GAS COMBUSTION RETORTING
DETAILED RUN SUMMARY SHEET

05130180 24

Date

Purpose: To determine operability and yield with ¼ – 2½ inch shale at 40 gpm sprayrate and with heat carrier (W/o dilution Gas)

| GENERAL | |
|---|---|
| Run No. | C1098-3 |
| Length, hours | 12 |
| Retort Type Number | RC VII |
| Oil Recovery System Number | C-2 |
| Tons Total Raw Shale Charged, ~~lbs.~~ | 130.80 |
| Bed Height above Dist., ft | 9½ |
| Type Air Dist. | AD XI |
| Bed Below Air Dist., ft | 16 |
| **RATES AND QUANTITIES** | |
| Raw Shale, lbs/(hr)(ft²) | 395 |
| Spent Shale, % of RS | 81.8 |
| Liquid Product, lbs/hr | 22847 |
| Oil Collected, gal/ton RS | 24.6 |
| Air, SCF/ton RS (dry) | 9540 |
| Total Recycle*, SCF/ton RS(wet) | 12590 |
| Dilution, SCF/ton RS (wet) | — |
| Calc. Vent Gas SCF/ton RS(dry) | 6104 |
| Gas Losses, SCF/ton RS(wet) | 925 |
| Propane, SCF/ton RS | 20.2 |
| **TEMPERATURES AND HEAT BALANCE** | |
| Retort Offgas, °F | 140 |
| Spent Shale, F | 513 |
| Raw Shale, °F | 88 |
| Recycle Gas Inlet, °F | 271 |
| Dilution Gas Inlet, °F | — |
| Air Inlet, °F | 124 |
| Retort Air Inlet, F | 124 |
| Heat of Comb. MBtu/ton RS | 426 |
| Heat Lost, MBtu/ton RS | 25 |
| **RAW SHALE PROPERTIES** | |
| Fischer Assay, gal/ton RS | 30.1 |
| Oil, Wt % | 11.4 |
| Water, Wt % | 0.8 |
| Gas, Wt % | 2.4 |
| Mineral $CO_2$, Wt % | 17.8 |
| Ash, Wt % | 66.8 |
| Moisture, Wt % (Uncrushed) | 0.95 |
| Carbon (Total), Wt % | 18.0 |
| Hydrogen (Total), Wt % | 1.84 |
| Nominal Size Range, inches | ¼" - 2½" |
| 5 % passing thru | 0.371 |
| 98 % passing thru | 2.50 |
| Da | 1.013 |
| $D_V$ | 1.418 |
| Line Burner °F | 860 |

| SPENT SHALE PROPERTIES | |
|---|---|
| Fischer Assay, Gal/ton | 0.0 |
| Mineral $CO_2$, Wt % | 16.7 |
| Ash, Wt % | 81.7 |
| Carbon (total), Wt % | 6.83 |
| Organic Carbon, Wt % | 2.27 |
| Hydrogen (total), Wt % | 0.17 |
| **LIQUID PRODUCT PROPERTIES** | |
| Oil, Wt % | 93.7 |
| Density, lb/gal | 7.788 |
| Gravity, API | 19.8 |
| Ash, Wt % | — |
| **PRODUCT GAS PROPERTIES** | |
| Water Vapor, lbs/MSCF(dry) | 4.3 |
| Oil, lbs/MSCF(dry)** | 0.177 |
| Analysis (dry) | |
| $CO_2$, Vol % | 23.1 |
| $O_2$, Vol % | 0.0 |
| $N_2$ + Argon, Vol % | 58.9 |
| $CH_4$, Vol % | 2.6 |
| CO, Vol % | 4.2 |
| $H_2$, Vol % | 6.9 |
| Other, Vol % | 4.3 |
| Gross Heating Value(calc), Btu/SCF | 139 |
| Carbon (Total), lbs/MSCF (dry) | 12.4 |
| Hydrogen (Total), lbs/MSCF (dry) | 1.14 |
| **YIELDS AND BALANCES** | |
| Oil Collected, Vol % RSFA | 81.6 |
| Oil in Gas**, Vol % RSFA | 0.5 |
| Oil in Spent Shale, Vol % RSFA | 0.0 |
| Total Oil Meas., Vol % RSFA | 82.1 |
| Carbonate Decomposition, % | 23.3 |
| Water Recovered, lb/ton RS | 52.7 |
| Ash Balance, % - As Measured | — |
| Ash Balance, % - Assumed | 97.5100 |
| Overall Balance, % | 99.6 |
| Carbon Balance, % - Organic | 95.2 |
| Carbon Balance, % - Total | 97.5 |
| Hydrogen Balance, % - Organic | 91.6 |
| Hydrogen Balance, % - Total | 93.9 |
| Water Balance, % | 94.4 |
| **MISCELLANEOUS** | |
| Avg. Retort ΔP, in $H_2O$/ft | 0.54 |
| ΔP Above Air Dist., in $H_2O$/ft | 0.59 |
| NaCl Soln., Wt % | — |
| NaCl Rate, gal/ton RS | — |

Comments: Operation good.

*Measured Recycle + Dilution Gas
** Oil Mist + Condensibles to 77 °F
*** Rates are for moisture-free raw shale. All shale analyses are on a moisture-free basis.

Signed Earl E. Jones DATE July 17, 1967

OSRC-10
Revised 7/19/66

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//A100
2080. C1048-3 6-29-67

A. YIELDS
FAY      8.164E 01    DRYGAS   6.104E 03    MISTFA   4.600E-01
H2       4.212E 02    OTHER    2.625E 02    UNRETO   0.0
CH4      1.587E 02    O2       0.0          SSY      8.176E 01
CO       2.564E 02    CO2DEC   2.329E 01    MH2O     5.270E 01
CO2      1.410E 03    OILCOL   2.457E 01

B. METERED GAS RATES
RECG     1.259E 04    DIL      0.0          WVENTG   5.731E 03
AIR      4.543E 03    TRECG    1.259E 04    TGF      0.0

C. MOL WT & HEATING VALUE OF VENT GAS
MWWG     2.930E 01    HVGT     8.506E 02    MWDG     3.032E 01
GBTU     1.394E 02

D. COMBUSTION PRODUCTS
CO2C     6.270E 02    COC      2.358E 02    H2OC     2.021E 01
CHR      1.206E 01    COMBCP   1.033E 01

E. MATERIAL IN
ORGCIN   2.647E 02    RSR      3.948E 02    ORH2IN   3.544E 01
MATIN    2.370E 03

F. MATERIAL OUT
ORGCVG   5.398E 01    COKEC    3.713E 01    UNRETH   0.0
ORGCOL   1.609E 02    ORH2VG   9.344E 00    COKEH    1.864E 00
UNRETC   0.0          ORH2OL   2.124E 01    ORCOLP   6.080E 01
ORCVGP   2.039E 01    ORCSSP   1.403E 01    HCCVGP   1.006E 01

G. MATERIAL BALANCES
OVALL    9.961E 01    ORH2     9.157E 01    O2BAL    9.960E 01
ASH      0.0          TC       9.753E 01    WATER    9.438E 01
ORGC     9.522E 01    TH2      9.386E 01    GASL     9.254E 02
ASHB    -1.000E 00

H. HEAT IN
QCOMB    4.260E 05    QH2OC    1.055E 04    QAIR     2.760E 03
QPROP    3.112E 01    QOILC    1.340E 04    QRCYL    4.993E 04
QSUMIN   5.026E 05

I. HEAT OUT
QMCO2D   1.343E 05    QKEROD   1.096E 05    QH2OV    3.905E 04
QLIQO    3.690E 03    QOFGAS   2.076E 04    QSS      1.616E 05
QGASL    8.872E 03    LBLOSS   0.0          HETLOS   2.473E 04
QSUMOT   5.026E 05

J. MISCELLANEOUS
ORCSS    2.271E 00    VPOIL    1.767E-01    TGL      3.616E 03
VPM      4.307E 00    WCG      8.306E 00    PROP     2.018E 01

END MESSAGE


SYSTEM CLOSING


-GOODBYE
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# HEAT AND MATERIAL BALANCE FOR PILOT RETORTS – DATA SHEET

| LINE # | PROGRAM ID | USER IDENTIFICATION | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 2080, | C1048-3 | | | 6/29/67 | | | |
| | WRS | OLRS | TRS | B | MRS | | | |
| 1 | 0.8 | 11.3 | 88 | -1 | 21799.9 | | | RAW SHALE |
| | FA | GRS | CORS | XA | | | | |
| 2 | 30.1 | 2.4 | 17.8 | 55.22 | | | | |
| | ASRS | CRS | HRS | BP | TOG | | | |
| 3 | 66.8 | 18.0 | 1.84 | 24.90 | 140 | | | |
| | CRA | MFA | TA | PA | WA | LBHL | | AIR |
| 4 | 826.0 | 1.0 | 121 | 124 | 0.14 | 0 | | |
| | CRRG | MFRG | TRG | PRG | CRTG | MFTG | | RECYCLE A TOTAL GAS |
| 5 | 2299.4 | 1.0 | 271 | 67 | 0.0 | 0.0 | | |
| | CRDG | MFDG | TDG | PDG | | | | DILUTION G |
| 6 | 0.0 | 0.0 | 0 | 0 | | | | |
| | P | TP | PP | W | N | | | PROPANE A NUCLEATIN AGENT |
| 7 | 4.22 | 0.4 | 128.2 | 206.9 | 0.0 | | | |
| | WSS | OLSS | GSS | SS | | | | SPENT SHALE |
| 8 | 0.5 | 0.0 | 0.0 | 0.0 | | | | |
| | COSS | ASSS | CSS | HSS | TSS | | | |
| 9 | 16.7 | 81.7 | 6.83 | 0.17 | 513 | | | |
| | OILLP | COL | HOL | DOL | WLP | | | LIQUID PRODUCT |
| 10 | 2086.0 | 84.1 | 11.1 | 7.788 | 198.7 | | | |
| | CRVG | MFVG | TVG | WG | OILM | M | | VENT GAS |
| 11 | 1073.4 | 1.0 | 259 | 0.0 | 0.0 | 0 | | |
| | CG | H | COOG | OG | NG | | | |
| 12 | 12.4 | 0 | 23.1 | 0.0 | 58.9 | | | |
| | MEG | COG | HHG | OTG | HG | | | |
| 13 | 2.6 | 4.2 | 6.9 | 4.3 | 1.14 | | | |
| | CRVP | VPMF | TVP | PVP | | | | VENT PURGE |
| 14 | 2.9 | 2.2 | 165 | 32 | | | | |
| | TVPC | VPOIL | VPW | GL | | | | |
| 15 | 77 | 58.4 | 1.8 | 50.5 | | | | |

*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 6-30-67 Run No. C1048-3

Sample Time: RS 0615 ; SS _____

| FISCHER ASSAY | RAW SHALE | SPENT SHALE | |
|---|---|---|---|
| | ~~24.8~~ 25.8 | 0.0 | Gal/Ton |
| | 0.910 | — | S.G., g/ml |
| | 11.3 | 0.0 | Oil, wt % |
| | ~~1.7~~ 1.7 | 0.5 | Water, wt % |
| | ~~85.3~~ 84.6 | 99.3 | Sp. Shale, wt % |
| | 3.4 | 0.2 | Gas & Loss, wt % |
| | slight | none | COKING TENDENCY |

RETORT SHALE MOISTURE: 0.95 wt %

RAW SHALE FISCHER ASSAY MOISTURE: 0.74 wt %

| | RAW SHALE | SPENT SHALE | |
|---|---|---|---|
| MINERAL $CO_2$ | 17.7 | 16.7 | wt % |
| ASH (SHALE) | 66.3 | ~~6.16~~ 81.7 | wt % |
| MOISTURE | 0.33 | 0.10 | wt % |
| CARBON | 17.9 | 6.83 | wt % |
| HYDROGEN | 1.83 | 0.17 | 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 $CO_2$", "Carbon", and "Hydrogen". The "FA Moisture" is for the sample used for the Fischer Assay.

COMMENTS _____

DATE COMPLETED JUL 3 1967 CHECKED BY _____

OSRC-12A
Revised 6/20/66

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 6-30-67 Run No. C1048-3

## LIQUID PRODUCTS

| | D3 PUMPOUT | | | | T3 PUMPOUT | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 |
| WATER, wt % | 6.3 | | | | | |
| GRAVITY, °API | 19.8 | | | | | |
| OIL ASH, wt % | | | | | | |

○ DISTILLATION (See attached sheet - OSRC-24)

## VENT PURGE PRODUCT

OIL WT, g 701.0

WATER VOL, ml 14.0

GRAVITY OIL, °API 42.4

## VENT GAS

⊗ MAJOR COMPONENTS

| | | |
|---|---|---|
| $CO_2$ | 23.1 | vol % |
| $O_2$ | 0.0 | " |
| $N_2$ | 58.2 | " |
| $CH_4$ | 7.6 | " |
| CO | 4.2 | " |
| $H_2$ | 6.9 | " |
| Ar | 0.7 | " |
| Others | 1.3 | " |

⊗ CARBON, 12.4 lbs/MSCFDG

○ $C_1$ 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 $C_4H_{10}$ | . | " |
| $\emptyset C_3H_6$ | . | " |
| n $C_5H_{12}$ | . | " |

⊗ HYDROGEN, 1.14 lbs/MSCFDG

COMMENTS

DATE COMPLETED JUL 3 1967 CHECKED BY

# SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C 1048 -P 4 SAMPLE NO. 4 DATE 6-20-62

UNIT RETORT #3 DESCRIPTION TYLER

APPROX. SHALE SIZE 3/4 - 1/4 SHAKING TIME 10 MIN ANALYSIS BY

TOTAL SAMPLE WT. GROSS 69.2 - TARE 7.3 = NET 61.9

| SCREEN SIZE | | | WEIGHTS | | |
|---|---|---|---|---|---|
| SCREENS REQD. | OPENING SIZE | MESH | GROSS LBS. | TARE LBS. | NET WT. RETAINED |
| | 4.25 | | | | |
| | 3.00 | | | | |
| | 2.50 | | 17.9 | 16.7 | 1.2 |
| | 2.00 | | 31.4 | 20.2 | 11.2 |
| | 1.50 | | 40.8 | 23.5 | 17.3 |
| | 1.05 | | 31.2 | 19.2 | 12.0 |
| | 0.742 | | 28.1 | 20.4 | 7.7 |
| | 0.525 | | 23.9 | 18.5 | 5.4 |
| | 0.371 | | 22.2 | 19.2 | 3.0 |
| | 0.263 | 3 | 21.2 | 18.4 | 2.8 |
| | 0.185 | 4 | 19.0 | 18.6 | .4 |
| | 0.131 | 6 | 19.6 | 19.4 | .2 |
| | 0.093 | 8 | 20.6 | 20.6 | .0 |
| | 0.065 | 10 | 19.3 | 19.2 | .1 |
| | PAN | | 21.6 | 21.0 | .6 |
| TOTAL ON SCREENS AND PAN | | | | | 61.9 |
| LOSS (BY DIFFERENCE) | | | | | |
| TOTAL SAMPLE WEIGHT | | | | | |

| SCREEN SIZE | Di * | 1/Di | % RETAINED | CUM. % RETAINED | % PASSING |
|---|---|---|---|---|---|
| 4.25 | | | | | |
| 3.00 | (3.125) | (0.3200) | | | |
| 2.50 | (2.625) 2.750 | (0.3809) 0.3636 | 1.94 | | 98.06 |
| 2.00 | 2.250 | 0.4444 | 18.09 | | 79.97 |
| 1.50 | 1.750 | 0.5714 | 27.95 | | 52.02 |
| 1.05 | (1.087) 1.275 | (0.9199) 0.7843 | 19.39 | | 32.63 |
| 0.742 | 0.896 | 1.116 | 12.44 | | 20.19 |
| 0.525 | 0.634 | 1.577 | 8.72 | | 11.47 |
| 0.371 | 0.448 | 2.232 | 4.85 | | 6.62 |
| 0.263 | 0.317 | 3.154 | 4.52 | | 2.10 |
| 0.185 | 0.224 | 4.464 | 0.65 | | 1.45 |
| 0.131 | 0.158 | 6.329 | 0.32 | | 1.13 |
| 0.093 | 0.112 | 8.928 | 0 | 98.87 | 1.13 |
| 0.065 | | | 0.16 | | 0.97 |
| PAN | | | 0.97 | | 0 |
| LOSS | | | | | |
| TOTAL | | | | | |

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

| | | | |
|---|---|---|---|
| $\sum_{+8m}^{m} Di$ | | $\sum_{+8m}^{m} Xi$ | |
| $1/\sum_{+8m}^{m} Di$ | | $\sum_{+8m}^{m} Xi / Di$ | 097599 |
| Da | 1.01302 | $\sum_{+8m}^{m} Xi\ Di$ | 1.40149 |
| Dv | 1.41750 | | |

REMARKS:

OSRC-4