

GAS COMBUSTION RETORTING  
DETAILED RUN SUMMARY SHEET

15-13013012

Date 4-13-67

Purpose: To determine calorific value and yield at 500 mesh with recycle gas  
with 50 lbs/hr, 36 lb/hr of AD and 3000 lbs/hr of recycle gas.

GENERAL	
Run No.	C-1028-5
Length, hours	12
Retort Type Number	RC-IV
Oil Recovery System Number	C-2
Tons Total Raw Shale Charged, lbs.	164.81
Bed Height above Dist., ft	12 1/2
Type Air Dist.	AD-VIII
Bed Below Air Dist., ft	7
RATES AND QUANTITIES	
Raw Shale, lbs/(hr)(ft <sup>2</sup> )	4.97
Spent Shale, % of RS	81.2
Liquid Product, lbs/hr	2470.4
Oil Collected, gal/ton RS	21.1
Air, SCF/ton RS (dry)	4780
Total Recycle*, SCF/ton RS (wet)	17100
Dilution, SCF/ton RS (wet)	-
Calc. Vent Gas SCF/ton RS (dry)	6210
Gas Losses, SCF/ton RS (wet)	-286
Propane, SCF/ton RS	-
TEMPERATURES AND HEAT BALANCE	
Retort Offgas, °F	141
Spent Shale, F	387
Raw Shale, °F	58
Recycle Gas Inlet, °F	250
Dilution Gas Inlet, °F	-
Air Inlet, °F	128
Retort Air Inlet, F	128
Heat of Comb. MBtu/ton RS	4.47
Heat Lost, MBtu/ton RS	2.9
RAW SHALE PROPERTIES	
Fischer Assay, gal/ton RS	25.4
Oil, Wt %	9.8
Water, Wt %	1.2
Gas, Wt %	2.0
Mineral CO <sub>2</sub> , Wt %	17.5
Ash, Wt %	68.6
Moisture, Wt % (Uncrushed)	1.0 Est.
Carbon (Total), Wt %	16.1
Hydrogen (Total), Wt %	1.73
Nominal Size Range, inches	1"-2 1/2"
5 % passing thru	0.742
98 % passing thru	2.50
D <sub>50</sub>	1.455
D <sub>90</sub>	1.655

SPENT SHALE PROPERTIES	
Fischer Assay, Gal/ton	0.0
Mineral CO <sub>2</sub> , Wt %	14.2
Ash, Wt %	84.4
Carbon (total), Wt %	5.97
Organic Carbon, Wt %	2.09
Hydrogen (total), Wt %	0.16
LIQUID PRODUCT PROPERTIES	
Oil, Wt %	94.7
Density, lb/gal	7.804
Gravity, API	19.5
Ash, Wt %	-
PRODUCT GAS PROPERTIES	
Water Vapor, lbs/MSCF (dry)	6.7
Oil, lbs/MSCF (dry)**	0.041
Analysis (dry)	
CO <sub>2</sub> , Vol %	26.3
O <sub>2</sub> , Vol %	0.5
N <sub>2</sub> + Argon, Vol %	68.9
CH <sub>4</sub> , Vol %	1.9
CO, Vol %	3.8
H <sub>2</sub> , Vol %	5.4
Other, Vol %	1.2
Gross Heating Value (calc), Btu/SCF	121.0
Carbon (Total), lbs/MSCF (dry)	1.23
Hydrogen (Total), lbs/MSCF (dry)	0.10
YIELDS AND BALANCES	
Oil Collected, Vol % RSFA	93.1
Oil in Gas**, Vol % RSFA	0.1
Oil in Spent Shale, Vol % RSFA	0.0
Total Oil Meas., Vol % RSFA	93.2
Carbonate Decomposition, %	74.0
Water Recovered, lb/ton RS	63.4
Ash Balance, % - As Measured	-
Ash Balance, % - Assumed	75-100
Overall Balance, %	98.6
Carbon Balance, % - Organic	98.4
Carbon Balance, % - Total	98.9
Hydrogen Balance, % - Organic	91.2
Hydrogen Balance, % - Total	91.0
Water Balance, %	84.7
MISCELLANEOUS	
Avg. Retort ΔP, in H <sub>2</sub> O/ft	0.55
ΔP Above Air Dist., in H <sub>2</sub> O/ft	0.53
NaCl Soln., Wt %	-
NaCl Rate, gal/ton RS	-

Comments: *Operating sample*

\*Measured Recycle + Dilution Gas  
 \*\* Oil Mist + Condensibles to 75 °F  
 \*\*\* Rates are for moisture-free raw shale. All shale analyses are on a moisture-free basis.

YIELDS

FAY	8.309 01	DRY205	6.819 03	MIETFA	1.299-01		
HD	3.354 02	OTHER	7.454 01	UNRETC	3.000 00	ORA	1.130 00
Q2	3.106 01	STY	3.137 01	CG	2.360 00	CG2020	3.404 01
NR0	6.344 01	CG2	1.533 03	OILCOL	2.110 01		

METERED GAS RATES

REGS	1.307 04	DIL	6.000 00	UNRETC	7.375 03	AIR	4.781 03
TREGG	1.307 04	TGF	6.000 00				

MOL WT. & HEATING VALUE OF VENT GAS

WVWG	2.921 01	HWAT	7.521 02	NR0	3.080 01	GAH	1.210 02
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COMBUSTION PRODUCTS

CO2C	5.531 02	COO	2.195 02				
H2OC	2.921 01	ORA	7.323 02	CG2020	1.072 01		

MATERIAL IN

ORCOIN	2.254 02	PSR	4.974 02	OPHEIN	3.101 01	MAIN	2.336 03
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MATERIAL OUT

ORCVS	5.053 01	ORXFC	3.493 01	UNRETC	3.000 00		
ORCOL	1.375 02	ORNEV	3.961 00	CG2020	1.772 00	UNRETC	3.000 00
ORHPOL	1.325 01	ORCCLP	5.117 01	ORCVOP	2.922 01	ORCOSP	1.530 01
HCCVOP	1.140 01						

MATERIAL BALANCES

ORVAL	2.255 01	ORCHP	2.124 01				
ORBAL	2.753 01	ACH	0.000 00	TC	2.323 01	WATER	3.494 01
ORBO	2.342 01	TR2	2.100 01	GASL	-2.355 02	ASH5	-1.000 00

HEAT IN

ORONS	4.455 05	ORPCC	6.333 07	RAIP	6.151 03		
ORPOP	3.080 00	ORILC	1.152 04	ORCYL	5.192 04	ORHEIN	5.245 05

HEAT OUT

ORCC20	1.930 05	ORFAC3	2.440 04	ORCOV	5.055 04		
ORLCO	4.945 03	ORFG48	3.492 04	ORF	1.182 05	ORASL	-1.933 03
ORLOSS	0.000 00	ORFLOS	2.936 04	ORH0T	5.245 05		

MISCELLANEOUS

ORCSS	2.093 00	VPCIL	4.123-02	TCL	5.085 03	VRV	6.723 00
WCG	1.238 01	PRCP	0.000 00				

MATERIAL AND HEAT BALANCE INPUT SHEET

RIF 92 | RUN NO. | C-10-5-5 | STARTED | 4-13-67 | CALC. ON | 4-18-67

102 | 908 | 58 | -1 | 27467.06  
 H<sub>2</sub>O, wt% | Oil, wt% | °F | (1) | Rate, lbs/hr

2504 | 200 | 1705 | 55022  
 Oil, gal/T | Gas, L, wt% | CO<sub>2</sub>, wt% | Retort XS, ft<sup>2</sup>

6806 | 1601 | 1073 | 24030 | 141  
 Ash, wt% | Carbon, wt% | H<sub>2</sub>, wt% | Bar. Press, " Hg | Oil Gas Temp, °F

RAW SHALE  
 BAROMETRIC  
 PRESSURE  
 AND  
 OFF-GAS  
 TEMPERATURE

1097.5 | 100 | 128 | 127 | 0014 | 0  
 Chart Reading | Meter Factor | Temp, °F | Press, " H<sub>2</sub>O gauge | Moist, lbs/HSCF | Heat Loss, Btu/hr

AIR

3009.7 | 100 | 250 | 69 | 000 | 000  
 Recycle Ch. Read | Meter Factor | Temp, °F | Press, " H<sub>2</sub>O gauge | Tot Gas Ch. Read | Meter Factor

RECYCLE AIR  
 TOTAL GAS

000 | 000 | 0 | 0  
 Dil Gas Ch. Read | Meter Factor | Temp, °F | Press, " H<sub>2</sub>O gauge

DILUTION  
 GAS

000 | 0 | 0 | 27705 | 000  
 C<sub>3</sub> Ret. meter R. | Temp, °F | Press, " H<sub>2</sub>O gauge | Water added, lbs/hr | Nucl. Agent, lb/hr.

PROPANE, WATER  
 & NUCLEATING  
 AGENT

004 | 000 | 000 | 000  
 H<sub>2</sub>O, wt% | Oil, wt% | Gas, wt% | Rate, lbs/hr.

SPENT  
 SHALE

1402 | 8404 | 5097 | 0016 | 387  
 CO<sub>2</sub>, wt% | Ash, wt% | Carbon, wt% | H<sub>2</sub>, wt% | Temp, °F

LIQUID  
 PRODUCT

226201 | 8401 | 1101 | 70804 | 20803  
 Dry Oil, lbs/hr | Carbon, wt% | H<sub>2</sub>, wt% | Den, lbs/gal | Water, lbs/hr

170600 | 100 | 250 | 000 | 000 | 0 | 1303  
 Vent + Dil Gas Chart Reading | Meter Factor | Temp, °F | Moist, lbs/HSCF | Mist, lbs/HSCF (2) | Carbon, lbs/HSCF

VENT +  
 DILUTION  
 GAS,  
 VENT PURGE  
 GAS, AND  
 TOP SEAL  
 GAS

0 | 2603 | 005 | 6009 | 109 | 308 | 504  
 (3) CO<sub>2</sub>, vol% | O<sub>2</sub>, vol% | N<sub>2</sub>, vol% | CH<sub>4</sub>, vol% | CO, vol% | H<sub>2</sub>, vol%

102 | 0090 | 1502  
 Others, vol% | H<sub>2</sub>, lbs/HSCF | V. Purge Ch. Reading

1083 | 177 | 166 | 75 | 2908 | 806 | 1304  
 Meter Factor | Temp, °F | Press, " H<sub>2</sub>O gauge | Cond. Gas | Dry Oil, gal/hr | Water, lbs/hr | Top Seal Gas Rate, cc/min

OPTIONS:

- (1) Insert "0" to calc. with measured rates; "1" to calc. with spent shale rate and ash analyses; "-1" to calc. with raw shale rate and ash analyses.
- (2) Insert "1" to calc. with measured moisture and mist; "0" to calc. from vent purge data.
- (3) Insert "0" for Retort No. 3 (pressure and temperature have no effect on gas rates); "1" for Retort No. 1&2 (pressure and temperature have effect on gas rates).

JRGilmore  
 1/17/67

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 4-14-67

Run No. C 10 25-5  
0-1029-1

Sample Time: RS 0600; SS \_\_\_\_\_

FISCHER ASSAY

RAW SHALE <sup>R</sup>  SPENT SHALE

<u>25.2</u>	<u>0.0</u>	Gal/Ton
<u>0.915</u>	<u>—</u>	S.G., g/ml
<u>9.7</u>	<u>0.0</u>	Oil, wt %
<u>2.0</u>	<u>0.4</u>	Water, wt %
<u>86.3</u>	<u>99.5</u>	Sp. Shale, wt %
<u>2.0</u>	<u>0.1</u>	Gas & Loss, wt %
<u>slight</u>	<u>None</u>	COKING TENDENCY

RETORT SHALE MOISTURE  
1.0 <sup>Est</sup> wt %

<sup>R</sup>  RAW SHALE FISCHER ASSAY MOISTURE  
0.85 wt %

MINERAL CO<sub>2</sub>

<sup>R</sup>  17.5 <sup>R</sup>  14.2 wt %

ASH (SHALE)

<sup>R</sup>  18.4 <sup>R</sup>  84.4 wt %

MOISTURE

<sup>R</sup>  0.28 <sup>R</sup>  0.10 wt %

CARBON

<sup>R</sup>  16.1 <sup>R</sup>  5.97 wt %

HYDROGEN

<sup>R</sup>  1.73 <sup>R</sup>  0.16 wt %

BENZENE EXTRACTABLES

—  — wt %

SHALE RICHNESS DISTRIBUTION  
(See attached graph)

SCREEN ANALYSIS  
(See back of this sheet)

All results are "as received" unless noted. "Moisture" designates the moisture content of the -48 mesh material used for "Ash", "Mineral CO<sub>2</sub>", "Carbon", and "Hydrogen". The "FA Moisture" is for the sample used for the Fischer Assay.

COMMENTS \_\_\_\_\_

DATE COMPLETED APR 17 1967

CHECKED BY PPP

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 4-14-67

Run No. C-1022-5

LIQUID PRODUCTS

D3 PUMPOUT

T3 PUMPOUT

	1	2	3	4	1	2
WATER, wt %	<u>5.3</u>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>
GRAVITY, °API	<u>19.5</u>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>	<del>    </del>

OIL ASH, wt %

DISTILLATION (See attached sheet - OSRC-24)

VENT PURGE PRODUCT

OIL WT, g 358.0

WATER VOL, ml 7.0

GRAVITY OIL, °API 41.4

VENT GAS

MAJOR COMPONENTS

C<sub>1</sub> thru C<sub>4</sub>, plus n-Pentane

CO<sub>2</sub> 26.3 vol %  
 O<sub>2</sub> 0.5 "  
 N<sub>2</sub> 60.2 "  
 CH<sub>4</sub> 1.9 "  
 CO 3.8 "  
 H<sub>2</sub> 5.4 "  
 Ar 0.7 "  
 Others 1.2 "

CH<sub>4</sub> \_\_\_\_\_ vol %  
 C<sub>2</sub>H<sub>4</sub>-C<sub>2</sub>H<sub>6</sub> \_\_\_\_\_ "  
 C<sub>3</sub>H<sub>8</sub> \_\_\_\_\_ "  
 C<sub>3</sub>H<sub>6</sub> \_\_\_\_\_ "  
 i C<sub>4</sub>H<sub>10</sub> \_\_\_\_\_ "  
 n C<sub>4</sub>H<sub>10</sub> \_\_\_\_\_ "  
 ∅C<sub>3</sub>H<sub>6</sub> \_\_\_\_\_ "  
 n C<sub>5</sub>H<sub>12</sub> \_\_\_\_\_ "

CARBON, 13.3 lbs/MSCFDG

HYDROGEN, 0.90 lbs/MSCFDG

COMMENTS \_\_\_\_\_

DATE COMPLETED APR 17 1967

CHECKED BY KCP

# SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C-1078-5 SAMPLE NO. 1 DATE 4-17-67  
 UNIT Pet. #3 DESCRIPTION Top soil  
 APPROX. SHALE SIZE 1-04 SHAKING TIME 10 min ANALYSIS BY S. J. ...  
 TOTAL SAMPLE WT. GROSS 67.8 - TARE 6 = NET 61.8

SCREEN SIZE			WEIGHTS								
SCREENS REQD.	OPENING SIZE	MESH	GROSS LBS.	TARE LBS.	NET WT. RETAINED	SCREEN SIZE	D <sub>i</sub> *	1/D <sub>i</sub>	% RETAINED	CUM. % RETAINED	% PASSING
	4.25					4.25					
	3.00					3.00	(3.125)	(0.3200)			
	2.50		17.3	16.7	.6	2.50	(2.625) 2.750	(0.3809) 0.3636	0.97		99.02
	2.00		39.7	20.2	13.7	2.00	2.250	0.4444	22.20		76.82
	1.50		49.5	23.4	26.1	1.50	1.750	0.5714	42.30		34.52
	1.05		32.1	19.2	12.9	1.05	(1.087) 1.275	(0.9193) 0.7843	20.91		13.61
	0.742		25.1	20.5	5.6	0.742	0.896	1.116	9.08		4.53
	0.525		18.8	18.5	1.3	0.525	0.634	1.577	2.11		2.42
	0.371		19.5	19.3	.2	0.371	0.448	2.232	0.32		2.10
	0.263	3	19.5	18.3	.2	0.263	0.317	3.154	0.32		1.78
	0.185	4	19.5	19.4	.1	0.185	0.224	4.464	0.16		1.62
	0.131	6	19.4	19.3	.1	0.131	0.158	6.329	0.16		1.46
	0.093	8	20.6	20.6	.0	0.093	0.112	8.928	0.00	98.53	1.46
	0.065	10	19.8	19.7	.1	0.065			0.16		1.30
	PAN		21.8	21.0	.8	PAN			1.30		0.00
TOTAL ON SCREENS AND PAN					61.7	LOSS			-	-	-
LOSS (BY DIFFERENCE)					.1	TOTAL			99.99	-	-
TOTAL SAMPLE WEIGHT					61.8						

\* NUMBERS IN PARENTHESES SHOULD BE USED WHEN THESE SCREEN SIZES REPRESENT THE TOP OF THE SHALE SIZE RANGE.

REMARKS: \_\_\_\_\_

$\sum_{+8m}^m D_i$	1.63082	$\sum_{+8m}^m X_i$	
$1/\sum_{+8m}^m D_i$	0.67716	$\sum_{+8m}^m X_i / D_i$	
D <sub>a</sub>	1.45504	$\sum_{+8m}^m X_i D_i$	
D <sub>v</sub>	1.65515		