GAS COMBUSTION RETORTING
DETAILED RUN SUMMARY SHEET

1513018006

Date 6-20-67

Purpose: To determine operability and yield with ¼ - 2½ in. shale using hot dilution gas.

| GENERAL | X-1 |
|---|---|
| Run No. | C1096-4 |
| Length, hours | 17 |
| Retort Type Number | RC-VII |
| Oil Recovery System Number | C-1 |
| Tons Total Raw Shale Charged, ~~lbs~~ | 98.70 |
| Bed Height above Dist., ft | 9½ |
| Type Air Dist. | ADX1 |
| Bed Below Air Dist., ft | 6 |
| **RATES AND QUANTITIES** | |
| Raw Shale, lbs/(hr)(ft²) | 296 |
| Spent Shale, % of RS | 79.1 |
| Liquid Product, lbs/hr | 1679.7 |
| Oil Collected, gal/ton RS | 72.9 |
| Air, SCF/ton RS (dry) | 5160 |
| Total Recycle*, SCF/ton RS(wet) | 13200 |
| Dilution, SCF/ton RS (wet) | 1940 |
| Calc. Vent Gas SCF/ton RS(dry) | 6670 |
| Gas Losses, SCF/ton RS(wet) | 633 |
| Propane, SCF/ton RS | 19.6 |
| **TEMPERATURES AND HEAT BALANCE** | |
| Retort Offgas, °F | 141 |
| Spent Shale, F | 544 |
| Raw Shale, °F | 84 |
| Recycle Gas Inlet, °F | 280 |
| Dilution Gas Inlet, °F | 769 |
| Air Inlet, °F | 141 |
| Retort Air Inlet, F | 141 |
| Heat of Comb. MBtu/ton RS | 484 |
| Heat Lost, MBtu/ton RS | 18 |
| **RAW SHALE PROPERTIES** | |
| Fischer Assay, gal/ton RS | 29.2 |
| Oil, Wt % | 11.1 |
| Water, Wt % | 2.9 |
| Gas, Wt % | 2.1 |
| Mineral $CO_2$, Wt % | 17.5 |
| Ash, Wt % | 66.2 |
| Moisture, Wt % (Uncrushed) | 1.67 |
| Carbon (Total), Wt % | 18.2 |
| Hydrogen (Total), Wt % | 1.91 |
| Nominal Size Range, inches | ¼"-2½" |
| 5 % passing thru | 0.371 |
| 98 % passing thru | 2.50 |
| $D_a$ | 1.084 |
| $D_v$ | 1.490 |
| Line Burner °F | 740 |

| SPENT SHALE PROPERTIES | |
|---|---|
| Fischer Assay, Gal/ton | 0.0 |
| Mineral $CO_2$, Wt % | 15.0 |
| Ash, Wt % | 93.7 |
| Carbon (total), Wt % | 6.17 |
| Organic Carbon, Wt % | 2.09 |
| Hydrogen (total), Wt % | 0.17 |
| **LIQUID PRODUCT PROPERTIES** | |
| Oil, Wt % | 98.8 |
| Density, lb/gal | 7.762 |
| Gravity, API | 50.4 |
| Ash, Wt % | — |
| **PRODUCT GAS PROPERTIES** | |
| Water Vapor, lbs/MSCF(dry) | 5.4 |
| Oil, lbs/MSCF(dry)** | 0.102 |
| Analysis (dry) | |
| $CO_2$, Vol % | 25.5 |
| $O_2$, Vol % | 0.3 |
| $N_2$ + Argon, Vol % | 61.2 |
| $CH_4$, Vol % | 1.9 |
| CO, Vol % | 3.6 |
| $H_2$, Vol % | 5.9 |
| Other, Vol % | 1.6 |
| Gross Heating Value(calc),Btu/SCF | 104.6 |
| Carbon (Total), lbs/MSCF (dry) | 12.3 |
| Hydrogen (Total), lbs/MSCF (dry) | 0.78 |
| **YIELDS AND BALANCES** | |
| Oil Collected, Vol % RSFA | 78.5 |
| Oil in Gas**, Vol % RSFA | 0.3 |
| Oil in Spent Shale, Vol % RSFA | 0.0 |
| Total Oil Meas., Vol % RSFA | 78.8 |
| Carbonate Decomposition, % | 32.2 |
| Water Recovered, lb/ton RS | 77.8 |
| Ash Balance, % - As Measured | — |
| Ash Balance, % - Assumed | R.S./100 |
| Overall Balance, % | 97.5 |
| Carbon Balance, % - Organic | 86.7 |
| Carbon Balance, % - Total | 91.1 |
| Hydrogen Balance, % - Organic | 81.5 |
| Hydrogen Balance, % - Total | 86.0 |
| Water Balance, % | 99.0 |
| **MISCELLANEOUS** | |
| Avg. Retort ΔP, in $H_2O$/ft | 0.34 |
| ΔP Above Air Dist., in $H_2O$/ft | 0.35 |
| NaCl Soln., Wt % | — |
| NaCl Rate, gal/ton RS | — |

Comments: Line burner went out approximately 15 times during the first 6 hours of retorting. Line burner ignition and sensing lines were plugged - cleaned - Line burner worked better.

*Measured Recycle + Dilution Gas

** Oil Mist + Condensibles to 95 °F

*** Rates are for moisture-free raw shale. All shale analyses are on a moisture-free basis.

Signed Earl E. Turner DATE July 17 1967

OSRC-10
Revised 7/19/66

//A100
2080, C1046-4 R-1 6-20-67

A. YIELDS

| | | | | | |
|---|---|---|---|---|---|
| FAY | 7.845E 01 | DRYGAS | 6.673E 03 | MISTFA | 3.005E-01 |
| H2 | 3.937E 02 | OTHER | 1.068E 02 | UNRETO | 0.0 |
| CH4 | 1.268E 02 | 02 | 2.002E 01 | SSY | 7.909E 01 |
| CO | 2.402E 02 | CO2DEC | 3.221E 01 | MH2O | 7.784E 01 |
| CO2 | 1.702E 03 | OILCOL | 2.291E 01 | | |

B. METERED GAS RATES

| | | | | | |
|---|---|---|---|---|---|
| RECG | 1.125E 04 | DIL | 1.937E 03 | WVENTG | 6.804E 03 |
| AIR | 5.161E 03 | TRECG | 1.319E 04 | TGF | 0.0 |

C. MOL WT & HEATING VALUE OF VENT GAS

| | | | | | |
|---|---|---|---|---|---|
| MWWG | 2.931E 01 | HVGT | 6.980E 02 | MWDG | 3.060E 01 |
| GBTU | 1.046E 02 | | | | |

D. COMBUSTION PRODUCTS

| | | | | | |
|---|---|---|---|---|---|
| CO2C | 6.728E 02 | COC | 2.229E 02 | H2OC | 2.695E 01 |
| CHR | 9.388E 00 | COMBCP | 1.050E 01 | | |

E. MATERIAL IN

| | | | | | |
|---|---|---|---|---|---|
| ORGCIN | 2.703E 02 | RSR | 2.964E 02 | ORH2IN | 3.660E 01 |
| MATIN | 2.431E 03 | | | | |

F. MATERIAL OUT

| | | | | | |
|---|---|---|---|---|---|
| ORGCVG | 5.191E 01 | COKEC | 3.282E 01 | UNRETH | 0.0 |
| ORGCOL | 1.495E 02 | ORH2VG | 8.301E 00 | COKEH | 1.803E 00 |
| UNRETC | 0.0 | ORH2OL | 1.974E 01 | ORCOLP | 5.532E 01 |
| ORCVGP | 1.920E 01 | ORCSSP | 1.214E 01 | HCCVGP | 8.699E 00 |

G. MATERIAL BALANCES

| | | | | | |
|---|---|---|---|---|---|
| OVALL | 9.745E 01 | ORH2 | 8.153E 01 | O2BAL | 1.001E 02 |
| ASH | 0.0 | TC | 9.107E 01 | WATER | 9.903E 01 |
| ORGC | 8.667E 01 | TH2 | 8.595E 01 | GASL | 6.330E 02 |
| ASHB | -1.000E 00 | | | | |

H. HEAT IN

| | | | | | |
|---|---|---|---|---|---|
| QCOMB | 4.838E 05 | QH2OC | 1.020E 04 | QAIR | 5.421E 03 |
| QPROP | 5.282E 01 | QOILC | 1.245E 04 | QRCYL | 5.370E 04 |
| QSUMIN | 5.656E 05 | | | | |

I. HEAT OUT

| | | | | | |
|---|---|---|---|---|---|
| QMCO2D | 1.826E 05 | QKEROD | 1.056E 05 | QH2OV | 5.516E 04 |
| QLIQO | 3.748E 03 | QOFGAS | 2.458E 04 | QSS | 1.695E 05 |
| QGASL | 6.266E 03 | LBLOSS | 0.0 | HETLOS | 1.808E 04 |
| QSUMOT | 5.656E 05 | | | | |

J. MISCELLANEOUS

| | | | | | |
|---|---|---|---|---|---|
| ORCSS | 2.075E 00 | VPOIL | 1.021E-01 | TGL | 2.963E 03 |
| VPM | 5.444E 00 | WCG | 1.027E 01 | PROP | 1.962E 01 |

END MESSAGE

END OUTPUT

# HEAT AND MATERIAL BALANCE FOR PILOT RETORTS – DATA SHEET

| LINE # | PROGRAM ID | USER IDENTIFICATION | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 2080, | C-1046-4 R-1 6-20-67 | | | | | | |
| | WRS | OLRS | TRS | B | MRS | | | |
| 1 | 0.9 | 11.1 | 84 | -1 | 16367.3 | | | RAW SHALE |
| | FA | GRS | CORS | XA | | | | |
| 2 | 29.2 | 2.1 | 17.5 | 55.22 | | | | |
| | ASRS | CRS | HRS | BP | TOG | | | |
| 3 | 66.2 | 18.2 | 1.91 | 24.40 | 141 | | | |
| | CRA | MFA | TA | PA | WA | LBHL | | AIR |
| 4 | 704.5 | 1.0 | 141 | 128 | 0.14 | 0 | | |
| | CRRG | MFRG | TRG | PRG | CRTG | MFTG | | RECYCLE AI TOTAL GAS |
| 5 | 1543.3 | 1.0 | 280 | 75 | 0.0 | 0.0 | | |
| | CRDG | MFDG | TDG | PDG | | | | DILUTION GA |
| 6 | 5.86 | 56.4 | 269 | 57 | | | | |
| | P | TP | PP | W | N | | | PROPANE AI NUCLEATIN AGENT |
| 7 | 3.08 | 0.4 | 128.2 | 269.5 | 0.0 | | | |
| | WSS | OLSS | GSS | SS | | | | SPENT SHALE |
| 8 | 0.5 | 0.0 | 0.0 | 0.0 | | | | |
| | COSS | ASSS | CSS | HSS | TSS | | | |
| 9 | 15.6 | 83.7 | 6.17 | 0.17 | 544 | | | |
| | OILLP | COL | HOL | DOL | WLP | | | LIQUID PRODUCT |
| 10 | 1455.1 | 84.1 | 11.1 | 7.762 | 224.6 | | | |
| | CRVG | MFVG | TVG | WG | OILM | M | | VENT GAS |
| 11 | 1260.8 | 1.0 | 269 | 0.0 | 0.0 | 0 | | |
| | CG | H | COOG | OG | NG | | | |
| 12 | 12.3 | 0 | 25.5 | 0.3 | 61.2 | | | |
| | MEG | COG | HHG | OTG | HG | | | |
| 13 | 1.9 | 3.6 | 5.9 | 1.6 | 0.78 | | | |
| | CRVP | VPMF | TVP | PVP | | | | VENT PURGE |
| 14 | 4.5 | 2.17 | 163 | 44 | | | | |
| | TVPC | VPOIL | VPW | GL | | | | |
| 15 | 85 | 42.0 | 2.8 | 83.6 | | | | |

*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.*

| Mesh | Wt. Grams | Wt % |
|---|---|---|
| 6 | 19.9 | 5.0 |
| 14 | 136.8 ~~19.9~~ | 34.7 |
| 28 | 89.2 | 22.5 |
| 35 | 37.1 | 9.4 |
| 48 | 27.5 | 6.9 |
| 65 | 24.2 | 6.1 |
| 100 | 18.9 | 4.8 |
| 150 | 13.2 | 3.3 |
| Pan | 28.9 | 7.3 |
| TOTAL | 395.7 | 100% |
| | | |
| | | |

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 6-21-67 Run No. C1046-4

Sample Time: RS 0600; SS 1115

FISCHER ASSAY

| (X) RAW SHALE | (X) SPENT SHALE | |
|---|---|---|
| 28.8 | 0.0 | Gal/Ton |
| .912 | — | S.G., g/ml |
| 10.9 | 0.0 | Oil, wt % |
| 2.2 | 0.5 | Water, wt % |
| 84.8 | 99.3 | Sp. Shale, ~~wt~~ % |
| 2.1 | 0.2 | Gas & Loss, wt % |
| Slight | None | COKING TENDENCY |

( ) RETORT SHALE MOISTURE

1.62 ~~1.6~~ wt %

(X) RAW SHALE FISCHER ASSAY MOISTURE

1.36 wt %

MINERAL $CO_2$

| | | |
|---|---|---|
| (X) 17.4 | (X) 15.0 | wt % |

ASH (SHALE)

| | | |
|---|---|---|
| (X) ~~55.9~~ ~~60.3~~ | (X) 83.7 | wt % |

MOISTURE

| | | |
|---|---|---|
| (X) 0.46 | (X) 0.20 | wt % |

( ) SHALE RICHNESS DISTRIBUTION (See attached graph)

CARBON

| | | |
|---|---|---|
| (X) ~~18.1~~ ~~17.7~~ | (X) 6.17 | wt % |

(X) SCREEN ANALYSIS (See back of this sheet)

HYDROGEN

| | | |
|---|---|---|
| (X) 1.90 ~~1.83~~ | (X) 0.17 | wt % |

BENZENE EXTRACTABLES

| | | |
|---|---|---|
| ( ) . | ( ) . | wt % |

18.1
4.75
13.35

All results are "as received" unless noted. "Moisture" designates the moisture content of the -48 mesh material used for "Ash", "Mineral $CO_2$", "Carbon", and "Hydrogen". The "FA Moisture" is for the sample used for the Fischer Assay.

COMMENTS

DATE COMPLETED JUN 24 1967 CHECKED BY

OSRC-12A

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 6-21-67 Run No. C1046-4

## LIQUID PRODUCTS

| | D3 PUMPOUT | | | | T3 PUMPOUT | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 |
| WATER, wt % | 1.2 | | | | | |
| GRAVITY, °API | 20.3 | | | | | |
| OIL ASH, wt % | | | | | | |

DISTILLATION (See attached sheet - OSRC-24)

## VENT PURGE PRODUCT

OIL WT, g 503.4

WATER VOL, ml 34.2

GRAVITY OIL, °API 41.2

## VENT GAS

MAJOR COMPONENTS

| | | |
|---|---|---|
| $CO_2$ | 25.5 | vol % |
| $O_2$ | 0.3 | " |
| $N_2$ | 60.5 | " |
| $CH_4$ | 1.9 | " |
| CO | 3.6 | " |
| $H_2$ | 5.2 | " |
| Ar | 0.7 | " |
| Others | 1.6 | " |

$C_1$ thru $C_4$, plus n-Pentane

| | | |
|---|---|---|
| $CH_4$ | . | vol % |
| $C_2H_4$-$C_2H_6$ | . | " |
| $C_3H_8$ | . | " |
| $C_3H_6$ | . | " |
| i $C_4H_{10}$ | . | " |
| n $C_4H_{10}$ | . | " |
| $\phi C_3H_6$ | . | " |
| n $C_5H_{12}$ | . | " |

CARBON, 12.3 lbs/MSCFDG HYDROGEN, 0.78 lbs/MSCFDG

COMMENTS

DATE COMPLETED JUN 22 1967 CHECKED BY REP

# SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C 1046-4 SAMPLE NO. _____ DATE 6-21-67.

UNIT RETORT #3 DESCRIPTION TYLAB

APPROX. SHALE SIZE 2½" TO ¼" SHAKING TIME 10 MIN. ANALYSIS BY Stalter + Valdez

TOTAL SAMPLE WT. GROSS 80.8 − TARE 6.0 = NET 74.8

| SCREEN SIZE | | | WEIGHTS | | |
|---|---|---|---|---|---|
| SCREENS REQD. | OPENING SIZE | MESH | GROSS LBS. | TARE LBS. | NET WT. RETAINED |
| | 4.25 | | | | |
| | 3.00 | | | | |
| | 2.50 | | 21.4 | 16.7 | 4.7 |
| | 2.00 | | 34.0 | 20.2 | 13.8 |
| | 1.50 | | 42.9 | 23.4 | 19.5 |
| | 1.05 | | 32.0 | 19.2 | 12.8 |
| | 0.742 | | 29.5 | 20.5 | 9.0 |
| | 0.525 | | 25.4 | 18.5 | 6.9 |
| | 0.371 | | 22.6 | 19.2 | 3.4 |
| | 0.263 | 3 | 20.8 | 18.6 | 2.2 |
| | 0.185 | 4 | 19.8 | 19.4 | .4 |
| | 0.131 | 6 | 19.5 | 19.4 | .1 |
| | 0.093 | 8 | 20.4 | 20.4 | .0 |
| | 0.065 | 10 | 19.3 | 19.2 | .1 |
| | PAN | | 22.6 | 21.0 | 1.6 |
| TOTAL ON SCREENS AND PAN | | | | | 74.6 |
| LOSS (BY DIFFERENCE) | | | | | +.2 |
| TOTAL SAMPLE WEIGHT | | | | | 74.8 |

| SCREEN SIZE | Di * | 1/Di | % RETAINED | CUM. % RETAINED | % PASSING |
|---|---|---|---|---|---|
| 4.25 | | | | | |
| 3.00 | (3.125) | (0.3200) | | | 100.00 |
| 2.50 | (2.625) 2.750 | (0.3809) 0.3636 | 6.28 | | 93.70 |
| 2.00 | 2.250 | 0.4444 | 18.45 | | 75.25 |
| 1.50 | 1.750 | 0.5714 | 26.07 | | 49.18 |
| 1.05 | (1.087) 1.275 | (0.9199) 0.7843 | 17.11 | | 32.07 |
| 0.742 | 0.896 | 1.116 | 12.03 | | 20.04 |
| 0.525 | 0.634 | 1.577 | 9.22 | | 10.82 |
| 0.371 | 0.448 | 2.232 | 4.55 | | 6.27 |
| 0.263 | 0.317 | 3.154 | 3.07 | | 3.20 |
| 0.185 | 0.224 | 4.464 | 0.53 | | 2.67 |
| 0.131 | 0.158 | 6.329 | 0.13 | | 2.54 |
| 0.093 | 0.112 | 8.928 | 0.00 | 97.44 | 2.54 |
| 0.065 | | | 0.13 | | 2.41 |
| PAN | | | 2.14 | | 0.27 |
| LOSS | | | 0.27 | | 0.00 |
| TOTAL | | | 79.98 | — | — |
| | | | — | — | — |

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

| | | | |
|---|---|---|---|
| $\sum_{+8m}^{m} Di$ | 1,45210 | $\sum_{+8m}^{m} Xi$ | |
| $1/\sum_{+8m}^{m} Di$ | 0.89899 | $\sum_{+8m}^{m} Xi / Di$ | |
| Da | 1.08328 | $\sum_{+8m}^{m} Xi\ Di$ | |
| Dv | 1.49625 | | |

REMARKS: _____

OSRC-4