

GAS COMBUSTION RETORTING
DETAILED RUN SUMMARY SHEET

1513018010

Date 6-22-67

Purpose: *To determine gas solubility and yield with 1-2 inch shale using hot dilution gas and apparatus (maximum possible gas rate)*

GENERAL		SPENT SHALE PROPERTIES	
Run No.	R-10 01046-8	Fischer Assay, Gal/ton	0.0
Length, hours	12	Mineral CO ₂ , Wt %	15.5
Retort Type Number	RC VII	Ash, Wt %	82.3
Oil Recovery System Number	C-1	Carbon (total), Wt %	6.41
7045 Total Raw Shale Charged, lbs.	97.69	Organic Carbon, Wt %	2.18
Bed Height above Dist., ft	9 1/2	Hydrogen (total), Wt %	0.24
Type Air Dist.	AD XI	LIQUID PRODUCT PROPERTIES	
Bed Below Air Dist., ft	6	Oil, Wt %	96.0
RATES AND QUANTITIES		Density, lb/gal	7.727
Raw Shale, lbs/(hr)(ft ²)	295	Gravity, API	20.6
Spent Shale, % of RS	82.3	Ash, Wt %	—
Liquid Product, lbs/hr	1616.5	PRODUCT GAS PROPERTIES	
Oil Collected, gal/ton RS	22.1	Water Vapor, lbs/MSCF (dry)	5.7
Air, SCF/ton RS (dry)	4800	Oil, lbs/MSCF (dry)**	0.093
Total Recycle*, SCF/ton RS (wet)	19300	Analysis (dry)	
Dilution, SCF/ton RS (wet)	1810	CO ₂ , Vol %	25.1
Calc. Vent Gas SCF/ton RS (dry)	6152	O ₂ , Vol %	0.5
Gas Losses, SCF/ton RS (wet)	1299	N ₂ + Argon, Vol %	61.7
Propane, SCF/ton RS	23.4	CH ₄ , Vol %	1.9
TEMPERATURES AND HEAT BALANCE		CO, Vol %	2.7
Retort Offgas, °F	141	H ₂ , Vol %	5.3
Spent Shale, F	548	Other, Vol %	2.8
Raw Shale, °F	89	Gross Heating Value (calc), Btu/SCF	100.9
Recycle Gas Inlet, °F	279	Carbon (Total), lbs/MSCF (dry)	11.8
Dilution Gas Inlet, °F	277	Hydrogen (Total), lbs/MSCF (dry)	0.79
Air Inlet, °F	152	YIELDS AND BALANCES	
Retort Air Inlet, F	143	Oil Collected, Vol % RSFA	83.8
Heat of Comb. MBtu/ton RS	479	Oil in Gas**, Vol % RSFA	6.3
Heat Lost, MBtu/ton RS	25	Oil in Spent Shale, Vol % RSFA	0.0
RAW SHALE PROPERTIES		Total Oil Meas., Vol % RSFA	84.1
Fischer Assay, gal/ton RS	26.4	Carbonate Decomposition, %	22.1
Oil, Wt %	10.1	Water Recovered, lb/ton RS	25.3
Water, Wt %	1.0	Ash Balance, % - As Measured	—
Gas, Wt %	2.2	Ash Balance, % - Assumed	R.S. 100
Mineral CO ₂ , Wt %	17.5	Overall Balance, %	99.9
Ash, Wt %	67.7	Carbon Balance, % - Organic	90.4
Moisture, Wt % (Uncrushed)	1.01	Carbon Balance, % - Total	97.2
Carbon (Total), Wt %	16.7	Hydrogen Balance, % - Organic	90.5
Hydrogen (Total), Wt %	1.73	Hydrogen Balance, % - Total	97.0
Nominal Size Range, inches	1/4" - 2 1/2"	Water Balance, %	117.5
5 % passing thru	0.371	MISCELLANEOUS	
98 % passing thru	2.50	Avg. Retort ΔP, in H ₂ O/ft	0.34
Da	1.109	ΔP Above Air Dist., in H ₂ O/ft	0.33
Dv	1.543	NaCl Soln., Wt %	—
Line Burner °F	700	NaCl Rate, gal/ton RS	—

Comments: *Operations satisfactory except for spent shale sample. Total sample used for spent shale sample.*

*Measured Recycle + Dilution Gas
 ** Oil Mist + Condensibles to 83 °F
 *** Rates are for moisture-free raw shale. All shale analyses are on a moisture-free basis.

Signed Earl E. Jumper DATE July 17 1967

//A100

2080, C1046-8 R-1 6-22-67

A. YIELDS

FAY	8.378E 01	DRYGAS	6.152E 03	MISTFA	2.791E-01
H2	3.261E 02	OTHER	1.723E 02	UNRETO	0.0
CH4	1.169E 02	O2	3.076E 01	SSY	8.226E 01
CO	1.661E 02	CO2DEC	2.714E 01	MH2O	7.526E 01
CO2	1.544E 03	OILCOL	2.212E 01		

B. METERED GAS RATES

RECG	1.250E 04	DIL	1.836E 03	WVENTG	5.589E 03
AIR	4.797E 03	TRECG	1.434E 04	TGF	0.0

C. MOL WT & HEATING VALUE OF VENT GAS

MWWG	2.953E 01	HVGT	6.208E 02	MWDG	3.091E 01
GBTU	1.009E 02				

D. COMBUSTION PRODUCTS

CO2C	6.645E 02	COC	1.477E 02	H2OC	2.300E 01
CHR	9.973E 00	COMBCP	1.070E 01		

E. MATERIAL IN

ORGCIN	2.407E 02	RSR	2.948E 02	ORH2IN	3.286E 01
MATIN	2.391E 03				

F. MATERIAL OUT

ORGCVG	4.717E 01	COKEC	3.584E 01	UNRETH	0.0
ORGCOL	1.441E 02	ORH2VG	7.502E 00	COKEH	3.211E 00
UNRETC	0.0	ORH2OL	1.902E 01	ORCOLP	5.988E 01
ORCVGP	1.960E 01	ORCSSP	1.489E 01	HCCVGP	8.902E 00

G. MATERIAL BALANCES

OVALL	9.985E 01	ORH2	9.049E 01	O2BAL	1.029E 02
ASH	0.0	TC	9.724E 01	WATER	1.175E 02
ORGC	9.437E 01	TH2	9.698E 01	GASL	1.299E 03
ASHB	-1.000E 00				

H. HEAT IN

QCOMB	4.478E 05	QH2OC	8.489E 03	QAIR	4.775E 03
QPROP	5.989E 01	QOILC	1.199E 04	QRCYL	5.795E 04
QSUMIN	5.311E 05				

I. HEAT OUT

QMC02D	1.539E 05	QKEROD	9.840E 04	QH2OV	4.559E 04
QLIQO	3.309E 03	QOFGAS	2.277E 04	QSS	1.777E 05
QGASL	1.310E 04	LBLOSS	0.0	HETLOS	1.631E 04
QSUMOT	5.311E 05				

J. MISCELLANEOUS

ORCSS	2.179E 00	VPOIL	9.278E-02	TGL	2.937E 03
VPM	5.685E 00	WCG	1.068E 01	PROP	2.337E 01

END MESSAGE

END OUTPUT

HEAT AND MATERIAL BALANCE FOR PILOT RETORTS - DATA SHEET

LINE #	PROGRAM ID	← USER IDENTIFICATION →					
0	2080,	C1046-8 R-1 6-22-67					
1	WRS	OLRS	TRS	B	MRS	← RAW SHALE	
	1.0	10.1	89	-1	16281.1		
2	FA	GRS	CORS	XA			
	26.4	2.2	17.5	55.22			
3	ASRS	CRS	HRS	BP	TOG		
	67.7	16.7	1.73	24.27	141		
4	CRA	MFA	TA	PA	WA	LBHL	← AIR
	653.1	1.0	143	124	0.14	0	
5	CRRG	MFRG	TRG	PRG	CRTG	MFTG	← RECYCLE A TOTAL GAS
	1716.4	1.0	279	71	0.0	0.0	
6	CRDG	MFDG	TDG	PDG			← DILUTION G
	5.49	56.4	277	72			
7	P	TP	PP	W	N		← PROPANE A NUCLEATING AGENT
	3.65	0.4	129.9	166.1	0.0		
8	WSS	OLSS	GSS	SS			← SPENT SHALE
	0.4	0.0	0.0	0.0			
9	COSS	ASSS	CSS	HSS	TSS		
	15.5	82.3	6.41	0.24	548		
10	OILLP	COL	HOL	DOL	WLP		← LIQUID PRODUCT
	1394.91	84.1	11.1	7.747	221.5		
11	CRVG	MFVG	TVG	WG	OILM	M	← VENT GAS
	1083.2	1.0	277	0.0	0.0	0	
12	CG	H	COOG	OG	NG		
	11.8	0	25.1	0.5	61.7		
13	MEG	COG	HHG	OTG	HG		
	1.9	2.7	5.3	2.8	0.79		
14	CRVP	VPMF	TVP	PVP			← VENT PURGE
	4.2	2.18	151	39			
15	TVPC	VPOIL	VPW	GL			
	83	36.9	3.0	84.2			

OPTIONS:

1. 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.
2. M Enter "1" to Calculate with Measured Moisture and Mist,
Or "0" to Calculate from Vent Purge Data.
3. 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 6-23-67

Run No. 1046-8

Sample Time: RS 0600; SS _____

FISCHER ASSAY

RETORT SHALE MOISTURE

RAW SHALE

SPENT SHALE

1.01 wt %

26.2

0.2

Gal/Ton

RAW SHALE FISCHER ASSAY MOISTURE

.914

1

S.G., g/ml

0.92 wt %

10.0

0.1

Oil, wt %

1.9

0.4

Water, wt %

85.9

99.4

Sp. Shale, wt %

S.S. sample no good.

2.2

0.1

Gas & Loss, wt %

Not the right sample.

Slight

none

COKING TENDENCY

L.B.S.

MINERAL CO₂

17.4

15.5

wt %

ASH (SHALE)

67.5

82.5

wt %

MOISTURE

0.36

0.10

wt %

CARBON

16.6

6.64

wt %

HYDROGEN

1.72

0.18

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

JUN 26 1967

CHECKED BY _____

MESH

wt gram

wt %

8	217.0	28.5
14	243.0	31.9
28	123.8	16.3
35	37.9	5.0
48	20.0	2.6
65	21.2	2.8
100	10.1	1.4
150	15.8	2.1
PAN	64.2	8.4
TOTAL	761.0	100%

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 6-23-67

Run No. C1046-8 Grab

Sample Time: RS _____; SS _____

FISCHER ASSAY

RAW SHALE SPENT SHALE

_____	<u>0.0</u>	Gal/Ton
_____	<u>—</u>	S.G., g/ml
_____	<u>0.0</u>	Oil, wt %
_____	<u>0.4</u>	Water, wt %
_____	<u>99.4</u>	Sp. Shale, wt %
_____	<u>0.2</u>	Gas & Loss, wt %
_____	<u>None</u>	COKING TENDENCY

RETORT SHALE MOISTURE
_____ wt %

RAW SHALE FISCHER ASSAY MOISTURE
_____ wt %

MINERAL CO₂

_____ 15.5 wt % ^{ES}

ASH (SHALE)

_____ 82.3 wt % ^{FA}

MOISTURE

_____ 0.05 wt % ^{FA}

CARBON

_____ 6.41 wt % ^{ES}

HYDROGEN

_____ 0.24 wt % ^{ES}

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 JUN 26 1967

CHECKED BY SEP

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 6-23-67

Run No. C1046-8
(0900)

LIQUID PRODUCTS

	<u>D3 PUMPOUT</u>				<u>T3 PUMPOUT</u>	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1</u>	<u>2</u>
<input checked="" type="checkbox"/> WATER, wt %	<u>4.0</u>					
<input checked="" type="checkbox"/> GRAVITY, °API	<u>20.6</u>					
<input type="checkbox"/> OIL ASH, wt %						

DISTILLATION (See attached sheet - OSRC-24)

VENT PURGE PRODUCT

OIL WT, g 442.6
WATER VOL, ml 14.0
GRAVITY OIL, °API 41.3

VENT GAS

<input checked="" type="checkbox"/> MAJOR COMPONENTS	<input type="checkbox"/> C ₁ thru C ₄ , plus n-Pentane
CO ₂ <u>25.1</u> vol %	CH ₄ _____ vol %
O ₂ <u>0.5</u> "	C ₂ H ₄ -C ₂ H ₆ _____ "
N ₂ <u>61.0</u> "	C ₃ H ₈ _____ "
CH ₄ <u>1.9</u> "	C ₃ H ₆ _____ "
CO <u>2.7</u> "	i C ₄ H ₁₀ _____ "
H ₂ <u>5.3</u> "	n C ₄ H ₁₀ _____ "
Ar <u>0.7</u> "	∅C ₃ H ₆ _____ "
Others <u>2.8</u> "	n C ₅ H ₁₂ _____ "

CARBON, 11.8 lbs/MSCFDG

HYDROGEN, 0.77 lbs/MSCFDG

COMMENTS _____

SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C1046-8 SAMPLE NO. 8 DATE 6-23-67.

UNIT R.T. #3 DESCRIPTION TYLAB

APPROX. SHALE SIZE 2 1/2" to 4" SHAKING TIME 10. MIN. ANALYSIS BY W. J. ...

TOTAL SAMPLE WT. GROSS 75.5 - TARE 6.4 = NET 69.1

SCREEN SIZE			WEIGHTS								
SCREENS REQD.	OPENING SIZE	MESH	GROSS LBS.	TARE LBS.	NET WT. RETAINED	SCREEN SIZE	D_i *	$1/D_i$	% RETAINED	CUM. % RETAINED	% PASSING
	4.25					4.25					
	3.00					3.00	(3.125)	(0.3200)			
	2.50		20.9	16.7	4.2	2.50	(2.625) 2.750	(0.3809) 0.3636	6.07		93.92
	2.00		34.1	20.2	13.9	2.00	2.250	0.4444	20.09		73.83
	1.50		44.2	23.4	20.8	1.50	1.750	0.5714	30.06		43.77
	1.05		30.8	19.2	11.6	1.05	(1.087) 1.275	(0.9199) 0.7843	16.76		27.61
	0.742		27.7	20.5	7.2	0.742	0.896	1.116	10.40		16.61
	0.525		24.2	18.5	5.7	0.525	0.634	1.577	8.24		8.37
	0.371		21.9	19.2	2.7	0.371	0.448	2.232	3.90		4.47
	0.263	3	20.2	18.5	1.7	0.263	0.317	3.154	2.46		2.01
	0.185	4	19.7	19.4	.3	0.185	0.224	4.464	0.43		1.58
	0.131	6	19.5	19.4	.1	0.131	0.158	6.329	0.14		1.44
	0.093	8	20.3	20.2	.1	0.093	0.112	8.928	0.14	98.69	1.30
	0.065	10	19.3	19.2	.1	0.065			0.14		1.16
	PAN		21.8	21.0	.8	PAN			1.16		0.00
TOTAL ON SCREENS AND PAN					69.2	LOSS			-	-	-
LOSS (BY DIFFERENCE)					.1	TOTAL			99.99	-	-
TOTAL SAMPLE WEIGHT					69.1				-	-	-

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

REMARKS: _____

$\sum_{+8m}^m D_i$	1.52314	$\sum_{+8m}^m X_i$	
$1/\sum_{+8m}^m D_i$	0.86681	$\sum_{+8m}^m X_i / D_i$	
D_a	1.13854	$\sum_{+8m}^m X_i D_i$	
D_v	1.54335		

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