

15/05/002/003

NOTICE

The information contained in this report is regarded as confidential and proprietary. It is provided subject to the provisions regarding confidential, proprietary information contained in the Research Agreement among the Participating Parties.

CONFIDENTIALITY RELEASED

CONOCO INC. *[Signature]*

SOCONY MOBIL OIL COMPANY, INC. DATE 2/11/92

RESEARCH DEPARTMENT

TECHNICAL MEMORANDUM NO. 65-2

DEMONSTRATION OF HIGH-YIELD-RETORTING  
AT 500 LBS/(HR) (FT<sup>2</sup>) SHALE RATE

ANVIL POINTS OIL SHALE RESEARCH CENTER

Rifle, Colorado

March 4, 1965

Authors:

I. A. Jefcoat  
P. W. Snyder, Jr.

Approval:

*RHCramer*  
R. H. Cramer  
Program Manager

NOTICE

The primary object of the Anvil Points Oil Shale Research Center TECHNICAL MEMORANDUM is to advise authorized personnel employed by the Participating Parties (1) that various activities are in progress or that certain significant data have been obtained within the Research Center.

These TECHNICAL MEMORANDA have been prepared to provide rapid, on-the-spot reporting of research currently in progress at Anvil Points. The conclusions drawn by project personnel are tentative and may be subject to change as work progresses. The TECHNICAL MEMORANDA have not been edited in detail.

(1) Socony Mobil Oil Company, Inc., Project Manager

Humble Oil and Refining Company

Continental Oil Company  
Pan American Petroleum Corporation  
Phillips Petroleum Company  
Sinclair Research, Inc.

DEMONSTRATION OF HIGH-YIELD-RETORTING  
AT 500 LBS/(HR)(FT<sup>2</sup>) SHALE RATE

TABLE OF CONTENTS

	<u>Page</u>
Introduction . . . . .	4
Conclusions . . . . .	5
Detailed Discussion. . . . .	7
A. No. 1 Pilot Retort Description . . . . .	7
B. Run History and Retort Performance . . . . .	7
C. Reproducibility of Run No. 433 . . . . .	8
D. Precision of Control . . . . .	9
E. Accuracy of Process Variable Measurements and Sampling Procedure. . . . .	9
F. Precision of Results . . . . .	.10
G. Temperature Profile. . . . .	11

FIGURES

1. Configuration of Peripheral Air Distributor.
2. Block Diagram of Retort No. 1.
3. Effect of Air Rate and Raw Shale Moisture on Shale Oil Yields.
4. Calculated and Measured Vertical Temperature Profiles for Runs 433 and 454 L - P.

TABLES

1. Comparison of Run 433 with Run 454 L - P.
2. Properties of Shale Oil Produced During Run 454 L - P.

APPENDIX

- A. Summary Sheets.
- B. Detailed Summary Sheets.
- C. Comparison of Raw Shale Particle Size Distribution.
- D. Temperature Profiles.
  1. Horizontal Profiles.
  2. Temperature Probe Data.

DEMONSTRATION OF HIGH-YIELD-RETORTING  
AT 500 LBS/(HR) (FT<sup>2</sup>) SHALE RATE

I. Introduction

Pilot Retort No. 1 was operated for four weeks beginning the last week in December 1964 at the operating conditions of an earlier run (Number 433). This earlier run showed that the Gas-Combustion retort could be operated 500 lbs/(hr) (ft<sup>2</sup>), at nearly twice the shale rate that the Bureau of Mines operated, with yield above 90 vol % Fischer Assay. The objectives of this period of operation were to:

1. Demonstrate the reproducibility of high yields while operating at high shale rate.
2. Establish the accuracy and precision of our process variable measurements, sampling procedure and analytical methods.
3. Establish the precision of the major results such as shale oil yield and gas produced.
4. Obtain a supply of typical Gas-Combustion shale oil for filling sample requests from the Participating Parties.

Operating difficulties were encountered at the first attempt to precisely duplicate the operating conditions of Run 433. This difficulty was traced to excessive water in the raw shale feed (4 - 7 wt % of raw shale versus the normal 1.5 - 2.0 wt %). The excessive water along with the below freezing weather prevented smooth control of the raw shale feed rate and caused low temperatures in the combustion zone of the retort resulting in incomplete retorting. This problem was overcome by installing a shale drying system. The retort operated very smoothly after drying the shale and five 24-hour material balances were completed without any difficulties.

## II CONCLUSIONS

1. The high yield of Run 433 was reproduced as shown below:

Run	433	454 L - P (Avg)
<u>Date Started</u>	11-11-64	1-15-65
<u>Operating Conditions:</u>		
Raw Shale Rate, lbs/(hr) (ft <sup>2</sup> )	480	495
Air Rate, SCF/Ton RS	5,150	4,964
Recycle Gas Rate, SCF/Ton RS	14,150	12,294
<u>Yields:</u>		
Oil Yield, vol % F.A.	91.2	92.9
Dry Gas Make, SCF/Ton RS	6,519	6,661
Mineral CO <sub>2</sub> Decomposition, %	30.9	42.8

A more detailed comparison is shown in Table 1.

2. The precision of control of the process variables appears adequate as shown below by the mean and the standard deviation of the five demonstration runs:

<u>Process Variable</u>	<u>Mean and Standard Deviation</u>
Raw Shale Rate, lb/(hr) (ft <sup>2</sup> )	495 ± 8
Raw Shale Assay, gal/ton RS	26.8 ± 0.4
Air Rate, SCF/Ton RS	4,964 ± 105
Recycle Gas Rate, SCF/Ton RS	12,294 ± 266

3. Accuracy of our process variable measurements and major sampling procedures also appears good, with exception of the raw shale rate as indicated by the ash balance, based on the mean and standard deviation of the material balances as shown below:

<u>Balance</u>	<u>Mean and Standard Deviation</u>
Overall	100.7 ± 0.2
Ash	101.6 ± 0.6
Total Carbon	99.2 ± 1.7
Organic Carbon	99.0 ± 2.4
Organic Hydrogen	98.2 ± 1.9
Water	101.0 ± 15.1

The water content of the vent gas is being measured since completing this study, and will further improve the precision of the hydrogen and water balances. A more rigorous and more frequent calibration of the raw and spent shale weighing systems will be used on future runs to improve the ash balances.

4. The precision of the results from the five demonstration runs, which indicates the precision we should expect from future runs, are shown below:

<u>Reported Result</u>	<u>Standard Deviation</u>
Oil Yield, % F.A.	± 1.6
Dry Gas Make, SCF/Ton RS	± 1.20
Mineral CO <sub>2</sub> Decomposition, %	± 3.7
Offgas Temperature, ° F	± 2
Spent Shale Temperature, ° F	± 3

5. A sufficient quantity of typical Gas-Combustion shale oil was produced from Runs 454 L through P and drummed for sending to Participants on request. The properties of this shale oil are shown in Table 2.
6. Excessive water in the raw shale feed increases operating problems and can reduce oil yield if not compensated for by increasing air rate.

### III. Detailed Discussion

#### A. No. 1 Pilot Retort Description

This study was carried out in the pilot Retort No. 1 which is a cylindrical retort 20-inches in diameter. A 10.5 foot bed height was used with the top of the bed 5.0 feet above the air distributor. The peripheral air distributor was used with 12 equally spaced ports around the retort and one in the center. A diagram of this distributor is shown in Figure 1. The ratio of peripheral air flow to the center air flow was adjusted to produce a uniform temperature pattern across the retort. A surge vessel was added to the retort offgas line prior to any of the recovery equipment to settle any large pieces of shale that may be carried out of the retort. Fines carryover, however, during the demonstration run was negligible. A condenser-demister was added in parallel to the electrostatic precipitator to test its ability to recover the fine mist. A block diagram of the process flow with the recovery alternatives is shown in Figure 2.

#### B. Run History and Retort Performance

The first week's operation was hampered by a 2-inch pipe that was placed horizontally to the center of the retort about 1-foot above the table feeder. This pipe was put in to direct part of the recycle gas to the center of the bed and thus improve gas distribution. However, the pipe caused the shale to be drawn off faster down one side of the retort than the other and thus created a severe maldistribution of shale and gas flow. Horizontal temperature probes varied 1,000° F at the combustion zone.

The first run, Number 454, was accomplished by directing the majority of the inlet air into the faster moving shale area - this forced a uniform temperature profile thus apparently correcting the poor gas distribution. Oil yield for this first run was 94.5 vol % of raw shale Fischer Assay which was better than the 91.3 vol % for Run 433 which was being duplicated.

After removal of the 2-inch recycle pipe good temperature distribution was obtained by adjusting the ratio of center-air flow to peripheral-air flow to 0.25. At this time a supply of very wet shale was encountered which along with below freezing weather caused shale feed control problems and poor retorting for Runs 454 A through K. The raw shale during this period contained 4 - 7 wt % water compared to the normal 1.5 - 2.0 wt %, and yields averaged 78 vol % of raw shale Fischer Assay with about 8 vol % of raw shale Fischer Assay leaving with the spent shale retorted. Temperatures in the combustion zone were erratic with the peak measurements below 1,300° F. Air rate was increased about 500 SCF/T for Runs H through K in order to determine if a greater heat input would compensate for

the effect of higher raw shale moisture. The higher air rate increased oil yield to an average of 87 vol % Fischer Assay. It appeared that a further increase in air rate would completely compensate for the higher moisture content. However, since we were attempting to duplicate Run 433 where the raw shale contained only 1.7 wt % water, a raw shale drying system was installed and five Runs, 454 L through P, were made to complete the objectives of this study. The raw shale feed system and the retort operated smoothly without incident during this period. The effect of air rate on oil yield for dry and wet shale is shown in Figure 3.

Shale oil product quality appeared reasonably constant during the entire study including the period of operation with high raw shale moisture. The shale oil product was decanted to remove excess water, drummed, and stored. The properties of this oil are shown in Table 2.

A check on the spent shale weigh hopper prior to Run 454-K indicated that the hopper weight was approximately 3% light. This correction does not appear in the data for Runs 454 A through K since it is not known for how long this discrepancy existed and whether this was a gradual change or a sudden one. The spent shale system was cleaned and checked prior to Run 454-L and checked after Run 454-P. The system at this time was within 0.2% of the true weight.

### C. Reproducibility of Run No. 433

The high yield of Run 433 was duplicated when operating with dry shale as shown in Table 1. Operating conditions were essentially the same except a slightly smaller particle size raw shale was processed and the gas recycle rate was about 12% lower.

Results were very similar, the minor differences were:

1. Oil yield was 1 vol % higher than Run 433, probably because of the gas condenser-demister which was added to the mist recovery system.
2. Carbonate decomposition was 40% higher than Run 433, probably the result of the lower recycle rate, which produces slightly higher peak temperatures, and the smaller particle size.
3. Offgas temperature was 20° F lower than Run 433, probably the result of the smaller particle size and higher carbonate decomposition.
4. Heating value of the gas was lower than Run 433 because of calculating it from measured carbon content instead of estimating the amount of C<sub>2</sub>+ from gas chromatograph analyses as had to be done for Run 433.

D. Precision of Control

The precision of control for the five 24-hour runs appeared adequate as shown below by the mean and standard deviation.

Raw Shale Rate, lb/(hr) (ft <sup>2</sup> )	495 ± 8
Raw Shale Assay, gal/ton RS	26.8 ± 0.4
Air Rate, SCF/Ton RS	4,964 ± 105
Recycle Gas Rate, SCF/Ton RS	12,294 ± 266

E. Accuracy of Process Variable Measurements and Sampling Procedure

The accuracy of our measurements and sampling procedure appears adequate for all items except the raw shale rate and water analyses as measured by the mean material balances and their standard deviation for the five runs as shown below:

<u>Balances</u>	<u>Mean</u>	<u>Standard Deviation</u>
<u>As Measured Balance:</u>		
Ash	101.6	± 0.6
<u>Raw Shale Rate Calculated</u>		
<u>From 100% Ash Balance:</u>		
Overall	100.7	+ 0.2
Total Carbon	99.2	± 1.7
Organic Carbon	99.0	+ 2.4
Organic Hydrogen	98.2	+ 1.9
Water	101.0	± 15.1

The ash balance is not as good as desired for these runs because of calibration difficulties with the raw shale feed system. The raw shale weigh system was calibrated prior to Run 454-L and found to have a calibration factor of 20.4; however, it was checked after Run 454-P and the calibration factor was 21.0. In addition a piece of shale was found on the head of the Syntron raw shale balance during Run 454-O. The piece of shale indicated a 50 lb/hr correction was necessary. The spent shale weigh system, as discussed under Run History, was calibrated before Run 454-L and estimated to be within ± 0.2% when using the calibration. Because of the drift or error in original calibration of the raw shale feed and the good precision of the spent shale weigh system the yields and balances have been based on the raw shale rate calculated from the spent shale rate and ash analyses assuming 100% ash balance. Further evidence of the reliability of this procedure is that the mean for the balances are closer to 100%. If measured raw shale rates were used the mean total carbon balance would be 101.3% and oil yield 95.4 vol % RS FA. A revised procedure for calibrating the raw and spent shale weighing system more rigorously will be used on future runs. This should improve the ash balance.

The initial carbon balances averaged 108% but a careful examination of the raw shale carbon analyses revealed them to be low due to selective removal of rich shale particles during sample preparation. The raw shale samples were reanalyzed with an improved sample preparation procedure.

The revised carbon balances are excellent, however, the ash, hydrogen and water balances are not as good as desired. The poorer results on water and hydrogen balances are probably due to our inability, at the time, to accurately measure water content of the vent gas. Since completing this study a humidity measuring instrument has been installed on the recycle gas line and should improve the balances.

F. Precision of Results

The precision of the results from the five demonstration runs are shown below:

Reported Result	<u>Mean</u>	<u>Standard Deviation</u>	<u>95% Confidence in the Mean</u>
<u>Products Recovered</u>			
Oil Yield, vol % RS FA	92.9	± 1.6	± 2.0
Dry Gas, SCF/Ton RS	6,661	± 119	± 149
Mineral CO <sub>2</sub> Decomposition, %	42.8	± 3	± 4
<u>Operating Data</u>			
Offgas Temperature, ° F	121	± 2	± 3
Spent Shale Temp., ° F	245	± 3	± 4
<u>Product Properties</u>			
<u>Shale Oil</u>			
Gravity, ° API	20.1	± 0.1	± 0.2
Ash, wt %	0.03	± 0.01	± 0.02
<u>Dry Gas</u>			
Gross Heating Value, Btu/SCF	80.4	± 8.7	± 10.9
Total Carbon Content, lbs/MSCF	12.3	± 0.4	± 0.5
CO <sub>2</sub> , vol %	28.2	± 1.3	± 1.6
<u>Spent Shale</u>			
Organic Carbon, wt %	1.6	± 0.2	± 0.3

The precision of these results appears adequate and indicates that we can be 67% confident that the reported oil yield for any single future run is ± 1.6 vol % of the raw shale Fischer Assay. For 95% confidence the reliability is ± 4.5 vol %.

G. Temperature Profile

The calculated vertical temperature profile is compared to the average measured probe temperatures in Figure 4 for both Runs No. 433 and 454 L - P. The measured profile is close to what was expected, the nearly two foot low temperature-gradient zone at the top of the bed and a three foot low temperature-gradient zone just below the air distributor. The math models' prediction of spent shale temperature was 160° F <sup>HIGHER</sup> ~~lower~~ than the measured temperature. This difference is probably a combination of:

3-15-65  
note

1. Inability to measure the precise mean shale temperature at the bottom of the bed where temperatures are changing so rapidly, and
2. The model is calculating much lower carbonate decomposition, 14% versus 40%. Thus less heat is removed from the spent shale by the model than by the pilot plant. This effect is further evidenced by the lower measured temperature of the low temperature-gradient zone below the air distributor.

The horizontal temperature profiles for Runs 454 L - P are shown in Appendix D-1. These profiles show a reasonably even temperature distribution across the retort.

FIGURE 1

AIR DISTRIBUTOR USED WITH RUN 454 INCLUSIVE

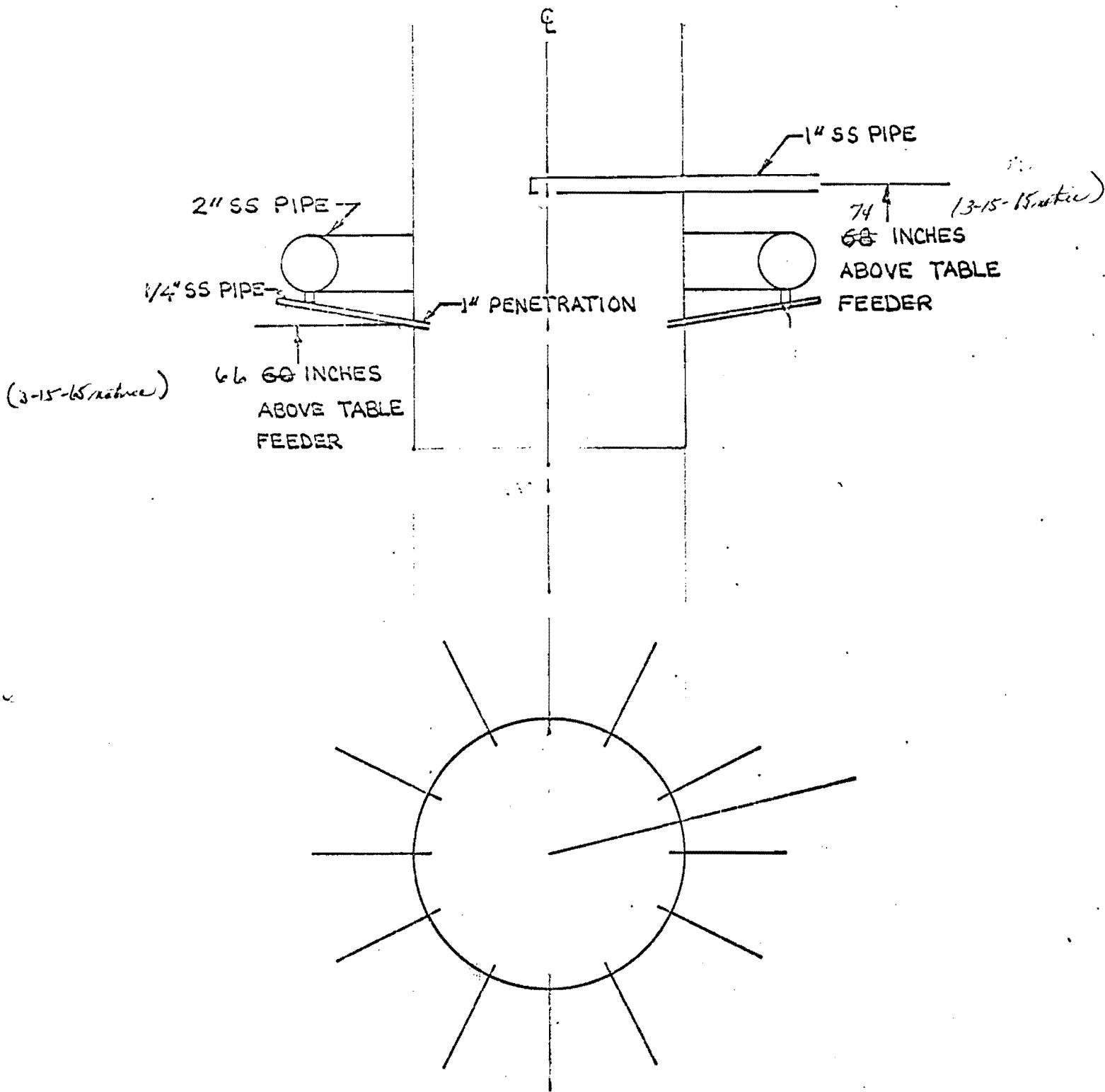
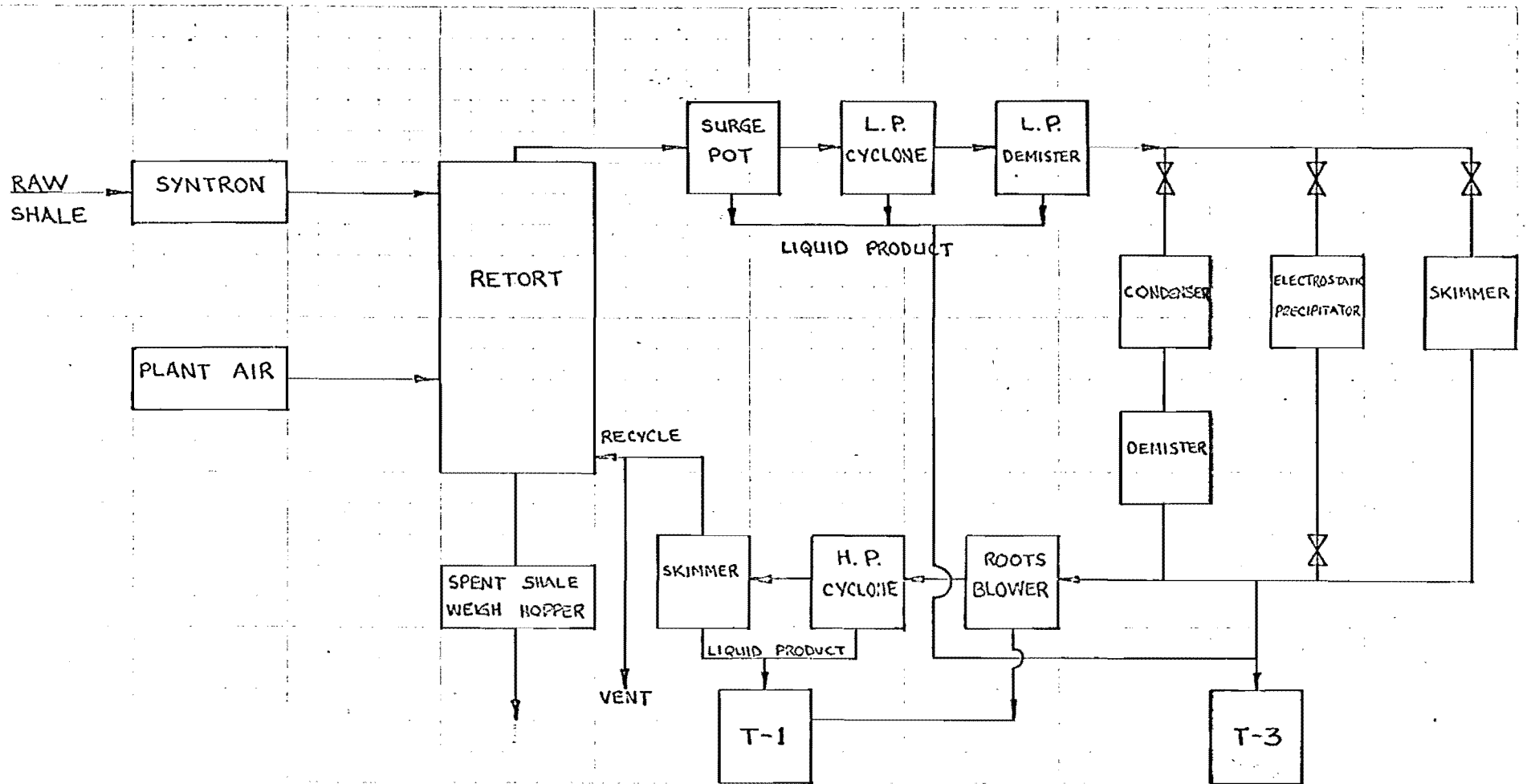


Figure 2



BLOCK DIAGRAM OF RETORT NO. 1 AND THE ASSOCIATED SYSTEMS USED DURING RUN NO. 454, etc.

FIGURE 3

EFFECT OF AIR RATE AND RAW SHALE  
MOISTURE ON SHALE OIL YIELD

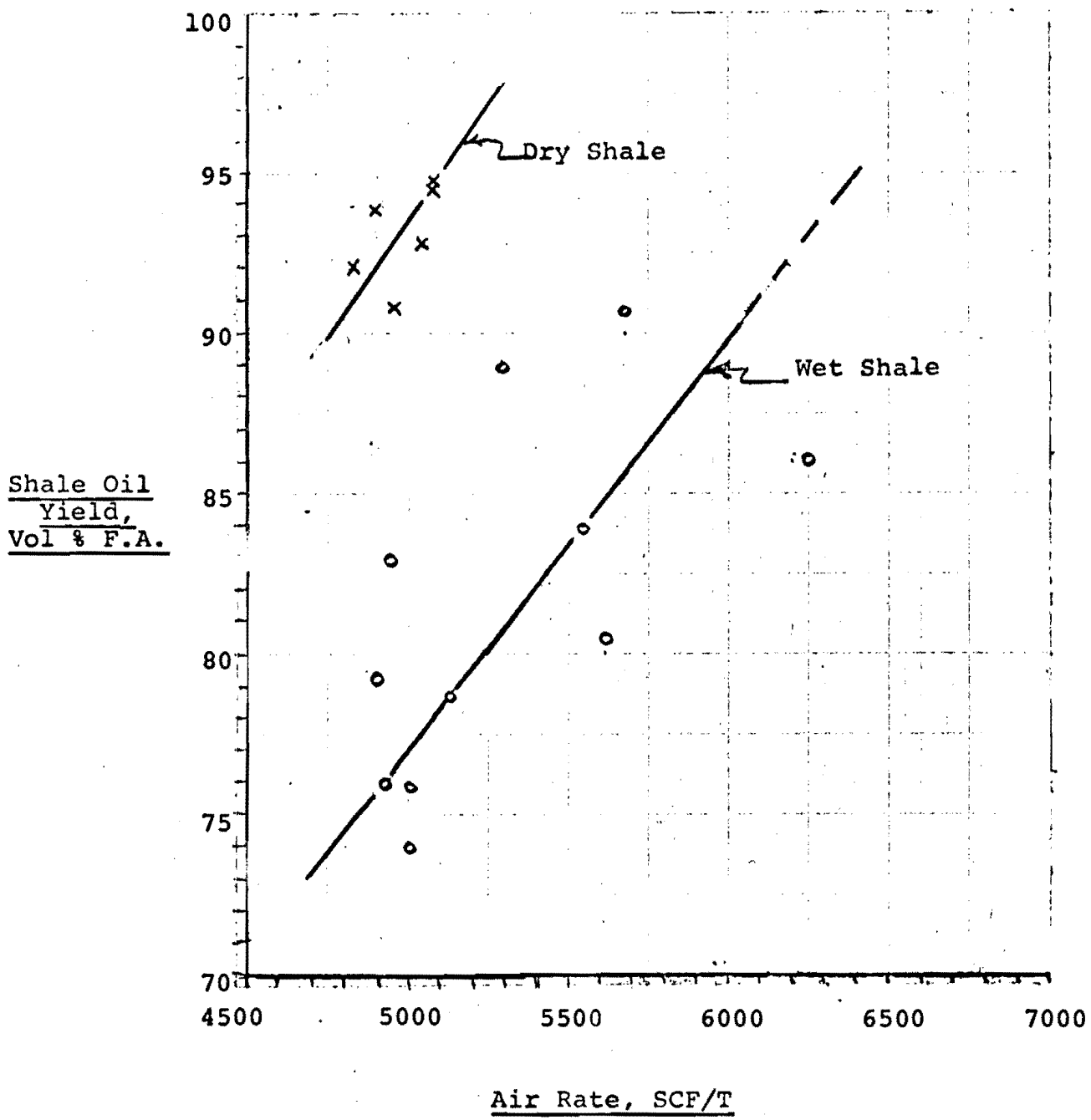


FIGURE 4

CALCULATED AND MEASURED VERTICAL TEMPERATURE PROFILES  
FOR RUNS 433 AND 454 L-P

- - - Temperatures calculated by Math Model
- X - Average Probe Temperatures for Run 454 L-P
- O - Average Probe Temperatures for Run 433

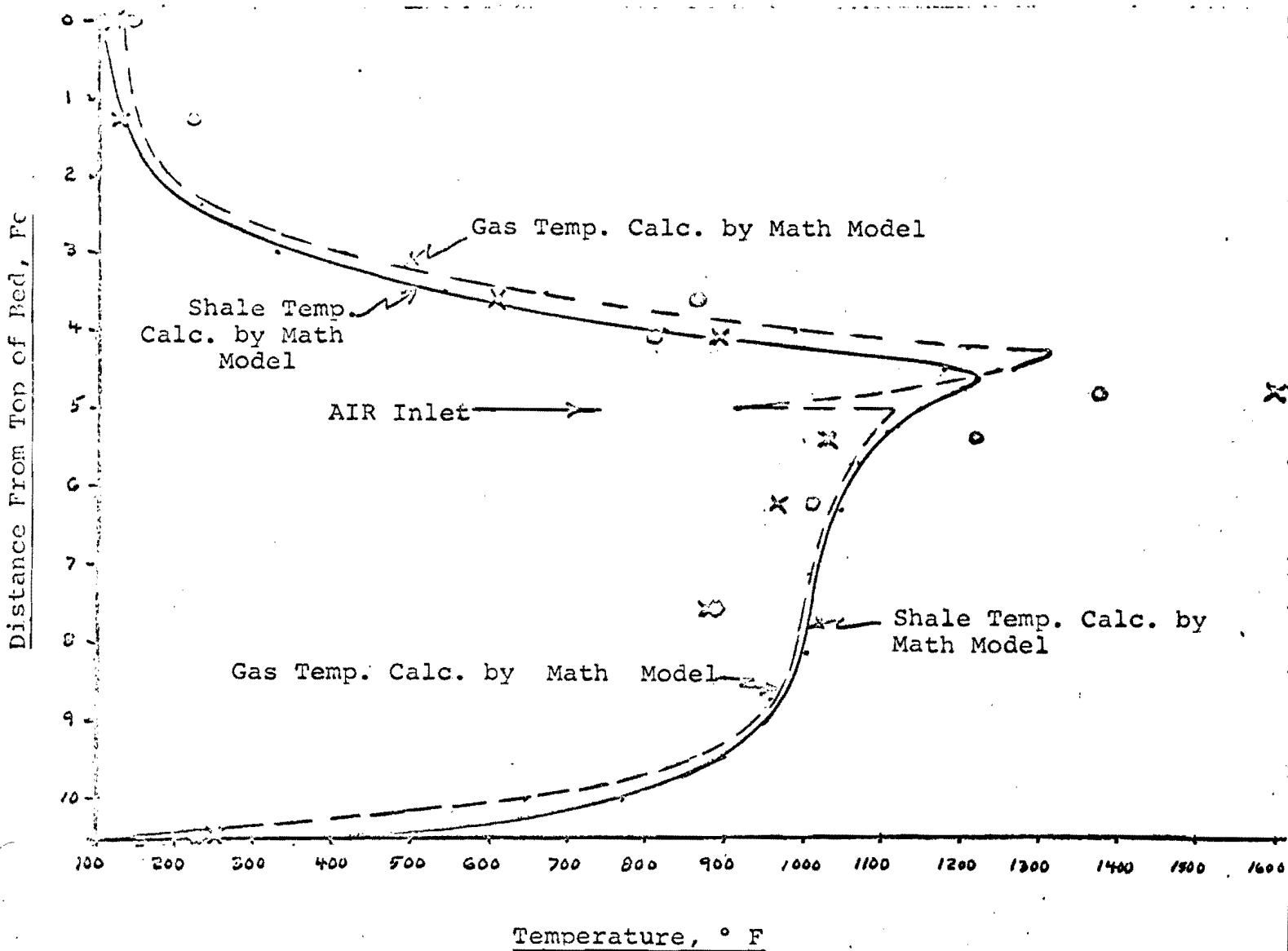


TABLE 1

COMPARISON OF RUN 454 WITH RUN 433

RUN NO.	433		454 I - P	
	DATE STARTED	11-11-64	1-15-65	
LENGTH OF RUN, Hours	12		120	
	95% Confid. Limits			
	Mean		of Mean	of Future Single Run
<u>OPERATING CONDITION:</u>				
Raw Shale Rate, lbs/(hr) (ft <sup>2</sup> )	482	495	± 9	± 20
Fischer Assay, gal/ton RS	27.7	26.8	± 0.5	± 1.1
Nom. Size Range, inches	1/4 - 1	1/4 - 3/4	--	--
Water Content, wt %	1.7	2.1	± 0.2	± 0.5
Air, SCF/Ton RS	5,150	4,964	± 130	± 290
Total Recycle Rate, SCF/Ton RS	14,150	12,294	± 330	± 740
Bed Height Above Air Distr., ft	5.0	5.0	--	--
<u>OPERATING DATA:</u>				
Offgas Temperature, ° F	141	121	± 3	± 6
Recycle Gas Temperature, ° F	161	161	± 3	± 6
Spent Shale Temperature, ° F	238	245	± 4	± 8
Average Retort Pressure Drop, " H <sub>2</sub> O/ft	1.2	1.09	± 0.14	± 0.32
<u>PRODUCTS RECOVERED:</u>				
Oil Collected, vol % RS FA	91.2	92.9	± 2.0	± 4.5
Oil Lost as Mist, vol % RS FA	1.0	0.2	--	--
Oil in Spent Shale, vol % RS FA	0.0	0.0	--	--
Total Oil Measured, vol % RS FA	92.2	93.1	± 2.0	± 4.5
Total Water, lbs/Ton RS	75.9	73.2	± 10.9	± 24.2
Calc. Dry Vent Gas	6,519	6,661	± 149	± 330
Mineral CO <sub>2</sub> Decomposition	30.9	42.8	± 3.9	± 8.7
<u>MATERIAL BALANCES:</u>				
<u>As Measured</u>				
Ash	95.9	101.6	± 0.8	± 1.7
<u>Raw Shale Calc. from 100% Ash Bal.</u>				
Overall	102.2	100.7	± 0.3	± 0.7
<u>Carbon</u>				
Total	111.8	99.2	± 2.1	± 4.6
Organic	117.0	99.0	± 3.0	± 6.5
Organic Hydrogen	115.5	98.2	± 2.3	± 5.2
Water	114.5	101.0	± 19	± 42
<u>SHALE OIL PROPERTIES:</u>				
Gravity, ° API	19.7	20.1	± 0.1	± 0.3
Ramsbottom Carbon, wt %	2.27	2.26	± 0.16	± 0.35
Ash, wt %	0.07	0.03	± 0.02	± 0.02
<u>GAS PROPERTIES:</u>				
Gross Heating Value, Btu/SCF	114	80	± 11	± 24
<u>SPENT SHALE:</u>				
Organic Carbon, wt %	2.4	1.6	± 0.3	± 0.6

TABLE 2

PROPERTIES OF SHALE OIL PRODUCED  
DURING RUN 454 L - P

Gravity, ° API	29.0
Viscosity, SUS @ 130° F	142
, SUS	52
Pour Point, ° F	85
Ramsbottom Carbon, wt %	2.32
Ash, wt %	0.02
Carbon, wt %	83.7
Hydrogen, wt %	10.9
Nitrogen, wt %	2.19
Water, wt %	0.3

APPENDIX A  
SUMMARY SHEET

RUN NUMBER(1)	454	454A	454B	454C	454D
DATE STARTED	12-31-64	1-4-65	1-4-65	1-5-65	1-5-65
LENGTH OF RUN, hours	10	12	12	12	12
RETORT TYPE NUMBER					
OIL RECOVERY SYSTEM NUMBER					
OPERATING CONDITIONS:					
Raw Shale, lbs/(hr) (ft <sup>2</sup> )	487	520	527	464	532
Fischer Assay, Gal/Ton RS	27.6	25.1	24.7	24.6	24.0
Nom. Size Range, inches	1/4-3/4	1/4-3/4	1/4-3/4	1/4-3/4	1/4-3/4
Avg. Part. Diam., inches	0.282	0.268	0.293	0.278	0.260
Air, SCF/Ton RS	5085	5016	4923	5614	4900
Tot. Recycle, SCF/Ton RS (wet) (2)	13,451	11,520	11,526	13,340	11,920
Dilution Gas, SCF/Ton RS (wet)	0	0	0	0	0
Propane, SCF/Ton RS	0	0	0	0	0
Brine, Gal/Ton RS	0	0	0	0	0
Air Temp. Entering Retort, °F	70	93	80	76	76
Bed Hgt. Above Air Dist., ft	5	5	5	5	5
OPERATING DATA:					
Offgas Temperature, °F	125	132	134	135	134
Recycle Gas Temperature, °F	159	158	163	163	163
Spent Shale Temperature, °F	220	235	238	238	238
Avg. Retort ΔP, in. H <sub>2</sub> O/ft	1.00	1.27	1.18	1.18	1.23
ΔP Above Air Dist. in H <sub>2</sub> O/ft	<del>6.66</del>				
Overall Oper. Performance	GOOD	GOOD	GOOD	GOOD	GOOD
PRODUCTS RECOVERED:					
Oil Collected, vol % RSFA	94.5	74.1	76.0	80.5	79.3
Oil Lost as Mist, vol % RSFA	-	-	-	-	-
Oil in Spent Shale, vol % RSFA	.3	8.2	5.3	9.1	14.2
Total Oil Meas., vol % RSFA	-	-	-	-	-
Total Water, lbs/Ton RS	28.8	104.8	96.7	105.9	83.9
Calc. Dry Vent Gas, SCF/Ton RS	6553	6550	6429	7074	5965
Mineral CO <sub>2</sub> Decomposed, %	35.3	35.4	35.6	49.7	35.4
MATERIAL BALANCES:					
Ash, wt % (measured)	106.8	106.0	96.6	73.5	97.7
Basis for Yields & Mat'l. Bal.	SS	SS	SS	SS	SS
Overall Balance, wt %	98.5	101.3	102.0	102.0	98.1
Organic Carbon Balance, wt %	-	-	-	-	-
Total Carbon Balance, wt %	101.2	99.6	97.8	104.0	98.0
Organic Hydrogen Balance, wt %	-	-	-	-	-
Water Balance, wt %	-	-	-	-	-
Gas Loss, SCF/Ton RS (dry)	3208	3417	3220	3406	2810
HEAT BALANCE:					
Heat of Combustion, MBtu/Ton RS	-	-	-	-	-
Unaccounted Heat, MBtu/Ton RS	-	-	-	-	-
SHALE OIL PROPERTIES:					
Gravity, °API	20.0	19.4	19.0	18.9	18.9
Ramsbottom Carbon, wt %	2.75	2.26	2.79	2.64	2.50
Ash, wt %	0.67	0.14	0.13		
GAS PROPERTIES (DRY):					
Moisture, lbs/MSCF of dry gas	0.95	10.0	9.5	9.5	8.1
Gross Heating Value, Btu/SCF	75.9	114.2	84.1	125.6	58.1
O <sub>2</sub> vol %	0.3	0.3	0.6	1.3	0.6
CO <sub>2</sub> vol %	25.5	26.3	27.2	23.4	25.1
SPENT SHALE:					
Fischer Assay, Gal/Ton SS	0.1	2.5	1.6	2.7	4.1
Organic Carbon, wt %	2.0	2.7	2.4	2.9	2.8

(1) Retort No. 1 runs - no prefix; Retort No. 2 runs - "P" prefix.

(2) Measure Recycle + Dilution Gas Rate Minus Wet Gas Loss

APPENDIX A  
SUMMARY SHEET

RUN NUMBER(1)	454E	454F	454G	454H	454I
DATE STARTED	1-6-65	1-6-65	1-7-65	1-7-65	1-8-65
LENGTH OF RUN, hours	12	12	12	12	12
RETORT TYPE NUMBER					
OIL RECOVERY SYSTEM NUMBER					
OPERATING CONDITIONS:					
Raw Shale, lbs/(hr)(ft <sup>2</sup> )	509	528	519	440	494
Fischer Assay, Gal/Ton RS	24.6	24.6	25.0	23.9	26.4
Nom. Size Range, inches	1/4-3/4	1/4-3/4	1/4-3/4	1/4-3/4	1/4-3/4
Avg. Part. Diam., inches	0.257	0.282	0.285	0.282	0.236
Air, SCF/Ton RS	5135	4942	5014	6363	5321
Tot. Recycle, SCF/Ton RS (wet) (2)	13,640	13,430	13,631	14,460	11,700
Dilution Gas, SCF/Ton RS (wet)	0	0	0	0	0
Propane, SCF/Ton RS	0	0	0	0	0
Brine, Gal/Ton RS	0	0	0	0	0
Air Temp. Entering Retort, °F	73	77	77	80	72
Bed Hgt. Above Air Dist., ft	5	5	5	5	5
OPERATING DATA:					
Offgas Temperature, °F	134	136	136	136	125
Recycle Gas Temperature, °F	165	168	168	168	158
Spent Shale Temperature, °F	223	225	220	225	270
Avg. Retort ΔP, in. H <sub>2</sub> O/ft	1.68	1.50	1.45	2.07	1.27
ΔP Above Air Dist. in H <sub>2</sub> O/ft	-	-	-	-	-
Overall Oper. Performance	GOOD	GOOD	GOOD	GOOD	GOOD
PRODUCTS RECOVERED:					
Oil Collected, vol % RSFA	78.8	83.0	75.8	86.2	88.9
Oil Lost as Mist, vol % RSFA	-	-	-	-	-
Oil in Spent Shale, vol % RSFA	7.4	7.8	6.6	3.8	2.7
Total Oil Meas., vol % RSFA	-	-	-	-	-
Total Water, lbs/Ton RS	102.7	102.7	101.0	98.4	60.9
Calc. Dry Vent Gas, SCF/Ton RS	6807	6246	6410	8120	6791
Mineral CO <sub>2</sub> Decomposed, %	37.7	31.6	37.3	42.3	42.3
MATERIAL BALANCES:					
Ash, wt % (measured)	97.3	96.3	93.3	86.5	90.3
Basis for Yields & Mat'l. Bal.	SS	SS	SS	SS	SS
Overall Balance, wt %	100.6	100.5	99.5	100.2	99.7
Organic Carbon Balance, wt %	-	-	-	-	-
Total Carbon Balance, wt %	106.0	108.0	103.0	114.0	107.0
Organic Hydrogen Balance, wt %	-	-	-	-	-
Water Balance, wt %	-	-	-	-	-
Gas Loss, SCF/Ton RS (dry)	3888	3536	3547	5420	3897
HEAT BALANCE:					
Heat of Combustion, MBtu/Ton RS	-	-	-	-	-
Unaccounted Heat, MBtu/Ton RS	-	-	-	-	-
SHALE OIL PROPERTIES:					
Gravity, °API	19.4	19.0	19.0	20.6	19.7
Ramsbottom Carbon, wt %	2.09	2.43	2.59	1.51	2.06
Ash, wt %					
GAS PROPERTIES (DRY):					
Moisture, lbs/MSCF of dry gas	9.5	10.0	9.9	9.7	6.6
Gross Heating Value, Btu/SCF	92.1	45.7	69.8	110.3	47.3
O <sub>2</sub> vol %	0.6	0.4	0.3	2.5	0.8
CO <sub>2</sub> vol %	28.2	27.0	26.4	23.5	26.7
SPENT SHALE:					
Fischer Assay, Gal/Ton SS	2.2	2.3	2.0	1.1	0.9
Organic Carbon, wt %	2.6	2.7	2.4	2.7	2.0

(1) Retort No. 1 runs - no prefix; Retort No. 2 runs - "B" prefix.

(2) Measure Recycle + Dilution Gas Rate Minus Wet Gas Loss

APPENDIX A  
SUMMARY SHEET

RUN NUMBER(1)	454J	454K		
DATE STARTED	1-10-65	1-11-65		
LENGTH OF RUN, hours	12	12		
RETORT TYPE NUMBER				
OIL RECOVERY SYSTEM NUMBER				
OPERATING CONDITIONS:				
Raw Shale, lbs/(hr) (ft <sup>2</sup> )	467	455		
Fischer Assay, Gal/Ton RS	25.6	27.0		
Nom. Size Range, inches	1/4-3/4	1/4-3/4		
Avg. Part. Diam., inches	0.488	0.490		
Air, SCF/Ton RS	5540	5673		
Tot. Recycle, SCF/Ton RS (wet) (2)	12,200	12,284		
Dilution Gas, SCF/Ton RS (wet)	0	0		
Propane, SCF/Ton RS	0	0		
Brine, Gal/Ton RS	0	0		
Air Temp. Entering Retort, °F	75	76		
Bed Hgt. Above Air Dist., ft	5	5		
OPERATING DATA:				
Offgas Temperature, °F	132	130		
Recycle Gas Temperature, °F	164	162		
Spent Shale Temperature, °F	230	250		
Avg. Retort ΔP, in. H <sub>2</sub> O/ft	1.00	1.00		
ΔP Above Air Dist. in H <sub>2</sub> O/ft	-	-		
Overall Oper. Performance	GOOD	GOOD		
PRODUCTS RECOVERED:				
Oil Collected, vol % RSFA	83.8	90.7		
Oil Lost as Mist, vol % RSFA	-	-		
Oil in Spent Shale, vol % RSFA	8.2	5.9		
Total Oil Meas., vol % RSFA	-	-		
Total Water, lbs/Ton RS	99.3	89.3		
Calc. Dry Vent Gas, SCF/Ton RS	7307	7571		
Mineral CO <sub>2</sub> Decomposed, %	41.0	44.5		
MATERIAL BALANCES:				
Ash, wt % (measured)	89.6	84.7		
Basis for Yields & Mat'l. Bal.	SS	SS		
Overall Balance, wt %	100.5	100.4		
Organic Carbon Balance, wt %	-	-		
Total Carbon Balance, wt %	105.0	114.0		
Organic Hydrogen Balance, wt %	-	-		
Water Balance, wt %	-	-		
Gas Loss, SCF/Ton RS (dry)	3959	4293		
HEAT BALANCE:				
Heat of Combustion, MBtu/Ton RS	-	-		
Unaccounted Heat, MBtu/Ton RS	-	-		
SHALE OIL PROPERTIES:				
Gravity, °API	19.5	19.7		
Ramsbottom Carbon, wt %	2.44	2.40		
Ash, wt %	0.04			
GAS PROPERTIES (DRY):				
Moisture, lbs/MSCF of dry gas	8.6	8.3		
Gross Heating Value, Btu/SCF	623	73.6		
O <sub>2</sub> vol %	0.5	0.5		
CO <sub>2</sub> vol %	28.8	28.1		
SPENT SHALE:				
Fischer Assay, Gal/Ton SS	2.6	2.0		
Organic Carbon, wt %	2.3	2.2		

(1) Retort No. 1 runs - no prefix; Retort No. 2 runs - "B" prefix.

(2) Measure Recycle + Dilution Gas Rate Minus Wet Gas Loss

APPENDIX A  
SUMMARY SHEET

NO. OF RUNS (1)	1-18-65	1-18-65	1-17-65	1-18-65	1-19-65	4-33
DATE STARTED	1-18-65	1-18-65	1-17-65	1-18-65	1-19-65	11-11-64
LENGTH OF RUN, hours	24	24	24	24	24	12
RETORT TYPE NUMBER						
OIL RECOVERY SYSTEM NUMBER						
OPERATING CONDITIONS:						
Raw Shale, lbs/(hr) (ft <sup>2</sup> )	496.4	496.5	501.5	497.0	497.4	482
Fischer Assay, Gal/Ton RS	26.1	26.2	24.0	27.0	27.3	27.7
Nom. Size Range, inches	1/4-3/4	1/4-3/4	1/4-3/4	1/4-3/4	1/4-3/4	1/4-1
Avg. Part. Diam., inches	0.247	0.256	0.257	0.260	0.257	0.372
Air, SCF/Ton RS	493.2	493.5	499.0	497.0	500.0	5150
Tot. Recycle, SCF/Ton RS (wet) (2)	1215.7	1205.0	1215.6	1237.3	1220.2	14150
Dilution Gas, SCF/Ton RS (wet)	0	0	0	0	0	0
Propane, SCF/Ton RS	0	0	0	0	0	0
Brine, Gal/Ton RS	0	0	0	0	0	0
Air Temp. Entering Retort, °F	111	73	75	75	75	65
Bed Hgt. Above Air Dist., ft	5	5	5	5	5	5
GAS:						
Outlet Temperature, °F	119	123	122	122	121	141
Recycle Gas Temperature, °F	147	162	162	160	157	161
Spent Shale Temperature, °F	240	245	245	245	249	238
Avg. Retort ΔP, in. H <sub>2</sub> O/ft	1.23	1.10	1.05	1.05	1.19	1.20
ΔP Above Air Dist. in H <sub>2</sub> O/ft	1.00	0.74	0.80	0.85	1.06	—
Overall Oper. Performance	EXCEL	LL NT	—	—	—	EXCEL
PRODUCTS RECOVERED:						
Oil Collected, vol % RSFA	93.1	90.7	93.9	94.9	93.8	91.2
Oil Lost as Mist, vol % RSFA	0.4	0.2	0.4	0.2	0.2	1.0
Oil in Spent Shale, vol % RSFA	0.0	0.0	0.0	0.0	0.0	0.0
Total Oil Meas., vol % RSFA	93.5	90.9	94.3	95.0	93.9	92.2
Total Water, lbs/Ton RS	72.2	73.2	67.0	73.9	79.9	70.0
Calc. Dry Vent Gas, SCF/Ton RS	6499	6636	6586	6785	6798	6524
Mineral CO <sub>2</sub> Decomposed, %	42.1	42.8	39.3	41.6	47.9	30.8
MATERIAL BALANCES:						
Ash, wt % (measured)	101.4	101.6	100.6	101.5	102.7	95.8
Basis for Yields & Mat'l. Bal.	85	85	85	85	85	85
Overall Balance, wt %	100.4	100.9	100.4	101.3	100.6	102.4
Organic Carbon Balance, wt %	101.2	96.1	97.2	101.5	98.4	117.0
Total Carbon Balance, wt %	100.5	97.2	98.0	101.0	99.1	111.8
Organic Hydrogen Balance, wt %	101.3	97.1	97.1	96.5	98.3	115.5
Water Balance, wt %	86.2	93.3	91.2	119.4	114.9	114.5
Gas Loss, SCF/Ton RS	4269	4558	4631	4753	4642	2227
HEAT BALANCE:						
Heat of Combustion, MBtu/Ton RS	465.1	465.6	461.7	454.7	470.0	485.6
Unaccounted Heat, MBtu/Ton RS	57.8	37.0	46.2	43.9	51.4	102.5
SHALE OIL PROPERTIES:						
Gravity, °API	20.1	20.1	20.2	20.0	20.0	19.7
Ramsbottom Carbon, wt %	2.06	2.31	2.35	2.30	2.20	2.27
Ash, wt %	0.04	0.04	0.04	0.03	0.02	0.07
GAS PROPERTIES (DRY):						
Moisture, lbs/MSCF of dry gas	8.2	9.2	8.0	8.2	8.2	10.97
Gross Heating Value, Btu/SCF	85.9	70.4	88.5	82.0	74.4	114.3
O <sub>2</sub> vol %	0.6	0.4	0.2	0.5	0.2	0.6
CO <sub>2</sub> vol %	21.0	27.7	27.3	29.1	30.0	22.9
SPENT SHALE:						
Fischer Assay, Gal/Ton SS	0	0	0	0	0	0
Organic Carbon, wt %	1.77	1.50	1.35	1.26	1.43	2.39

(1) Retort No. 1 runs - no prefix; Retort No. 2 runs - "P" prefix.

(2) Measure Recycle + Dilution Gas Rate Minus Wet Gas Loss

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 2-31-64

Purpose:

1. General		7. Product Gas Properties	
Run No.	454	Water Vapor, lbs/MSCF (dry)	0.95
Length, hours	10	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	487	CO <sub>2</sub> , vol %	25.5
Spent Shale, % of RS	70.7	O <sub>2</sub> , vol %	0.3
Liquid Product, lbs/hr	119.7	N <sub>2</sub> + Argon, vol %	61.3
Oil Collected, gal/ton RS	26.1	CH <sub>4</sub> , vol %	1.7
Air, SCF/ton RS (dry)	5085	CO, vol %	5.5
Total Recycle, SCF/ton RS (wet)	13451	H <sub>2</sub> , vol %	4.7
Dilution, SCF/ton RS (wet)	0	Other, vol %	0.7
Calc. Vent Gas SCF/ton RS (dry)	6553	Gross Heating Value (calc), Btu/SCF	759
Gas Losses, SCF/ton RS	3208	Carbon (Total), lbs/MSCF (dry)	11.8
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.64
Total Flow, SCF/M (wet)	254	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	125	Pressure Drop, in H <sub>2</sub> O	11
Spent Shale Outlet	220	Dist. Back Press., in H <sub>2</sub> O	19
Raw Shale Inlet	36	NaCl Solution, Wt %	0
Recycle Gas Inlet	159	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	-	9. Yields & Balances	
Air Inlet	70	Oil Collected, vol % FA	94.5
Retort Air Inlet	70	Carbonate Decomp. %	35.4
4. Raw Shale Properties		Water Recovered, gal/ton RS	3.45
Fischer Assay, gal/ton RS	27.6	Overall Balance, %	98.8
Oil, Wt %	10.6	Carbon Balance, %	101.7
Water, Wt %	1.8	Hydrogen Balance, %	94.8
Gas, Wt %	1.9	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.0	Oxygen Balance, %	93.4
Ash, Wt %	67.7	As Measured Ash Balance, %	106.8
Moisture, Wt %	0.35	REMARKS	
Carbon (Total), Wt %	16.7	PORTS 1, 4, 5, & 12 PLUGGED.	
Hydrogen (Total), Wt %	1.76	2" RECYCLE LINE TO CENTER	
Nitrogen, Wt %	0.40	WIDE OPEN.	
APD, in	0.282	2" RECYCLE LINE TO CENTER	
5. Spent Shale Properties		CAUSED SHALE FLOW TO BE	
Fischer Assay, gal/ton	0.1	FASTER ON WEST SIDE.	
Mineral CO, Wt %	13.0	REMOVED AT THE COMPLETION	
Ash, Wt %	85.0	OF THIS RUN.	
Carbon (Total), Wt %	5.58		
Hydrogen (Total), Wt %	0.2		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	84.7		
b. Hydrogen, Wt %	11.1		
c. Density, lb/gal	7.78		
d. Gravity, API	20.0		
e. Viscosity SUS @ 130° F	125.1		
f. Viscosity SUS @ 210° F	49.9		
g. Ramsbottom Carbon, Wt %	2.75		
h. Pour Point, ° F	85		
i. Ash, Wt %	0.67		
j. Nitrogen, Wt %	2.18		

OSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-4-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454A	Water Vapor, lbs/MSCF (dry)	10.0
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	520	CO <sub>2</sub> , vol %	76.3
Spent Shale, % of RS	82.1	O <sub>2</sub> , vol %	0.3
Liquid Product, lbs/hr	104.6	N <sub>2</sub> + Argon, vol %	20.5
Oil Collected, gal/ton RS	18.6	CH <sub>4</sub> , vol %	0.0
Air, SCF/ton RS (dry)	5016	CO, vol %	5.1
Total Recycle, SCF/ton RS (wet)	11520	H <sub>2</sub> , vol %	4.2
Dilution, SCF/ton RS (wet)	0	Other, vol %	3.0
Calc. Vent Gas SCF/ton RS (dry)	6550	Gross Heating Value (calc).Btu/SCF	114.7
Gas Losses, SCF/ton RS	3417	Carbon (Total), lbs/MSCF (dry)	11.4
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.2
Total Flow, SCF/M (wet)	273	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	132	Pressure Drop, in H <sub>2</sub> O	14
Spent Shale Outlet	235	Dist. Back Press., in H <sub>2</sub> O	20
Raw Shale Inlet	41	NaCl Solution, Wt %	0
Recycle Gas Inlet	158	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	93	Oil Collected, vol % FA	74.1
Retort Air Inlet	93	Carbonate Decomp. %	35.4
4. Raw Shale Properties		Water Recovered, gal/ton RS	12.57
Fischer Assay, gal/ton RS	25.1	Overall Balance, %	101.3
Oil, Wt %	10.0	Carbon Balance, %	99.6
Water, Wt %	2.0	Hydrogen Balance, %	118.1
Gas, Wt %	2.0	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.4	Oxygen Balance, %	110.0
Ash, Wt %	68.3	As Measured Ash Balance, %	106.0
Moisture, Wt %	0.5	REMARKS	
Carbon (Total), Wt %	15.1	WET MUDDY SHALE.	
Hydrogen (Total), Wt %	1.58	FAIRLY SMOOTH RUN FROM	
Nitrogen, Wt %	0.35	OPERATIONAL VIEWPOINT.	
APD, in	0.268		
5. Spent Shale Properties			
Fischer Assay, gal/ton	2.5		
Mineral CO, Wt %	13.7		
Ash, Wt %	83.7		
Carbon (Total), Wt %	6.48		
Hydrogen (Total), Wt %	0.24		
6. Liquid Product Properties			
1. Oil, Wt %			
	78.7		
a. Carbon Content, Wt %	82.9		
b. Hydrogen, Wt %	11.1		
c. Density, lb/gal	7.81		
d. Gravity, API	19.4		
e. Viscosity SUS @ 130° F	125.0		
f. Viscosity SUS @ 210° F	49.1		
g. Ramsbottom Carbon, Wt %	2.26		
h. Pour Point, ° F	80		
i. Ash, Wt %	0.14		
j. Nitrogen, Wt %	2.17		

DSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-4-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	4575	Water Vapor, lbs/MSCF (dry)	9.5
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	527	CO <sub>2</sub> , vol %	27.7
Spent Shale, % of RS	82.4	O <sub>2</sub> , vol %	0.6
Liquid Product, lbs/hr	105	Na + Argon, vol %	60.6
Oil Collected, gal/ton RS	18.8	CH <sub>4</sub> , vol %	1.3
Air, SCF/ton RS (dry)	4923	CO, vol %	5.5
Total Recycle, SCF/ton RS (wet)	11526	H <sub>2</sub> , vol %	3.3
Dilution, SCF/ton RS (wet)	0	Other, vol %	1.6
Calc. Vent Gas SCF/ton RS (dry)	6429	Gross Heating Value (calc), Btu/SCF	83.1
Gas Losses, SCF/ton RS	3220	Carbon (Total), lbs/MSCF (dry)	10.1
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	2.45
Total Flow, SCF/M (wet)	277	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	134	Pressure Drop, in H <sub>2</sub> O	13
Spent Shale Outlet	73.5	Dist. Back Press., in H <sub>2</sub> O	18
Raw Shale Inlet	47	NaCl Solution, Wt %	0
Recycle Gas Inlet	16.3	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	80	Oil Collected, vol % FA	76.0
Retort Air Inlet	80	Carbonate Decomp. %	35.6
4. Raw Shale Properties		Water Recovered, gal/ton RS	11.6
Fischer Assay, gal/ton RS	24.7	Overall Balance, %	102
Oil, Wt %	9.4	Carbon Balance, %	97.8
Water, Wt %	2.2	Hydrogen Balance, %	113
Gas, Wt %	1.6	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.9	Oxygen Balance, %	109
Ash, Wt %	69.7	As Measured Ash Balance, %	96.6
Moisture, Wt %	0.51	REMARKS	
Carbon (Total), Wt %	14.7		
Hydrogen (Total), Wt %	1.53		
Nitrogen, Wt %	0.32		
APD, in	0.293		
5. Spent Shale Properties			
Fischer Assay, gal/ton	1.6		
Mineral CO, Wt %	13.2		
Ash, Wt %	84.5		
Carbon (Total), Wt %	6.0		
Hydrogen (Total), Wt %	0.28		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	80.4		
b. Hydrogen, Wt %	84.2		
c. Density, lb/gal	10.3		
d. Gravity, API	7.83		
e. Viscosity SUS @ 130° F	19.0		
f. Viscosity SUS @ 210° F	163.0		
g. Ramsbottom Carbon, Wt %	55.2		
h. Pour Point, °F	2.79		
i. Ash, Wt %	85		
j. Nitrogen, Wt %	0.13		
	2.21		

OSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-5-65

Purpose:

<u>1. General</u>		<u>7. Product Gas Properties</u>	
Run No.	4510	Water Vapor, lbs/MSCF (dry)	9.5
Length, hours	12	Oil, lbs/MSCF (dry)	
<u>2. Rates &amp; Quantities</u>		<u>Analysis (dry)</u>	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	464	CO <sub>2</sub> , vol %	25.4
Spent Shale, % of RS	83.0	O <sub>2</sub> , vol %	1.3
Liquid Product, lbs/hr	97.2	N <sub>2</sub> + Argon, vol %	47.7
Oil Collected, gal/ton RS	19.8	CH <sub>4</sub> , vol %	1.3
Air, SCF/ton RS (dry)	5614	CO, vol %	5.3
Total Recycle, SCF/ton RS (wet)	13,340	H <sub>2</sub> , vol %	2.7
Dilution, SCF/ton RS (wet)	0	Other, vol %	3.3
Calc. Vent Gas SCF/ton RS (dry)	7074	Gross Heating Value (calc), Btu/SCF	125.6
Gas Losses, SCF/ton RS	3406	Carbon (Total), lbs/MSCF (dry)	10.1
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.49
Total Flow, SCF/M (wet)	296	<u>8. Miscellaneous</u>	
<u>3. Temperature, ° F</u>		Bed Height Above Dist., ft.	5
Retort Gas Outlet	135	Pressure Drop, in H <sub>2</sub> O	13
Spent Shale Outlet	239	Dist. Back Press., in H <sub>2</sub> O	18
Raw Shale Inlet	45	NaCl Solution, Wt %	0
Recycle Gas Inlet	163	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	<u>9. Yields &amp; Balances</u>	
Air Inlet	76	Oil Collected, vol % FA	80.5
Retort Air Inlet	76	Carbonate Decomp. %	49.7
<u>4. Raw Shale Properties</u>		Water Recovered, gal/ton RS	12.7
Fischer Assay, gal/ton RS	24.6	Overall Balance, %	102
Oil, Wt %	9.3	Carbon Balance, %	104
Water, Wt %	2.6	Hydrogen Balance, %	126
Gas, Wt %	1.4	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.5	Oxygen Balance, %	92.4
Ash, Wt %	69.8	As Measured Ash Balance, %	73.5
Moisture, Wt %	0.38	<u>REMARKS</u>	
Carbon (Total), Wt %	14.3		
Hydrogen (Total), Wt %	1.46		
Nitrogen, Wt %	0.32		
APD, in	0.273		
<u>5. Spent Shale Properties</u>			
Fischer Assay, gal/ton	2.7		
Mineral CO, Wt %	10.6		
Ash, Wt %	84.1		
Carbon (Total), Wt %	5.82		
Hydrogen (Total), Wt %	0.36		
<u>6. Liquid Product Properties</u>			
<u>1. Oil, Wt %</u>			
Oil, Wt %	80		
a. Carbon Content, Wt %	89.0		
b. Hydrogen, Wt %	10.3		
c. Density, lb/gal	7.84		
d. Gravity, API	18.1		
e. Viscosity SUS @ 130° F	166.5		
f. Viscosity SUS @ 210° F	55.8		
g. Ramsbottom Carbon, Wt %	2.64		
h. Pour Point, ° F	85		
i. Ash, Wt %	—		
j. Nitrogen, Wt %	2.22		

OSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-5-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454D	Water Vapor, lbs/MSCF (dry)	8.1
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	532	CO <sub>2</sub> , vol %	25.1
Spent Shale, % of RS	83.3	O <sub>2</sub> , vol %	0.6
Liquid Product, lbs/hr	108	Na # Airflow, Vol %	44.8
Oil Collected, gal/ton RS	19.0	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	4900	CO, vol %	4.2
Total Recycle, SCF/ton RS (wet)	11,920	H <sub>2</sub> , vol %	3.3
Dilution, SCF/ton RS (wet)	0	Other, vol %	0.8
Calc. Vent Gas SCF/ton RS (dry)	5965	Gross Heating Value (calc), Btu/SCF	58.1
Gas Losses, SCF/ton RS	2810	Carbon (Total), lbs/MSCF (dry)	11.1
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.7
Total Flow, SCF/M (wet)	302	8. Miscellaneous	
3. Temperature, ° F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	134	Pressure Drop, in H <sub>2</sub> O	13.5
Spent Shale Outlet	238	Dist. Back Press., in H <sub>2</sub> O	2.3
Raw Shale Inlet	43	NaCl Solution, Wt %	0
Recycle Gas Inlet	163	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	76	Oil Collected, vol % FA	79.3
Retort Air Inlet	76	Carbonate Decomp. %	35.4
4. Raw Shale Properties		Water Recovered, gal/ton RS	10.3
Fischer Assay, gal/ton RS	24.0	Overall Balance, %	98.1
Oil, Wt %	9.0	Carbon Balance, %	98.0
Water, Wt %	2.2	Hydrogen Balance, %	96.1
Gas, Wt %	1.7	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.8	Oxygen Balance, %	86.5
Ash, Wt %	69.2	As Measured Ash Balance, %	97.7
Moisture, Wt %	0.38	REMARKS	
Carbon (Total), Wt %	15.2		
Hydrogen (Total), Wt %	1.52		
Nitrogen, Wt %	0.34		
APD, in	0.260		
5. Spent Shale Properties			
Fischer Assay, gal/ton	4.1		
Mineral CO <sub>2</sub> , Wt %	13.8		
Ash, Wt %	83.2		
Carbon (Total), Wt %	6.6		
Hydrogen (Total), Wt %	0.36		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	80		
b. Hydrogen, Wt %	81.8		
c. Density, lb/gal	10.4		
d. Gravity, API	7.84		
e. Viscosity SUS @ 130° F	18.9		
f. Viscosity SUS @ 210° F	156.2		
g. Ramsbottom Carbon, Wt %	52.8		
h. Pour Point, ° F	2.50		
i. Ash, Wt %	85		
j. Nitrogen, Wt %	—		
	2.13		

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-6-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454.5	Water Vapor, lbs/MSCF (dry)	9.5
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	509	CO <sub>2</sub> , vol %	28.2
Spent Shale, % of RS	82.2	O <sub>2</sub> , vol %	0.6
Liquid Product, lbs/hr	105	N <sub>2</sub> + Argon, vol %	59.6
Oil Collected, gal/ton RS	19.4	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	5135	CO, vol %	5.1
Total Recycle, SCF/ton RS (wet)	13,440	H <sub>2</sub> , vol %	3.3
Dilution, SCF/ton RS (wet)	0	Other, vol %	2.0
Calc. Vent Gas SCF/ton RS (dry)	6807	Gross Heating Value (calc), Btu/SCF	92.1
Gas Losses, SCF/ton RS	3283	Carbon (Total), lbs/MSCF (dry)	11.4
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.6
Total Flow, SCF/M (wet)	315	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	134	Pressure Drop, in H <sub>2</sub> O	18.5
Spent Shale Outlet	223	Dist. Back Press., in H <sub>2</sub> O	23
Raw Shale Inlet	43	NaCl Solution, Wt %	0
Recycle Gas Inlet	165	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	73	Oil Collected, vol % FA	78.8
Retort Air Inlet	73	Carbonate Decomp. %	37.7
4. Raw Shale Properties		Water Recovered, gal/ton RS	12.3
Fischer Assay, gal/ton RS	24.6	Overall Balance, %	100.6
Oil, Wt %	9.4	Carbon Balance, %	106
Water, Wt %	2.6	Hydrogen Balance, %	105
Gas, Wt %	1.6	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.0	Oxygen Balance, %	97.3
Ash, Wt %	70.4	As Measured Ash Balance, %	97.3
Moisture, Wt %	0.60	REMARKS	
Carbon (Total), Wt %	14.2	RECOVERY FROM ESP WITH HIGH	
Hydrogen (Total), Wt %	1.43	VOLTAGE OFF 105/HR	
Nitrogen, Wt %	0.32		28.3
APD, in	0.257		
5. Spent Shale Properties			
Fischer Assay, gal/ton	2.2		
Mineral CO, Wt %	12.1		
Ash, Wt %	85.3		
Carbon (Total), Wt %	5.87		
Hydrogen (Total), Wt %	0.27		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	89.1		
b. Hydrogen, Wt %	11.0		
c. Density, lb/gal	7.81		
d. Gravity, API	19.4		
e. Viscosity SUS @ 130° F	141.9		
f. Viscosity SUS @ 210° F	51.3		
g. Ramsbottom Carbon, Wt %	2.09		
h. Pour Point, °F	80		
i. Ash, Wt %	—		
j. Nitrogen, Wt %	2.23		

## APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEETDate 1-6-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	45AF	Water Vapor, lbs/MSCF (dry)	10.0
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	528	CO <sub>2</sub> , vol %	27.0
Spent Shale, % of RS	83.6	O <sub>2</sub> , vol %	0.4
Liquid Product, lbs/hr	115	N <sub>2</sub> + Argon, vol %	62.5
Oil Collected, gal/ton RS	20.4	CH <sub>4</sub> , vol %	1.4
Air, SCF/ton RS (dry)	4942	CO, vol %	5.0
Total Recycle, SCF/ton RS (wet)	13430	H <sub>2</sub> , vol %	3.6
Dilution, SCF/ton RS (wet)	0	Other, vol %	0.1
Calc. Vent Gas SCF/ton RS (dry)	6246	Gross Heating Value (calc), Btu/SCF	45.7
Gas Losses, SCF/ton RS	3536	Carbon (Total), lbs/MSCF (dry)	11.2
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.52
Total Flow, SCF/M (wet)	314	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	136	Pressure Drop, in H <sub>2</sub> O	16.5
Spent Shale Outlet	225	Dist. Back Press., in H <sub>2</sub> O	20.5
Raw Shale Inlet	48	NaCl Solution, Wt %	0
Recycle Gas Inlet	168	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	77	Oil Collected, vol % FA	83.0
Retort Air Inlet	77	Carbonate Decomp. %	31.6
4. Raw Shale Properties		Water Recovered, gal/ton RS	12.3
Fischer Assay, gal/ton RS	24.6	Overall Balance, %	100.5
Oil, Wt %	9.4	Carbon Balance, %	108
Water, Wt %	2.8	Hydrogen Balance, %	99.1
Gas, Wt %	2.2	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.0	Oxygen Balance, %	95.6
Ash, Wt %	70.6	As Measured Ash Balance, %	96.3
Moisture, Wt %	0.50	REMARKS	
Carbon (Total), Wt %	14.3	RECOVERY FROM ESP WITH HIGH	
Hydrogen (Total), Wt %	1.57	VOLTAGE ON, lbs/hr	
Nitrogen, Wt %	0.32		27.5
APD, in	0.282		
5. Spent Shale Properties			
Fischer Assay, gal/ton	2.3		
Mineral CO <sub>2</sub> , Wt %	13.1		
Ash, Wt %	84.6		
Carbon (Total), Wt %	6.23		
Hydrogen (Total), Wt %	0.32		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	83.6		
b. Hydrogen, Wt %	10.8		
c. Density, lb/gal	7.83		
d. Gravity, API	19.0		
e. Viscosity SUS @ 130° F	188.1		
f. Viscosity SUS @ 210° F	49.8		
g. Ramsbottom Carbon, Wt %	2.43		
h. Pour Point, ° F	85		
i. Ash, Wt %	—		
j. Nitrogen, Wt %	2.22		

OSRC-10

## APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEETDate 1-7-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	4546	Water Vapor, lbs/MSCF (dry)	9.9
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	519	CO <sub>2</sub> , vol %	26.4
Spent Shale, % of RS	82.6	O <sub>2</sub> , vol %	0.3
Liquid Product, lbs/hr	105	N <sub>2</sub> + Argon, vol %	61.8
Oil Collected, gal/ton RS	19.0	CH <sub>4</sub> , vol %	1.0
Air, SCF/ton RS (dry)	5014	CO, vol %	4.9
Total Recycle, SCF/ton RS (wet)	1363	H <sub>2</sub> , vol %	4.5
Dilution, SCF/ton RS (wet)	0	Other, vol %	1.1
Calc. Vent Gas SCF/ton RS (dry)	6410	Gross Heating Value (calc), Btu/SCF	69.8
Gas Losses, SCF/ton RS	3547	Carbon (Total), lbs/MSCF (dry)	12.2
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.7
Total Flow, SCF/M (wet)	318	B. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	136	Pressure Drop, in H <sub>2</sub> O	16
Spent Shale Outlet	220	Dist. Back Press., in H <sub>2</sub> O	20
Raw Shale Inlet	47	NaCl Solution, Wt %	0
Recycle Gas Inlet	168	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	77	Oil Collected, vol % FA	75.8
Retort Air Inlet	77	Carbonate Decomp. %	37.3
4. Raw Shale Properties		Water Recovered, gal/ton RS	12.1
Fischer Assay, gal/ton RS	25.0	Overall Balance, %	99.5
Oil, Wt %	9.6	Carbon Balance, %	103
Water, Wt %	2.6	Hydrogen Balance, %	99.7
Gas, Wt %	2.0	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.0	Oxygen Balance, %	92.8
Ash, Wt %	70.3	As Measured Ash Balance, %	93.3
Moisture, Wt %	0.51	REMARKS	
Carbon (Total), Wt %	14.5	ESP. ON, lbs/MZ	26.8
Hydrogen (Total), Wt %	1.48		
Nitrogen, Wt %	0.33		
APD, in	0.285		
5. Spent Shale Properties			
Fischer Assay, gal/ton	2.0		
Mineral CO, Wt %	12.9		
Ash, Wt %	85.1		
Carbon (Total), Wt %	5.93		
Hydrogen (Total), Wt %	0.22		
6. Liquid Product Properties			
1. OIL, Wt %			
a. Carbon Content, Wt %	82.8		
b. Hydrogen, Wt %	10.6		
c. Density, lb/gal	7.83		
d. Gravity, API	19.0		
e. Viscosity SUS @ 130° F	131.8		
f. Viscosity SUS @ 210° F	49.7		
g. Ramsbottom Carbon, Wt %	2.50		
h. Pour Point, ° F	85		
i. Ash, Wt %	—		
j. Nitrogen, Wt %	2.18		

OSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-7-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454H	Water Vapor, lbs/MSCF (dry)	9.7
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	440	CO <sub>2</sub> , vol %	23.5
Spent Shale, % of RS	81.9	O <sub>2</sub> , vol %	2.5
Liquid Product, lbs/hr	86	N <sub>2</sub> + Argon, vol %	61.9
Oil Collected, gal/ton RS	20.6	CH <sub>4</sub> , vol %	1.0
Air, SCF/ton RS (dry)	6363	CO, vol %	4.9
Total Recycle, SCF/ton RS (wet)	14460	H <sub>2</sub> , vol %	3.4
Dilution, SCF/ton RS (wet)	0	Other, vol %	2.8
Calc. Vent Gas SCF/ton RS (dry)	8120	Gross Heating Value (calc), Btu/SCF	110.3
Gas Losses, SCF/ton RS	5420	Carbon (Total), lbs/MSCF (dry)	12.2
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.64
Total Flow, SCF/M (wet)	310	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	136	Pressure Drop, in H <sub>2</sub> O	22.7
Spent Shale Outlet	225	Dist. Back Press., in H <sub>2</sub> O	27.7
Raw Shale Inlet	54	NaCl Solution, Wt %	0
Recycle Gas Inlet	168	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	80	Oil Collected, vol % FA	86.2
Retort Air Inlet	80	Carbonate Decomp. %	42.3
4. Raw Shale Properties		Water Recovered, gal/ton RS	11.8
Fischer Assay, gal/ton RS	23.9	Overall Balance, %	100.3
Oil, Wt %	9.1	Carbon Balance, %	114
Water, Wt %	2.4	Hydrogen Balance, %	105
Gas, Wt %	1.8	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.6	Oxygen Balance, %	90.7
Ash, Wt %	70.2	As Measured Ash Balance, %	86.5
Moisture, Wt %	0.72	REMARKS	
Carbon (Total), Wt %	14.4	ESP ON, lbs/hr	17.7
Hydrogen (Total), Wt %	1.52	MOISTURE ON RAW SHALE AS	
Nitrogen, Wt %	0.33	MEASURED ON SAMPLES TAKEN	
APD, in	0.282	AT TOP OF RETORT, WT%	
5. Spent Shale Properties			2.7
Fischer Assay, gal/ton	1.1		
Mineral CO <sub>2</sub> , Wt %	11.7		
Ash, Wt %	85.3		
Carbon (Total), Wt %	5.83		
Hydrogen (Total), Wt %	0.26		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	89.1		
b. Hydrogen, Wt %	82.9		
c. Density, lb/gal	10.6		
d. Gravity, API	7.75		
e. Viscosity SUS @ 130° F	20.6		
f. Viscosity SUS @ 210° F	148.7		
g. Ramsbottom Carbon, Wt %	51.6		
h. Pour Point, °F	1.51		
i. Ash, Wt %	85		
j. Nitrogen, Wt %	—		
	2.15		

## APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEETDate 1-8-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	4541	Water Vapor, lbs/MSCF (dry)	6.6
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	494	CO <sub>2</sub> , vol %	26.7
Spent Shale, % of RS	85.1	O <sub>2</sub> , vol %	0.8
Liquid Product, lbs/hr	107.3	N <sub>2</sub> + Argon, vol %	61.9
Oil Collected, gal/ton RS	23.5	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	5321	CO, vol %	6.5
Total Recycle, SCF/ton RS (wet)	11700	H <sub>2</sub> , vol %	4.1
Dilution, SCF/ton RS (wet)	0	Other, vol %	—
Calc. Vent Gas SCF/ton RS (dry)	6791	Gross Heating Value (calc), Btu/SCF	47.3
Gas Losses, SCF/ton RS	3897	Carbon (Total), lbs/MSCF (dry)	12.5
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.62
Total Flow, SCF/M (wet)	322	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	125	Pressure Drop, in H <sub>2</sub> O	14
Spent Shale Outlet	270	Dist. Back Press., in H <sub>2</sub> O	25
Raw Shale Inlet	39	NaCl Solution, Wt %	0
Recycle Gas Inlet	158	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	72	Oil Collected, vol % FA	88.9
Retort Air Inlet	72	Carbonate Decomp. %	42.8
4. Raw Shale Properties		Water Recovered, gal/ton RS	7.3
Fischer Assay, gal/ton RS	26.4	Overall Balance, %	99.7
Oil, Wt %	10.0	Carbon Balance, %	107
Water, Wt %	1.8	Hydrogen Balance, %	108
Gas, Wt %	2.0	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.4	Oxygen Balance, %	96.6
Ash, Wt %	69.7	As Measured Ash Balance, %	90.3
Moisture, Wt %	0.53	REMARKS	
Carbon (Total), Wt %	15.1	ESP ON, 165/hr	
Hydrogen (Total), Wt %	1.51		22.1
Nitrogen, Wt %	0.34		
APD, in	0.236		
5. Spent Shale Properties			
Fischer Assay, gal/ton	0.9		
Mineral CO <sub>2</sub> , Wt %	11.8		
Ash, Wt %	86.9		
Carbon (Total), Wt %	5.26		
Hydrogen (Total), Wt %	0.18		
6. Liquid Product Properties			
Oil, Wt %	91.8		
a. Carbon Content, Wt %	83.7		
b. Hydrogen, Wt %	10.3		
c. Density, lb/gal	7.79		
d. Gravity, API	19.7		
e. Viscosity SUS @ 130° F	139.9		
f. Viscosity SUS @ 210° F	48.3		
g. Ramsbottom Carbon, Wt %	2.06		
h. Pour Point, °F	85		
i. Ash, Wt %			
j. Nitrogen, Wt %	2.20		

OSRC-10

APPENDIX P

GAS-COMBUSTION PL. CRT NO. 1  
DETAILED TEST SHEET

Date 1-10-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	4571	Water Vapor, lbs/MSCF (dry)	3.6
Length, hours	1.2	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	217	CO <sub>2</sub> , vol %	23.3
Spent Shale, % of RS	27.4	O <sub>2</sub> , vol %	0.5
Liquid Product, lbs/hr	103.5	N <sub>2</sub> + Argon, vol %	10.0
Oil Collected, gal/ton RS	21.4	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	55.10	CO, vol %	1.9
Total Recycle, SCF/ton RS (wet)	12.20	H <sub>2</sub> , vol %	3.0
Dilution, SCF/ton RS (wet)	0	Other, vol %	0.8
Calc. Vent Gas SCF/ton RS (dry)	7307	Gross Heating Value (calc), Btu/SCF	47.3
Gas Losses, SCF/ton RS	3959	Carbon (Total), lbs/MSCF (dry)	12.3
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	2.50
Total Flow, SCF/M (wet)	3348	8. Miscellaneous	
3. Temperature, ° F		Bed Height Above Dist., ft.	5'
Retort Gas Outlet	137	Pressure Drop, in H <sub>2</sub> O	11
Spent Shale Outlet	230	Dist. Back Press., in H <sub>2</sub> O	24
Raw Shale Inlet	46	NaCl Solution, Wt %	0
Recycle Gas Inlet	164	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	75	Oil Collected, vol % FA	85.2
Retort Air Inlet	75	Carbonate Decomp. %	41.0
4. Raw Shale Properties		Water Recovered, gal/ton RS	11.9
Fischer Assay, gal/ton RS	25.6	Overall Balance, %	100.5
Oil, Wt %	9.7	Carbon Balance, %	105
Water, Wt %	3.6	Hydrogen Balance, %	100
Gas, Wt %	1.4	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.2	Oxygen Balance, %	93.6
Ash, Wt %	69.4	As Measured Ash Balance, %	89.6
Moisture, Wt %	1.0	REMARKS	
Carbon (Total), Wt %	15.2		
Hydrogen (Total), Wt %	1.64		
Nitrogen, Wt %	0.35		
APD, in	0.423		
5. Spent Shale Properties			
Fischer Assay, gal/ton	2.6		
Mineral CO <sub>2</sub> , Wt %	11.9		
Ash, Wt %	36.4		
Carbon (Total), Wt %	5.54		
Hydrogen (Total), Wt %	0.24		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	87.2		
b. Hydrogen, Wt %	84.1		
c. Density, lb/gal	10.9		
d. Gravity, API	7.79		
e. Viscosity SUS @ 130° F	19.5		
f. Viscosity SUS @ 210° F	140.2		
g. Ramsbottom Carbon, Wt %	50.4		
h. Pour Point, ° F	2.42		
i. Ash, Wt %	385		
j. Nitrogen, Wt %	0.04		
	2.27		

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-11-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454K	Water Vapor, lbs/MSCF (dry)	8.3
Length, hours	12	Oil, lbs/MSCF (dry)	
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	455	CO <sub>2</sub> , vol %	28.1
Spent Shale, % of RS	88.0	O <sub>2</sub> , vol %	2.5
Liquid Product, lbs/hr	107.5	N <sub>2</sub> + Argon, vol %	59.2
Oil Collected, gal/ton RS	24.5	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	5673	CO, vol %	5.7
Total Recycle, SCF/ton RS (wet)	12,284	H <sub>2</sub> , vol %	4.2
Dilution, SCF/ton RS (wet)	0	Other, vol %	1.1
Calc. Vent Gas SCF/ton RS (dry)	7571	Gross Heating Value (calc), Btu/SCF	73.6
Gas Losses, SCF/ton RS	4293	Carbon (Total), lbs/MSCF (dry)	12.7
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.62
Total Flow, SCF/M (wet)	331	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	130	Pressure Drop, in H <sub>2</sub> O	11
Spent Shale Outlet	250	Dist. Back Press., in H <sub>2</sub> O	24
Raw Shale Inlet	43	NaCl Solution, Wt %	0
Recycle Gas Inlet	162	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	—	9. Yields & Balances	
Air Inlet	76	Oil Collected, vol % FA	90.7
Retort Air Inlet	76	Carbonate Decomp. %	41.5
4. Raw Shale Properties		Water Recovered, gal/ton RS	10.7
Fischer Assay, gal/ton RS	27.0	Overall Balance, %	100.4
Oil, Wt %	10.3	Carbon Balance, %	114
Water, Wt %	2.6	Hydrogen Balance, %	98.4
Gas, Wt %	2.0	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.3	Oxygen Balance, %	91.7
Ash, Wt %	69.4	As Measured Ash Balance, %	84.7
Moisture, Wt %	0.7	REMARKS	
Carbon (Total), Wt %	15.2	MOISTURE ON RAW SHALE FEP	
Hydrogen (Total), Wt %	1.59	TO TOP OF RETORT, Wt %	
Nitrogen, Wt %	0.35		2.60
APD, in	0.490		
5. Spent Shale Properties			
Fischer Assay, gal/ton	2.0		
Mineral CO, Wt %	12.0		
Ash, Wt %	86.6		
Carbon (Total), Wt %	5.49		
Hydrogen (Total), Wt %	0.22		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	88.0		
b. Hydrogen, Wt %	84.5		
c. Density, lb/gal	10.2		
d. Gravity, API	7.79		
e. Viscosity SUS @ 130° F	19.7		
f. Viscosity SUS @ 210° F	138.9		
g. Ramsbottom Carbon, Wt %	48.9		
h. Pour Point, °F	29.0		
i. Ash, Wt %	85		
j. Nitrogen, Wt %	—		
	2.18		

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-15-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454-L	Water Vapor, lbs/MSCF (dry)	8.2
Length, hours	24	Oil, lbs/MSCF (dry)	0.18
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	494	CO <sub>2</sub> , vol %	27.0
Spent Shale, % of RS	77.2	H <sub>2</sub> , vol %	2.2
Liquid Product, lbs/hr	108.7	N <sub>2</sub> + Argon, vol %	58.5
Oil Collected, gal/ton RS	24.0	CH <sub>4</sub> , vol %	1.0
Air, SCF/ton RS (dry)	4832	CO, vol %	4.6
Total Recycle, SCF/ton RS (wet)	12757	H <sub>2</sub> , vol %	3.6
Dilution, SCF/ton RS (wet)	0	Other, vol %	4.4
Calc. Vent Gas SCF/ton RS (dry)	6494	Gross Heating Value (calc), Btu/SCF	88.4
Gas Losses, SCF/ton RS (wet)	4269	Carbon (Total), lbs/MSCF (dry)	12.4
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.62
Total Flow, SCF/M (wet)	346	8. Miscellaneous	
3. Temperature, °C F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	119	Pressure Drop, in H <sub>2</sub> O	14
Spent Shale Outlet	240	Dist. Back Press., in H <sub>2</sub> O	17
Raw Shale Inlet	54	NaCl Solution, Wt %	0
Recycle Gas Inlet	162	NaCl Rate, lb/ton RS	0
Dilution Gas Inlet	-	9. Yields & Balances	
Air Inlet	111	Oil Collected, vol % FA	92.1
Retort Air Inlet	111	Carbonate Decomp. %	42.1
4. Raw Shale Properties		Water Recovered, lb/ton RS	72.2
Fischer Assay, gal/ton RS	26.1	Overall Balance, %	100.4
Oil, Wt %	9.9	Carbon Balance, % (Total)	100.8
Water, Wt %	1.8	Hydrogen Balance, % (Total)	98.7
Gas, Wt %	2.0	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.0	Water Balance, %	86.2
Ash, Wt %	69.4	As Measured Ash Balance, %	101.4
Moisture, Wt %	0.44	REMARKS	
Carbon (Total), Wt %	15.9		
Hydrogen (Total), Wt %	1.73		
Nitrogen, Wt %	0.34		
APD, in	0.264		
5. Spent Shale Properties			
Fischer Assay, gal/ton	0		
Mineral CO <sub>2</sub> , Wt %	12.8		
Ash, Wt %	86.1		
Carbon (Total), Wt %	5.26		
Hydrogen (Total), Wt %	0.14		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	83.5		
b. Hydrogen, Wt %	11.1		
c. Density, lb/gal	7.77		
d. Gravity, API	20.1		
e. Viscosity SUS @ 130° F	121.5		
f. Viscosity SUS @ 210° F	47.5		
g. Ramsbottom Carbon, Wt %	2.06		
h. Pour Point, ° F	8.5		
i. Ash, Wt %	0.04		
j. Nitrogen, Wt %	1.97		

DCRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-17-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454A1	Water Vapor, lbs/MSCF (dry)	8.2
Length, hours	24	Oil, lbs/MSCF (dry)	0.041
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	497	CO <sub>2</sub> , vol %	32.7
Spent Shale, % of RS	79.2	O <sub>2</sub> , vol %	0.4
Liquid Product, lbs/hr	116.8	N <sub>2</sub> + Argon, vol %	58.6
Oil Collected, gal/ton RS	24.3	CH <sub>4</sub> , vol %	1.0
Air, SCF/ton RS (dry)	4956	CO, vol %	4.8
Total Recycle, SCF/ton RS (wet)	12070	H <sub>2</sub> , vol %	3.6
Dilution, SCF/ton RS (wet)	0	Other, vol %	3.9
Calc. Vent Gas, SCF/ton RS (dry)	6681	Gross Heating Value (calc), Btu/SCF	71.1
Gas Losses, SCF/ton RS (wet)	4558	Carbon (Total), lbs/MSCF (dry)	11.7
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.56
Total Flow, SCF/M (wet)	3408	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	123	Pressure Drop, in H <sub>2</sub> O	16.5
Spent Shale Outlet	245	Dist. Back Press., in H <sub>2</sub> O	15.5
Raw Shale Inlet	53	NaCl Solution, Wt %	0
Recycle Gas Inlet	162	NaCl Rate, lb/ton RS	0
Dilution Gas Inlet	-	9. Yields & Balances	
Air Inlet	78	Oil Collected, vol % FA	90.7
Retort Air Inlet	78	Carbonate Decomp. %	42.8
4. Raw Shale Properties		Water Recovered, lb/ton RS	73.2
Fischer Assay, gal/ton RS	26.8	Overall Balance, %	100.9
Oil, Wt %	10.2	Carbon Balance, % (Total)	91.2
Water, Wt %	1.8	Hydrogen Balance, % (Total)	96.6
Gas, Wt %	1.9	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.2	Water Balance, %	93
Ash, Wt %	69.4	As Measured Ash Balance, %	106.6
Moisture, Wt %	0.45	REMARKS	
Carbon (Total), Wt %	16.3		
Hydrogen (Total), Wt %	1.75		
Nitrogen, Wt %	0.35		
APD, in	0.256		
5. Spent Shale Properties			
Fischer Assay, gal/ton	0		
Mineral CO <sub>2</sub> , Wt %	12.7		
Ash, Wt %	86.1		
Carbon (Total), Wt %	5.27		
Hydrogen (Total), Wt %	0.11		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	82.1		
b. Hydrogen, Wt %	11.1		
c. Density, lb/gal	7.77		
d. Gravity, API	20.1		
e. Viscosity SUS @ 130° F	147.4		
f. Viscosity SUS @ 210° F	50.3		
g. Ramsbottom Carbon, Wt %	2.31		
h. Pour Point, °F	85		
i. Ash, Wt %	0.04		
j. Nitrogen, Wt %	2.25		

OSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-17-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	4544	Water Vapor, lbs/MSCF (dry)	8.0
Length, hours	24	Oil, lbs/MSCF (dry)	0.162
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	505	CO <sub>2</sub> , vol %	27.3
Spent Shale, % of RS	75.6	O <sub>2</sub> , vol %	0.2
Liquid Product, lbs/hr	115	N <sub>2</sub> + Argon, vol %	58.8
Oil Collected, gal/ton RS	25.3	CH <sub>4</sub> , vol %	1.0
Air, SCF/ton RS (dry)	4549	CO, vol %	4.6
Total Recycle, SCF/ton RS (wet)	12156	H <sub>2</sub> , vol %	3.5
Dilution, SCF/ton RS (wet)	0	Other, vol %	4.6
Calc. Vents Gas SCF/ton RS (dry)	6586	Gross Heating Value (calc), Btu/SCF	88.7
Gas Losses, SCF/ton RS (wet)	4631	Carbon (Total), lbs/MSCF (dry)	12.4
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.64
Total Flow, SCF/M (wet)	321	8. Miscellaneous	
3. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	122	Pressure Drop, in H <sub>2</sub> O	11
Spent Shale Outlet	245	Dist. Back Press., in H <sub>2</sub> O	15
Raw Shale Inlet	48	NaCl Solution, Wt %	0
Recycle Gas Inlet	162	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	-	9. Yields & Balances	
Air Inlet	75	Oil Collected, vol % FA	93.9
Retort Air Inlet	75	Carbonate Decomp. %	39.3
4. Raw Shale Properties (See Remarks)		Water Recovered, lb/ton RS	67.0
Fischer Assay, gal/ton RS	26.7	Overall Balance, %	100.4
Oil, Wt %	10.2	Carbon Balance, % (Total)	98.0
Water, Wt %	1.8	Hydrogen Balance, % (Total)	96.0
Gas, Wt %	1.7	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	17.0	Water Balance, %	91.2
Ash, Wt %	69.6	As Measured Ash Balance, %	100.6
Moisture, Wt %	0.43	REMARKS	
Carbon (Total), Wt %	16.5	Raw Shale properties are an	
Hydrogen (Total), Wt %	1.75	average of M40. Sample was	
Nitrogen, Wt %	0.20	broken and grab sample is not	
APD, in	0.342	representative	
5. Spent Shale Properties		APD is on grab sample.	
Fischer Assay, gal/ton	0		
Mineral CO <sub>2</sub> , Wt %	13.5		
Ash, Wt %	86.6		
Carbon (Total), Wt %	4.93		
Hydrogen (Total), Wt %	0.12		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	83.3		
b. Hydrogen, Wt %	10.6		
c. Density, lb/gal	7.41		
d. Gravity, API	20.2		
e. Viscosity SUS @ 130° F	136.1		
f. Viscosity SUS @ 210° F	49.5		
g. Ramsbottom Carbon, Wt %	2.35		
h. Pour Point, ° F	85		
i. Ash, Wt %	0.04		
j. Nitrogen, Wt %	2.23		

OSRC-10

APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEET

Date 1-19-65

Purpose:

1. General		7. Product Gas Properties	
Run No.	454-5	Water Vapor, lbs/MSCF (dry)	5.2
Length, hours	24	Oil, lbs/MSCF (dry)	206
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	48.5	CO <sub>2</sub> , vol %	21.1
Spent Shale, % of RS	18.9	O <sub>2</sub> , vol %	0.5
Liquid Product, lbs/hr	114.3	N <sub>2</sub> + Argon, vol %	57.7
Oil Collected, gal/ton RS	25.6	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	508.5	CO, vol %	4.9
Total Recycle, SCF/ton RS (wet)	1236.8	H <sub>2</sub> , vol %	3.4
Dilution, SCF/ton RS (wet)	0	Other, vol %	1.2
Calc. Vent Gas, SCF/ton RS (dry)	673.5	Gross Heating Value (calc), Btu/SCF	80.4
Gas Losses, SCF/ton RS (wet)	47.55	Carbon (Total), lbs/MSCF (dry)	12.5
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.63
Total Flow, SCF/M (wet)	215	8. Miscellaneous	
5. Temperature, °F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	122	Pressure Drop, in H <sub>2</sub> O	11
Spent Shale Outlet	245	Dist. Back Press., in H <sub>2</sub> O	15
Raw Shale Inlet	47	NaCl Solution, Wt %	0
Recycle Gas Inlet	159	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	-	9. Yields & Balances	
Air Inlet	75	Oil Collected, vol % FA	24.8
Retort Air Inlet	75	Carbonate Decomp. %	41.6
4. Raw Shale Properties		Water Recovered, lb/ton RS	739
Fischer Assay, gal/ton RS	27.0	Overall Balance, %	100.8
Oil, Wt %	10.2	Carbon Balance, % (Total)	101.0
Water, Wt %	1.8	Hydrogen Balance, % (Total)	101.2
Gas, Wt %	1.6	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	16.8	Water Balance, %	119.4
Ash, Wt %	19.8	As Measured Ash Balance, %	101.5
Moisture, Wt %	0.30	REMARKS	
Carbon (Total), Wt %	16.6		
Hydrogen (Total), Wt %	1.75		
Nitrogen, Wt %	0.31		
APD, in	0.269		
5. Spent Shale Properties			
Fischer Assay, gal/ton	0		
Mineral CO <sub>2</sub> , Wt %	12.8		
Ash, Wt %	86.2		
Carbon (Total), Wt %	5.35		
Hydrogen (Total), Wt %	0.11		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	83.6		
b. Hydrogen, Wt %	11.0		
c. Density, lb/gal	7.78		
d. Gravity, API	28.0		
e. Viscosity SUS @ 130° F	126.9		
f. Viscosity SUS @ 210° F	56.4		
g. Ramsbottom Carbon, Wt %	2.30		
h. Pour Point, ° F	80		
i. Ash, Wt %	0.03		
j. Nitrogen, Wt %	2.40		

OSRC-10

## APPENDIX B

GAS-COMBUSTION RETORT NO. 1  
DETAILED TEST SHEETDate 1-20-65

Purpose:

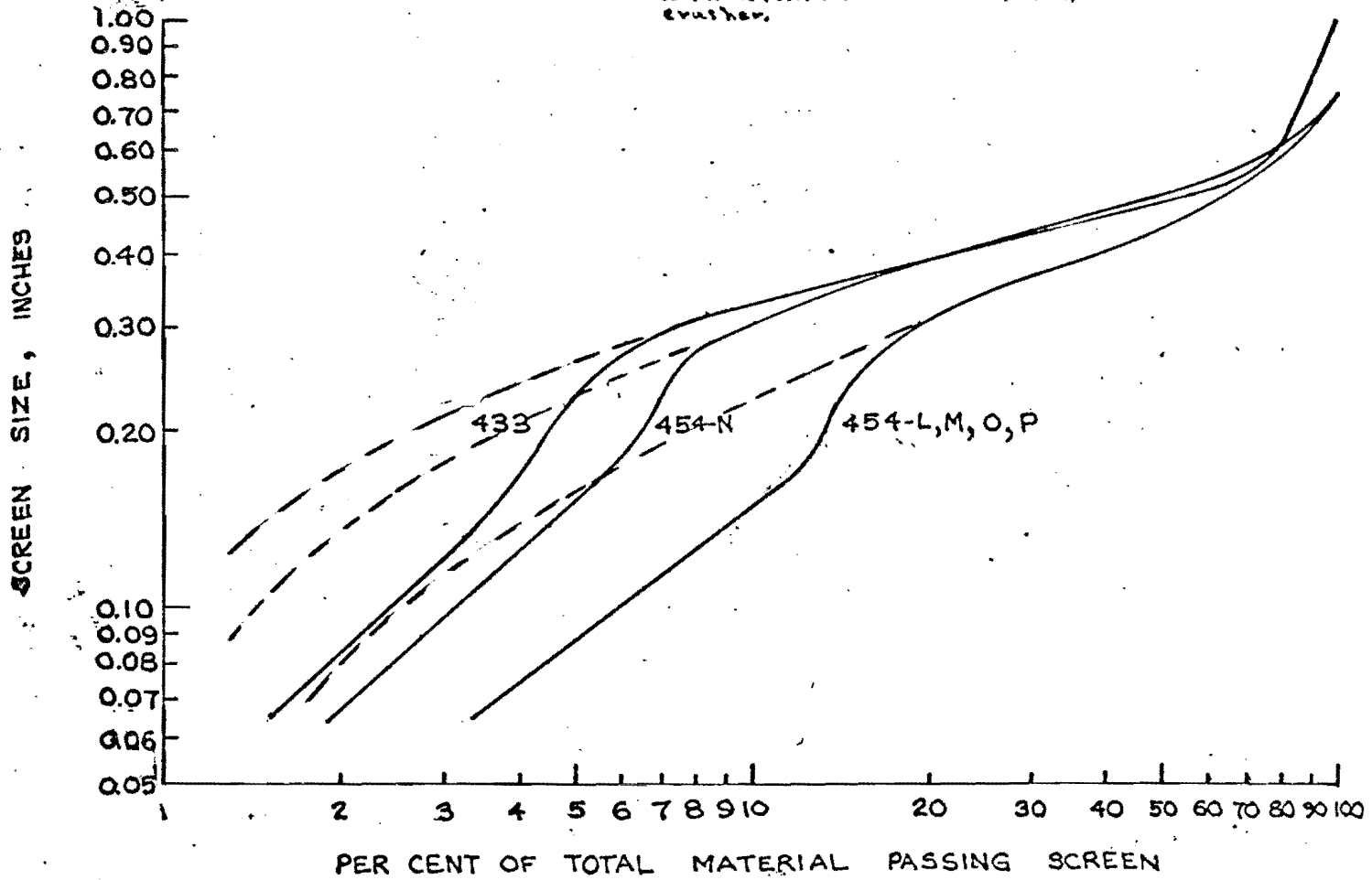
1. General		F. Product Gas Properties	
Run No.	450-12	Water Vapor, lbs/MSCF (dry)	8.2
Length, hours	24	Oil, lbs/MSCF (dry)	0.044
2. Rates & Quantities		Analysis (dry)	
Raw Shale, lb/(hr)(ft <sup>2</sup> )	442	CO <sub>2</sub> , vol %	30.0
Spent Shale, % of RS	71.7	O <sub>2</sub> , vol %	6.2
Liquid Product, lbs/hr	117.0	N <sub>2</sub> + Argon, vol %	58.7
Oil Collected, gal/ton RS	25	CH <sub>4</sub> , vol %	1.2
Air, SCF/ton RS (dry)	5346	CO, vol %	4.6
Total Recycle, SCF/ton RS (wet)	12282	H <sub>2</sub> , vol %	3.3
Dilution, SCF/ton RS (wet)	0	Other, vol %	2.0
Calc. Vent Gas SCF/ton RS (dry)	1778	Gross Heating Value (calc), Btu/SCF	122.6
Gas Losses, SCF/ton RS (wet)	1682	Carbon (Total), lbs/MSCF (dry)	12.6
Propane, SCF/ton RS	0	Hydrogen (Total), lbs/MSCF (dry)	0.58
Total Flow, SCF/M (wet)	36.5	8. Miscellaneous	
3. Temperature, °C F		Bed Height Above Dist., ft.	5
Retort Gas Outlet	121	Pressure Drop, in H <sub>2</sub> O	12.5
Spent Shale Outlet	249	Dist. Back Press., in H <sub>2</sub> O	16.5
Raw Shale Inlet	52	NaCl Solution, Wt %	0
Recycle Gas Inlet	158	NaCl Rate, gal/ton RS	0
Dilution Gas Inlet	-	9. Yields & Balances	
Air Inlet	7.5	Oil Collected, vol % FA	92.8
Retort Air Inlet	7.5	Carbonate Decomp. %	47.9
4. Raw Shale Properties		Water Recovered, lb/ton RS	79.9
Fischer Assay, gal/ton RS	27.3	Overall Balance, %	100.8
Cal., Wt %	10.4	Carbon Balance, % (Total)	98.3
Water, Wt %	1.6	Hydrogen Balance, % (Total)	102.3
Gas, Wt %	1.5	Ash Balance, % Assumed	100
Mineral CO <sub>2</sub> , Wt %	11.0	Water Balance, %	114.8
Ash, Wt %	68.2	As Measured Ash Balance, %	102.7
Moisture, Wt %	0.24	REMARKS	
Carbon (Total), Wt %	16.4		
Hydrogen (Total), Wt %	1.76		
Nitrogen, Wt %	0.38		
APD, in	0.257		
5. Spent Shale Properties			
Fischer Assay, gal/ton	0		
Mineral CO <sub>2</sub> , Wt %	11.7		
Asn, Wt %	87.5		
Carbon (Total), Wt %	4.62		
Hydrogen (Total), Wt %	0.04		
6. Liquid Product Properties			
1. Oil, Wt %			
a. Carbon Content, Wt %	84.8		
b. Hydrogen, Wt %	11.3		
c. Density, lb/gal	7.78		
d. Gravity, API	20.0		
e. Viscosity SUS @ 130° F	125.0		
f. Viscosity SUS @ 210° F	49.4		
g. Ramsbottom Carbon, Wt %	2.30		
h. Pour Point, ° F	85		
i. Ash, Wt %	0.02		
j. Nitrogen, Wt %	2.26		

OSRC-10

APPENDIX C

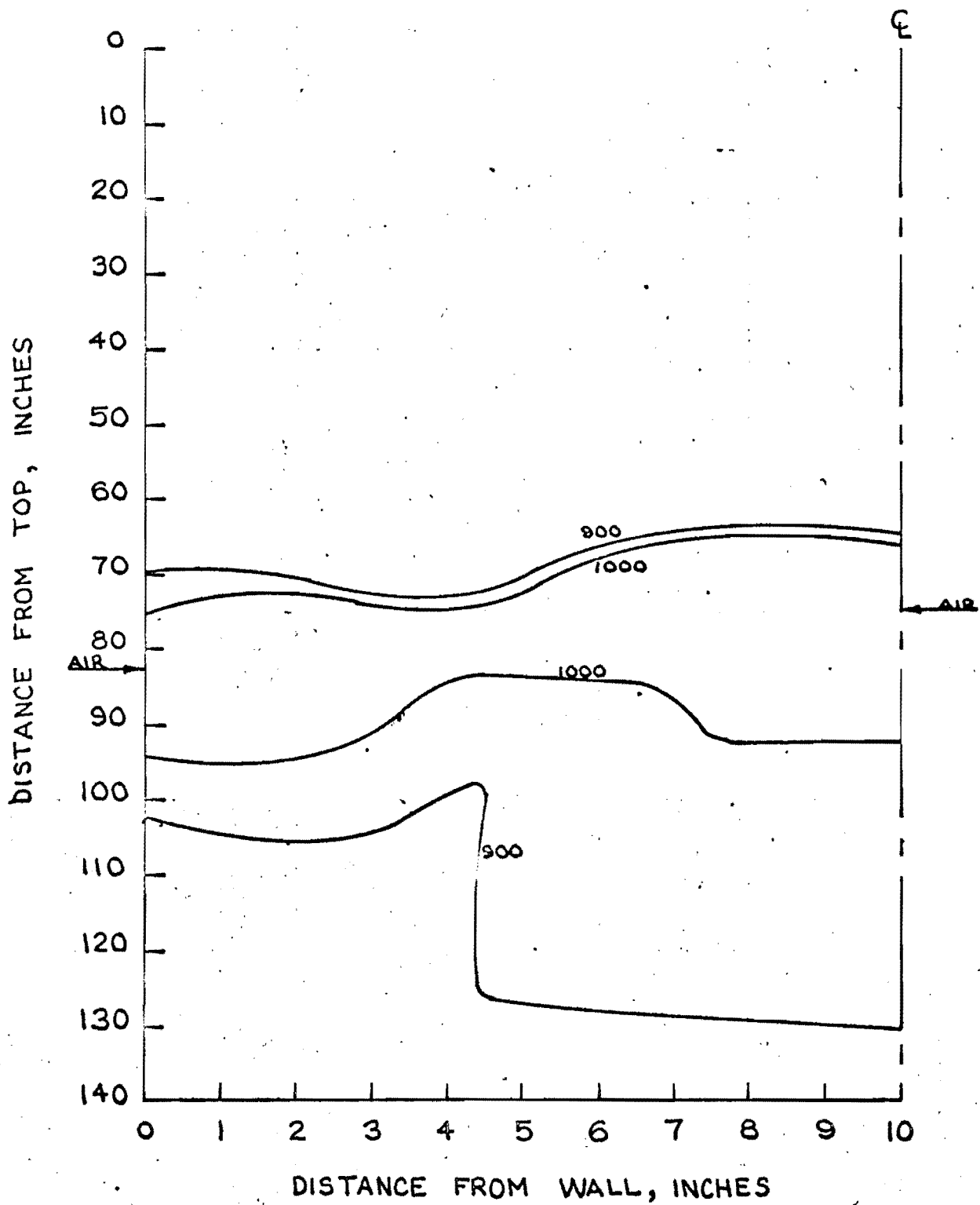
COMPARISON OF PARTICLE SIZE DISTRIBUTION FOR RUN 433  
WITH RUN 454-L, M, N, O, P

- observed screen analysis.
- - - estimated after correcting for contamination from continuous sample crusher.



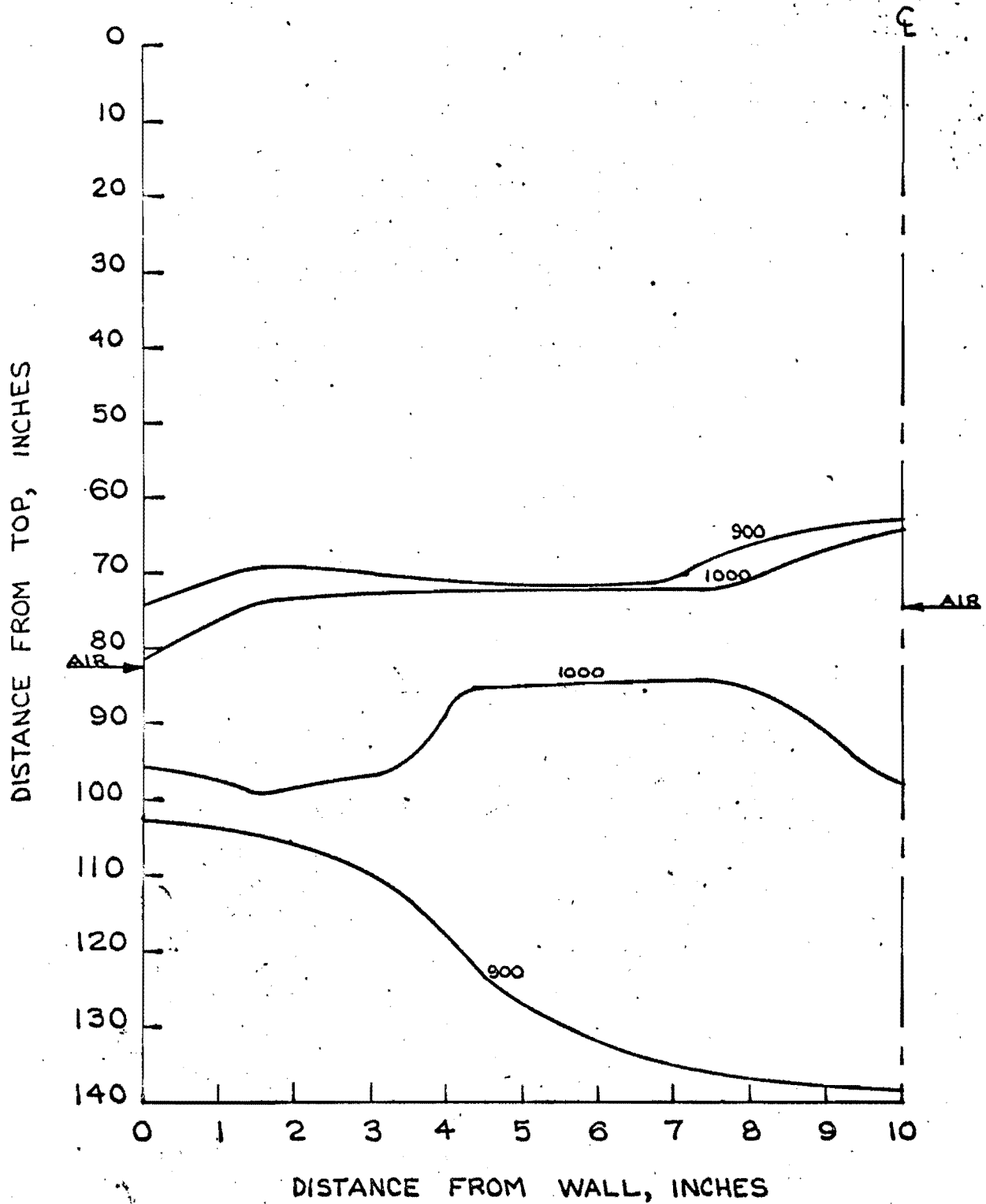
APPENDIX D-1.

TEMPERATURE PROFILE FOR RUN 454-L



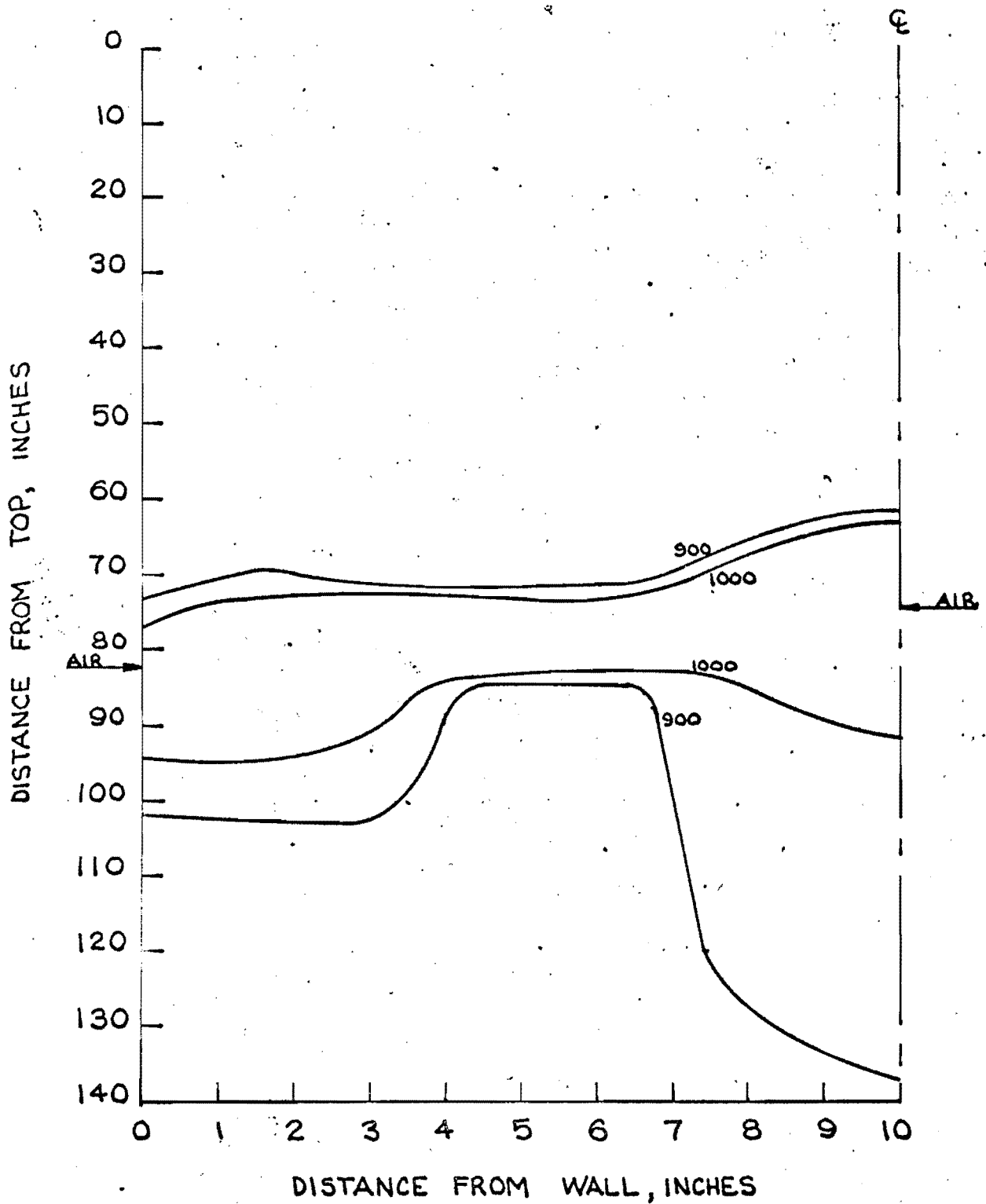
APPENDIX D-1

TEMPERATURE PROFILE FOR RUN 454-M



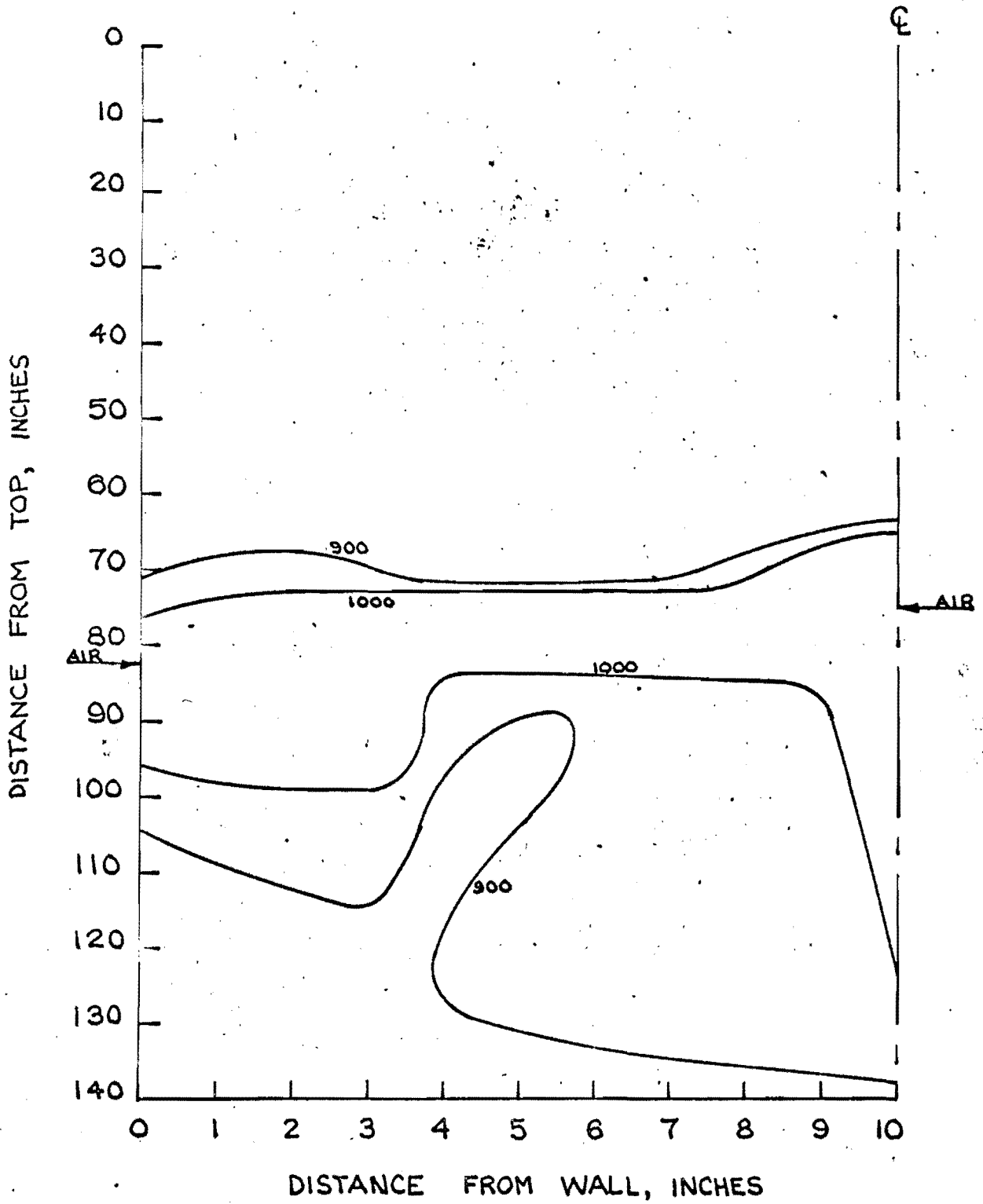
APPENDIX D-1

TEMPERATURE PROFILE FOR RUN 454-N



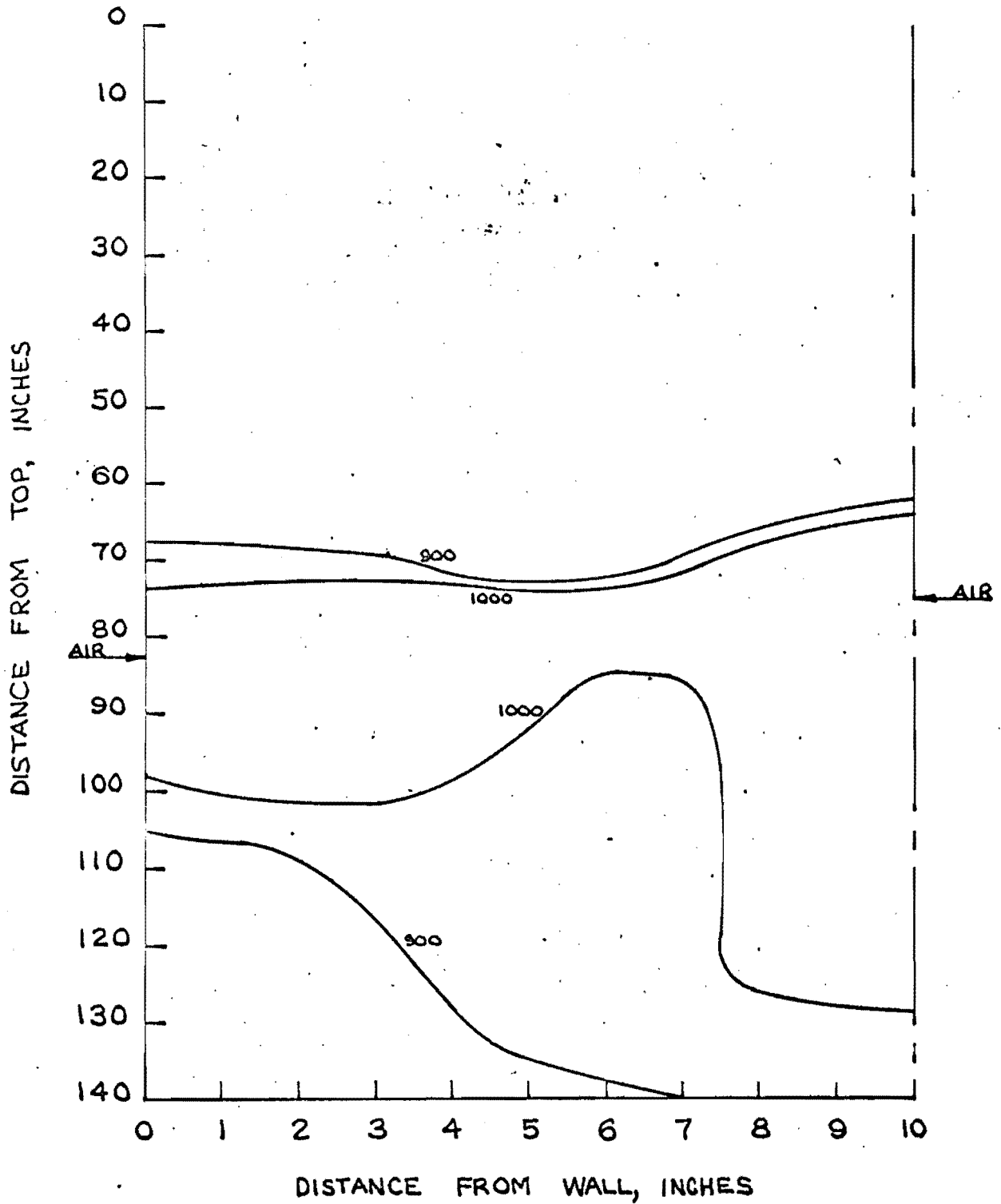
APPENDIX D-1

TEMPERATURE PROFILE FOR RUN 454-0



APPENDIX D-1

TEMPERATURE PROFILE FOR RUN 454-P



APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454

DATE 12-31-64

TIME PROBES START 1000

END 1120

OPERATOR Stordice

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2- <del>4</del> 5	180	140	125	130	125	125	130
TR- 2-6	140	160	145	135	135	135	140
TR- 2- <del>10</del> 15	1170	1120	910	705	690	745	1080
TR- 2-13	995	630	810	720	760	690	285
TR- 2-16	1080	1160	1015	980	920	1000	1140
TR- 3-3	1040	970	885	845	925	970	975
TR- 3-6	560	565	565	565	565	565	565
TR- 3-10	435	440	440	440	440	445	445
TR- 2-12	800	785	705	640	590	570	620

SKIN TEMPERATURE °F

TI-1	<u>122</u>	°F	TI-11	<u>1123</u>	°F
2	<u>129</u>	°F	12	<u>1200</u> +	°F
3	<u>123</u>	°F	13	<u>1200</u> +	°F
4	<u>144</u>	°F	14	<u>1114</u>	°F
5	<u>168</u>	°F	15	<u>1118</u>	°F
6	<u>329</u>	°F	16	<u>72</u>	°F
7	<u>614</u>	°F	17	<u>998</u>	°F
8	<u>942</u>	°F	18	<u>827</u>	°F
9	<u>824</u>	°F	19	<u>712</u>	°F
10	<u>1108</u>	°F	20	<u>534</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 4.54 A

DATE 1-4-65

TIME PROBES START 0820

END 0925

OPERATOR Hoaglund

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2- <del>4</del> 5	130	130	130	130	130	130	130
TR- 2-6	130	130	130	130	140	130	130
TR- 2-10 12	600	665	655	600	510	375	350
TR- 2-13	910	855	785	700	760	880	1020
TR- 2-16							
TR- 3-3	1080	1080	930	770	810	870	890
TR- 3-6							
TR- 3-10	790	800	800	800	800	800	790
TR- 2-15	1060	1035	750	580	490	550	860

SKIN TEMPERATURE °F

TI-1 <u>124</u> °F	TI-11 <u>1200</u> °F
2 <u>130</u> °F	12 <u>1200</u> °F
3 <u>130</u> °F	13 <u>1200</u> °F
4 <u>134</u> °F	14 <u>1168</u> °F
5 <u>136</u> °F	15 <u>1140</u> °F
6 <u>142</u> °F	16 <u>70</u> °F
7 <u>343</u> °F	17 <u>990</u> °F
8 <u>924</u> °F	18 <u>820</u> °F
9 <u>660</u> °F	19 <u>680</u> °F
10 <u>1065</u> °F	20 <u>440</u> °F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TLST NO. 454 B

DATE 1-4-65

TIME PROBES START 1340

END 1455

OPERATOR Hooglund

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4 5	130	130	130	130	140	140	140
TR- 2-6	130	130	130	130	150	150	140
TR- 2-10 12	730	720	660	580	430	400	410
TR- 2-13	910	950	790	730	780	920	1110
TR- 2-16	1240	1290	1190	1010	900	980	1250
TR- 3-3	1100	1200	920	885	810	860	900
TR- 3-6	900	940	885	780	760	790	800
TR- 3-10	OUT	-	-	-	-	-	-
TR-2-15	990	940	840	590	560, 650		980

SKIN TEMPERATURE °F

TI-1 <u>126</u> °F	TI-11 <u>1200</u> °F
2 <u>130</u> °F	12 <u>1200</u> °F
3 <u>130</u> °F	13 <u>1200</u> °F
4 <u>136</u> °F	14 <u>1190</u> °F
5 <u>138</u> °F	15 <u>1170</u> °F
6 <u>160</u> °F	16 <u>80</u> °F
7 <u>430</u> °F	17 <u>1016</u> °F
8 <u>936</u> °F	18 <u>830</u> °F
9 <u>746</u> °F	19 <u>690</u> °F
10 <u>1022</u> °F	20 <u>436</u> °F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TLST NO. 454 C

DATE 1-5-65

TIME PROBES START 0820

END 0925

OPERATOR Heasland

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4 5	140	140	140	140	140	140	140
TR- 2-6	140	140	140	140	140	140	140
TR- 2-10 12	660	600	510	350	230	180	270
TR- 2-13	840	740	590	500	520	820	1100
TR- 2-16	1150	1090	910	720	770	990	1010
TR- 3-3	1025	860	740	650	670	775	900
TR- 3-6	820	790	720	600	630	630	710
TR- 2-10 04T	-	-	-	-	-	-	-
TR- 2-15	1000	1010	830	625	370	420	1010

SKIN TEMPERATURE °F

TI-1 <u>132</u> °F	TI-11 <u>1192</u> °F
2 <u>136</u> °F	12 <u>1200</u> °F
3 <u>136</u> °F	13 <u>1200</u> °F
4 <u>142</u> °F	14 <u>1070</u> °F
5 <u>144</u> °F	15 <u>1170</u> °F
6 <u>144</u> °F	16 <u>75</u> °F
7 <u>242</u> °F	17 <u>920</u> °F
8 <u>864</u> °F	18 <u>768</u> °F
9 <u>594</u> °F	19 <u>640</u> °F
10 <u>994</u> °F	20 <u>426</u> °F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TLST NO. 454 E

DATE 1-6-65

TIME PROBES START 0815

END 0915

OPERATOR \_\_\_\_\_

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2- <del>4</del> 5	130	130	135	140	140	140	140
TR- 2-6	130	130	135	140	140	140	140
TR- 2- <del>10</del> 12	690	590	640	470	440	420	460
TR- 2-13	950	890	820	750	800	1000	1150
TR- 2-16	1210	1250	1020	1030	910	1010	1020
TR- 3-3	1050	1045	930	755	760	810	820
TR- 3-6	820	860	800	750	750	720	700
<del>TR- 3-10</del> TR- 2-15	1150	1100	900	580	450	400	1060

SKIN TEMPERATURE °F

TI-1 <u>130</u> °F	TI-11 <u>1200</u> °F
2 <u>134</u> °F	12 <u>1176</u> °F
3 <u>134</u> °F	13 <u>1200</u> °F
4 <u>140</u> °F	14 <u>1120</u> °F
5 <u>142</u> °F	15 <u>1022</u> °F
6 <u>148</u> °F	16 <u>74</u> °F
7 <u>306</u> °F	17 <u>900</u> °F
8 <u>932</u> °F	18 <u>730</u> °F
9 <u>708</u> °F	19 <u>580</u> °F
10 <u>1130</u> °F	20 <u>354</u> °F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454 F

DATE 1-6-65

TIME PROBES START 1710

END 1840

OPERATOR St. Andree

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR-2-5	140	140	140	140	140	140	140
TR-2-6	140	140	140	140	140	140	140
TR-2-10 12	500	375	680	570	320	280	180
TR-2-13	930	880	830	730	700	850	1100
TR-2-16	1200	1170	880	925	865	1090	1060
TR-3-3	1025	1045	750	735	765	780	830
TR-3-6	800	810	815	705	710	710	730
TR-3-10	65 Buyout	-	-	-	-	-	-
TR-2-15	960	950	980	850	530	480	660

SKIN TEMPERATURE °F

TI-1	<u>132</u>	°F	TI-11	<u>1200<sup>+</sup></u>	°F
2	<u>136</u>	°F	12	<u>1200<sup>+</sup></u>	°F
3	<u>138</u>	°F	13	<u>1200<sup>+</sup></u>	°F
4	<u>144</u>	°F	14	<u>1080</u>	°F
5	<u>142</u>	°F	15	<u>1104</u>	°F
6	<u>146</u>	°F	16	<u>no Good</u>	°F
7	<u>348</u>	°F	17	<u>910</u>	°F
8	<u>950</u>	°F	18	<u>750</u>	°F
9	<u>706</u>	°F	19	<u>620</u>	°F
10	<u>1058</u>	°F	20	<u>388</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RLORT

RUN & TEST NO. 4.54 H

DATE 1-7-64

TIME PROBES START 1631

END 1756

OPERATOR \_\_\_\_\_

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-5	140	140	140	135	145	155	160
TR- 2-6	185	160	150	165	230	255	265
TR- 2-10	—	—	—	—	—	—	—
TR- 2-13	820	840	885	900	785	810	1005
TR- 2-16	1260	1250	1075	930	935	995	1215
TR- 3-3	1070	1040	885	845	890	960	1050
TR- 3-6	850	970	860	810	815	870	825
TR- 2-15 TR- 3-10	1185	1000	850	845	810	880	1155

SKIN TEMPERATURE °F

TI-1 <u>128</u> °F	TI-11 <u>1200<sup>+</sup></u> °F
2 <u>132</u> °F	12 <u>1200<sup>+</sup></u> °F
3 <u>135</u> °F	13 <u>1200<sup>+</sup></u> °F
4 <u>162</u> °F	14 <u>1078</u> °F
5 <u>194</u> °F	15 <u>1200<sup>+</sup></u> °F
6 <u>226</u> °F	16 <u>1138</u> °F
7 <u>336</u> °F	17 <u>894</u> °F
8 <u>786</u> °F	18 <u>735</u> °F
9 <u>920</u> °F	19 <u>621</u> °F
10 <u>1112</u> °F	20 <u>444</u> °F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454 I

DATE 1-8-65

TIME PROBES START 2100

END 2235

OPERATOR Stanley

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-5	150	140	135	135	135	130	135
TR- 2-6	200	145	140	135	140	130	135
TR- 2-10 15	1290	1270	1085	820	785	840	1270
TR- 2-13	880	870	775	755	770	945	1390
TR- 2-16	1140	1200	1135	935	900	945	1215
TR- 3-3	1025	950	845	820	895	1030	1070
TR- 3-6	920	875	735	865	845	900	940
TR- 3-10	-	-	-	-	-	-	-

SKIN TEMPERATURE °F

TI-1	<u>126</u>	°F	TI-11	<u>1184</u>	°F
2	<u>130</u>	°F	12	<u>1200<sup>+</sup></u>	°F
3	<u>130</u>	°F	13	<u>1200<sup>+</sup></u>	°F
4	<u>142</u>	°F	14	<u>1130</u>	°F
5	<u>154</u>	°F	15	<u>1200<sup>+</sup></u>	°F
6	<u>288</u>	°F	16	<u>1200<sup>+</sup></u>	°F
7	<u>562</u>	°F	17	<u>980</u>	°F
8	<u>960</u>	°F	18	<u>828</u>	°F
9	<u>1056</u>	°F	19	<u>704</u>	°F
10	<u>1200<sup>+</sup></u>	°F	20	<u>506</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 4.54 J

DATE 1-10-65

TIME PROBES START 1100

END 1200

OPERATOR Hoffmeister

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2- <del>5</del> 5	140	140	140	140	140	140	140
TR- 2-6	140	140	140	140	140	140	140
TR- 2- <del>10</del> 15	1000	960	840	540	470	610	770
TR- 2-13	880	850	750	800	810	910	1210
TR- 2-16	1160	1190	1140	1000	1080	1160	1300
TR- 3-3	1030	1000	830	870	1010	1020	960
TR- 3-6	830	890	830	790	860	830	780
TR- 3-10	--						

SKIN TEMPERATURE °F

TI-1 <u>132</u> °F	TI-11 <u>1038</u> °F
2 <u>136</u> °F	12 <u>1200+</u> °F
3 <u>136</u> °F	13 <u>1200+</u> °F
4 <u>142</u> °F	14 <u>1010</u> °F
5 <u>142</u> °F	15 <u>1200+</u> °F
6 <u>148</u> °F	16 <u>1200+</u> °F
7 <u>344</u> °F	17 <u>880</u> °F
8 <u>854</u> °F	18 <u>740</u> °F
9 <u>966</u> °F	19 <u>630</u> °F
10 <u>1064</u> °F	20 <u>454</u> °F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454 K

DATE 1-11-65

TIME PROBES START 0330

END 0435

OPERATOR Hoglund

THERMOCOUPLE NUMBER	TEMPERATURE, °F IMMERSION INTO BED						
	0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4	135	135	135	135	140	135	130
TR- 2-6	135	135	135	135	140	135	140
TR- 2-10	170	175	170	175	170	180	180
TR- 2-13	850	790	790	920	1105	1295	1500
TR- 2-16	1180	1260	1070	960	1010	1050	1310
TR- 3-3	950	930	950	1040	1010	985	990
TR- 3-6	860	830	860	850	820	770	740
TR- 3-10	Out						

TR - 2 - 15      870      780      685      635      815      1200      1580  
 SKIN TEMPERATURE °F

TI-1	<u>128</u>	°F	TI-11	<u>1078</u>	°F
2	<u>132</u>	°F	12	<u>1200+</u>	°F
3	<u>131</u>	°F	13	<u>1200+</u>	°F
4	<u>139</u>	°F	14	<u>1051</u>	°F
5	<u>139</u>	°F	15	<u>1200+</u>	°F
6	<u>155</u>	°F	16	<u>1200+</u>	°F
7	<u>434</u>	°F	17	<u>918</u>	°F
8	<u>894</u>	°F	18	<u>764</u>	°F
9	<u>971</u>	°F	19	<u>650</u>	°F
10	<u>1094</u>	°F	20	<u>464</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454L

DATE 1-15-65

TIME PROBES START 2105

END 2200

OPERATOR BALDWIN

THERMOCOUPLE NUMBER	DISTANCE FROM TOP, INCHES	TEMPERATURE, °F IMMERSION INTO BED						
		0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4	13.5	140	140	140	140	140	140	130
TR- 2-6	37.6	130	130	100	110	150	110	110
TR- 2-10	65.9	630	580	600	500	530	600	670
TR- 2-13	71.1	910	940	800	810	1300	1750	DIDN'T GO IN MIGHT B.O.
TR- 2-16	80.1	1120	1740	B.O.	TOO	HOT	SLIDING	
TR- 3-3	86.6	1150	1185	1075	910	970	1030	1020
TR- 3-6	96.6	960	970	930	900	960	980	980
TR- 3-10	113.9	610	750	810	910	930	930	940

DISTANCE FROM TOP - INCHES	TI-1	TEMPERATURE °F	TI-11	TEMPERATURE °F	DISTANCE FROM TOP - INCHES
- 8.4	1	126 °F	11	1310 °F	80.1
0	2	128 °F	12	1125 °F	80.1
13.5	3	127 °F	13	1315 °F	80.1
28.2	4	144 °F	14	1150 °F	86.6
37.6	5	176 °F	15	1165 °F	86.6
49.2	6	356 °F	16	1235 °F	86.6
65.9	7	700 °F	17	1026 °F	96.6
71.1	8	965 °F	18	860 °F	108.6
71.1	9	1030 °F	19	720 °F	113.9
71.1	10	700 °F	20	442 °F	134.0

Notes: Distances are with reference to the top of the retort; the top of the bed OSRC-3 is 22.5 inches below the top; and the air distributor is 80.1 inches below the top.

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454-M

DATE 1-16-65

TIME PROBES START 1210

END 1330

OPERATOR STANDLEE

THERMOCOUPLE NUMBER	DISTANCE FROM TOP, INCHES	TEMPERATURE, °F IMMERSION INTO BED						
		0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4	13.5							
TR- 2-6	37.6	175	125	120	110	110	110	110
TR- 2-10	65.9	650	590	660	590	540	510	650
TR- 2-13	71.1	870	940	910	780	780	970	1720
TR- 2-16	80.1	980	1140	1500	1950	GETTING HOTTER		
TR- 3-3	86.6	1210	1215	1150	920	930	970	1020
TR- 3-6	96.6	965	1035	990	930	950	980	1000
TR- 3-10	113.9	580	630	805	900	940	950	980

SKIN TEMPERATURE °F

TI-1	<u>126</u>	°F	TI-11	<u>1325</u>	°F
2	<u>128</u>	°F	12	<u>1175</u>	°F
3	<u>127</u>	°F	13	<u>1305</u>	°F
4	<u>144</u>	°F	14	<u>1185</u>	°F
5	<u>180</u>	°F	15	<u>1190</u>	°F
6	<u>340</u>	°F	16	<u>1230</u>	°F
7	<u>600</u>	°F	17	<u>1062</u>	°F
8	<u>1025</u>	°F	18	<u>890</u>	°F
9	<u>1010</u>	°F	19	<u>754</u>	°F
10	<u>590</u>	°F	20	<u>474</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454-N

DATE 1-17-65

TIME PROBES START 1200

END 1309

OPERATOR STANDLEE

THERMOCOUPLE NUMBER	DISTANCE FROM TOP, INCHES	TEMPERATURE, °F IMMERSION INTO BED						
		0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4	13.5							
TR- 2-6	37.6	165	160	160	105	105	105	110
TR- 2-10	65.9	540	590	510	440	525	610	840
TR- 2-13	71.1	855	920	845	705	770	1020	1735
TR- 2-16	80.1	1080	1240	1860	—	—	—	—
TR- 3-3	86.6	1185	1200	1060	840	870	940	1050
TR- 3-6	96.6	935	960	925	865	870	920	955
TR- 3-10	113.9	560	620	775	885	890	900	935

SKIN TEMPERATURE °F

TI-1	<u>126</u>	°F	TI-11	<u>1330</u>	°F
2	<u>130</u>	°F	12	<u>1135</u>	°F
3	<u>126</u>	°F	13	<u>1355</u>	°F
4	<u>142</u>	°F	14	<u>1170</u>	°F
5	<u>166</u>	°F	15	<u>1180</u>	°F
6	<u>340</u>	°F	16	<u>1215</u>	°F
7	<u>610</u>	°F	17	<u>1030</u>	°F
8	<u>1000</u>	°F	18	<u>868</u>	°F
9	<u>1020</u>	°F	19	<u>740</u>	°F
10	<u>620</u>	°F	20	<u>474</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454-0

DATE 1-18-65

TIME PROBES START 0921

END 1029

OPERATOR STANDLEE

THERMOCOUPLE NUMBER	DISTANCE FROM TOP INCHES	TEMPERATURE, °F IMMERSION INTO BED						
		0"	1½"	3"	4½"	6"	7½"	10"
TR- 2-4	13.5	1						
TR- 2-6	37.6	130	125	110	100	105	105	105
TR- 2-10	65.9	595	680	620	560	555	550	630
TR- 2-13	71.1	900	960	910	785	790	950	1650
TR- 2-16	80.1	1085	1185	1590	—	—	—	—
TR- 3-3	86.6	1235	1260	1070	925	915	980	1020
TR- 3-6	96.6	990	1050	1020	830	945	980	1010
TR- 3-10	113.9	620	720	860	940	965	990	1000

SKIN TEMPERATURE °F

TI-1	<u>124</u>	°F	TI-11	<u>1345</u>	°F
2	<u>128</u>	°F	12	<u>1115</u>	°F
3	<u>126</u>	°F	13	<u>1235</u>	°F
4	<u>140</u>	°F	14	<u>1205</u>	°F
5	<u>170</u>	°F	15	<u>1210</u>	°F
6	<u>342</u>	°F	16	<u>1230</u>	°F
7	<u>620</u>	°F	17	<u>1080</u>	°F
8	<u>1015</u>	°F	18	<u>920</u>	°F
9	<u>975</u>	°F	19	<u>784</u>	°F
10	<u>610</u>	°F	20	<u>518</u>	°F

APPENDIX D-2

TEMPERATURE PROBES

NUMBER ONE RETORT

RUN & TEST NO. 454-P

DATE 1-19-65

TIME PROBES START 1300

END 1420

OPERATOR STANDLEE

THERMOCOUPLE NUMBER	DISTANCE FROM TOP, INCHES	TEMPERATURE, °F IMMERSION INTO BED						
		0"	1½"	2"	4½"	6"	7½"	10"
TR- 2-4	13.5							
TR- 2-6	37.6	200	145	140	135	140	150	160
TR- 2-10	65.9	640	700	670	650	600	620	720
TR- 2-13	71.1	980	940	955	820	830	1090	1760
TR- 2-16	80.1	1110	1320	1780	—	—	—	—
TR- 3-3	86.6	1230	1240	1110	1130	950	1020	1055
TR- 3-6	96.6	1000	1060	1055	990	990	1000	1025
TR- 3-10	113.9	600	685	880	965	990	1000	1015

SKIN TEMPERATURE °F

TI-1	<u>124</u>	°F	TI-11	<u>1325</u>	°F
2	<u>128</u>	°F	12	<u>1120</u>	°F
3	<u>130</u>	°F	13	<u>1300</u>	°F
4	<u>200</u>	°F	14	<u>1200</u>	°F
5	<u>266</u>	°F	15	<u>1170</u>	°F
6	<u>462</u>	°F	16	<u>1230</u>	°F
7	<u>670</u>	°F	17	<u>1084</u>	°F
8	<u>998</u>	°F	18	<u>924</u>	°F
9	<u>950</u>	°F	19	<u>812</u>	°F
10	<u>640</u>	°F	20	<u>560</u>	°F