

GAS COMBUSTION RETORTING
DETAILED RUN SUMMARY SHEET

1513013007

Date 4-11-67

Purpose: To determine combustibility and yield at 500 mscf rate using 1-2 1/2" shale with SS lining, 3/4" diameter AD level ports & air-recycle headers.

GENERAL	
Run No.	C-1028-1
Length, hours	12
Retort Type Number	AC-2E
Oil Recovery System Number	C-2
Tons Total Raw Shale Charged, lbs.	16461
Bed Height above Dist., ft	12 1/2'
Type Air Dist.	AD-VIII
Bed Below Air Dist., ft	71
RATES AND QUANTITIES	
Raw Shale, lbs/(hr)(ft ²)	4.97
Spent Shale, % of RS	81.5
Liquid Product, lbs/hr	2481.3
Oil Collected, gal/ton RS	21.7
Air, SCF/ton RS (dry)	4740
Total Recycle*, SCF/ton RS (wet)	12400
Dilution, SCF/ton RS (wet)	-
Calc. Vent Gas SCF/ton RS (dry)	6150
Gas Losses, SCF/ton RS (wet)	-222
Propane, SCF/ton RS	-
TEMPERATURES AND HEAT BALANCE	
Retort Offgas, °F	139
Spent Shale, F	407
Raw Shale, °F	64
Recycle Gas Inlet, °F	250
Dilution Gas Inlet, °F	-
Air Inlet, °F	136
Retort Air Inlet, F	136
Heat of Comb. MBtu/ton RS	436
Heat Lost, MBtu/ton RS	25
RAW SHALE PROPERTIES	
Fischer Assay, gal/ton RS	25.7
Oil, Wt %	9.9
Water, Wt %	1.1
Gas, Wt %	1.8
Mineral CO ₂ , Wt %	17.6
Ash, Wt %	68.4
Moisture, Wt % (Uncrushed)	1.0 F.S.T.
Carbon (Total), Wt %	16.0
Hydrogen (Total), Wt %	1.62
Nominal Size Range, inches	1 1/2 - 2 1/2"
5 % passing thru	0.742
98 % passing thru	7.50
D _a	1.387
D _v	1.571

SPENT SHALE PROPERTIES	
Fischer Assay, Gal/ton	0.0
Mineral CO ₂ , Wt %	14.6
Ash, Wt %	83.9
Carbon (total), Wt %	6.12
Organic Carbon, Wt %	2.13
Hydrogen (total), Wt %	0.15
LIQUID PRODUCT PROPERTIES	
Oil, Wt %	95.6
Density, lb/gal	7.904
Gravity, API	19.5
Ash, Wt %	-
PRODUCT GAS PROPERTIES	
Water Vapor, lbs/MSCF (dry)	8.0
Oil, lbs/MSCF (dry)**	0.045
Analysis (dry)	
CO ₂ , Vol %	25.4
O ₂ , Vol %	0.7
N ₂ + Argon, Vol %	61.0
CH ₄ , Vol %	2.6
CO, Vol %	2.9
H ₂ , Vol %	5.6
Other, Vol %	0.8
Gross Heating Value (calc), Btu/SCF	109.0
Carbon (Total), lbs/MSCF (dry)	12.6
Hydrogen (Total), lbs/MSCF (dry)	0.80
YIELDS AND BALANCES	
Oil Collected, Vol % RSFA	82.4
Oil in Gas**, Vol % RSFA	0.1
Oil in Spent Shale, Vol % RSFA	0.0
Total Oil Meas., Vol % RSFA	82.5
Carbonate Decomposition, %	32.4
Water Recovered, lb/ton RS	71.3
Ash Balance, % - As Measured	-
Ash Balance, % - Assumed	100-100
Overall Balance, %	98.8
Carbon Balance, % - Organic	98.4
Carbon Balance, % - Total	98.9
Hydrogen Balance, % - Organic	94.6
Hydrogen Balance, % - Total	97.1
Water Balance, %	98.6
MISCELLANEOUS	
Avg. Retort ΔP, in H ₂ O/ft	0.49
ΔP Above Air Dist., in H ₂ O/ft	0.53
NaCl Soln., Wt %	-
NaCl Rate, gal/ton RS	-

Comments: Operations good. No problems with combustion control, air inlet and the clean-up. Exceptional low heating value.

*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.

Signed Earl E. Jumper

DATE 4/21/67

221, RUN NO. C-1025-1

Started 4/11/67

4/17/67
etc

YIELDS

FAY	3.257 01	DRYGAS	6.149 03	MISPSA	1.373-01		
H2	3.443 02	OTHER	4.919 01	UNRETD	0.000 00	CH4	1.593 02
OP	4.504 01	SBY	3.152 01	CC	2.303 02	CCO2DC	3.237 01
WH2O	7.126 01	CC2	1.569 03	SILCOL	2.117 01		

METERED GAS RATES

TRCG	1.244 04	DIL	0.000 00	VVENTS	7.403 03	AIR	4.741 03
TRCG	1.244 04	TGF	0.000 00				

MOL WT & HEATING VALUE OF VENT GAS

NWMS	2.267 01	NWGT	6.707 02	WH2O	3.045 01	CBTU	1.090 02
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COMBUSTION PRODUCTS

CO2C	5.335 02	COG	2.257 02		
H2CC	2.944 01	CH2	7.254 00	CO2DCP	1.075 01

MATERIAL IN

ORGIN	2.230 02	RSR	4.263 02	ORH2IN	2.903 01	MATIN	2.333 03
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MATERIAL OUT

ORCOVC	4.664 01	COXEC	3.479 01	UNREIN	0.000 00		
ORCOL	1.369 02	ORH2VC	2.250 00	COXEN	1.715 00	UNRETC	0.000 00
ORH2OL	1.733 01	OROGLP	6.235 01	OROVSP	2.063 01	OROSSP	1.554 01
HCOVSP	1.008 01						

MATERIAL BALANCES

OVALL	9.970 01	ORGH2	9.455 01	TC	9.380 01	WATER	9.255 01
CP5AL	1.000 02	ASH	0.000 00	GASL	-2.216 02	ASHE	-1.000 00
OROC	9.845 01	TR2	9.703 01				

HEAT IN

COXMS	4.664 05	CH2CC	3.413 03	SAIR	6.279 03		
OPROP	0.000 00	CCILC	1.156 04	ORCYL	4.769 04	OSUNIN	5.103 05

HEAT OUT

OROCOD	1.845 05	OREROD	9.360 04	OR2OV	4.797 04		
OLIGC	4.403 03	ORFGAS	3.034 04	ORSS	1.255 05	ORASL	-1.001 03
LBLOSS	0.000 00	NETLOS	2.506 04	OSUNCI	5.103 05		

MISCELLANEOUS

OROSS	2.134 00	VPCIL	4.496-02	TGL	4.831 03	VPM	7.930 00
VOS	1.437 01	PRGF	0.000 00				

MATERIAL AND HEAT BALANCE INPUT SHEET

RIF 92 | , RUN NO. | C-10-8-1 | STARTED | 4-11-67 | CALC. ON | 4-17-67

10 | 9.9 | 64 | -1 | 27434.06
 H₂O, wt% | Oil, wt% | °F | (1) | Rate, lbs/hr

25.7 | 1.8 | 17.6 | 5522
 Oil, gal/T | Gas+L, wt% | CO₂, wt% | Retort XS, ft²

68.04 | 16.00 | 1.062 | 23090 | 139
 Ash, wt% | Carbon, wt% | H₂, wt% | Bar. Press, " Hg | Offgas Temp, °F

RAW SHALE
 BAROMETRIC
 PRESSURE
 AND
 OFFGAS
 TEMPERATURE

1096.0 | 1.00 | 136 | 110 | 0.014 | 0
 Chart Reading | Meter Factor | Temp, °F | Press, "H₂O gauge | Moist, lbs/HSCF | Heat Loss, Btu/hr

AIR

2859.7 | 1.00 | 250 | 69 | 0.00 | 0.00
 Recycle Ch. Press | Meter Factor | Temp, °F | Press, "H₂O gauge | Tot Gas Ch. Press | Meter Factor

RECYCLE AIR
 TOTAL GAS

0.0 | 0.00 | 0 | 0
 Dil Gas Ch. Press | Meter Factor | Temp, °F | Press, "H₂O gauge

DILUTION
 GAS

0.00 | 0 | 0 | 277.01 | 0.00
 C₃ Rotameter R. | Temp, °F | Press, "H₂O gauge | Water added, lbs/hr | Nucl. Agent, lb/hr

PROPANE, WATER
 & NUCLEATING
 AGENT

0.04 | 0.00 | 0.00 | 0.00
 H₂O, wt% | Oil, wt% | Gas, wt% | Rate, lbs/hr

SPENT
 SHALE

14.06 | 83.9 | 6.12 | 0.15 | 4.07
 CO₂, wt% | Ash, wt% | Carbon, wt% | H₂, wt% | Temp, °F

2266.4 | 84.01 | 11.01 | 708.04 | 214.09
 Dry Oil, lbs/hr | Carbon, wt% | H₂, wt% | Den, lbs/gal | Water, lbs/hr

LIQUID
 PRODUCT

1714.8 | 1.00 | 250 | 0.00 | 0.00 | 0 | 12.66
 Vent + Dil Gas Chart Reading | Meter Factor | Temp, °F | Moist, lbs/HSCF | Mist, lbs/HSCF (2) | Carbon, lb/MSCF

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

0 | 25.4 | 0.7 | 61.00 | 2.6 | 3.9 | 5.6
 (3) CO₂, vol% | O₂, vol% | N₂, vol% | CH₄, vol% | CO, vol% | H₂, vol%

0.8 | 0.80 | 15.8
 Other, vol% | H₂, lbs/MSCF | % Purge Ch. Reading

1.83 | 176 | 138 | 75 | 32.02 | 10.03 | 24.44
 Meter Factor | Temp, °F | Press, "H₂O gauge | Cond. Gas Cut Temp, °F | Dry Oil, gal/hr | Water, lbs/hr | Top Seal Gas Rate, SCFM

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).

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 4-12-67

Run No. C1028-1

Sample Time: RS 0615; SS 1115

<u>FISCHER ASSAY</u>		
<input checked="" type="checkbox"/> RAW SHALE	<input checked="" type="checkbox"/> SPENT SHALE	
<u>25.5</u>	<u>0.0</u>	Gal/Ton
<u>.915</u>	<u>—</u>	S.G., g/ml
<u>9.8</u>	<u>0.0</u>	Oil, wt %
<u>1.8</u>	<u>0.4</u>	Water, wt %
<u>86.6</u>	<u>99.6</u>	Sp. Shale, wt %
<u>1.8</u>	<u>0.0</u>	Gas & Loss, wt %
<u>Slight</u>	<u>None</u>	COKING TENDENCY

RETORT SHALE MOISTURE

1.0 ^{EST} wt %

RAW SHALE FISCHER ASSAY MOISTURE

0.67 wt %

MINERAL CO₂

17.6 14.6 wt %

ASH (SHALE)

68.2 83.9 wt %

MOISTURE

0.24 0.08 wt %

CARBON

15.5 6.12 wt %

HYDROGEN

1.51 0.15 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

APR 14 1967

CHECKED BY

[Signature]

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 4-12-67

Run No. C1028-1 0900

LIQUID PRODUCTS

EF
⊗

D3 PUMPOUT

T3 PUMPOUT

	1	2	3	4	1	2
WATER, wt %	<u>4.4</u>	_____	_____	_____	_____	_____
GRAVITY, °API	<u>19.5</u>	_____	_____	_____	_____	_____

○ OIL ASH, wt %

○ DISTILLATION (See attached sheet - OSRC-24)

VENT PURGE PRODUCT

EF
⊗

OIL WT, g 386.3

WATER VOL, ml 4.0

GRAVITY OIL, °API 40.6

VENT GAS

EF
⊗

MAJOR COMPONENTS

CO ₂	<u>25.4</u>	vol %
O ₂	<u>0.7</u>	"
N ₂	<u>60.3</u>	"
CH ₄	<u>2.6</u>	"
CO	<u>3.9</u>	"
H ₂	<u>5.6</u>	"
Ar	<u>0.7</u>	"
Others	<u>0.8</u>	"

○ C₁ thru C₁₁, plus n-Pentane

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	_____	"

EF
⊗

CARBON, 12.6 lbs/MSCFDG

EF

⊗ HYDROGEN, 0.80 lbs/MSCFDG

COMMENTS _____

DATE COMPLETED APR 13 1967

CHECKED BY _____

OSRC-12B

SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C-1008-1 SAMPLE NO. _____ DATE 4-12-67

UNIT 3 DESCRIPTION Tylob

APPROX. SHALE SIZE 1-2 1/2 SHAKING TIME 10 min ANALYSIS BY S. M. ...

TOTAL SAMPLE WT. GROSS 69.4 - TARE 6.0 = NET 63.4

SCREEN SIZE			WEIGHTS		
SCREENS REQD.	OPENING SIZE	MESH	GROSS LBS.	TARE LBS.	NET WT. RETAINED
	4.25				
	3.00				
	2.50		17.8	16.7	1.1
	2.00		28.8	20.2	8.6
	1.50		52.3	23.4	28.9
	1.05		34.8	19.5	15.3
	0.742		26.4	20.5	5.9
	0.525		20.0	18.5	1.5
	0.371		19.6	18.3	1.3
	0.263	3	18.5	18.4	.1
	0.185	4	19.5	19.4	.1
	0.131	6	19.4	19.3	.1
	0.093	8	20.5	20.4	.1
	0.065	10	19.2	19.0	.2
	PAN		21.4	21.0	.4
TOTAL ON SCREENS AND PAN					63.7
LOSS (BY DIFFERENCE)					0.7
TOTAL SAMPLE WEIGHT					63.4

SCREEN SIZE	D _i *	1/D _i	% RETAINED	CUM. % RETAINED	% PASSING
4.25					
3.00	(3.125)	(0.3200)			
2.50	(2.625)	(0.3809)	1.74		98.27
2.00	2.250	0.4444	13.56		84.71
1.50	1.750	0.5714	45.58		39.13
1.05	(1.087)	(0.9199)	24.61		14.52
0.742	0.896	1.116	9.31		5.21
0.525	0.634	1.577	2.37		2.84
0.371	0.448	2.232	0.47		2.37
0.263	0.317	3.154	0.16		2.21
0.185	0.224	4.464	0.16		2.05
0.131	0.158	6.329	0.16		1.89
0.093	0.112	8.928	0.16	98.28	1.73
0.065			0.00		0.77
PAN			0.63		1.10
LOSS			1.10	-	0.00
TOTAL			100.01	-	-

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

REMARKS: _____

$\sum_{+8m}^m D_i$	1.56405	$\sum_{+8m}^m X_i$	
$1/\sum_{+8m}^m D_i$	0.70871	$\sum_{+8m}^m X_i / D_i$	
D _a	1.39674	$\sum_{+8m}^m X_i D_i$	
D _v	1.59142		