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# OIL-WEATHERING COMPUTER PROGRAM
# USER 'S MANUAL

for

MULTIVARIATE ANALYSIS OF PETROLEUM
WEATHERING IN THE MARINE ENVIRONMENT
SUB ARCTIC

Submitted" to:

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# ABSTRACT

The Open-Ocean Oil-Weathering User's Manual is written to provide specific instructions on the use the computer code CUTVP2.FOR. This code calculates crude oil properties and the weathering of oil for a set of environmental parameters. The use of the code requires knowledge about the physical properties of crude oil and the weathering of oil. In order to aid the user, the code has been written to ask the user for specific input and provide examples of input. The best way to learn to use the code is to access the computer and work through some of the examples presented in this manual.

OIL-WEATHERING COMPUTER PROGRAM
USER'S MANUAL

## Model Overview

The open-ocean oil-weathering code is written in FORTRAN as a stand-alone code that can be easily installed on any machine. All the trial-and-error routines, integration routines, and other special routines are written in the code so that nothing more than the normal system functions such as EXP are required. The code is user-interactive and requests input by prompting questions with suggested input. Therefore, the user can actually learn about the nature of crude oil and its weathering by using this code.

The open-ocean oil-weathering model considers the following weathering processes:

- evaporation
- dispersion (oil into water)
- mousse {water into oil)
- spreading

These processes are used to predict the mass balance and composition of oil remaining in the slick as a function of time and environmental parameters. Dissolution of oil into the water column is not considered because this weathering process is not significant with respect to the over-all material balance of the oil slick.

An important assumption required in order to write material balance equations for evaporation is the state of mixedness of the oil in the slick. The open-ocean oil-weathering model is based on the assumption that the oil is well mixed. This might not always be true but data have been taken and interpreted as if the oil is well mixed. Thus, experimental results based on this

assumption must be used in the same way mathematically. There is growing thought based on physical observations (not compositional) that the oil is not always well mixed. As the oil weathers its viscosity increases (measured and known to be true) resulting in a slab-like oil phase. Clearly, the mass transfer within the oil will change drastically in going from a well-mixed to a slab-like phase.

The other three processes noted above are not explicitly component specific as is evaporation. However, the dispersion process is a function of the oil viscosity; oil viscosity is a function of composition. Thus the dispersion process does depend on the evaporation process. Mousse formation also alters the oil viscosity but the present knowledge of this process does not point to any quantifiable compositional dependence. The spreading of the slick results in an ever-increasing area for mass transfer.

The composition of the oil is described in terms of pseudocomponents that are obtained by fractionating the oil in a true-boiling-point distillation column. This procedure yields cuts of the oil which are characterized by boiling point and density. This information is then used to calculate many more parameters about the cut. The most important calculated parameters pertain to vapor pressure and molecular weight. The evaporation process is driven by vapor pressures, and system partial pressures are calculated assuming Raoult's law.

## Mode? Description

The pseudocomponents characterization of crude oil for the open-ocean oil-weathering model is described in detail (Payne, Kirstein, et al., 1983). The specific detail presented in the oil characterization can vary depending upon exactly which literature references are used. Those references used to write the current open-ocean oil-weathering model are all essentially contained in *a* standard text (Hougen, Watson and Ragatz, 1965).

The pseudocomponent evaporation model and the over-all mass-transfer coefficient required for evaporation has also been described in detail (Payne, Kirstein, et al ., 1983). The fundamental process of evaporation is described in many texts, such as Mass Transfer Operations (Treybal, 1955) and in papers in the open literature. A paper on this subject relevant to oil weathering is that by Liss and Slater (Liss and Slater, 1974).

The equation which describes slick spreading has also been described (Payne, Kirstein, et al., 1983). The spreading equation is based on observations due to Mackay (Mackay, et al., 1980) and is not based on the many publications which describe oil spreading due to gravity-viscosity-surface tension. The phenomenological approach to oil spreading does not pertain to a rough ocean surface, and the empirical approach at least reflects reality.

The viscosity prediction used in early oil-weathering model calculations is based on a (mole fraction) •(cut viscosity) summation (Reid, et al., 1977) . This viscosity prediction has been found to be inadequate in that the predicted viscosity is always too low. This viscosity prediction has been replaced with one due to Tebeau and Mackay (Tebeau, Mackay, et al., 1981) where the viscosity at 25*C is a function of the fraction of oil evaporated on a dispersion-free basis. The functional relationship is $\exp(K_4F)$ where $K_4$ is an oil-dependent constant and F is the fraction evaporated. The viscosity *is* scaled with respect to temperature according to the Andrade equation (Gold and 01 ge, 1969).

The prediction of water-in-oil emulsification is based on three parameters (Mackay, et al., 1980) appearing in the following equation:

$$(1 - K_2W) \exp\left[\frac{-2.5W}{1-K_1W}\right] \equiv \exp\left[-K_3t\right]$$

where W is the weight fraction water in the oil-water mixture, $K_1$ is a constant in a viscosity equation due to Mooney (Mooney, 1951), $K_2$ is a

coalescing-tendency constant, and $K_3$ is a lumped water incorporation rate constant. The viscosity equation due to Mooney is

$$\mu \cdot \mu_o \exp\left[\frac{-2.5W}{1-K_1W}\right]$$

where $\mu_o$ is the parent oil viscosity. $K_1$ is usually around 0.62 to 0.65 and apparently does not change much with respect to different types of oils. The constant $K_2$ above must satisfy the relation $K_2W < 1$ in order for the water incorporation rate term (right-hand side) to be > 0. Thus, $K_2$ is the inverse of the maximum weight fraction water in the mixture. $K_3$ is the water incorporation rate constant and is a function of wind speed in knots.

The dispersion (oil into water) weathering process is described by two equations (Mackay, et al ., 1980). These equations are

$$F = K_a(U + 1)^2$$

$$F_B = (1 + K_b\mu^{0.5}\delta\ \chi)$$

where F is the fraction of sea surface subject to dispersions per second, U is the wind speed in m/see and $K_a$ is constant. $F_b$ is the fraction of droplets of oil below a critical size which do not return to the slick, $K_b$ is a constant, $\mu$ is the viscosity in centipoise, X is the slick thickness in meter, and $\delta$ is the surface tension in dynes/cm. The mass fraction that leaves the slick as dispersed droplets is $F_b$ .F and this fraction applies to each cut of oil.

## User Input Description

The initial input required to perform an oil-weathering calculation is the distillation characterization of the crude oil. The desired input is termed a true-boiling-point (TBP) distillation and consists of distillate cuts

of the oil with each cut characterized by its average boiling point and API gravity. For a description of the TBP distillation see Van Winkle (Van Winkle, 1967). An example of a TBP distillation is shown in Table 1 for a typical crude oil.

TBP distillations of crude oils are not always readily available. The more common inspection on crude oil is termed an ASTM (D-86) distillation. The ASTM distillation (Perry, R. H., and C. H. Chilton, 1973) differs in that the ASTM distillation is essentially a flask distillation and thus has no more than a few theoretical plates. The TBP distillation (ASTM D-2982, 1977) is performed in a column with greater than 15 theoretical plates and at high reflux ratios. The high degree of fractionation in this distillation yields an accurate component distribution for the crude oil (mixture). Another type of crude oil inspection available is the equilibrium flash vaporation (EFV) which differs from both the ASTM and TBP distillation in that the vapor is allowed to equilibrate with the liquid, and the quantity vaporized reported. In the distillations vapor is continuously removed from the still pot.

Both the ASTM distillation and EFV can be converted to a TBP distillation (API, 1964). However, at the present the ASTM D-86 distillation results can be used directly in the oil-weathering calculations because it is a reasonable approximation to the TBP-distillation result at the light end of the barrel. The differences between the two distillations at the heavy end of the barrel are noticeable but since the heavy ends of the barrel do not evaporate in oil weathering, this difference is of little consequence.

Currently the best sources of distillation data are "Evaluation of World's Important Crudes" (O&GJ, 1973) where a tremendous number of distil 1 a-tions and other characterizations are reported. The distillations reported are a mix of ASTMs and TBPs. Another excellent source of distillation data is "Analyses of 800 Crude Oils from United States Oilfields" (Coleman, et al., 1978). The distillations reported by Coleman are not TBP distillations but are essentially ASTM distillations and can be used in the oil-weathering

TABLE 1. Example of True Boiling Point (TBP) Distillation of Crude Oil (from Van Winkle, 1967).

| % Distilled | T, 'F | API Gravity |
|---|---|---|
| 0 | 105 | first drop |
| 5 | 230 | 63.5 |
| 10 | 300 | 46.7 |
| 20 | 392 | 39.0 |
| 30 | 458 | 34*5 |
| 40 | 505 | 32.0 |
| 50 | 542 | 30.8 |
| 60 | 585 | 27.5 |
| 70 | 640 | 23.5 |
| 80 | 720 | 20.4 |
| 90 | 880 | 13.1 |
| 99 | 1090 | ---- |

calculations when the boiling points are all converted to one atmosphere total pressure. The reason parts of the ASTM or TBP distillations are conducted at sub-atmospheric pressure is that cracking begins to occur in the still pot at temperatures around 700°F. Thus, the data reported by Coleman are around atmospheric pressure up to 527°F, and for fractions boiling above this temperature the distillation is performed at 40-mm Hg. In order for the entire distillation to be used as input to the oil-weathering calculation, the cut data must be converted to one atmosphere total pressure. The procedure for converting sub-atmospheric boiling points to atmospheric boiling points is described in many places (Edmister and Okamoto, 1959; ASTM D-2892, 1977; API, 1964). An example of the sub-atmospheric boiling-point conversion is shown in Table 2 for Prudhoe Bay Crude Oil. The reported distillation pressure for Prudhoe Bay crude oil in Table 2 which is near atmospheric but not exactly at one atmosphere is not critical for the oil-weathering calculations.

An example of the use of the distillation data as input for the oil-weathering calculation is shown in Table 3. This table is an actual computer display of what the user sees beginning with the EXecute command. In this example the user is using data that is programmed into data statements and will not have to enter the distillation characterization data. The TBP cuts echoed to the user in Table 3 were obtained from the data of Coleman (Coleman, et al., 1978) in Table 2, and illustrate the transfer of these data to the oil-weathering calculation. Notice that cut 1 (fraction 1) in Table 2 has been deleted and the cuts renumbered. The reason cut 1 was deleted is because it is not the first cut with any measurable volume. Also note that the residuum cut is assigned a boiling point of $\geq$ 850°F. This assigned boiling point is fictitious and used to indicate that this cut is indeed a residuum.

A similar example of the use of distillation data from Coleman (Coleman, et al., 1978) is illustrated in Tables 4 and 5. Table 4 again is the published data and Table 5 illustrates how these data appear as input to the oil-weathering calculation.

TABLE 2. Distillation Data for Prudhoe Bay Crude Oil Showing Conversion of Sub-Atmosphere Boiling Points to Atmospheric Boiling Points (see text) (_Coleman, et al, 1978)..

Prudhoe Bay field
Sadlerochit, Triassic
8,890 - 9,008 feet

Alaska
North Slope

GENERAL CHARACTERISTICS

Gravity, specific, 0.893 Gravity, ° API, 27.0 Pour point, °F. 15
Sulfur, percent, 0.92 Color, brownish black
Viscosity, Saybolt Universal at 77° F, 111 sec; 100° F, 84 sec Nitrogen, percent, 0.220

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmosphere pressure, 741 mm. Hg
First drop, 91

| Fraction No. | Cut temp. °F. | Percent | Sum percent | Sp. gr. 60/60° F. | ° API 60° F. | C. I. | Refractive index, $n_D$ at 20° C. | Specific dispersion | S. U. visc. 100° F. | Cloud test, °F. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 123 | | | | | | | | | |
| 2 | 167 | 2.1 | 2.1 | 0.693 | 72.7 | - | 1.38591 | 127.9 | | |
| 3 | 212 | 2.6 | 4.7 | .723 | 64.2 | 23 | 1.40312 | 139.0 | | |
| 4 | 257 | 3.5 | 8.2 | .752 | 56.7 | 27 | 1.41922 | 143.9 | | |
| 5 | 302 | 3.5 | 11.8 | .773 | 51.6 | 30 | [illegible] | 147.0 | | |
| 6 | 347 | 3.7 | 15.5 | .790 | 41.6 | 31 | 1.43522 | 149.6 | | |
| 7 | 392 | 3.5 | 19.0 | .801 | 45.2 | 30 | 1.44626 | 152.1 | | |
| 8 | 437 | 4.3 | 23.3 | .818 | 41.5 | 33 | 1.45528 | 154.7 | | |
| 9 | 482 | 4.8 | 28.1 | .836 | 37.8 | 36 | 1.46565 | 157.0 | | |
| 10 | [illegible] | 5.0 | 33.1 | .851 | 34.8 | 38 | 1.47467 | 160.5 | | |

Stage 2—Distillation continued at 40 mm. Hg

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 392 | 2.8 | 35.9 | 0.873 | 30.6 | 45 | 1.48218 | 161.5 | 40 | 10 |
| 12 | 437 | 6.5 | 42.4 | .881 | 29.1 | 45 | 1.48650 | 168.6 | 45 | 30 |
| 13 | 482 | 6.8 | 49.2 | | 26.2 | 49 | 1.49477 | 169.4 | 58 | 50 |
| W | [illegible] | 6.0 | 55.2 | % | 1.024 | .052 | 52 | | 93 | 70 |
| 1 | [illegible] | 7.4 | 62.6 | .919 | 22.5 | 53 | 53 | | 176 | 90 |
| Residuum | | 36.3 | 98.9 | .990 | 11.4 | | | | | |

Carbon residue, Conradson: Residuum 11.6 percent; crude 4.7 percent. Residuum: sulfur, percent, [illegible]
Nitrogen, percent, [illegible]

APPROXIMATE SUMMARY

| | Percent | Sp. gr. | ° API | Viscosity |
|---|---|---|---|---|
| Light ends | 4.7 | 0.710 | 67.9 | |
| Total gasoline and naphtha | 19.0 | 0.762 | 54.2 | |
| Intermediate | 4.3 | .811 | 41.5 | |
| Gas oil | 18.4 | .860 | 33.1 | |
| Various lubricating distillate | 11.0 | .887-.911 | 28.0-23.9 | 50-100 |
| Medium lubricating distillate | 8.1 | .911-.922 | 23.9-22.0 | 100-200 |
| Viscous lubricating distillate | 1.8 | .922-.924 | 22.*2.6 | Above 200 |
| Residuum | 36.3 | .990 | 11.4 | |
| Distillation loss | 1.1 | | | |

| Fraction No. | Cut Temperature, "F at 1 Atmosphere |
|---|---|
| 10 | 580 |
| 11 | 638 |
| 12 | 685 |
| 13 | 738 |
| 14 | 790 |
| Residuum | --- |

TABLE 3. Distillation Cut Data as Used in Oil-Weathering Calculation (data obtained from Table 2)

```
. EX
LINK:   Loading
[LNKXCT CUTVP2  execution]
ENTER  THE  NUMBER  OF  TBP CUTS TO BE CHARACTERIZED ON I2
IF  YOU HAVE NO INPUT DATA JUST  ENTER 99
A 99  ENTRY  WILL USE A LIBRARY EXAMPLE
99
CHOOSE  A CRUDE ACCORDING TO:
1 = PRUDHOE BAY, ALASKA
2 = COOK INLET, ALASKA
3 = WILMINGTON, CALIFORNIA
4 = MURBAN, ABU  DHABI
5 = LAKE CHICOT, LOUISIANA
6 = LIGHT DIESEL CUT
1

YOU CHOSE: PRUDHOE BAY, ALASKA
```

| CUT | TB | API | VOL |
|---|---|---|---|
| 1 | 167.0 | 72,7 | 2.1 |
| 2 | 212.0 | 64.2 | 2.6 |
| 3 | 257.0 | 56.7 | 3.5 |
| 4 | 302.0 | 51.6 | 3.6 |
| 5 | 347.0 | 47.6 | 3.7 |
| 6 | 392.0 | 45*2 | 3*5 |
| 7 | 437 .0 | 41.5 | 4*3 |
| 8 | 482.0 | 37,8 | 4.8 |
| 9 | 527.0 | 34.8 | 5.0 |
| 10 | 580.0 | 30.6 | 2.8 |
| 11 | 638.0 | 29.1 | 6.5 |
| 12 | 685.0 | 26.2 | 6*8 |
| 13 | 738.0 | 24.0 | 6.0 |
| 14 | 790.0 | 22.5 | 7.4 |
| 15 | 850.0 | 11.4 | 36,3 |

```
DO YOU WANT TO CHANGE ANY?
Y
```

TABLE 4. Distillation Data for Wilmington Field Crude Oil (.Coleman, et al, 1978)

Wilmington field
Repetto, Lower Pliocene
and Puente, Miocene

California
Los Angeles County

## GENERAL CHARACTERISTICS

Gravity, specific, ....0..... Gravity, ° API, .....19.4..... Pour point, ° F . . . below 5.....
sulfur, ....1.59 percent, Color, .. brownish black .....
Viscosity, Saybolt Universal at . . . 100° F. 470 sec; 130° F. 229 sec... Nitrogen, percent, . . . 0.597 . .

## DISTILLATION, BUREAU OF MINES ROUTINE METHOD

Stage 1—Distillation at atmospheric pressure. . . . . /58 mm. Hg
First drop, ..118 .... ° F.

| Fraction No. | Cut temp. ° F. | Percent | Sum. percent | Sp. gr. 60/60° F. | ° API 60° F. | C. I. | Refractive index, $n_D$ at 20° C. | Specific dispersion | S. U. vis. 100° F. | Cloud test, ° F. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1..... | 122 | . . | ..... | ..... | ..... | | ..... | | | |
| 2..... | 167 | | | | | | | | | |
| 3..... | 212 | 2.3 | 2.3 | 0.707 | 68.6 | ... | 1. 39794 | 122.7 | | |
| 4..... | 257 | 2.4 | 4.7 | .744 | 58.7 | 24 | 1.41215 | 125.7 | | |
| s..... | 302 | 2.4 | 7.1 | .2.767 | 53.?.... | ...27.... | 1.42308 | 127.1 | | |
| b..... | 347 | 2.5 | 9.6 | .788 | 4,1 . . . | ...30.... | 1.43480 | 128. 8 | | |
| r..... | 392 | .2.s4... | 12.4 | .810 | ..43.2... | ...34 | .?..46S1 | 133. | | |
| 8..... | 437 | 3.6 | 16.0 | ...s.831 | 38.8 | 39 | 1.45771 | 148.6 | | |
| m..... | 482 | 4.4 | 20.4 | .848 | 35.4 | 41 | 1.46754 | 150.5 | | |
| 19 . . | ...! | 5.3 | 2s.7 | .864 | 32.3 | 44 | 1.47736 | 152.9 | | |

Stage 2—Distillation continued at 40 mm. Hg

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 11..... | 392 | ...4.7 | 30.4 | 0.894 | .2686 | ..... | J . : 4 2 | @15s.3. | .. 42.. | Below 5 |
| 1s..... | 437 | 6.3 | 36.7 | .907 | ..24.5. | 57 | 1.49898 | 163.8 | 56 | do. |
| la..... | 482 | 4.1 | 40.8 | .920 | 22.3 | 60 | | | 87 | do. |
| 1/ 14..... | 527 | 5.5 | 46.3 | .932 | 20.3 | 62 | | | 172 | do. |
| m..... | 572 | | | | | | | | | |
| Residuum. | . . . | ...53.3 | 99.6 | 1.008 | 8.9 | | | | | |

Carbon residue, Conradson: Residuum. 8.6 .. percent; crude 4.9 . percent.

Residuum:
Sulfur, percent, .....
Nitrogen, percent, . 1.043 .

## APPROXIMATE SUMMARY

| | Percent | Sp. gr. | ° API | Viscosity |
|---|---|---|---|---|
| Light gasoline | 2.3 | 0.707 | 68.6 | |
| Total gasoline and naphtha | 12.4 | 0.765 | 53.4 | |
| Kerosine distillate | — | — | — | |
| Gas oil | 18.8 | .863 | 32.5 | |
| Nonviscous lubricating distillate | 8.3 | .901-.922 | 25.5-22.0 | 50-100 |
| Medium lubricating distillate | 5.6 | .922-.936 | 22.0-19.7 | 100-300 |
| Viscous lubricating distillate | 1.2 | .936-.939 | 19.7-19.2 | Above 300 |
| Residuum | 53.3 | 1.008 | 8.9 | |
| Distillation loss | .4 | | | |

1/ Distillation discontinued at 527° F.

TABLE 5. Distillation Data for Wilmington Field Crude Oil Illustrating Use in Oil-Weathering Calculations (See Table 4 for published data).

```
● EX CUTVP2.FOR
LINK :    Loading
[LNKXCT CUTVP2 execution]
ENTER THE NUMBER OF TBP CUTS TO BE CHARACTERIZED ON I2
IF YOU HAVE NO INPUT DATA JUST ENTER 99
A 99 ENTRY WILL USE A LIBRARY EXAMFILE
99
CHOOSE A CRUDE ACCORDING TO:
1 =  PRUDHOE BAY, ALASKA
2 =  COOK INLET, ALASKA
3 = WILMINGTON, CALIFORNIA
4 = MURBAN, ABU DHABI
5 = LAKE CHICOT, LOUISIANA
6 = LIGHT DIESEL CUT
3

YOU CHOSE: WILMINGTON, CALIFORNIA
```

| CUT | TB | AP I | VOL |
|---|---|---|---|
| 1 | 212.0 | 68.6 | 2.3 |
| 2 | 257.0 | 58.7 | 2.4 |
| 3 | 302.0 | 53.0 | 2.4 |
| 4 | 347*0 | 48.1 | 2.5 |
| 5 | 392,0 | 43.2 | 2.8 |
| 6 | 437.0 | 38.8 | 3.6 |
| 7 | 482,0 | 33*4 | 4,4 |
| 8 | 527 + 0 | 32.3 | 5.3 |
| 9 | 580.0 | 26.8 | 4.7 |
| 10 | 638.0 | 24.5 | 6.3 |
| 11 | 685.0 | 22.3 | 4.1 |
| 12 | 738 . 0 | 20.3 | 5.5 |
| 13 | 850.0 | 8.9 | 53.3 |

```
DO YOU WANT TO CHANGE ANY?
N
ENTER THE TEMPERATURE IN DEG F FOR THE VAPOR PRESSURE CALCULATION
32.
THE TBP CUTS HAVE BEEN CHARACTERIZED
DO YOU WANT TO WEATHER THIS CRUDE?
N
DO IT AGAIN?
N
```

The distillation cut data can be entered by the user. An example of this entering procedure is illustrated using the TBP data for a gasoline cut (O&GJ, 1973, page 57) which is presented in Table 6. The user's entries to the oil-weathering calculation is shown in Table 7. Each time an input is required the user is prompted with an appropriate question. Since it is impossible to enter many numbers into the oil-weathering calculation without an error, the distillation cut data are always echoed to the user for review. In the event an input error is discovered or it is desired to change an entry, the user's response to DO YOU WANT TO CHANGE ANY? is yes. The error recovery is illustrated in Table 8 where the gasoline-cut data from Table 6 is entered. Note the input error for TB (boiling temperature) for cut 3 where 22.8 was entered instead of 228. The user is prompted for the error-recovery information and the final data is echoed to the user. In the event another error is to be corrected, a "YES" would be entered in response to the very last question in Table 8.

After entering the distillation-cut data, the user is asked for a temperature in degrees Fahrenheit. This temperature is used to calculate the vapor pressure of each cut as previously described (J. R. Payne, 8. E. Kirstein, et al., 1983). At this point the calculation can be stopped and the crude oil characterization is all that will have been calculated. However, in order to "weather the crude", the user types "YES" in response to DO YOU WANT TO WEATHER THIS CRUDE?

The user input required for an oil-weathering calculation begins with a YES in response to the question DO YOU WANT TO WEATHER THIS CRUDE? The user is then prompted for the spill size in barrels and the number of hours for oil weathering to occur. The input responses presented in Table 9 follow the specification of a library crude (i.e., programmed into the code) such as those illustrated in Tables 3 or 5.

After specifying the spill size and number of hours for weathering to occur, and a library crude has been specified, the user is prompted for mousse-formation constants and an oil-water surface tension. By responding NO

TABLE 6. True Boiling Point Distillation Data for a Gasoline Cut (O&GJ, 1973, page 57).

| cut | Cut temp, "F | Vol % | API Gravity |
|---|---|---|---|
| 1 | 137 | 1.5 | 71.6 |
| 2 | 196 | 2.1 | 59.7 |
| 3 | 228 | 2.0 | 55.0 |
| 4 | 256 | 2.0 | 53.8 |
| 5 | " 283 | 2.0 | 49.6 |

TABLE 7. Illustration of User Input of Data for a Gasoline Cut (See Table 6 for "published" data).

```
●EX CUTVP2.FOR
LINK :    Loading
[LNKXCT CUTVP2 execution]
ENTER THE NUMBER OF TBP CUTS TO BE CHARACTERIZED ON I2
IF YOU HAVE NO INPUT DATA JUST ENTER 99
A 99 ENTRY WILL USE A LIBRARY EXAMPLE
5
ENTER THE NAME OF THE CRUDE
GASOLINE CUT
ENTER AN IDENTIFICATION NUMBER FOR THIS CRUDE ON 15
11111
ENTER A SAMPLE NUMBER ON I5
22222
ENTER THE BULK API GRAVITY
55.

YOU MUST ENTER THE TRUE BOILING POINT CUT DATA STARTING
WITH THE MOST VOLATILE CUT AND GOING TO THE BOTTOM OF THE BARREL

ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT 1
137.
ENTER API GRAVITY FOR CUT 1
71*6
ENTER VOLUME PER CENT FOR CUT 1
I*5
ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT 2
196.
ENTER API GRAVITY FOR CUT 2
59.7
ENTER VOLUME PER CENT FOR CUT 2
2.1
ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT 3
228.
ENTER API GRAVITY FOR CUT 3
55.
ENTER VOLUME PER CENT FOR CUT 3
2.
ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT 4
256.
ENTER API GRAVITY FOR CUT 4
53.8
ENTER VOLUME PER CENT FOR CUT 4
2.
ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT 5
283.
ENTER API GRAVITY FOR CUT 5
49.6
ENTER VOLUME PER CENT FOR CUT 5
2.

CUT      TB          API         VOL
 1      137*0       71.6        1*5
 2      196.0       59.7        2.1
 3      228.0       55.0        2.0
 4      256.0       53*8        2*0
 5      283 .0      49,6        2*0
DO YOU WANT TO CHANGE ANY?
N
ENTER THE TEMPERATURE IN DEG F FOR THE VAPOR PRESSURE CALCULATION
32.
THE TBP CUTS HAVE BEEN CHARACTERIZED
DO YOU WANT TO WEATHER THIS CRUDE?
N
DO IT AGAIN?
N
```

TABLE 8. Illustration of Input-Error Recovery (Note error for cut 3 boiling temperature).

```
ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT  5
283.
ENTER API GRAVITY FOR CUT  5
49.6
ENTER VOLUME PER CENT FOR CUT  5
2.

CUT      TB          API         VOL
 1      137.0       71.6        1.5
 2      196.0       59.7        2.1
 3       22.8       55.0        2.0
 4      256.0       53.8        2.0
 5      283.0       49.6        2.0
DO YOU WANT TO CHANGE ANY?
Y
ENTER THE CUT NUMBER TO BE CHANGED ON I2
3
ENTER 1 TO CHANGE TB, 2 FOR API, 3 FOR VOL%
1
ENTER THE CHANGED DATA
228.

CUT      TB          API         VOL
 1      137.0       71.6        1.5
 2      196.0       59.7        2.1
 3      228.0       55.0        2.0
 4      256.0       53.8        2.0
 5      283.0       49.6        2.0
DO YOU WANT TO CHANGE ANY?
N
```

TABLE 9. Illustration of User Input for Oil-Weathering Calculation with a Library-Specified Crude

```
ENTER THE TEMPERATURE IN DEG F FOR THE VAPOR PRESSURE CALCULATION
32.
THE TBP CUTS HAVE BEEN CHARACTERIZED
DO YOU WANT TO WEATHER THIS CRUDE?
YES
ENTER THE SPILL SIZE IN BARRELS
10000.
ENTER NUMBER OF HOURS FOR OIL WEATHERING TO OCCUR
240.
DO YOU WANT TO ENTER MOUSSE FORMATION CONSTANTS?
NO
DO YOU WANT TO ENTER AN OIL-WATER SURFACE TENSION (DYNES/CM)?
NO
ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1, 2, OR 3 WHERE:
1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT
2=CORRELATION MASS-TRANSFER COEFFICIENT BY MACKAY & MATSUGU
3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
2
ENTER THE WIND SPEED IN KNOTS
10.
DO Y5U WANT THE SLICK TO SPREAD?
YES
DO YOU WANT TO ENTER VISCOSITY CONSTANTS?
NO
DO YOU WANT THE WEATHERING TO OCCUR WITH DISPERSION?
YES
DO YOU WANT TO ENTER THE DISPERSION CONSTANTS?
NO
NUMBER OF LINES WRITTEN TO CUTVP2.PLT = 71
DO IT AGAIN?
YES
```

to these prompts the calculation procedure will use library constants for the specified crude. The user is then prompted for mass-transfer coefficient information. The mass-transfer coefficient is for the evaporation weathering process, not dissolution. There are three possible mass-tranfer coefficient input specifications, and the one recommended is 2 as illustrated in Table 9. The next entry is wind speed which is in knots and should be less than 40 knots because oil-weathering processes at and above this wind speed are not quantified. Also, the lowest wind speed used in the calculation is 2 knots and any value entered lower than this is reset to 2.

After specifying the wind speed the user specifies if the slick is to spread (YES) or not (NO). Viscosity constants can then be entered if desired for a library crude, and finally the dispersion process (oil into water) can be specified as occurring (YES) or not (NO) along with the dispersion constants. At this point all input information has been supplied and the calculation proceeds.

The preceding input description illustrates a straight-forward use of the information programmed in the oil-weathering code. Illustrations of how the programmed information can be changed is presented in the following discussion. Altering the programed information allows other crudes or petroleum cuts to be entered into the calculation, or actual spills and experiments can be analyzed to find the best physical properties or rate constants which predict observed data.

The first input information that can be changed by the user is the mousse-formation constants as illustrated in Table 10. The mousse constants appear in an equation which quantifies the rate of water incorporation into the oil with respect to time. This rate equation is (Mackay, et al., 1980)'

$$(1 - K_2W) \exp\left[\frac{-2.5W}{1-K_1W}\right] \equiv \exp\left[-K_3t\right]$$

TABLE 10. Illustration of User-Specified Mousse-Formation-Constants

```
DO YOU WANT TO ENTER MOUSSE FORMATION CONSTANTS?
YES
1. ENTER THE MAXIMUM WEIGHT FRACTION WATER IN OIL
.60
2. ENTER THE MOUSSE-VISCOSITY CONSTANT, TRY 0.65
.65
3. ENTER THE WATER INCORPORATION RATE CONSTANT, TRY 0.001
.001
DO YOU WANT TO ENTER AN OIL-WATER SURFACE TENSION (DYNES/CM)?
YES
.001
30 .
```

where W is the weight fraction water in mousse. $K_1$ is a constant in the viscosity equation, $K_2$ is a coalescing-tendency constant and $K_3$ is a lumped water incorporation rate constant. $K_1$ appears in a stand-alone equation for the apparent viscosity of the emulsion as (Mooney, 1951)

$$\mu = \mu_o \exp\left[\frac{-2.5W}{1-K_1W}\right]$$

where $\mu_o$ is the parent oil viscosity. $K_1$ is usually around 0.62 to 0.65 and apparently does not change much with respect to different types of oils.

The constant $K_2$ must satisfy the relation $K_2W < 1$ in order for the water incorporation rate to be > 0. Thus, $K_2$ is the inverse of the maximum weight fraction water in mousse. $K_3$ is the water incorporation rate constant and is a function of wind speed in knots. Currently the oil-weathering code calculates $K_3$ from

$$K_3 = 0.001\ (\text{WIND SPEED})^2$$

and the constant actually entered by the user is the 0.001 constant above.

Thus, referring to Table 10, the first mousse formation constant entered is the maximum weight fraction water in the mousse. The reciprocal of this number is used for $K_1$. The second constant entered is the viscosity constant in Mooney's equation and this number should be 0.62 to 0.65 unless experimental evidence suggests otherwise. The third constant entered is the multiplier of the (wind speed)$^2$ which then yields $K_3$. This number is around 0.001 as indicated. Note that the prompting for input also prints suggested values for each constant.

The next input parameter that the user can change is the mass-transfer coefficient for evaporation. The input illustration in Table 9 uses the correlation mass transfer coefficient as developed by Mackay and Matsugu (Mackay and Matsugu, 1973). Table 11 illustrates the three possible input

TABLE 11. Illustrations of Three Input Options for the Mass Tranfer Coefficient for Evaporation

```
ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1, 2, OR 3 WHERE:
1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT
2=CORRELATION MASS-TRANSFER COEFFICIENT BY MACKAY & MATSUGU
3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
1
ENTER THE WIND SPEED IN KNOTS
10.
DO YOU WANT THE SLICK TO SPREAD?
YES
ENTER THE OVER-ALL MASS-TRANSFER COEFFICIENT, CM/HR, TRY 10
10.


ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1, 2, OR 3 WHERE: .
1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT
2=CORRELATION MASS-TRANSFER COEFFICIENT BY MACKAY & MATSUGU
3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
2
ENTER THE WIND SPEED IN KNOTS .
10.
DO YOU WANT THE SLICK TO SPREAD?
YES
DO YOU WANT TO ENTER VISCOSITY CONSTANTS?
NO
DO YOU WANT THE WEATHERING TO OCCUR WITH DISPERSION?
NO


ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1, 2, OR 3 WHERE:
1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT
2=CORRELATION MASS-TRANSFER COEFFICIENT BY MACKAY & MATSUGU
3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
3
ENTER THE WIND SPEED IN KNOTS
10.
DO YOU WANT THE SLICK TO SPREAD?
YES
ENTER THE OIL-PHASE MASS-TRANSFER COEFFICIENT IN CM/HR, TRY 10 .
10.
ENTER THE AIR-PHASE MASS-TRANSFER COEFFICIENT IN CM/HR, TRY 1000
1000.
ENTER THE MOLECULAR WEIGHT OF THE COMPOUND FUR K-AIR ABOVE, TRY 200
200.
```

options for the evaporation mass transfer coefficient. The first input option shown in Table 11 allows the user to input the mass transfer coefficient directly in contrast to the second input option where the coefficient is calculated as a function of wind speed and slick diameter. In the third input option the user can enter individual-phase mass transfer coefficients. In this last option the entered coefficient is scaled according to the square root of the molecular of each cut to yield a coefficient specific to each cut (Liss and Slater, 1974). The coefficient in this last option is also scaled according to wind speed according to Garratt's drag coefficient (Garratt, 1977).

After specifying the mass-transfer coefficient options the user can specify if the slick is to spread or not. This option is illustrated in Table 12 by entering YES or NO to the prompt. In this particular illustration the user has specified that the slick does not spread. This option is useful for investigating evaporation from spills on solid surfaces such as ice or land. When the no-spreading option is selected the user is prompted for a starting thickness. In the illustration in Table 12 the entered thickness is 3 cm.

The final physical property optional input that can be specified by the user is the viscosity. The viscosity-prediction for the bulk weathered oil is important when dispersion of oil into water occurs since viscosity appears in the rate equation for dispersion. The current method of viscosity prediction is based on the viscosity of the initial crude at 25°C, a temperature-scaling constant, and a fraction-oil-weathered constant. The viscosity predicted is for oil only, and must not be interpreted as that viscosity when on water-in-oil emulsion is present.

The viscosity at 25°C is scaled to other temperatures by the Andrade equation {Gold and Olge, 1969) which is

$$\ln \frac{\mu_1}{\mu_o} = B \left(\frac{1}{T_1} - \frac{1}{T_o}\right)$$

TABLE 12. Illustration of the 'No-Spreading' Option and Starting Thickness Specification

```
ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1, 2, OR 3 WHERE:
1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT
2=CORRELATION MASS-TRANSFER COEFFICIENT BY MACKAY & MATSUGU
3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
2
ENTER THE WIND SPEED IN KNOTS
10*
DO YOU WANT THE SLICK TO SPREAD?
NO
SINCE THE SLICK DOES NOT SPREAD, ENTER A STARTING THICKNESS IN CM
3.
```

and the temperature-scaling constant is B. The viscosity of the weathered oil is calculated according to $\exp(K_4 F)$ where F is the fraction weathered (Tebeau, Mackay, et al., 1982) i.e., fresh crude oil has F = O. As weathering proceeds, the parent oil viscosity increase exponentially with respect to F.

The user can enter the three viscosity constants by answering YES to the prompt illustrated in Table 13. In this illustration suggested input viscosity constants are printed along with the prompt.

The constants which appear in the dispersion process can also be specified by the user. The dispersion of oil into the water column is described by two equations (Mackay, et al., 1980):

$$F = K_a (U + 1)^2$$

and

$$F_B = (1 + K_b \mu^{0.5} \delta \chi)$$

where F is the fraction of sea surface subject to dispersion per second, U is the wind speed in m/see and $K_a$ is a constant, typically 0.1 $hr^{-1}$. $F_B$ is the fraction of droplets of oil below a critical size which do not return to the slick, $K_b$ is a constant, around 50, $\mu$ is the viscosity in centipoise, $\chi$ is the slick thickness in meter, and $\delta$ is the surface tension in dynes/cm. The mass fraction that leaves the slick as dispersed droplets is $F_b \cdot F$ and this fraction applies to each cut of oil. Table 14 illustrates the user input of the constants $K_a$ and $K_b$.

TABLE 13. Illustration of Viscosity-Constant Input Options

```
ENTER THE MASS-TRANSFER COEFFICIENT CODE:1,2,OR 3 WHERE:
1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT
2=CORRELATION MASS-TRANSFER COEFFICIENT BY MACKAY & MATSUGU
3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
2
ENTER THE WIND SPEED IN KNOTS
10.
DO YOU WANT THE SLICK TO SPREAD?
YES
DO YOU WANT TO ENTER VISCOSITY CONSTANTS?
YES
1. ENTER THE BULK CRUDE VISCOSITY AT 25 DEG C, CENTIPOISE, TRY 35.
40.
2. ENTER THE VISCOSITY TEMPERATURE SCALING CONSTANT (ANDRADE), TRY 9000.
9000 .
3. ENTER THE VISCOSITY-FRACTION-OIL-WEATHERED CONSTANT, TRY 10.5
10*5
DO YOU WANT THE WEATHERING TO OCCUR WITH DISPERSION?
YES
DO YOU WANT TO ENTER THE DISPERSION CONSTANTS?
```

TABLE 14. Illustration of Dispersion Constants Input

```
DO YOU WANT TO ENTER VISCOSITY CONSTANTS?
NO
DO YOU WANT THE WEATHERING TO OCCUR WITH DISPERSION?
YES
DO YOU WANT TO ENTER THE DISPERSION CONSTANTS?
YES
ENTER THE WIND SPEED CONSTANT, TRY 0.1
.2
ENTER THE CRITICAL DROPLET SIZE CONSTANT, TRY 50
70,
NUMBER OF LINES WRITTEN TO CUTVP2.PLT = 71
DO IT AGAIN?
NO
```

## Output Description

The output generated by the oil-weathering code is written to three disk files: CUTVP2.OUT, CUTVP2.TYP and CUTVP2.PLT. These files contain the calculated results in various forms. The CUTVP2.OUT file is 130 columns wide and intended to be printed on an appropriate high speed printer. The CUTVP2.TYP file is 80 columns wide and intended for printing on portable terminals. The CUTVP2.TYP file is an abbreviated version of CUTVP2.OUT. The CUTVP2.PLT is a numbers-only raw data file and intended to be read by a plotting routine or other data processing routines.

An example of the CUTVP2.OUT file (130 column) is presented in Table 15a where the calculated results for an oil-weathering calculation at 32*F for Prudhoe Bay crude is presented. The first page of this output is crude characterization information calculated according to previous descriptions (J. R. Payne, B. E. Kirstein, et al., 1983), and page two is the result of the vapor pressure calculation for each cut of the crude. Page three presents the input parameters and constants, and the beginning of the results of the oil-weathering calculation. The information presented for various times is self explanatory but some care must be taken in order to identify the cuts at each time step. There are cases where the first cuts can be so volatile that they evaporate away immediately (< 1 hour). In this case the cut(s) will be deleted from the calculation and the remaning cuts renumbered.

Table 15b illustrates the output where a cut has been deleted because it evaporates too fast to be considered in the calculation. The cut renumbering occurs immediately before the time integration begins and will always be noted on the output before the time = 0 print. The user must know that a cut has been deleted or interpretation of the results will be shifted by one (or more) cut. The deletion of a cut is also noted before the final mass fractions are printed by telling the user the number of the first cut printed. This is illustrated in Table 15b (final page) where it is noted that the cut numbering begins with 2.

Examples of the 80-column output is presented in Tables 16a and 16b for weathering Prudhoe Bay crude oil at 32 and 60°F. The output in Tables 16a and 16b was generated at the same time as the output in Tables 15a and 15b. Note that the output in Tables 16a and 16b is essentially a condensed, self-contained, version of the calculated results.

Most of the output information is self explanatory as illustrated in Tables 15a and 15b. These two tables are examples of calculated results at two different temperatures for Prudhoe Bay crude oil. Currently some of the information printed is not used. Refer to Table 15a (page 3) which begins at the top of the page with: OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT CODE 2. On this page of the output the two 1 ines beginning with KINEMATIC VISCOSITY present information that is not used. This viscosity information was used early in program development and found not to be applicable for predicting the viscosity of weathered crude. The viscosity of weathered crude is now calculated according to the fraction weathered, as previously described in the input description and noted here by the parameters printed immediately below the kinematic viscosity information.

## Accessing the Computer

Currently the oil-weathering code resides on a DEC System-10® at Science Applications, Inc. in La Jolla, California. Table 17 presents a description of the commands to execute the code that pertain to this specific installation. Accessing the DEC-10 from anywhere in the United States can be accomplished through TELENET. The TELENET access procedure is described in Appendix A. Once access to DEC-10 has been obtained the system will then ask for a project-programmer number (PPN) which in the example in Table 17 is 4601,4601. The password must then be typed in. The typed password will not show up at the terminal. The current password must be obtained by calling SAI. Once 1 egged in the code can be executed by typing EX CUTVP2.FOR. The code will then execute and the user will be prompted for input. After an oil-weathering calculation is finished the FORTRAN code will ask the user: DO

IT AGAIN? By replying NO a normal exit and file closing will be accomplished. The system will then print CPU time and elapsed time. In order to obtain the calculated results the user must instruct the system to print or type the results from the appropriate disk files. To obtain 130-column detailed output the user types PRINT CUTVP2.OUT. The output will be printed at SAI's La Jolla facility and it must then be picked up by the user. By typing TYPE CUTVP2.TYP the user will obtain the 80-column abbreviated output file at his terminal. To log off the computer type BYE.

There will be times when the connection to the DEC-10 will be lost during execution or while the user is doing something else. When this happens the job becomes detached but can be picked up again by the user. When computer access is obtained the user must login using the same PPN and PASSWORD. The system will then type to the user the detached job number, program name, and status. The user will then be asked if he wants to attach. The attach procedure is illustrated in Table 18.

A listing of the open-ocean oil-weathering code is presented in Appendix B.

TABLE 15a: Illustration of Output from Oil-Weathering Calculations; Prudhoe Bay Crude Oil Characterization.

SUMMARY OF TBP CUTS CHARACTERIZATION FOR: PRUDHOE BAY, ALASKA

CODE VERSION Is CUTVP2 OF FEDRUARY 22
ITEM 9, SAMPLE 71011

| | TB | API | SPGR | VOL | MW | TC | PC | VC | A | B | T10 | VIS | NC | NS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.67E+02 | 7.27E+01 | 6.81E-01 | 2.12E+00 | 8.92E+01 | 9 .31E+02 | a.83E+01 | 3.88E+02 | 8.23E+00 | 1.98E-01 | 4.60E+02 | 4.14E-01 | 3 | 1 |
| 2 | 2.12E+02 | 6.42E+01 | 7.11E-01 | 2.63E+00 | 1.02E+02 | 9.85E+02 | 3.65E+01 | 4.37E+02 | 8.31E+00 | 2.11E-01 | 4.95E+02 | 4.92E-01 | 3 | 1 |
| 3 | 2.57E+02 | 5.67E+01 | 7.39E-01 | 3.54E+00 | 1.14E+02 | 1.04E+03 | 3.51E+01 | 4.86E+02 | 3.39E+00 | 2.23E-01 | 5.31E+02 | 6.01E-01 | 3 | 1 |
| 4 | 3.02E+02 | 5.16E+01 | 7.60E-01 | 3.64E+00 | 1.28E+02 | 1.09E+03 | 3.36E+01 | 5.41E+02 | 3.49E+00 | 2.34E-01 | 5.68E+02 | 7.47E-01 | 3 | 1 |
| 5 | 3.47E+02 | 4.76E+01 | 7.77E-01 | 3.74E+00 | 1.43E+02 | 1.14E+03 | 3.22E+01 | 6.01E+02 | 3.61E+00 | 2.45E-01 | 6.04E+02 | 9.43E-01 | 3 | 1 |
| 6 | 3.92E+03 | 4.52E+01 | 7.87E-01 | 3.54E+00 | 1.61E+02 | 1.1OEW2 | 3.06E+01 | ● .7iE+02 | 3.77E+00 | 2.55E-01 | 6.42E+02 | 1.20E+00 | 3 | 1 |
| 7 | 4.37E+02 | 4.15E+01 | 0.04E-01 | 4.35E+00 | 1.78E+02 | 1.23E+03 | 2.94E+01 | 7.40E+02 | 3.91E+00 | 2.64E-01 | 6.80E+02 | 1.56E+00 | 3 | 1 |
| 8 | 4.82E+02 | 3.78E+01 | 8.22E-01 | 4.05E+00 | 1.96E+02 | 1.27E+03 | 2.83E+01 | 8.11E+02 | 4.06E+00 | 2.72E-01 | 7.18E+02 | 2.05E+00 | 3 | 1 |
| 9 | :.277:: | 3.4BE+01 | 8.36E-01 | 5.06E+00 | 2.12E+02 | 1.32E+03 | 2.76E+01 | 8.77E+02 | 4.18E+00 | 2.79E-01 | 7.55E+02 | 2.00E+00 | 3 | 1 |
| 10 | [illegible] | 3.06E+01 | 8.58E-01 | 2.83E+00 | 2.36E+02 | 1.37E+03 | 2.65E+01 | 9.71E+02 | 4.37E+00 | 2.87E-01 | 8.01E+02 | 3.04E+00 | 3 | 1 |
| 11 | 6.38E+02 | 2.91E+01 | 8.66E-01 | 6.57E+00 | 2.72E+02 | 1.42E+03 | 2.49E+01 | 1.11E+03 | 4.68E+00 | 2.97E-01 | 8.53E+02 | 5.26E+00 | 3 | 1 |
| 12 | 6.85E+02 | 2.62E+01 | 8.82E-01 | 6.88E+00 | 2.99E+02 | 1.46E+03 | 2.40E+01 | 1.22E+03 | 4.89E+00 | 3.03E-01 | 8.95E+02 | 9.26E+00 | 3 | 1 |
| 13 | 7.38E+02 | 2.40E+01 | 8.94E-01 | 6.07E+00 | 3.35E+02 | 1.51E+03 | 2.29E+01 | 1.36E+03 | 5.20E+00 | 3.10E-01 | 9.44E+02 | 1.88E+01 | 3 | 1 |
| 14 | 7.90E+02 | 2.25E+01 | 9.03E-01 | 7. 48E+00 | 3.76E+02 | 1.55E+03 | 2.18E+01 | 1.52E+03 | 5.58E+00 | 3.17E-01 | 9.94E+02 | 4.05E+01 | 3 | 1 |
| 15 | 8.58E+02 | 1.14E+01 | 9.73E-01 | 3.67E+01 | 6.00E+02 | ● *OOC+44 | 0.00E+00 | ● .@OEt06 | ● .00E+OO | ● .00EtOO | ● .@@E+@@ | 1.81E+02 | 0 | 0 |

BULK API GRAVITY = 27.0

TB. NORHAL BOILING TEMPERATURE, DEG F
API .API GRAVITY
VOL = VOLIME PER CENT OF TOTAL CRUDE
MW , MOLECULAR WEIGHT
TC. CRITICAL TEMPERATURE, DEG RANKINE
PC = CRITICAL PRESSURE, ATMOSPHERES
VC = CRITICAL VOLUME, CC/MOLE
A AND B ARE PARAMETERS IN THE VAPOR PRESSUSE EQUATION
T10 IS THE TEMPERATURE IN DEG R WHERE THE VAPOR PRESSURE IS 10 MM HG
VIS IS THE KINEMATIC VISCOSITY IN CENTISTOKES AT 122 DEG F
NC = ERROR CODE, SHOULD BE LESS THAN 20
NS . ERROR CODE, SHOULD BE EQUAL TO 1
IGNORE THE ERROR CODES FOR COMPONENT NUMBER 15 IF IT IS A RESIDUUM

TABLE 15a (Continued): Output from Oil-Weathering Calculations; Prudhoe Bay Crude Oil Vapor Pressures at 32°F.

CRUDE OIL CHARACTERIZATION AND PSEUDOCOMPONENT EVAPORATION MODEL
IDENTIFICATION: PRUDHOE BAY, ALASKA

ITEM 9, SAMPLE 71011
VAPOR PRESSURE IN ATMOSPHERES AT 3.200E+01 DEG F

| | VP |
|---|---|
| 1 | 3.784E-02 |
| 2 | 1.086E-02 |
| 3 | 2.584E-03 |
| 4 | 5.643E-04 |
| 5 | 1.123E-04 |
| 6 | 1.955E-05 |
| 7 | 3.176E-06 |
| 8 | 4.635E-07 |
| 9 | 6.603E-08 |
| 10 | 5.303E-09 |
| 11 | 2.092E-10 |
| 12 | 1.422E-11 |
| 13 | 4.512E-13 |
| 14 | 8.824E-15 |

MEAN MOLECULAR WEIGHT OF THE CRUDE = 2.739E+02

TABLE 15a (Continued) : Output from Oil-Weathering Calculations; Prudhoe Bay Crude Oil, Mass-Transfer Coefficients, Problem'Specifications, and Beginning of Calculated Results at 32°F.

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OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT CODE 2

OVEN-ALL MASS-TRANSFER COEFFICIENT FOR CUMENE =  1.926E+01 M/HR

 CUT          M/HR        GM-MOLES/(HR )(ATM)(M**2)
  1         2.062E+01          9.212E+02
  2         2.031E+01          9.074E+02
  3         2. 007E+01         8.964E+02
  4         1.984E+01          8.864E+02
  5         1.965E+01          8.776E+02
  6         1.946E+01          8.695E+02
  7         1.932E+01          8.630E+02
  8         1.919E+01          8.574E+02
  9         1.910E+01          8.531E+02
 10         1.898E+01          8.479E+02
 11         1.885E+01          8.418E+02
 12         1.876E+01          8.382E+02
 13         1.868E+01          8.342E+02
 14         1.859E+01          8.306E+02

FOR THIS SPILL OF 1.000E+03 BARRELS, TRE MASS IS 1.412E+02 METRIC TONNES

VOLUME FROM SUMMING THE CUTS =  1.6E+02 M**3, On 1.000E+03 BARRELS

WIND SPEED =  1.000E+01 KNOTS, OR  1.853E+04 M/HR

INITIAL SLICK DIAMETER = 1.006E+02 M, OR AREA = 7.950E+03 M**2

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM TRE COTS = 4.9E+00 CENTISTOKES AT 122 DEG F

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS = 8.9E+00 AT T = 32.9 DEG F, SCALE FACTOR = 1.8E+00

VISCOSITY ACCORDING TO MASS EVAPORATEI): VIS25C = 3.50E+01, ANDRADE = 9.00E+03, FRACT WEATHERED =1.05E+01, VSLEAD = 5.50E+02 CP

MOUSSE CONSTANTS: MOONEY= 6.20E-01, MAX H20= 0.79, WIND**2= 1.00E-03

THE FRACTIONAL SLICK AnEA SUBJECT TO DISPERSION IS 4.1E+00 PER HOUR
TNE DISPENSION PARAMETERS USED: KA =  1.08E-01, KB = 5.00E+01, SURFACE TENSION = 3.00E+01 DYNES/CM

COUNT THE COTS IN TNE FOLLOWING OUTPUT FROM LEFT TO RIGHT

TNE INITIAL GRAM MOLES IN TOE SLICK ARE:
 2.565E+04  2.911E+04  3.633E+04  3.423E+04  3.213E+04  2.743E+04  3.108E+04  3.219E+04  3.148E+04  1.625E+04  3.309E+04
 3.211E+04  2.566E+04  2.846E+04  9.420E+04

THE INITIAL MASSES (GRAMS) IN TNE SLICK ARE:                                                                                  1
 2.288E+06  2.956E+06  4.138E+06  4.375E+06  4.596E+06  4.407E+06  5.530E+06  6.308E+06  6.690E+06  3.843E+06  9.005E+06
 9.594E+06  8.585E+06  1.069E+07  5.652E+07
THE TOTAL MASS FROM THESE CUTS 1S 1.395E+08 GRAMS


STEP SIZE OF 9.191E-02 IS BASED ON CUT 1

TIME = 0.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    2
1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00
1 .0E+00
MASS REMAINING = 1.395E+08, MASS DISPERSED=0.000E+00, MASS EVAPORATED = 0.000E+00, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 1.0E+00, AREA= 7.9E+03 M**2, THICKNESS= 2.0E+00 CM, MOLE WT=273.9
WEIGHT FRACTION WATER IN OIL =  6.9E-05, VISCOSITY = 5.5E+02 CENTISTOKES, DISPERSION TERM = 4.4E-04 WEIGHT FRACTION/HR
MASS/AREA= 1.8E+04 GMS/M*M, SPGR= 8.0E-01, TOTAL VOLUME= 1.0E+03 BBL, DISPERSION= 7.7E+00 GMS/M*M/HR, EVAP RATE= 0.0E+00 GMS/M*M/HR


TIME =  1.0E+00 HOURS, MASS FRACTION OF EACN CUT REMAINING:                                                                   3
2.2E-01  6.6E-01  9.1E-01 9.8E-01 1. 0E+00 1 .0E+00 1 .0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1. 0E+00  1. 0E+00
1. 0E+00
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TABLE 15a (.Continued): Output from Oil-Weathering Calculations; Prudhoe Bay Crude Oil, Time versus Calculated Results at 32 F.

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MASS REMAINING .  1.362E+08, NASS DISPERSED = 6.123E+04, MASS EVAPORATED = 3.299E+06, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 3.1E+04 M**2, THICKNESS= 5.0E-01 CM, MOLE WT=286.7
WEIGHT FRACTION WATER IN OIL = 2.5E-02, VISCOSITY = 7.6E+02 CENTISTOKES, DISPERSION TERM =  1.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.4E+03 GMS/M*M, SPGR= 8.8E-01, TOTAL VOLUME= 9.7E+02 BBL, DISPERSION= 6.6E+00 GMS/M*M/HR, EVAP RATE= 9.9E+01 GMS/M*M/HR

TIME =  2.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          4
1.6E-02  3.1E-01  7.6E-01  9.4E-01  9.9E-01  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00
1.0E+00
MASS REMAINING =  1.337E+08, MASS DISPERSED =  2.675E+05, HASS EVAPORATED = 5.585E+06, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN TUE SLICK= 9.6E-01, AREA= 4.3E+04 M**2, THICKNESS= 3.5E-01 CM, MOLE WT=295.6
WEIGHT FJIACTION WATER IN OIL = 5.0E-02, VISCOSITY =  9.7E+02 CENTISTOKES, DISPF.BS1ON TERM = 1.9E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.1E+03 CMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.5E+02 BBL, DISPERSION= 5.9E+00 GMS/M*M/HR, EVAP RATE= 4.2E+01 GMS/M*M/HR

STEP SIZEOF 5.591E-02 1S BASED ON COT 2

TIME = 3.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                           5
5.1E-04  1.2E-01  6.0E-01  8.9E-01  9.7E-01  9.9E-01  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00
1.0E+00
MASS REMAINING =  1.319E+08, MASS DISPERSED = 5.228E+05, MASS EVAPORATED = 7.094E+06, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN TNE SLICK* 9.5E-01, AREA= 5.2E+04 M**2, THICKNESS= 2.9E-01 CM, MOLE WT=301.4
WEIGHT FRACTION WATER IN OIL = 7.4E-02, VISCOSITY =  1.2E+03 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.5E+03 CMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+02 BBL, DISPERSION= 5.3E+00 GMS/M*M/HR,  EVAP RATE= 2.5E+01 GMS/M*M/HR

STEP SIZE OF 4.679E-02 IS BASED ON (NIT 2

TIME = .4.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          6
7.5E-06  3.5E-02  4.5E-01  8.4E-01  9.6E-01  9.9E-01  9.9E-01  9.9E-01  9.9E-01  9.9E-01  9.9E-01  9.9E-01  9.9E-01  9. 9E-01
9.9E-01
MASS REMAINING =  1.305E+08, NASS DISPERSED = 8.083E+05, MASS EVAPORATED = 8.237E+06, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK=9.4E-01, AREA= 6.0E+04 M**2, THICKNESS= 2.5E-01 CM, MOLE WT=305.8
WEIGHT FRACTION WATER IN OIL = 9.7E-02, VISCOSITY =  1.4E+03 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.2E+03 CMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+02 BBL, DISPERSION= 4.9E+00 GMS/M*M/HR, EVAP RATE= 1.6E+01 GMS/M*M/HR

STEP SIZE OF 4.020E-02 IS BASED ON COT 2

TIME =  5.1E+00 HOURS, NASS FRACTION OF EACH CUT REMAINING:                                                          7
6.8E-08  9.4E-03  3.3E-01  7.8E-01  9.5E-01  9.8E-01  9.9E-01  9.9E-01  9.9E-01  9. 9E-01  9. 9E-01  9.9E-01  9.9E-01
9. 9E-01
MASS REMAINING = 1.293E+08, MASS DISPERSED = 1.101E+06, MASS EVAPORATED =  9.126E+06, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AnEA. 6.6E+04 M**2, THICKNESS= 2.2E-01 CM, MOLE WT=309.1
WEIGHT FRACTION WATER IN OIL = 1.2E-01, VISCOSITY =  1.7E+03 CENTISTOKES, DISPERSION TERM =  2.3E-03  WEIGHT FRACTION/HR
MASS/AREA=2.0E+03 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.1E+02 BBL, DISPERSION= 4.5E+00 GMS/M*M/HR, EVAP RATE= 1.2E+01 GMS/M*M/HR

STEP SIZE OF 3.578E-02 IS BASED ON CUT 2

TIME = 6.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAININGI                                                           8
3.8E-10  2.1E-03  2.3E-01  7.2E-01  9.3E-01  9.8E-01  9.9E-01  9.9E-01  9.9E-01  9. 9E-01  9. 9E-01  9.9E-01  9.9E-01  9. 9E-01
9. 9E-01
MASS REMAINING =  1.283E+08, MASS DISPERSED =  1.401E+06, MASS Evaporated = 9.871E+06, SUM =  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 7.2E+04 M**2, THICKNESS= 2.0E-01 CM, MOLE WT=312.0
WEIGHT FRACTION WATER IN OIL = 1.4E-01, VISCOSITY =  1.9E+03 CENTISTOKES, DISPERSION TERM = 2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.8E+03 CMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.0E+02 BBL, DISPERSION= 4.2E+00 GMS/M*M/HR,  EVAP RATE= 9.5E+00 GMS/M*M/HR

TIME =  7.1E+00 SOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          9
0.0E+00  4.3E-04  1.6E-01  6.7E-01  9.1E-01  9.7E-01  9.8E-01  9.9E-01  9.9E-01  9.9E-01  9. 9E-01  9. 9E-01  9.9E-01  9.9E-01
9.9E-01
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TABLE 15a (.Continued): Output from Qil-Weathering Calculations; Prudhoe Bay Crude Oil, Final Time Step at 32°F.

```
TIME=8.2E+01 HOURS. NASS FRACTION OF EACH CUT REMAINING:                                                                  64
0.0E+00  0.0E+00  0.0E+00  2.7E-08  2.9E-02  4.9E-01  8.1E-01  8.7E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
0. 9E-01
MASS REMAINING =  1.053E+08,MASS DISPENSED =  1.401E+07, MASS EVAPORATED = 2.018E+07, SUM =  1.395E+08
FRACTION (BASED On MASS) REMAINING IN TSE SLICK= 7.5E-01, AREA= 2.4E+05 M**2, THICKNESS= 4.9E-02 CM. MOLE WT=351.9
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 2.2E+05 CENTISTOKES, DISPERSION TERM = 8.9E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.5E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 7.3E+02 BBL, DISPERSION= 4.0E-01 GMS/M*M/HR, EVAP RATE=1.8E-01GMS/M*M/HR


STEP SIZE OF 5.000E-01 IS BASED ON CUT 5

TIME =  9.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                               55
0.0E+00 0.0E+00 0.0E+00   9.1E-10   1.5E-02   4.4E-01   7.8E-01   8.6E-01   8.8E-01   8.8E-01   8.8E-01   8.8E-01   8.8E-01   8.8E-01
8. 8E-0 1
MASS REMAINING =  1.040E+08, MASS DISPERSED .  1.494E+07, MASS EVAPORATED  2.058E+07, SUM "  1.395E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.5E-01, AREA= 2.5E+05 M**2, THICKNESS= 4.6E-02 CM. MOLE WT=353.5
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 2.6E+05 CENTISTOKES, DISPERSION TERM = 8.8E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.2E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 7.2E+02 BBL, DISPERSION= 3.7E-01 GMS/M*M/HR,  EVAP RATE= 1.5E-01 GMS/M*M/HR


TBE CUT NUMBERING BEGINS WITS 1 BASED ON T8E ORIGINAL COT NUMBERS

TOE FINAL NASS FRACTIONS FOn TNE SLICK AT 1.0E+02 HOURS ARE:                                                              56
0.000E+00  0.000E+00  0.000E+00  0.000E+00  8.129E-03  3.894E-01  7.661E-01  8.562E-01  8.702E-01  8.723E-01  8.725E-01
8.725E-01  8.725E-01  8.725E-01  8.725E-01
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.4E-01, AREA= 2.6E+05 M**2, THICKNESS= 4.4E-02 CM, MOLE WT=353.5
MASS REMAINING = 1.029E+08, MASS DISPERSED =  1.571E+07, MASS EVAPORATED = 2.089E+07, SUM =  1.395E+08

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TABLE 15b: Output from Oil-Weathering Calculations; Prudhoe Bay Crude Oil Vapor Pressures at 60°F.

CRUDE OIL CHARACTERIZATION AND PSEUDOCOMPONENT EVAPORATION MODEL
IDENTIFICATION: PRUDHOE BAY, ALASKA

ITEM 9, SAMPLE 71011
VAPOR PRESSURE IN ATMOSPHERES AT 6.000E+01 DEG F

| | VP |
|---|---|
| 1 | 8.843E-02 |
| 2 | 2.830E-02 |
| 3 | 8.209E-03 |
| 4 | 2.004E-03 |
| 5 | 4.492E-04 |
| 6 | 8.934E-05 |
| 7 | 1.662E-05 |
| 8 | 2.801E-06 |
| 9 | 4.596E-07 |
| 10 | 4.453E-08 |
| 11 | 2.257E-09 |
| 12 | 1.879E-10 |
| 13 | 7.774E-12 |
| 14 | 2.070E-13 |

MEAN MOLECULAR WEIGHT OF TEE CRUDE = 2.739E+02

TABLE 15.b (Continued) Output from Oil-Weathering Calculations; Prudhoe Bay Crude Oil, Mass-Transfer Coefficients, Problem Specifications, and Beginning of Calculated Results at 60°F (Note deletion of cut 1 and renumbering of cuts)..

```
OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT CODE 2

OVER-ALL MASS-TRANSFER COEFFICIENT FOR CUMENE =  1.926E+01 M/HR

 CUT          M/HR        GM-MOLES/(HR )(ATM)(: M**2 )
  1        2.062E+01          8.716E+02
  2        2.031E+01          8.585E+02
  3        2.007E+01          8.4 81E+02
  4        1.984E+01          8. 386E+02
  5        1.965E+01          8. 303E+02
  6        1.946E+01          8.226E+02
  7        1.932E+01          6.1 65E+02
  8        1.919E+01          8.11 2E+02
  9        1.910E+01          8.071E+02
 10        1.898E+01          8.022E+02
 11        1.885E+01          7.965E+02
 12        1.876E+01          7.930E+02
 13        1.868E+01          7.893E+02
 14        1.859E+01          7.858E+02

FOR THIS SPILL OF 1.000E+03 BARRELS, THE NASS IS 1.412E+02 METRIC TONNES

VOLUME FROM SUMMING T8E CUTS =  1.6E+02 M**3, OR 1.000E+03 BARRELS

WIND SPEED ▫  1.000E+01 KNOTS, on 1.853E+04 M/HR

INITIAL SLICK DIAMETER =  1.006E+02 H, OR AREA = 7.950E+03 M**2

KINEMATIc VISCOSITY OF TRE BULK CRUDE FROM TBE COTS = 4.9E+00 CENTISTOKES AT 122 DEO F

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS = 7.2E+00 ATT = 60.0 DEG F, SCALE FACTOR =  1. 5E+00

VISCOSITY ACCORDING TO MASS EVAPORATED: VIS25C = 3.50E+01, ANDRADE = 9.00E+03, FRACT WEATHERED = 1.05E+01, VSLEAD = 9.30E+01 CP

MOUSSE CONSTANTS: MOONEY= 6.20E-01, NAX H20= 0.70, WIND**2= 1.00E-03

TOE FRACTIONAI. SLICK AREA SUBJECT TO DISPERS1ON IS4.1E+00 PEN NOUR
THE DISPERSION PARAMETERS USED: KA =  1.08E-01,KB = 5.00E+01, SURFACE TENSION = 3.00E+01 DYNES/CM

COURT THE COTS IN THE FOLLOWING OUTPUT FROM LEFT TO RIGHT

THE INITIAL GRAM MOLES IN TEE SLICK ARE:
 2.565E+04 2.911E+04 3.633E+04 3.423E+04  3.213E+04  2.743E+04  3.108E+04  3.219E+04  3.148E+04  1.625E+04  3.309E+04
 3.211E+04  2.566E+04  2.846E+04  9.420E+04

TUE  INITIAL MASSES (GRAMS) IN TUE SLICK  ARE:                                                                          1
 2.208E+06  2.956E+06  4.138E+06  4.375E+06  4.596E+06  4.407E+06  5.530E+06  6.308E+06  6.690E+06  3.843E+06  9.005E+06
 9.594E+06  8.585E+06  1.069E+07  5.652E+07
THE TOTAL NASS FROM THESE COTS IS 1.395E+08 GRAMS .

CDT 1 GOES AWAY IN MINUTES, THEREFORE IT WAS DELETED AND TBE CUTS renumbered

 STEP SIZE OF 1.279E-01 IS BASED ON CUT 1

 TIME = 0.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                             2
 1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1. 0E+00
 MASS REMAINING =  1.372E+08, MASS DISPENSED =  0.000E+00, MASS EVAPORATED = 0.000E+00, SUM =  1.372E+08
 FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 7.8E+03 M**2,  THICKNESS= 2.0E+00 CM, MOLE WT=283.7
 WEIGHT FRACTION WATER IN OIL = 6.9E-05, VISCOSITY =  1.1E+02 CENTISTOKES,DISPERSION TERM =  9.8E-04 WEIGHT FRACTION/HR
 MASS/AREA= 1.8E+04 GMS/M*M, SPGR= 8.8E-01, TOTAL VOLUME= 9.8E+02 BBL, DISPERSION= 1.7E+01 GMS/M*M/HR, EVAP RATE= 0.0E+00 GMS/M*M/HR

 TIME = 1.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                             3
 3.3E-01   7.3E-01 9.3E-01 9.8E-01 1.0E+00 1.0E+00 1.0E+00   1.0E+00   1.0E+00  1.0E+00  1.0E+00  1.0E+00  1.0E+00  1. 0E+00
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TABLE 15.b (Continued) Output from Oil-Weathering Calculations, Prudhoe Bay Crude Oil, Final Time Step at 60°F (Note Renumbering of cuts).

```
MASS REMAINING = 9.346E+07, MASS DISPERSED = 2.191E+07, MASS Evaporated = 2.187E+07, SUM =  1.372E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.7E-01, AREA= 2.2E+05 M**2, THICKNESS= 4.6E-02 CM, MOLE WT=367.6
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY =  1.4E+05 CENTISTOKES, DISPERSION TERM =  1.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.2E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.4E+02 BBL, DISPERSION= 5.0E-01 GMS/M*M/HR, EVAP RATE= 2.2E-01 GMS/M*M/HR


STEP SIZE OF 5.0001%-01 IS BASED ON CUT 6

TIME = 9.2E+01 NOUNS, MASS FRACTION OF EACH CUT REMAINING:                                                    62
0.0E+00  0.0E+00  0.0E+00  3.8E-08  2.9E-02  4.4E-01  7.3E-01  8.0E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01
MASS REMAINING = 9.190E+07, MASS DISPENSED = 2.301E+07, MASS Evaporated = 2.233E+07, SUM =  1.372E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.6E-01, AREA= 2.3E+05 M**2, THICKNESS= 4.3E-02 CM, MOLE WT=369.5
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY =  1.8E+05 CENTISTOKES, DISPERSION TERM .  1.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.9E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.3E+02 BBL, DISPERSION= 4.5E-01 GMS/M*M/HR, EVAP RATE= 1.8E-01 GMS/M*M/HR


STEP SIZE OF 5.000E-01 IS BASED ON GUT 5

THE CUT NUMBERING BEGINS WITH 2 BASED ON THE ORIGINAL CUT NUMBENS

TNE FINAL HASS FRACTIONS FOR TBE SLICK AT 1.0E+02 HOURS ARE:                                                  53
0.000E+00  0.000E+00  0.000E+00  2.582E-09  1.699E-02  3.930E-01  7.105E-01  7.850E-01  7.989E-01 8.003E-01 8.004E-01
8.004E-01  8.004E-01  8.004E-01
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.5E-01, AREA= 2.4E+05 M**2, THICKNESS= 4.1E-02 CM, MOLE WT=369.5
MASS REMAINING = 9.060E+07, HASS DISPENSED =  2.394E+07, MASS EVAPORATED = 2.269E+07, SUM = 1.372E+08

*****************************************************************
```

TABLE 16a: Illustration of 80-Column Output from Open-Ocean Oil-Weathering Code, Prudhoe Bay Crude OIl at 32°F.

OIL WEATHERING FOR PRUDHOE BAY, ALASKA

CODE VERSION IS CUTVP2 OF FEBRUARY 83
TEMPERATURE= 32.0 DEG F. WIND SPEED= 19.0 KNOTS
SPILL SIZE= 1.000E+03 BARRELS
MASS-TRANSFER COEFFICIENT CODE= 2

FOR TEE OUTPUT TEAT FOLLOWS, MOLES=GRAM MOLES
GMS=GRAMS, VP=VAPOR PRESSURE IN ATMOSPHERES
BP=BOILING POINT IN DEG F, API=GRAVITY
MW=MOLECULAR WEIGHT

| CUT | MOLES | GMS | VP | BP | API | MW |
|---|---|---|---|---|---|---|
| 1 | 2.56E+04 | 2.29E+06 | 3.78E-02 | 1.67E+02 | 7.27E+01 | 89 |
| 2 | 2.91E+04 | 2.96E+06 | 1.09E-02 | 2.12E+02 | 6.42E+01 | 101 |
| 3 | 3.63E+04 | 4.14E+06 | 2.58E-03 | 2.57E+02 | 5.67E+01 | 113 |
| 4 | 3.42E+04 | 4.37E+06 | 5.64E-04 | 3.02E+02 | 5.16E+01 | 127 |
| 5 | 3.21E+04 | 4.60E+06 | 1.12E-04 | 3.47E+02 | 4.76E+01 | 143 |
| 6 | 2.74E+04 | 4.41E+06 | 1.96E-05 | 3.92E+02 | 4.52E+01 | 160 |
| 7 | 3.11E+04 | 5.53E+06 | 3.18E-06 | 4.37E+02 | 4.15E+01 | 177 |
| 8 | 3.22E+04 | 6.31E+06 | 4.63E-07 | 4.82E+02 | 3.78E+01 | 195 |
| 9 | 3.15E+04 | 6.69E+06 | 6.60E-08 | 5.27E+02 | 3.48E+01 | 212 |
| 10 | 1.63E+04 | 3.84E+06 | 5.30E-09 | 5.80E+02 | 3.06E+01 | 236 |
| 11 | 3.31E+04 | 9.01E+06 | 2.09E-10 | 6.38E+02 | 2.91E+01 | 272 |
| 12 | 3.21E+04 | 9.59E+06 | 1.42E-11 | 6.85E+02 | 2.62E+01 | 298 |
| 13 | 2.57E+04 | 8.59E+06 | 4.51E-13 | 7.38E+02 | 2.40E+01 | 334 |
| 14 | 2.85E+04 | 1.07E+07 | 8.82E-15 | 7.90E+02 | 2.25E+01 | 375 |
| 15 | 9.42E+04 | 5.65E+07 | 0.00E+00 | 8.50E+02 | 1.14E+01 | 600 |

MOUSSE CONSTANTS: MOONEY= 6.20E-01, MAX H20= 0.70, WIND**2= 1. 00E-03
DISPERSION CONSTANTS: KA= 1.08E-01, KB= 5.00E+01, S-TENSION= 3.00E+01
VIS CONSTANTS: VIS25C= 3.50E+01, ANDRADE = 9.00E+03, FRACT = 1.05E+01

FOR TBE OUTPUT THAT FOLLOWS, TIME=HOURS
BBL=BARRELS, SPGR=SPECIFIC GRAVITY, AREA=M*M
THICKNESS=CM. W=PERCENT WATER Ii ? OIL (MOUSSE)
DISP=DISPERSION RATE IN GMS/M*M/HR
ERATE=EVAPORTION RATE IN GMS/M*M/HR
M/A=MASS PER M*M OF OIL IN THE SLICK
I=FIRST CUT WITH GREATER THAN 1% (MASS) REMAINING
J=FIRST CUT WITH GREATER THAN 50% (MASS) REMAINING

| TIME | BBL | SPGR | AREA | THICKNESS | W | DISP | ERATE | M/A | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.0E+03 | 0.88 | 7.9E+03 | 2.0E+00 | 0 | 7.7E+00 | 0.0E+00 | 1.8E+04 | i | i |
| i | 9.7E+02 | 9.88 | 3.1E+04 | 5.0E-01 | 2 | 6.6E+00 | 9.9E+01 | 4.4E+03 | i | 2 |
| 2 | 9.5E+02 | 0.89 | 4.3E+04 | 3.5E-01 | 4 | 5.9E+00 | 4.2E+01 | 3.1E+03 | i | 3 |
| 3 | 9.3E+02 | 0.89 | 5.2E+04 | 2.9E-01 | 7 | 5.3E+00 | 2.5E+01 | 2.5E+03 | 2 | 3 |
| 4 | 9.2E+02 | 0.89 | 6.0E+04 | 2.5E-01 | 9 | 4.9E+00 | 1.6E+01 | 2.2E+03 | 2 | 4 |
| 5 | 9.1E+02 | 0.89 | 6.6E+04 | 2.2E-01 | 11 | 4.5E+00 | 1.2E+01 | 2.0E+03 | 3 | 4 |
| 6 | 9.0E+02 | 9.89 | 7.2E+04 | 2.0E-01 | 14 | 4.2E+00 | 9.5E+00 | 1.8E+03 | 3 | 4 |
| 7 | 9.0E+02 | 0.89 | 7.7E+04 | 1.8E-01 | 16 | 3.9E+00 | 7.7E+00 | 1.6E+03 | 3 | 4 |
| 8 | 8.9E+02 | 0.89 | 8.3E+04 | 1.7E-01 | 18 | 3.7E+00 | 6.3E+00 | 1.5E+03 | 3 | 4 |
| 9 | 8.8E+02 | 0.90 | 8.7E+04 | 1.6E-01 | 20 | 3.4E+00 | 5.2E+00 | 1.4E+03 | 3 | 4 |
| 10 | 8.8E+02 | 0.90 | 9.2E+04 | 1.5E-01 | 22 | 3.2E+00 | 4.4E+00 | 1.4E+03 | 3 | 5 |
| 11 | 8.7E+02 | 0.90 | 9.6E+04 | 1.4E-01 | 24 | 3.0E+00 | 3.8E+00 | 1.3E+03 | 3 | 5 |
| 12 | 8.7E+02 | 0.90 | 1.0E+05 | 1.4E-01 | 26 | 2.9E+00 | 3.3E+00 | 1.2E+03 | 3 | 5 |
| 13 | 8.6E+02 | 0.90 | 1.0E+05 | 1.3E-01 | 27 | 2.7E+00 | 2.9E+00 | 1.2E+03 | 4 | 5 |
| 14 | 8.6E+02 | 6.90 | 1.1E+05 | 1.3E-01 | 29 | 2.6E+00 | 2.6E+00 | 1.1E+03 | 4 | 5 |
| 15 | 8.5E+02 | 0.90 | 1.1E+05 | 1.2E-01 | 31 | 2.4E+00 | 2.4E+00 | 1.1E+03 | 4 | 5 |
| 16 | 8.5E+02 | 0.90 | 1.1E+05 | 1.2E-01 | 32 | 2.3E+00 | 2.2E+00 | 1.1E+03 | 4 | 5 |
| 17 | 8.4E+02 | 0.90 | 1.2E+05 | 1.1E-01 | 34 | 2.2E+00 | 2.0E+00 | 1.0E+03 | 4 | 5 |
| 18 | 8.4E+02 | 0.90 | 1.2E+05 | 1.1E-01 | 35 | 2.1E+00 | 1.8E+00 | 9.9E+02 | 4 | 5 |
| 19 | 8.4E+02 | 0.90 | 1.2E+05 | 1.1E-01 | 37 | 2.0E+00 | 1.7E+00 | 9.6E+02 | 4 | 5 |
| 20 | 8.3E+02 | 0.90 | 1.3E+05 | 1.0E-01 | 38 | 1.9E+00 | 1.6E+00 | 9.4E+02 | 4 | 5 |

TABLE 16b: Illustration of 80-Column Output from Open-Ocean Oil-Weathering Code, Prudhoe Bay Crude Oil at 60 °F. (Note deletion of cut 1 at beginning out of weathering output).

OIL WEATHERING FOR PRUDHOE BAY, ALASKA

CODE VERSION IS CUTVP2 OF FEBRUARY 83
TEMPERATURE= 60.0 DEG F, WIND SPEED= 10.0 KNOTS
SPILL SIZE= 1.000E+03 BARRELS
MASS-TRANSFER COEFFICIENT CODE= 2

FOR THE OUTPUT THAT FOLLOWS, MOLES=GRAM MOLES
GMS=GRAMS, VP=VAPOR PRESSURE IN ATMOSPHERES
BP=BOILING POINT IN DEG F, API=GRAVITY
MW=MOLECULAR WEIGHT

| CUT | MOLES | GMS | VP | BP | API | MW |
|---|---|---|---|---|---|---|
| 1 | 2.5[illegible]E+04 | 2.29E+06 | 8. 84E-02 | 1.67E+02 | 7.27E+01 | 89 |
| 2 | 2.9[illegible]E+04 | 2.96E+06 | 2. 83E-02 | 2.12E+02 | 6 .42E+91 | 101 |
| 3 | 3.6[illegible]E+04 | 4.14E+06 | 8.21E-03 | 2.57E+02 | 5.67E+01 | 113 |
| 4 | 3.42E+04 | 4.37E+06 | 2.00E-03 | 3.02E+02 | 5.16E+01 | 127 |
| 5 | 3.2[illegible]E+04 | 4.60E+06 | 4.49E-04 | 3.47E+02 | 4.76E+01 | 143 |
| 6 | 2.7[illegible]E+04 | 4.41E+06 | 8.93E-05 | 3.92E+02 | 4.52E+01 | 160 |
| 7 | 3.1[illegible]E+04 | 5.53E+06 | 1.66E-05 | 4.37E+02 | 4.15E+01 | 177 |
| 8 | 3.22E+04 | 6.31E+06 | 2. 80E-06 | 4. 82E+02 | 3. 78E+01 | 195 |
| 9 | 3.15E+04 | 6.69E+06 | 4.60E-07 | 5.27E+02 | 3.[illegible]E+01 | 212 |
| 10 | 1.63E+04 | 3.84E+06 | 4.45E-08 | 5.80E+02 | 3.06E+01 | 236 |
| 11 | 3.3[illegible]E+04 | 9.01E+06 | 2 .26E-09 | 6.38E+02 | 2.91E+01 | 272 |
| 12 | 3.2[illegible]E+04 | 9.59E+06 | 1 .88E-10 | 6.85E+02 | 2.62E+01 | 298 |
| 13 | 2.5[illegible]E+04 | 8.59E+06 | 7.77E-12 | 7.38E+02 | 2.40E+01 | 334 |
| 14 | 2*85E+04 | 1.07E+07 | 2.07E-13 | 7.90E+02 | 2. 25E+01 | 375 |
| 15 | 9.42E+04 | 5.63E+07 | 0.00E+00 | 8.50E+02 | 1 .14E+01 | 600 |

MOUSSE CONSTANTS: MOONEY= 6.20E-01, MAX H20= 0.70, WIND**2= 1.00E-03
DISPERSION CONSTANTS: KA= 1.08E-01, KB= 5.00E+01, S-TENSION= 3.00E+01
VIS CONSTANTS: VIS25C= 3.50E+01, ANDRADE = 9.00E+03, FRACT = 1.05E+01

FOR THE OUTPUT TEAT FOLLOWS, TIME=HOURS
BBL=BARRELS, SPGR=SPECIFIC GRAVITY, AREA=M*M
THICKNESS=CM, W=PERCENT WATER IN OIL (MOUSSE)
DISP=DISPERSION RATE IN GMS/M*M/HR
ERATE=EVAPORTION RATE IN GMS/M*M/HR
M/A=MASS PER M*M OF OIL IN THE SLICE
I=FIRST CUT WITH GREATER THAN 1% (MASS) REMAINING
J=FIRST CUT WITH GREATER THAN 50% (MASS) REMAINING
GUT 1 GOES AWAY IN MINUTES, THEREFORE IT WAS DELETED AND THE CUTS RENUMBERED

| TIME | BBL | SPGR | AREA | THICKNESS | W | DISP | ERATE | M/A | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 9.8E+02 | 0.88 | 7.8E+03 | 2.0E+00 | 0 | 1.7E+01 | 0.0E+00 | 1.8E+04 | 1 | 1 |
| 1 | 9.5E+02 | 0.89 | 3.1E+04 | 4.9E-01 | 2 | 1.5E+01 | 1.2E+02 | 4.3E+03 | 1 | 2 |
| 2 | 9.2E+02 | 0.89 | 4.2E+04 | 3.4E-01 | 5 | 1.3E+01 | 5.3E+01 | 3.1E+03 | 1 | 3 |
| 3 | 9.0E+02 | 6.S9 | 5.1E+04 | 2.8E-01 | 7 | 1.1E+01 | 2.9E+01 | 2.5E+03 | 2 | 3 |
| 4 | 8.9E+02 | 0.90 | 5.9E+04 | 2.4E-01 | 9 | 1.0E+01 | 1.9E+01 | 2.1E+03 | 2 | 3 |
| 5 | 8.7E+02 | 0.90 | 6.5E+04 | 2.1E-01 | 12 | 9.1E+00 | 1.3E+01 | 1.9E+03 | 2 | 4 |
| 6 | 8.6E+02 | 0.90 | 7.1E+04 | 1.9E-01 | 14 | 8.3E+00 | 1.0E+01 | 1.7E+03 | 3 | 4 |
| 7 | 8.5E+02 | 0.90 | 7.6E+04 | 1.8E-01 | 16 | 7.7E+00 | 8.1E+00 | 1.6E+03 | 3 | 4 |
| 8 | 8.4E+02 | 0.90 | 8.1E+04 | 1.7E-01 | 18 | 7.1E+00 | 6.7E+00 | 1.5E+03 | 3 | 4 |
| 9 | 8.3E+02 | 0.90 | 8.5E+04 | 1.6E-01 | 20 | 6.5E+00 | 5.6E+00 | 1.4E+03 | 3 | 4 |
| 10 | 8.3E+02 | 0.90 | 9.0E+04 | 1.5E-01 | 22 | 6.0E+00 | 4.7E+00 | 1.3E+03 | 3 | 4 |
| 11 | 8.2E+02 | 0.90 | 9.4E+04 | 1.4E-01 | 24 | 5.6E+00 | 4.0E+00 | 1.2E+03 | 3 | 5 |
| 12 | 8.1E+02 | 0.90 | 9.8E+04 | 1.3E-01 | 26 | 5.2E+00 | 3.5E+00 | 1.2E+03 | 3 | 5 |
| 13 | 8.1E+02 | 0.90 | 1.0E+05 | 1.3E-01 | 27 | 4.9E+00 | 3.1E+00 | 1.1E+03 | 3 | 5 |
| 14 | 8.0E+02 | 0.93 | 1.0E+05 | 1.2E-01 | 29 | 4.5E+00 | 2.8E+00 | 1.1E+03 | 3 | 5 |
| 15 | 7.9E+02 | 0.90 | 1.1E+05 | 1.2E-01 | 31 | 4.2E+00 | 2.5E+00 | 1.1E+03 | 4 | 5 |
| 16 | 7.9E+02 | 0.90 | 1.1E+05 | 1.1E-01 | 33 | 4.0E+00 | 2.2E+00 | 1.0E+03 | 4 | 5 |
| 17 | 7.8E+02 | 0.90 | 1.1E+05 | 1.1E-01 | 34 | 3.7E+00 | 2.1E+00 | 9.8E+02 | 4 | 5 |
| 18 | 7.8E+02 | 0.90 | 1.2E+05 | 1.0E-01 | 36 | 3.5E+00 | 1.9E+00 | 9.5E+02 | 4 | 5 |
| 20 | 7.7E+02 | 0.90 | 1.2E+05 | 1.0E-01 | 37 | 3.3E+00 | 1.7E+00 | 9.2E+02 | 4 | 5 |

TABLE 17: Execution of Open-Ocean Oil-Weathering Code on SAI's DEC-10 system. Underlined Characters are Entered by User.

```
connecting to host system.
Science App Inc 701a.20 09:50:19 TTY31 system 1256
Connected to Node LJASYN(2) Line # 57
Please LOGIN or ATTACH

●LOG
JOB 58 Science App Ine 701a.20 TTY31
PPN:4601,4601
Password:
09:50    8-Mar-83        Tue

.EX CUTVP2.FOR
LINK:   Loading
[LNKXCT  CUTVP2 execution]



DO 11 AGAIN?
N

CPU time 1.75   Elapsed time 2:19.85

EXIT

.PRINT CUTVP2.OUT
[Printer Job CUTVP2 queued, request #6115, limit 35]



.TYPE CUTVP2.TYP

 OIL WEATHERING FOR LIGHT DIESEL CUT

 CODE VERSION IS CUTVP2 OF FEBRUARY 83
 TEMPERATURE=  32.0 DEG F, WIND SPEED=  10.0 KNOTS
 SPILL SIZE=  1.000E+04 BARRELS
 MASS-TRANSFER COEFFICIENT CODE= 2


.BYE
 Charge....  0.1 J     3*7 CP    614 RD     61 WR= $   0.67
Job 58 User OIL-WEATHER [4601,4601]
Logged-off TTY31 at 9:54:29 on 8-Mar-83
Runtime:0:00:03,KCS:97, Connect time:0:04:02
Disk Reads:648, Writes:66, Blocks saved:279
```

TABLE 18. Illustration of Procedure to Attach to a Job

```
.log 1234,1234
303 29 Science App Inc 701.17e TTY'S
Password:<cr>

Other jobs detached with same PPN:
  Job 73 <program name> running
Do you want to ATTACH to this job? [Y]<cr>
.ATTACH 73[1234,1234]
[LGNATJ Attaching to job 73 running <program name> in user mode]
<cr>
```

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# APPENDIX A

# HOW TO USE TELENET

# HOW TO USE TELENET

## INFORMATION FOR TERMINAL USERS

### WELCOME TO TELENET

The Telenet public network makes it possible for terminal users to dial up a computer anywhere in the country at rates that are many times lower than long distance telephone rates.

Once you have become an authorized user of any of the computer centers on the network, you simply dial a local Telenet telephone number to make your connection. No prior arrangements with Telenet are necessary.

We think you will find the Telenet public network easy to use and highly reliable. If you are a new user, we suggest that you read through this entire writeup first. If you have any questions, the Customer Service Desk, (800) 336-0437, wi I I be happy to help answer them.

### TELENET SIGN-ON PROCEDURE

The instructions below explain how to connect to your computer through Telenet if you are using an ASCII-type terminal. In the examples, <cr> = carriage return and _ (underscore) = space. All other messages are automatically typed by Telenet.

### STEPS

1. Turn on the terminal and coupler.

2. Dial the nearest Telenet access number. When you hear a high-pitched tone, place the telephone receiver into the acoustic coupler.

3. Type two carriage returns.

4. Telenet will give you a port identification number and ask you to identify your terminal. Your response to "TERMINAL=" is a carriage return or appropriate terminal type such as DECW<cr> for DECwriter or D1<cr> for a CRT or TI745.

5. The La Jolla Computer Center will require an identification code and password before accepting your connection. In this case, after Telenet prompts with an @, type ID, skip a space, and type your ID code, followed by a carriage return.

   Example:

   @ID_LAJOLLA<cr>

Type in your password:

Password=nnnnnn<cr> ; cal I 454-3811 ext 2731 for the password

6. After Telenet prompts with an @, type a C, skip a space and type the network address of your computer, followed by a carriage return.

Example:

@C_714_20<cr> (for DEC-10)

7. Telenet will respond with a connection message. You are now ready to begin your conversation with the computer.

Example:

<cr>

SAI banner

PLEASE LOGIN OR ATTACH

LOG_P,PN<cr>

Password . .....<cr>

If the wrong password is typed, the response is .KJOB.

8. To disconnect from your computer, log off as usual.

Hang up the phone to disconnect from Telenet.

* * * *

DO NOT USE TELENET 800 DIALIN DATA ACCESS. This in watts service costs SAI far more than the cost allocated to computer users.

* * * $

## CUSTOMER SERVICE

TELEPHONE 800-336-0437 (From Virginia 800-572-0408)

Telenet's Customer Service Desk is available to assist users around the clock, seven days a week. Important: If you are reporting a problem with a network connection, be sure to give the port identification number which you received at call set-up time. If you are not sure what this number is, use the STAT network command (see page 5).

You may also contact Customer Service from your terminal. Follow exactly the same procedure given for connecting to any network address.

## CUSTOMER SERVICE NETWORK ADDRESS - 202 CS

This is a receive-only terminal on which you should leave your name, telephone number, and a brief description of your problem. Your message will be responded to promptly by telephone.

If you would like general information about Telenet and its services, please contact their corporate headquarters or any of the regional sales offices listed below:

| | |
|---|---|
| Boston | (617) 890-0202. |
| Chicago | (312) 298-2188 |
| Los Angeles | (213) 477-2048 |
| New York | (212) 594-6644 |
| Orange County, CA | (714) 891-4481 |
| San Francisco | (415) 854-5845 |
| Washington | (202) 637-7920 |

## EXPLANATION OF NETWORK MESSAGES

Messages that appear at call set-up time:

| | |
|---|---|
| @ | A Telenet prompt character that indicates that the network is waiting for a command. |
| TERMINAL = | A request to enter your terminal model identifier. |
| ? | The network does not understand your command. Check to see if you have made a typing error. If not, contact Telenet Customer Service. |

Messages that appear after you have requested a computer connection:

| | |
|---|---|
| CONNECTED | Your computer connection has been established. Follow normal log-in procedures. |
| BUSY, CONNECTIONS UNAVAILABLE | All computer ports are temporarily in *use,* Try again in a few minutes. If this condition persists, notify your computer center. |
| NOT AVAILABLE<br>NOT RESPONDING<br>NOT OPERATING | Your computer is not currently available to network users, Check with your computer center to see when service will be resumed. |
| ILLEGAL ADDRESS | Non-existent network address. Check for a typing error. |
| ILLEGAL DESTINATION ADDRESS<br>ILLEGAL SOURCE ADDRESS | You are not recognized as an authorized user of this computer system. No connection can be made by Telenet. |
| SUBPROCESS UNAVAILABLE | The application program requested is not available at this time. |
| NOT REACHABLE | Indicates a temporary network problem. Report condition to Telenet Customer Service. |
| REFUSED COLLECT CONNECTION | You must obtain a 'caller paid" identification code and password in order to access this system. Check with your computer center. |
| STILL CONNECTED | Your terminal is still actively connected to this address. If you wish to resume your session, enter the CONT command. |

STILL PENDING — You have a request still pending for connection to the address given. If you wish to connect to a different network address, you must disconnect with the D command.

DISCONNECTED — This message normally appears when you have logged off your computer or when you have given the D command to the network. If it appears by itself, it indicates your connection has been reset due to a problem. Follow normal connection procedures to continue your session. See Sign-On Procedure, Step 5, page 1.

## NETWORK COMMANDS

C — To request a connection to a computer address. The command is followed by a space, the computer address and a carriage return.

D<cr> — To disconnect from your computer system. This command is used in cases where the computer does not automatically send a DISCONNECTED message at logout time.

<cr>@<cr> — To interrupt your computer session to return to network command mode.

CONT<cr> — To return to your computer session after you have been in Telenet command mode.

FULL<cr> — To echo keyboard input on ASCII termina is.

HALF<cr> — To stop the network from echoing keyboard input on ASCII terminals.

STAT<cr> — To determine the identification number of the Telenet port you are using.

TAPE<cr> — To signify that your input wil i be paper tape or cassette. After you have set up the computer utility program for tape transmission, return to Telenet command mode. Type the TAPE command. Then start your tape. When the tape is completed, depress the BREAK key.

TERM = — To thange the terminal identifier specified at tail set-up time. The command is followed by a new two or four-character terminal identifier and a carriage return.

LAST UPDATE: 08/09/82

* NEW TELENET CENTRAL OFFICE
\# NEW 1200 BAUD ACCESS AVAILABLE
& NEW TELENET CENTRAL OFFICE ADDED CURRENT MONTH
$ NEW 1200 BAUD ACCESS AVAILABLE ADDED CURRENT MONTH
% NEW-LEAD NUMBER/NUMBER CHANGED

GTE/TELENET PROVIDES LOCAL NETWORK ACCESS IN THESE U.S. CITIES OF 50,000 POPULATION OR MORE. IN-WATS ACCESS IS AVAILABLE IN OTHER LOCATIONS. 1200 BPS ACCESS NUMBERS REQUIRE THE USE OF BELL 212- OR VADIC 3405- COMPATIBLE MODEMS, AS NOTED.
(B) = BELL 212, (V) = VADIC 3405, (B/V) = EITHER BELL 212 OR VADIC 3405.

< > INDICATES THE ACTUAL LOCATION OF TELENET FACILITIES. IN SOME CASES, LOCAL ACCESS MAY REQUIRE EXTENDED METRO TELEPHONE SERVICE OR INVOLVE MESSAGE UNIT CHARGES.

TELENET CUSTOMER SERVICE:
CONTINENTAL USA -- 800/336-0437
IN VIRGINIA -- 800/572-0408
OUTSIDE CONTINENTAL USA -- 703/442-2200

TELEMAIL CUSTOMER SERVICE: 703/442-1900

| | 300 BPS | | | 1200 BPS |
|---|---|---|---|---|
| AL%205 BESSEMER | 326-3420 | <BIRMINGHAM> | (B/V) | 326-3420 |
| AL%205 BIRMINGHAM | 326-3420 | | (B/V) | 326-3420 |
| AL%205 FLORENCE | 766-9101 | | (B/V) | 766-9101 |
| AL 205 HUNTSVILLE | 539-2281 | | (B/V) | 539-2281 |
| AL%205 MOBILE | 432-1680 | | (B/V) | 432-1680 |
| AL 205 MONTGOMERY | 265-1500 | | (B/V) | 265-1500 |
| AL%205 SHEFFIELD | 766-9101 | <FLORENCE> | (B/V) | 766-9101 |
| AK 907 ANCHORAGE | 276-0271 | | (B/V) | 276-0271 |
| AK 907 JUNEAU | 586-9700 | | (B/V) | 586-9700 |
| AR%501 LITTLE ROCK | 372-4616 | | (B/V) | 372-4616 |
| AZ%602 MESA | 254-0244 | <PHOENIX> | (B/V) | 254-0244 |
| AZ%602 PHOENIX | 254-0244 | | (B/V) | 254-0244 |
| AZ%602 SCOTTSDALE | 254-0244 | <PHOENIX> | (B/V) | 254-0244 |
| AZ%602 TEMPE | 254-0244 | <PHOENIX> | (B/V) | 254-0244 |
| AZ 602 TUCSON | 745-1666 | | (B/V) | 745-1666 |
| CA 213 ALHAMBRA | 507-0909 | <GLENDALE) | (B/V) | 507-0909 |
| CA 714 ANAHEIM | 558-6061 | <SANTA ANA> | (B/V) | 558-7078 |
| CA 805 BAKERSFIELD | 327-8146 | | (B/V) | 327-8146 |
| CA 415 BURLINGAME | 595-0360 | <SAN CARLOS> | (B/V) | 591-0726 |
| CA%213 CANOGA PARK | 306-2984 | <MARINA DEL REY> | (B/V) | 306-2984 |
| CA%714 COLTON | 824-9000 | | (B/V) | 824-9000 |
| CA%408 CUPERTINO | 294-9119 | <SAN JOSE> | (B/V) | 294-9119 |
| CA%714 ES CONDIDO | 743-1210 | | (B/V) | 743-1210 |
| CA 213 EL MONTE | 507-0909 | <GLENDALE) | (B/V) | 507-0909 |
| CA 714 FULLERTON | 558-6061 | <SANTA ANA> | (B/V) | 558-7078 |
| CA 209 FRESNO | 233-0961 | | (B/V) | 233-0961 |
| CA 714 GARDEN GROVE | 898-9820 | | (B/V) | 898-9820 |
| CA%213 GLENDALE | 507-0909 | | (B/V) | 507-0909 |

| | | | | | |
|---|---|---|---|---|---|
| CA 415 | HAYWARD | 881-1382 | | | |
| CA 213 | HOLLYWOOD | 689-9040 | {LOS ANGELES> | (B/V) | 624-2251 |
| CA#213 | HOLLYWOOD | 937-3580 | <LOS ANGELES> | (B/V) | 937-3580 |
| CA 714 | HUNTINGTON BEACH | 558-6061 | <SANTA ANA> | (B/V) | 558-7078 |
| CA 213 | INGLEWOOD | 689-9040 | <LOS ANGELES> | (B/V) | 624-2251 |
| CA#213 | INGLEWOOD | 937-3580 | {LOS ANGELES> | (B/V) | 937-3580 |
| CA 213 | LOS ANGELES | 689-9040 | | (B/V) | 624-2251 |
| CA#213 | LOS ANGELES | 937-3580 | | (B/V) | 937-3580 |
| CA 415 | LOS ALTOS | 856-9930 | <PALO ALTO} | (B/V) | 856-9995 |
| CA 213 | LONG BEACH | 549-5150 | <SAN PEDRO> | (B/V) | 548-6141 |
| CA%213 | MARINA DEL REY | 306-2984 | | (B/V) | 306-2984 |
| CA 209 | MODESTO | 576-2852 | | (B/V) | 576-2852 |
| CA 415 | MOUNTAIN VIEW | 856-9930 | <PALO ALTO> | (B/V) | 856-9995 |
| CA 714 | NEWPORT BEACH | 558-6061 | <SANTA ANA} | (B/V) | 558-7078 |
| CA%415 | OAKLAND | 836-4911 | | (B/V) | 836-4911 |
| CA 805 | OXNARD | 659-4660 | <VENTURA} | (B/V) | 656-6760 |
| CA 415 | PALO ALTO | 856-9930 | | (B/V) | 856-9995 |
| CA 213 | PASADENA | 507-0909 | <GLENDALE> | (B/V) | 507-0909 |
| CA 415 | REDWOOD CITY | 595-0360 | <SAN CARLOS> | (B/V) | 591-0726 |
| CA%714 | RIVERSIDE | 824-9000 | <COLTON> | (B/V) | 824-9000 |
| CA%916 | SACRAMENTO | 448-6262 | | (B/V) | 448-6262 |
| CA%408 | SALINAS | 443-4940 | | (B/V) | 443-4940 |
| CA%714 | SAN BERNADINO | 824-9000 | <COLTON> | (B/V) | 824-9000 |
| CA%415 | SAN CARLOS | 591-0726 | | (B/V) | 591-0726 |
| CA 714 | SAN DIEGO | 231-1922 | | (B/V) | 233-0233 |
| CA 415 | SAN FRANCISCO | 362-6200 | | (B/V) | 956-5777 |
| CA%408 | SAN JOSE | 294-9119 | | (B/V) | 294-9119 |
| CA 415 | SAN MATEO | 595-0360 | {SAN CARLOS> | (B/V) | 591-0726 |
| CA 213 | SAN PEDRO | 549-5150 | | (B/V) | 548-6141 |
| CA 714 | SANTA ANA | 558-6061 | | (B/V) | 558-7078 |
| CA 805 | SANTA BARBARA | 682-5361 | | (B/V) | 682-5361 |
| CA%408 | SANTA CLARA | 294-9119 | <SAN JOSE> | (B/V) | 294-9119 |
| CA%213 | SANTA MONICA | 306-2984 | <MARINA DEL REY> | (B/V) | 306-2984 |
| CA%408 | SUNNYVALE | 294-9119 | <SAN JOSE> | (B/V) | 294-9119 |
| CA 213 | TORRANCE | 549-5150 | <SAN PEDRO> | (B/V) | 548-6141 |
| CA 213 | WOODLAND HILLS | 992-0144 | | | |
| CA 415 | WOODSIDE | 856-9930 | {PALO ALTO> | (B/V) | 856-9995 |
| CA%805 | VENTURA | 656-6760 | | (B/V) | 656-6760 |
| CO#303 | AURORA | 773-8500 | <DENVER> | (B/V) | 694-2710 |
| | | | | (B/V) | 741-4000 |
| CO#303 | BOULDER | 773-8500 | <DENVER> | (B/V) | 694-2710 |
| | | | | (B/V) | 741-4000 |
| CO%303 | COLORADO SPRINGS | 634-5676 | | (B/V) | 635-5361 |
| CO#303 | DENVER | 773-8500 | | (B/V) | 694-2710 |
| | | | | (B/V) | 741-4000 |
| CO#303 | LAKEWOOD | 773-8500 | <DENVER> | (B/V) | 694-2710 |
| | | | | (B/V) | 741-4000 |
| CT 203 | DANBURY | 794-9075 | | (B/V) | 794-9075 |
| CT 203 | GREENWICH | 348-0787 | {STAMFORD> | (B/V) | 348-0787 |
| CT 203 | HARTFORD | 522-0344 | | (B/V) | 247-9479 |
| CT%203 | MILFORD | 624-5954 | <NEW HAVEN> | (B/V) | 624-5954 |
| CT%203 | NEW HAVEN | 624-5954 | | (B/V) | 624-5954 |
| CT%203 | STAMFORD | 348-0787 | | (B/V) | 348-0787 |
| CT 203 | WEST HARTFORD | 522-0344 | {HARTFORD} | (B/V) | 247-9479 |
| DC%202 | WASHINGTON | 429-7896 | | (B/V) | 429-7800 |

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|---|---|---|---|---|
| DE 302 | WILMINGTON | '454-7710 | | (B/V) 454-7710 |
| FL 813 | CLEARWATER | 323-4026 | <ST. PETE> | (B/V) 323-4026 |
| FL 305 | FT. LAUDERDALE | 764-4505 | | (B/V) 764-4505 |
| FL%904 | JACKSONVILLE | 356-2264 | | (B/V) 356-2264 |
| FL%305 | MIAMI | 372-0230 | | (B/V) 372-0230 |
| FL 305 | ORLANDO | 422-4088 | | (B/V) 422-4088 |
| FL 813 | ST PETERSBURG | 323-4026 | | (B/V) 323-4026 |
| FL*904 | TALLAHASSEE | 224-6824 | | (B/V) 224-6824 |
| FL 813 | TAMPA | 224-9920 | | (B/V) 223-1088 |
| FL 305 | W PALM BEACH | 833-6691 | | |
| GA 404 | ATLANTA | 577-8911 | | (B/V) 523-0834 |
| GA 912 | SAVANNAH | 236-2605 | | |
| HI 808 | HONOLULU | 524-8110 | | (B) 524-8221 |
| IA 319 | CEDAR RAPIDS | 364-0911 | | (B/V) 364-0911 |
| IA 402 | COUNCIL BLUFFS | 341-7733 | <OMAHA, NE> | (B/V) 341-7733 |
| IA 515 | DES MOINES | 288-4403 | | (B/V) 288-4403 |
| ID 208 | BOISE | 343-0611 | | (B/V) 343-0611 |
| IL 312 | ARLINGTON HEIGHTS | 938-0500 | <CHICAGO> | (B/V) 938-0600 |
| IL 217 | CHAMPAIGN | 384-6428 | <URBANA> | (B/V) 384-6428 |
| IL 312 | CHICAGO | 938-0500 | | (B/V) 938-0600 |
| IL 312 | CICERO | 938-0500 | <CHICAGO} | (B/V) 938-0600 |
| IL 314 | EAST ST LOUIS | 421-4990 | <ST LOUIS, MO> | (B/V) 421-4990 |
| IL 312 | OAK PARK | 938-0500 | <CHICAGO> | (B/V) 938-0600 |
| IL 309 | PEORIA | 637-8570 | | (B/V) 637-8570 |
| IL 312 | SKOKIE | 938-0500 | <CHICAGO> | (B/V) 938-0600 |
| IL 217 | SPRINGFIELD | 753-1373 | | (B/V) 753-1373 |
| IL 217 | URBANA | 384-6428 | | (B/V) 384-6428 |
| IN*812 | EVANSVILLE | 424-5250 | | (B/V) 424-5250 |
| IN*219 | FT. WAYNE | 426-4022 | | (B/V) 426-4022 |
| IN 219 | GARY | 882-8800 | | (B/V) 882-8800 |
| IN 317 | INDIANAPOLIS | 635-9630 | | (B/V) 634-5708 |
| IN 219 | MISHAWKA | 233-7104 | <SOUTH BEND> | (B/V) 233-7104 |
| IN 219 | OSCEOLA | 233-7104 | <SOUTH BEND} | (B/V) 233-7104 |
| IN 219 | SOUTH BEND | 233-7104 | | (B/V) 233-7104 |
| KS 816 | KANSAS CITY | 221-9900 | <KANSAS CITY, MO> | (B/V) 221-9900 |
| KS 913 | TOPEKA | 233-9880 | | (B/V) 233-9880 |
| KS 316 | WICHITA | 262-5669 | | (B/V) 262-5669 |
| KY*502 | BOWLING GREEN | 843-9026 | | (B/V) 843-9026 |
| KY%502 | FRANKFORT | 875-3920 | | (B/V) 875-3920 |
| KY 606 | LEXINGTON | 233-0312 | | |
| KY%502 | LOUISVILLE | 589-5580 | | (B/V) 589-5580 |
| LA 504 | BATON ROUGE | 343-0753 | | |
| LA 318 | MONROE | 387-6330 | | |
| LA%504 | NEW ORLEANS | 524-4094 | | (B/V) 524-4094 |
| LA 318 | SHREVEPORT | 221-5833 | | (B/V) 221-5833 |
| ME 207 | AUGUSTA | 623-5136 | | (B/V) 623-5136 |
| MD 301 | ANNAPOLIS | 266-6886 | | |
| MD 301 | BALTIMORE | 962-5010 | | (B/V) 727-6060 |
| MD%202 | BETHESDA | 429-7896 | <WASH., D.C.> | (B/V) 429-7800 |
| MD 301 | DUNDALK | 962-5010 | <BALTIMORE> | (B/V) 727-6060 |
| MD%202 | ROCKVILLE | 429-7896 | <WASH., D.C.> | (B/V) 429-7800 |
| MD%202 | SILVER SPRING | 429-7896 | <WASH., D.C.> | (B/V) 429-7800 |
| MD 301 | TOWSON | 962-5010 | <BALTIMORE> | (B/V) 727-6060 |
| MA 617 | ARLINGTON | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 617 | BOSTON | 338-1400 | | (B/V) 338-7495 |

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|---|---|---|---|
| MA 617 BROOKLINE | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 617 CAMBRIDGE | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 413 CHICOPEE | 781-3811 | <SPRINGFIELD> | (B/V) 781-3811 |
| MA 413 HOLYOKE | 781-3811 | <SPRINGFIELD> | (B/V) 781-3811 |
| MA#617 LEXINGTON | 863-1550 | | (B/V) 863-1550 |
| MA 617 MEDFORD | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 617 NEWTON | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 617 QUINCY | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 617 SOMERVILLE | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA 413 SPRINGFIELD | 781-3811 | | (B/V) 781-3811 |
| MA 617 WALTHAM | 338-1400 | <BOSTON> | (B/V) 338-7495 |
| MA%617 WORCESTER | 755-4740 | | (B/V) 755-4740 |
| MI 313 ANN ARBOR | 996-0351 | | (B/V) 996-5995 |
| MI 616 BATTLE CREEK | 968-0929 | | (B/V) 968-0929 |
| MI 313 DETROIT | 964-5538 | | (B/V) 964-2989 |
| MI 313 FLINT | 233-3050 | | (B/V) 233-3050 |
| MI 616 GRAND RAPIDS | 458-1200 | | (B/V) 774-0966 |
| MI 616 KALAMAZOO | 385-0160 | | |
| MI%517 LANSING | 372-5400 | | (B/V) 484-2067 |
| MI 517 SAGINAW | 790-5166 | | |
| MI%313 WARREN | 575-9480 | | (B/V) 575-9480 |
| MN%218 DULUTH | 722-1719 | | (B/V) 722-1719 |
| MN%612 MINNEAPOLIS | 341-2459 | | (B/V) 341-2459 |
| MN%612 ST. PAUL | 341-2459 | <MINNEAPOLIS> | (B/V) 341-2459 |
| MO 314 FLORISSANT | 421-4990 | <ST. LOUIS> | (B/V) 421-4990 |
| MO 816 KANSAS CITY | 221-9900 | | (B/V) 221-9900 |
| MO 314 ST. LOUIS | 421-4990 | | (B/V) 421-4990 |
| MS#601 JACKSON | 969-0036 | | (B/V) 969-0036 |
| MT 406 HELENA | 443-0000 | | |
| NE*402 LINCOLN | 475-8392 | | (B/V) 475-8392 |
| NE 402 OMAHA | 341-7733 | | (B/V) 341-7733 |
| NH 603 CONCORD | 224-8110 | | (B/V) 224-1024 |
| NH 603 PORTSMOUTH | 431-2302 | | |
| NV 702 LAS VEGAS | 733-2158 | | (B/V) 737-6861 |
| NJ 609 ATLANTIC CITY | 348-0561 | | |
| NJ 201 BAYONNE | 623-6818 | <NEWARK> | (B/V) 623-0469 |
| NJ 201 JERSEY CITY | 623-6818 | <NEWARK> | (B/V) 623-0469 |
| NJ 609 MARLTON | 596-1500 | | (B/V) 596-1500 |
| NJ 201 MORRISTOWN | 455-0275 | | (B/V) 455-0275 |
| NJ 201 NEW BRUNSWICK | 246-1090 | | |
| NJ 201 NEWARK | 623-6818 | | (B/V) 623-0469 |
| NJ 201 PASSAIC | 777-0952 | | |
| NJ 201 PATERSON | 684-7560 | | (B/V) 684-7560 |
| NJ*609 PRINCETON | 683-1312 | | (B/V) 683-1312 |
| NJ 609 TRENTON | 989-8847 | | (B/V) 989-8847 |
| NJ 201 UNION CITY | 623-6818 | <NEWARK> | (B/V) 623-0469 |
| NM 505 ALBUQUERQUE | 243-7701 | | (B/V) 243-4479 |
| NY 518 ALBANY | 445-9111 | | (B/V) 465-8444 |
| NY 607 BINGHAMTON | 772-6642 | | (B/V) 772-6642 |
| NY 716 BUFFALO | 847-0600 | | (B/V) 847-1440 |
| NY#516 DEER PARK | 667-5566 | | (B/V) 667-5566 |
| NY 516 HEMPSTEAD | 292-0320 | | (B/V) 292-3800 |
| NY#212 NEW YORK | 785-2540 | | (B/V) 785-3860 |
| | 736-0099 | | (B/V) 947-9600 |
| NY%914 POUGHKEEPSIE | 473-2240 | | (B/V) 473-2240 |

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|---|---|---|---|---|
| NY 716 | ROCHESTER | 454-3430 | | (B/V) 454-1020 |
| NY 518 | SCHENECTADY | 445-9111 | <ALBANY> | (B/V) 465-8444 |
| NY 315 | SYRACUSE | 472-5503 | | (B/V) 472-5583 |
| NY 518 | TROY | 445-9111 | <ALBANY> | (B/V) 465-8444 |
| NY 315 | UTICA/ROME | 797-0920 | | (B/V) 797-0920 |
| NY 914 | WHITE PLAINS | 328-9199 | | (B/V) 328-9199 |
| NC 704 | ASHEVILLE | 253-3517 | | (B/V) 253-3517 |
| NC 704 | CHARLOTTE | 374-0371 | | (B/V) 332-3131 |
| | | | | (B/V) 377-6865 |
| NC 919 | DAVIDSON | 549-8311 | <RESEARCH TRI. PARK> | (B/V) 549-8139 |
| NC 919 | DURHAM | 549-8311 | <RESEARCH TRI. PARK> | (B/V) 549-8139 |
| NC 919 | GREENSBORO | 273-2851 | | (B/V) 273-2851 |
| NC 919 | HIGH POINT | 899-2253 | | (B/V) 889-2253 |
| NC 919 | RALEIGH | 549-8311 | {RESEARCH TRI. PARK> | (B/V) 549-8139 |
| NC 919 | RESEARCH TRI.PARK | 549-8311 | | (B/V) 549-8139 |
| NC 919 | WINSTON-SALEM | 725-2126 | | (B/V) 725-2126 |
| OH 216 | AKRON | 762-9791 | | (B/V) 762-9791 |
| OH 216 | CANTON | 452-0903 | | |
| OH%513 | CINCINNATI | 579-0390 | | (B/V) 579-0390 |
| OH%216 | CLEVELAND | 575-1658 | | (B/V) 575-1658 |
| OH 614 | COLUMBUS | 463-9340 | | (B/V) 463-9340 |
| OH%513 | DAYTON | 461-5254 | | (B/V) 461-5254 |
| OH 216 | EUCLID | 241-0940 | <CLEVELAND> | (B/V) 696-4225 |
| OH 216 | KENT | 678-5115 | | |
| OH 216 | PARMA | 241-0940 | <CLEVELAND> | (B/V) 696-4225 |
| OH%419 | TOLEDO | 255-7881 | | (B/V) 255-7881 |
| OH 216 | YOUNGSTOWN | 743-2296 | | (B/V) 7'43-2296 |
| OK 405 | BETHANY | 232-4546 | <OKLAHOMA CITY) | (B/V) 232-4546 |
| OK 405 | NORMAN | 232-4546 | <OKLAHOMA CITY> | (B/V) 232-4546 |
| OK 405 | OKLAHOMA CITY | 232-4546 | | (B/V) 232-4546 |
| OK 405 | STILLWATER | 624-1112 | | |
| OK 918 | TULSA | 584-32,47 | | (B/V) 584-3247 |
| OR 503 | PORTLAND | 295-3000 | | (B/V) 295-3028 |
| OR 503 | SALEM | 378-7712 | | (B/V) 378-7712 |
| PA 215 | ALLENTOWN | 435-3330 | | (B/V) 435-3330 |
| PA 814 | ERIE | 453-7561 | | (B/V) 453-6859 |
| PA%717 | HARRISBURG | 236-6882 | | (B/V) 236-6882 |
| PA 814 | JOHNSTOWN | 535-7576 | | (B/V) 535-8541 |
| PA 215 | KING OF PRUSSIA | 337-4300 | | (B/V) 337-4300 |
| PA 412 | PENN HILLS | 288-9950 | <PITTSBURGH> | (B/V) 288-9974 |
| PA 215 | PHILADELPHIA | 574-0620 | | (B/V) 574-9462 |
| PA 412 | PITTSBURGH | 288-9950 | | (B/V) 288-9974 |
| PA 717 | SCRANTON | 961-5321 | | |
| PA 215 | UPPER DARBY | 574-0620 | <PHILADELPHIA> | (B/V) 574-9462 |
| PA 717 | YORK | 846-6550 | | (B/V) 846-6550 |
| RI%401 | PROVIDENCE | 751-7912 | | (B/V) 751-7912 |
| RI%401 | WARWICK | 751-7912 | <PROVIDENCE) | (B/V) 751-7912 |
| SC%803 | CHARLESTON | 722-4303 | | (B/V) 722-4303 |
| SC%803 | COLUMBIA | 254-0695 | | (B/V) 254-0695 |
| SC%803 | GREENVILLE | 233-3486 | | (B/V) 233-3486 |
| SD 605 | PIERRE | 224-6188 | | (B/V) 224-6188 |
| TN%615 | CHATTANOOGA | 756-1161 | | (B/V) 756-1161 |
| TN 615 | KNOXVILLE | 523-5500 | | (B/V) 523-5500 |
| TN%901 | MEMPHIS | 521-0215 | | (B/V) 521-0215 |
| TN 615 | NASHVILLE | 244-8310 | | (B/V) 244-5099 |

| | | | | |
|---|---|---|---|---|
| TX%915 | ABILENE | 676-8545 | | (B/V) 676-8545 |
| TX 512 | AUSTIN | 928-1130 | | (B/V) 928-1130 |
| TX 512 | CORPUS CHRISTI | 884-9030 | | (B/V) 884-9030 |
| TX 214 | DALLAS | 748-0127 | | (B/V) 748-6371 |
| TX 915 | EL PASO | 532-7907 | | (B/V) 532-7907 |
| TX 817 | FORT WORTH | 336-7791 | | (B/V) 332-4307 |
| TX 713 | GALVESTON | 762-3308 | | (B/V) 762-3308 |
| TX%713 | HOUSTON | 227-1018 | | (B/V) 227-1018 |
| TX%512 | LACKLAND | 225-8004 | {SAN ANTONIO} | (B/V) 225-8004 |
| TX%713 | NEDERLAND | 724-6717 | i | (B/V) 724-6717 |
| TX%915 | SAN ANGELO | 944-7621 | | (B/V) 944-7621 |
| TX%512 | SAN ANTONIO | 225-8004 | | (B/V) 225-8004 |
| UT%801 | SALT LAKE CITY | 359-0149 | | (B/V) 359-0149 |
| VA%202 | ALEXANDRIA | 429-7896 | <WASHINGTON, D.C.} | (B/V) 429-7800 |
| VA%202 | ANNANDALE | 429-7896 | <WASHINGTON, D.C.} | (B/V) 429-7800 |
| VA 804 | CHESAPEAKE | 625-1186 | <NORFOLK} | (B/V) 625-1186 |
| VA%202 | FAIRFAX | 429-7896 | <WASHINGTON, D.C.> | (B/V) 429-7800 |
| VA%202 | FALLS CHURCH | 429-7896 | <WASHINGTON, D.C.> | (B/V) 429-7800 |
| VA 703 | HERNDON | 435-3333 | | |
| VA 804 | NEWPORT NEWS | 596-6600 | | (B/V) 596-6600 |
| VA 804 | NORFOLK | 625-1186 | | (B/V) 625-1186 |
| VA 804 | PORTSMOUTH | 625-1186 | <NORFOLK> | (B/V) 625-1186 |
| VA 804 | RICHMOND | 788-9902 | | (B/V) 788-9902 |
| VA%202 | SPRINGFIELD | 429-7896 | <WASHINGTON, D.C.> | (B/V) 429-7800 |
| VA%202 | VIENNA | 429-7896 | <WASHINGTON, D.C.} | (B/V) 429-7800 |
| VA 804 | VIRGINIA BEACH | 625-1186 | <NORFOLK> | (B/V) 625-1186 |
| VT*802 | BURLINGTON | 864-7942 | | (B/V) 864-7942 |
| VT 802 | MONTPELIER | 229-4966 | | |
| WA%206 | AUBURN | 939-9982 | | (B/V) 939-9982 |
| WA 206 | BELLEVUE | 447-9012 | <SEATTLE> | (B/V) 625-9612 |
| WA 206 | LONGVIEW | 577-5835 | | |
| WA 206 | SEATTLE | 447-9012 | | (B/V) 625-9612 |
| WA%509 | SPOKANE | 455-4071 | | (B/V) 455-4071 |
| WA%206 | TACOMA | 627-1791 | | (B/V) 627-1791 |
| WA 509 | WENATCHEE | 662-1901 | | (B/V) 662-1901 |
| WI 608 | MADISON | 251-5904 | | (B/V) 257-5010 |
| WI 414 | MILWAUKEE | 271-2560 | | (B/V) 271-3914 |
| WV 304 | CHARLESTON | 345-6471 | | (B/V) 345-6471 |
| WY%307 | CHEYENNE | 638-4421 | | (B/V) 638-4421 |
| IN-WATS 800 | | 424-9494 | | (B/V) 424-9494 |

# APPENDIX B

## CODE LISTING FOR OPEN-OCEAN OIL-WEATHERING CALCULATIONS

```
00010   C        ***** CUTVP2.FOR *****
00020   C
00030   C        THIS IS THE OPEN-OCEAN OIL-WEATHERING CODE AND
00040   C        THE OIL PHASE IS CONSIDERED WELL-STIRRED ALL THE
00050   C        TIME.
00060   C
00070   C        THIS VERSION OF THE OIL-WEATHERING CODE DIFFERS
00080   C        FROM CUTVP1 IN THE VISCOSITY CALCULATION.
00090   C
00100   C        JANUARY. 1983
00110   C
00120   C        GET YOUR OUTPUT FROM CUTVP2.OUT/FILE:FORTRAN
00130   C        THE PLOT FILE IS CUTVP2.PLT
00140   C        THE TYPE FILE IS CUTVP2.TYP
00150   C
00160          REAL*4 MW,MW1,KH,MTCA ,MTC,MASS ,MOLES,EOIL ,KAIR,KA,KB
00170         1,MK3,MK4,MK3L ,MK4L
00180          COMMON /COIL/ MW1,TC1 ,VC1,PC1,CNUM1 ,VIS1
00190          COMMON /SPILL/ MTC(30) ,VP(30) ,VLOC(30) ,RHO(30),MW(30)
00200         1,SPGR(30),FRACTS ,STEN,KB,DISPER ,Z,TERM2,SPREAD ,KMTC
00210          COMMON ,'PCODE/ VSLEAD,MK4, IOU, IPU, ITY
00220          COMMON /MOOSE/ WINDS,C1,C2,C3,C4
00230          DIMENSION TB(30),API (30) ,A(30 ),B(30) ,TBL( 6,30) ,APIL( 6,30)
00240         1,TC(30) ,PC(30),CNUM(30 ),T10(30) ,HVAP1 (30),HVAPZ(30 )
00250         2,VOLL( 6,30) ,VOL(30 ),MOLES(30) ,MTCA(30) ,VIS(30),VISK(30)
00260         3,VLOGK(30 ),HLAW(30 ),VC(30 ),APIBL( 6),NC(30)
00270         4,NCTS(6) ,NS(30) ,ITEML(6) ,ISAMPL(6)
00280          DIMENSION ANAME( 5),ANAMEL(6,5) ,C1 L(6),C2L(6),C4L(6 )
00290         1,STENL(6),VISZL( 6),MK3L( 6),MK4L(6)
00300          DATA (ANAMEL(1,J),J=1,5)/'PRUDH ','OE B-4" ,'Y, AL','ASKA "
00310         1,'      '/
00320          DATA (ANAMEL(2,J),J=1,5)/'COOK ', 'INLET".', ALA' ,'SKA "
00330         1,'      '/
00340          DATA (ANAMEL(3,J),J=1,5)/ 'WILMI','NGTON' .', CAL', 'IFORN'
00350         1,'IA    '/
00360          DATA (ANAMEL(4,J),J=1,5)/'MURBA' ,'If, AB','U DHA','BI "
00370         1,'      '/
00380          DATA (ANAMEL(5,J),J=1,5)/ 'LAKE ', 'CHICO' ."T, LO', 'UISIA'
00390         1,"NA    '/
00400          DATA  (ANAMEL(6,J),J=1,5)/'LIGHT' ,' DIES" ,'EL CU','T ',
430410        1'       '/
00420          DATA APIBL/27.,35.4,19.4,40 .5,54.7,38.9/
004343         DATA ITEML/9,7,94,99999,221 .1/
00440          DATA ISAMPL/71011,72025,71052, 99999,54062.2/
00450          DATA NCTS/15,16,13,16,16,11/
00460   C
00470   C        FOR CRUDE OIL THE RESIDUUM CUT IS ASSIGNED A NORMAL
00480   C        BOILING POINT OF 850.
00490   C
00500          DATA (TBL(1,J),J=1,30)/167. .212. .257..302..347..392.
00510         1.437..482..527.,580. .638. .685..738.,790..850 .,15*0./
00520          DATA (TBL(2,J),J=1,20)/122 . .167.,212.,257.,302 ..347.
00530         1,392..437.,482.,527. ,580.,638.,685.,738. ,790.,850.
00540         2,4*0./
00550          DATA (TBL(3,J),J=1,20)/212. .257 ..302..347.,392. ,437.
00560         1.482.,527.,580..638. ,685.,738.,850.,7*0 ./
00570          DATA (TBL(4,J),J=1,20)/122. . 167..212..257..302. .347.
00580         1.392..437.,482.,527. ,580..638.,685.,738. .790. .850.
00590         2.4*(3./
00600          DATA (TBL(5,J),J=1,20)/122. . 167..212..257..302..347 .
00610         1,392.,437.,482.,527 .,580 ..638. ,68S. ,738. .790. .850.
00620         2,4*0./
00630          DATA (TBL(6,J),J=1,11)/313 . .342 . .366. .395..41 5..48S. .461.
00640         1.479.,501 .,518.,538./
00650          DATA (APIL(1,J),J=1,30)/72 .7 . 64.2.56.7.51 .6.47 .6.45.2
00660         1,41.5,37.8,34.8,30. 6 ,29.1,26.2.24.,22.5 ,11.4,15*0./
```

```
00670          DATA (APIL(2,J),J=1,20)/89 .2.77.2. 65..59.5,55.4 ,50.8
00680         1,46.5.43.,39.6.37. ,32.8.31.3,28.7.26. 6.25.,11.6,4*0./
00690          DATA (APIL(3,J),J=1,20)/68. 6.58.7 .53. ,4S.1.43.2,3S.8
00700         1.35.4.32.3.26.8,24. 5,22.3,20 .3.8.9.7*0 ./
00710          DATA (APIL(4,J),J=1,20)/96.7 ,86.2.70.6.62.3,55.7,51 .6
00720         1.48.5,45.6.43..40.,35 .8,34 . ,30. ,28.4,26.6, 16.7.4*0./
00730          DATA (APIL(5,J),J=1,20)/92.4 .81 .,68.9. 62. 1.57.2.52 .5
00740         1.48.8.45.2.41.7,38.2.34 .4,33 .2.3(2.6.28.9.26. 1.18.1.4*0./
00750          DATA (APIL(6,J),J=1,11)/49 .6,47.3 |46 .,44..38.6.38.8.37.2
00760         1,35.4.33.9,33.1.32 .2/
00770          DATA (VOLL(1,J),J=1,30)/2.1.2 .6,3! 5.3.6,3.7,3.5,4.3,4 .8 . .
00780         1.5 . .2.8,6.5,6.8.6.0,7.4 .36.3.15*0./
00790          DATA (VOLL(2,J),J=1,20)/2.4 .2.5.5.9.6.1.5.1.5.2.4 .9
00800         1 ,5.1,5.2.5.,3.3.5.2 ,7.,4.2.4.2.25.6.4*() ./
00810          DATA (VOLL(3,J),J=1,20)/2.3 .2.4.2.4.2.5.2.8.3.6.4 .4
00820         1,5.3,4.7,6.3,4.1.5. 5.53.3,7*0./
00830          DATA (VOLL(4,J),J=1,20)/1.7 ,2.9.4 .9,6..6.8,6.5,5.7
00840         1 ,5.6,6.,4.9,5.7,5.6 .6.5. 6..5.6.19.3.4*0 ./
00850          DATA (VOLL(5,J),J=1,20)/7 . 5,8.2,9.7,11.,9.1.8.3 .7.2
00860         1.7.2.7.4. 6.9,3.5,3. .1.6 .1.4.1.9.2..4*0./
00870          DATA (VOLL(6,J),J=1,11)/4. 78.9. 57.9.09 .9.57.9.57. 9.57
00880         1.9.57.9.57,9.57,9.57 ,9.57/
00890   C
00900   C        C1L. C2L. AND C4L ARE THE MOUSSE FORMATION CONSTANTS,
00910   C        C1L 1S THE VISCOSITY CONSTANT.
00920   C        C2L IS THE INVERSE OF THE MAXIMUM WATER IN OIL WEIGHT
00930   c        FRACTION.  C4L IS THE WATER INCORPORATION RATE.
00940   C
00950          DATA C1L/0.62.0.62.0.63.0.64.0 .65,0.65/
00960          DATA C2L/1.42.3.33.1.43.5., -1..-1./
00970          DATA C4L/0.001.0 .001.0.01.0 .001.0.,0./
00980   C
00990   C        FOR THE DISPERSION PROCESS. KA IS THE CONSTANT IN THE
01000   C        SEA SURFACE DISPENSION EQUATION. KB IS THE CONSTANT IN
01010   C        THE DROPLET FRACTION EOUATION.  STENL(6) IS THE LIBRARY
01020   C        OIL-WATER SURFACE TENSION IN DYNES/CM.
01030   C
01040          DATA KA.KB.STENL/0.108.50 .,30. ,30. .30. .30. .30 .,3(3./
01050          DATA VISZL/35..35..195..15. ,13.5,11.5/
01060          DATA MK3L/9000. , 9000.,9000.,9000.,9000. .3000./
01070          DATA MK4W10.5. 7.4.15.3.10.5,_?,2./
01080          YI(X)=((1.-X)**0.38)/(X*X)
01090          OPEN(UNIT=32,DIALOG= 'DSKD:CUTVP2 .OUT' )
01100          OPEN(UNIT=34 ,DIALOG='DSKD :CUTVP2.PLT' )
01110          OPEN(UNIT=35 .DIALOG= 'DSKD:CUTVP2 .TYP')
01120          IOU=32
01130          IPU=34
01140          ITY=35
01150   c
01160   c        FILL IN SOME LIBRARY IDENTIFICATIONS.
01170   C
01180   10     TYPE 20
01190   20     FORMAT(1X. 'ENTER THE NUMBER OF TBP CUTS TO BE CHARACTERIZED
01200         1 ON 12")
01210          TYPE 30
01220   30     FORMAT(1X.'IF YOU HAVE NO INPUT DATA JUST ENTER 99")
01230          TYPE 40
01240   40     FORMAT(1X.'A 99 ENTRY WILL USE A LIBRARY EXAMPLE")
01250          I CODE= 1
01260          ACCEPT 50. NCUTS
01270   50     FORNAT(12)
01280          LSWTCH=NCUTS
01290   c
01300   c        LSWTCH=99 IS USED TO INDICATE THAT A LIBRARY CRUDE WAS
01310   c        CHOSEN .
01320   c
```

```
01330          IF(NCUTS. NE.99) GO TO 120
01340    C
01350    C       USING A LIBRARY CRUDE.
01360    C
01370          TYPE 60
01380    60    FORMAT(1X, 'CHOOSE A CRUDE ACCORDING TO:')
(31390         DO 80 I=1,6
01400          TYPE 70, I, (ANAMEL(I,J),J=1 ,5)
01410    70    FORMAT( X.11,' = ',5A5)
01420    80    CONTINUE
01430          ACCEPT 90, IC
01440    90    FORMAT(II)
01450          APIB=APIBL(IC)
01460          ITEM=ITEML(IC)
01470          ISAMP=ISAMPL(IC)
014s0          NCUTS=NCTS(I C)
01490          ICODE=2
01500          DO 100 J=1,5
01510          ANAME(J)=ANAMEL(IC,J)
01520    100   CONTINUE
01530          TYPE 110, (ANAME(J),J=1,5)
01540    110   FORMAT(/,1X,'YOU CHOSE: ',5A5)
01350          GO TO 200
01560    C
01570    C       USER IS ENTERING THE CRUDE DATA.
01580    C
01590    120   TYPE 130
01600    120   FORMAT(1X,'ENTER THE NAME OF THE CRUDE")
01610          ACCEPT 140, (ANAME(I),I=1,5)
01620    140   FORMAT(10A5 )
01630          TYPE 150
01640    150   FORMAT(1X,'ENTER AN IDENTIFICATION NUMBER FOR
01650         1 THIS CRUDE ON 15')
01660          ACCEPT 160. ITEM
01670    160   FORMAT(15)
01680          TYPE 170
01690    170   FORMAT( IX. 'ENTER A SAMPLE NUMBER ON 15')
01700          ACCEPT 160, ISAMP
01710          TYPE 180
01720    180   FORMAT(1X,'ENTER THE BULK API GRAVITY')
01730          ACCEPT 230, APIB
01740          TYPE 190
01750    190   FORMAT(/, 1X,'YOU MUST ENTER THE TRUE BOILING POINT
01'760        1 CUT DATA STARTING',/,1X,'WITH THE MOST VOLATILE CUT
01770         2 AND GOING TO THE BOTTOM OF THE BARREL",/)
01780    C
01790    C       CALCULATE THE BULK DENSITY OF THE CRUDE AT 60/60.
01800    C
01810    200   DCRUDE=141.5/(APIB+131 .5)
01820          DCRUDE=0 .983*DCRUDE
01830    C
01840    C       TRANSFER CRUDE INPUT DATA TO THE VARIABLES USED IN
018543   C       THE CALCULATIONS.
01860    C
01870          DO 270 I=1,NCUTS
01880          GO TO (210.260), ICODE
01890    210   TYPE 220, I
019~30   C
01910    C       ENTER THE CRUDE CUT DATA.
01920    C
01930    220   FORMAT(1X,'ENTER THE BOILING POINT AT 1 ATM IN DEG F
01940         1 FOR CUT' ,I3)
01950          ACCEPT 230, TB(I)
01960    230   FORMAT(F10.0)
01970          TYPE 240, I
01980    240   FORMAT(1X, 'ENTER API GRAVITY FOR CUT' ,I3)
```

```
01990          ACCEPT 230. API(I)
02000          TYPE 250, I
02010    250   FORMAT(1X, 'ENTER VOLUME PER CENT FOR CUT" ,13)
02020          ACCEPT 230, VOL(I)
02030          GO TO 270
02040    C
02050    C       TRANSFER CRUDE CUT INPUT DATA FROM THE LIBRARY.
02060    C
02070    260   TB(I)=TBL(IC,I)
02080          API(I)=APIL(IC,I)
02090          VOL(I)=VOLL(IC,I)
02100    270   CONTINUE
02110    C
02120    C       DISPLAY THE CUTS BACK TO THE USER.
02130    C
02140    280   TYPE 290
02150    290   FORMAT(/,1X,'CUT',5X,'TB' ,lox,'API '.8x. "voL')
02160          DO 310 I=1,NCUTS
02170          TYPE 300, I,TB(I),API(I),VOL(I)
02180    300   FORMAT(1X,I2,5X,F5.1,7X,F4.1,6X,F5.1)
02190    310   CONTINUE
02200          TYPE 320
02210    320   FORMAT(1X, 'DO YOU WANT' TO CHANGE ANY?' )
02220    330   ACCEPT 340, ANS
02230    340   FORMAT(A1)
02240          IF(ANS.EQ. 'N') GO TO 420
02250    C
02260    C       ALLOW THE INPUT TO BE CHANGED,
02270    C
02280          TYPE 350
02290    350   FORMAT(1X, "ENTER THE CUT NUMBER TO BE CHANGED ON 12')
02300          ACCEPT 50. N
02310          TYPE  360
02320    360   FORMAT(1X, 'ENTER 1 TO CHANGE TB, 2 FOR API. 3 FOR VOL%')
02330          ACCEPT 370, IC
02340    370   FORMAT(I1)
02350          TYPE 380
02360    380   FORMAT(1X, 'ENTER THE CHANGED DATA")
02370          GO TO (390,400,410), IC
02380    390   ACCEPT 230, TB(N)
02390          GO TO 280
02400    400   ACCEPT 230, API(N)
02410          GO TO 280
02420    410   ACCEPT 230. VOL(N)
02430          GO TO 280
02440    420   DO 430 I=2,NCUTS
02450          IM1=I-1
02460          IF(TB(I).LT.TB(IM1)) GO TO 440
02470    430   CONTINUE
02480          GO TO 460
02490    440   TYPE 450, I,IM1
02500    450   FORMAT(/,1X,'THE BOILING POINT OF CUT ",12
02510         1,' IS LESS THAN CUT ',I2,/,1X,'AND THIS ORDER IS NOT
02520         2 ACCEPTABLE, SO START OVER' ,/)
02530          GO TO 10
02540    C
02550    C       ALWAYS RENORMALIZE THE INPUT VOLUMES TO 100%.
02560    C
02570    460   VTOTAL=0.
02580          DO 470 I=1,NCUTS
02590          VTOTAL=VTOTAL+VOL (I)
02600    470   CONTI NUE
02610          DO 480 I=1,NCUTS
02620          VOL(I)=100.*VOL (I)/VTOTAL
02630    480   CONTINUE
02640    C
```

```
02650   c        NOW CHARACTERIZE ALL THE CUTS.   IF THE LAST CUT IS
02660   c        RESIDUUM DO NOT CHARACTERIZE IT BUT USE A VAPOR
02670   c        PRESSURE OF 0. AND A MOLECULAR WEIGHT OF 600.
02680   c
02690          MW(NCUTS)=600 .
02700          VP(NCUTS)=0.
02710   C
02720   C        NV=1 MEANS NC) RESIDUUM CUT PRESENT.
02730   C        NV=2 MEANS A RESIDUUM IS PRESENT.
02740   C
02750          NV=1
02760          NC1=NCUTS
02770          DO 550 I=1,NCUTS
02780          APIN=API(I)
02790          SPGR(I)=141.5/(API(I)+131.5)
02800          SPGR(I)=0.983*SPGR(I)
02810          TBN=TB(I)
02820   C
02830   C        THE RESIDUUM CUT IS IDENTIFIED BY A NORMAL BOILING
02840   C        POINT OF 850.   LOOP AROUND THE NV=2 SWITCH IF A
02850   C        RESIDUUM IS PRESENT.   NC1 IS THE NUMBER OF PSEUDO  COMPONENTS
02860   c        WITH FINITE VAPOR PRESSURES.
02870   c
02880          IF(TBN.LT.850. ) GO TO 490
02890          NV=2
02900          NC1=NCUTS- 1
02910   490    CALL CHAR(APIN,TBN,AN,BN,NSN,NV)
02920   c
02930   c        THE CHARACTERIZATION SUBROUTINE RETURNS THE LOG10 OF THE
02940   c        KINEMATIC VISCOSITY (CENTISTOKES) AT 122 DEG F.
02950   c
02960          VISK(I)=10.**VIS1
02970          VLOGK(I)=ALOG(VISK(I) )
02980          CO TO (500,550), NV
02990   c
03000   c        STORE THE CUT INFORMATION FOR A NON-RESIDUUM CUT.
03010   c
03020   500    NS(I)=NSN
03030          A(I)=AN
03040          B(I)=BN.
03050          MW(I)=MW1
03060          TC(I)=TC1
03070          TC(I)=TC(I)+459.
03080          VC(I)=VC1
03090          PC(I)=PC1
03100          CNUM(I)=CNUM1
03110   c
03120   C        FIND THE TEMPERATURE AT WHICH THE VAPOR PRESSURE IS 10 MMHG
03130   c        BY USING NEWTON-RAPHSON WITH TB AS THE FIRST GUESS.
03140   c
03150          NC(I)=0
03160          YTEN=ALOG10(0.01315/PC( I))
03170          X=(TB(I)+459.)/TC(I)
03180   510    EX=EXP(-20 .*(X-B(I))**2)
03190          Y=-A(I)*(1.-X)/X-EX
03200          YOBJ=Y-YTEN
03210          VP(I)=PC(I)*10.**Y
03220          TEST=ABS(VP(I)-0.01315)
03230          IF(TEST.LT.0.001315) GO TO 540
03240          NC(I)=NC(I)+1
03250          IF(NC(I).GT.20) CO TO 520
03260          DY=A(I)/(X*X)+40.*(X-B(I))*EX
03270          BI=YOBJ-DY*X
03280          X=-BI/DY
03290          GO TO 510
03300   c
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```
033 10   C        UNSUCCESSFUL EXIT FROM NEWTON-RAPHSON
03320    C
03330    520    TYPE  530, I,X,Y
03340    530    FORFL4T(1X.'TIO FAILURE FOR' ,I4,' AT T = ".1PE10.3, " WHERE
03350          1 LOG10(P) = ',IPE10.3)
03360           GO TO 2130
03370    C
03380    C        SUCCESSFUL EXIT FROM NEWTON-RAPHSON
03390    C
03400    540    T10(I)=X*TC(I)
03410    C
03420    C        CALCULATE THE HEAT OF VAPORIZATION AT 10 MMHG WITH THE
03430    C        CLAPEYRON EQUATION AND USE WATSONS METHOD FOR THE
03440    C        VAPOR PRESSURE BELOW 10 MMHG.  SEE GAMSON AND WATSON,
03450    C        1944, NATIONAL PETROLEUM NEWS, R-258 TO R-264.
03460    C
03470           TR2=T10(I)/TC(I)
03480           EX=92.12*(TR2-B(I))*EXP(-20.*(TR2-B(I))**2)
03490           HVAP=1.987*T10(I)*T10(I)*(2.303*A(I)/(TR2*TR2)+EX)/TC(I)
03500           HVAP1(I)=HVAP/MW(I)
03510           HVAPZ(I)=HVAP/(1.-TR2)**0.38
03520    550    CONTINUE
03530    C
03540    C        END OF TRUE-BOILING-POINT CUTS CHARACTERIZATION
03550    C
03560           WRITE (IOU,560) (ANAME(I), I=1,5)
03570    560    FORMAT(1H1, 'SUMMARY OF TBP CUTS CHARACTERIZATION  FOR '
03580          1, 5A5)
03590           WRITE (IOU,570)
03600    570    FORMAT(/,1X,'CODE VERSION IS CUTVP2 OF FEBRUARY 83")
03610           WRITE (10U.WIO) ITEM. ISAMP
03620    580    FORMAT(1X, 'ITEM ',15.'. SAMPLE ',I5)
03630           WRITE (IOU,590)
03640    590    FORMAT(/,8X,'TB',7X,'API',6X,'SPGR',7X,'VOL',8X,'MW',8X
03650          1,'TC',8X,'PC',8X,'VC',8X,'A',9X,'B',8X,'T10',7X,'VIS'
03660          2,4X, 'NC NS')
03670           DO 610 I=1,NCUTS
03680           WRITE(IOU,600) I,TB(I),API(I),SPGR(I),VOL(I),MW(I),TC(I)
03690          1,PC(I),VC(I),A(I),B(I),TIO(I),VISK(I),NC(I),NS(I)
03700    600    FORMAT(1X,I2,12(1X,1PE9.2),2(1X, I2))
03710    610    CONTINUE
03720           WRITE   (IOU,620)   API B
03730    620    FORMAT(//,1X,'BULK API GRAVITY = ',F5.1)
03740           WRITE (IOU,630)
0:1750   630    FORMAT(//,1X,'TB = NORMAL BOILING TEMPERATURE, DEG F')
03760           WRITE (IOU,640)
03770    640    FORMAT(1X,'API = API GRAVITY')
03780           WRITE (IOU,650)
03790    650    FORMAT(1X,'VOL = VOLUME PER CENT OF TOTAL CRUDE")
03800           WRITE (10U,660)
038 10   660    FORMAT(1X,'MW = MOLECULAR WEIGHT')
03820           WRITE (IOU,670)
03830    670    FORMAT(1X,'TC = CRITICAL TEMPERATURE. DEG RANKINE')
03840           WRITE (IOU,680)
03850    680    FORMAT(1X,'PC = CRITICAL PRESSURE. ATMOSPHERES')
03860           WRITE (IOU,690)
03870    690    FORMAT(1X, 'VC = CRITICAL VOLUME, CC/MOLE')
03880           WRITE (IOU,700)
03890    700    FORMAT(1X,'A AND B ARE PARAMETERS IN THE VAPOR PRESSURE
03900          1 EQUATION')
03910           WRITE (10U.710)
03920    710    FORMAT(1X,'T10 IS THE TEMPERATURE IN DEG R WHERE THE VAPOR
03930          1 PRESSURE IS 10 MM HG')
03940           WRITE (IOU,720)
03950    720    FORMAT(1X,'VIS IS THE KINEMATIC VISCOSITY IN CENTISTOKES
03960          i AT 122 DEG F')
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03970          WRITE (I OU,730)
03'380   730   FORMAT(1X, 'NC = ERROR CODE, SHOULD BE LESS THAN 20')
03990          WRITE (IOU,740)
04'000   740   FORMAT(1X, 'NS = ERROR CODE, SHOULD BE EQUAL TO 1')
04010          WRITE (IOU,750) NCUTS
04020   750    FORMAT(1X, "IGNORE THE ERROR CODES FOR COMPONENT NUMBER ',I2
04030         1." IF IT IS A RESIDUUM")
04040   760    WRITE (IPU,770) ITEM,ISAMP
04050   770    FORMAT(2I5)
04060          WRITE (IPU,780) (ANAME(I ),I=1,5)
04070   780    FORMAT(5A5)
04080   C
04090   C        THE CUTVP2.PLT PLOT FILE IS WRITTEN AS:
041 00  C             1.   ITEM AND SAMPLE NUMBER ON 2I5
04110   C             2.   THE CRUDE NAME ON 5A5
04 I 20 C             3.   NCUTS ON 15
04130   C             4.   BOILING POINT IN DEG F OF EACH CUT ON
04140   C                  1(3(1X. 1PE10.3).
04150   C             5.   TEMPERATURE IN DEG F OF EVAPORATION. XPRINT
04160   C                  WIND SPEED IN KNOTS, WINDS
04170   C                  KA AND KB IN THE DISPERS1ON EQUATION.
04180   C                  SURFACE TENSION IN DYNES/CM. STEN
04190   C                  VOLUME OF THE SPILL IN BARRELS. BBL
04200   C                  cl . C2, AND C4 IN THE MOUSSE EQUATION.
04210   C                  KMTC, MASS TRANSFER COEFFICIENT CODE (FLOATED).
04220   C                  ALL ON 10(IX.IPE10.3).
04230   C             6.   NUMBER OF CUTS+1 ON I5
04240   C             7.   TIME. MASS OF CUTS. AREA ON 10(1X.1PEI0.3)
04250   C             8.   TOTAL MASS FR,ICTION REMAINING IN THE OIL
04260   C                  SLICK FOR EACH TIME STEP PRINTED ON
04270   C                  10(lX. IPE10.3)
04280   C
04290   C        ITEMS 6 AND 7 ABOVE ARE WRITTEN FOR EACH TIME STEP
04300   C        WITH THE FIRST TIME STEP BEING ZERO.  WHEN THE
04310   C        VERY LAST TIME STEP IS WRITTEN THEN ITEM 8 IS WRITTEN.
04320   C
04330   C        THE NUMBER OF LINES WRITTEN ON THE CUTVP2.PLT PLOT FILE
04340   C        REFERS TO THE NUMBER OF "TIMES' WRITTEN THROUGH
04350   C        ITEMS 6 AND 7 ABOVE .
04360   C
04370          WRITE (IPU,790) NCUTS
04380   790    FORMAT(15)
04390          WRITE (IPU,800) (TB(I),I=1,NCUTS)
04400   800    FORMAT( 10(1X,1PE10.3))
04410          TYPE 810
04420   810    FORMAT(1X,'ENTER THE TEMPERATURE IN DEG F FOR
04430         1 THE VAPOR PRESSURE CALCUIATION")
04440          ACCEPT 230, XSAVE
04450   C
04460   C        TK IS THE ABSOLUTE TEMPERATURE IN DEG K.
04470   C
04480          TK=(XSAVE-32. )/1.8+273.
04490          XPRINT=XSAVE
04500   C
04510   C        CALCULATE AN ABSOLUTE TEMPERATURE IN DEG RANKINE.
04520   C
04530          XSAVE=XSAVE+4 59.
04540   C
04550   C        CALCULATE THE VAPOR PRESSURE AT THE INPUT TEMPERATURE.
04560   C
04570   C        AT THIS POINT IF THE INPUT TEMPERATURE IS LESS THAN THE
04580   C        10-MMHG TEMPERATURE USE THE WATSON-CLAPEYRON EQUIATION.
04590   C
04600   C        THE WATSON-CLAPEYRON EQUATION IS:
04610   C
04620   C        LN(P2/P1) = (HVAPZ/(R*TC ))*INTEGRAL
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04630   C
04640   C        WHERE P1 . PRESSURE AT TR1 . P2 = PRESSURE AT TR2. HVAPZ IS
04650   C        THE HEAT OF VA PORIZATION AT ABSOLUTE ZERO.
04660   C        R =1.987 BTU/(LBMOLE, DEG R),
04670   C        TC = CRITICAL TEMPERATURE AND INTEGRAL = VAPORIZATION
04680   C        INTEGRAL BETWEEN TR1 AND TR2.
04690   C
04700          WRITE (IOU,820)
04710   820    FORMAT(1H1 . 'CRUDE OIL CHARACTERIZATION AND PSEUDOCOMPONENT
04720         1 EVAPORATION MODEL')
04730          WRITE (IOU,830) (ANAME(I ),I=1,5)
04740   830    FORMAT(1X, ' IDENTIFICATION: ●,5A5,/)
04750          WRITE (IOU,580) ITEM, ISAMP
04760          WRITE (IOU,840) XPRINT
04770   840    FORMAT(1X,'VAPOR PRESSURE IN ATMOSPHERES AT ',1PE10.3,' DEG F')
04780          WRITE (IOU,850)
04790   850    FORMAT(/,12X,'VP',/)
04800          DO 900 I=1,NC1
04810          X=XSAVE
04820          IF(X.LT.T10(I)) CO TO 860
04830          X=X/TC(I )
04840          EX=EXP(-20.*(X-B(I))**2)
04850          Y=-A(I )*(1.-X)/X-EX
04860          VP(I) =PC(I)*10.**Y
04870          GO TO 880
04880   S60    TR1=X/TC(I)
04890   C
04900   C        DO INTEGRAL BY SIMPSONS RULE WITH 21 POINTS
04910   C
04920          TR2=T10(I)/TC(I)
04930          DH=(TR2-TR1 )/20.
04940          RESULT=YI(TR1 )
04950          TR=TR1
04960          DO 870 K=1,10
04970          TR=TR+DH
04980          RESULT=RESULT+4 .*YI(TR)
04990          TR=TR+DH
05000          RESULT=RESULT+2 .*YI(TR)
05010   870    CONTINUE
05020          TR=TR+DH
05030          RESULT=RESULT+4 .*YI(TR)
05040          TR=TR+DH
05050          RESULT=DH* (RESULT+Y I(TR))/3.
05060          P1=-4.33-HVAPZ (I)*RESULT/( 1 .987*TC(I))
05070          VP(I)=EXP(P1)
05080   880    WRITE (IOU,890) I.VP(I)
05090   890    FORMAT(1X,I2 ,5X,1PE10.3)
05100   900    CONTINUE
05110          TYPE 910
05120   910    FORMAT(1X,'THE TBP CUTS HAVE BEEN CHARACTERIZED')
05130          TYPE 920
05140   920    FORMAT(1X, 'DO YOU WANT TO WEATHER THIS CRUDE?")
05150          MWSCTH=1
05160          ACCEPT 340, ANS
05170          IF(ANS.EQ.'Y') CO TO 930
05180   C
05190   C        GO CALCULATE THE MEAN MOLECULAR WEIGHT OF THE CRUDE
05200   C        BEFORE EXITING. MWSCTH IS THE ROUTING SWITCH TO
05210   C        WEATHER THE CRUDE OR STOP.
05220   C
05230          MWSCTH=2
05240          BBL=1000.
05250          CO TO 1210
05260   C
05270   C        THIS ENDS THE CRUDE CHARACTERIZATION. BEGIN THE OIL-
05280   C        WEATHERING INPUT.
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05290   c
05300   930   TYPE 940
05310   940   FORMAT (1X,'ENTER THE SPILL SIZE IN BARRELS')
05320         ACCEPT 230, BBL
05330         TYPE 950
05340   950   FORMAT(1X, 'ENTER NUMBER OF HOURS FOR OIL WEATHERING TO OCCUR')
05350         ACCEPT 230, X2
05360         IF(LSWTCH.EQ.99) GO TO 980
05370         TYPE 960
05380   960   FORMAT(1X,'SINCE YOU DID NOT USE A LIBRARY CRUDE. ")
05390         TYPE 970
05400   970   FORMAT(1X,'YOU MUST ENTER THE FOLLOWING THREE MOUSSE
05410        1 FORMATION CONSTANTS')
05420         GO TO 1000
05430   980   TYPE 990
05440   990   FORMAT(1X,'DO YOU WANT TO ENTER MOUSSE FORMATION CONS
05450        1TANTS?' )
05460         ACCEPT 340, ANS
05470         IF(ANS.EQ. " N') GO TO 1060
05480   c
05490   c       TO SPECIFY NO MOUSSE. ENTER C2  = 0
05500   c
05510   1000  TYPE 1010
05520   1010  FORMAT(1X, '1 .  ENTER THE MAXIMUM WEIGHT FRACTION WATER
05530        1 IN OIL')
05540         ACCEPT 230, C2
05550         IF(C2.GT.0.) GO TO 1030
05560   C
05570   c       SET C2=-1 .  IF A MOUSSE CANNOT BE FORMED AND LOOP OUT.
05580   c
05590         C2=-1.
05600         TYPE 1020
05610   1 020 FORMAT(/,1X, ●SINCE A 0% WATER CONTENT WAS SPECIFIED
05620        1, THE REMAINING TWO MOUSSE" ,/,1X, 'CONSTANTS ARE NOT
05630        2 NEEDED' )
05640         GO TO 1070
05650   ! 030 C2=1 ./C2
05660         TYPE 1040
05670   1040 FORMAT(1X, *2. ENTER TRE MOUSSE-VISCOSITY CONSTANT
05680        1, TRY 0.65')
05690         ACCEPT 230. Cl
05700         TYPE 1050
05710   10543 FORMAT(1X, '3.  ENTER THE WATER INCORPORATION RATE CONSTANT
05720        1. TRY 0.001')
05730         ACCEPT 230, C4
05740         CO TO 1070
05750   1060  C1=C1L(IC)
05760         C2=C2L(IC)
05770         C4=C4L(IC)
05780   1070  IF(LSWTCH.EQ.99) GO To 1100
05790         TYPE 1080
05800   1080 FORMAT(/,1X,'YOU MUST ALSO ENTER AN OIL-WATER SURFACE
05810        1 TENSION (DYNES/CM')
05820         TYPE 1090
05830   1090 FORMAT(1X, *FOR DISPERSION. TRY 30.')
05840         GO TO 1130
05850   1100  TYPE 1110
05860   1110 FORMAT(1X,'DO YOU WANT TO ENTER AN OIL-WATER SURFACE
05870        1  TENSION   (DYNES/CM)?")
05880         ACCEPT 340. ANS.
05890         IF(ANS.EQ. 'N') GO TO 1140
05900         TYPE 1120
05910   1120 FORMAT(1X, 'TRY 30.')
05920   1130 ACCEPT 230. STEN
05930         GO TO 1150
05940   1140  STEN=STENL(IC)
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05950   C
05960   C       START THE MASS-TRANSFER COEFFICIENT SPECIFICATION
05970   C
05980   1150  TYPE 1160
05990   1160  FORMAT(1X,'ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1
06000        1, 2, OR 3 WHERE:')
06010         TYPE 1170
06020   1170  FORMAT(1X,'1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEF
06030        1FICIENT')
06040         TYPE 1180
06050    180  FORMAT(1X,'2=CORRELATION MASS-TRANSFER COEFFICIENT BY
06060        1 MACKAY & MATSUGU')
06070         TYPE 1190
06080   1190  FORMAT(1X,'3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS
06090         ACCEPT 370, KMTC
06100   C
06110   C       NOW ENTER THE WIND SPEED IN KNOTS AND CONVERT TO METER/SEC
06120   C       AND METER/HOUR.
06130   C
06140         TYPE 1200
06150   1200  FORMAT(1X,'ENTER THE WIND SPEED IN KNOTS')
06160         ACCEPT 230, WINDS
06170   C
06180   C       NEVER LET THE WIND SPEED DROP BELOW 2 KNOTS.  A ZERO WIND
06190   C       SPEED DESTROYS THE MASS-TRANSFER CALCULATION AND WILL
06200   C       YIELD A ZERO MASS-TRANSFER COEFFICIENT.
06210   C
06220         IF(WINDS.LT.2.) WINDS=2.
06230         WINDMS=0.514*WINDS
06240         WINDMH=1853.*WINDS
06250   C
06260   C       NOW CALCULATE THE INITIAL GRAM MOLES FOR EACH COMPONENT TO
06270   C       GET THE INTEGRATION STARTED.
06280   C
06290   1210  BM=0.159*BBL
06300         TMOLES=0.
06310         DO 1220 I=1,NCUTS
06320         AMASS=1582.*SPGR(I)*BBL*VOL
06330         MOLES(I)=AMASS/MW(I)
06340         TMOLES=TMOLES+MOLES(I)
06350   C
06360   C       RHO IS THE DENSITY IN GM MOLES/CUBIC METER.
06370   C
06380         RHO(I)=100.*MOLES(I)/(BM*VOL(I))
06390   1220  CONTINUE
06400   C
06410   C       CALCULATE THE MEAN MOLECULAR WEIGHT OF THE CRUDE
06420   C
06430         WTMOLE=0.
06440         DO 1230 I=1,NCUTS
06450         WTMOLE=WTMOLE+MW(I *MOLES(  /TMOLES
06460   1230  CONTINUE
06470         WRITE (IOU,1240) WTMOLE
06480   1240  FORMAT(/,1X,'MEAN MOLECULAR WEIGHT OF THE CRUDE = ',PE10.3)
06490   C
06500   C       IF MWSCTH=1, WEATHER THE OIL
06510   C       IF MWSCTH=2, EXIT.
06520   C
06530         GO TO (1250,2110) MWSCTH
06540   C
06550   C       SPECIFY SLICK SPREADING.
06560   C
06570   1250  SPREAD=0.
06580         TYPE 1260
06590   1260  FORMAT(1X,'DO YOU WANT THE SLICK TO SPREAD?')
06600         ACCEPT 340, ANS
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06610          IF(ANS.EQ. 'N') GO TO 1270
06620          SPREAD=1.
06630          GO TO 1290
06640    C
06650    C       CALCULATE AN AREA IN SAME WAY IT WILL BE CALCULATED
06660    C       AS THE SLICK WEATHERS .   Z=THICKNESS IN METERS.
06670    C
06680    1270  TYPE 1280
06690    1280  FORMAT(1X, 'SINCE THE SLICK DOES NOT SPREAD. ENTER
06700         1 A STARTING THICKNESS IN CM")
06710          ACCEPT 230, Z
06720          Z=Z/100.
06730          CO TO 1300
06740    C
06750    C       THE SLICK ALWAYS STARTS AT 2-CM THICKNESS.
06760    C
06770    1290  Z=0.02
06780    1300  VOLUM=0.
06790          DO 1310 I=1,NCUTS
06800          VOLUM=VOLUM+MOLES (1)/RHO(I)
06810    1310  CONTINUE
06820    C
06830    C       CALCULATE THE INITIAL AREA AND DIAMETER.
06840    C
06850          AREA=VOLUM/Z
06860          DIA=SQRT(AREA/0 .785)
06870    C
0 6880   C       THE MASS-TRANSFER COEFFICIENT CAN BE CALCULATED ACCORDING TO:
06890    C
06900    C             1.  A USER-SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
06910    C
06920    C             2.  THE MASS-TRANSFER COEFFICIENT CORREIATIOPJ ACCORDINC
06930    C                 TO MACKAY AND MATSUCU, 1973, CAN. J. CHE. V51,
06940    C                 P434-439.
06950    C
06960    C             3.  INDIVIDUAL OIL- AND AIR-PHASE MASS-TRANSFER COEFFI-
06970    C                 CIENTS BASED ON SOME REAL ENVIRONMENTAL DATA SUCH
06980    C                 AS THAT OF LISS AND SLATER.  SCALE THE AIR-PHASE
06990    C                 VALUE WITH RESPECT TO WIND SPEED ACCORDING TO
07000    C                 GARRATT, 1977, MONTHLY WEATHER REVIEW, V105,
0'7010   C                 P915-920.
07020    C
07030    C      TEMP IS R*T AND USED TO CHANCE THE UNITS ON THE MASS-
07040    C      TRANSFER COEFFICIENT.
07050    C
07060    1320  TEMP=(8.2E-05)*TK
07070          GO TO (1330, 1370,1450). KMTC
07080    C
07090    C       USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
07100    C
07110    1330  TYPE 1340
07120    1340  FORMAT(1X, 'ENTER THE OVER-ALL MASS--TRANSFER COEFFICIENT
07130         1. CM/HR, TRY 10')
07140          ACCEPT 230, UMTC
07150          WRITE (IOU,1350) UMTC
07160    1350  FORMAT(1H1, 'OVER-ALL MASS-TRANSFER COEFFICIENT WAS USER
07170         1-SPECIFIED AT ',1PE10.3,' CM/HR BY INPUT CODE 1 ")
07180    C
07"190   C       CONVERT CM/HR TO GM-MOLES/(HR)(ATM)(M**2) SINCE VAPOR
07200    C       PRESSURE IS THE DRIVING FORCE FOR MASS TRANSFER.
072 1 0  C
07220          UMTC=UMTC/TEMP/ 100.
07230          DO 1360 I=1,NC1
07240          MTC(I)=UMTC
07250    1360  CONTINUE
07260          GO TO 1530
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07270   C
07280   C        USE THE MACKAY AND MATSUGUMASS-TRANSFER  COEFFICIENT,
07290   C
07300   1370  TERM I =0 . 0 1 5*WI NDMH**0 .78
07310         IF(SPREAD. EQ. 0.) GO TO 1380
07320         TERM2=DIA** (-0.11)
07330         GO TO 1390
07340   C
07350   C        IF THE SLICK DOES NOT SPREAD BASE THE DIAMETER DEPENDENCE
07360   C        ON 1000 METERS AND DIVIDE THE RESULT BY (3.7
07370   C
07330   1380  TERM2=0.65
07390   C
07400   C        KH INCLUDES THE SCHMIDT NUMBER FOR CUMENE.
07410   C
07420   1390  KH=TERM1*TERM2
07430         WRITE (IOU,1400) KMTC
07440   1400  FORMAT(1H1 . 'OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT
07450        1 CODE',I2)
07460         WRITE (IOU,1410) KH
07470   1410  FORMAT(/,1X , ' OVER-ALL MASS-TRANSFER COEFFICIENT  FOR CUMENE = '
07480        1,1PE10.3,' M/HR',/)
07490         WRITE (IOU,1420)
07500   1420  FORMAT(3X, "CUT" ,12X,'M/HR' ,7X. 'GM-MOLES/ (HR)(ATM)( M**2) ')
07510         DO 1440 I=1,NC1
07520   C
07530   C        THE MASS-TRANSFER COEFFICIENT IS CORRECTED FOR THE
07540   C        DIFFUSIVITY OF COMPONENT I IN AIR.   THE SQRT IS USED
07550   C        (Ii?,. LISS AND SLATER) .  BUT THE 1/3 POWER COULD ALSO
07560   C        BE USED (I.E. THE SCHMIDT NUMBER).
07570   C
07 580        MTCA(I)=KH*0 .93*SQRT((MW( I)+29.)/MW( I))
07590   C
07600   C        MTC(I) IS THE OVER-ALL MASS-TRANSFER COEFFICIENT DIVIDED
07610   C        BY R*T.  R=82.06E-06 (ATM)(M**3)/(G-MOLE)(DEG  K)
07620   C
(37630        MTC(I)=MTCA( I)/TEMP
07640         WRITE (IOU,1430) I,MTCA(I),MTC(I)
07650   1 430 FORMAT(2X, I3,2(10X,1PE10 .3))
07660   1440  CONTINUE
07670         GO TO 1530
07680   C
07690   C        USER  SPECIFIED  INDIVIDUAL-PHASE  MASS-TRANSFER
07700   C        COEFFICIENTS .
07710   C
07720   1450  TYPE 1460
07730   1460  FORMAT(1X,'ENTER THE OIL-PHASE MASS-TRANSFER COEFFICIENT
07'740       1 IN CM/HR, TRY 10')
077 50        ACCEPT 230, KOIL
07760         TYPE 1470
07770   1470  FORMAT(1X, 'ENTER THE AIR-PHASE MASS-TRANSFER COEFFICIENT
07780        1 IN CM/HR, TRY 1000')
07790         ACCEPT 230, KAIR
07800         TYPE 1480
07810   1480  FORMAT(1X,'ENTER THE MOLECULAR WEIGHT OF THE COMPOUND
07820        1 FOR K-AIR ABOVE, TRY 200')
07830         ACCEPT 230. DATAMW
07840   C
07850   C        SCALE K-AIR ACCORDING TO WIND SPEED (GARRATT, 1977).
07860   C        SO THAT AS THE WIND SPEED GOES UP THE MASS TRANSFER
07870   C        GOES UP. I.E., THE CONDUCTANCE INCREASES.
07880   C
07890         KAIR=KAIR*( 1.+0.089*WINDMS)
07900         RKAIR=1./KAIR
07910   C
(3792X3 C        CALCULATE R*T IN ATM*CM**3/GM-MOLE
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07930   C
07940          RT=82.06*TK
07950          HTERM=WTMOLE/ (DCRUDE*RT)
07960          WRITE (IOU, 1400) KMTC
07970   C
07980   C        WRITE THE USERS INPUT, WIND SPEED, AND HENRYS LAW
07990   C        TERM TO THE OUTPUT.
08000   C
08010          WRITE (IOU,1490) KAIR,KOIL,DATAMW
08020   1490   FORMAT(/,1X,'K-AIR = ',1PE10.3. ", AND K-OIL = ',1PE10.3
08030         1," CM/HR , BASED ON .4 MOLECULAR WEIGHT OF ',1PE10.3)
08040          WRITE (IOU,1500) WINDMS
08050   1500   FORMAT(1X,'WIND SPEED  =  ",1PE10.3,  "  M/S')
08060          WRITE (IOU. 1510) HTERM
08070   1510   FORMAT(1X, 'THE HENRYS LAW CONVERSION TERM FOR OIL = '
08080         1,1PE10.3.' 1/ATM')
08090          WRITE (IOU, 1420)
08100   C
08110   C        CLACULATE THE OVER-ALL MASS-TRANSFER COEFFICIENT BASED
08120   C        ON GAS-PHASE CONCENTRATIONS FOR EACH CUT.
08130   C
08140          DO 1520 I=1,NC1
08150          HLAW(I)=HTERM*VP( I)
08160          MTCA(I) =RKAIR+HLAW( I)/KOIL
08170   C
08180   C        NOW TAKE THE INVERSE TO OBTAIN CM/HR AND THEN  MULTIPLY
08190   C        BY 0.01 TO GET M/HR.
08200   C
08210          MTCA(I)=0.01/MTCA(I)
08220   C
08230   C        CORRECT FOR MOLECULAR WEIGHT ACCORDING TO LISS & SLATER.
08240   C        1974, NATURE.  V247, P181-184.
08250   C
08260          MTCA(I)=MTCA (I)*SQRT(DATAMW/MW (I))
08270          MTC(I)=MTCA (I)/TEMP
08280   C
08290   C        AND WRITE THE OVER-ALL MASS-TRANSFER COEFFICIENT
08300   C        IN M/HR AND MOLE/HR*ATM*M*M.
08310   C
08320          WRITE (IOU,1430) I,MTCA(I).MTC(I)
08330   1520   CONTINUE
08340   1530   SPGRB=141.5/(APIB+131  .5)
08350          MASS=0.1582*BBL*SPGRB
08360          WRITE (IOU,1540) BBL,MASS
08370   1540   FORMAT(/,1X,'FOR THIS SPILL OF ',1PE10.3,' BARRELS.  THE
08380         1 MASS IS ',1PE10.3,' METRIC TONNES')
08390          VOLUMB=VOLUM/0.159
08400          WRITE (IOU,1550) VOLUM,VOLUMB
08410   1550   FORMAT(/,1X, 'VOLUME FROM SUMMING THE CUTS = ',1PE8.1,' M**3
08420         1. OR ',1PE10.3.' B-lRRELS")
08430          GO TO (1580,1560,1580), KMTC
08440   1560   WRITE (IOU,1570) WINDS,WINDMH
08450   1570   FORMAT(/,1X,'WIND SPEED = ' ,1PE10.3,' KNOTS,  OR ',1PE10.3
08460         1," M/HR ' )
08470   1580   WRITE (IOU,1590) DIA,AREA
08480   1590   FORMAT(/,1X,'INITIAL SLICK DIAMETER = '.1PE10.3.' M, OR AREA
08490         1 = ".1PE10.3,' M**2')
08500          IF(SPREAD.GT.0.) GO TO 1610
08510          WRITE (IOU,1600)
08520   1600   FORMAT(/,1X,'THIS SLICK DOES NOT SPREAD FOR THIS CALCULATION')
08530   C
08540   C        CALCULATE THE KINEMATIC VISCOSITY OF THE CRUDE AT 122
08550   C        DEG F AND THE ENTERED ENVIRONMENTAL TEMPERATURE.
08560   C        USE THE VISCOSITY MIXING RULE OF (MOLE FRACTION)*(LOG),
08570   C        SEE PAGE 460 OF REID, PRAUSNITZ & SHERWOOD IN
08580   C        THE BOOK 'THE PROPERTIES OF GASES AND LIQUIDS'
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C
1610  VISMIX=0.
      DO 1620 I=1,NCUTS
      VISMIX=VISMIX+MOLES (I)*VLOGK(I )/TMOLES
1620  CONT I NUE
      VISMIX=EXP(VISMIX)
      WRITE (IOU,1630) VISMIX
1630  FORMAT(/,1X,'KINEMATIC VISCOSITY OF THE BULK CRUDE FROM
     1 THE CUTS = ',1PE8.1,' CENTISTOKES AT 122 DEG F')
      VISMIX=0.
C
C       SCALE THE VISCOSITY WITH TEMPERATURE ACCORDING TO
C       ANDRADE.
C
      EXPT=EXP(1923.*( 1 ./XSAVE-0.001721 ))
      DO 1640 I=1,NCUTS
      VIS(I)=VISK( I)*EXPT
      VLOG(I )=ALOG(VIS( I))
      VISMIX=VISMIX+MOLES( I)*VLOG(I)/TMOLES
1640  CONTINUE
      VISMIX=EXP(VISMIX)
      WRITE (IOU,1650) VISMIX,XPRINT,EXPT
1650  FORMAT(/,1X,'KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE
     1 CUTS = ',1PE8.1,' AT T = ',0PF5.1,' DEG F, SCALE
     2 FACTOR = ',1PE8.1)
C
C       IMPORTANT NOTE:  THE VISCOSITY PREDICTION OF THE WHOLE
C       CRUDE FROM CUT INFORMATION IS NOT GOOD AT ALL,.   SO THE
C       VISCOSITY Information CALCULATED ABOVE IS NOT USED IN
C       THIS VERSION OF THE CODE, BUT IT COULD BE IF A GOOD
C       MIXING RULE IS EVER DETERMINED.
C       THEREFORE, FOR THE TIME BEING. THE VISCOSITY OF THE WHOLE
C       WEATHERED CRUDE IS CALCULITED ACCORDING TO MACKAY.
C
C       NOW LOAD THE VISCOSITY INFORMATION IN THE FORM
C       OF THREE CONSTANTS:
C            1.  THE VISCOSITY IN CP AT 25 DEG C
C            2.  THE ANDRADE-VISCOSITY-SCALI NG CONSTANT
C                WITH RESPECT TO TEMPERATURE, SEE GOLD &
C                OGLE . 1969, CHEM. ENC.. JULY 14, P121-123
C            3.  THE VISCOSITY AS AN EXPONENTIAL FUNCTION OF
C                THE FRACTION OF OIL WEATHERED
C
      IF(LSWTCH.EQ.99) GO TO 1670
      TYPE 1660
1660 FORMAT(1X, *SINCE A LIBRARY CRUDE WAS NOT USED
     1.",/,1X,'ENTER THE FOLLOWING THREE VISCOSITY CONSTANTS')
      GO TO 1690
1670  TYPE 1680
1680  FORMAT( 1X,'DO YOU WANT TO ENTER VISCOSITY CONSTANTS?")
      ACCEPT 340, ANS
      IF(ANS.EQ. 'N') GO TO 1730
1690  TYPE 1700
1700  FORMAT(1X, "1.  ENTER THE BULK CRUDE VISCOSITY
     1 AT 25 DEG C,  CENTIPOISE,  TRY 35.')
      ACCEPT 230, VISZ
      TYPE 1710
1710  FORMAT(1X,'2. ENTER THE VISCOSITY TEMPERATuRE SCALING
     1 CONSTANT (ANDRADE), TRY  9000.")
      ACCEPT 230. MK3
      TYPE 1720
1720  FORMAT(1X,'3. ENTER THE VISCOSITY-FRACTION-OIL
     1-WEATHERED CONSTANT,  TRY 10.5')
      ACCEPT 230. MK4
      GO TO 1740
C
```

```
09250   C        USE THE LIBRARY VISCOSITY DATA
09260   C
09270   1730  VISZ=VISZL(IC)
09280         MK3=MK3L(IC)
09290         MK4=MK4L(IC)
09300   C
09310   C        INSERT VISCOSITY CALCULATION ACCORDING TO MASS
09320   C        FRACTION EVAPORATED.  THIS IS THE VISCOSITY
09330   C        MODIFICATION RELATIVE TO CUTVP1
09340   C
09350   1740  VSLEAD=VISZ*EXP(MK3*(1./TK-0.003357))
09360         WRITE (IOU,1750) VISZ,MK3,MK4,VSLEAD
09370   1750  FORMAT(/,1X,'VISCOSITY ACCORDING TO MASS EVAPORATED:
09380        1 VIS25C =',1PE9.2,', ANDRADE =',1PE9.2
09390        2,",  FRACT WEATHERED =',1PE9.2', VSLEAD =',1PE9.2
09400        3,' CP')
09410         C2P=1./C2
09420         WRITE (IOU, 1960) C1,C2P,C4
09430         NEQ=NCUTS
09440   C
09450   C        SET UP THE DISPERSION PROCESS CONSTANTS.
09460   C        CALCULATE THE FRACTION OF THE SEA SURFACE SUBJECT TO
09470   C        DISPERSIONS/HOUfi .
09480   C
09490         TYPE 1760
09500   1760  FORMAT(1X,"DO YOU WANT THE FEATHERING TO OCCUR WITH
09510        1 DISPERS1ON?")
09520         ACCEPT 340, ANS
09530         FRACTS=0.
09540         IF(ANS.EQ. 'N') GO TO 1810
09550         TYPE 1770
09560   1770  FORMAT(1X,'DO YOU WANT TO ENTER THE DISPERSION
09570        1 CONSTANTS?')
09580         ACCEPT 340. ANS
09590         IF(ANS.EQ.'N') CO TO 1800
09600         TYPE 1780
09610   1780  FORMAT(1X,'ENTER THE WIND SPEED CONSTANT. TRY 0.1')
09620         ACCEPT 230. KA
09630         TYPE 1790
09640   1790  FORMAT(1X,'ENTER THE CRITICAL DROPLET SIZE CONSTANT
09650        1* TRY 50')
09660         ACCEPT 230, KB
09670   1800  FRACTS=KA*(1.+WINDMS)**2
09680   1810  WRITE (IOU,1820) FRACTS
09690   1820  FORMAT(/,1X,'THE FRACTION.AL SLICK AREA SUBJECT TO
09700        1 DISPERSION IS ',1PE8. 1," PER HOUR")
09710         IF(ANS.EQ.'N') GO TO 1840
09720         WRITE (10U.1830) KA,KB,STEN
09730   1830  FORMAT(1X,'THE DISPERSION PARAMETERS USED:  KA = '
09740        1,1PE9.2,', KB  = ',1PE9.2,', SURFACE TENSION  = ',1PE9.2
09750        2," DYNES/CM')
09760   C
09770   C        PRINT EVERY XP TIME INCREMENT (HOURS).
0'?780  C        Xl IS THE STARTING TIME = O.
09790   C        x2 IS THE NUMBER OF HOURS FOR WEATHERING To OCCUR.
09800   C
09810   1840  XP=l .
09820         X1=0.
09830         MOLES(NCUTS+ 1)=AREA
09840   C
09850   C        PRINT AN OUTPUT FILE FOR 80 COLUMN OUTPUT, THIS IS
09860   C        THE CUTVP2.TYP FILE.
09870   C
09880         WRITE (ITY,1850) (ANAME(J),J=1,5)
09890   1850  FORMAT(/,1X,'OIL WEATHERING FOR ',5A5)
09900         WRITE (ITY,570)
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```
09910          WRITE (ITY,1860) XPRINT,WINDS
09920    1860  FORMAT( 1X, 'TEMPERATURE= ',F5. 1,' DEG F, WIND SPEED= "
09930         1,F5. 1,' KNOTS")
09940          WRITE (ITY, 1870) BBL
09950    1870  FORMAT(1X,'SPILL SIZE= ",1PE10.3, " BARRELS')
09960          WRITE (ITY,1880) KMTC
09970    1880  FORMAT( 1X, 'MASS-TRANSFER COEFFICIENT CODE=',I3)
09980          WRITE (ITY,1890)
09990    1890  FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS. MOLES
10000         1=GRAM MOLES' )
10010          WRITE (ITY,1900)
10020    1 900 FORMAT(1X, 'GMS=GRAMS, VP=VAPOR PRESSSURE IN ATMOSPHERES')
10030          WRITE 1ITY,1910)
10040    1910  FORMAT( 1X, 'BP=BOILING POINT IN DEG F. API=GRAVITY')
100.50         WRITE (ITY,1920)
10060    1 920 FORMAT(1X, "MW=MOLECULAR WEIGHT')
10070          WRITE (ITY,1930)
10080    1930  FORMAT(/,2X, 'CUT' .3X. "MOLES" ,6X, 'GMS',8X, 'VP',8X, 'BP'
10090         1,7X,'API',5X, 'MW')
10100          DO 1950 I=1,NCUTS
10110          GMS=MOLES(I)*MW(I)
10120          IMW=MW(I)
10130          WRITE (ITY,1940) I,MOLES(I),GMS,VP(I),TB(I),API(I), IMW
10140    1940  FORMAT(3X, I2,5(1X,1PE9.2) .1X,13)
10150    1950  CONTINUE
10160          WRITE (ITY,1960) C1,C2P,C4
10170    1960  FORMAT(/,1X,'MOUSSE CONSTANTS: MOONEY=',1PE9.2
10180         1,', MAX H20=',0PF5.2,', WIND**2=',1PE9.2)
10190          WRITE (ITY,1970) KA,KB,STEN
10200    1970  FORMAT(1X,'DISPERSION CONSTANTS: KA=',1PE9.2
10210         1,'. KB=',1PE9.2,', S-TENSION= ',1PE9.2)
10220          WRITE (ITY,1980) VISZ,MK3,MK4
10230    19!30 FORMAT(1X,'VIS CONSTANTS: VIS25C=',1PE9.2
10240         1,', ANDRADE =',1PE9.2
10250          WRITE (ITY,1990)       ,', FRACT =' ,1PE9.2)
10260    1990  FORMAT(/,1X, ' FOR THE OUTPUT THAT FOLLOWS, TIME=HOURS')
10270          WRITE (ITY,2000)
102ao    2000  FORMAT( 1X. 'BBL=BARRELS . SPGR=SPECIFIC GRAVITY, AREA=M*M')
10290          WRITE (1TY,2010)
10300    2010  FORMAT(1X, 'THICKNESS=CM . W=PERCENT WATER IN OIL (
10310         1MOUSSE)' )
10320          WRITE (ITY,2020)
10330    2020  FORMAT( 1X,'DISP=DISPERSION RATE IN GMS/M*M/HR')
10340          WRITE (ITY,2030)
10350    2030  FORMAT(1X,'ERATE=EVAPORTION RATE IN GMS/M*M/HR')
10360          WRITE (ITY,2040)
10370    2040  FORMAT(1X,'M/A=MASS PER M*M OF OIL IN THE SLICK")
10380          WRITE (ITY,2050)
10390    2050  FORMAT(1X,'I=FIRST CUT WITH GREATER THAN  1% (MASS)
104,00         1 REMAINING")
10410          WRITE (ITY,2060)
1042!0   2060  FORMAT(1X,'J=FIRST CUT WITH GREATER THAN 50% (MASS)
10430         1 REMAINING")
10440          IF(FRACTS.NE.0.) GO TO 2080
10450          WRITE (ITY,2070)
10460    2070  FORMAT(1X,'DISPERSION WAS TURNED OFF')
10470    2080  IF(SPREAD.NE.0. ) GO TO 2100
104t30         WRITE (ITY,2090)
10490    2090  FORMAT(/,1X,'SPREADING WAS TURNED OFF')
10500    C
10510    C       WRITE SOME INFORMATION TO THE PLOT FILE.
10520    C
10530    2100  TCODE=KMTC
10540    C
10550    C       XPRINT IS THE ENVIRONMENTAL TEMPERATuRE. DEG F.
10560    C
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10570          WRITE ( PU,8>0  XPRINT,WINDS,KA KB,STEN ≡BL C1 C2,C4
10580          ,TCODE
10590   C
10600   C        TO THIS POINT IT WAS JUST GETTING READY, NOW
10610   C        INTEGRATE IT.
10620   C
10630          CALL BRKG4(MOLES,X1,X2,XP,NEQ)
10640   2110   TYPE 2120
10650   2120   FORMAT(1X,'DO IT AGAIN?')
10660          ACCEPT 340' ANS
10670          IF(ANS.EQ.'Y') GO TO 760
10680   2130   CONTINUE
10690          END
10700          SUBROUTINE CHAR(API,TB,A,B,NS,NV)
10710          REAL*4 MW1
10720          COMMON /COIL/ MW1,TC1,VC1 PC1,CNUM1,V S
10730          DIMENSION C(2,6),T(2,6),P(4),V(2,6)
10740          DATA ((C(I,J),J=1,6),I=1,2)/6.241E+01,-4.595E-02,-2.836E-01
10750         1,3.256E-03,4.578E-04,5.279E-04
10760         2,4.268E+02,-1.007,-7.449,1.38E-02,1.047E-03,2.621E-02/
10770          DATA ((T(I,J),J=1,6),I=1,2)/4.055E+02,1.337,-2.662,-2.169E-03
10780         1,-4.943E-04,1.454E-02
10790         2,412.2,1.276,-2.865,-2.≡≥3E-03,-3.707E-04 2.888E-02/
10800          DATA P/1.237E-02,0.2516,4.039E-02,-4.024E-02/
10810          DATA ((V(I,J),J=1,6),I=1,2)/ -0.4488,-9.344E-04,0 01583
10820         1,-5.219E-05,5.268E-06,1.536E-04
10830         2,-0.6019,1.793E-03,-3.159E-03,-5  E-06,9.067E-07,3.522E-05/
10840   C
10850   C        THIS SUBROUTINE CHARACTERIZES A CUT OF CRUDE OIL WITH RESPECT
10860   C        TO VAPOR PRESSURE.  THE INPUT REQUIRED IS API GRAVITY AND THE
10870   C        BOILING POINT AT 1 ATMOSPHERE.  THE OUTPUT IS A SWITCH NS
10880   C        WHERE NS=1 MEANS THE VAPOR PRESSURE EQUATION CAN BE USED DOWN TO
10890   C        10MM HG AND NS=2 MEANS THE CLAPEYRON EQUATION SHOULD BE USED.
10900   C
10910   C        THE VAPOR PRESSURE EQUATION IS:
10920   C
10930   C        LOG10(PR) = -A*( .-TR)/TR - EXP(-20*(TR-B)**2)
10940   C
10950   C        WHERE PR = REDUCED PRESSURE, TR = REDUCED TEMPERATURE AND
10960   C        A AND B ARE RETURNED BY THIS SUBROUTINE.
10970   C
10980   C        API = GRAVITY, TB = BOILING POINT AT 1 ATMOSPHERE IN DEG F.
10990   C        CALCULATE CRITICAL TEMPERATURE AND MOLECULAR WEIGHT.
11000   C
11010          API2=API*API
11020          TB2=TB*TB
11030          CROSS=API*TB
11040          I=1
11050          IF(API.GT.35.) I=2
11060          VIS1=V(I,1)+V( ,2)*TB+V(I,3)*API+V(I,4 *CROSS+V( ,5 *T≥2
11070          +V(I,6)*API2
11080          GO TO (10,30), NV
11090   10     I=1
11100          IF(TB.GT.500.)  =2
11110          MW1=C(I,1)+C(I,2)*TB+C I,3)*API+C(I,4)*CROSS+C I,5)*TB2
11120         1+C(I,6)*API2
11130          TC1=T(I,1)+T(I,2)*TB+T(I,3)*API+T( ,4 *CROSS+T I,5)*TB2
11140         1+T(I,6)*API2
11150          TCK=(TC1+459.)/1.8
11160   C
11170   C        CALCULATE THE VISCOSITY OF THE CUT.
11180   C
11190          I=1
11200          IF(API.GT.35.) I=2
11210          VIS1=V(I,1)+V( ,2)*TB+V( ,3)*API+V I,4)*CROSS+V  ,5)*TB2
11220         1+V(I,6)*API2
```

```
C
C       CALCULATE THE CARBON NUMBER
C
      CNUM1=(MW1-2. )/14.
      X= ALOG10(CNUM1 )
C
C       CALCULATE B FOR THE VAPOR PRESSURE EQUATION
C
      BPRIME=P( 1)+X*(P(2)+X*(P(3 )+X*P(4)))
      B=BPRIME-0.02
C
C       CALCULATE THE CRITICAL VOLUME. CC/GMOLE
C
      VW=1.88+2.44*CNUM 1
      VC1=VW/0.044
C
C       CALCULATE THE CRITICAL PRESSURE IN ATMOSPHERES
C
      PCP=20.8*TCK/ (VC1-8.)
      PC1=PCP+10.
      TR=(TB+459. )/(TC1+459.)
      PR=1./PC1
      NS=1
      IF(TR.LE.B) GO TO 20
      A=(ALOG10(PR)+EXP(-20 .*(TR-B)**2))*TR/(TR-1 .)
      GO TO 30
20    NS=2
30    RETURN
      END
      SUBROUTINE BRKG4(Y,X1,X2,XP,NEQ)
      REAL*4 K1,K2,K3,K4,MTC,MW,MWU,KB,MK4
      COMMON /SPILL/ MTC(30),VP(30),VLOC(30),RHO(30),MW(30)
     1,SPGR(30), FRACTS,STEN,KB,DISPER,Z,TERM2,SPREAD,KMTC
      COMMON /PCODE/ VSLEAD,MK4,IOU,IPU,ITY
      COMMON /TALK/ MWU(30 ),NEQ1,NEQ2,NEQ3
      DIMENSION Y(30), YARG(30),K1(30),K2(30),K3(30),K4(30)
     1,GONE(200),YSAVE(30),YF(30),YMSAVE(30),YM(30),YM1 (30)
C
C       RUNGA-KUTTA 4-TN ORDER NUMERICAL INTEGTIATION FOR SIMULTANEOUS
C       DIFFERENTIAL EQUATIONS, SEE C.R. WYLIE, PAGES 108-II7 OR
C       D. GREENSPAN, PAGES 113-115.
C
C       THIS SUBROUTINE DOES THE PRINTING, THE INITIAL AND FINAL VALUES
C       ARE ALWAYS PRINTED.  PRINT THE RESULTS EVERY XP INCREMENT
C       IN X.
C
C       THE USER MUST WRITE SUBROUTINE FXYZ WHICH CALCULATES THE
C       K1, K2, K3, AND K4 VECTORS AS A FUNCTION OF X AND THE
C       CURRENT Y VECTOR.  INTECRATION FOLLOWS THE REFERENCES AND
C       WAS TESTED ON PROBLEM 5, PAGE 116 IN WYLIE.
C
C       THE FIRST NCUTS POSITIONS IN THE Y VECTOR ARE THE MOLES
C       OF THE COMPONENTS, POSITION NCUTS+1 IS THE AREA OF THE
C       SLICK.  POSITION NCUTS+2 IS THE MASS LOST FROM THE SLICK
C       BY DISPERSION ALONE.  POSITION NCUTS+3 IS THE MASS LOST
C       FROM THE SLICK BY EVAPORATION ALONE.
C
C       LINE KEEPS TRACK OF HOW MANY LINES ARE WRITTEN TO THE
C       PLOT FILE.  NEQ1 IS THE NUMBER OF COMPONENTS+1 .  NS IS
C       A ROUTING SWITCH TO CHANGE THE PRINT INTERVAL.  IN IS
C       AN INPUT ROUTING SWITCH TO DELETE RAPIDLY CHANGING
C       COMPONENTS .  GONE(LINE) 1S THE MASS FRACTION REMAINING
C       AT TIME STEP LINE.  INT IS A SWITCH TO INDICATE WHEN THE
C       INTEGRATION HAS STARTED: INT=1 , NOT STARTED; INT=2,
C       STARTED.  ITYP IS A HEADER PRINT SWITCH FOR THE
C       80-COLUMN FILE.
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```
11890   C
11900          INT=1
11910          ITYP= 1
11920          LINE=0
11930          NEQ1 =NEQ+1
11940          NEQ2=NEQ+2
11950          NEQ3=NEQ+3
11960          NS=1
11970          IN=1
11980          I KEEP= 1
11990          GONE(1)=1.
12000          DISPER=0.
12010   C
12020   C        TOTAL IS THE INITIAL NUMBER OF MOLES.
12030   C        TSAVE IS THE INITIAL MASS.
12040   C
12050          TOTAL=0.
12060          TSAVE=0.
12070          DO 10 I=1,NEQ
12080   C
12090   C        CALCULATE AND SAVE THE INITIAL CONDITIONS.
12100   C
12110          YSAVE(I)=Y(I)
12120          YMSAVE( I)=Y(I)*MW(I)
12130          MWU(I)=MW(I)
12140          TSAVE=TSAVE+YMSAVE (I)
12150          TOTAL=TOTAL+Y (I)
12160    10    CONTI NUE
12170   C
12180   C        SAVE THE INITIAL AREA.
12190   C
12200          YMSAVE(NEQ1 )=Y(NEQ1)
12210   C
12220   C        INITIALIZE THE MASS LOST BY DISPERSION ALONE AND
12230   C        EVAPORATION ALONE.
12240   C
12250          Y(NEQ2)=0.
12260          Y(NEQ3)=0.
12270   C
12280   C        NDEL IS THE NUMBER OF COMPONENTS DELETEI) BECAUSE THEY
12290   C        EVAPORATE TOO FAST.  NFAST IS THE CURRENT ARRAY LOCATION
12300   C        OF THE FASTEST MOVING COMPONENT.
12310   C
12320          NDEL=0
12330          NFAST=0
12340          X=X1
12350   C
12360   C        INITIALIZE THE PRINT SWITCH TO FORCE A PRINT AND
12370   C        SUBSEQUENT CALCULATIONS THE FIRST TIME THROUGH.
12380   C
12390          XW=-1 .
12400          WRITE (IOU,20)
12410    20    FORMAT(/,1X,'COUNT THE CUTS IN THE FOLLOWING OUTPUT FROM LEFT
12420         1 TO RIGHT',/)
12430          WRITE (IOU,30)
12440    30    FORMAT(1X,'THE INITIAL GRAM MOLES IN THE SLICK ARE:')
12450          WRITE (IOU,40) (Y(I),I=1,NEQ)
12460    40    FCMU$IAT(ll( 1X.1PE10.3))
12470          W R I T E   (IOU,50)
12480    50    FORMAT(/,1X,'THE INITIAL MASSES (CRAMS) IN THE SLICK .4RE
12490         1:')
12500          WRITE (IOU,40) (YMSAVE( I),I=1,NEQ)
12510          WRITE (1OU,60) TSAVE
12520    60    FORMAT(1X,'THE TOTAL MASS FROM THESE CUTS IS "
12530         1,1PE10.3. * GRAMS")
12540          WRITE (IOU,70)
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12550   70    FORMAT(/)
12560   C
1 2570  C       CALCULATE DY/DX AND SET THE STEP SIZE TO APPROXIMATE
1 2580  C       A 5% CHANGE IN THE MOST RAPIDLY CHANGING Y.   WHEN THIS
12590   C       Y DECREASES BY A FACTOR OF 20. RESET THE STEP SIZE
12600   C       ACCORDING TO THE NEXT 'f.
12610   C       SOME Y'S WILL CHANGE SO FAST THAT THEY WILL BE GONE
12620   C       IN A FEW MINUTES.   THESE ARE DELETED BEFORE INTEGR.4TION
12630   C       STARTS AND NOTED ON THE PRINTED RESULTS.
12640   C
12650   C       INITIALIZE OR INCREMENT NFAST.
12660   C
12c.7q  80    NFAST=NFAST+ 1
1 2680  90    CALL FXYZ(X,Y,K1,NEQ)
12t?9u  C
1270U   C       THE TIME UNIT IS HOUR.
12710   C       SET THE STEP SIZE TO H=0.05*Y/(DY/DX) .
1 2720  C
12T3(;        H=0.05*Y(NFAST)/K1(NFAST)
12740         YOLD=Y(NFAST )
1 2750        H=ABS (H)
1276i*        H2=H/2.
12770         GO TO (100,170), IN
12780   C
12790   C       IF THERE IS A RAPIDLY MOVING COMPONENT AT THE BEGINNING
1 2800  C       ITS STEP SIZE WILL BE VERY SMALL. DO NOT LET THE
12810   C       STEP SIZE BE LESS THAN 0.05 HOUR.
12&?o   C
12830   100   IF(H.GT.0.05) GO TO 130
12840   C
128.50  C       Y(NFAST) CHANGES TOO FAST TO CALCULATE. DELETE IT AND MOVE
1 2860  C       EVERYBODY ONE SPACE TO THE LEFT.
12870   C
1 2880  C       WHEN YOU MOVE THE AREA BE SURE TO SUBTRACT THE CONTRIBUTION
12890   C       OF THE CUT JUST DELETED.
12900   C
12910         ISTART=1
1 2920        NFAST=1
12930         NDEL=NDEL+1
12940   C
12950   C       DECREASE THE NUMBER OF COMPONENTS BY 1
12960   C
12970         NEQ=NEQ-1
12980         NEQ1=NEQ+1
12990         NEQ2=NEQ+2
13000         NEQ3=NEQ+3
13010         NEQ4=NEQ+4
13020         AD=Y( 1 )/RHO( 1 )/Z
i 3030        DO 110 I=1,NEQ
13040   C
13050   C       SHIFT THE ARRAYS.
13of30  C
13070         I1=I+1
13080         Y(I)=Y(I1)
13090         VP(I)=VP( I1)
13100         MTC(I)=MTC(I1)
13110         YSAVE(I)=YSAVE (I1)
13120         VLOG(I)=VLOG(I1)
13130         RHO(I)=RHO(I1 )
13140         MWU(I)=MWU(I1)
13150         YMSAVE(I)=YMSAVE (I1)
13160   110   CONTINUE
13170   C
13180   C       BE SURE AND DO THE LAST THREE POSITIONS WHEN SHIFTING
13190   C
13200"        Y(NEQ1)=Y(NEQ2)-AD
```

```
13210          Y(NEQ2)=Y(NEQ3)
13220          Y(NEQ3)=Y(NEQ4)
13230          WRITE (IOU,120) NDEL
13240    120   FORMAT(1X,'CUT ',I2,' GOES AWAY IN MINUTES, THEREFORE IT WAS
13250         . DELETED AND THE CUTS RENUMBERED',/)
13260          WRITE (ITY,120) NDEL
13270          GO TO 90
13280    130   IN=2
13290          GO TO (140,160) ITYP
13300    140   ITYP=2
13310          WRITE (ITY,150)
13320    150   FORMAT(/,1X,'TIME',2X,'BBL',3X,'SPGR',2X,'AREA',2X
13330         .,'THICKNESS  W',2X,'DISP',4X,'ERATE',4X,'M/A   I  J')
13340    C
13350    C       THE COMPONENTS THAT MOVE TOO FAST TO CONSIDER (AT TIME
13360    C       ZERO) HAVE BEEN DELETED AND THE ARRAYS SHIFTED.
13370    C
13380    160   NEQ1=NEQ+1
13390          NEQ2=NEQ+2
13400          NEQ3=NEQ+3
13410    C
13420    C       NEVER LET THE STEP   ZE BE GREATER THAN 0.
13430    C
13440    170   IF(H.GT.0.5) H=0.5
13450          WRITE (IOU,180) H,NFAST
13460    180   FORMAT(/,2X,'STEP SIZE OF ',1PE10.3,' IS BASED ON CUT ',I3,/)
13470    C
13480    C       CHECK THE PRINT SWITCH.
13490    C
13500    190    F(X.LT.XW) GO TO 380
13510    C
13520    C       INCREMENT THE PRINT SWITCH AND CALCULATE INTERMEDIATE
13530    C       RESULTS NOT CARRIED WITH THE INTEGRATION.
13540    C
13550          XW=X+XP
13560          YTOT=0.
13570          TMASS=0.
13580          DO 200 I=1,NEQ
13590          YF(I)=Y(I)/YSAVE(
13600          YTOT=YTOT+Y(I)
13610          YM(I)=Y(I)*MWU(I)
13620          YM1(I)=YM(I)
13630          TMASS=TMASS+YM(I)
13640          YM(I)=YM(I)/YMSAVE(I)
13650    200   CONTINUE
13660          YM1(NEQ1)=Y(NEQ1)
13670    C
13680    C       CALCULATE THE MEAN MOLECULAR WEIGHT OF THE SLICK.
13690    C
13700          WMEANS=0.
13710          DO 210 I=1,NEQ
13720          WMEANS=WMEANS+MWU(I)*Y(I)/YTOT
13730    210   CONTINUE
13740          LINE=LINE+1
13750          WRITE (IOU,220) X,LINE
13760    220   FORMAT(2X,'TIME = ',1PE8.1,' HOURS, MASS FRACTION OF EACH
13770         1 CUT REMAINING:',65X,I3)
13780          WRITE (IOU,230) (YM(I),I=1,NEQ)
13790    230   FORMAT(14(1X,1PE8.1))
13800          CHECK=TMASS+Y(NEQ2)+Y(NEQ3)
13810          WRITE (IOU,240) TMASS,Y(NEQ2),Y(NEQ3),CHECK
13820    240   FORMAT(2X,'MASS REMAINING = ',1PE10.3,', MASS   SPERSED
13830         1 = ',1PE10.3,', MASS EVAPORATED = ',1PE10.3,'
13840         2, SUM = ',1PE10.3)
13850          WRITE (IPU,250) NEQ1
13860    250   FORMAT(I5)
```

```
13870          WRITE (IPU,260) X, (YM1(I), I=1,NEQ1)
13880    260   FORPLAT( 10( 1X.1PE10.3))
18890    C
13900    C       WHEN TRE FRACTION REMAINING OF COMPONENT I GETS LOW.
13910    C       SET ITS VAPOR PRESSURE .4ND MOLES EQUAL TO ZERO.
1392V    C
13930          DO 270 I=ISTART,NEQ
13940          IF(YF(I).GT.1.0E-08) GO TO 270
13950          IKEEP=I+1
13960          VP(I)=0.
13970          Y(I)=0.
13980    270   CONTINUE
13990          ISTART=IKEEP
14000          NFAST=IKEEP
14010          CONE(LINE)=TMASS/TSAVE
14020          ZP=Z*100.
1403f*         WRITE (IOU,280) CONE(LINE),Y(NEQ1),ZP,WMEANS
14040    280   FORMAT(2X,'FRACTION (BASED ON MASS) REMAINING IN THE SLICK
14050         1=',1PE8.1,', AREA=',1PE8.1,' M**2, THICKNESS='
14060         2,1PE8.1,' CM. MOLE WT=',0PF5.1)
14070    C
14omJ    C       WIO IS THE MOUSSE CALCULATION.
14099    C
14100          CALL WIO(X,W,VTERM)
14110    C
14120    C       VISCP1 IS THE VISCOSITY OF THE PARENT OIL WITH NO WATER
14130    C       INCORPORATED .
14140    C       VISCP1 IS IN CENTIPOISE. FEVAP IS THE FRACTION OF OIL
14150    C       EVAPORATED .  NOTE THAT FEVAP IS NOT
14160    C       1 - (FRACTION REMAINING) BECAUSE DISPERSION LOSSES
14170    C       WOULD BE INCLUDED.  THE FRACTION EVAPORATED MUST
14180    C       CORRECT FOR THE LOSS DUE TO DISPERSION.
14190    C
14200          FEVAP=1.0-CONE(LINE)
14210          FEVAP=FEVAP/YM (NEQ)
1 4220         VISCP1=VSLEAD*EXP (MK4*FEVAP)
14230    C
1 4240   C       VTERM IS THE VISCOSITY MULTIPLIER FROM THE MOUSSE
14250    C       CALCUIATION.
14~~~    C
14270          VISCP=VISCP1*VTERM
14~&3    C
14290    C       CALCULATE THE BULK SPGR.
14300    C
14310          BSPGR=0.
14320          DO 290 I=ISTART,NEQ
14330          BSPGR=BSPGR+SPGR (I)*Y(I)/YTOT
14340    290   CONTINUE
14330          VISQT=SQRT(VISCP/10. )
14360    C
14370    C       CALCULATE THE DISPERSION FACTOR.
14380    C
14390          FB=1./(1.+KB*VISQT*Z*STEN/0 .024)
14400          DISPER=FRACTS*FB
14410          WRITE (IOU,300) W,VISCP,DISPER
14420    300   FORMAT(2X,"WEIGHT FRACTION WATER IN OIL = ',1PE8. 1,', VIS
1443(V        1COSITY = ',1PE8. 1,' CENTISTOKES, DISPERSION TERM = ''
14440         2,1PE8. 1," WEIGHT FRACTION/HR')
14450          CVOLUM=Y(NEQ 1)*Z
14460          TBBL=CVOLUM/0 .159
14470          CVOLUM=(1.0E+06 )*CVOLUM
144G0          CSPGR=TMASS/CVOLUM
14490          WAREA=(1 .0E+06)*Z*CSPGR
14500          WDISP=WAREA*DISPER
14510          IF(INT.EQ.1) ERATE=0.
14520          ERATE=ERATE/Y (NEQ1)
```

```
14530          WRITE (I OU,310) WAREA, CSPGR, TBBL, WDISP, ERATE
14540    310   FORMAT ( 2X , 'MASS/AREA= ' , 1PE8.1 , ' GMS/M*M, SPGR= '
14550         1,1PE8. 1,", TOTAL VOLUME=', 1PE8. 1,' BBL, DISPERSION='
14560         2,1PE8. 1," GMS/M*M/HR, EVAP RATE=',1PE8.1, " GMS/M*M/HR')
14570    C
145G0    C       PRINT AN OUTPUT FILE FOR 80 COLUMN OUTPUT.
145943   C
14600          DO 320 J=1,NEQ
14610          JCUT=J
14620          IF(YM(J).GT.0.5) GO TO 330
14630    320   CONTINUE
14640    330   DO 340 I=1,NEQ
14650          I CUT= I
14660          IF(YM(I).GT.0.01) GO TO 350
14670    340   CONTINUE
14680    3543  IX=X
14690          IW=W*100.
I 4700         WRITE (ITY,360) IX,TBBL,CSPGR,Y(NEQ1 ),ZP,IW,WDISP
14710         1,ERATE,WAREA ,ICUT,JCUT
14720    360   FORMAT( 1X,I3,1PE8.1,0PF5 .2,2(1PE8.1),1X,I3
14730         1,3( 1PE8.1),I2,I3)
14740          WRITE (IOU,70)
14750    C
14760    C       INCREASE XP TO 10 HOURS AFTER 50 HOURS OF WEATHERING.
14770    C
14780          GO TO (370,380), NS
I 4790   370   IF(X.LT.50. ) GO TO 380
14800          NS=2
14810          XP=10.
14820    C
14830    C       TAKE A STEP IN TIME
14840    C
14850    380   XARG= X
14860          DO 390 I=1,NEQ3
14870          YARG(I)=Y(I)
14880    390   CONTINUE
14f390   C
14900    C       INT IS A SWITCH TO INDICATE THAT THE INTEGRATION WAS
14910    C       INITIATED.
14920    C
14930          INT=2
14'340         CALL FXYZ(XARG,YARG,K1 ,NEQ)
14950          XARG=X+H2
14960          DO 400 I=1,NEQ3
14970          YARG(I)=Y(I)+H*K1(I)/2.
14980    400   CONTINUE
14990    C
15000    C       SAVE THE EVAPORATION RATE FROM THE FIRST TIME
15010    C       THE DERIVATIVES ARE CALCULATED.
15020    C
15030          ERATE=K1(NEQ3 )
15040          CALL FXYZ(XARG,YARG,K2,NEQ)
15050          DO 410 I=1,NEQ3
15060          YARG(I )=Y(I)+H*K2(I )/2.
15070    410   CONTINUE
15080          CALL FXYZ(XARG,YARG,K3,NEQ)
15090          XARG=X+H
15100          DO 420 I=1,NEQ3
15110          YARG(I)=Y( I)+H*K3(I)
15120    420   CONTINUE
15130          CALL FXYZ(XARG ,YARG,K4,NEQ)
15140          DO 430 I=1,NEQ3
15150          Y(I)=Y( I)+H*(K1( I)+2.*(K2( I)+K3(I))+K4(I))/6.
15160    430   CONTINUE
15170    C
15180    C       IF 10 PER CENT BY MOLES OR LESS OF THE SLICK IS LEFT, STOP
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15190   c        THE CALCULATION BECAUSE STRANGE THINGS HAPPEN CLOSE TO
1520Q   C        ZERO OIL.
15210   c
1 5220          REMAIN= (3.
15230           DO 440 I=1.NEQ
15240           REMAIN=REMAIN+Y( I)
15250   440     CONTINUE
15260           TEST=REMAIN/TOTAL
15270           IF(TEST.GT.0.1) GO TO 470
15280           WRITE (IOU.450)
15290   450     FORMAT(/.1X.'THE SLICK (MOLES) HAS DECREASED TO 10%
15300          1 OR LESS. THEREFORE THE CALCULATION WAS STOPPED.')
15310           WRITE (ITY.460)
15320   460     FORMAT(/.1X.'SLICK DECREASED TO 10% MASS **STOP**" )
15330           GO TO 510
15340   C
15:150  C        RECALCULATE THE OVER-ALL MASS-TRANSFER COEFFICIENTS OUTSIDE
15360   c        THE DERIVATIVE SUBROUTINE.  THE DIAMETER DEPENDENCE IS VERY
15370   c        SLOW .  TERM2 IS THE OLD DIA**(-0.11).  SO DIVIDE THE OLD
15380   c        COEFFICIENT BY TERM2 AND MULTIPLY IN THE NEW ONE.
15390   C
154(NJ  c        WHEN YOU CHANGE THE WIND SPEED WITH RESPECT TO TIME.
15410   C        CHANGE THE MASS-TRANSFER COEFFICIENT HERE.  DIVIDE
15420   C        OUT THE OLD WIND TERM AND MULTIPLY IN THE NEW ONE.
15430   c        ALSO ,  IF THE TEMPERATURE CHANGES. RECALCULATE THE
15440   c        VAPOR PRESSURE HERE.  THIS APPLIES ONLY TO MACKAY
15450   c        AND MATSUGU.
15460   c
15'470  470     GO TO (500,480,500). KMTC
15480   480     DIA=SQRT(Y(NEQ1 )/0.785)
15490           TNEW=DIA**( -0.11)
15500           ADJUST=TNEW/TERM2
15510           DO 490 I=1,NEQ
15520           MTC(I)=MTC(I )*ADJUST
15530   490     CONTINUE
15540           TERM2=TNEW
15550   c
15560   c        CHECK TO SEE IF THE INTEGRATION IS COMPLETED.
15570   c
15580   500     IF(X.GE.X2) GO TO 51(3
15590           X= XARG
1 5600  c
15610   C        CHECK TO SEE IS THE FIRST NON-ZERO MOLES HAS FALLEN TO
15620   c        0.01 OF ITS STARTING VALUE.  IF IT HAS. RECALCULATE THE
15630   C        STEP SIZE ON THE NEXT NON-ZERO COMPONENT.  NOTE THAT
15640   c        A COMPONENT IS NOT ZEROED UNTIL ITS MOLE NUMBER HAS
15650   C        FALLEN TO LESS THAN 1.0E-08.
15660   C
15670           TEST=ABS(Y( NFAST)/YOLD )
1 5680          IF(TEST.LT.0.01) GO TO 80
15690           GO TO 190
15700   510     NDEL=NDEL+1
15710           WRITE (IOU.520) NDEL
1 5720  520     FORMAT(/.1X.'THE CUT NUMBERING BEGINS WITH'.I3.' BASED ON
15730          1 THE ORIGINAL CUT NUMBERS',/)
15740           LINE=LINE+1
i 5750          WRITE (IOU.530) X.LINE
15760   530     FORMAT(1X. 'THE FINAL MASS FRACTIONS FOR THE SLICK AT '
157'70         1.1PE8.1.' HOURS ARE: '.65X.I3)
15780           TYPE 540, LINE
15790   540     FORMAT(1X. "NUMBER OF LINES WRITTEN TO CUTVP2.PLT = '.I4)
1 5800          TMASS=0.
15810           DO 550 I=1.NEQ
15B20           YM(I)=Y(I)*MWU(I)
150:10          TMASS=TMASS+YM (I)
15840           YM1(I)=YM(I)
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15850          YM(I)=YM(I)/YMSAVE(I)
15860   550    CONTINUE
15870          YM1(NEQ1)=Y(NEQ1)
15880          CONE(LINE)=TMASS/TSAVE
15890          WRITE (IOU,40) (YM(I),I=  NEQ
15900          WRITE (IPU,250) NEQ1
15910          WRITE (IPU,260) X,(YM1(I),I=1,NEQ1)
15920          WRITE (IPU,260) (CONE(I),I=1,LINE)
15930          ZP=Z*100.
15940          WRITE (IOU,280) CONE(LINE), (NEQ1),ZP,WMEANS
15950          CHECK=TMASS+Y(NEQ2)+Y(NEQ3)
15960          WRITE (IOU,240) TMASS,Y(NEQ2),Y(NEQ3),CHECK
15970          WRITE (IOU,560)
15980   560    FORMAT(/,1X,'*****************************************
15990         1*************************',/)
16000          RETURN
16010          END
16020          SUBROUTINE FXYZ(XARG,MOLES,K,NEQ)
16030          REAL*4 MOLES,K,MTC,MW,MWU,KB
16040          COMMON /SPILL/ MTC(30),VP(30),VLOC(30),RHO(30),MW(30)
16050         1,SPGR(30),FRACTS,STEN,KB,DISPER,Z,TERM2,SPREAD,KMTC
16060          COMMON /TALK/ MWU(30),NEQ1,NEQ2,NEQ3
16070          DIMENSION MOLES(30),K(30),TMPVP(30),TMPDS(30)
16080   C
16090   C        THE VECTOR BEING INTEGRATED RESIDES IN MOLES(I).
16100   C        POSITIONS I=1 THROUGH I=NEQ ARE THE PSEUDO COMPONENTS.
16110   C        POSITION NEQ1=NEQ+1 IS THE AREA.
16120   C        POSITION NEQ2=NEQ+2 IS THE MASS LOST BY DISPERSION ALONE.
16130   C        POSITION NEQ3=NEQ+3 IS THE MASS LOST BY EVAPORATION ALONE.
16140   C
16150   C
16160          SUM=0.
16170          DO 10 I=1,NEQ
16180          SUM=SUM+MOLES
16190   10     CONTINUE
16200          DO 20 I=1,NEQ
16210   C
16220   C        CALCULATE THE MOLE DERIVATIVES
16230   C
16240          TMPVP(I)=MTC(I)*MOLES(NEQ1 *VP(I)*MOLES(I)/SUM
16250          TMPDS(I)=DISPER*MOLES(I)
16260          K(I)=TMPVP(I)+TMPDS(I)
16270          K(I)=-K(
16280   20     CONTINUE
16290          VOL=0.
16300          DO 30 I=1,NEQ
16310          VOL=VOL+MOLES(I)/RHO(I)
16320   30     CONTINUE
16330   C
16340   C        CALCULATE THE AREA DERIVATIVE.
16350   C
16360          Z=VOL/MOLES(NEQ1)
16370          K(NEQ1)=(5.4E+05)*(Z**1.33)*MOLES(NEQ1)**0.33
16380          K(NEQ1)=SPREAD*K(NEQ1)
16390   C
16400   C        CALCULATE THE MASS LOST FROM THE SLICK DUE TO
16410   C        EVAPORATION ALONE AND THEN DISPERSION ALONE.
16420   C
16430          K(NEQ2)=0.
16440          K(NEQ3)=0.
16450          DO 40 I=1,NEQ
16460          K(NEQ3)=K(NEQ3)+TMPVP(I)*MWU(I)
16470          K(NEQ2)=K(NEQ2)+TMPDS(I)*MWU(I)
16480   40     CONTINUE
16490          RETURN
16500          END
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16510          SUBROUTINE WI O(TIME, W,VTERM)
16520          COMMON /MOOSE/ WIN DS, C1 ,C2, C3, C4
16530          WFUNC(W)=(1 .0-C2*W )*EXP( -2.5* W/(1 .0-C1*W))
16540          VIS(W)=EXP(2 .5*W/(1.0-C1*W) )
16550          DATA WSAVE,C4SAVE/-1 .,-1 ./
16560    C
1 6570   C       THIS IS THE WATER-IN-OIL (MOUSSE) ROUTINE.
16580    C       W IS THE FRACTIONAL WATER CONTENT IN THE OIL.
1 6590   C       WINDS IS THE WIND SPEED IN KNOTS.
16600    C       TIME IS IN HOURS.
16610    C       Cl IS A VISCOSITY CONSTANT = 0.65
16620    c       C2 IS AN OIL-COALESCING CONSTANT AND IS OIL
1 6630   c       DEPENDENT. AND IS THE INVERSE OF THE MAXIMUM WEIGHT
16640    C       FRACTION WATER IN OIL.
16650    c       C3 IS A WATER INCORPORATION RATE (1 ./HR). USUALLY 0.01*U*U
1 6660   c
16670    c       THE PREDICTION EQUATION FOR W IS IMPLICIT AND IS
1 6680   c       SOLVED BY TRIAL AND ERROR.
16690    c
16700    C       REFERENCE:  CHAPTER 4 BY MACKAY IN OIL SPILL PROCESSES
16710    c       AND MODELS.
16720    c
16730    c       DECEMBER, 1981
16740    C
16750    C       IERR IS THE ERROR CODE.
16760    C       IERR=1 IS A NORMAL EXIT. IERR=2 IS A PROBLEM IN THE
16770    C       TRIAL-AND-ERROR ROUTINE,  IERR=3 IS A STEADY-STATE
16780    C       MOUSSE EXIT.
16790    c
16800    c       IF THE OIL DOES NOT FORM MOUSSE, C2 WAS SET TO -1.
16810    c
16820          IF(C2.GT.0. ) GO TO 10
16830    c
16840    c       NO MOUSSE FOR THIS OIL, SET TERMS AND RETURN.
16.550   c
16860          W=0.
16870          VTERM=1.
16880          GO TO 90
16890    10    IERR=1
16900    c
16910    C       CHECK TO SEE IF THE WIND OR INCORPORATION RATE CONSTANT
16920    c       CHANGED.
16930    c
16940          IF(WINDS .EQ.WSAVE.AND.C4.EQ .C4SAVE) GO TO 20
16950          WSAVE=WINDS
16960          C4SAVE=C4
16970          U2=WINDS*WINDS
16930          C3=C4*U2
1 6990   20    EX=C3*TIME
17@oo          IF(EX.GT.20.) GO TO 80
17010          TEST=EXP(-EX )
17020    C
17030    C       BRACKET THE TIME WITH TWO VALUES OF W.
17040    C
17050          W=0.
17060          WMAX=1 ./C2
17070          WSTEP=WMAX/ 10.
17080    30    W=W+WSTEP
17090          TRY=WFUNC(W)
17100          IF(TRY.LT.TEST) GO TO 40
17110          IF(W.LT.WMAX) GO TO 30
17120          IERR=2
1713(?         GO TO 90
17140    C
17150    C       NOW DO INTERVAL HALVING TO FIND W.
17160    C
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17170   40    NTRY=0
17180         WR=W
17190         WL=W-WSTEP
17200   50    W=(WR+WL)/2.
17210         TRY=WFUNC( W)
17~~~         IF(TRY.LT.TEST) GO TO 60
17230         WL=W
17240         GO TO 70
17250   60    WR=W
1726(3  70    NTRY=NTRY+1
17270         IF(NTRY.LT.10) GO TO 50
17~80         VTERM=VIS(W)
17290         GO TO 90
17300   80    IERR=3
17310   90    CONTINUE
17320         RETURN
17330         END
```

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   CCCCCCCCCCCC      UUU          UUU      TTTTTTTTTTTTTTT      VVV          VVV      P
   CCCCCCCCCCCC      Uuu          UUU      TTTTTTTTTTTTTTT      VVV          VVV      P
   CCCCCCCCCCCC      Uuu          Uuu      TTTTTTTTTTTTTTT      VVV          VVV      P
CCC                  UUU          UUU             TTT           VVV          VVV      P
CCC                  UUU          UUU             TTT           VVV          VVV      P
CCC                  UUU          m u             TTT           VVV          VVV      F
CCC                  UUU          UUU             TTT           VVV          VVV      F
CCC                  UUU          UUU             TTT           VVV          VVV      F
CCC                  Uuu          Uuu             TTT           VVV          VVV      F
CCC                  UUU          UUU             TTT           VVV          VVV      F
CCC                  Uuu          Uuu             TTT           VVV          VVV      F
CCC                  UUU          UUU             TTT           VVV          VVV      F
CCC                  Uuu          UUU             TTT           VVV          VVV      F
CCC                  UUU          Uuu             TTT           VVV          VVV      F
CCC                  UUU          UUU             TTT           VVV          VVV      F
CCC                  Uuu          Uuu             TTT              VVV    VVV         F
CCC                  Uuu          Uuu             TTT              VVV    VVV         F
CCC                  UUu          UUU             TTT              VVV    VVV         F
   CCCCCCCCCCCC      UUUUUUUUUUUUUUU              TTT                 VVV              F
   CCCCCCCCCCCC      UUUUUUUUUUUUUUU              TTT                 VVV              F
   CCCCCCCCCCCC      UUUUUUUUUUUUUUU              TTT                 VVV              F


FFFFFFFFFFFFFFF          000000000         RRRRRRRRRRRRR
FFFFFFFFFFFFFFF          000000000         RRRRRRRRRRRRR
FFFFFFFFFFFFFFF          000000000         RRRRRRRRRRRRR
FFF                 000          000      RRR          RRR
FFF                 000          000      RRR          RRR
FFF                 000          000      RRR          RRR
FFF                 000          000      RRR          RRR
FFF                 000          000      RRR          RRR
FFF                 000          000      RRR          RRR
FFFFFFFFFFFF        000          000      RRRRRRRRRRRRR
FFFFFFFFFFFF        000          000      RRRRRRRRRRRRR
FFFFFFFFFFFF        000          000      RRRRRRRRRRRRR
FFF                 000          000      RRR    RRR
FFF                 000          000      RRR    RRR
FFF                 000          000      RRR    RRR
FFF                 000          000      RRR       RRR
FFF                 000          000      RRR       RRR
FFF                 000          000      RRR       RRR
FFF                      000000000        RRR          RRR
FFF                      000000000        RRR          RRR
FFF                      000000000        RRR          RRR
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*START* Job CUTVP2 Req #4487 for OIL-WEATHER [4601 .46011     Date  5-May-83 13:25:32 M
File DSKD:CUTVP2 .FOR[4601 ,4601 1, created: 22-Mar-82 15:17:00, printed:   5-May-83 13:2
Job parameters: Request created: 5-May-83 13:25:32   Page limit:333   Forms:V  Accoun
File  parameters: Copy:2 of 2   Spacing:SINGLE   File format:ASCII   Print mode:ASCII
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