

1518  
1575015009

GAS COMBUSTION RETORTING  
DETAILED RUN SUMMARY SHEET

Date 5-19-67

Purpose: *To study operability and yields with 1/2-1 inch shale using own type A/B  
to recycle dilution gas and B. of Honey type 55 chloro system.*

| GENERAL                       |                |
|-------------------------------|----------------|
| Run No.                       | R-1<br>C1037-3 |
| Length, hours                 | 12             |
| Retort Type Number            | RC-VII         |
| Oil Recovery System Number    | C-1            |
| Total Raw Shale Charged, lbs. | 95.43          |
| Bed Height above Dist., ft    | 5 1/2'         |
| Type Air Dist.                | A B-X          |
| Bed Below Air Dist., ft       | 6'             |

| SPENT SHALE PROPERTIES         |      |
|--------------------------------|------|
| Fischer Assay, Gal/ton         | 0.4  |
| Mineral CO <sub>2</sub> , Wt % | 14.0 |
| Ash, Wt %                      | 84.4 |
| Carbon (total), Wt %           | 5.95 |
| Organic Carbon, Wt %           | 2.13 |
| Hydrogen (total), Wt %         | 0.17 |

| LIQUID PRODUCT PROPERTIES |       |
|---------------------------|-------|
| Oil, Wt %                 | 99.2  |
| Density, lb/gal           | 7.762 |
| Gravity, API              | 20.3  |
| Ash, Wt %                 | -     |

| RATES AND QUANTITIES                  |        |
|---------------------------------------|--------|
| Raw Shale, lbs/(hr)(ft <sup>2</sup> ) | 288    |
| Spent Shale, % of RS                  | 80.8   |
| Liquid Product, lbs/hr                | 1622.3 |
| Oil Collected, gal/ton RS             | 22.9   |
| Air, SCF/ton RS (dry)                 | 5780   |
| Total Recycle*, SCF/ton RS (wet)      | 13500  |
| Dilution, SCF/ton RS (wet)            | 2420   |
| Calc. Vent Gas SCF/ton RS (dry)       | 7030   |
| Gas Losses, SCF/ton RS (wet)          | 621    |
| Propane, SCF/ton RS                   | 25.0   |

| PRODUCT GAS PROPERTIES        |       |
|-------------------------------|-------|
| Water Vapor, lbs/MSCF (dry)   | 8.2   |
| Oil, lbs/MSCF (dry)**         | 0.057 |
| Analysis (dry)                |       |
| CO <sub>2</sub> , Vol %       | 25.0  |
| O <sub>2</sub> , Vol %        | 0.8   |
| N <sub>2</sub> + Argon, Vol % | 65.0  |
| CH <sub>4</sub> , Vol %       | 1.6   |
| CO, Vol %                     | 2.5   |
| H <sub>2</sub> , Vol %        | 4.6   |
| Other, Vol %                  | 0.5   |

| TEMPERATURES AND HEAT BALANCE |     |
|-------------------------------|-----|
| Retort Offgas, °F             | 136 |
| Spent Shale, F                | 809 |
| Raw Shale, °F                 | 68  |
| Recycle Gas Inlet, °F         | 250 |
| Dilution Gas Inlet, °F        | 250 |
| Air Inlet, °F                 | 136 |
| Retort Air Inlet, F           | 136 |
| Heat of Comb. MBtu/ton RS     | 542 |
| Heat Lost, MBtu/ton RS        | -50 |

|                                     |      |
|-------------------------------------|------|
| Gross Heating Value (calc), Btu/SCF | 78.8 |
| Carbon (Total), lbs/MSCF (dry)      | 11.1 |
| Hydrogen (Total), lbs/MSCF (dry)    | 0.59 |

| RAW SHALE PROPERTIES           |           |
|--------------------------------|-----------|
| Fischer Assay, gal/ton RS      | 27.3      |
| Oil, Wt %                      | 10.4      |
| Water, Wt %                    | 1.2       |
| Gas, Wt %                      | 2.1       |
| Mineral CO <sub>2</sub> , Wt % | 17.1      |
| Ash, Wt %                      | 68.2      |
| Moisture, Wt % (Uncrushed)     | 0.66      |
| Carbon (Total), Wt %           | 16.5      |
| Hydrogen (Total), Wt %         | 1.76      |
| Nominal Size Range, inches     | 1/4" - 1" |
| 5 % passing thru               | 0.263     |
| 98 % passing thru              | 1.05      |
| D <sub>a</sub>                 | 0.615     |
| D <sub>v</sub>                 | 0.735     |
| Line burner °F                 | 900       |

| YIELDS AND BALANCES            |        |
|--------------------------------|--------|
| Oil Collected, Vol % RSFA      | 83.9   |
| Oil in Gas**, Vol % RSFA       | 0.2    |
| Oil in Spent Shale, Vol % RSFA | 0.8    |
| Total Oil Meas., Vol % RSFA    | 84.9   |
| Carbonate Decomposition, %     | 33.8   |
| Water Recovered, lb/ton RS     | 105.5  |
| Ash Balance, % - As Measured   | -      |
| Ash Balance, % - Assumed       | RS 100 |
| Overall Balance, %             | 100.2  |
| Carbon Balance, % - Organic    | 96.5   |
| Carbon Balance, % - Total      | 98.9   |
| Hydrogen Balance, % - Organic  | 90.2   |
| Hydrogen Balance, % - Total    | 102.7  |
| Water Balance, %               | 142.4  |

| MISCELLANEOUS                              |      |
|--|------|
| Avg. Retort ΔP, in H <sub>2</sub> O/ft     | 0.46 |
| ΔP Above Air Dist., in H <sub>2</sub> O/ft | 0.44 |
| NaCl Soln., Wt %                           | -    |
| NaCl Rate, gal/ton RS                      | -    |

Comments: *Operation good*

\*Measured Recycle + Dilution Gas  
 \*\* Oil Mist + Condensibles to 80 °F  
 \*\*\* Rates are for moisture-free raw shale. All shale analyses are on a moisture-free basis.

Signed *Carl E. Turner*

DATE *June 8, 1967*

END OUTPUT

END MESSAGE

| Code                                  | Description | Value  | Code      | Description | Value      |
|---------------------------------------|-------------|--------|-----------|-------------|------------|
| A. YIELDS                             |             |        |           |             |            |
| FAY                                   | 2.386E 01   | DEYAS  | 7.032E 03 | MISFA       | 1.879E-01  |
| H2                                    | 3.235E 02   | CH2F   | 3.516E 01 | UNPFI0      | 7.770E-01  |
| CH4                                   | 1.125E 02   | OS     | 5.626E 01 | SSY         | 8.081E 01  |
| CO                                    | 1.758E 02   | CO2D3C | 3.324E 01 | WHS0        | 1.055E 02  |
| CO2                                   | 1.758E 02   | CLTOP  | 2.290E 01 |             |            |
| B. REFERED GAS RATES                  |             |        |           |             |            |
| REOG                                  | 1.111E 04   | DIL    | 2.416E 03 | WENTIG      | 7.617E 03  |
| AIR                                   | 5.777E 03   | TR0G   | 1.355E 04 | TGF         | 0.0        |
| C. MOL WT & HEATING VALUE OF VENT GAS |             |        |           |             |            |
| WVAG                                  | 2.527E 01   | WVGT   | 5.544E 02 | WVDS        | 3.073E 01  |
| GAJU                                  | 7.884E 01   |        |           |             |            |
| D. COMBUSTION PRODUCTS                |             |        |           |             |            |
| CO2C                                  | 7.031E 02   | COG    | 1.563E 02 | W2CC        | 3.601E 01  |
| CH2                                   | 6.758E 00   | CONCP  | 1.143E 01 |             |            |
| E. MATERIAL IN                        |             |        |           |             |            |
| ORGAIN                                | 2.392E 02   | RSR    | 2.830E 02 | OSHMIM      | 3.305E 01  |
| MALIN                                 | 2.459E 03   |        |           |             |            |
| F. MATERIAL OUT                       |             |        |           |             |            |
| CRGVA                                 | 4.682E 01   | COKEC  | 3.303E 01 | UNRBTN      | 1.773E-01  |
| ORGCOL                                | 1.495E 02   | ORHVA  | 2.229E 00 | COXRN       | 1.845E 00  |
| UNRBTN                                | 1.359E 00   | ORHOL  | 1.955E 01 | CRCOLP      | 6.253E 01  |
| ORGVA                                 | 1.992E 01   | ORSSP  | 1.439E 01 | HCOVCP      | 2.163E 00  |
| G. MATERIAL BALANCE                   |             |        |           |             |            |
| OVALL                                 | 1.022E 02   | ORH2   | 9.013E 01 | CEVAL       | 1.073E 02  |
| ASH                                   | 0.0         | TC     | 9.892E 01 | WATER       | 1.424E 02  |
| ORGC                                  | 9.651E 01   | TRG    | 1.027E 02 | GASL        | 6.211E 02  |
| ASHB                                  | -1.000E 00  |        |           |             |            |
| H. HEAT IN                            |             |        |           |             |            |
| GCORP                                 | 5.417E 05   | CHCC   | 2.339E 03 | GAIR        | 7.622E 03  |
| ORPRP                                 | 7.222E 01   | QOLC   | 1.244E 04 | ORCYL       | 5.032E 04  |
| GSURIN                                | 5.201E 05   |        |           |             |            |
| I. HEAT OUT                           |             |        |           |             |            |
| ORCO2D                                | 1.675E 05   | OREROD | 9.255E 04 | ORHGV       | 4.385E 04  |
| ELICG                                 | 4.391E 03   | COFGAS | 3.030E 04 | SSS         | 2.944E 05  |
| ORGASL                                | 9.796E 03   | TRLOSS | 0.0       | HEHLOS      | -4.957E 04 |
| OSURVOT                               | 5.201E 05   |        |           |             |            |
| J. MISCELLANEOUS                      |             |        |           |             |            |
| OROS                                  | 2.123E 00   | VPOL   | 5.622E-02 | TOL         | 3.045E 03  |
| VBN                                   | 2.156E 00   | W00    | 1.464E 01 | OROP        | 2.503E 01  |

62.5  
14.6  
10  
10  
10

# HEAT AND MATERIAL BALANCE FOR PILOT RETORTS - DATA SHEET

| LINE # | PROGRAM ID                          | ← USER IDENTIFICATION → |              |              |                |                   |                                    |
|--------|-------------------------------------|-------------------------|--------------|--------------|----------------|-------------------|------------------------------------|
| 0      | 2080,                               | C1037-3 R-1 5-19-67     |              |              |                |                   |                                    |
| 1      | WRS<br>1.2                          | OLRS<br>10.4            | TRS<br>68    | B<br>-1      | MRS<br>15905.5 | ←<br>RAW<br>SHALE |                                    |
| 2      | FA<br>27.3                          | GRS<br>2.1              | CORS<br>17.1 | XA<br>55.22  |                |                   |                                    |
| 3      | ASRS<br>68.2                        | CRS<br>16.5             | HRS<br>1.76  | BP<br>24.5.1 | TOG<br>136     |                   |                                    |
| 4      | CRA<br>764.5                        | MFA<br>1.0              | TA<br>136    | PA<br>117    | WA<br>0.14     | LBHL<br>0         | ← AIR                              |
| 5      | CRRG<br>1466.2                      | MFRG<br>1.0             | TRG<br>250   | PRG<br>72    | CRTG<br>0.0    | MFTG<br>0.0       | ← RECYCLE A<br>TOTAL GAS           |
| 6      | CRDG<br>3.0<br><small>229.5</small> | MFDG<br>129.5           | TDG<br>250   | PDG<br>71    |                |                   | ← DILUTION G                       |
| 7      | P<br>3.82                           | TP<br>0.4               | PP<br>126.7  | W<br>105.7   | N<br>0.0       |                   | ← PROPANE A<br>NUCLEATING<br>AGENT |
| 8      | WSS<br>0.4                          | OLSS<br>0.1             | GSS<br>0.0   | SS<br>0.0    |                |                   | ←<br>SPENT<br>SHALE                |
| 9      | COSS<br>14.0                        | ASSS<br>84.4            | CSS<br>5.95  | HSS<br>0.17  | TSS<br>809     |                   |                                    |
| 10     | OILLP<br>1413.2                     | COL<br>84.1             | HOL<br>11.0  | DOL<br>7.762 | WLP<br>208.9   |                   | ← LIQUID<br>PRODUCT                |
| 11     | CRVG<br>1374.3                      | MFVG<br>1.0             | TVG<br>250   | WG<br>0.0    | OILM<br>0.0    | M<br>0            | ←<br>VENT<br>GAS                   |
| 12     | CG<br>11.1                          | H<br>0                  | COG<br>25.0  | OG<br>0.8    | NG<br>65.0     |                   |                                    |
| 13     | MEG<br>1.6                          | COG<br>2.5              | HHG<br>4.6   | OTG<br>0.5   | HG<br>0.59     |                   |                                    |
| 14     | CRVP<br>0.7                         | VPMF<br>1.83            | TVP<br>122   | PVP<br>71    |                |                   | ←<br>VENT<br>PURGE                 |
| 15     | TVPC<br>80                          | VPOIL<br>8.3            | VPW<br>2.0   | GL<br>15.5   |                |                   |                                    |

**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 5-20-67

Run No. C 1037-3

Sample Time: RS none; SS \_\_\_\_\_

FISCHER ASSAY

RAW SHALE  SPENT SHALE

7.7

0.35

Gal/Ton

.907

—

S.G., g/ml

10.4

0.1

Oil, wt %

1.6

0.4

Water, wt %

86.0

89.5

Sp. Shale, wt %

2.1

0.0

Gas & Loss, wt %

—

none

COKING TENDENCY

MINERAL CO<sub>2</sub>

17.1  14.0

wt %

ASH (SHALE)

68.0  34.4

wt %

MOISTURE

0.23  0.06

wt %

CARBON

16.5  5.95

wt %

HYDROGEN

1.76  0.17

wt %

BENZENE EXTRACTABLES

—  —

wt %

RETORT SHALE MOISTURE

0.66 wt %

RAW SHALE FISCHER ASSAY MOISTURE

~~0.43~~ wt %  
0.43

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<sub>2</sub>", "Carbon", and "Hydrogen". The "FA Moisture" is for the sample used for the Fischer Assay.

COMMENTS \_\_\_\_\_

DATE COMPLETED MAY 25 1967

CHECKED BY REP

LABORATORY ANALYSIS SHEET

ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 5-20-67

Run No. C 1037-3

LIQUID PRODUCTS

D3 PUMPOUT

T3 PUMPOUT

*JA*

|               | <u>1</u>    | <u>2</u> | <u>3</u> | <u>4</u> | <u>1</u> | <u>2</u> |
|---------------|-------------|----------|----------|----------|----------|----------|
| WATER, wt %   | <u>0.8</u>  |          |          |          |          |          |
| GRAVITY, °API | <u>20.3</u> |          |          |          |          |          |

OIL ASH, wt %

DISTILLATION (See attached sheet - OSRC-24)

VENT PURGE PRODUCT

*JA*

OIL WT, g 100  
 WATER VOL, ml 11  
 GRAVITY OIL, °API 43.7

VENT GAS

*JA*

MAJOR COMPONENTS

CO<sub>2</sub> 25.0 vol %  
 O<sub>2</sub> 0.8 "  
 N<sub>2</sub> 64.2 "  
 CH<sub>4</sub> 1.6 "  
 CO 2.5 "  
 H<sub>2</sub> 4.6 "  
 Ar 0.3 "  
 Others 0.5 "

C<sub>1</sub> thru C<sub>4</sub>, plus n-Pentane

CH<sub>4</sub> \_\_\_\_\_ vol %  
 C<sub>2</sub>H<sub>4</sub>-C<sub>2</sub>H<sub>6</sub> \_\_\_\_\_ "  
 C<sub>3</sub>H<sub>8</sub> \_\_\_\_\_ "  
 C<sub>3</sub>H<sub>6</sub> \_\_\_\_\_ "  
 i C<sub>4</sub>H<sub>10</sub> \_\_\_\_\_ "  
 n C<sub>4</sub>H<sub>10</sub> \_\_\_\_\_ "  
 C<sub>3</sub>H<sub>6</sub> \_\_\_\_\_ "  
 n C<sub>5</sub>H<sub>12</sub> \_\_\_\_\_ "

*JA*

CARBON, 11.1 lbs/MSCFDG

*JA*

HYDROGEN, 0.59 lbs/MSCFDG

COMMENTS \_\_\_\_\_

DATE COMPLETED MAY 22 1967

CHECKED BY REP

OSRC-12B

# SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C/1037-3 SAMPLE NO. 5-20-67  
 UNIT 23 DESCRIPTION R.R. shale  
 APPROX. SHALE SIZE 1/4" - 1" SHAKING TIME 10 min ANALYSIS BY Smith  
 TOTAL SAMPLE WT. GROSS 124.6 - TARE 18.2 = NET 106.4

| SCREEN SIZE              |              | WEIGHTS |            |           | Di *             | 1/Di               | % RETAINED | CUM. % RETAINED | % PASSING |
|--------------------------|--------------|---------|------------|-----------|------------------|--------------------|------------|-----------------|-----------|
| SCREENS REQD.            | OPENING SIZE | MESH    | GROSS LBS. | TARE LBS. |                  |                    |            |                 |           |
|                          | 4.25         |         |            |           |                  |                    |            |                 |           |
|                          | 3.00         |         |            |           | (3.125)          | (0.3200)           |            |                 |           |
|                          | 2.50         |         |            |           | (2.625)<br>2.750 | (0.3809)<br>0.3636 |            |                 |           |
|                          | 2.00         |         |            |           | 2.250            | 0.4444             |            |                 |           |
|                          | 1.50         |         |            |           | 1.750            | 0.5714             |            |                 |           |
|                          | 1.05         |         | 32.2       | 19.2      | (1.087)<br>1.275 | (0.9199)<br>0.7843 | 12.24      |                 | 87.77     |
|                          | 0.742        |         | 62.3       | 20.5      | 0.896            | 1.116              | 39.27      |                 | 48.50     |
|                          | 0.525        |         | 42.7       | 18.5      | 0.634            | 1.577              | 22.79      |                 | 25.71     |
|                          | 0.371        |         | 30.0       | 19.2      | 0.448            | 2.232              | 10.08      |                 | 15.63     |
|                          | 0.263        | 3       | 28.1       | 18.3      | 0.317            | 3.154              | 8.23       |                 | 6.40      |
|                          | 0.185        | 4       | 23.1       | 19.4      | 0.224            | 4.464              | 2.54       |                 | 3.86      |
|                          | 0.131        | 6       | 19.7       | 19.3      | 0.158            | 6.329              | 0.38       |                 | 3.48      |
|                          | 0.093        | 8       | 20.6       | 20.5      | 0.112            | 8.928              | 0.09       | 96.62           | 3.39      |
|                          | 0.065        | 10      | 19.4       | 19.2      |                  |                    | 0.19       |                 | 3.20      |
|                          | PAN          |         | 24.3       | 7.0       |                  |                    | 3.20       |                 | 0.00      |
| TOTAL ON SCREENS AND PAN |              |         |            |           |                  |                    |            |                 |           |
| LOSS (BY DIFFERENCE)     |              |         |            |           |                  |                    |            |                 |           |
| TOTAL SAMPLE WEIGHT      |              |         |            |           |                  |                    |            |                 |           |
|                          |              |         |            |           |                  |                    |            |                 |           |

|                          |         |                        |  |
|--------------------------|---------|------------------------|--|
| $\sum_{+8m}^m Di$        | 0.71020 | $\sum_{+8m}^m Xi$      |  |
| $\sqrt{\sum_{+8m}^m Di}$ | 1.57182 | $\sum_{+8m}^m Xi / Di$ |  |
| Da                       | 061470  | $\sum_{+8m}^m Xi Di$   |  |
| Dv                       | 0.73504 |                        |  |

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

# SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. C 1037-3 SAMPLE NO. COV # 8 DATE 5-20-67  
 UNIT Report DESCRIPTION TY Lab  
 APPROX. SHALE SIZE 1/4 - 1/8 SHAKING TIME 10 min ANALYSIS BY Smith & Anderson  
 TOTAL SAMPLE WT. GROSS 40 TARE 3.3 = NET 36.7

| SCREEN SIZE              |              | WEIGHTS |            |           | SCREEN SIZE      | Di *               | 1/Di | % RETAINED | CUM. % RETAINED | % PASSING |
|--------------------------|--------------|---------|------------|-----------|------------------|--------------------|------|------------|-----------------|-----------|
| SCREENS REQD.            | OPENING SIZE | MESH    | GROSS LBS. | TARE LBS. |                  |                    |      |            |                 |           |
|                          | 4.25         |         |            |           |                  |                    |      |            |                 |           |
|                          | 3.00         |         |            |           | (3.125)          | (0.3200)           |      |            |                 |           |
|                          | 2.50         |         |            |           | (2.625)<br>2.750 | (0.3809)<br>0.3636 |      |            |                 |           |
|                          | 2.00         |         |            |           | 2.250            | 0.4444             |      |            |                 |           |
|                          | 1.50         |         |            |           | 1.750            | 0.5714             |      |            |                 |           |
|                          | 1.05         |         | 22.8       | 19.2      | (1.087)<br>1.275 | (0.9199)<br>0.7843 |      |            |                 |           |
|                          | 0.742        |         | 36.3       | 20.3      | 0.896            | 1.116              |      |            |                 |           |
|                          | 0.525        |         | 28.0       | 19.8      | 0.634            | 1.577              |      |            |                 |           |
|                          | 0.371        |         | 22.6       | 19.3      | 0.448            | 2.232              |      |            |                 |           |
|                          | 0.263        | 3       | 20.9       | 18.3      | 0.317            | 3.154              |      |            |                 |           |
|                          | 0.185        | 4       | 20.1       | 19.4      | 0.224            | 4.464              |      |            |                 |           |
|                          | 0.131        | 6       | 19.5       | 19.4      | 0.158            | 6.329              |      |            |                 |           |
|                          | 0.093        | 8       | 20.7       | 20.6      | 0.112            | 8.928              |      |            |                 |           |
|                          | 0.065        | 10      | 19.2       | 19.2      |                  |                    |      |            |                 |           |
|                          | PAN          |         | 3.5        | 20.9      |                  |                    |      |            |                 |           |
| TOTAL ON SCREENS AND PAN |              |         |            |           |                  |                    |      |            |                 |           |
| LOSS (BY DIFFERENCE)     |              |         |            |           | 36.5             |                    |      |            |                 |           |
| TOTAL SAMPLE WEIGHT      |              |         |            |           | 36.7             |                    |      |            |                 |           |

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

REMARKS:

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