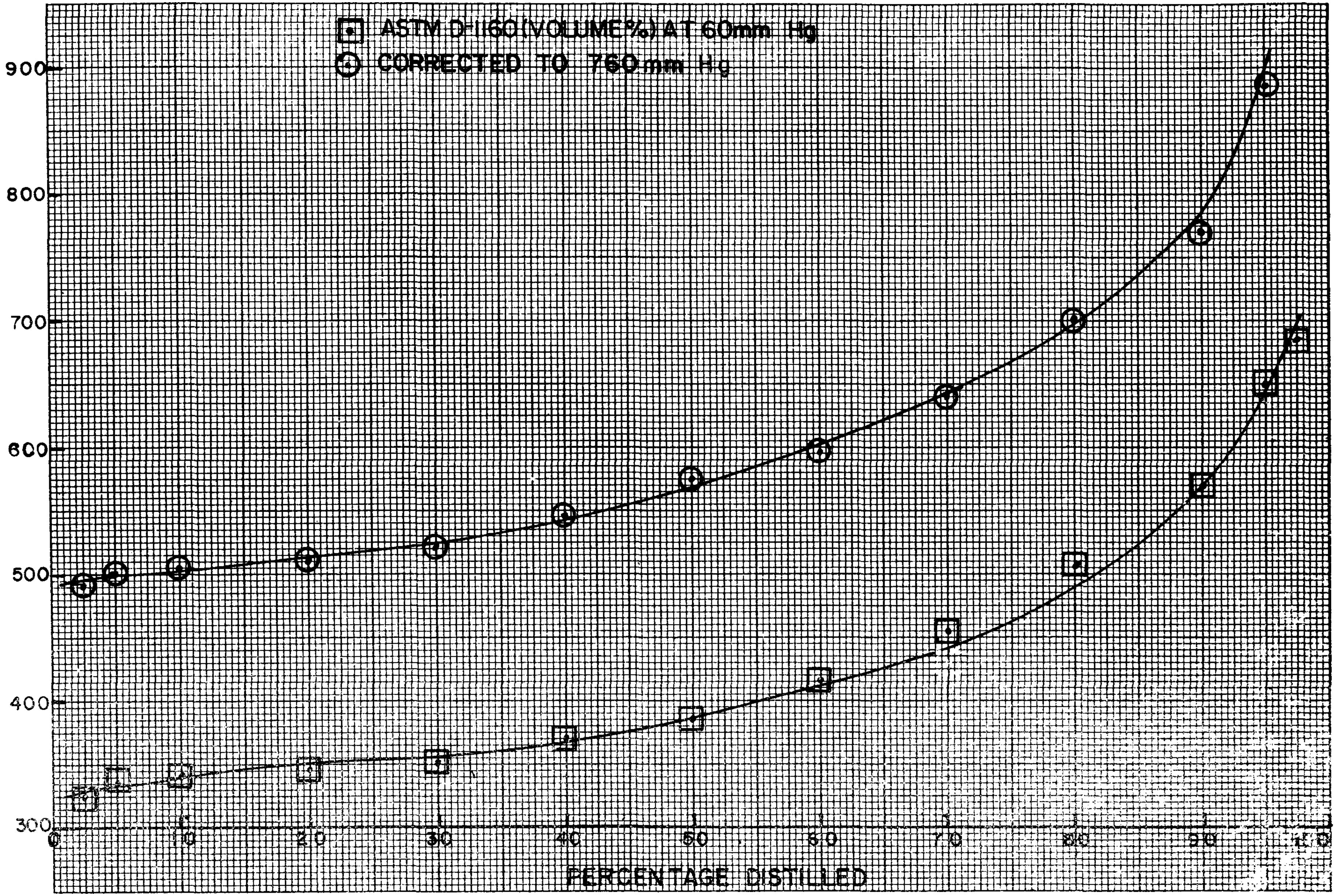

FIGURE 20. PROCESS SOLVENT DISTILLATION CURVE (RUN 201A MB)

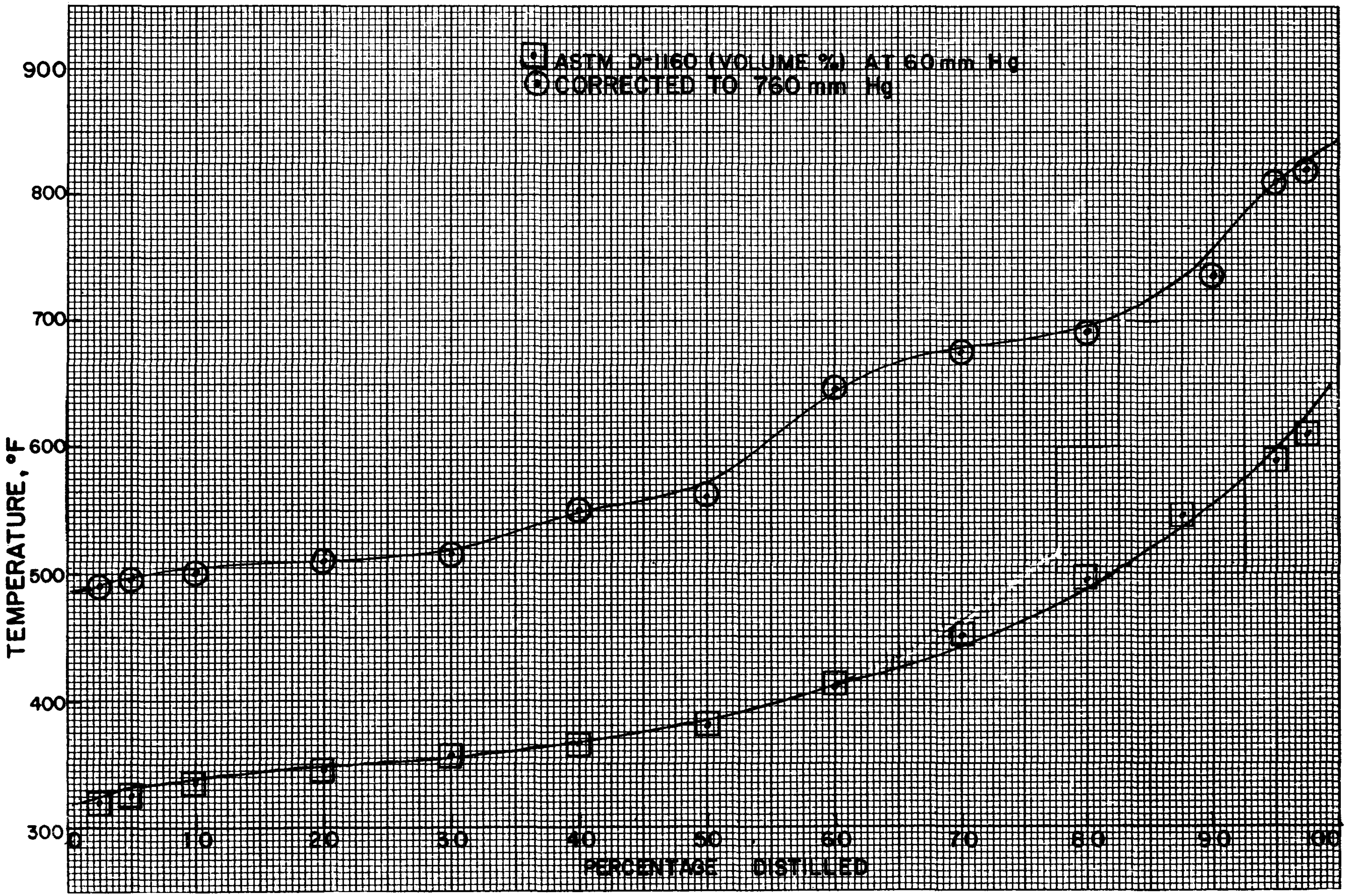

FIGURE 21. PROCESS SOLVENT DISTILLATION CURVE (RUN 202 AMB)

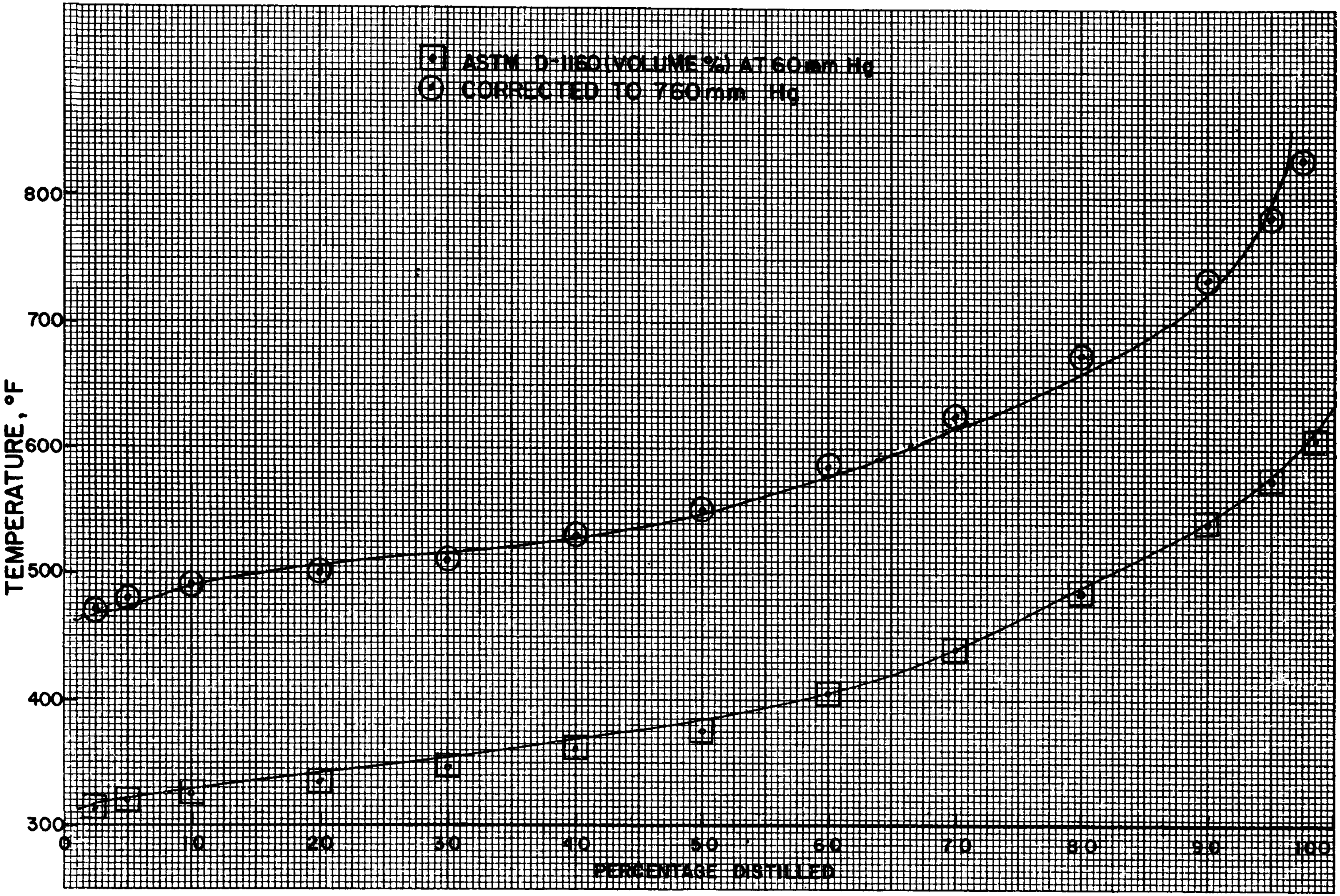

FIGURE 22. PROCESS SOLVENT DISTILLATION CURVE (RUN 203 DE MB)

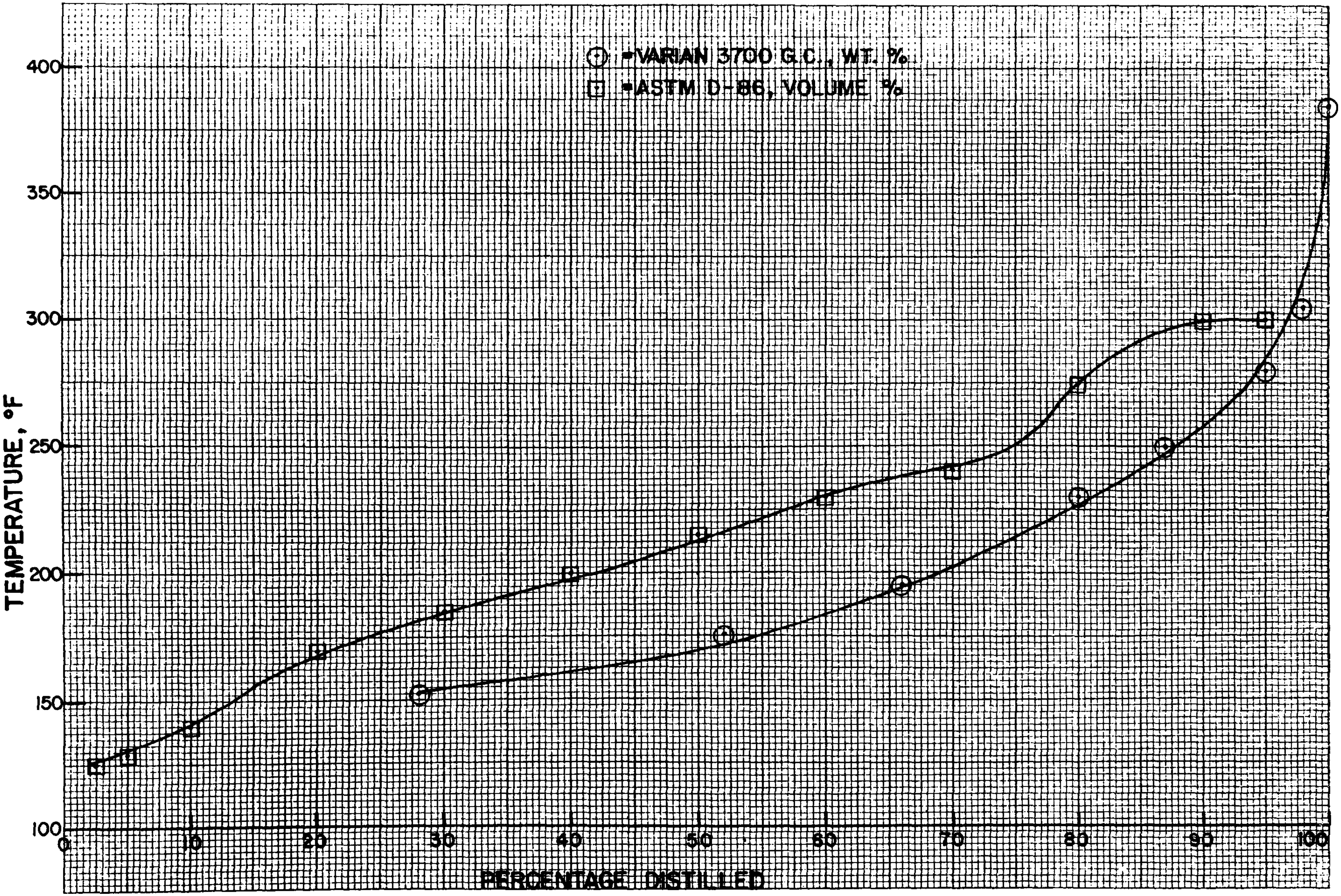

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FIGURE 23. LIGHT ORGANIC LIQUID DISTILLATION CURVES (RUN 201A MB)

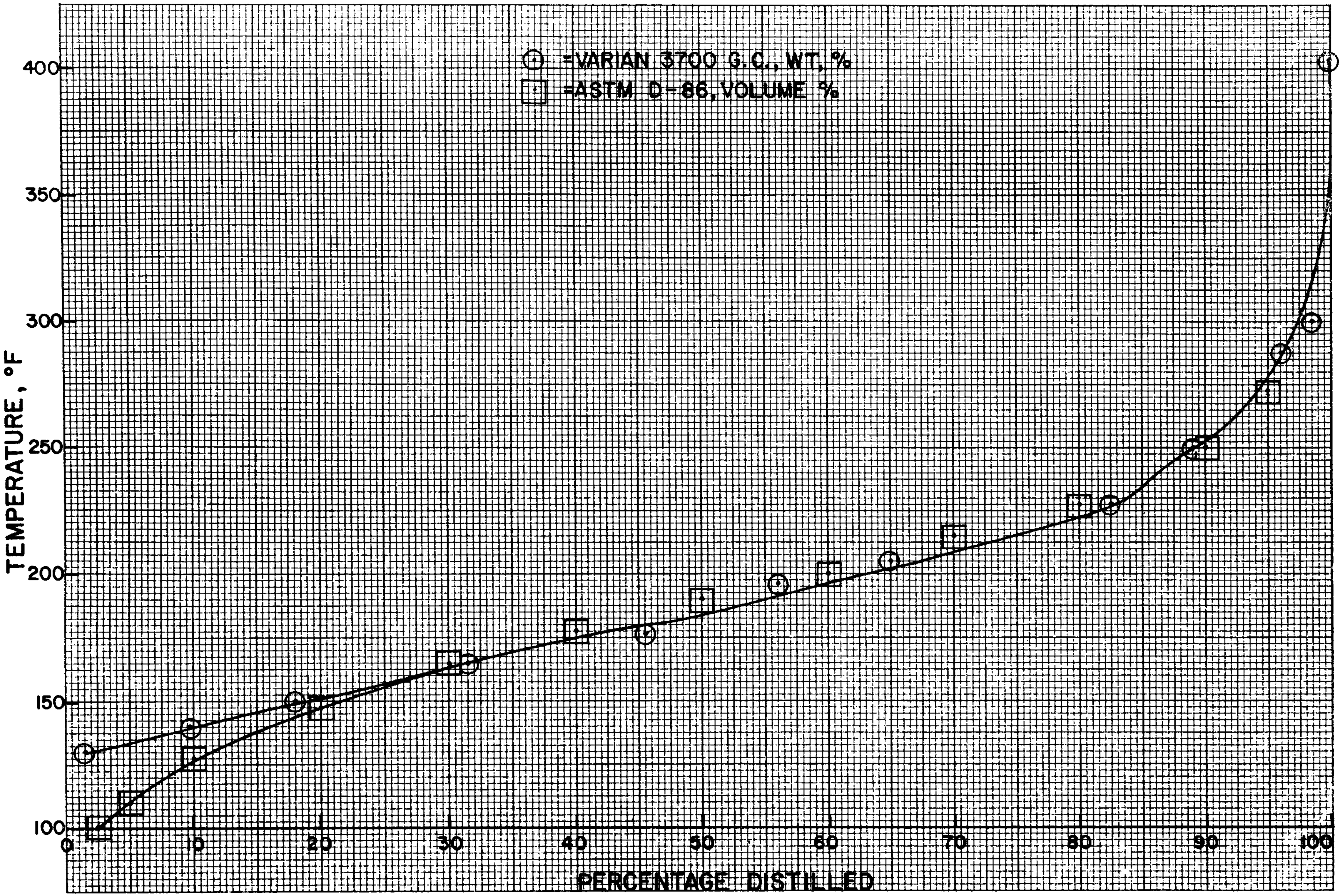

FIGURE 24. LIGHT ORGANIC LIQUID DISTILLATION CURVES (RUN 202A MB)

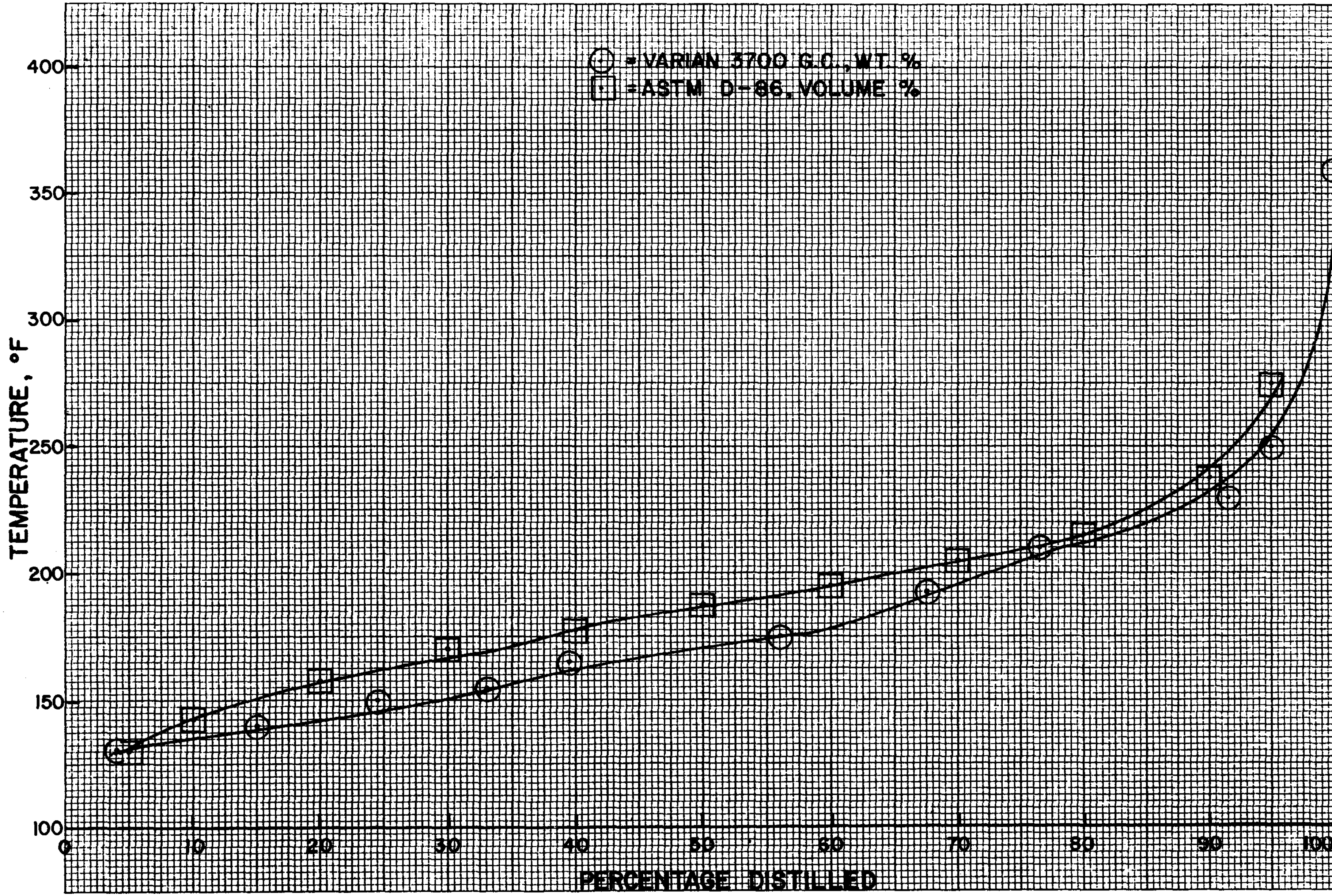

FIGURE 25. LIGHT ORGANIC LIQUID DISTILLATION CURVES (RUN 203DE MB)

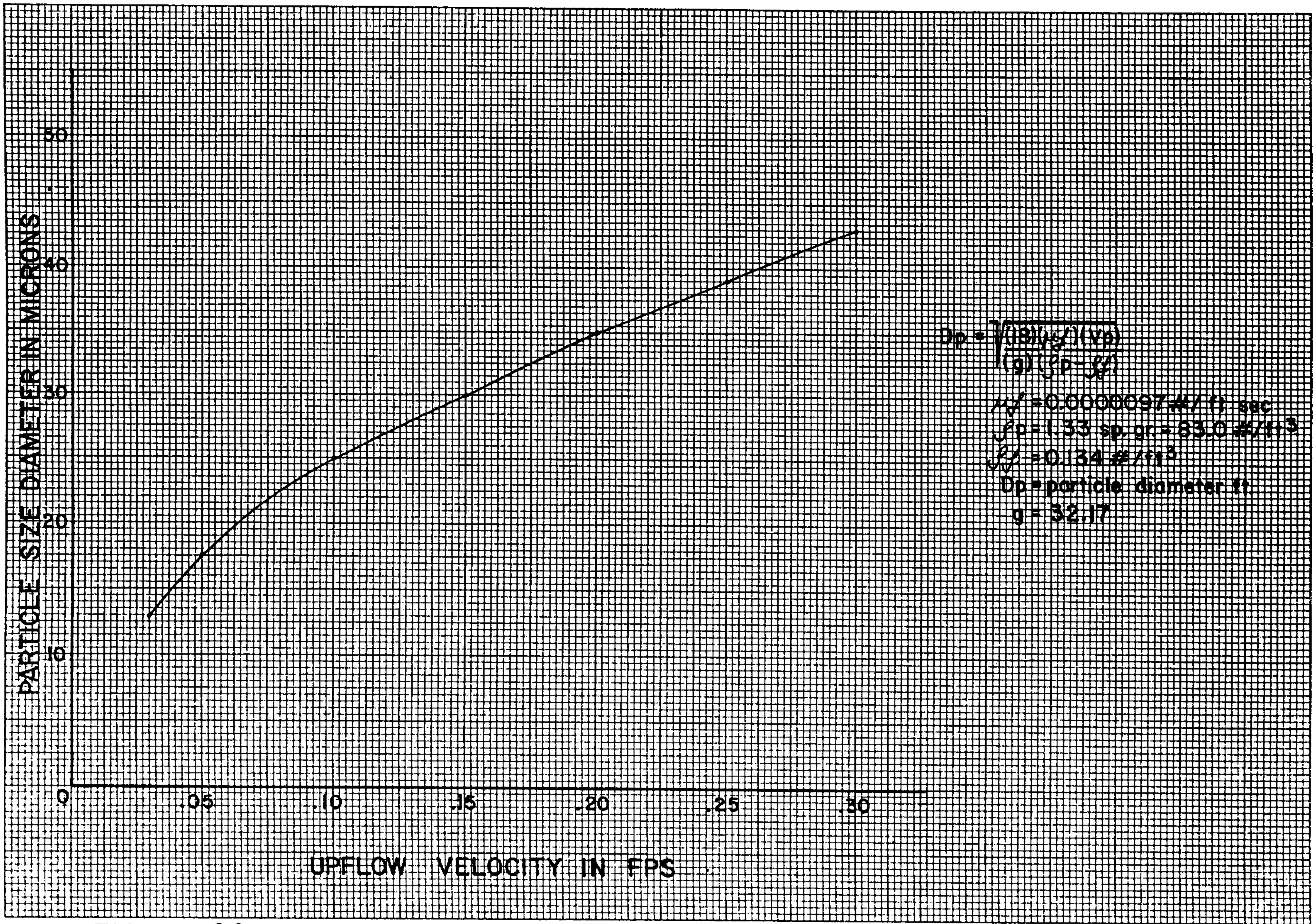

FIGURE 26. TERMINAL SETTLING VELOCITIES OF PARTICLES IN THE CSD ASH CONCENTRATE VESSEL

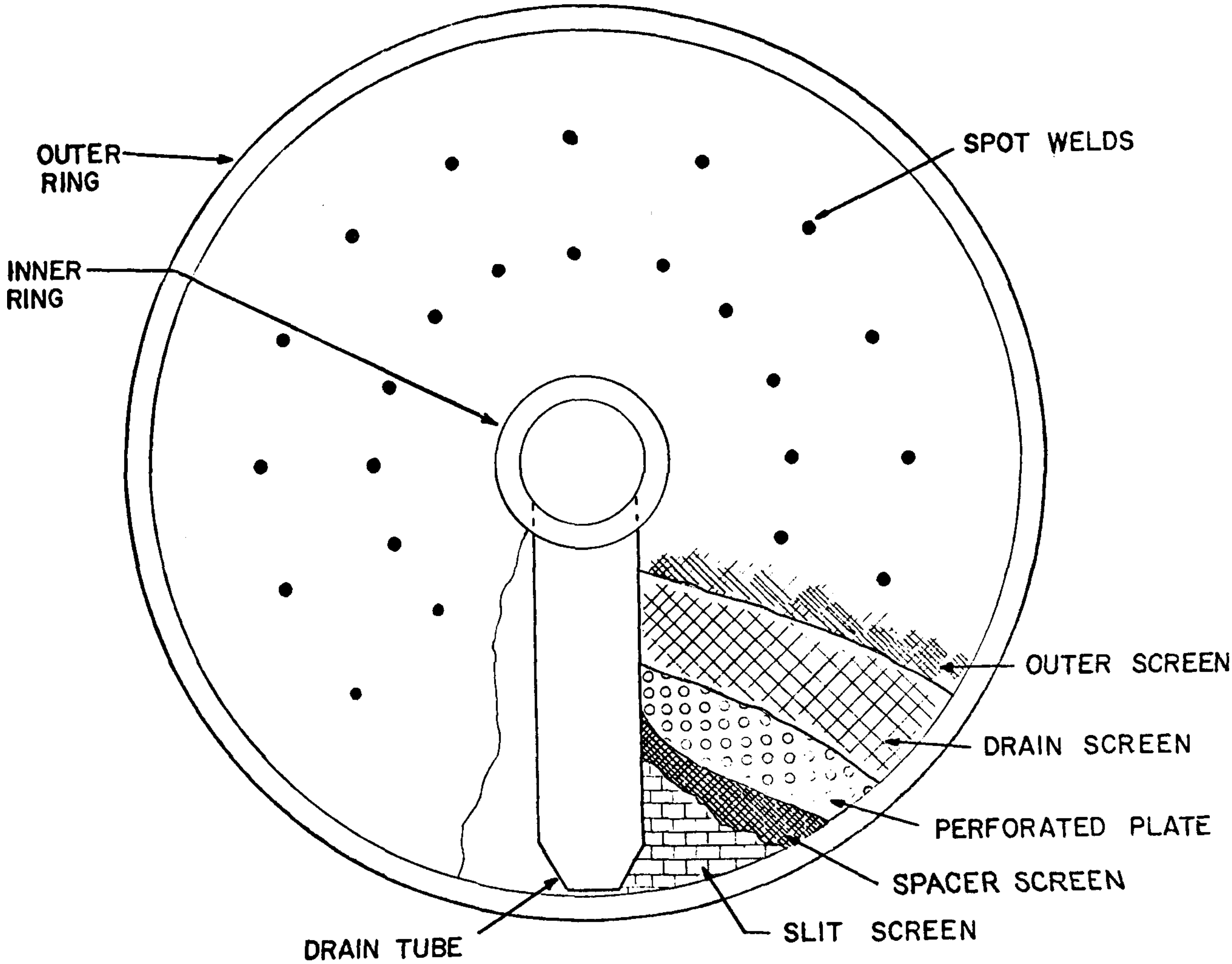

FIGURE 27.

U.S.F. MICHIGAN DYNAMICS FILTER LEAF

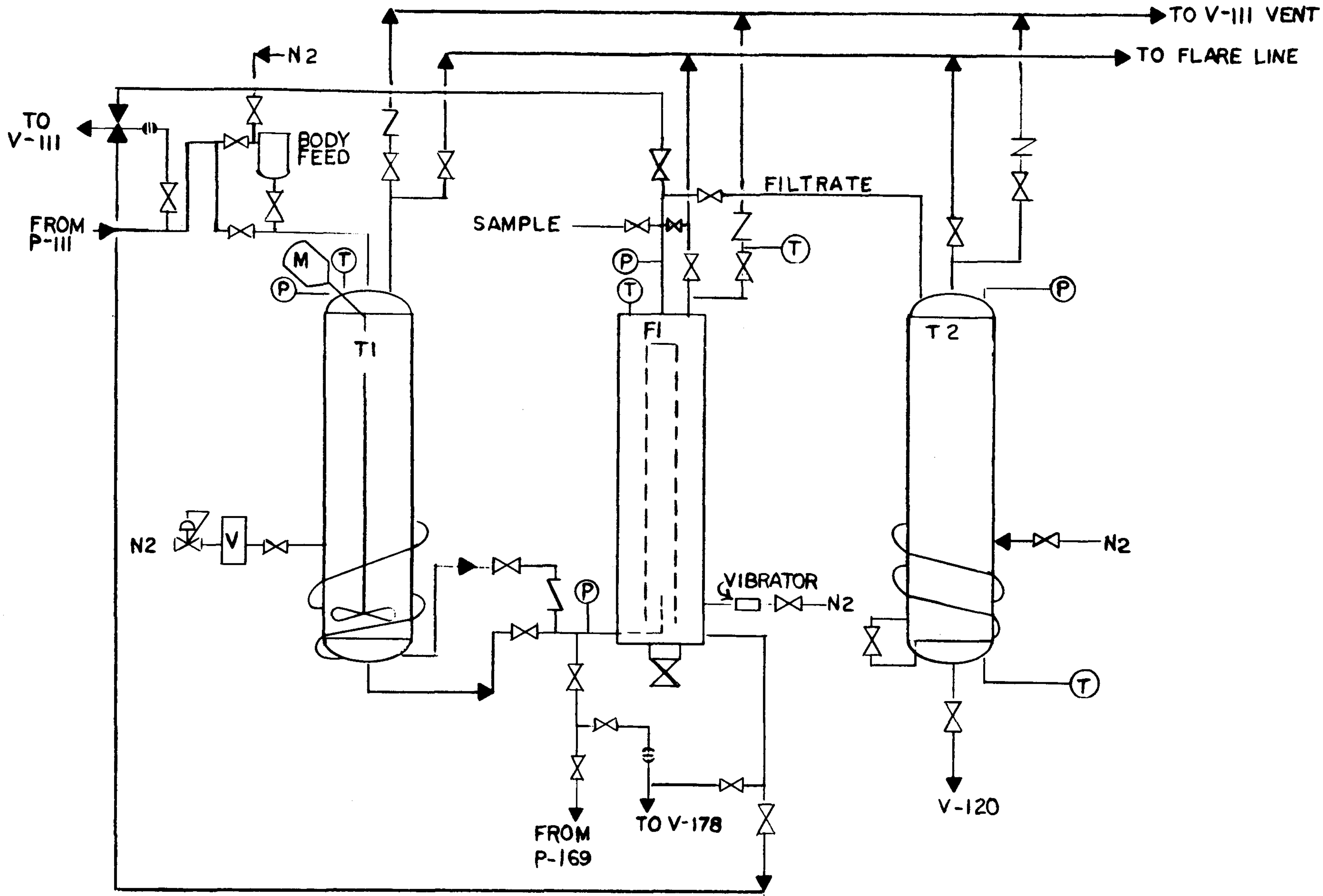

FIGURE 28. INDUSTRIAL FILTER TEST UNIT

*U.S. GOVERNMENT PRINTING OFFICE: 1980-740-145/1178