

GAS COMBUSTION RETORTING
DETAILED RUN SUMMARY SHEET

T. L. H. Bolome
1513017004

Date 5-31-67

Purpose: To determine operability and yield with hot dilution gas using 1/4"-1" shale, - Mobil Task Force recommendations.

| GENERAL | | SPENT SHALE PROPERTIES | |
|---------------------------------------|----------|--|--------|
| Run No. | C1040-1 | Fischer Assay, Gal/ton | 1.7 |
| Length, hours | 12 | Mineral CO ₂ , Wt % | 14.7 |
| Retort Type Number | RC-III | Ash, Wt % | 83.0 |
| Oil Recovery System Number | C-1 | Carbon (total), Wt % | 6.62 |
| Total Raw Shale Charged, lbs. | 98.12 | Organic Carbon, Wt % | 2.61 |
| Bed Height above Dist., ft | 5 1/2 | Hydrogen (total), Wt % | 0.22 |
| Type Air Dist. | A11-X | LIQUID PRODUCT PROPERTIES | |
| Bed Below Air Dist., ft | 0' | Oil, Wt % | 99.6 |
| RATES AND QUANTITIES | | Density, lb/gal | 7.768 |
| Raw Shale, lbs/(hr)(ft ²) | 296 | Gravity, API | 20.2 |
| Spent Shale, % of RS | 82.9 | Ash, Wt % | - |
| Liquid Product, lbs/hr | 1569.7 | PRODUCT GAS PROPERTIES | |
| Oil Collected, gal/ton RS | 21.9 | Water Vapor, lbs/MSCF(dry) | 8.1 |
| Air, SCF/ton RS (dry) | 5250 | Oil, lbs/MSCF(dry)** | 0.091 |
| Total Recycle*, SCF/ton RS(wet) | 14100 | Analysis (dry) | |
| Dilution, SCF/ton RS (wet) | 2740 | CO ₂ , Vol % | 25.4 |
| Calc. Vent Gas SCF/ton RS(dry) | 6310 | O ₂ , Vol % | 0.9 |
| Gas Losses, SCF/ton RS(wet) | 422 | N ₂ + Argon, Vol % | 65.8 |
| Propane, SCF/ton RS | 9.6 | CH ₄ , Vol % | 1.4 |
| TEMPERATURES AND HEAT BALANCE | | CO, Vol % | 2.3 |
| Retort Offgas, °F | 135 | H ₂ , Vol % | 3.9 |
| Spent Shale, F | 694 | Other, Vol % | 0.3 |
| Raw Shale, °F | 70 | Gross Heating Value(calc), Btu/SCF | 54.1 |
| Recycle Gas Inlet, °F | 250 | Carbon (Total), lbs/MSCF (dry) | 9.84 |
| Dilution Gas Inlet, °F | 250 | Hydrogen (Total), lbs/MSCF (dry) | 0.49 |
| Air Inlet, °F | 137 | YIELDS AND BALANCES | |
| Retort Air Inlet, F | 137 | Oil Collected, Vol % RSFA | 86.6 |
| Heat of Comb. MBtu/ton RS | 492 | Oil in Gas**, Vol % RSFA | 0.3 |
| Heat Lost, MBtu/ton RS | -21 | Oil in Spent Shale, Vol % RSFA | 5.0 |
| RAW SHALE PROPERTIES | | Total Oil Meas., Vol % RSFA | 91.9 |
| Fischer Assay, gal/ton RS | 25.3 | Carbonate Decomposition, % | 30.4 |
| Oil, Wt % | 10.0 | Water Recovered, lb/ton RS | 103.0 |
| Water, Wt % | 1.0 | Ash Balance, % - As Measured | - |
| Gas, Wt % | 2.0 | Ash Balance, % - Assumed | RS-100 |
| Mineral CO ₂ , Wt % | 17.5 | Overall Balance, % | 100.5 |
| Ash, Wt % | 68.8 | Carbon Balance, % - Organic | 98.4 |
| Moisture, Wt % (Uncrushed) | 1.0 Est. | Carbon Balance, % - Total | 99.5 |
| Carbon (Total), Wt % | 15.9 | Hydrogen Balance, % - Organic | 91.5 |
| Hydrogen (Total), Wt % | 1.64 | Hydrogen Balance, % - Total | 105.3 |
| Nominal Size Range, inches | 1/4"-1" | Water Balance, % | 138.5 |
| 5 % passing thru | 0.263 | MISCELLANEOUS | |
| 98 % passing thru | 1.05 | Avg. Retort ΔP, in H ₂ O/ft | 0.42 |
| D _a | 0.637 | ΔP Above Air Dist., in H ₂ O/ft | 0.36 |
| D _v | 0.758 | NaCl Soln., Wt % | - |
| Line Burner °F | 800 | NaCl Rate, gal/ton RS | - |

Comments: Difficult run with large oil-water separator and RS samples. otherwise run looks good.

*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 June 20, 1967

86/9/6

//A100

2080, C1040-1 5-31-67

A. YIELDS

| | | | | | |
|-----|-----------|--------|-----------|--------|-----------|
| FAY | 8.657E 01 | DRYGAS | 6.303E 03 | MISTFA | 2.924E-01 |
| H2 | 2.460E 02 | OTHER | 1.892E 01 | UNRETC | 4.973E 00 |
| CH4 | 3.831E 01 | O2 | 5.577E 01 | SSY | 3.289E 01 |
| CO | 1.451E 02 | CO2DEC | 3.037E 01 | NH2O | 1.030E 02 |
| CO2 | 1.502E 03 | OILCOL | 2.190E 01 | | |

B. METERED GAS RATES

| | | | | | |
|------|-----------|-------|-----------|-------|-----------|
| RECG | 1.131E 04 | DIL | 2.744E 03 | VENTG | 6.965E 03 |
| AIR | 5.245E 03 | TREGG | 1.405E 04 | TGF | 0.0 |

C. MOL WT & HEATING VALUE OF VENT GAS

| | | | | | |
|------|-----------|------|-----------|------|-----------|
| MMWG | 2.903E 01 | HVGT | 3.412E 02 | MMWG | 3.097E 01 |
| GBTU | 5.409E 01 | | | | |

D. COMBUSTION PRODUCTS

| | | | | | |
|------|-----------|--------|-----------|------|-----------|
| CO2C | 6.324E 02 | COC | 1.283E 02 | H2OC | 3.346E 01 |
| CHR | 6.426E 00 | COXRCF | 1.030E 01 | | |

E. MATERIAL IN

| | | | | | |
|--------|-----------|-----|-----------|--------|-----------|
| ORGCIN | 2.234E 02 | RSR | 2.961E 02 | OPH2IN | 3.076E 01 |
| NATIN | 2.424E 03 | | | | |

F. MATERIAL OUT

| | | | | | |
|--------|-----------|--------|-----------|--------|-----------|
| ORCVG | 3.356E 01 | COKEC | 3.253E 01 | UNRETH | 1.214E 00 |
| ORCCOL | 1.431E 02 | CRHPVC | 6.906E 00 | COXEN | 1.133E 00 |
| UNRETC | 1.059E 01 | OPH2OL | 1.388E 01 | ORCOLP | 6.406E 01 |
| ORCVGP | 1.503E 01 | ORCSSP | 1.935E 01 | HCCVGP | 4.224E 00 |

G. MATERIAL BALANCES

| | | | | | |
|-------|------------|------|-----------|-------|-----------|
| CVALL | 1.005E 02 | ORH2 | 9.146E 01 | ORBAL | 1.069E 02 |
| ASH | 0.0 | TC | 9.946E 01 | WATER | 1.385E 02 |
| ORCC | 9.843E 01 | TH2 | 1.053E 02 | GASL | 4.219E 02 |
| ASHB | -1.000E 00 | | | | |

H. HEAT IN

| | | | | | |
|--------|-----------|-------|-----------|-------|-----------|
| QCOYB | 4.917E 05 | QH2OC | 1.497E 04 | QAIR | 6.465E 03 |
| QPROP | 2.990E 01 | QOILC | 1.191E 04 | QRCYL | 5.154E 04 |
| QSUMIN | 5.757E 05 | | | | |

I. HEAT OUT

| | | | | | |
|--------|-----------|--------|-----------|--------|------------|
| QVCO2D | 1.722E 05 | QXEROD | 2.937E 04 | QH2OV | 4.540E 04 |
| QLIQ | 4.022E 03 | QOFGAS | 2.392E 04 | QSS | 2.520E 05 |
| QGASL | 5.512E 03 | LBLOSS | 0.0 | HETLCS | -2.079E 04 |
| QSUMOT | 5.757E 05 | | | | |

J. MISCELLANEOUS

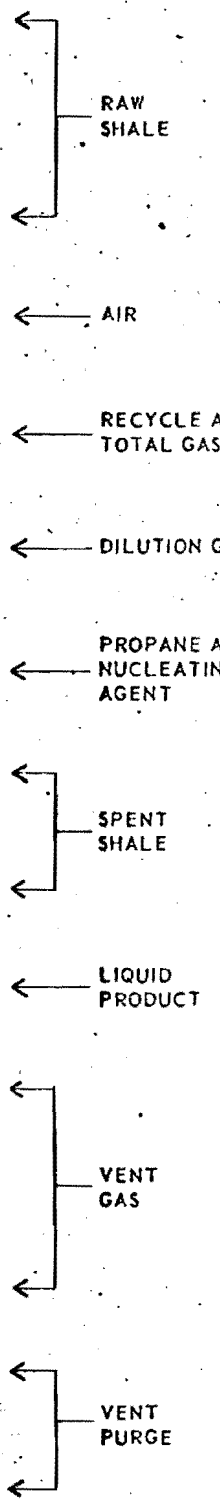
| | | | | | |
|-------|-----------|-------|-----------|------|-----------|
| ORCSS | 2.607E 00 | VPOIL | 9.109E-02 | TGL | 3.112E 03 |
| VPX | 8.130E 00 | WCG | 1.460E 01 | PROP | 2.561E 00 |

END MESSAGE

END OUTPUT

HEAT AND MATERIAL BALANCE FOR PILOT RETORTS - DATA SHEET

| LINE # | PROGRAM ID | ← USER IDENTIFICATION → | | | | |
|--------|------------|-------------------------|-------|---------|---------|------|
| 0 | 2080, | C-1040-1 | | 5-31-67 | | |
| 1 | WRS | OLRS | TRS | B | MRS | |
| | 1.0 | 10.0 | 70 | -1 | 16353.4 | |
| 2 | FA | GRS | CORS | XA | | |
| | 25.3 | 2.0 | 17.5 | 55.22 | | |
| 3 | ASRS | CRS | HRS | BP | TOG | |
| | 68.8 | 15.9 | 1.64 | 24.07 | 135 | |
| 4 | CRA | MFA | TA | PA | WA | LBHL |
| | 720.3 | 1.0 | 137 | 112 | 0.14 | 0 |
| 5 | CRRG | MFRG | TRG | PRG | CRTG | MFTG |
| | 1554.3 | 1.0 | 250 | 73 | 0.0 | 0.0 |
| 6 | CRDG | MFDG | TDG | PDG | | |
| | 3.65 | 129.5 | 250 | 48 | | |
| 7 | P | TP | PP | W | N | |
| | 1.5 | 0.4 | 132.7 | 165.2 | 0.0 | |
| 8 | WSS | OLSS | GSS | SS | | |
| | 0.7 | 0.6 | 0.14 | 0.0 | | |
| 9 | COSS | ASSS | CSS | HSS | TSS | |
| | 14.7 | 83.0 | 6.62 | 0.22 | 694 | |
| 10 | OILLP | COL | HOL | DOL | WLP | |
| | 1391.1 | 84.1 | 11.1 | 7.768 | 178.6 | |
| 11 | CRVG | MFBG | TVG | WG | OILM | M |
| | 1424.3 | 1.0 | 250 | 0.0 | 0.0 | 0 |
| 12 | CG | H | COOG | OG | NG | |
| | 9.84 | 0 | 25.4 | 0.9 | 65.8 | |
| 13 | MEG | COG | HHG | OTG | HG | |
| | 1.4 | 2.3 | 3.9 | 0.3 | 0.49 | |
| 14 | CRVP | VPMF | TVP | PVP | | |
| | 3.8 | 1.83 | 122 | 72 | | |
| 15 | TVPC | VPOIL | VPW | GL | | |
| | 75 | 30.8 | 4.8 | 68.2 | | |



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 Row 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 5-31-67

Run No. C-1040-1

Sample Time: RS ^{Grab} 18:15 SS 1115

RS Grab Sample

FISCHER ASSAY

RETORT SHALE MOISTURE

Est. 1.0 wt %

| RAW SHALE | SPENT SHALE |
|--|-------------|
| <u>25.1</u> AVS <u>25.8</u> ^{20.4} | <u>1.7</u> |
| <u>0.914</u> | <u>—</u> |
| <u>9.9</u> | <u>0.6</u> |
| <u>1.7</u> | <u>0.7</u> |
| <u>66.4</u> | <u>98.3</u> |
| <u>2.0</u> | <u>0.4</u> |
| <u>51.96</u> | <u>NONE</u> |

Gal/Ton FISCHER ASSAY MOISTURE

S.G., g/ml Est 0.68 wt %

Oil, wt %

Water, wt %

Sp. Shale, wt %

Gas & Loss, wt %

COKING TENDENCY

MINERAL CO₂ ^{BKM}

17.4 14.7 wt %

ASH (SHALE)

68.5 ⁶⁵ 83.0 wt %

MOISTURE

0.37 ^{ET} 0.22 wt %

CARBON

15.8 ^{BKM} 6.62 wt %

HYDROGEN

1.63 ^{BKM} 0.22 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 8 1967

CHECKED BY REP

OSRC-12A
(Initiated 4/29/66)

12.6

LABORATORY ANALYSIS SHEET
 ANVIL POINTS OIL SHALE RESEARCH CENTER

Date Sampled 5-31-67

Run No. C 1040-1

LIQUID PRODUCTS

| | D-3 PUMPOUT | | | | T-3 PUMPOUT | |
|---------------|-------------|---|---|---|-------------|---|
| | 1 | 2 | 3 | 4 | 1 | 2 |
| WATER, WT % | <u>0.4</u> | / | / | / | / | / |
| GRAVITY, °API | <u>20.2</u> | / | / | / | / | / |
| OIL ASH, WT % | | | | | | |

DISTILLATION (See attached sheet - OSRC-24)

VENT PURGE PRODUCT

WT OIL, GM 370
 VOL WATER, ML 57
 OIL GRAVITY, °API 40.3

VENT GAS

MAJOR COMPONENTS

| Component | Value | Unit |
|-----------------|-------------|-------|
| CO ₂ | <u>23.4</u> | vol % |
| O ₂ | <u>0.9</u> | " |
| N ₂ | <u>65.0</u> | " |
| CH ₄ | <u>1.4</u> | " |
| CO | <u>2.3</u> | " |
| H ₂ | <u>3.9</u> | " |
| Ar | <u>0.8</u> | " |
| Others | <u>0.3</u> | " |

C₁ thru C₄, plus n-Pentane

| Component | Value | Unit |
|--|----------|-------|
| CH ₄ | <u>.</u> | vol % |
| C ₂ H ₄ -C ₂ H ₆ | <u>.</u> | " |
| C ₃ H ₈ | <u>.</u> | " |
| C ₃ H ₆ | <u>.</u> | " |
| i C ₄ H ₁₀ | <u>.</u> | " |
| n C ₄ H ₁₀ | <u>.</u> | " |
| ∅C ₃ H ₆ | <u>.</u> | " |
| n C ₅ H ₁₂ | <u>.</u> | " |

CARBON, lbs/MSCFDG 9.24

HYDROGEN 0.49

COMMENTS

DATE COMPLETED

JUN 5 1967

CHECKED BY

PPD

OSRC-12B
 (Initiated 1/29/65)

SCREEN ANALYSIS DATA SHEET (TY-LAB)

RUN NO. 5-1048-1 SAMPLE NO. 1 DATE 5-31-67
 UNIT Retort #3 DESCRIPTION TY-Lab
 APPROX. SHALE SIZE 1-1" SHAKING TIME 10 min ANALYSIS BY Smith
 TOTAL SAMPLE WT. GROSS 57.2 - TARE 4.2 = NET 53

| 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 | | | | | 2.50 | (2.625) 2.750 | (0.3809) 0.3636 | | | |
| | 2.00 | | | | | 2.00 | 2.250 | 0.4444 | | | |
| | 1.50 | | | | | 1.50 | 1.750 | 0.5714 | | | |
| | 1.05 | | 25.2 | 19.2 | 6.0 | 1.05 | (1.087) 1.275 | (0.9199) 0.7843 | 11.32 | | 88.69 |
| | 0.742 | | 45.0 | 20.5 | 24.5 | 0.742 | 0.896 | 1.116 | 46.23 | | 42.46 |
| | 0.525 | | 33.8 | 18.5 | 12.3 | 0.525 | 0.634 | 1.577 | 23.21 | | 19.25 |
| | 0.371 | | 23.1 | 19.2 | 3.9 | 0.371 | 0.448 | 2.232 | 7.36 | | 11.89 |
| | 0.263 | 3 | 23.0 | 18.3 | 3.7 | 0.263 | 0.317 | 3.154 | 6.98 | | 4.91 |
| | 0.185 | 4 | 20.7 | 19.3 | 1.4 | 0.185 | 0.224 | 4.464 | 2.64 | | 2.27 |
| | 0.131 | 6 | 20.7 | 20.5 | .2 | 0.131 | 0.158 | 6.329 | 0.38 | | 1.89 |
| | 0.093 | 8 | 19.5 | 19.5 | .2 | 0.093 | 0.112 | 8.928 | 0.38 | 98.50 | 1.51 |
| | 0.065 | 10 | 19.3 | 19.2 | .1 | 0.065 | | | 0.19 | | 1.32 |
| | PAN | | 21.6 | 20.9 | .7 | PAN | | | 1.32 | | 0.00 |
| TOTAL ON SCREENS AND PAN | | | | | 53.0 | LOSS | | | - | - | - |
| LOSS (BY DIFFERENCE) | | | | | 0 | TOTAL | | | 100.01 | - | - |
| TOTAL SAMPLE WEIGHT | | | | | 53.0 | | | | - | - | - |

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

REMARKS: _____

| | | | |
|----------------------|---------|--------------------------|--|
| $\sum_{+8m}^m D_i$ | 0.74646 | $\sum_{+8m}^m X_i$ | |
| $1/\sum_{+8m}^m D_i$ | 1.54633 | $\sum_{+8m}^m X_i / D_i$ | |
| D_a | 0.63699 | $\sum_{+8m}^m X_i D_i$ | |
| D_v | 0.75782 | | |

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