

GAS COMBUSTION RETORTING
DETAILED RUN SUMMARY SHEET

1513018026

Date 6-30-67

Purpose: *To determine operability and yield with 4-2 1/2 inch shale at 500 mass rate and with hot gas (w/o dilution gas)*

GENERAL		SPENT SHALE PROPERTIES	
Run No.	01099-1	Fischer Assay, Gal/ton	0.5
Length, hours	12	Mineral CO ₂ , Wt %	16.9
Retort Type Number	RC-VII	Ash, Wt %	80.9
Oil Recovery System Number	C-2	Carbon (total), Wt %	7.02
<i>Tons</i> Total Raw Shale Charged, lbs.	163.07	Organic Carbon, Wt %	2.41
Bed Height above Dist., ft	9 1/2	Hydrogen (total), Wt %	0.19
Type Air Dist.	ADXI	LIQUID PRODUCT PROPERTIES	
Bed Below Air Dist., ft	6	Oil, Wt %	93.0
RATES AND QUANTITIES		Density, lb/gal	7.804
Raw Shale, lbs/(hr)(ft ²)	492	Gravity, API	19.5
Spent Shale, % of RS	84.4	Ash, Wt %	—
Liquid Product, lbs/hr	2303.6	PRODUCT GAS PROPERTIES	
Oil Collected, gal/ton RS	19.9	Water Vapor, lbs/MSCF (dry)	5.9
Air, SCF/ton RS (dry)	4600	Oil, lbs/MSCF (dry)**	0.491
Total Recycle*, SCF/ton RS (wet)	1142.0	Analysis (dry)	
Dilution, SCF/ton RS (wet)	—	CO ₂ , Vol %	22.1
Calc. Vent Gas SCF/ton RS (dry)	5998	O ₂ , Vol %	0.0
Gas Losses, SCF/ton RS (wet)	432	N ₂ + Argon, Vol %	60.8
Propane, SCF/ton RS	26.2	CH ₄ , Vol %	2.4
TEMPERATURES AND HEAT BALANCE		CO, Vol %	3.9
Retort Offgas, °F	142	H ₂ , Vol %	6.1
Spent Shale, F	573	Other, Vol %	4.7
Raw Shale, °F	91	Gross Heating Value (calc), Btu/SCF	157
Recycle Gas Inlet, °F	268	Carbon (Total), lbs/MSCF (dry)	12.9
Dilution Gas Inlet, °F	—	Hydrogen (Total), lbs/MSCF (dry)	1.14
Air Inlet, °F	136	YIELDS AND BALANCES	
Retort Air Inlet, F	119	Oil Collected, Vol % RSFA	75.3
Heat of Comb. MBtu/ton RS	432	Oil in Gas**, Vol % RSFA	1.4
Heat Lost, MBtu/ton RS	36	Oil in Spent Shale, Vol % RSFA	1.7
RAW SHALE PROPERTIES		Total Oil Meas., Vol % RSFA	78.4
Fischer Assay, gal/ton RS	26.4	Carbonate Decomposition, %	19.4
Oil, Wt %	10.1	Water Recovered, lb/ton RS	58.9
Water, Wt %	0.7	Ash Balance, % - As Measured	—
Gas, Wt %	2.2	Ash Balance, % - Assumed	2.5100
Mineral CO ₂ , Wt %	17.7	Overall Balance, %	100.1
Ash, Wt %	68.3	Carbon Balance, % - Organic	100.2
Moisture, Wt % (Uncrushed)	1.0 Est.	Carbon Balance, % - Total	101.7
Carbon (Total), Wt %	16.3	Hydrogen Balance, % - Organic	91.4
Hydrogen (Total), Wt %	1.62	Hydrogen Balance, % - Total	96.7
Nominal Size Range, inches	1/4" - 2 1/2"	Water Balance, %	110.2
5 % passing thru	0.371	MISCELLANEOUS	
98 % passing thru	2.50	Avg. Retort ΔP, in H ₂ O/ft	0.65
D _a	0.897	ΔP Above Air Dist., in H ₂ O/ft	0.57
D _v	1.458	NaCl Soln., Wt %	—
Line Burner °F	860	NaCl Rate, gal/ton RS	—

Comments: *Adjusted air supply down and back up to control temperature*

*Measured Recycle + Dilution Gas
 ** Oil Mist + Condensibles to 84 °F
 *** Rates are for moisture-free raw shale. All shale analyses are on a moisture-free basis.

Signed Earl E. Turner DATE July 18, 1967

//A100

2080, C1049-1 6-30-67

A. YIELDS

FAY	7.531E 01	DRYGAS	5.998E 03	MISTFA	1.429E 00
H2	3.659E 02	OTHER	2.819E 02	UNRETO	1.672E 00
CH4	1.439E 02	O2	0.0	SSY	8.443E 01
CO	2.339E 02	CO2DEC	1.939E 01	MH2O	5.837E 01
CO2	1.326E 03	OILCOL	1.988E 01		

B. METERED GAS RATES

RECG	1.144E 04	DIL	0.0	WVENTG	6.315E 03
AIR	4.609E 03	TRECG	1.144E 04	TGF	0.0

C. MOL WT & HEATING VALUE OF VENT GAS

MWWG	2.908E 01	HVGT	9.422E 02	MWDG	3.046E 01
GBTU	1.571E 02				

D. COMBUSTION PRODUCTS

CO2C	6.727E 02	COC	2.155E 02	H2OC	1.813E 01
CHR	1.383E 01	COMBCP	1.215E 01		

E. MATERIAL IN

ORGCIN	2.318E 02	RSR	4.922E 02	ORH2IN	3.139E 01
MATIN	2.377E 03				

F. MATERIAL OUT

ORGCVG	6.113E 01	COKEC	3.720E 01	UNRETH	4.029E-01
ORGCOL	1.305E 02	ORH2VG	9.197E 00	COKEH	1.860E 00
UNRETC	3.431E 00	ORH2OL	1.722E 01	ORCOLP	5.628E 01
ORCVGP	2.637E 01	ORCSSP	1.753E 01	HCCVGP	1.422E 01

G. MATERIAL BALANCES

OVALL	1.001E 02	ORH2	9.137E 01	O2BAL	1.016E 02
ASH	0.0	TC	1.017E 02	WATER	1.102E 02
ORGC	1.002E 02	TH2	9.672E 01	GASL	4.318E 02
ASHB	-1.000E 00				

H. HEAT IN

QCOMB	4.318E 05	QH2OC	1.039E 04	QAIR	3.822E 03
QPROP	5.571E 01	QOILC	1.086E 04	QRCYL	4.416E 04
QSUMIN	5.016E 05				

I. HEAT OUT

QMC02D	1.112E 05	QKEROD	9.637E 04	QH2OV	3.765E 04
QLIQO	2.946E 03	QOFGAS	1.980E 04	QSS	1.932E 05
QGASL	4.774E 03	LBLOSS	0.0	HETLOS	3.563E 04
QSUMOT	5.016E 05				

J. MISCELLANEOUS

ORCSS	2.406E 00	VPOIL	4.907E-01	TGL	4.369E 03
VPM	5.941E 00	WCG	1.111E 01	PROP	2.617E 01

END MESSAGE

END OUTPUT

HEAT AND MATERIAL BALANCE FOR PILOT RETORTS - DATA SHEET

LINE #	PROGRAM ID	USER IDENTIFICATION					
0	2080,	C1099-1		6/30/67			
1	WRS	OLRS	TRS	B	MRS	RAW SHALE	
	0.7	10.1	91	-1	27177.5		
2	FA	GRS	CORS	XA			
	26.4	2.2	17.7	55.22			
3	ASRS	CRS	HRS	BP	TOG		
	68.3	16.3	1.62	24.36	142		
4	CRA	MFA	TA	VPA	WA	LBHL	AIR
	1045.4	1.0	136	119	0.14	0	
5	CRRG	MFRG	TRG	PRG	CRTG	MFTG	RECYCLE AND TOTAL GAS
	2596.4	1.0	268	66	0.0	0.0	
6	CRDG	MFDG	TDG	PDG			DILUTION GAS
	0.0	0.0	0	0			
7	P	TP	PP	W	N		PROPANE AND NUCLEATING AGENT
	6.83	0.4	127.8	274.5	0.0		
8	WSS	OLSS	GSS	SS			SPENT SHALE
	0.5	0.2	0.1	0.0			
9	COSS	ASSS	CSS	HSS	TSS		
	16.9	80.9	7.02	0.19	573		
10	OILLP	COL	HOL	DOL	WLP		LIQUID PRODUCT
	2103.37	84.1	11.1	7.804	194.3		
11	CRVG	MFVG	TVG	WG	OILM	M	VENT GAS
	1472.0	1.0	263	0.0	0.0	0	
12	CG	H	COOG	OG	NG		
	12.9	0	22.1	0.0	60.8		
13	MEG	COG	HHG	OTG	HG		
	2.4	3.9	6.1	4.7	1.14		
14	CRVP	VPMF	TVP	PVP			VENT PURGE
	6.6	2.21	169	24			
15	TVPC	VPOIL	VPW	GL			
	84	241.6	3.8	71.2			

OPTIONS:

- B Enter "1" to Calculate with Spent Shale Rate and Ash Analyses,
Or "0" to Calculate with Measured Rates,
Or ".1" to Calculate with Raw Shale Rate and Ash Analyses.
- M Enter "1" to Calculate with Measured Moisture and H₂O,
Or "0" to Calculate from Vent Purge Data.
- H Enter "1" to Calculate using Retort #2,
Or "0" to Calculate using Retort #3.

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 7-1-67

Run No. C1049-1

Sample Time: RS 0715; SS 1115

FISCHER ASSAY

<input checked="" type="checkbox"/> RAW SHALE	<input checked="" type="checkbox"/> SPENT SHALE	
<u>26.1</u>	<u>0.5</u> <u>0.47</u>	Gal/Ton
<u>.914</u>	<u>—</u>	S.G., g/ml
<u>10.0</u>	<u>0.2</u>	Oil, wt %
<u>1.7</u>	<u>0.5</u>	Water, wt %
<u>86.1</u>	<u>99.2</u>	Sp. Shale, wt %
<u>2.2</u>	<u>0.1</u>	Gas & Loss, wt %
<u>SLIGHT</u>	<u>NONE</u>	COKING TENDENCY

RETORT SHALE MOISTURE
Est 1.0 wt %
 RAW SHALE FISCHER ASSAY MOISTURE
0.60 wt %

MINERAL CO₂

17.6 16.9
~~17.9~~ wt %

ASH (SHALE)

67.9 50.9 wt %

MOISTURE

0.29 0.06 wt %

CARBON

16.2 7.02 wt %

HYDROGEN

1.61 0.19 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 CO₂", "Carbon", and "Hydrogen". The "FA Moisture" is for the sample used for the Fischer Assay.

COMMENTS _____

DATE COMPLETED JUL 3 1967

CHECKED BY RCR

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 7-1-67

Run No. C1049-1

BKM
⊗

LIQUID PRODUCTS

D3 PUMPOUT

T3 PUMPOUT

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1</u>	<u>2</u>
WATER, wt %	<u>7.0</u>	_____	_____	_____	_____	_____
GRAVITY, °API	<u>19.5</u>	_____	_____	_____	_____	_____

OIL ASH, wt %

DISTILLATION (See attached sheet - OSRC-24)

BKM
⊗

VENT PURGE PRODUCT

OIL WT, g 2899.0

WATER VOL, ml 4.0

GRAVITY OIL, °API 42.0

BKM
⊗

VENT GAS

MAJOR COMPONENTS

C₁ thru C₄, plus n-Pentane

CO ₂	<u>22.1</u>	vol %
O ₂	<u>0.0</u>	"
N ₂	<u>60.1</u>	"
CH ₄	<u>2.4</u>	"
CO	<u>3.9</u>	"
H ₂	<u>6.1</u>	"
Ar	<u>0.7</u>	"
Others	<u>4.7</u>	"

CH ₄	_____	vol %
C ₂ H ₄ -C ₂ H ₆	_____	"
C ₃ H ₈	_____	"
C ₃ H ₆	_____	"
i C ₄ H ₁₀	_____	"
n C ₄ H ₁₀	_____	"
∅C ₃ H ₆	_____	"
n C ₅ H ₁₂	_____	"

MA
⊗

CARBON, 12.9 lbs/MSCFDG

MA
⊗

HYDROGEN, 1.14 lbs/MSCFDG

COMMENTS _____

DATE COMPLETED JUL 3 1967

CHECKED BY REJ

SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. 010219-21 SAMPLE NO. J. J. 1. DATE 7-1-67
 UNIT P.T. 100 DESCRIPTION 1
 APPROX. SHALE SIZE 10-20 SHAKING TIME 12 min. ANALYSIS BY 1
 TOTAL SAMPLE WT. GROSS 90.1 - TARE 6.6 = NET 83.5

SCREEN SIZE			WEIGHTS								
SCREENS REQD.	OPENING SIZE	MESH	GROSS LBS.	TARE LBS.	NET WT. RETAINED	SCREEN SIZE	Di *	1/Di	% RETAINED	CUM. % RETAINED	% PASSING
	4.25					4.25					
	3.00					3.00	(3.125)	(0.3200)			
	2.50		17.1	13.7	3.4	2.50	(2.625) 2.750	(0.3809) 0.3636	2.92		97.08
	2.00		33.4	20.2	13.2	2.00	2.250	0.4444	19.68		77.40
	1.50		53.0	23.4	29.6	1.50	1.750	0.5714	31.12		46.29
	1.05		36.1	19.3	16.8	1.05	(1.087) 1.275	(0.9199) 0.7843	17.98		28.31
	0.742		28.9	22.5	6.4	0.742	0.896	1.116	10.21		18.16
	0.525		25.5	18.5	7.0	0.525	0.634	1.577	8.51		9.59
	0.371		22.6	19.9	2.7	0.371	0.448	2.232	4.13		5.46
	0.263	3	20.7	18.5	2.2	0.263	0.317	3.154	2.67		2.79
	0.185	4	19.9	19.4	.5	0.185	0.224	4.464	0.49		2.30
	0.131	6	19.6	19.4	.2	0.131	0.158	6.329	0.24		2.06
	0.093	8	20.5	20.5	.0	0.093	0.112	8.928	0	97.94	2.06
	0.065	10	19.4	19.3	.1	0.065			6.12		1.94
	PAN		22.6	21.0	1.6	PAN			1.94		0
TOTAL ON SCREENS AND PAN					82.3	LOSS					
LOSS (BY DIFFERENCE)					-1.2	TOTAL					
TOTAL SAMPLE WEIGHT					83.5						

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

REMARKS: _____

$\sum_{+8m}^m D_i$		$\sum_{+8m}^m X_i$	14.66
$1/\sum_{+8m}^m D_i$		$\sum_{+8m}^m X_i / D_i$	0.87837
D_a	0.8968	$\sum_{+8m}^m X_i D_i$	14.66998
D_v	1.4978		