# OCEAN-ICE OIL-WEATHERING COMPUTER PROGRAM USER'S MANUAL

by

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**Final Report**
**Outer Continental Shelf Environmental Assessment Program**
**Research Unit 664**

**October 1987**

ACKNOWLEDGMENTS

This study was funded in part by the Minerals Management Service through interagency agreement with the National Oceanic and Atmospheric Administration, as part of the Outer Continental Shelf Environmental Assessment Program. Additional funding for research and Oil/First-Year Ice Interactions was provided through a U.S. Coast Guard/OCSEAP Interagency Agreement for RU 640.

Because the Oil in Ice Program is an extension of our ongoing oil weathering investigations, the contributions of numerous individuals over many years and months have been critical to its successful development. As in our open-ocean oil-weathering research, Professor D. Mackay of the University of Toronto has contributed extensively through his decade of experience in oil weathering, and we draw upon this vast experience for mass transfer, slick spreading, and water-in-oil emulsification. Professor Seelye Martin at the University of Washington was extremely helpful through his assistance in the design and execution of cold room/wave tank studies at Kasitsna Bay. Lt. Cmdr. Peter A, Tebeau, Environmental Technology Branch, USCG, is gratefully acknowledged for his interest and support in the areas of vertical migration of oil in brine channels, evaporation, and emulsification. The continued and sustained efforts of Russell and Linda Geagel in completing the design and fabrication of the cold room and wave tank system at NOAA'S Kasitsna Bay Laboratory are gratefully acknowledged. Mr. George Lapiene and Lt. Cmdr. Mike Meyer are also thanked for their assistance in expediting activities at Kasitsna Bay. Mabel O'Byrne, Laurie Hughey, Lucy Kaelin and Jimmie Stone produced the final copy of this document on the word processor.

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## MODEL OVERVIEW

The ocean-ice oil-weathering code is written in FORTRAN as a series of stand-alone subroutines that can easily be installed on most any computer. All of 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 oil weathering by using this code. A complete code listing of the ocean-ice oil-weathering code is presented in the Appendix to this report.

The ocean-ice 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 as part of the main code because this weathering process is not significant with respect to the overall material balance of the oil slick. The companion document to this User's Manual (Final Report for RU 664, Payne et al. 1987)* contains computer code for stand-alone models which consider component-specific dissolution from oil slicks and from dispersed droplets.

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 ocean-ice 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

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*See pages 147-465 of this volume.

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 and compositional observations 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 weathering processes 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.

Sample runs of the model are included in this User's Manual in the following manner. Examples of the various input options are presented and described on pages 17 through 39. Examples of various calculated results appear on pages 40 through 81. Each output or run of the computer model always echoes the input to the output. In other words, what was entered as input is documented in the output. Therefore, the calculated results appearing on pages 40 through 81 contain all the user-entered parameters. The illustrations of input are intended to illustrate all the options available and a real computer run would (probably) not invoke all these options (i.e., spreading versus no spreading, dispersion versus increased dispersion, and many other on-off examples).

## MODEL DESCRIPTION

The pseudo-component characterization of crude oil for the open-ocean oil-weathering model is described in detail (Payne et al., 1984a). The specific detail presented in 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 pseudo-component evaporation model and the over-all mass-transfer coefficient required for evaporation has also been described in detail (Payne, Kirstein, et al., 1983 and 1984a). 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 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 $\exp(K_4 F)$ 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 Olge, 1969).

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

$$(1 - K_2W) \exp\left[\frac{-2.5W}{1-K_1W}\right] = \exp(-K_5K_3t)$$

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, $K_3$ is a lumped water incorporation rate constant, and $K_5$ is a factor by which the mousse formation rate is increased during broken- ice field weathering.

The change in visiosity due to mousse formation is predicted by:

$$\mu = \mu_0 \exp\left[\frac{-2.5W}{1-K_1W}\right]$$

where $\mu^\circ$ 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:

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

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

where F is the fraction of sea surface subject to dispersions per second, U is the wind speed in m/see, $K_a$ is constant, and Kc is a factor by which dispersion is increased during broken-ice field weathering. $F_b$ 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 meters, 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 (1967). An example of a TBP distillation is shown in Table 1. The petroleum product characterized in this table is a whole crude oil. The reason for choosing this example is that it is a text-book example of a true-boiling-point distillation. The introduction of the true-boiling-point distillation to characterize crude oil and products for environmental predictions is a new concept. Therefore, the objective in using this example is to illustrate that the concept is common in another branch of engineering. By providing this example, the reader has access to a readily available reference that actually used a TBP (i.e. , Van Winkle, 1967).

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

Table 1.--Example of True Boiling Point (TBP) Distillation of Crude Oil (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 | -- |

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 distillations 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 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 700F. Thus, the data reported by Coleman are around atmospheric pressure up to 527F, 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-atmosphere 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.

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, 0.82 — Color, brownish black
Viscosity, Saybolt Universal at 77° F, 111 sec; 100° F, 84 sec — Nitrogen, percent, 0.230

**DISTILLATION, BUREAU OF MINES ROUTINE METHOD**

Stage 1—Distillation at atmospheric pressure, 741 mm Hg
First drop 81 ° F

| Fraction No. | Cut temp. ° F | Percent | Sum percent | Sp. gr. 60/60° F | API 60° F | C/H | Refractive index $n_D$ at 20° C | Specific dispersion | S.U. visc. 100° F | Cloud test, ° F |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 122 | | | | | | | | | |
| 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 | 141.9 | | |
| 5 | 302 | 3.6 | 11.8 | .773 | 51.6 | 30 | 1.43082 | 147.0 | | |
| 6 | 347 | 3.7 | 15.5 | .790 | 47.6 | 31 | 1.43922 | 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 | 527 | 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 | 43 | 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 | .897 | 26.2 | 49 | 1.49477 | 169.4 | 58 | 50 |
| 14 | 527 | 6.0 | 55.2 | .910 | 24.0 | 52 | | | 93 | 70 |
| 15 | 572 | 7.4 | 62.6 | .919 | 22.5 | 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, -
Nitrogen, percent, -

**APPROXIMATE SUMMARY**

| | Percent | Sp. gr. | API | Viscosity |
|---|---|---|---|---|
| Light gasoline | 4.7 | 0.710 | 67.9 | |
| Total gasoline and naphtha | 19.0 | 0.762 | 54.2 | |
| Kerosene distillate | 4.3 | .818 | 41.5 | |
| Gas oil | 18.4 | .860 | 33.1 | |
| Nonviscous lubricating distillate | 11.0 | .887-.911 | 28.0-23.9 | 50-100 |
| Medium lubricating distillate | 8.1 | .911-.922 | 23.9-22.0 | 100-300 |
| Viscous lubricating distillate | 1.8 | .922-.924 | 22.0-21.6 | Above 300 |
| Residuum | 36.3 | .990 | 11.4 | |

| Fraction no. | Cut temperature, °F at 1 atmosphere |
|---|---|
| 10 | 580 |
| 11 | 638 |
| 12 | 638 |
| 13 | 738 |
| 14 | 790 |
| Residuum | -- |

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 code execution. 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 >850F. This assigned boiling point is fictitious and used to indicate that this cut is indeed a residuum.

It can be noted that the true boiling point data presented here (e.g., Table 3) differ from values presented in the open-ocean oil weathering model (Payne et al., 1984a). Reasons for these differences can be explained as follows. The distillation data in Table 2 are presented as cumulative-cut temperatures and are to be interpreted as follows: Fraction #4 (for example) has a cut temperature of 257°F, which means the distillate receiver was changed at this temperature and Fraction #5 began being collected. Thus, the Fraction #4 temperature tabulated is the upper temperature at which that fraction was collected. The temperature used to characterize the entire fraction is the average temperature that is (rounded up to) 235°F.

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.

The distillation cut data for non-library oils can be entered by the user. The user can either enter this data via the keyboard or use data from a disk file created from a previous execution of the model. An example of keyboard input is illustrated in Table 7 using TBP data for a gasoline cut (O&GJ, 1973, pg. 57) which is presented in Table 6.

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

```
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 | 150.0 | 72.7 | 2.1 |
| 2 | 190.0 | 64.2 | 2.6 |
| 3 | 235.0 | 56.7 | 3.5 |
| 4 | 280.0 | 51.6 | 3.6 |
| 5 | 325.0 | 47.6 | 3.7 |
| 6 | 370.0 | 45.2 | 3.5 |
| 7 | 415.0 | 41.5 | 4.3 |
| 8 | 460.0 | 37.8 | 4.8 |
| 9 | 505.0 | 34.8 | 5.0 |
| 10 | 554.0 | 30.6 | 2.8 |
| 11 | 609.0 | 29.1 | 6.5 |
| 12 | 662.0 | 26.2 | 6.8 |
| 13 | 712.0 | 24.0 | 6.0 |
| 14 | 764.0 | 22.5 | 7.4 |
| 15 | 850.0 | 11.4 | 36.3 |

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

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 0.938 Gravity, ° API. 19.4 Pour point, ° F. below 5
Sulfur, percent. 1.59 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. 738 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. visc. 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 | | |
| 5 | 302 | 2.4 | 7.1 | .747 | S3.0 | 27 | 1.42308 | 127.1 | | |
| 6 | 347 | 2.s | 9.6 | .788 | 48.1 | 30 | 1.43480 | 128.8 | | |
| 7 | 392 | 2.8 | 12.4 | .810 | 43.2 | I 34 | 1.44651 | 133.3 | | |
| 8 | 437 | 3.6 | 16.0 | .831 | 38.8 | 39 | 1,45771 | 149,6 | | |
| 9 | 482 | 4.4 | 20.4 | .848 | 35.4 | 41 | 1.46754 | ISO. S | | |
| 10 | 527 | 5.3 | 25.7 | .864 | 32.3 | u | 1.47/36 | 152.9 | | |
| Stage 2—Distillation continued at 40 mm Hg | | | | | | | | | | |
| 11 | 392 | 4.7 | 30.4 | 0.894 | 26.8 | 55 | 1.48843 | 155.3 | 42 | Below 5 |
| 12 | 437 | 6.3 | 34.7 | .907 | 24.5 | 57 | 1.49898 | I 163.,8 | 56 | do. |
| 13 | 482 | 4.1 | 40.8 | .920 | 22.3 | 60 | | | 87 | do. |
| 1/ 14 | 527 | 5.5 | 46.3 | .932 | 20.3 | 62 | | | 172 | do. |
| 15 | 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 | |
| Kerosene distillate | - | - | - | |
| Gas oil | 18.8 | .863 | 32.5 | |
| Non-lubricating distillate | 8.3 | .901-.922 | 25.5-22.0 | 50-100 |
| Medium lubricating distillate | 5.6 | .922-.936 | 22.0-19.7 | 100-200 |
| Viscous lubricating distillate | 1.2 | .936-.939 | 19.7-19.2 | Above 200 |
| 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.)

```
ENTER THE NUMBER OF TBP CUTS TO BE CHARACTERIZED ON I2
IF ● fOU 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
3

YOU CHOSE: WILMINGTON, CALIFORNIA
```

| CUT | TB | API | VOL |
|---|---|---|---|
| 1 | 195.0 | 68.6 | 2.3 |
| 2 | 235.0 | S8.7 | 2.4 |
| 3 | 280.0 | 53.0 | 2.4 |
| 4 | 325.o | 48.1 | 2.5 |
| 5 | 370.0 | 43,2 | 2.8 |
| 6 | 415.0 | 38.8 | 3.6 |
| 7 | 460.0 | 3s.4 | 4*4 |
| 8 | 505.o | 32*3 | 5.3 |
| 9 | 554.0 | 26.8 | 4.7 |
| 10 | 609.0 | 24.5 | 6.3 |
| 11 | 662.0 | 22,3 | 4.1 |
| 12 | 712.0 | 20.3 | 5.5 |
| 13 | 850.0 | 8.9 | 53.3 |

```
DO You WANT TO CHANGE ANYT
N
DO YOU WANT THE MACKAY CONSTANTS?
```

Table 6.--True Boiling Distillation Data for a Gasoline Cut (O&GJ, ' 1973, pg. 57).

| cut | Cut Temp. , "F | vol. % | API Gravity |
|---|---|---|---|
| 1 | 137 | 1.5 | 71.6 |
| 2 | 196 | 2.1 | 69.7 |
| 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.)

```
ENTER THE NUMBER OF TBP CUTS TO BE CHARACTERIZED ON I2
IF YOU HAVE HO INPUT DATA JUST ENTER 99
A 99 ENTRY WILL USE A LIBRARY EXAMPLE
5
IS THE CRUDE ON A FILE ?
N
ENTER THE NAME OF THE CRUDE
GASOLINE CUT
ENTER AN IDENTIFICATION NUMBER FOR THIS CRUDE ON I5
11111
ENTER A SAMPLE NUMBER ON I5
22222
ENTER THE BULK API GRAVITY
5s.

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
1.5
ENTER THE BOILING POINT AT 1 ATM IN DEG F FOR CUT 2
196.
```

Table 7.--(Continued)

```
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
2.0
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  s
2.

CUT      TB          API         VOL
 1      137.0       71.6        1*S
 2      196.0       59.7        2.1
 3      228.0       5s.0        2.0
 4      256.0       53.8        2.0
 5      283.0       49.6        2.0
DO YOU WANT TO CHANGE ANY?
N
THIS CRUDE WILL NOW BE WRITTEN TO A FILE. WHAT WOULD YOU LIKE
TO CALL IT?
[FRSNAM OFEN unit 38    DSK:FOR38.DAT at MAIN.+526 (FC 14421)]
[FRSEFS Enter correct file specs]
*GASCUT.OIL
DO YOU WANT THE MACKAY CONSTANTS?
N
```

Each time an input is required the user is prompted with an appropriate question. Since it is nearly 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.

Following keyboard data entry, the user will be prompted for a name to be assigned to a disk file which will contain the TBP data for the oil of interest. The format for this name is one to six characters followed by an optional period and one to three letter extension. In the example (Table 7), the file was named GASCUT.OIL.

An example of disk file input is illustrated in Table 9. In this example, the disk file created in the previous example (Table 7) is used as input for the model.

After the TBP data required as input have been specified, the user is asked if the Mackay Constants are desired. These constants are input constants for the Mackay evaporation model (Mackay, 1982). The calculation of these constants are an "add-on" calculation and do not affect the "weathering" portion of the model.

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 S
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 12
3
ENTER 1 TO CHANGE TB,2 FOR API,3 F(3R VOL%
1
ENTER THE CHANGED DATA
228.

CUT      TB          API         VOL
 1      137.0       71.6        1.5
 2      196*O       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 Disk-file Input of TBP Distillation Data.

```
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
IS THE CRUDE ON A FILE ?
Y
WHAT IS THE FILE NAME?
[FRSNAM OPEN unit 36    DSK:FOR36.DAT at MAIN.+156 (FC 14051)]
[FRSEFS Enter correct file specs]
*GASCUT.OIL

CUT      TB          API         UOL
 1      137.0       71.6        15.6
 2      196.0       59,7        21.9
 3      228.0       55.0        20.8
 4      256.0       53.8        20.8
 5      283.0       49.6        ,20.8
DO '(OU WANT TO CHANGE ANY?
N
DO YOU WANT THE MACKAY CONSTANTS?
N
```

At this point the calculation can be stopped. The crude oil characterization and, if desired, the Mackay Constants are 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.

Following this, the user is "led" through a series of three "compartments" of possible oil weathering. These three compartments are:

1. Oil weathering in pools on top of ice.
2. Oil weathering on the ocean surface in a broken-ice field.
3. Open ocean oil weathering.

The user is allowed to "mix and match" combinations of these three environmental configurations in order to design a scenario that will best match the actual or hypothetical conditions for which an oil weathering prediction is desired. Individual compartments can be skipped and environmental parameters such as temperature, wind speed, etc. can be changed from compartment to compartment. An example of user input for a scenario that involves all three compartments using a library crude oil is illustrated in Table 10. Following the spill size specification the user is asked WILL THE WEATHERING SCENARIO INCLUDE SEA ICE? If the user responds with "N", the first two compartments are not used and open ocean weathering follows. If the user enters 'Y', as in the example, all three weathering compartments are offered.

For weathering of oil on top of ice the required input data are: the number of hours for oil weathering, the temperature, the depth of the oil pools, the mass-transfer coefficient code, the wind speed, and, if desired, new viscosity constants.

Table 10.--Illustration of User Input for Oil-Weathering Calculation with a Library-Specified Crude.

```
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      150.0       72.7        2.1
 2      190.0       64.2        2.6
 3      235.0       56.7        3.5
 4      280.0       51.6        3.6
 5      325.0       47.6        3.7
 6      370.0       45.2        3.5
 7      415.0       41.5        4.3
 8      460.0       37.8        4,8
 9      505.0       34.8        S*O
10      554,0       30,6        2.8
11      609.0       29*1        6.5
12      662.0       26.2        6.8
13      712.0       2400        6.0
14      764.0       22.5        7.4
15      850.0       11.4       36.3
DO YOU WANT TO CHANGE ANY?
N
DO YOU WANT THE MACKAY CONSTANTS?
Y
AT WHAT TEMPERATURE, DEG F?
32.

PLEASE WAIT

DO YOU WANT TO WEATHER THIS OIL?
Y
WHAT IS THE SPILL SIZE IN BARRELS?
10000
WILL THE WEATHERING SCENARIO INCLUDE SEA ICE?
Y
WHEN THE OIL REACHES THE OIL SURFACE,
WILL IT WEATHER IN POOLS ON TOP OF THE ICE?
Y
```

Table 10.--(Continued)

```
AT WHAT TEMPERATURE, DEG F?
20.
FOR HOW MANY HOURS?
24.
HOW DEEP WILL THE POOLS BE IN CM?  TRY 2
2
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 WEED IN KNOTS
10
DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?
N

PLEASE WAIT
WILL THE OIL NOW WEATHER IN THE BROKEN ICE FIELD?
Y
FOR HOW MANY HOURS?
100.
AT WHAT TEMPERATURE, DEG F?
32.
ENTER THE FRACTION OF ICE COVER, I.E. 0.7
.66
DO YOU WANT To ENTER NEW MOUSSE FORMATION CONSTANTS?
N
DO YOU WANT TO ENTER A NEW OIL-WATER SURFACE TENSION (DYNES/CM)?
N
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
1.5.
110 YOU WANT THE SLICK TO SPREAD?
Y
DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?
N
DO YOU WANT THE WEATHERING TO OCCUR WITH DISPERSION?
Y
DO YOU WANT TO ENTER NEW DISPERSION CONSTANTS?
N

PLEASE WAIT
```

Table 10.--(continued)

```
WILL OPEN OCEAN WEATHERING NOW OCCUR?
Y
FOR HOW MANY HOURS?
240.
AT WHAT TEMPERATURE, DEG F?
40.
DO YOU WANT TO ENTER NEW MOUSSE FORMATION CONSTANTS?
N
DO YOU WANT TO ENTER A NEW OIL-WATER SURFACE TENSION (DYNES/CM)?
N
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
20.
DO YOU WANT THE SLICK TO SPREAD?
Y
DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?
N
DO YOU WANT THE FEATHERING TO OCCUR WITH DISPERSION?
Y
DO YOU WANT TO ENTER NEW DISPERSION CONSTANTS?
N

PLEASE WAIT
CPU time 19.73   Elapsed time 2:36.35
```

The mass-transfer coefficient is for the evaporation weathering process, not dissolution. There are three possible mass-transfer coefficient input specifications, and the one recommended is 2 as illustrated in Table 10.

The wind speed, which is in knots, 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.

For now, new viscosity constant are not entered. The procedure for specifying new constants will be detailed later in this manual.

After all of the required data have been entered, the user is asked to wait while the numerical integration routine is executed. Following this pause, the user is asked if broken ice field weathering will take place. In the example (Table 10), the answer is "YES" so the input parameters for broken-ice field weathering are now requested. For library oils the required data are the same for broken-ice and open-ocean weathering (with one minor exception noted below) so the following discussion applies to both of these compartments of the model.

The required data at this point are: the number of hours for weathering to occur, the temperature, new mousse formation constants (if desired), new oil-water surface tension (if desired), the mass-transfer coefficient code, the wind speed, whether or not the slick is to spread (YES) or (NO), new viscosity constants (if desired), whether or not the slick is to disperse (YES) or (NO), and new dispersion constants (if desired). For broken-ice weathering one other parameter is required, the fraction of ice cover.

As shown in Table 10, dispersion and spreading are "on" for the example and no new constants have been specified to replace the library values.

The same guidelines for mass-transfer coefficient code and wind speed outlined above apply for the last two compartments as well.

The fraction of ice cover is used to calculate the reduction in spreading rate due to the broken ice. The spreading equation (or algorithm) used in the oil weathering code(s) is a correlation based on observation. At present, there is not a mechanistic model (except possibly Elliot, 1986) that applies to the open ocean, and especially the situation where ice occurs or where ice cover changes as a function of time. The correlation algorithm for spreading can be changed quite readily in the oil-weathering codes in the event a useable algorithm is published. The search for a more realistic and mechanistic spreading model for all situations is on-going.

The preceding input description illustrates a straightforward use of the information programmed in the oil-weathering code. Illustrations of how the programmed information can be changed are presented in the following discussion. Altering the programmed 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. Such alteration can be used in each of the three compartments of the model so the following discussion applies to each of those compartments.

The first input information that can be changed by the user is the mousse-formation constants as illustrated in Table 11. 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).

$$(1 - K_2W) \exp \left[ \frac{-2.5W}{1-K_1W} \right] \exp (-K_3K_5t)$$

where W is the weight fraction water is mousse. $K_1$ is a constant in the viscosity equation, $K_2$ is a coalescing-tendency constant, $K_3$ is a lumped water incorporation rate constant, and $K_5$ is the factor included in the equation to increase the mousse formation rate in the broken-ice field. $K_1$ appears in a stand-alone equation for the apparent viscosity of the emulsion as (Mooney, 1951).

Table 11.--Illustration of User-Specified Mousse-Formation Constants.

```
DO YOU WANT TO ENTER NEW MOUSSE FORMATION CONSTANTS?
Y
1. ENTER THE MAXIMUM WEIGHT FRACTION WATER IN OIL
.60
2. ENTER THE MOUSSE-VISCOSITY CONSTANT, TRY 0.65
●&5
3. ENTER THE WATER INCORPORATION RATE CONSTANT, TRY 0.001
*001
4. ENTER THE BROKEN ICE FIELD MULTIPLIER FOR MOUSSE FORMATION
5.
DO YOU WANT TO ENTER A NEW OIL-WATER SURFACE TENSION (DYNES/CM)?
Y
TRY 30.
30.
```

$$\mu = \mu_0 \exp\left[\frac{-2.5W}{1-K_1W}\right]$$

where $\mu^\circ$ 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 11, 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. There is limited data available for $K_5$ but some evidence points to a typical value of about 10 for broken-ice fields, which is the default value. In the open ocean, $K_5$ is by definition 1.0 so input is not required for this constant in the open-ocean section of the code, Note that most of 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 10 uses the correlation mass transfer coefficient as developed by Mackay and Matsugu (Mackay and Matsugu, 1973). Table 12 illustrates the three possible input

Table 12.--Illustration of Three Input Options for the Mass Transfer 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?
'f
ENTER THE OVER-ALL MASS-TRANSFER COEFFICIENT, CM/HR, TRY 10
10.
DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?
```

```
ENTER THE MASS-TRANSFER COEFFICIENT CODE:1,2,OR 3 WHERE:
I-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?
Y
```

```
ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1, 2, OR 3 WHERE:
1=USER SPECIFIESI 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?
't
ENTER THE OIL-PHASE MASS-TRANSFER COEFFICIENT IN CM/HR, TRY10
10.
ENTER THE AIR-PHASE MASS-TRANSFER COEFFICIENT IN CM/HR, TRY 1000
1000.
ENTER THE MOLECULAR WEIGHT OF THE COMPOUND FOR K-AIR ABOVE, TRY 200
200.
DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?
N
```

options for the evaporation mass transfer coefficient. The first input option shown in Table 12 allows the user tp 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 weight 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 13 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, unless previous weathering has occurred in which case the remaining thickness is used. In the illustration in Table 13 the entered thickness is 2 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 methaod 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 at this stage of optional input is for oil only, and must not be interpreted as that viscosity when a water-in-oil emulsion is present. The further change in viscosity due to water-in-oil emulsification (mousse formation) was described on page 12.

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

$$\ln\left[\frac{\mu_1}{\mu_0}\right] = B\left[\frac{1}{T_1} - \frac{1}{T_0}\right]$$

and the temperature-scaling constant is B. This 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 = 0. As weathering proceeds, the parent oil viscosity increases exponentially with respect to F.

The user can enter the three viscosity constants by answering YES to the prompt illustrated in Table 14. 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):

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

and

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

where F is the fraction of sea surface subject to dispersions per second, U is the wind speed in m\sec, 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, x is the slick thickness in meters, w is the surface tension in dynes/cm, and Kc is the constant which determines the increase in dispersion for broken-ice fields. Little experimental data is available for $K_C$, however some limited data suggests a value of 10, which is the default value. In open-ocean weathering, Kc is by definition 1.0, so input for this variable is not required in the

Table 13.--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?
N
SINCE "THE SLICK DOES NOT SPREAD, ENTER A STARTING THICKNESS IN CM
2.
```

Table 14---Illustration of Viscosity-Constant Input Options.

```
DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?
Y
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 "T(J OCCUR WITH DISPERSION?
Y
DO YOU WANT TO ENTER NEW DISPERSION CONSTANTS?
Y
ENTER THE WIND SPEED CONSTANT, "TRY 0.1
.1
ENTER THE CRITICAL DROPLET SIZE CONSTANT, TRY 50
50.
ENTER THE BROKEN ICE FIELD DISPERSION MULTIFLIER
8.
DO YOU WANT THE WEATHERING TO OCCUR WITH DISPERSION?
```

open-ocean portion of the model. Ths mass fraction that leaves the slick as dispersed droplets is ($F_b$) .(F) and this fraction applies to each cut of oil. Table 15 illustrates the user input of the constants $K_a$, $K_b$, and $K_c$.

## OUTPUT DESCRIPTION

The output generated by the ocean-ice oil-weathering code is written to four disk files: OILICE.OUT, OILICE.TYP, OILICE.PLT, and MACKAY.DAT. These files contain the calculated results in various forms. The OILICE.OUT file is 130 columns wide and intended to be printed on an appropriate high speed printer. The OILICE.TYP file is an abbreviated version of OILICE.OUT. The OILICE.PLT is a numbers-only raw data file and intended to be read by a plotting routine or other data processing routines which must be supplied by the user. The MACKAY.DAT file contains the input parameters for the MACKAY evaporation model.

An example of the OILICE.OUT file (130 column) is presented in Table 16 where the calculated results for an oil-weathering calculation for Prudhoe Bay crude are presented. The first page of this output (page 40) is crude characterization information for fresh Prudhoe Bay crude oil as calculated according to previous descriptions (Payne et al., 1983, 1984a). Page 41 presented the mass-transfer coefficients, the input parameters and constants, and the beginning of the results of the calculations for weathering in pools on top of ice. Pages 42 through 45 are the remainder of these calculations. Page 46 presents characterization of the oil after "pool-weathering ." The intermediate characterization is used automatically as input for further weathering as directed by the user. (Note that the volume percents and bulk API gravity have changed.)

For the scenario presented in Table 16, weathering in the broken-ice field at 32°F was chosen next. Page 47 presents the input constants and the beginning of the results for this weathering.

One important aspect of the code output to notice is the deletion of very volatile cuts. The information presented for various times is self

Table 15.--Illustration of Dispersion Constants Input.

```
DO YOU WANT THE WEATHERING TO OCCUR  WITH  DISPERSION?
Y
DO YOU WANT TO ENTER NEW  DISPERSION  CONSTANTS?
Y
ENTER  THE WIND SPEED CONSTANT, TRY 0.1
.2
ENTER THE CRITICAL DROPLET SIZE CONSTANT, TRY 50
50.
ENTER 'THE BROKEN ICE FIELD DISPERSION MULTIPLIER
89.

PLEASE WAIT
```

Table 16.--Illustration of Output from Oil-Weathering Calculations: Fresh Prudhoe Bay Crude Oil Characterization.

SUMMARY OF TBP CUTS CHARACTERIZATION FOR: PRUDHOE BAY, ALASKA

CODE VERSION IS CUTICA OF NAY 84
'TEM v, SAMPLE 71011

| | TB | API | SPGR | VOL. | MW | TC | PC | VC | A | B | T10 | VIS | NC | NS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.50E+02 | 7.27E+01 | 6.81E-01 | 2.12E+00 | 8.35E+01 | 9.14E+02 | 3.95E+01 | 3.66E+02 | 3.17E+00 | 1.90E-01 | 4.47E+02 | 3.80E-01 | 3 | 1 |
| 2 | 1.90E+02 | 6.42E+01 | 7.11E-01 | 2.63E+00 | 9.39E+01 | 9.63E+02 | 3.79E+01 | 4.07E+02 | 3.24E+00 | 2.03E-01 | 4.78E+02 | 4.48E-01 | 3 | 1 |
| 3 | 2.35E+02 | 5.67E+01 | 7.39E-01 | 3.54E+00 | 1.06E+02 | 1.02E+03 | 3.64E+01 | 4.54E+02 | 3.31E+00 | 2.15E-01 | 5.13E+02 | 5.44E-01 | 3 | 1 |
| 4 | 2.80E+02 | 5.16E+01 | 7.60E-01 | 3.64E+00 | 1.19E+02 | 1.07E+03 | 3.48E+01 | 5.07E+02 | 3.41E+00 | 2.27E-01 | 5.49E+02 | 6.73E-01 | 3 | 1 |
| 5 | 3.25E+02 | 4.76E+01 | 7.77E-01 | 3.74E+00 | 1.34E+02 | 1.12E+03 | 3.32E+01 | 5.65E+02 | 3.52E+00 | 2.39E-01 | 5.86E+02 | 8.46E-01 | 3 | 1 |
| 6 | 3.70E+02 | 4.52E+01 | 7.87E-01 | a.54E+00 | 1.51E+02 | 1.16E+03 | 3.16E+01 | 6.32E+02 | 3.67E+00 | 2.50E-01 | 6.23E+02 | 1.07E+00 | 3 | 1 |
| 7 | 4.15E+02 | 4.15E+01 | 8.04E-01 | 4.35E+00 | 1.67E+02 | 1.21E+03 | 3.03E+01 | 6.98E+02 | 3.80E+00 | 2.59E-01 | 6.60E+02 | 1.38E+00 | 3 | 1 |
| 8 | 4.60E+02 | 3.78E+01 | 8.22E-01 | 4.85E+00 | 1.85E+02 | 1.26E+03 | 2.91E+01 | 7.67E+02 | 3.94E+00 | 2.67E-01 | 6.98E+02 | 1.81E+00 | 3 | 1 |
| 9 | 5.05E+02 | 3.40E+01 | 8.36E-01 | 5.06E+00 | 2.00E+02 | 1.31E+03 | 2.84E+01 | 8.28E+02 | 4.06E+00 | 2.74E-01 | 7.36E+02 | 1.75E+00 | 3 | 1 |
| 10 | 5.54E+02 | 3.06E+01 | 8.50E-01 | 2.83E+00 | 2.21E+02 | 1.35E+03 | 2.74E+01 | 9.09E+02 | 4.22E+00 | 2.82E-01 | 7.77E+02 | 2.48E+00 | 3 | 1 |
| 11 | 6.09E+02 | 2.91E+01 | 8.66E-01 | 6.57E+00 | 2.52E+02 | 1.40E+03 | 2.58E+01 | 1.03E+03 | 4.49E+00 | 2.92E-01 | 8.26E+02 | 4.00E+00 | 3 | 1 |
| 12 | 6.62E+02 | 2.62E+01 | 8.82E-01 | 6.88E+00 | 2.81E+02 | 1.45E+03 | 2.47E+01 | 1.15E+03 | 4.73E+00 | 2.99E-01 | 8.73E+02 | 7.18E+00 | 3 | 1 |
| 13 | 7.12E+02 | 2.40E+01 | 8.94E-01 | 6.07E+00 | 3.13E+02 | 1.49E+03 | 2.36E+01 | 1.27E+03 | 5.00E+00 | 3.06E-01 | 9.19E+02 | 1.36E+01 | 3 | 1 |
| 14 | 7.64E+02 | 2.25E+01 | 9.03E-01 | 7.48E+00 | 3.51E+02 | 1.53E+03 | 2.25E+01 | 1.43E+03 | 5.35E+00 | 3.13E-01 | 9.68E+02 | 2.81E+01 | 3 | 1 |
| 15 | 8.50E+02 | 1.14E+01 | 9.73E-01 | 3.67E+01 | 6.00E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.81E+02 | 0 | 0 |

| | UOP K | CORRELATION INDEX |
|---|---|---|
| 1 | 1.24E+01 | 1.16E+01 |
| 2 | 1.22E+01 | 1.66E+01 |
| 3 | 1.20E+01 | 2.12E+01 |
| 4 | 1.19E+01 | 2.32E+01 |
| 5 | 1.19E+01 | 2.43E+01 |
| 6 | 1.19E+01 | 2.32E+01 |
| 7 | 1.19E+01 | 2.56E+01 |
| 8 | 1.18E+01 | 2.90E+01 |
| 9 | 1.18E+01 | 3.15E+01 |
| 10 | 1.17E+01 | 3.73E+01 |
| 11 | 1.18E+01 | 3.66E+01 |
| 12 | 1.18E+01 | 4.02E+01 |
| 13 | 1.18E+01 | 4.27E+01 |
| 14 | 1.18E+01 | 4.36E+01 |
| 15 | 1.12E+01 | 7.21E+01 |

BULK API GRAVITY = 28.9

TB = NORMAL BOILING TEMPERATURE, DEG F
API = API GRAVITY
VOL = VOLUME 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 PRESSURE 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
UOP K IS THE U.O.P. K CHARACTERIZATION FACTOR
CORRELATION INDEX IS DEFINED IN (COLEMAN, 1978)
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

MEAN MOLECULAR WEIGHT OF THE CRUDE - 2.593E+02

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results of Weathering in Pools on Top of Ice at 32°F.

```
WEATHERING OF OIL IN POOLS ON TOP OF ICE

OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT CODE 2

OVER-ALL MASS-TRANSFER COEFFICIENT FOR COMENE -  2.079E+01 M/HR

  CUT          M/HR        CM-MOLES/(HR)(ATM)(M**2)
   1        2.245E+01          1.028E+03
   2        2.212E+01          1.013E+03
   3        2.183E+01          9.994E+02
   4        2.156E+01          9.873E+02
   5        2.133E+01          9.767E+02
   6        2.112E+01          9.669E+02
   7        2.095E+01          9.591E+02
   8        2.080E+01          9.525E+02
   9        2.069E+01          9.474E+02
  10        2.057E+01          9.419E+02
  11        2.042E+01          9.351E+02
  12        2.031E+01          9.300E+02
  13        2.022E+01          9.257E+02
  14        2.012E+01          9.213E+02

FOR THIS SPILL OF  1.000E+04 BARRELS, THE MASS IS  1.395E+03 METRIC TONNES

VOLUME FROM SUMMING THE CUTS =  1.6E+03 M**3, OR  1.000E+04 BARRELS

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

INITIAL SLICK DIAMETER =  3.182E+02 M, OR AREA =  7.950E+04 M**2

THIS SLICK DOES NOT SPREAD FOR THIS CALCULATION

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS =  4.0E+00 CENTISTOKES AT 122 DEG F

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE C UTS - 1.1E+00 AT T =  32.0 DEG k', SCALE FACTOR  =  2.8E-01

VISCOSITY ACCORDING TO MASS EVAPORATED: VIS25C - 3.50E+01  ANDRADE = 9.00E+03, FRACT WEATHERED = 1.05E+01, VSLEAD = 1.25E+03 CP

MOUSSE CONSTANTS: MOONEY= 0.00E+00, MAX H20=-1.00, WIND**2= 0.00E+00

THE FRACTIONAL SLICK AREA SUBJECT TO DISPERSION IS  0.0E+00 PER HOUR

COUNT THE CUTS IN THE FOLLOWING OUTPUT FROM LEFT TO RIGHT

THE INITIAL GRAM MOLES IN THE SLICK ARE:
 2.740E+05  3.140E+05  3.907E+05  3.668E+05  3.433E+05  2.923E+05  3.304E+05  3.414E+05  3.340E+05  1.741E+05  3.576E+05
 3.412E+05  2.745E+05  3.042E+05  9.420E+05

THE INITIAL MASSES (GRAMS) IN THE SLICK ARE:
 2.288E+07  2.956E+07  4.138E+07  4.375E+07  4.596E+07  4.407E+07  5.530E+07  6.308E+07  6.690E+07  3.843E+07  9.005E+07
 9.594E+07  8.385E+07  1.069E+08  5.652E+08
THE TOTAL MASS FROM THESE CUTS IS  1.395E+09 GRAMS


 STEP SIZE OF  8.047E-02 IS BASED ON CUT   1

 TIME -  0.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:
 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+09, MASS DISPERSED -  0.000E+00, MASS EVAPORATED -  0.000E+00, SUM =  1.395E+09
 FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 1.0E+00, AREA- 7.9E+04 M**2, THICKNESS= 2.0E+00 CM, MOLE WT-259.3
 WEIGHT FRACTION WATER IN OIL    0.0E+00, VISCOSITY -  1.3E+03 CENTISTOKES, DISPERSION TERM -  0.0E+00 WEIGHT FRACTION/HR
 MASS/AREA- 1.8E+04 GMS/M*M, SPGR- 8.8E 01, TOTAL VOLUME- 1.0E+04 BBL, DISPERSION= 0.0E+00 GMS/M*M HR, EVAP RATE- 0.0E+00 GMS/M*M/HR
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32*F for Weathering in Pools on Top of Ice.

```
TIME =  1.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    2
5.8E-01  8.4E-01  9.6E-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  1.0E+00
1.0E+00
MASS REMAINING =  1.379E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  1.673E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.9E-01, AREA  7.9E+04 M**2, THICKNESS= 2.0E+00 CM, MOLE WT=265.4
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  1.4E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.8E-01, TOTAL VOLUME= 9.8E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.7E+02 GMS/M*M/HR

TIME =  2.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    3
3.3E-01  7.0E-01  9.2E-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
MASS REMAINING =  1.367E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  2.864E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.8E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=270.0
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  1.6E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.8E-01, TOTAL VOLUME= 9.7E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.3E+02 GMS/M*M/HR

TIME =  3.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    4
1.9E-01  5.8E-01  8.8E-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  1.0E+00
1.0E+00
MASS REMAINING =  1.358E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  3.755E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.7E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=273.4
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  1.7E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.8E-01, TOTAL VOLUME= 9.7E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 9.5E+01 GMS/M*M/HR

TIME =  4.2E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    5
1.0E-01  4.8E-01  8.4E-01  9.6E-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
1.0E+00
MASS REMAINING =  1.351E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  4.447E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.7E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=276.0
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  1.8E+03 CENTISTOKES, DISPERSION TERM = 0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.8E-01, TOTAL VOLUME= 9.6E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 7.5E+01 GMS/M*M/HR

TIME =  5.2E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    6
5.8E-02  4.0E-01  8.0E-01  9.5E-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
1.0E+00
MASS REMAINING =  1.345E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  5.005E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.6E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=278.2
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  1.8E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.6E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 6.2E+01 GMS/M*M/HR

TIME =  6.3E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    7
3.2E-02  3.3E-01  7.7E-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
1.0E+00
MASS REMAINING =  1.341E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  5.471E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.6E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=280.0
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  1.9E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.5E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 5.2E+01 GMS/M*M/HR

TIME =  7.3E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    8
1.8E-02  2.7E-01  7.3E-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
1.0E+00
MASS REMAINING =  1.337E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  5.870E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICE= 9.6E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=281.5
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.0E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.5E+03 BBL., DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 4.5E+01 GMS/M*M/HR

STEP SIZE OF  2.656E+01 IS BASED ON CUT  2
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Weathering in Pools on Top of Ice.

```
TIME =  8.4E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  9
9.7E-03  2.2E-01  7.0E-01  9.3E-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
1.0E+00
MASS REMAINING =  1.333E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  6.219E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.6E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=282.8
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.0E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.4E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 4.0E+01 GMS/M*M/HR

TIME =  9.4E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 10
5.2E-03  1.8E-01  6.7E-01  9.2E-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
MASS REMAINING =  1.330E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  6.535E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=284.0
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.1E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.4E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 3.6E+01 GMS/M*M/HR

TIME =  1.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 11
2.8E-03  1.5E-01  6.4E-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
MASS REMAINING =  1.327E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  6.819E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=285.1
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.1E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.4E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 3.3E+01 GMS/M*M/HR

STEP SIZE w  2.619E-01 IS BASED ON CUT  2

TIME =  1.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 12
1.5E-03  1.2E-01  6.1E-01  9.0E-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
MASS REMAINING =  1.324E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  7.076E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=286.0
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.1E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.4E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 3.0E+01 GMS/M*M/HR

STEP SIZE OF  2.606E-01 IS BASED ON CUT  2

TIME =  1.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 13
8.2E-04  9.9E-02  5.8E-01  8.9E-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
MASS REMAINING =  1.322E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  7.310E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=286.9
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.2E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.4E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 2.8E+01 GMS/M*M/HR

STEP SIZE OF  2.594E-01 IS BASED ON CUT  2

TIME =  1.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 14
4.4E-04  8.1E-02  5.5E-01  8.8E-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
MASS REMAINING =  1.320E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  7.525E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=287.7
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.2E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 2.6E+01 GMS/M*M/HR

STEP SIZE OF  2.502E-01 IS BASED ON CUT  2
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Weathering in Pools on Top of Ice.

```
TIME =  1.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    15
2.4E-04  6.6E-02  5.3E-01  8.7E-01  9.7E-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
MASS REMAINING =  1.318E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  7.725E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=288.4
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.2E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 2.4E+01 GMS/M*M/HR


STEP SIZE OF  2.572E-01 IS BASED ON CUT  2

TIME =  1.6E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    16
1.3E-04  5.4E-02  5.0E-01  8.6E-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
1.0E+00
MASS REMAINING =  1.316E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  7.911E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=289.1
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.3E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 2.2E+01 GMS/M*M/HR


STEP SIZE OF  2.562E-01 IS BASED ON CUT  2

TIME =  1.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    17
6.9E-05  4.4E-02  4.8E-01  8.5E-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
1.0E+00
MASS REMAINING =  1.314E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  8.086E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=289.8
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.3E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 2.1E+01 GMS/M*M/HR


STEP SIZE OF  2.553E-01 IS BASED ON CUT  2

TIME =  1.8E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    18
3.7E-05  3.6E-02  4.6E-01  8.4E-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
1.0E+00
MASS REMAINING =  1.313E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  8.250E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=290.4
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.3E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 2.0E+01 GMS/M*M/HR


STEP SIZE OF  2.545E-01 IS BASED ON CUT  2

TIME =  1.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    19
2.0E-05  3.0E-02  4.3E-01  8.4E-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
1.0E+00
MASS REMAINING =  1.311E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  8.405E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.9E+00 CM, MOLE WT=291.0
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.4E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.6E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.3E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.9E+01 GMS/M*M/HR


STEP SIZE OF  2.537E-01 IS BASED ON CUT  2

TIME =  2.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    20
1.1E-05  2.4E-02  4.1E-01  8.3E-01  9.6E-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 =  1.310E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  8.552E+07, SUM =  1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=291.5
WEIGHT FRACTION WATER IN OIL =  0.0E+00, VISCOSITY =  2.4E+03 CENTISTOKES, DISPERSION TERM =  0.0E+00 WEIGHT FRACTION/HR
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Weathering in Pools on Top of Ice.

```
MASS/AREA= 1.6E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.8E+01 GMS/M*M/HR

STEP SIZE OF 2.530E-01 IS BASED ON CUT 2

TIME = 2.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          21
5.9E-06  2.0E-02  3.9E-01  8.2E-01  9.6E-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 = 1.308E+09, MASS DISPERSED = 0.000E+00, MASS EVAPORATED = 8.693E+07, SUM = 1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=292.0
WEIGHT FRACTION WATER IN OIL = 0.0E+00, VISCOSITY = 2.4E+03 CENTISTOKES, DISPERSION TERM = 0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.6E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.7E+01 GMS/M*M/HR

STEP SIZE OF 2.522E-01 IS BASED ON CUT 2

TIME = 2.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          22
3.2E-06  1.6E-02  3.8E-01  8.1E-01  9.6E-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 = 1.307E+09, MASS DISPERSED = 0.000E+00, MASS EVAPORATED = 8.826E+07, SUM = 1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=292.5
WEIGHT FRACTION WATER IN OIL = 0.0E+00, VISCOSITY = 2.4E+03 CENTISTOKES, DISPERSION TERM = 0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.6E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.6E+01 GMS/M*M/HR

STEP SIZE OF 2.516E-01 IS BASED ON CUT 2

TIME = 2.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          23
1.7E-06  1.3E-02  3.6E-01  8.0E-01  9.6E-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 = 1.306E+09, MASS DISPERSED = 0.000E+00, MASS EVAPORATED = 8.954E+07, SUM = 1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=293.0
WEIGHT FRACTION WATER IN OIL = 0.0E+00, VISCOSITY = 2.5E+03 CENTISTOKES, DISPERSION TERM = 0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.6E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.6E+01 GMS/M*M/HR

STEP SIZE OF 2.509E-01 IS BASED ON CUT 2

TIME = 2.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          24
9.3E-07  1.1E-02  3.4E-01  7.9E-01  9.6E-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 = 1.304E+09, MASS DISPERSED = 0.000E+00, MASS EVAPORATED = 9.076E+07, SUM = 1.395E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=293.4
WEIGHT FRACTION WATER IN OIL = 0.0E+00, VISCOSITY = 2.5E+03 CENTISTOKES, DISPERSION TERM = 0.0E+00 WEIGHT FRACTION/HR
MASS/AREA= 1.6E+04 GMS/M*M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+03 BBL, DISPERSION= 0.0E+00 GMS/M*M/HR, EVAP RATE= 1.5E+01 GMS/M*M/HR

STEP SIZE OF 2.503E-01 IS BASED ON CUT 2

THE CUT NUMBERING BEGINS WITH 1 BASED ON THE ORIGINAL CUT NUMBERS

THE FINAL MASS FRACTIONS FOR THE SLICK AT 2.4E+01 HOURS ARE:                                                        25
6.842E-07  9.889E-03  3.344E-01  7.906E-01  9.549E-01  9.921E-01  9.987E-01  9.998E-01  1.000E+00  1.000E+00  1.000E+00
1.000E+00  1.000E+00  1.000E+00  1.000E+00
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=293.4
MASS REMAINING = 1.304E+09, MASS DISPERSED = 0.000E+00, MASS EVAPORATED = 9.136E+07, SUM = 1.395E+09

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Table 16.--Output from Oil-Weathering Calculations (Continued): Characterization of Prudhoe Bay Crude Oil After Weathering in Pools on Top of Ice.

SUMMARY OF TBP CUTS CHARACTERIZATION FOR: PRUDHOE BAY, ALASKA
AFTER:
ICE POOL WEATHERING FOR 2.400E+01 HOURS

CODEVERSION 1SCUTICA OF MAY 84
ITEM 9, SAMPLE 71011

| | TB | API | SPGR | VOL. | MW | TC | PC | VC | A | B | T10 | VIS | NC | NS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.50E+02 | 7.27E+01 | 6.81E-01 | 1.58E-06 | 8.35E+01 | 9.14E+02 | 3.95E+01 | 3.66E+02 | 3.17E+00 | 1.90E-01 | 4.47E+02 | 3.88E-01 | 3 | 1 |
| 2 | 1.90E+02 | 6.42E+01 | 7.11E-01 | 2.83E-02 | 9.39E+01 | 9.63E+02 | 3.79E+01 | 4.07E+02 | 3.24E+00 | 2.03E-01 | 4.78E+02 | 4.48E-01 | 3 | 1 |
| 3 | 2.35E+02 | 5.67E+01 | 7.39E-01 | 1.29E+00 | 1.06E+02 | 1.02E+03 | 3.64E+01 | 4.54E+02 | 3.31E+00 | 2.15E-01 | 5.13E+02 | 5.44E-01 | 3 | 1 |
| 4 | 2.80E+02 | 5.16E+01 | 7.60E-01 | 3.13E+00 | 1.19E+02 | 1.07E+03 | 3.48E+01 | 5.07E+02 | 3.41E+00 | 2.27E-01 | 5.49E+02 | 6.73E-01 | 3 | 1 |
| 5 | 3.25E+02 | 4.76E+01 | 7.77E-01 | 3.89E+00 | 1.34E+02 | 1.12E+03 | 3.32E+01 | 5.65E+02 | 3.52E+00 | 2.39E-01 | 5.86E+02 | 8.46E-01 | 3 | 1 |
| 6 | 3.70E+02 | 4.52E+01 | 7.87E-01 | 3.82E+00 | 1.51E+02 | 1.16E+03 | 3.16E+01 | 6.32E+02 | 3.67E+00 | 2.50E-01 | 6.23E+02 | 1.07E+00 | 3 | 1 |
| 7 | 4.15E+02 | 4.15E+01 | 8.04E-01 | 4.72E+00 | 1.67E+02 | 1.21E+03 | 3.03E+01 | 6.98E+02 | 3.80E+00 | 2.59E-01 | 6.60E+02 | 1.38E+00 | 3 | 1 |
| 8 | 4.60E+02 | 3.78E+01 | 8.22E-01 | 5.28E+00 | 1.85E+02 | 1.26E+03 | 2.91E+01 | 7.67E+02 | 3.94E+00 | 2.67E-01 | 6.98E+02 | 1.81E+00 | 3 | 1 |
| 9 | 5.05E+02 | 3.48E+01 | 8.36E-01 | 5.50E+00 | 2.00E+02 | 1.31E+03 | 2.84E+01 | 8.28E+02 | 4.06E+00 | 2.74E-01 | 7.36E+02 | 1.75E+00 | 3 | 1 |
| 10 | 5.54E+02 | 3.06E+01 | 8.58E-01 | 3.08E+00 | 2.21E+02 | 1.35E+03 | 2.74E+01 | 9.09E+02 | 4.22E+00 | 2.82E-01 | 7.77E+02 | 2.48E+00 | 3 | 1 |
| 11 | 6.09E+02 | 2.91E+01 | 8.66E-01 | 7.15E+eo | 2.52E+02 | 1.40E+03 | 2.58E+01 | 1.03E+03 | 4.49E+00 | 2.92E-01 | 8.26E+02 | 4.00E+00 | 3 | 1 |
| 12 | 6.62E+02 | 2.62E+01 | 8.82E-01 | 7.48E+00 | 2.81E+02 | 1.45E+03 | 2.47E+01 | 1.15E+03 | 4.73E+00 | 2.99E-01 | 8.73E+02 | 7.18E+00 | 3 | 1 |
| 13 | 7.12E+02 | 2.40E+01 | 8.94E-01 | 6.60E+00 | 3.13E+02 | 1.49E+03 | 2.36E+01 | 1.27E+03 | 5.00E+00 | 3.06E-01 | 9.19E+02 | 1.36E+01 | 3 | 1 |
| 14 | 7.64E+02 | 2.25E+01 | 9.03E-01 | 8.14E+00 | 3.51E+02 | 1.53E+03 | 2.25E+01 | 1.43E+03 | 5.35E+00 | 3.13E-01 | 9.68E+02 | 2.81E+01 | 3 | 1 |
| 15 | 8.50E+02 | 1.14E+01 | 9.73E-01 | 3.99E+01 | 6.00E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.81E+02 | 0 | 0 |

| | UOP V | CORRELATION INDEX |
|---|---|---|
| 1 | 1.24E+01 | 1.16E+01 |
| 2 | 1.22E+01 | 1.66E+01 |
| 3 | 1.20E+01 | 2.12E+01 |
| 4 | 1.19E+01 | 2.32E+01 |
| 5 | 1.19E+01 | 2.43E+01 |
| 6 | 1.19E+01 | 2.32E+01 |
| 7 | 1.19E+01 | 2.56E+01 |
| 8 | 1.18E+01 | 2.90E+01 |
| 9 | 1.18E+01 | 3.15E+01 |
| 10 | 1.17E+01 | 3.73E+01 |
| 11 | 1.18E+01 | 3.66E+01 |
| 12 | 1.18E+01 | 4.02E+01 |
| 13 | 1.18E+01 | 4.27E+01 |
| 14 | 1.18E+01 | 4.36E+01 |
| 15 | 1.12E+01 | 7.21E+01 |

BULK API GRAVITY = 26.4

TB = NORMAL BOILING TEMPERATURE, DEG F
API = API GRAVITY
VOL. = VOLUME 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 PRESSURE EQUATION
T10 IS THE TEMPERATURE IN DEG F WHERE THE VAPOR PRESSURE IS 10 MM HG
VIS IS THE KINEMATIC VISCOSITY IN CENTISTOKES AT 122 DEG F
UOP K IS THE U.O.P. K CHARACTERIZATION FACTOR
CORRELATION INDEX IS DEFINED IN (COLEMAN, 1978)
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

MEAN MOLECULAR WEIGHT OF THE CRUDE - 2.937E+02

Table 16.--Output from Oil-Weathering Calculations (Continued): Beginning of Calculated Results for Broken Ice Field Weathering at 32°F. (Note deletion of cut 1 and renumbering of cuts).

```
WEATHERING DATA FOR OIL IN A BROKEN ICE FIELD
AFTER ICE POOL WEATHERING FOR 2.400E+01 HOURS

OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT CODE 2

OVER-ALL MASS-TRANSFER COEFFICIENT FOR COMENE =  1.957E+01 M/HR

  CUT            M/HR        CM-MOLES/(HR)(ATM)(M**2)
   1          2.112E+01            9.435E+02
   2          2.082E+01            9.299E+02
   3          2.054E+01            9.174E+02
   4          2.029E+01            9.063E+02
   5          2.007E+01            8.965E+02
   6          1.987E+01            8.876E+02
   7          1.971E+01            8.804E+02
   8          1.957E+01            8.743E+02
   9          1.947E+01            8.697E+02
  10          1.935E+01            8.646E+02
  11          1.922E+01            8.584E+02
  12          1.911E+01            8.537E+02
  13          1.902E+01            8.497E+02
  14          1.893E+01            8.457E+02

FOR THIS SPILL OF  9.195E+03 BARRELS, THE MASS IS  1.304E+03 METRIC TONNES

VOLUME FROM SUMMING THE CUTS =  1.5E+03 M**3, OR  9.195E+03 BARRELS

WIND SPEED =  1.200E+01 KNOTS, OR  2.224E+04 M/HR

INITIAL SLICK DIAMETER =  3.102E+02 M, OR AREA =  7.950E+04 M**2

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS =  6.4E+00 CENTISTOKES AT 122 DEG F

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS =  1.2E+01 AT T =  32.0 DEG F, SCALE FACTOR =  1.8E+00

VISCOSITY ACCORDING TO MASS EVAPORATED: 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= 0.70, WIND**2= 1.00E-02

THE FRACTIONAL SLICK AREA SUBJECT TO DISPERSION IS  5.5E+01 PER HOUR

COUNT THE CUTS IN THE FOLLOWING OUTPUT FROM LEFT TO RIGHT

THE INITIAL GRAM MOLES IN THE SLICK ARE:
 1.875E-01  3.113E+03  1.307E+05  2.900E+05  3.278E+05  2.899E+05  3.299E+05  3.413E+05  3.339E+05  1.741E+05  3.576E+05
 3.412E+05  2.745E+05  3.042E+05  9.420E+05

THE INITIAL MASSES (GRAMS) IN THE SLICK ARE:
 1.566E+01  2.923E+05  1.384E+07  3.458E+07  4.389E+07  4.372E+07  5.523E+07  6.307E+07  6.689E+07  3.843E+07  9.005E+07
 9.594E+07  8.585E+07  1.069E+08  5.652E+08
THE TOTAL MASS FROM THESE CUTS IS  1.304E+09 GRAMS


CUT  1 GOES AWAY IN MINUTES, THEREFORE IT WAS DELETED AND THE CUTS RENUMBERED


 STEP SIZE OF  1.457E-01 IS BASED ON CUT  1

 TIME =  0.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  1
 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 =  1.304E+09, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  0.000E+00, SUM =  1.304E+09
 FRACTION (BASED ON MASS) REMAINING IN THE SLICK = 1.0E+00, AREA= 7.9E+04 M**2, THICKNESS= 1.8E+00 CM, MOLE WT=293.7
 WEIGHT FRACTION WATER IN OIL =  6.9E-05, VISCOSITY =  1.1E+03 CENTISTOKES, DISPERSION TERM =  4.6E-03 WEIGHT FRACTION/HR
 MASS AREA= 1.6E+04 GMS/M/M, SPGR= 8.9E-01, TOTAL VOLUME= 9.2E+03 BBL, DISPERSION= 7.6E+01 GMS/M*M/HR, EVAP RATE= 0.0E+00 GMS/M*M/HR
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Broken Ice Field Weathering.

```
TIME =   1.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  2
6.5E-01  8.9E-01  9.7E-01  9.9E-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 =  1.295E+09, MASS DISPERSED =  6.121E+06, MASS EVAPORATED =  2.650E+06, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.9E-01, AREA= 1.1E+05 M**2, THICKNESS= 1.3E+00 CM, MOLE WT=294.6
WEIGHT FRACTION WATER IN OIL =  3.0E-01, VISCOSITY =  1.2E+03 CENTISTOKES, DISPERSION TERM =  6.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+04 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 9.1E+03 BBL, DISPERSION= 7.3E+01 GMS/M*M/HR, EVAP RATE= 2.5E+01 GMS/M*M/HR

TIME =   2.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  3
3.8E-01  7.7E-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  9.9E-01
MASS REMAINING =  1.204E+09, MASS DISPERSED =  1.437E+07, MASS EVAPORATED =  5.734E+06, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 1.4E+05 M**2, THICKNESS= 1.1E+00 CM, MOLE WT=295.8
WEIGHT FRACTION WATER IN OIL = 4.9E-01, VISCOSITY =  3.2E+03 CENTISTOKES, DISPERSION TERM =  4.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.5E+03 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 9.0E+03 BBL, DISPERSION= 4.4E+01 GMS/M*M/HR, EVAP RATE= 2.3E+01 GMS/M*M/HR

TIME =   3.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  4
2.0E-01  6.5E-01  9.0E-01  9.7E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  1.274E+09, MASS DISPERSED =  2.045E+07, MASS EVAPORATED =  9.005E+06, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 1.6E+05 M**2, THICKNESS= 9.2E-01 CM, MOLE WT=297.0
WEIGHT FRACTION WATER IN OIL =  6.1E-01, VISCOSITY =  8.0E+03 CENTISTOKES, DISPERSION TERM =  3.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.2E+03 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 9.0E+03 BBL, DISPERSION= 2.8E+01 GMS/M*M/HR, EVAP RATE= 2.1E+01 GMS/M*M/HR

TIME =   4.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  5
9.6E-02  5.4E-01  8.6E-01  9.5E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  1.267E+09, MASS DISPERSED =  2.408E+07, MASS EVAPORATED =  1.232E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.7E-01, AREA= 1.7E+05 M**2, THICKNESS= 8.2E-01 CM, MOLE WT=298.2
WEIGHT FRACTION WATER IN OIL =  6.7E-01, VISCOSITY =  1.7E+04 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 7.3E+03 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 8.9E+03 BBL, DISPERSION= 1.9E+01 GMS/M*M/HR, EVAP RATE= 1.9E+01 GMS/M*M/HR

TIME =   5.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  6
4.3E-02  4.3E-01  8.1E-01  9.4E-01  9.7E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  1.260E+09, MASS DISPERSED =  2.829E+07, MASS EVAPORATED =  1.559E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.7E-01, AREA= 1.9E+05 M**2, THICKNESS= 7.4E-01 CM, MOLE WT=299.5
WEIGHT FRACTION WATER IN OIL =  6.9E-01, VISCOSITY =  2.7E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 6.7E+03 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 8.9E+03 BBL, DISPERSION= 1.5E+01 GMS/M*M/HR, EVAP RATE= 1.7E+01 GMS/M*M/HR

TIME =   6.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  7
1.8E-02  3.5E-01  7.7E-01  9.3E-01  9.7E-01  9.7E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  1.254E+09, MASS DISPERSED =  3.121E+07, MASS EVAPORATED =  1.876E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.6E-01, AREA= 2.0E+05 M**2, THICKNESS= 6.9E-01 CM, MOLE WT=300.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.5E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 6.1E+03 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 8.8E+03 BBL, DISPERSION= 1.3E+01 GMS/M*M/HR, EVAP RATE= 1.5E+01 GMS/M*M/HR

STEP SIZE OF  2.030E-01 IS BASED ON CUT   2

TIME =   7.3E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  8
6.2E-03  2.6E-01  7.2E-01  9.2E-01  9.6E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01
MASS REMAINING =  1.247E+09, MASS DISPERSED =  3.432E+07, MASS EVAPORATED =  2.214E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.6E-01, AREA= 2.2E+05 M**2, THICKNESS= 6.4E-01 CM, MOLE WT=301.9
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.9E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.7E+03 GMS/M*M, SPCR= 8.9E-01, TOTAL VOLUME= 8.8E+03 BBL, DISPERSION= 1.3E+01 GMS/M*M/HR, EVAP RATE= 1.3E+01 GMS/M*M/HR

STEP SIZE OF  1.960E-01 IS BASED ON CUT   2

TIME =   8.4E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  9
1.9E-03  1.9E-01  6.7E-01  9.0E-01  9.6E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01
MASS REMAINING =  1.241E+09, MASS DISPERSED =  3.761E+07, MASS EVAPORATED =  2.547E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 2.3E+05 M**2, THICKNESS= 5.9E-01 CM, MOLE WT=303.2
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Broken Ice Field Weathering.

```
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 4.2E+04 CENTISTOKES, DISPERSION TERM = 2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.3E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 8.7E+03 BBL, DISPERSION= 1.2E+01 GMS/M*M/HR, EVAP RATE= 1.2E+01 GMS/M*M/HR

STEP SIZE OF 1.831E-01 IS BASED ON CUT 2

TIME = 9.6E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          10
5.8E-04 1.4E-01 6.3E-01 8.9E-01 9.5E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01
MASS REMAINING = 1.235E+09, MASS DISPERSED = 4.080E+07, MASS EVAPORATED = 2.043E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 2.5E+05 M**2, THICKNESS= 5.0E-01 CM, MOLE WT=304.3
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 4.4E+04 CENTISTOKES, DISPERSION TERM = 2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.0E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 8.7E+03 BBL, DISPERSION= 1.2E+01 GMS/M*M/HR, EVAP RATE= 1.1E+01 GMS/M*M/HR

STEP SIZE OF 1.730E-01 IS BASED ON CUT 2

TIME = 1.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          11
1.0E-04 1.0E-01 5.8E-01 8.7E-01 9.5E-01 9.6E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01 9.7E-01
MASS REMAINING = 1.229E+09, MASS DISPERSED = 4.388E+07, MASS EVAPORATED = 3.108E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 2.6E+05 M**2, THICKNESS= 5.3E-01 CM, MOLE WT=305.3
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 4.6E+04 CENTISTOKES, DISPERSION TERM = 2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.8E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 8.6E+03 BBL, DISPERSION= 1.2E+01 GMS/M*M/HR, EVAP RATE= 9.6E+00 GMS/M*M/HR

STEP SIZE OF 1.647E-01 IS BASED ON CUT 2

TIME = 1.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          12
4.5E-05 7.2E-02 5.4E-01 8.5E-01 9.4E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
MASS REMAINING = 1.223E+09, MASS DISPERSED = 4.736E+07, MASS EVAPORATED = 3.305E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 2.7E+05 M**2, THICKNESS= 5.1E-01 CM, MOLE WT=306.4
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 4.9E+04 CENTISTOKES, DISPERSION TERM = 2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.5E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 8.6E+03 BBL, DISPERSION= 1.1E+01 GMS/M*M/HR, EVAP RATE= 8.7E+00 GMS/M*M/HR

STEP SIZE OF 1.566E-01 IS BASED ON CUT 2

TIME = 1.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          13
1.1E-05 5.1E-02 4.9E-01 8.4E-01 9.4E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
MASS REMAINING = 1.217E+09, MASS DISPERSED = 5.074E+07, MASS EVAPORATED = 3.636E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 2.8E+05 M**2, THICKNESS= 4.8E-01 CM, MOLE WT=307.3
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 5.2E+04 CENTISTOKES, DISPERSION TERM = 2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.3E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 8.5E+03 BBL, DISPERSION= 1.1E+01 GMS/M*M/HR, EVAP RATE= 7.9E+00 GMS/M*M/HR

STEP SIZE OF 1.490E-01 IS BASED ON CUT 2

TIME = 1.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          14
2.9E-06 3.5E-02 4.6E-01 8.2E-01 9.3E-01 9.5E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
MASS REMAINING = 1.211E+09, MASS DISPERSED = 5.402E+07, MASS EVAPORATED = 3.864E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 2.9E+05 M**2, THICKNESS= 4.6E-01 CM, MOLE WT=308.2
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 5.4E+04 CENTISTOKES, DISPERSION TERM = 2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.2E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 8.5E+03 BBL, DISPERSION= 1.1E+01 GMS/M*M/HR, EVAP RATE= 7.3E+00 GMS/M*M/HR

STEP SIZE OF 1.441E-01 IS BASED ON CUT 2

TIME = 1.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          15
7.5E-07 2.5E-02 4.2E-01 8.1E-01 9.3E-01 9.5E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
MASS REMAINING = 1.206E+09, MASS DISPERSED = 5.720E+07, MASS EVAPORATED = 4.074E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 3.0E+05 M**2, THICKNESS= 4.5E-01 CM, MOLE WT=309.0
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Broken Ice Field Weathering.

```
WEIGHT FRACTION WATER IN OIL  7.0E-01 , VISCOSITY =  5.7E+04 CENTISTOKES, DISPERSION TERM :  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 4.0E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.5E+03 BBL., DISPERSION= 1.1E+01 CMS/M*M/HR, EVAP RATE= 6.8E+00 CMS/M*M/HR


STEP SIZE OF  1.390E-01 IS BASED ON CUT  2

TIME =  1.6E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              16
1.6E-07  1.6E-02  3.8E-01  7.9E-01  9.2E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  1.200E+09, MASS DISPERSED =  6.073E+07, MASS EVAPORATED =  4.295E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 3.1E+05 M**2, THICKNESS= 4.3E-01 CM, MOLE WT=309.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.0E+04 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.9E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.4E+03 BBL., DISPERSION= 1.0E+01 CMS/M*M/HR, EVAP RATE= 6.3E+00 CMS/M*M/HR


STEP SIZE OF  1.340E-01 IS BASED ON CUT 2

TIME =  1.7E+01 owns, MASS FIIALTION OF EACH CUT REMAINING:                                                              17
3.3E-08  1.1E-02  3.5E-01  7.7E-01  9.1E-01  9.4E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9. 5E-01  9. 5E-01
MASS REMAINING =  1.195E+09, MASS DISPERSED = 6.416E+07, MASS EVAPORATED  =  4.500E+07, SUM = 1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 3.2E+05 M**2, THICKNESS= 4.2E-01 CM, MOLE WT=310.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.3E+04 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.8E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.4E+03 BBL., DISPERSION= 1.0E+01 CMS/M*M/HR, EVAP RATE= 5.9E+00 CMS/M*M/HR


STEP SIZE OF  1.295E-01 Is BASED ON CUT 2

TIME =  1.8E+01 HOURS, HASS FRACTION OF EACH Cur REMAINING:                                                              18
6.9E-09  7.3E-03  3.2E-01  7.5E-01  9.1E-01  9.4E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  1.190E+09, MASS DISPERSED =  6.748E+07, HASS EVAPORATED =  4.690E+07, SUH =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.1E-01, AREA= 3.3E+05 M**2, THICKNESS= 4.1E-01 CM, MOLE WT=311.3
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY  =  6.6E+04 CENTISTOKES, DISPERSION TERM  =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.6E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.3E+03 BBL, DISPERSION= 9.8E+00 CMS/M*M/HR, EVAP RATE= 5.5E+00 CMS/M*M/HR


TIME =  1.9E+01 HOURS, MASS FRACTION OF EACH cur REMAINING:                                                              19
0.0E+00  4.8E-03  2.9E-01  7.4E-01  9.0E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  1.184E+09, MASS DISPERSED =  7.081E+07, HASS EVAPORATED = 4.872E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.1E-01, AREA= 3.4E+05 M**2, THICKNESS= 3.9E-01 CM, MOLE WT=312.0
WEIGHT FRACTION WATER IN OIL = 7.0E-01,  VISCOSITY  =  6.9E+04 CENTISTOKES, DISPERSION TERM  =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA=  3.5E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.3E+03 BBL., DISPERSION= 9.6E+00 CMS/M*M/HR, EVAP RATE= 5.2E+00 CMS/M*M/HR


TIME =  2.0E+01 nouns. HASS FRACTION OF EACH CUT REMAINING:                                                              20
0.0E+00  3.1E-03 2.6E-01  7.2E-01  9.0E-01  9.3E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  1.179E+09, MASS DISPERSED =  7.414E+07, MASS EVAPORATED =  5.048E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.0E-01, AREA= 3.4E+05 M**2, THICKNESS= 3.8E-01 CM, MOLE WT=312.7
WEIGHT FRACTION WATER IN 011. =  7.0E-01, VISCOSITY =  7.2E+04 CENTISTOKES, DISPERSION TERM  =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.4E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.3E+03 BBL., DISPERSION= 9.4E+00 CMS/M*M/HR, EVAP RATE= 4.9E+00 CMS/M*M/HR


TIME =  2.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              21
0.0E+00  2.0E-03  2.3E-01  7.0E-01  8.9E-01  9.3E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  1.174E+09, MASS DISPERSED =  7.747E+07, MASS EVAPORATED =  5.217E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.0E-01, AREA= 3.5E+05 M**2, THICKNESS= 3.7E-01 CM, MOLE WT=313.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.6E+04 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.3E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.2E+03 BBL., DISPERSION= 9.2E+00 CMS/M*M/HR, EVAP RATE= 4.6E+00 CMS/M*M/HR


TIME =  2.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              22
0.0E+00  1.3E-03  2.1E-01  6.9E-01  8.9E-01  9.3E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  1.169E+09, MASS DISPERSED =  8.080E+07, MASS EVAPORATED =  5.380E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.0E-01, AREA= 3.6E+05 M**2, THICKNESS= 3.6E-01 CM, MOLE WT=314.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.9E+04 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 320?? for Broken Ice Field Weathering.

```
MASS/AREA= 3.3E+03 CMS/M*M, SPCR= 9.0E-01 . TOTAL VOLUME= 8.2E+03 BBL. DISPERSION= 9.0E+00 CMS/M*M/HR, EVAP RATE= 4.3E+00 CMS/M*M/HR

TIME =  2.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    23
0.0E+00  8.0E-04  1.9E-01  6.7E-01  8.8E-01  9.2E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  1.164E+09, MASS DISPERSED =  8.412E+07, MASS EVAPORATED -  5.537E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.9E-01, AREA= 3.7E+05 M**2, THICKNESS= 3.5E-01 CM, MOLE WT=314.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  8.3E+04 CENTISTOKES, DISPERSION TERM =  2.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.2E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.1E+03 BBL., DISPERSION= 8.8E+00 CMS/M*M/HR, EVAP RATE= 4.1E+00 CMS/M*M/HR

TIME =  2.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    24
0.0E+00  5.0E-04  1.7E-01  6.6E-01  8.7E-01  9.2E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  1.160E+09, MASS DISPERSED =  8.743E+07, MASS EVAPORATED =  5.688E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.9E-01, AREA= 3.7E+05 M**2, THICKNESS= 3.5E-01 CM, MOLE WT=315.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  8.7E+04 CENTISTOKES, DISPERSION TERM =  2.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.1E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.1E+03 BBL., DISPERSION= 8.6E+00 CMS/M*M/HR, EVAP RATE= 3.9E+00 CMS/M*M/HR

TIME =  2.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    25
0.0E+00  3.1E-04  1.5E-01  6.4E-01  8.7E-01  9.2E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  1.155E+09, MASS DISPERSED =  9.074E+07, MASS EVAPORATED =  5.834E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.9E-01, AREA= 3.8E+05 M**2, THICKNESS= 3.4E-01 CM, MOLE WT=315.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  9.1E+04 CENTISTOKES, DISPERSION TERM =  2.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.0E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.1E+03 BBL., DISPERSION= 8.4E+00 CMS/M*M/HR, EVAP RATE= 3.7E+00 CMS/M*M/HR

TIME =  2.6E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    26
0.0E+00  1.9E-04  1.4E-01  6.2E-01  8.6E-01  9.1E-01  9.2E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  1.150E+09, MASS DISPERSED =  9.403E+07, MASS EVAPORATED =  5.974E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.8E-01, AREA= 3.9E+05 M**2, THICKNESS= 3.3E-01 CM, MOLE WT=316.3
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  9.5E+04 CENTISTOKES, DISPERSION TERM =  2.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 3.0E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.0E+03 BBL., DISPERSION= 8.2E+00 CMS/M*M/HR, EVAP RATE= 3.5E+00 CMS/M*M/HR

TIME =  2.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    27
0.0E+00  1.1E-04  1.2E-01  6.1E-01  8.5E-01  9.1E-01  9.X-444  9.2E-01  9.2E-01  9.2E-01  9,~&_@,  9.2E-01  9.2E-01  9.2E-0,
MASS REMAINING =  1.145E+09, MASS DISPERSED =  9.731E+07, MASS EVAPORATED =  6.110E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.8E-01, AREA= 3.9E+05 M**2, THICKNESS= 3.2E-01 CM, MOLE WT=316.9
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  9.9E+04 CENTISTOKES, DISPERSION TERM =  2.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.9E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.0E+03 BBL., DISPERSION= 8.0E+00 CMS/M*M/HR, EVAP RATE= 3.3E+00 CMS/M*M/HR

STEP SIZE OF  4.346E-01 IS BASED ON CUT  3

TIME =  2.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    28
0.0E+00  6.3E-05  1.1E-01  5.9E-01  8.5E-01  9.1E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01
MASS REMAINING =  1.141E+09, MASS DISPERSED =  1.009E+08, MASS EVAPORATED =  6.252E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 4.0E+05 M**2, THICKNESS= 3.2E-01 CM, MOLE WT=317.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.0E+05 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.9E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 8.0E+03 BBL., DISPERSION= 7.8E+00 CMS/M*M/HR, EVAP RATE= 3.1E+00 CMS/M*M/HR

STEP SIZE OF  4.237E-01 Is BASED ON CUT  3

TIME =  3.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    29
0.0E+00  3.3E-05  9.1E-02  5.7E-01  8.4E-01  9.0E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01
MASS REMAINING =  1.135E+09, MASS DISPERSED =  1.049E+08, MASS EVAPORATED =  6.407E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 4.1E+05 M**2, THICKNESS= 3.1E-01 CM, MOLE WT=318.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.1E+05 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.8E+03 CMS/M*M, SPCR= 9.0E-01, TOTAL VOLUME= 7.9E+03 BBL., DISPERSION= 7.6E+00 CMS/M*M/HR, EVAP RATE= 2.9E+00 CMS/M*M/HR
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Broken Ice Field Weathering.

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STEP SIZE OF  4.137E-01 IS BASED ON CUT   3

TIME =  3.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  30
0.0E+00  1.7E-05  7.0E-02  5.5E-01  8.3E-01  9.0E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  1.130E+09, MASS DISPERSED =  1.018E+08, MASS EVAPORATED =  6.553E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 4.1E+05 M**2, THICKNESS= 3.0E-01 CM, MOLE WT=318.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.2E+05 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.7E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.9E+03 BBL., DISPERSION= 7.4E+00 GMS/M*M/HR, EVAP RATE= 2.8E+00 GMS/M*M/HR

STEP SIZE OF  4.045E-01 Is BASED ON CUT   3

TIME =  3.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  31
0.0E+00  8.7E-06  6.7E-02  5.3E-01  8.3E-01  0.4)F.-QI  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  1.124E+09, MASS DISPERSED =  1.125E+08, MASS EVAPORATED =  6.689E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.6E-01, AREA= 4.2E+05 M**2, THICKNESS= 3.0E-01 CM, MOLE WT=319.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.2E+05 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.7E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.9E+03 BBL., DISPERSION= 7.3E+00 GMS/M*M/HR, EVAP RATE= 2.6E+00 GMS/M*M/HR

STEP SIZE OF  3.960E-01 Is BASED ON CUT   3

TIME =  3.4E+01 HOURS, MASS FRACTION OF EACH cur REMAINING:                                                                  32
0.0E+00  4.5E-06  5.8E-02  5.1E-01  8.2E-01  8.9E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  1.120E+09, MASS DISPERSED =  1.162E+08, MASS EVAPORATED =  6.817E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.6E-01, AREA= 4.3E+05 M**2, THICKNESS= 2.9E-01 CM, MOLE WT=319.7
WEIGHT FRACTION WATER IN 011. =  7.0E-01, VISCOSITY =  1.3E+05 CENTISTOKES, DISPERSION TERM  .  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.6E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7. 8E+03 BBL. . DISPERSION= 7.1E+00 GMS/M*M/HR, EVAP RATE= 2.5E+00 GMS/M*M/HR

STEPs I ZE OF  3.881E-01 1s BASED ON CUT 3

TIME =  3.5E+01 HOURS, HASS FRACTION OF EACH CUT REMAINING:                                                                  33
0.0E+00  2.3E-06  5.0E-02  5.0E-01  ii.1E-01  8.9E-01  9.0E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  1.115E+09, MASS DISPERSED =  1.197E+08, MASS EVAPORATED =  6.939E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.5E-01, AREA= 4.4E+05 M**2, THICKNESS= 2.8E-01 CM, MOLE WT=320.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.3E+05 CENTISTOKES, DISPERSION TERM  .  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.6E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.8E+03 BBL., DISPERSION= 6.9E+00 GMS/M*M/HR, EVAP RATE= 2.4E+00 GMS/M*M/HR

STEP SIZE OF  3.808E-01 1s BASED ON cur   3

TIME =  3.6E+01 HOURS, HASS FRACTION OF EACH CUT REMAINING:                                                                  34
0.0E+00  1.22E-06 4.3E-02  4.8E-01  8.0E-01  8.8E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  1.110E+09, MASS DISPERSED =  1.232E+08, MASS EVAPORATED = 7.054E+07, SUM  =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.5E-01, AREA= 4.4E+05 M**2, THICKNESS= 2.8E-01 CM, MOLE WT=320.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.4E+05 CENTISTOKES, DISPERSION TERM  =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.5E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.7E+03 BBL., DISPERSION= 6.8E+00 GMS/M*M/HR, EVAP RATE= 2.3E+00 GMS/M*M/HR

STEP SIZE OF  3.739E-01 IS BASED ON CUT   3

TIME =  3.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  35
0.0E+00  6.2E-07  3.7E-02  4.6E-01  8.0E-01  8.8E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  1.106E+09, MASS DISPERSED =  1.265E+08, MASS EVAPORATED =  7.163E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.5E-01, AREA= 4.5E+05 M**2, THICKNESS= 2.7E-01 CM, MOLE WT=321.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.5E+05 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.5E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.7E+03 BBL., DISPERSION= 6.6E+00 GMS/M*M/HR, EVAP RATE= 2.2E+00 GMS/M*M/HR
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude °il, Time ᵛersus Calculated Results at 32°F for Broken Ice Field Weathering.

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STEP SIZE OF  3.675E-01 IS BASED ON CUT   3

TIME =  3.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    36
0.0E+00  3.2E-07  3.1E-02  4.5E-01  7.9E-01  8.8E-01  8.9E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  1.101E+09, MASS DISPERSED =  1.298E+08, MASS EVAPORATED =  7.267E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.4E-01, AREA= 4.5E+05 M**2, THICKNESS= 2.7E-01 CM, MOLE WT=321.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.5E+05 CENTISTOKES, DISPERSION TERM =  2.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.4E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.7E+03 BBL, DISPERSION= 6.5E+00 GMS/M*M/HR, EVAP RATE= 2.1E+00 GMS/M*M/HR


STEP SIZE OF  3.614E-01 IS BASED ON CUT   3

TIME =  3.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    37
0.0E+00  1.7E-07  2.7E-02  4.3E-01  7.8E-01  8.7E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING =  1.097E+09, MASS DISPERSED =  1.330E+08, MASS EVAPORATED =  7.367E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.4E-01, AREA= 4.6E+05 M**2, THICKNESS= 2.7E-01 CM, MOLE WT=321.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.6E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.4E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.7E+03 BBL, DISPERSION= 6.3E+00 GMS/M*M/HR, EVAP RATE= 2.0E+00 GMS/M*M/HR


STEP SIZE OF  3.557E-01 IS BASED ON CUT   3

TIME =  4.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    38
0.0E+00  8.5E-08  2.3E-02  4.2E-01  7.8E-01  8.7E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING =  1.093E+09, MASS DISPERSED =  1.361E+08, MASS EVAPORATED =  7.462E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.4E-01, AREA= 4.6E+05 M**2, THICKNESS= 2.6E-01 CM, MOLE WT=322.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.7E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.4E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.6E+03 BBL, DISPERSION= 6.2E+00 GMS/M*M/HR, EVAP RATE= 1.9E+00 GMS/M*M/HR


STEP SIZE OF  3.503E-01 IS BASED ON CUT   3

TIME =  4.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    39
0.0E+00  4.4E-08  2.0E-02  4.1E-01  7.7E-01  8.7E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING =  1.089E+09, MASS DISPERSED =  1.392E+08, MASS EVAPORATED =  7.553E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.4E-01, AREA= 4.7E+05 M**2, THICKNESS= 2.6E-01 CM, MOLE WT=322.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.7E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.3E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.6E+03 BBL, DISPERSION= 6.1E+00 GMS/M*M/HR, EVAP RATE= 1.8E+00 GMS/M*M/HR


STEP SIZE OF  3.451E-01 IS BASED ON CUT   3

TIME =  4.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    40
0.0E+00  2.3E-08  1.7E-02  3.9E-01  7.6E-01  8.6E-01  8.8E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING =  1.085E+09, MASS DISPERSED =  1.421E+08, MASS EVAPORATED =  7.641E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.3E-01, AREA= 4.7E+05 M**2, THICKNESS= 2.5E-01 CM, MOLE WT=322.9
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.8E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.3E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.6E+03 BBL, DISPERSION= 6.0E+00 GMS/M*M/HR, EVAP RATE= 1.8E+00 GMS/M*M/HR


STEP SIZE OF  3.402E-01 IS BASED ON CUT   3

TIME =  4.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    41
0.0E+00  1.2E-08  1.5E-02  3.8E-01  7.6E-01  8.6E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01
MASS REMAINING =  1.082E+09, MASS DISPERSED =  1.450E+08, MASS EVAPORATED =  7.726E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.3E-01, AREA= 4.8E+05 M**2, THICKNESS= 2.5E-01 CM, MOLE WT=323.3
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.9E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.3E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.5E+03 BBL, DISPERSION= 5.8E+00 GMS/M*M/HR, EVAP RATE= 1.7E+00 GMS/M*M/HR
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Broken Ice Field Weathering.

```
STEP SIZE OF  3.356E-01 IS BASED ON CUT   3

TIME =  4.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    42
0.0E+00  6.1E-09  1.3E-02  3.7E-01  7.5E-01  8.6E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01
MASS REMAINING =  1.078E+09, MASS DISPERSED =  1.478E+08, MASS EVAPORATED =  7.807E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.3E-01, AREA= 4.8E+05 M**2, THICKNESS= 2.5E-01 CM, MOLE WT=323.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.0E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.2E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.5E+03 BBL, DISPERSION= 5.7E+00 GMS/M*M/HR, EVAP RATE= 1.7E+00 GMS/M*M/HR

TIME =  4.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    43
0.0E+00  0.0E+00  1.1E-02  3.5E-01  7.4E-01  8.6E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01
MASS REMAINING =  1.074E+09, MASS DISPERSED =  1.506E+08, MASS EVAPORATED =  7.887E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.2E-01, AREA= 4.9E+05 M**2, THICKNESS= 2.4E-01 CM, MOLE WT=323.9
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.0E+05 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.2E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.5E+03 BBL, DISPERSION= 5.6E+00 GMS/M*M/HR, EVAP RATE= 1.6E+00 GMS/M*M/HR

TIME =  4.6E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    44
0.0E+00  0.0E+00  9.4E-03  3.4E-01  7.4E-01  8.5E-01  8.7E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01
MASS REMAINING =  1.071E+09, MASS DISPERSED =  1.534E+08, MASS EVAPORATED =  7.964E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.2E-01, AREA= 4.9E+05 M**2, THICKNESS= 2.4E-01 CM, MOLE WT=324.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.1E+05 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.2E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.5E+03 BBL, DISPERSION= 5.5E+00 GMS/M*M/HR, EVAP RATE= 1.6E+00 GMS/M*M/HR

TIME =  4.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    45
0.0E+00  0.0E+00  8.0E-03  3.3E-01  7.3E-01  8.5E-01  8.7E-01  8.7E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01  8.8E-01
MASS REMAINING =  1.067E+09, MASS DISPERSED =  1.561E+08, MASS EVAPORATED =  8.041E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.2E-01, AREA= 5.0E+05 M**2, THICKNESS= 2.4E-01 CM, MOLE WT=324.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.2E+05 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.1E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.4E+03 BBL, DISPERSION= 5.4E+00 GMS/M*M/HR, EVAP RATE= 1.5E+00 GMS/M*M/HR

TIME =  4.8E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    46
0.0E+00  0.0E+00  6.8E-03  3.2E-01  7.3E-01  8.5E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01
MASS REMAINING =  1.064E+09, MASS DISPERSED =  1.588E+08, MASS EVAPORATED =  8.115E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.2E-01, AREA= 5.0E+05 M**2, THICKNESS= 2.3E-01 CM, MOLE WT=324.9
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.3E+05 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.1E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.4E+03 BBL, DISPERSION= 5.3E+00 GMS/M*M/HR, EVAP RATE= 1.5E+00 GMS/M*M/HR

TIME =  4.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    47
0.0E+00  0.0E+00  5.8E-03  3.1E-01  7.2E-01  8.4E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01
MASS REMAINING =  1.060E+09, MASS DISPERSED =  1.615E+08, MASS EVAPORATED =  8.189E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.1E-01, AREA= 5.1E+05 M**2, THICKNESS= 2.3E-01 CM, MOLE WT=325.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.4E+05 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.1E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.4E+03 BBL, DISPERSION= 5.2E+00 GMS/M*M/HR, EVAP RATE= 1.4E+00 GMS/M*M/HR

TIME =  5.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    48
0.0E+00  0.0E+00  4.9E-03  3.0E-01  7.1E-01  8.4E-01  8.6E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01
MASS REMAINING =  1.057E+09, MASS DISPERSED =  1.642E+08, MASS EVAPORATED =  8.261E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.1E-01, AREA= 5.1E+05 M**2, THICKNESS= 2.3E-01 CM, MOLE WT=325.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.4E+05 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.1E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.4E+03 BBL, DISPERSION= 5.1E+00 GMS/M*M/HR, EVAP RATE= 1.4E+00 GMS/M*M/HR

TIME =  5.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    49
0.0E+00  0.0E+00  4.2E-03  2.9E-01  7.1E-01  8.4E-01  8.6E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01
MASS REMAINING =  1.054E+09, MASS DISPERSED =  1.668E+08, MASS EVAPORATED =  8.331E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.1E-01, AREA= 5.2E+05 M**2, THICKNESS= 2.3E-01 CM, MOLE WT=325.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.5E+05 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 2.0E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.3E+03 BBL, DISPERSION= 5.0E+00 GMS/M*M/HR, EVAP RATE= 1.4E+00 GMS/M*M/HR
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 32°F for Broken Ice Field Weathering.

```
TIME =  6.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    50
0.0E+00  0.0E+00  7.3E-04  2.0E-01  6.5E-01  8.1E-01  8.4E-01  8.5E-01  8.5E-01  8.5E-01  8.5E-01  8.5E-01
MASS REMAINING =  1.022E+09, MASS DISPERSED =  1.925E+08, MASS EVAPORATED =  8.972E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.8E-01, AREA= 5.6E+05 M**2, THICKNESS= 2.0E-01 CM, MOLE WT=328.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.7E+05 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.8E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 7.1E+03 BBL, DISPERSION= 4.2E+00 GMS/M*M/HR, EVAP RATE= 1.1E+00 GMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

TIME =  7.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    51
0.0E+00  0.0E+00  1.0E-04  1.3E-01  5.9E-01  7.8E-01  8.2E-01  8.2E-01  8.3E-01  8.3E-01  8.3E-01  8.3E-01  8.3E-01  8.3E-01
MASS REMAINING =  9.926E+08, MASS DISPERSED =  2.161E+08, MASS EVAPORATED =  9.522E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.6E-01, AREA= 5.9E+05 M**2, THICKNESS= 1.8E-01 CM, MOLE WT=330.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  5.2E+05 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.7E+03 GMS/M*M, SPGR= 9.0E-01, TOTAL VOLUME= 6.9E+03 BBL, DISPERSION= 3.5E+00 GMS/M*M/HR, EVAP RATE= 8.4E-01 GMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

TIME =  8.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    52
0.0E+00  0.0E+00  1.3E-05  8.2E-02  5.3E-01  7.5E-01  8.0E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01
MASS REMAINING =  9.674E+08, MASS DISPERSED =  2.367E+08, MASS EVAPORATED =  9.979E+07, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.4E-01, AREA= 6.3E+05 M**2, THICKNESS= 1.7E-01 CM, MOLE WT=332.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.1E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.5E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.7E+03 BBL, DISPERSION= 3.0E+00 GMS/M*M/HR, EVAP RATE= 6.8E-01 GMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

TIME =  9.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                    53
0.0E+00  0.0E+00  1.3E-06  5.0E-02  4.0E-01  7.3E-01  7.8E-01  7.9E-01  7.9E-01  7.9E-01  7.9E-01  7.9E-01  7.9E-01  7.9E-01
MASS REMAINING =  9.440E+08, MASS DISPERSED =  2.554E+08, MASS EVAPORATED =  1.037E+08, SUM =  1.304E+09
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.2E-01, AREA= 6.6E+05 M**2, THICKNESS= 1.6E-01 CM, MOLE WT=334.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  9.5E+05 CENTISTOKES, DISPERSION TERM =  1.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.4E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.6E+03 BBL, DISPERSION= 2.6E+00 GMS/M*M/HR, EVAP RATE= 5.6E-01 GMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

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

THE FINAL MASS FRACTIONS FOR THE SLICK AT  1.0E+02 HOURS ARE:                                                                  54
0.000E+00  0.000E+00  1.517E-07  3.181E-02  4.338E-01  7.054E-01  7.682E-01  7.785E-01  7.802E-01  7.803E-01  7.803E-01
7.803E-01  7.803E-01  7.803E-01
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.1E-01, AREA= 6.8E+05 M**2, THICKNESS= 1.5E-01 CM, MOLE WT=334.4
MASS REMAINING =  9.264E+08, MASS DISPERSED =  2.706E+08, MASS EVAPORATED =  1.068E+08, SUM =  1.304E+09

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Table 16.--Output from Oil-Weathering Calculations (Continued): Characterization of Prudhoe Bay Crude Oil After Weathering in Pools on Top of Ice and Weathering in a Broken Ice Field.

SUMMARY OF TBP CUTS CHARACTERIZATION FOR: PRUDHOE BAY, ALASKA
AFTER:
ICE POOL WEATHERING FOR 2.400E+01 HOURS
BROKEN ICE FIELD WEATHERING FOR 1.000E+02 HOURS

CODE VERSION IS CUTICA OF MAY 84
ITEM 9, SAMPLE 71011

| | TB | API | SPGR | VOL | MW | TC | PC | VC | A | B | T10 | VIS | NC | NS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.80E+02 | 5.16E+01 | 7.60E-01 | 6.79E-07 | 1.19E+02 | 1.07E+03 | 3.48E+01 | 5.07E+02 | 3.41E+00 | 2.27E-01 | 5.49E+02 | 6.73E-01 | 3 | 1 |
| 2 | 3.25E+02 | 4.76E+01 | 7.77E-01 | 1.77E-01 | 1.34E+02 | 1.12E+03 | 3.32E+01 | 5.65E+02 | 3.52E+00 | 2.39E-01 | 5.86E+02 | 8.46E-01 | 3 | 1 |
| 3 | 3.70E+02 | 4.32E+01 | 7.87E-01 | 2.37E+00 | 1.51E+02 | 1.16E+03 | 3.16E+01 | 6.32E+02 | 3.67E+00 | 2.50E-01 | 6.23E+02 | 1.07E+00 | 3 | 1 |
| 4 | 4.15E+02 | 4.15E+01 | 8.04E-01 | 4.77E+00 | 1.67E+02 | 1.21E+03 | 3.03E+01 | 6.98E+02 | 3.80E+00 | 2.59E-01 | 6.60E+02 | 1.38E+00 | 3 | 1 |
| 5 | 4.60E+02 | 3.78E+01 | 8.22E-01 | 5.80E+00 | 1.85E+02 | 1.26E+03 | 2.91E+01 | 7.67E+02 | 3.94E+00 | 2.67E-01 | 6.98E+02 | 1.81E+00 | 3 | 1 |
| 6 | 5.05E+02 | 3.48E+01 | 8.36E-01 | 6.12E+00 | 2.00E+02 | 1.31E+03 | 2.84E+01 | 8.28E+02 | 4.06E+00 | 2.74E-01 | 7.36E+02 | 1.75E+00 | 3 | 1 |
| 7 | 5.54E+02 | 3.06E+01 | 8.50E-01 | 3.44E+00 | 2.21E+02 | 1.35E+03 | 2.74E+01 | 9.09E+02 | 4.22E+00 | 2.82E-01 | 7.77E+02 | 2.48E+00 | 3 | 1 |
| 8 | 6.09E+02 | 2.91E+01 | 8.66E-01 | 7.98E+00 | 2.52E+02 | 1.40E+03 | 2.58E+01 | 1.03E+03 | 4.49E+00 | 2.92E-01 | 8.26E+02 | 4.00E+00 | 3 | 1 |
| 9 | 6.62E+02 | 2.62E+01 | 8.82E-01 | 8.35E+00 | 2.81E+02 | 1.45E+03 | 2.47E+01 | 1.15E+03 | 4.73E+00 | 2.99E-01 | 8.73E+02 | 7.18E+00 | 3 | 1 |
| 10 | 7.12E+02 | 2.40E+01 | 8.94E-01 | 7.36E+00 | 3.13E+02 | 1.49E+03 | 2.36E+01 | 1.27E+03 | 5.00E+00 | 3.06E-01 | 9.19E+02 | 1.36E+01 | 3 | 1 |
| 11 | 7.64E+02 | 2.25E+01 | 9.03E-01 | 9.08E+00 | 3.51E+02 | 1.53E+03 | 2.25E+01 | 1.43E+03 | 5.35E+00 | 3.13E-01 | 9.68E+02 | 2.81E+01 | 3 | 1 |
| 12 | 8.50E+02 | 1.14E+01 | 9.73E-01 | 4.46E+01 | 6.00E+02 | 1.45E+03 | 2.47E+01 | 1.15E+03 | 4.73E+00 | 2.99E-01 | 8.27E-01 | 1.81E+02 | 3 | 1 |

| | UOP K | CORRELATION INDEX |
|---|---|---|
| 1 | 1.19E+01 | 2.32E+01 |
| 2 | 1.19E+01 | 2.43E+01 |
| 3 | 1.19E+01 | 2.32E+01 |
| 4 | 1.19E+01 | 2.56E+01 |
| 5 | 1.18E+01 | 2.90E+01 |
| 6 | 1.18E+01 | 3.15E+01 |
| 7 | 1.17E+01 | 3.73E+01 |
| 8 | 1.18E+01 | 3.66E+01 |
| 9 | 1.18E+01 | 4.02E+01 |
| 10 | 1.18E+01 | 4.27E+01 |
| 11 | 1.18E+01 | 4.36E+01 |
| 12 | 1.12E+01 | 7.21E+01 |

BULK API GRAVITY = 23.0

TB = NORMAL BOILING TEMPERATURE, DEG F
API = API GRAVITY
VOL = VOLUME 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 PRESSURE 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
UOP K IS THE U.O.P. K CHARACTERIZATION FACTOR
CORRELATION INDEX IS DEFINED IN (COLEMAN, 1978)
NC = ERROR CODE, SHOULD BE LESS THAN 20
NS = ERROR CODE, SHOULD BE EQUAL TO 1
IGNORE THE ERROR CODES FOR COMPONENT NUMBER 12 IF IT IS A RESIDUUM

MEAN MOLECULAR WEIGHT OF THE CRUDE = 3.358E+02

Table 16.--Output from Oil-Weathering Calculations (Continued): Beginning of Calculated Results for Open-Ocean Weathering at 40°F.

```
WEATHERING DATA FOR OIL ON THE OPEN OCEAN
AFTER:
        ICE POOL WEATHERING FOR 2.400E+01 HOURS
        BROKEN ICE FIELD WEATHERING FOR 1.000E+02 HOURS

OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT CODE 2

OVER-ALL MASS-TRANSFER COEFFICIENT FOR CUMENE =  2.590E+01 M/HR

  CUT            M/HR        GM-MOLES/(HR)(ATM)(M**2)
   1          2.685E+01            1.180E+03
   2          2.656E+01            1.168E+03
   3          2.630E+01            1.156E+03
   4          2.609E+01            1.147E+03
   5          2.590E+01            1.139E+03
   6          2.577E+01            1.133E+03
   7          2.562E+01            1.126E+03
   8          2.543E+01            1.118E+03
   9          2.529E+01            1.112E+03
  10          2.517E+01            1.107E+03
  11          2.506E+01            1.101E+03

FOR THIS SPILL OF  6.428E+03 BARRELS, THE MASS IS  9.264E+02 METRIC TONNES

VOLUME FROM SUMMING THE CUTS =  1.0E+03 M**3, OR  6.428E+03 BARRELS

WIND SPEED =  2.000E+01 KNOTS, OR  3.706E+04 M/HR

INITIAL SLICK DIAMETER =  9.315E+02 M, OR AREA =  6.811E+05 M**2

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS =  1.1E+01 CENTISTOKES AT 122 DEG F

KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE CUTS =  1.9E+01 AT T =  40.0 DEG F, SCALE FACTOR =  1.7E+00

VISCOSITY ACCORDING TO MASS EVAPORATED: VIS25C = 3.50E+01, ANDRADE = 9.00E+03, FRACT WEATHERED = 1.05E+01, VSLEAD = 3.24E+02 CP

MOUSSE CONSTANTS: MOONEY= 6.20E-01, MAX H2O= 0.70, WIND**2= 1.00E-03

THE FRACTIONAL SLICK AREA SUBJECT TO DISPERSION IS  1.4E+01 PER HOUR

COUNT THE CUTS IN THE FOLLOWING OUTPUT FROM LEFT TO RIGHT

THE INITIAL GRAM MOLES IN THE SLICK ARE:
 4.400E-02  1.043E+04  1.258E+05  2.327E+05  2.622E+05  2.600E+05  1.358E+05  2.790E+05  2.662E+05  2.142E+05  2.374E+05
 7.351E+05

THE INITIAL MASSES (GRAMS) IN THE SLICK ARE:
 5.247E+00  1.396E+06  1.897E+07  3.896E+07  4.845E+07  5.208E+07  2.998E+07  7.027E+07  7.487E+07  6.699E+07  8.343E+07
 4.410E+08
THE TOTAL MASS FROM THESE CUTS IS  9.264E+08 GRAMS


 STEP SIZE OF  9.670E-02 IS BASED ON CUT   1

 TIME =  0.0E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:
 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 =  9.264E+08, MASS DISPERSED =  0.000E+00, MASS EVAPORATED =  0.000E+00, SUM =  9.264E+08
 FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 1.0E+00, AREA= 6.8E+05 M**2, THICKNESS= 1.5E-01 CM, MOLE WT=335.8
 WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.3E+04 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
 MASS/AREA= 1.4E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.4E+03 BBL, DISPERSION= 3.5E+00 GMS/M*M/HR, EVAP RATE= 0.0E+00 GMS/M*M/HR


 TIME =  1.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  2
 5.7E-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
 MASS REMAINING =  9.231E+08, MASS DISPERSED =  2.517E+06, MASS EVAPORATED =  7.750E+05, SUM =  9.264E+08
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

```
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 1.0E+00, AREA= 6.9E+05 M**2, THICKNESS= 1.5E-01 CM, MOLE WT=336.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.4E+04 CENTISTOKES, DISPERSION TERM =  2.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.3E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.4E+03 BBL, DISPERSION= 3.4E+00 GMS/M*M/HR, EVAP RATE= 1.0E+00 GMS/M*M/HR

TIME =  2.1E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              3
3.3E-01  7.8E-01  9.5E-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 =  9.199E+08, MASS DISPERSED =  3.019E+06, MASS EVAPORATED =  1.532E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.9E-01, AREA= 7.0E+05 M**2, THICKNESS= 1.5E-01 CM, MOLE WT=336.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.5E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.3E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.4E+03 BBL, DISPERSION= 3.4E+00 GMS/M*M/HR, EVAP RATE= 1.0E+00 GMS/M*M/HR

TIME =  3.2E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              4
1.8E-01  6.9E-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
MASS REMAINING =  9.167E+08, MASS DISPERSED =  7.504E+06, MASS EVAPORATED =  2.272E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.9E-01, AREA= 7.1E+05 M**2, THICKNESS= 1.4E-01 CM, MOLE WT=336.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.7E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.3E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.4E+03 BBL, DISPERSION= 3.3E+00 GMS/M*M/HR, EVAP RATE= 9.8E-01 GMS/M*M/HR

TIME =  4.3E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              5
1.0E-01  6.1E-01  9.0E-01  9.7E-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 =  9.135E+08, MASS DISPERSED =  9.973E+06, MASS EVAPORATED =  2.997E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.9E-01, AREA= 7.1E+05 M**2, THICKNESS= 1.4E-01 CM, MOLE WT=337.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.8E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.3E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.3E+03 BBL, DISPERSION= 3.2E+00 GMS/M*M/HR, EVAP RATE= 9.5E-01 GMS/M*M/HR

TIME =  5.3E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              6
5.6E-02  5.3E-01  8.8E-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
MASS REMAINING =  9.103E+08, MASS DISPERSED =  1.242E+07, MASS EVAPORATED =  3.706E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 7.2E+05 M**2, THICKNESS= 1.4E-01 CM, MOLE WT=337.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  3.9E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.3E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.3E+03 BBL, DISPERSION= 3.2E+00 GMS/M*M/HR, EVAP RATE= 9.2E-01 GMS/M*M/HR

TIME =  6.4E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              7
3.1E-02  4.7E-01  8.5E-01  9.6E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  9.072E+08, MASS DISPERSED =  1.486E+07, MASS EVAPORATED =  4.401E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 7.3E+05 M**2, THICKNESS= 1.4E-01 CM, MOLE WT=337.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  4.1E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.3E+03 BBL, DISPERSION= 3.1E+00 GMS/M*M/HR, EVAP RATE= 8.9E-01 GMS/M*M/HR

TIME =  7.4E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              8
1.7E-02  4.1E-01  8.3E-01  9.5E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  9.041E+08, MASS DISPERSED =  1.727E+07, MASS EVAPORATED =  5.082E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.8E-01, AREA= 7.4E+05 M**2, THICKNESS= 1.4E-01 CM, MOLE WT=338.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  4.2E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.3E+03 BBL, DISPERSION= 3.1E+00 GMS/M*M/HR, EVAP RATE= 8.6E-01 GMS/M*M/HR

STEP SIZE OF  3.929E-01 IS BASED ON CUT   2

TIME =  8.8E+00 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                              9
7.6E-03  3.5E-01  8.0E-01  9.4E-01  9.7E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  9.002E+08, MASS DISPERSED =  2.034E+07, MASS EVAPORATED =  5.935E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.7E-01, AREA= 7.5E+05 M**2, THICKNESS= 1.3E-01 CM, MOLE WT=338.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  4.4E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.2E+03 BBL, DISPERSION= 3.0E+00 GMS/M*M/HR, EVAP RATE= 8.4E-01 GMS/M*M/HR

STEP SIZE OF  3.891E-01 IS BASED ON CUT   2
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

```
TIME =  1.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                    10
3.8E-03  3.0E-01  7.8E-01  9.4E-01  9.7E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01  9.8E-01
MASS REMAINING =  8.968E+08, MASS DISPERSED =  2.295E+07, MASS EVAPORATED =  6.653E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.7E-01, AREA= 7.5E+05 M**2, THICKNESS= 1.3E-01 CM, MOLE WT=338.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  4.0E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.2E+03 BBL, DISPERSION= 2.9E+00 GMS/M*M/HR, EVAP RATE= 8.1E-01 GMS/M*M/HR

STEP SIZE OF  3.835E-01 IS BASED ON CUT  2

TIME =  1.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                    11
1.9E-03  2.6E-01  7.5E-01  9.3E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01
MASS REMAINING =  8.936E+08, MASS DISPERSED =  2.550E+07, MASS EVAPORATED =  7.349E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.6E-01, AREA= 7.6E+05 M**2, THICKNESS= 1.3E-01 CM, MOLE WT=339.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  4.8E+04 CENTISTOKES, DISPERSION TERM =  2.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.2E+03 BBL, DISPERSION= 2.9E+00 GMS/M*M/HR, EVAP RATE= 7.9E-01 GMS/M*M/HR

STEP SIZE OF  3.783E-01 IS BASED ON CUT  2

TIME =  1.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                    12
9.5E-04  2.2E-01  7.3E-01  9.2E-01  9.6E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01
MASS REMAINING =  8.904E+08, MASS DISPERSED =  2.800E+07, MASS EVAPORATED =  8.023E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.6E-01, AREA= 7.7E+05 M**2, THICKNESS= 1.3E-01 CM, MOLE WT=339.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  5.0E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.2E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.2E+03 BBL, DISPERSION= 2.8E+00 GMS/M*M/HR, EVAP RATE= 7.6E-01 GMS/M*M/HR

STEP SIZE OF  3.732E-01 IS BASED ON CUT  2

TIME =  1.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                    13
4.7E-04  1.9E-01  7.1E-01  9.1E-01  9.6E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01  9.7E-01
MASS REMAINING =  8.873E+08, MASS DISPERSED =  3.045E+07, MASS EVAPORATED =  8.677E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.6E-01, AREA= 7.8E+05 M**2, THICKNESS= 1.3E-01 CM, MOLE WT=339.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  5.2E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.1E+03 BBL, DISPERSION= 2.8E+00 GMS/M*M/HR, EVAP RATE= 7.4E-01 GMS/M*M/HR

STEP SIZE OF  3.684E-01 IS BASED ON CUT  2

TIME =  1.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                    14
2.4E-04  1.6E-01  6.9E-01  9.1E-01  9.5E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01
MASS REMAINING =  8.843E+08, MASS DISPERSED =  3.204E+07, MASS EVAPORATED =  9.311E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=340.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  5.4E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.1E+03 BBL, DISPERSION= 2.7E+00 GMS/M*M/HR, EVAP RATE= 7.3E-01 GMS/M*M/HR

STEP SIZE OF  3.638E-01 IS  BASED ON CUT 2

TIME =  1.6E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                    15
1.2E-04  1.4E-01  6.7E-01  9.0E-01  9.5E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01
MASS REMAINING =  8.813E+08, MASS DISPERSED =  3.517E+07, MASS EVAPORATED =  9.927E+06, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 7.9E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=340.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  5.6E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.1E+03 BBL, DISPERSION= 2.7E+00 GMS/M*M/HR, EVAP RATE= 7.1E-01 GMS/M*M/HR

STEP SIZE OF  3.594E-01 IS BASED ON CUT  2
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

```
TIME =  1.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          16
5.9E-05  1.2E-01  6.5E-01  8.9E-01  9.5E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01
MASS REMAINING =  8.784E+08, MASS DISPERSED =  3.746E+07, MASS EVAPORATED =  1.053E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 8.0E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=340.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  5.8E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.1E+03 BBL, DISPERSION= 2.6E+00 GMS/M*M/HR, EVAP RATE= 6.9E-01 GMS/M*M/HR


STEP SIZE OF  3.552E-01 IS BASED ON CUT  2

TIME =  1.8E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          17
2.9E-05  1.0E-01  6.3E-01  8.9E-01  9.5E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01  9.6E-01
MASS REMAINING =  8.756E+08, MASS DISPERSED =  3.970E+07, MASS EVAPORATED =  1.111E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.5E-01, AREA= 8.1E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=340.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.0E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.1E+03 BBL, DISPERSION= 2.6E+00 GMS/M*M/HR, EVAP RATE= 6.8E-01 GMS/M*M/HR


STEP SIZE OF  3.511E-01 IS BASED ON CUT  2

TIME =  1.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          18
1.5E-05  8.9E-02  6.1E-01  8.8E-01  9.4E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  8.729E+08, MASS DISPERSED =  4.190E+07, MASS EVAPORATED =  1.168E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 8.1E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=341.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.2E+04 CENTISTOKES, DISPERSION TERM =  2.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.0E+03 BBL, DISPERSION= 2.5E+00 GMS/M*M/HR, EVAP RATE= 6.6E-01 GMS/M*M/HR


STEP SIZE OF  3.472E-01 IS BASED ON CUT  2

TIME =  2.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          19
7.3E-06  7.6E-02  5.9E-01  8.7E-01  9.4E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  8.702E+08, MASS DISPERSED =  4.405E+07, MASS EVAPORATED =  1.223E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 8.2E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=341.3
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.4E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.0E+03 BBL, DISPERSION= 2.5E+00 GMS/M*M/HR, EVAP RATE= 6.3E-01 GMS/M*M/HR


STEP SIZE OF  3.435E-01 IS BASED ON CUT  2

TIME =  2.1E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          20
3.7E-06  6.6E-02  5.7E-01  8.7E-01  9.4E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  8.675E+08, MASS DISPERSED =  4.616E+07, MASS EVAPORATED =  1.277E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.4E-01, AREA= 8.3E+05 M**2, THICKNESS= 1.2E-01 CM, MOLE WT=341.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.6E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.1E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.0E+03 BBL, DISPERSION= 2.5E+00 GMS/M*M/HR, EVAP RATE= 6.3E-01 GMS/M*M/HR


STEP SIZE OF  3.398E-01 IS BASED ON CUT  2

TIME =  2.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          21
1.8E-06  5.6E-02  5.5E-01  8.6E-01  9.3E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  8.649E+08, MASS DISPERSED =  4.823E+07, MASS EVAPORATED =  1.330E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 8.3E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=341.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  6.8E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.0E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.0E+03 BBL, DISPERSION= 2.4E+00 GMS/M*M/HR, EVAP RATE= 6.2E-01 GMS/M*M/HR


STEP SIZE OF  3.363E-01 IS BASED ON CUT  2
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40"F for Open-Ocean Weathering.

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TIME =  2.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          22
9.1E-07  4.9E-02  5.4E-01  8.5E-01  9.3E-01  9.4E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01  9.5E-01
MASS REMAINING =  8.624E+08, MASS DISPERSED =  5.026E+07, MASS EVAPORATED =  1.382E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 8.4E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=342.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.1E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.0E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.0E+03 BBL, DISPERSION= 2.4E+00 GMS/M*M/HR, EVAP RATE= 6.1E-01 GMS/M*M/HR


STEP SIZE OF  3.330E-01 IS BASED ON CUT  2

TIME =  2.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          23
4.6E-07  4.2E-02  5.2E-01  8.5E-01  9.3E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  8.599E+08, MASS DISPERSED =  5.225E+07, MASS EVAPORATED =  1.432E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.3E-01, AREA= 8.4E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=342.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.3E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.0E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 6.0E+03 BBL, DISPERSION= 2.3E+00 GMS/M*M/HR, EVAP RATE= 6.0E-01 GMS/M*M/HR


STEP SIZE OF  3.297E-01 IS BASED ON CUT  2

TIME =  2.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          24
1.8E-07  3.4E-02  5.0E-01  8.4E-01  9.2E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  8.566E+08, MASS DISPERSED =  5.485E+07, MASS EVAPORATED =  1.498E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 8.5E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=342.6
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.6E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 1.0E+03 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.9E+03 BBL, DISPERSION= 2.3E+00 GMS/M*M/HR, EVAP RATE= 5.8E-01 GMS/M*M/HR


STEP SIZE OF  3.255E-01 IS BASED ON CUT  2

TIME =  2.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          25
7.1E-08  2.8E-02  4.8E-01  8.3E-01  9.2E-01  9.3E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01  9.4E-01
MASS REMAINING =  8.534E+08, MASS DISPERSED =  5.739E+07, MASS EVAPORATED =  1.562E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 8.6E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=342.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.9E+04 CENTISTOKES, DISPERSION TERM =  2.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.9E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.9E+03 BBL, DISPERSION= 2.2E+00 GMS/M*M/HR, EVAP RATE= 5.7E-01 GMS/M*M/HR


STEP SIZE OF  3.215E-01 IS BASED ON CUT  2

TIME =  2.8E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          26
2.8E-08  2.3E-02  4.6E-01  8.2E-01  9.2E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  8.503E+08, MASS DISPERSED =  5.987E+07, MASS EVAPORATED =  1.624E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.2E-01, AREA= 8.7E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=343.1
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  8.2E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.8E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.9E+03 BBL, DISPERSION= 2.2E+00 GMS/M*M/HR, EVAP RATE= 5.5E-01 GMS/M*M/HR


STEP SIZE OF  3.176E-01 IS BASED ON CUT 2

TIME =  2.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          27
1.1E-08  1.9E-02  4.4E-01  8.2E-01  9.1E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  8.473E+08, MASS DISPERSED =  6.230E+07, MASS EVAPORATED =  1.684E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.1E-01, AREA= 8.7E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=343.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  8.6E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.7E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.9E+03 BBL, DISPERSION= 2.2E+00 GMS/M*M/HR, EVAP RATE= 5.4E-01 GMS/M*M/HR


STEP SIZE OF  3.140E-01 IS BASED ON CUT  2
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Table 16, --Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

```
TIME =  3.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  28
4.4E-09  1.5E-02  4.2E-01  8.1E-01  9.1E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  8.443E+08, MASS DISPERSED =  6.466E+07, MASS EVAPORATED =  1.743E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.1E-01, AREA= 8.8E+05 M**2, THICKNESS= 1.1E-01 CM, MOLE WT=343.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  8.9E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.6E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.8E+03 BBL, DISPERSION= 2.1E+00 GMS/M*M/HR, EVAP RATE= 5.3E-01 GMS/M*M/HR

TIME =  3.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  29
0.0E+00  1.2E-02  4.1E-01  8.0E-01  9.1E-01  9.2E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01  9.3E-01
MASS REMAINING =  8.414E+08, MASS DISPERSED =  6.700E+07, MASS EVAPORATED =  1.000E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.1E-01, AREA= 8.9E+05 M**2, THICKNESS= 1.0E-01 CM, MOLE WT=344.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  9.3E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.5E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.8E+03 BBL, DISPERSION= 2.1E+00 GMS/M*M/HR, EVAP RATE= 5.2E-01 GMS/M*M/HR

TIME =  3.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  30
0.0E+00  1.0E-02  3.9E-01  7.9E-01  9.0E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01
MASS REMAINING =  8.386E+08, MASS DISPERSED =  6.930E+07, MASS EVAPORATED =  1.857E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.1E-01, AREA= 8.9E+05 M**2, THICKNESS= 1.0E-01 CM, MOLE WT=344.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  9.6E+04 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.4E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.8E+03 BBL, DISPERSION= 2.0E+00 GMS/M*M/HR, EVAP RATE= 5.0E-01 GMS/M*M/HR

TIME =  3.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  31
0.0E+00  8.3E-03  3.8E-01  7.9E-01  9.0E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01
MASS REMAINING =  8.357E+08, MASS DISPERSED =  7.150E+07, MASS EVAPORATED =  1.913E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.0E-01, AREA= 9.0E+05 M**2, THICKNESS= 1.0E-01 CM, MOLE WT=344.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.0E+05 CENTISTOKES, DISPERSION TERM =  2.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.3E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.8E+03 BBL, DISPERSION= 2.0E+00 GMS/M*M/HR, EVAP RATE= 4.9E-01 GMS/M*M/HR

TIME =  3.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  32
0.0E+00  6.7E-03  3.6E-01  7.8E-01  8.9E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01
MASS REMAINING =  8.329E+08, MASS DISPERSED =  7.384E+07, MASS EVAPORATED =  1.968E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 9.0E-01, AREA= 9.1E+05 M**2, THICKNESS= 1.0E-01 CM, MOLE WT=344.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.0E+05 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.2E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.8E+03 BBL, DISPERSION= 2.0E+00 GMS/M*M/HR, EVAP RATE= 4.8E-01 GMS/M*M/HR

TIME = 3.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                   33
0.0E+00  5.4E-03  3.4E-01  7.7E-01  8.9E-01  9.1E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01  9.2E-01
MASS REMAINING = 8.301E+08, MASS DISPERSED = 7.607E+07, MASS EVAPORATED =  2.022E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK=  9.0E-01, AREA= 9.1E+05 M**2, THICKNESS= 1.0E-01 CM, MOLE WT=345.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.1E+05 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.1E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.7E+03 BBL, DISPERSION= 1.9E+00 GMS/M*M/HR, EVAP RATE= 4.7E-01 GMS/M*M/HR

TIME =  3.8E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  34
0.0E+00  4.4E-03  3.3E-01  7.6E-01  8.9E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  8.274E+08, MASS DISPERSED =  7.827E+07, MASS EVAPORATED =  2.076E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.9E-01, AREA= 9.2E+05 M**2, THICKNESS= 9.9E-02 CM, MOLE WT=345.3
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.1E+05 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 9.0E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.7E+03 BBL, DISPERSION= 1.9E+00 GMS/M*M/HR, EVAP RATE= 4.6E-01 GMS/M*M/HR

TIME =  3.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  35
0.0E+00  3.5E-03  3.2E-01  7.5E-01  8.8E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  8.247E+08, MASS DISPERSED =  8.045E+07, MASS EVAPORATED =  2.128E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.9E-01, AREA= 9.3E+05 M**2, THICKNESS= 9.8E-02 CM, MOLE WT=345.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.2E+05 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.9E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.7E+03 BBL, DISPERSION= 1.9E+00 GMS/M*M/HR, EVAP RATE= 4.5E-01 GMS/M*M/HR

TIME =  4.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                  36
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

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0.0E+00  2.8E-03  3.0E-01  7.5E-01  8.8E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  8.220E+08, MASS DISPERSED =  8.261E+07, MASS EVAPORATED =  2.180E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.9E-01, AREA= 9.3E+05 M**2, THICKNESS= 9.7E-02 CM, MOLE WT=345.8
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.2E+05 CENTISTOKES, DISPERSION TERM =  2.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.8E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.7E+03 BBL, DISPERSION= 1.8E+00 GMS/M*M/HR, EVAP RATE= 4.4E-01 GMS/M*M/HR

TIME =  4.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          37
0.0E+00  2.3E-03  2.9E-01  7.4E-01  8.8E-01  9.0E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  8.194E+08, MASS DISPERSED =  8.473E+07, MASS EVAPORATED =  2.231E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.8E-01, AREA= 9.4E+05 M**2, THICKNESS= 9.6E-02 CM, MOLE WT=346.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.2E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.7E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.7E+03 BBL, DISPERSION= 1.8E+00 GMS/M*M/HR, EVAP RATE= 4.3E-01 GMS/M*M/HR

TIME =  4.3E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          38
0.0E+00  1.8E-03  2.8E-01  7.3E-01  8.7E-01  9.0E-01  9.0E-01  9.0E-01  9.1E-01  9.1E-01  9.1E-01  9.1E-01
MASS REMAINING =  8.168E+08, MASS DISPERSED =  8.684E+07, MASS EVAPORATED =  2.281E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.8E-01, AREA= 9.4E+05 M**2, THICKNESS= 9.5E-02 CM, MOLE WT=346.3
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.3E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.7E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.6E+03 BBL, DISPERSION= 1.8E+00 GMS/M*M/HR, EVAP RATE= 4.2E-01 GMS/M*M/HR

TIME =  4.4E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          39
0.0E+00  1.4E-03  2.6E-01  7.3E-01  8.7E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  8.142E+08, MASS DISPERSED =  8.892E+07, MASS EVAPORATED =  2.331E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.8E-01, AREA= 9.5E+05 M**2, THICKNESS= 9.4E-02 CM, MOLE WT=346.5
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.3E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.6E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.6E+03 BBL, DISPERSION= 1.7E+00 GMS/M*M/HR, EVAP RATE= 4.1E-01 GMS/M*M/HR

TIME =  4.5E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          40
0.0E+00  1.2E-03  2.5E-01  7.2E-01  8.7E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  8.117E+08, MASS DISPERSED =  9.090E+07, MASS EVAPORATED =  2.380E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.8E-01, AREA= 9.6E+05 M**2, THICKNESS= 9.3E-02 CM, MOLE WT=346.7
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.4E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.5E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.6E+03 BBL, DISPERSION= 1.7E+00 GMS/M*M/HR, EVAP RATE= 4.1E-01 GMS/M*M/HR

TIME =  4.7E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          41
0.0E+00  9.2E-04  2.4E-01  7.1E-01  8.6E-01  8.9E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  8.091E+08, MASS DISPERSED =  9.301E+07, MASS EVAPORATED =  2.428E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 9.6E+05 M**2, THICKNESS= 9.2E-02 CM, MOLE WT=347.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.4E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.4E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.6E+03 BBL, DISPERSION= 1.7E+00 GMS/M*M/HR, EVAP RATE= 4.0E-01 GMS/M*M/HR

TIME =  4.8E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          42
0.0E+00  7.3E-04  2.3E-01  7.0E-01  8.6E-01  8.9E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01  9.0E-01
MASS REMAINING =  8.067E+08, MASS DISPERSED =  9.502E+07, MASS EVAPORATED =  2.475E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 9.7E+05 M**2, THICKNESS= 9.2E-02 CM, MOLE WT=347.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.5E+05 CENTISTOKES, DISPERSION TERM =  2.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.3E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.6E+03 BBL, DISPERSION= 1.6E+00 GMS/M*M/HR, EVAP RATE= 3.9E-01 GMS/M*M/HR

TIME =  4.9E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          43
0.0E+00  5.0E-04  2.2E-01  7.0E-01  8.6E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING =  8.042E+08, MASS DISPERSED =  9.701E+07, MASS EVAPORATED =  2.522E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 9.7E+05 M**2, THICKNESS= 9.1E-02 CM, MOLE WT=347.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.5E+05 CENTISTOKES, DISPERSION TERM =  1.9E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.3E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.6E+03 BBL, DISPERSION= 1.6E+00 GMS/M*M/HR, EVAP RATE= 3.8E-01 GMS/M*M/HR

TIME =  5.0E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          44
0.0E+00  4.6E-04  2.1E-01  6.9E-01  8.5E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING =  8.018E+08, MASS DISPERSED =  9.898E+07, MASS EVAPORATED =  2.568E+07, SUM =  9.264E+08
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe BayCrudeOil,Timeversus Calculated Results at 40°F for Open-Ocean Weathering.

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FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.7E-01, AREA= 9.8E+05 M**2, THICKNESS= 9.0E-02 CM, MOLE WT=347.7
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 1.6E+05 CENTISTOKES, DISPERSION TERM = 1.9E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.2E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.5E+03 BBL, DISPERSION= 1.6E+00 GMS/M*M/HR, EVAP RATE= 3.7E-01 GMS/M*M/HR

TIME = 5.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          45
0.0E+00  3.6E-04  2.0E-01  6.8E-01  8.5E-01  8.8E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01  8.9E-01
MASS REMAINING = 7.994E+08, MASS DISPERSED = 1.009E+08, MASS EVAPORATED = 2.613E+07, SUM = 9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.6E-01, AREA= 9.8E+05 M**2, THICKNESS= 8.9E-02 CM, MOLE WT=347.9
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 1.7E+05 CENTISTOKES, DISPERSION TERM = 1.9E-03 WEIGHT FRACTION/HR
MASS/AREA= 8.1E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.5E+03 BBL, DISPERSION= 1.6E+00 GMS/M*M/HR, EVAP RATE= 3.7E-01 GMS/M*M/HR

STEP SIZE OF 5.000E-01 IS BASED ON CUT 3

TIME = 6.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          46
0.0E+00  4.7E-05  1.3E-01  6.2E-01  8.3E-01  8.6E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01  8.7E-01
MASS REMAINING = 7.804E+08, MASS DISPERSED = 1.165E+08, MASS EVAPORATED = 2.960E+07, SUM = 9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.4E-01, AREA= 1.0E+06 M**2, THICKNESS= 8.3E-02 CM, MOLE WT=349.6
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 2.2E+05 CENTISTOKES, DISPERSION TERM = 1.8E-03 WEIGHT FRACTION/HR
MASS/AREA= 7.6E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.4E+03 BBL, DISPERSION= 1.4E+00 GMS/M*M/HR, EVAP RATE= 3.1E-01 GMS/M*M/HR

STEP SIZE OF 5.000E-01 IS BASED ON CUT 3

TIME = 7.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          47
0.0E+00  5.8E-06  8.9E-02  5.7E-01  8.0E-01  8.5E-01  8.6E-01  8.6E-01  8.6E-01  8.6E-01  8.6E-01  8.6E-01
MASS REMAINING = 7.636E+08, MASS DISPERSED = 1.303E+08, MASS EVAPORATED = 3.263E+07, SUM = 9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.2E-01, AREA= 1.1E+06 M**2, THICKNESS= 7.8E-02 CM, MOLE WT=351.1
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 2.8E+05 CENTISTOKES, DISPERSION TERM = 1.7E-03 WEIGHT FRACTION/HR
MASS/AREA= 7.1E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.3E+03 BBL, DISPERSION= 1.2E+00 GMS/M*M/HR, EVAP RATE= 2.7E-01 GMS/M*M/HR

STEP SIZE OF 5.000E-01 IS BASED ON CUT 3

TIME = 8.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          48
0.0E+00  6.2E-07  5.7E-02  5.2E-01  7.8E-01  8.3E-01  8.4E-01  8.4E-01  8.4E-01  8.4E-01  8.4E-01  8.4E-01
MASS REMAINING = 7.482E+08, MASS DISPERSED = 1.429E+08, MASS EVAPORATED = 3.536E+07, SUM = 9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 8.1E-01, AREA= 1.1E+06 M**2, THICKNESS= 7.4E-02 CM, MOLE WT=352.6
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 3.6E+05 CENTISTOKES, DISPERSION TERM = 1.6E-03 WEIGHT FRACTION/HR
MASS/AREA= 6.8E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.2E+03 BBL, DISPERSION= 1.1E+00 GMS/M*M/HR, EVAP RATE= 2.4E-01 GMS/M*M/HR

STEP SIZE OF 5.000E-01 IS BASED ON CUT 3

TIME = 9.2E+01 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          49
0.0E+00  5.8E-08  3.6E-02  4.7E-01  7.6E-01  8.2E-01  8.3E-01  8.3E-01  8.3E-01  8.3E-01  8.3E-01  8.3E-01
MASS REMAINING = 7.341E+08, MASS DISPERSED = 1.545E+08, MASS EVAPORATED = 3.787E+07, SUM = 9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.9E-01, AREA= 1.1E+06 M**2, THICKNESS= 7.0E-02 CM, MOLE WT=353.9
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 4.5E+05 CENTISTOKES, DISPERSION TERM = 1.5E-03 WEIGHT FRACTION/HR
MASS/AREA= 6.4E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.1E+03 BBL, DISPERSION= 9.4E-01 GMS/M*M/HR, EVAP RATE= 2.1E-01 GMS/M*M/HR

STEP SIZE OF 5.000E-01 IS BASED ON CUT 3

TIME = 1.0E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          50
0.0E+00  4.9E-09  2.2E-02  4.3E-01  7.4E-01  8.0E-01  8.2E-01  8.2E-01  8.2E-01  8.2E-01  8.2E-01  8.2E-01
MASS REMAINING = 7.211E+08, MASS DISPERSED = 1.651E+08, MASS EVAPORATED = 4.019E+07, SUM = 9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.8E-01, AREA= 1.2E+06 M**2, THICKNESS= 6.7E-02 CM, MOLE WT=355.1
WEIGHT FRACTION WATER IN OIL = 7.0E-01, VISCOSITY = 5.6E+05 CENTISTOKES, DISPERSION TERM = 1.4E-03 WEIGHT FRACTION/HR
MASS/AREA= 6.1E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 5.0E+03 BBL, DISPERSION= 8.4E-01 GMS/M*M/HR, EVAP RATE= 1.9E-01 GMS/M*M/HR
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

```
TIME =  1.1E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          51
0.0E+00  0.0E+00  1.3E-02  3.9E-01  7.2E-01  7.9E-01  8.0E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01  8.1E-01
MASS REMAINING =  7.091E+08, MASS DISPERSED =  1.750E+08, MASS EVAPORATED =  4.235E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.7E-01, AREA= 1.2E+06 M**2, THICKNESS= 6.4E-02 CM, MOLE WT=356.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  7.0E+05 CENTISTOKES, DISPERSION TERM =  1.3E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.9E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 4.9E+03 BBL, DISPERSION= 7.6E-01 GMS/M*M/HR, EVAP RATE= 1.7E-01 GMS/M*M/HR

TIME =  1.2E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          52
0.0E+00  0.0E+00  7.9E-03  3.5E-01  7.0E-01  7.8E-01  7.9E-01  8.0E-01  8.0E-01  8.0E-01  8.0E-01  8.0E-01
MASS REMAINING =  6.980E+08, MASS DISPERSED =  1.841E+08, MASS EVAPORATED =  4.438E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.5E-01, AREA= 1.2E+06 M**2, THICKNESS= 6.2E-02 CM, MOLE WT=357.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  8.5E+05 CENTISTOKES, DISPERSION TERM =  1.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.6E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 4.8E+03 BBL, DISPERSION= 6.9E-01 GMS/M*M/HR, EVAP RATE= 1.6E-01 GMS/M*M/HR

TIME =  1.3E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          53
0.0E+00  0.0E+00  4.6E-03  3.1E-01  6.8E-01  7.7E-01  7.8E-01  7.9E-01  7.9E-01  7.9E-01  7.9E-01  7.9E-01
MASS REMAINING =  6.876E+08, MASS DISPERSED =  1.926E+08, MASS EVAPORATED =  4.629E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.4E-01, AREA= 1.3E+06 M**2, THICKNESS= 5.9E-02 CM, MOLE WT=358.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.0E+06 CENTISTOKES, DISPERSION TERM =  1.2E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.4E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 4.7E+03 BBL, DISPERSION= 6.3E-01 GMS/M*M/HR, EVAP RATE= 1.5E-01 GMS/M*M/HR

TIME =  1.4E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          54
0.0E+00  0.0E+00  2.6E-03  2.8E-01  6.6E-01  7.6E-01  7.7E-01  7.8E-01  7.8E-01  7.8E-01  7.8E-01  7.8E-01
MASS REMAINING =  6.778E+08, MASS DISPERSED =  2.005E+08, MASS EVAPORATED =  4.811E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.3E-01, AREA= 1.3E+06 M**2, THICKNESS= 5.7E-02 CM, MOLE WT=359.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.2E+06 CENTISTOKES, DISPERSION TERM =  1.1E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.2E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 4.7E+03 BBL, DISPERSION= 5.7E-01 GMS/M*M/HR, EVAP RATE= 1.4E-01 GMS/M*M/HR

TIME =  1.5E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          55
0.0E+00  0.0E+00  1.4E-03  2.5E-01  6.4E-01  7.5E-01  7.7E-01  7.7E-01  7.7E-01  7.7E-01  7.7E-01  7.7E-01
MASS REMAINING =  6.687E+08, MASS DISPERSED =  2.079E+08, MASS EVAPORATED =  4.983E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.2E-01, AREA= 1.3E+06 M**2, THICKNESS= 5.5E-02 CM, MOLE WT=360.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.5E+06 CENTISTOKES, DISPERSION TERM =  1.0E-03 WEIGHT FRACTION/HR
MASS/AREA= 5.1E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 4.6E+03 BBL, DISPERSION= 5.3E-01 GMS/M*M/HR, EVAP RATE= 1.3E-01 GMS/M*M/HR

TIME =  1.6E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          56
0.0E+00  0.0E+00  7.8E-04  2.2E-01  6.2E-01  7.4E-01  7.6E-01  7.6E-01  7.6E-01  7.6E-01  7.6E-01  7.6E-01
MASS REMAINING =  6.602E+08, MASS DISPERSED =  2.140E+08, MASS EVAPORATED =  5.147E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.1E-01, AREA= 1.3E+06 M**2, THICKNESS= 5.4E-02 CM, MOLE WT=361.4
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  1.7E+06 CENTISTOKES, DISPERSION TERM =  9.9E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.9E+02 GMS/M*M, SPGR= 9.1E-01, TOTAL VOLUME= 4.5E+03 BBL, DISPERSION= 4.8E-01 GMS/M*M/HR, EVAP RATE= 1.2E-01 GMS/M*M/HR

TIME =  1.7E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          57
0.0E+00  0.0E+00  4.2E-04  2.0E-01  6.1E-01  7.3E-01  7.5E-01  7.5E-01  7.5E-01  7.5E-01  7.5E-01  7.5E-01
MASS REMAINING =  6.522E+08, MASS DISPERSED =  2.212E+08, MASS EVAPORATED =  5.303E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.0E-01, AREA= 1.4E+06 M**2, THICKNESS= 5.2E-02 CM, MOLE WT=362.3
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.0E+06 CENTISTOKES, DISPERSION TERM =  9.4E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.7E+02 GMS/M*M, SPGR= 9.2E-01, TOTAL VOLUME= 4.5E+03 BBL, DISPERSION= 4.5E-01 GMS/M*M/HR, EVAP RATE= 1.1E-01 GMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT  4

TIME =  1.8E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                          58
0.0E+00  0.0E+00  2.2E-04  1.7E-01  5.9E-01  7.2E-01  7.4E-01  7.5E-01  7.5E-01  7.5E-01  7.5E-01  7.5E-01
MASS REMAINING =  6.446E+08, MASS DISPERSED =  2.273E+08, MASS EVAPORATED =  5.451E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 7.0E-01, AREA= 1.4E+06 M**2, THICKNESS= 5.0E-02 CM, MOLE WT=363.2
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.4E+06 CENTISTOKES, DISPERSION TERM =  9.0E-04 WEIGHT FRACTION/HR
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Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, Time versus Calculated Results at 40°F for Open-Ocean Weathering.

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MASS/AREA= 4.6E+02 CMS/M*M, SPCR= 9.2E-01, TOTAL VOLUME= 4. 4E+03 BBL. , DISPERSION= 4.1E-01 CMS/M*M/HR, EVAP RATE= 1.0E-01 CMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

TIME =  1.9E+02 HOURS.MASS FRACTION OF EACH CUT REMAINING:                                                                  59
0.0E+00  0.0E+00  I.1E-04  1.5E-01  5.7E-01  7.1E 01  7.4E-01  7.4E 01  7.4E-01  7.4E-01  7.4E-01  7.4E-01
HASS REMAINING=  6.374E+08, MASS DISPERSED=  2.:1:1 1E+08. MASS EVAPORATED =  5.591E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.9E-01 , AREA= 1.4E+06 M**2, THICKNESS= 4.9E-02 CM, MOLE WT=364.0
WEIGHT FRACTION WATER IN OIL =  7.0E-01, VISCOSITY =  2.7E+06 CENTISTOKES, DISPERSION TERM .  8.6E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.5E+02 CMS/M*M, SPCR= 9.2E-01 , TOTAL VOLUME= 4.4E+03 11111., DISPERSION= 3.8E-01 CMS/M*M/HR, EVAP RATE= 9.7E-02 CMS/M*M/HR


STEP SIZE OF  5.000E-01 1S BASED ON CUT 4

TIME =  2.0E+02 HOURS, H.ASS FRACTION OF EACH CUT REMAINING:                                                                60
0.0E+00  0.0E+00  5.6E-05  1.3E-01  s 6E-01  7.0E-01  7.3E-01  7.3E-01  7.3E-01  7.3E-01  7.3E-01  7.3E-01
MASS REMAINING =  6.307E+08, MASS DISPERSED =  2.385E+08, MASS EVAPORATED =  5.2253E+02 , SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK=  6.8E-01, AREA= 1.4E+06 M**2, THICKNESS= 4.8E-02 CM, MOLE WT=364.8
WEIGHT FRACTION WATER IN OIL. =  7.0E-01, VISCOSITY =  3.2E+06 CENTISTOKES, DISPERSION TERM =  8.2E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.4E+02 CMS/M*M, SPCR= 9.2E-01, TUTAL VOLUME= 4.3E+03 BBL., DISPERSION= 3.6E-01 CMS/M*M/HR, EVAP RATE= 9.0E-02 CMS/M*M/HR


STEP SIZE OF  5.000E-01 1s BASED ON CUT 4

TIME =  2.1E+02 HOURS, MASS FRACTIÓN OF EACH CUT REMAINING:                                                                 61
0.0E+00  0.0E+00  2.8E-05  1.2E-01  3.4E-01  6.9E-01  7.2E-01  7.3E-01  7.3E-01  7.3E-01  7.3E-01  7.3E-01
MASS REMAINING =  6.243E+08, MASS DISPERSED =  2.436E+08, MASS EVAPORATED =  5.852E+07, sun =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.7E-01, AREA= 1.5E+06 M**2, THICKNESS=4.6E-02 CM, MOLE WT=365.6
WEIGHT FRACTION WATER IN OIL. =  7.0E-01, VISCOSITY =  3.6E+06 CENTISTOKES, DISPERSION TERM = 7.8E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.3E+02 CMS/M*M, SPCR= 9.2E-01, TOTAL VOLUME= 4.3E+03 BBL., DISPERSION= 3.3E-01 CMS/M*M/HR, EVAP RATE= 8.5E-02 CMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

TIME =  2.2E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 62
0.0E+00  0.0E+00  1.4E-05  1.0E-01  5.3E-01  6.9E-01  7.2E-01  7.2E-01  7.2E-01  7.2E-01  7.2E-01  7.2E-01
MASS REMAINING =  6.182E+08, MASS DISPERSED =  2.485E+08, MASS EVAPORATED =  5.973E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.7E-01, AREA= 1.5E+06 M**2, THICKNESS= 4.5E-02 CM, MOLE WT=366.4
WEIGHT FRACTION WATER IN OIL. =  7.0E-01, VISCOSITY =  4.2E+06 CENTISTOKES, DISPERSION TERM =  7.5E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.2E+02 CMS/M*M, SPCR= 9.2E-01, TOTAL VOLUME= 4.2E+03 BBL., DISPERSION= 3.1E-01 CMS/M*M/HR, EVAP RATE= 7.9E-02 CMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

TIME =  2.3E+02 HOURS, MASS FRACTION OF EACH CUT REMAINING:                                                                 63
0.0E+00  0.0E+00  6.5E-06  9.0E 02  5.1E-01  6.8E-01  7.1E-01  7.2E-01  7.2E-01  7.2E-01  7.2E-01  7.2E-01
MASS REMAINING =  6.124E+08, MASS DISPERSED =  2.531E+08, MASS EVAPORATED =  6.088E+07, SUM =  9.264E+08
FRACTION (BASED ON MASS) REMAINING IN THE SLICK= 6.6E-01, AREA= 1.5E+06 M**2, THICKNESS= 4.4E-02 CM, MOLE WT=367.1
WEIGHT FRACTION WATER IN OIL. =  7.0E-01, VISCOSITY =  4.7E+06 CENTISTOKES, DISPERSION TERM =  7.2E-04 WEIGHT FRACTION/HR
MASS/AREA= 4.1E+02 CMS/M*M, SPCR= 9.2E-01, TOTAL VOLUME= 4.2E+03 BBL., DISPERSION= 2.9E-01 CMS/M*M/HR, EVAP RATE= 7.5E-02 CMS/M*M/HR


STEP SIZE OF  5.000E-01 IS BASED ON CUT   4

THE CUT NUMBERING BEGINS WITH  1  BASED ON THE ORIGINAL CUT NUMBERS

THE FINAL MASS FRACTIONS FOR THE SLICE AT  2.4E+02 HOURS ARE:                                                               64
0.000E+00  0.000E+00  3.419E 06  7.975E 02  4.987E-01  6.735E 01  7.072E-01  7.114E-01  7.116E 01  7.117E-01  7.117E-01
```

Table 16.--Output from Oil-Weathering Calculations (Continued): Prudhoe Bay Crude Oil, End of Calculated Result, Including Final Mass Balance.

```
 7.117E-01
 FRACTION (BASED  011  MASS) REMAINING IN THE SLICK= 6.6E-01,  AREA=  1  .5E+06 M**2, THICKNESS= 4.3E-02 CM, MOLE WT=367.1
 MASS REMAINING =   6.077E+08, MASS DISPERSED  =   2.569E+08, MASS EVAPORATED =   6.181E+07, SUM =   9.264E+08

*****************************************************************


********* FINAL  OVERALL  MASS BALANCE FOR PARENT  OIL************

FINAL MASS FRACTIONS OF CUTS:
 0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  1.471E-06  5.619E-02  3.830E-01  5.243E-01  5.518E-01  5.551E-01
 5.553E-01  5.553E-01  5.553E-01  5.553E-01
FRACTION (BASED ON MASS) REMAINING=   4.356E-01
MASS REMAINING= 6.077E+08 MASS DISPERSED= 5.275E+08 MASS EVAPORATED= 2.600E+08 MASS DELETED= 1.566E+01 TOTAL= 1.395E+09
ORIGINAL MASS= 1.395E+09
```

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 (less than 1 hour). In this case the cut(s) will be deleted from the calculation and the remaining cuts renumbered.

Page 47 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 on page 55 where it is noted that the cut numbering begins with 2.

After pool-weathering and broken-ice field weathering, open ocean weathering at 40°C was chosen. Page 56 shows another intermediate characterization of the oil. Note that in this characterization only twelve cuts are shown. This is because the first three cuts have weathered away. The remaining cuts are renumbered and characterized in the usual manner. Thus, if a user desires to follow a particular cut through a scenario, care must be taken to correctly identify the desired cut. This is most easily accomplished by following the boiling point of the component (which does not change) through the various output.

As with the two previous weathering "compartments," the oil characterization data are followed by the input constants and the results of the weathering calculations (pages 57 through 67). Page 67 presents the end of the weathering calculations and the final overall mass balance for the parent oil. This mass balance serves as a means of checking that the sum of the mass evaporated, mass dispersed, mass remaining, and mass deleted (very volatile cuts) is equal to the original mass.

An example of the 80-column output is presented in Table 17. This output was generated at the same time as the output in Table 16. Note that the

Table 17--Illustration of 80-Column Output from Ocean-Ice Oil-Weathering Code : Prudhoe Bay Crude Oil, Weathering of Oil in Pools on Top of Ice at 32°F.

```
WEATHERING OF OIL IN POOLS ON TOP OF  I C E

OIL: PRUDHOE BAY, ALASKA
TEMPERATURE=  32.0 DEG F. WIND SPEED=  10.0 KNOTS
SPILL SIZE=  1.000E+04 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 | 2.74E+05 | 2.29E+07 | 4.09E-02 | 1.50E+02 | 7.27E+01 | 83 |
| 2 | 3.13E+05 | 2.96E+07 | 1.35E-02 | 1.90E+02 | 6.42E+01 | 93 |
| 3 | 3.91E+05 | 4.14E+07 | 3.25E-03 | 2.35E+02 | 5.67E+01 | 105 |
| 4 | 3.67E+05 | 4.37E+07 | 7.05E-04 | 2.80E+02 | 5.16E+01 | 119 |
| 5 | 3.43E+05 | 4.60E+07 | 1.40E-04 | 3.25E+02 | 4.76E+01 | 133 |
| 6 | 2.92E+05 | 4.41E+07 | 2.44E-05 | 3.70E+02 | 4.32E+01 | 150 |
| 7 | 3.30E+05 | 5.53E+07 | 3.98E-06 | 4.15E+02 | 4.15E+01 | 167 |
| 8 | 3.41E+05 | 6.31E+07 | 5.86E-07 | 4.60E+02 | 3.78E+01 | 184 |
| 9 | 3.34E+05 | 6.69E+07 | 8.22E-08 | 5.05E+02 | 3.48E+01 | 200 |
| 10 | 1 .74E+05 | 3.84E+07 | 8.24E-09 | 5.54E+02 | 3.06E+01 | 220 |
| 11 | 3.58E+05 | 9.01E+07 | 4.12E-10 | 6.09E+02 | 2.91E+01 | 251 |
| 12 | 3.41E+05 | 9.59E+07 | 2.02E-11 | 6.62E+02 | 2.62E+01 | 281 |
| 13 | 2.75E+05 | 8.59E+07 | 8.60E-13 | 7.12E+02 | 2.40E+01 | 312 |
| 14 | 3.04E+05 | 1.07E+08 | 1.96E-14 | 7.64E+02 | 2.25E+01 | 351 |
| 15 | 9.42E+05 | 5.65E+08 | 0.00E+00 | 8.50E+02 | 1.14E+01 | 600 |

```
MOUSSE CONSTANTS: MOONEY= 0.00E+00, MAX H20=-1.00, WIND**2= 0.00E+00
DISPERSION CONSTANTS:KA= 1.08E-01, KB= 3.00E+01, S-TENSION= 1.00E+00
VIS CONSTANTS: VIS25C= 3.50E+01, ANDRADE  =  9.00E+03, FRACT  =  1.05E+01

FOR THE OUTPUT THAT 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 SLICK
I=FIRST CUT WITH GREATER THAN  1% (MASS) REMAINING
J=FIRST CUT WITH GREATER THAN 50% (MASS) REMAINING
DISPERSION WAS TURNED OFF
SPREADING WAS TURNED OFF
```

| TIME | BBL | SPGR | AREA | THICKNESS | W | DISP | ERATE | M/A | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1.0E+04 | 0.88 | 7.9E+04 | 2.0E+00 | 0 | 0.0E+00 | 0.0E+00 | 1.8E+04 | 1 | 1 |
| 1 | 9.8E+03 | 0.88 | 7.9E+04 | 2.0E+00 | 0 | 0.0E+00 | 1.7E+02 | 1.7E+04 | 1 | 1 |
| 2 | 9.7E+03 | 0.88 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 1.3E+02 | 1.7E+04 | 1 | 2 |
| 3 | 9.7E+03 | 0.88 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 9.5E+01 | 1.7E+04 | 1 | 2 |
| 4 | 9.6E+03 | 0.88 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 7.5E+01 | 1.7E+04 | 1 | 3 |
| 5 | 9.6E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 6.2E+01 | 1.7E+04 | 1 | 3 |
| 6 | 9.5E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 5.2E+01 | 1.7E+04 | 1 | 3 |
| 7 | 9.5E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 4.5E+01 | 1.7E+04 | 1 | 3 |
| 8 | 9.4E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 4.0E+01 | 1.7E+04 | 2 | 3 |
| 9 | 9.4E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 3.6E+01 | 1.7E+04 | 2 | 3 |
| 10 | 9.4E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 3.3E+01 | 1.7E+04 | 2 | 3 |
| 11 | 9.4E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 3.0E+01 | 1.7E+04 | 2 | 3 |
| 12 | 9.4E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 2.8E+01 | 1.7E+04 | 2 | 3 |
| 13 | 9.3E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 2.6E+01 | 1.7E+04 | 2 | 3 |
| 14 | 9.3E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 2.4E+01 | 1.7E+04 | 2 | 3 |
| 15 | 9.3E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 2.2E+01 | 1.7E+04 | 2 | 3 |
| 16 | 9.3E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 2.1E+01 | 1.7E+04 | 2 | 4 |
| 17 | 9.3E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 2.0E+01 | 1.7E+04 | 2 | 4 |
| 18 | 9.3E+03 | 0.89 | 7.9E+04 | 1.9E+00 | 0 | 0.0E+00 | 1.9E+01 | 1.6E+04 | 2 | 4 |
| 19 | 9.2E+03 | 0.89 | 7.9E+04 | 1.8E+00 | 0 | 0.0E+00 | 1.8E+01 | 1.6E+04 | 2 | 4 |
| 20 | 9.2E+03 | 0.89 | 7.9E+04 | 1.8E+00 | 0 | 0.0E+00 | 1.7E+01 | 1.6E+04 | 2 | 4 |
| 21 | 9.2E+03 | 0.89 | 7.9E+04 | 1.8E+00 | 0 | 0.0E+00 | 1.6E+01 | 1.6E+04 | 2 | 4 |
| 22 | 9.2E+03 | 0.89 | 7.9E+04 | 1.8E+00 | 0 | 0.0E+00 | 1.6E+01 | 1.6E+04 | 2 | 4 |
| 23 | 9.2E+03 | 0.89 | 7.9E+04 | 1.8E+00 | 0 | 0.0E+00 | 1.5E+01 | 1.6E+04 | 2 | 4 |

Table 17 .--(Continued)

WEATHERING OF OIL IN A BROKEN ICE FIELD
AFTER ICE POOL WEATHERING FOR 2.400E+01 HOURS

OIL: PRUDHOE BAY, ALASKA
TEMPERATURE= 32.0 DEG F, WIND SPEED= 12.0 KNOTS
SPILL SIZE= 9.195E+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 | 1.87E-01 | 1.57E+01 | 5.99E-02 | 1.50E+02 | 7.27E+01 | 83 |
| 2 | 3.11E+03 | 2.92E+05 | 2.06E-02 | 1.90E+02 | 6.42E+01 | 93 |
| 3 | 1.31E+05 | 1.38E+07 | 5.42E-03 | 2.35E+02 | 5.67E+01 | 105 |
| 4 | 2.90E+05 | 3.46E+07 | 1.24E-03 | 2.80E+02 | 5.16E+01 | 119 |
| 5 | 3.28E+05 | 4.39E+07 | 2.59E-04 | 3.25E+02 | 4.76E+01 | 133 |
| 6 | 2.90E+05 | 4.37E+07 | 4.81E-05 | 3.70E+02 | 4.52E+01 | 150 |
| 7 | 3.30E+05 | 5.52E+07 | 8.33E-06 | 4.15E+02 | 4.15E+01 | 167 |
| 8 | 3.41E+05 | 6.31E+07 | 1.31E-06 | 4.60E+02 | 3.78E+01 | 184 |
| 9 | 3.34E+05 | 6.69E+07 | 1.95E-07 | 5.05E+02 | 3.48E+01 | 200 |
| 10 | 1.74E+05 | 3.84E+07 | 2.12E-08 | 5.54E+02 | 3.06E+01 | 220 |
| 11 | 3.58E+05 | 9.01E+07 | 1.17E-09 | 6.09E+02 | 2.91E+01 | 251 |
| 12 | 3.41E+05 | 9.59E+07 | 6.39E-11 | 6.62E+02 | 2.62E+01 | 281 |
| 13 | 2.75E+05 | 8.59E+07 | 3.03E-12 | 7.12E+02 | 2.40E+01 | 312 |
| 14 | 3.04E+05 | 1.07E+08 | 7.87E-14 | 7.64E+02 | 2.25E+01 | 351 |
| 15 | 9.42E+05 | 5.65E+08 | 0.00E+00 | 8.50E+02 | 1.14E+01 | 600 |

MOUSSE CONSTANTS: MOONEY=6.20E-01, MAX H20=0.70, WIND**2=1.00E-02
K4=1.000E+01
DISPERSION CONSTANTS: KA= 1.08E-01, KB= 5.00E+01, S-TENSION= 3.00E+01
KC=1.000E+01
FRACTION OF ICE COVER=6.600E-01
VIS CONSTANTS: VIS25C= 3.50E+01, ANDRADE = 9.00E+03, FRACT = 1.05E+01

FOR THE OUTPUT THAT 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 SLICK
I=FIRST CUT WITH GREATER THAN 1% (MASS) REMAINING
J=FIRST CUT WITH GREATER THAN 50% (MASS) REMAINING
CUT 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 | 9.2E+03 | 0.89 | 7.9E+04 | 1.8E+00 | 0 | 7.6E+01 | 0.0E+00 | 1.6E+04 | 1 | 1 |
| 1 | 9.1E+03 | 0.89 | 1.1E+05 | 1.3E+00 | 29 | 7.3E+01 | 2.5E+01 | 1.2E+04 | 1 | 1 |
| 2 | 9.0E+03 | 0.89 | 1.4E+05 | 1.1E+00 | 48 | 4.4E+01 | 2.3E+01 | 9.5E+03 | 1 | 2 |
| 3 | 9.0E+03 | 0.89 | 1.6E+05 | 9.2E-01 | 60 | 2.8E+01 | 2.1E+01 | 8.2E+03 | 1 | 2 |
| 4 | 8.9E+03 | 0.89 | 1.7E+05 | 8.2E-01 | 66 | 1.9E+01 | 1.9E+01 | 7.3E+03 | 1 | 2 |
| 5 | 8.9E+03 | 0.89 | 1.9E+05 | 7.4E-01 | 69 | 1.5E+01 | 1.7E+01 | 6.7E+03 | 1 | 3 |
| 6 | 8.8E+03 | 0.89 | 2.0E+05 | 6.9E-01 | 70 | 1.3E+01 | 1.5E+01 | 6.1E+03 | 1 | 3 |
| 7 | 8.8E+03 | 0.89 | 2.2E+05 | 6.4E-01 | 70 | 1.3E+01 | 1.3E+01 | 5.7E+03 | 2 | 3 |
| 8 | 8.7E+03 | 0.90 | 2.3E+05 | 5.9E-01 | 70 | 1.2E+01 | 1.2E+01 | 5.3E+03 | 2 | 3 |
| 9 | 8.7E+03 | 0.90 | 2.5E+05 | 5.6E-01 | 70 | 1.2E+01 | 1.1E+01 | 5.0E+03 | 2 | 3 |
| 10 | 8.6E+03 | 0.90 | 2.6E+05 | 5.3E-01 | 70 | 1.2E+01 | 9.6E+00 | 4.8E+03 | 2 | 3 |
| 11 | 8.6E+03 | 0.90 | 2.7E+05 | 5.1E-01 | 70 | 1.1E+01 | 8.7E+00 | 4.5E+03 | 2 | 3 |
| 12 | 8.5E+03 | 0.90 | 2.8E+05 | 4.8E-01 | 70 | 1.1E+01 | 7.9E+00 | 4.3E+03 | 2 | 4 |
| 13 | 8.5E+03 | 0.90 | 2.9E+05 | 4.6E-01 | 70 | 1.1E+01 | 7.3E+00 | 4.2E+03 | 2 | 4 |
| 14 | 8.5E+03 | 0.90 | 3.0E+05 | 4.5E-01 | 70 | 1.1E+01 | 6.8E+00 | 4.0E+03 | 2 | 4 |
| 16 | 8.4E+03 | 0.90 | 3.1E+05 | 4.3E-01 | 70 | 1.0E+01 | 6.3E+00 | 3.9E+03 | 2 | 4 |
| 17 | 8.4E+03 | 0.90 | 3.2E+05 | 4.2E-01 | 70 | 1.0E+01 | 5.9E+00 | 3.8E+03 | 2 | 4 |

Table 17.--(Continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 8.3E+03 | 0.90 | 3.3E+05 | 4.1E-01 | 70 | 9.8E+00 | 5.5E+00 | 3.6E+03 | 3 | 4 |
| 19 | 8.3E+03 | 0.90 | 3.4E+05 | 3.9E-01 | 70 | 9.6E+00 | 5.2E+00 | 3.5E+03 | 3 | 4 |
| 29 | 8.3E+03 | 0.90 | 3.4E+05 | 3.8E-01 | 70 | 9.4E+00 | 4.9E+00 | 3.4E+03 | 3 | 4 |
| 21 | 8.2E+03 | 0.90 | 3.5E+05 | 3.7E-01 | 70 | 9.2E+00 | 4.6E+00 | 3.3E+03 | 3 | 4 |
| 22 | 8.2E+03 | 0.90 | 3.6E+05 | 3.6E-01 | 70 | 9.0E+00 | 4.3E+00 | 3.3E+03 | 3 | 4 |
| 23 | 8.1E+03 | 0.90 | 3.7E+05 | 3.5E-01 | 70 | 8.8E+00 | 4.1E+00 | 3.2E+03 | 3 | 4 |
| 24 | 8.1E+03 | 0.90 | 3.7E+05 | 3.5E-01 | 70 | 8.6E+00 | 3.9E+00 | 3.1E+03 | 3 | 4 |
| 25 | 8.1E+03 | 0.90 | 3.8E+05 | 3.4E-01 | 70 | 8.4E+00 | 3.7E+00 | 3.0E+03 | 3 | 4 |
| 26 | 8.0E+03 | 0.90 | 3.9E+05 | 3.3E-01 | 70 | 8.2E+00 | 3.5E+00 | 3.0E+03 | 3 | 4 |
| 27 | 8.0E+03 | 0.90 | 3.9E+05 | 3.2E-01 | 70 | 8.0E+00 | 3.3E+00 | 2.9E+03 | 3 | 4 |
| 28 | 8.0E+03 | 0.90 | 4.0E+05 | 3.2E-01 | 70 | 7.8E+00 | 3.1E+00 | 2.9E+03 | 3 | 4 |
| 29 | 7.9E+03 | 0.90 | 4.1E+05 | 3.1E-01 | 70 | 7.6E+00 | 2.9E+00 | 2.8E+03 | 3 | 4 |
| 31 | 7.9E+03 | 0.90 | 4.1E+05 | 3.0E-01 | 70 | 7.4E+00 | 2.8E+00 | 2.7E+03 | 3 | 4 |
| 32 | 7.9E+03 | 0.90 | 4.2E+05 | 3.0E-01 | 70 | 7.3E+00 | 2.6E+00 | 2.7E+03 | 3 | 4 |
| 33 | 7.8E+03 | 0.90 | 4.3E+05 | 2.9E-01 | 70 | 7.1E+00 | 2.5E+00 | 2.6E+03 | 3 | 4 |
| 34 | 7.8E+03 | 0.90 | 4.4E+05 | 2.8E-01 | 70 | 6.9E+00 | 2.4E+00 | 2.6E+03 | 3 | 5 |
| 35 | 7.7E+03 | 0.90 | 4.4E+05 | 2.8E-01 | 70 | 6.8E+00 | 2.3E+00 | 2.5E+03 | 3 | 5 |
| 37 | 7.7E+03 | 0.90 | 4.5E+05 | 2.7E-01 | 70 | 6.6E+00 | 2.2E+00 | 2.5E+03 | 3 | 5 |
| 38 | 7.7E+03 | 0.90 | 4.5E+05 | 2.7E-01 | 70 | 6.5E+00 | 2.1E+00 | 2.4E+03 | 3 | 5 |
| 39 | 7.7E+03 | 0.90 | 4.6E+05 | 2.7E-01 | 70 | 6.3E+00 | 2.0E+00 | 2.4E+03 | 3 | 5 |
| 40 | 7.6E+03 | 0.90 | 4.6E+05 | 2.6E-01 | 70 | 6.2E+00 | 1.9E+00 | 2.4E+03 | 3 | 5 |
| 41 | 7.6E+03 | 0.90 | 4.7E+05 | 2.6E-01 | 70 | 6.1E+00 | 1.8E+00 | 2.3E+03 | 3 | 5 |
| 42 | 7.6E+03 | 0.90 | 4.7E+05 | 2.5E-01 | 70 | 6.0E+00 | 1.8E+00 | 2.3E+03 | 3 | 5 |
| 43 | 7.5E+03 | 0.90 | 4.8E+05 | 2.5E-01 | 70 | 5.8E+00 | 1.7E+00 | 2.3E+03 | 3 | 5 |
| 44 | 7.5E+03 | 0.90 | 4.8E+05 | 2.5E-01 | 70 | 5.7E+00 | 1.7E+00 | 2.2E+03 | 3 | 5 |
| 43 | 7.5E+03 | 0.90 | 4.9E+05 | 2.4E-01 | 70 | 5.6E+00 | 1.6E+00 | 2.2E+03 | 3 | 5 |
| 46 | 7.5E+03 | 0.90 | 4.9E+05 | 2.4E-01 | 70 | 5.5E+00 | 1.6E+00 | 2.2E+03 | 4 | 5 |
| 47 | 7.4E+03 | 0.90 | 5.0E+05 | 2.4E-01 | 70 | 5.4E+00 | 1.5E+00 | 2.1E+03 | 4 | 5 |
| 48 | 7.4E+03 | 0.90 | 5.0E+05 | 2.3E-01 | 70 | 5.3E+00 | 1.5E+00 | 2.1E+03 | 4 | 5 |
| 49 | 7.4E+03 | 0.90 | 5.1E+05 | 2.3E-01 | 70 | 5.2E+00 | 1.4E+00 | 2.1E+03 | 4 | 5 |
| 50 | 7.4E+03 | 0.90 | 5.1E+05 | 2.3E-01 | 70 | 5.1E+00 | 1.4E+00 | 2.1E+03 | 4 | 5 |
| 51 | 7.3E+03 | 0.90 | 5.2E+05 | 2.3E-01 | 70 | 5.0E+00 | 1.4E+00 | 2.0E+03 | 4 | 5 |
| 61 | 7.1E+03 | 0.90 | 5.6E+05 | 2.0E-01 | 70 | 4.2E+00 | 1.1E+00 | 1.8E+03 | 4 | 5 |
| 71 | 6.9E+03 | 0.90 | 5.9E+05 | 1.8E-01 | 70 | 3.5E+00 | 8.4E-01 | 1.7E+03 | 4 | 5 |
| 81 | 6.7E+03 | 0.91 | 6.3E+05 | 1.7E-01 | 70 | 3.0E+00 | 6.8E-01 | 1.5E+03 | 4 | 5 |
| 91 | 6.6E+03 | 0.91 | 6.6E+05 | 1.6E-01 | 70 | 2.6E+00 | 5.6E-01 | 1.4E+03 | 4 | 6 |

Table 17.--(Continued)

OPEN OCEAN WEATHERING
AFTER:
ICE POOL WEATHERING FOR 2.400E+01 HOURS
BROKEN ICE FIELD WEATHERING FOR 1.000E+02 HOURS

OIL: PRUDHOE BAY, ALASKA
TEMPERATURE= 40.0 DEG F, WIND SPEED= 20.0 KNOTS
SPILL SIZE= 6.428E+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 | 4.40E-02 | 5.25E+00 | 1.77E-03 | 2.80E+02 | 5.16E+01 | 119 |
| 2 | 1.04E+04 | 1.40E+06 | 3.84E-04 | 3.25E+02 | 4.76E+01 | 133 |
| 3 | 1.26E+05 | 1.90E+07 | 7.40E-05 | 3.70E+02 | 4.52E+01 | 150 |
| 4 | 2.33E+05 | 3.90E+07 | 1.33E-05 | 4.15E+02 | 4.15E+01 | 167 |
| 5 | 2.62E+05 | 4.84E+07 | 2.18E-06 | 4.60E+02 | 3.78E+01 | 184 |
| 6 | 2.60E+05 | 5.21E+07 | 3.40E-07 | 5.05E+02 | 3.48E+01 | 200 |
| 7 | 1.36E+05 | 3.00E+07 | 3.86E-08 | 5.54E+02 | 3.06E+01 | 220 |
| 8 | 2.79E+05 | 7.03E+07 | 2.29E-09 | 6.09E+02 | 2.91E+01 | 251 |
| 9 | 2.66E+05 | 7.49E+07 | 1.33E-10 | 6.62E+02 | 2.62E+01 | 281 |
| 10 | 2.14E+05 | 6.70E+07 | 6.76E-12 | 7.12E+02 | 2.40E+01 | 312 |
| 11 | 2.37E+05 | 8.34E+07 | 1.91E-13 | 7.64E+02 | 2.25E+01 | 351 |
| 12 | 7.35E+05 | 4.41E+08 | 0.00E+00 | 8.50E+02 | 1.14E+01 | 600 |

MOUSSE CONSTANTS: MOONEY=6.20E-01, MAX H2O= 0.70, WIND**2=1.00E-03
DISPERSION CONWANTS: 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 THAT 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 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 | 6.4E+03 | 0.91 | 6.8E+05 | 1.5E-01 | 70 | 3.5E+00 | 0.0E+00 | 1.4E+03 | 1 | 1 |
| 1 | 6.4E+03 | 0.91 | 6.9E+05 | 1.5E-01 | 70 | 3.4E+00 | 1.0E+00 | 1.3E+03 | 1 | 1 |
| 2 | 6.4E+03 | $3.91 | 7.0E+05 | 1.5E-01 | 70 | 3.4E+00 | 1.0E+00 | 1.3E+03 | 1 | 2 |
| 3 | 6.4E+03 | 0.91 | 7.1E+05 | 1.4E-01 | 70 | 3.3E+00 | 9.8E-01 | 1.3E+03 | 1 | 2 |
| 4 | 6.3E+03 | 0.91 | 7.1E+05 | 1.4E-01 | 70 | 3.2E+00 | 9.5E-01 | 1.3E+03 | 1 | 2 |
| 5 | 6.3E+03 | 9.91 | 7.2E+05 | 1.4E-01 | 70 | 3.2E+00 | 9.2E-01 | 1.3E+03 | 1 | 2 |
| 6 | 6.3E+03 | 0.91 | 7.3E+05 | 1.4E-01 | 70 | 3.1E+00 | 8.9E-01 | 1.2E+03 | 1 | 3 |
| 7 | 6.3E+03 | 0.91 | 7.4E+05 | 1.4E-01 | 70 | 3.1E+00 | 8.6E-01 | 1.2E+03 | 1 | 3 |
| 8 | 6.2E+03 | 0.91 | 7.5E+05 | 1.3E-01 | 70 | 3.0E+00 | 8.4E-01 | 1.2E+03 | 2 | 3 |
| 9 | 6.2E+03 | 0.91 | 7.5E+05 | 1.3E-01 | 70 | 2.9E+00 | 8.1E-01 | 1.2E+03 | 2 | 3 |
| 11 | 6.2E+03 | 0.91 | 7.6E+05 | 1.3E-01 | 70 | 2.9E+00 | 7.9E-01 | 1.2E+03 | 2 | 3 |
| 12 | 6.2E+03 | 0.91 | 7.7E+05 | 1.3E-01 | 70 | 2.8E+00 | 7.6E-01 | 1.2E+03 | 2 | 3 |
| 13 | 6.1E+03 | 0.91 | 7.8E+05 | 1.3E-01 | 70 | 2.8E+00 | 7.4E-01 | 1.1E+03 | 2 | 3 |
| 14 | 6.1E+03 | 0.91 | 7.9E+05 | 1.2E-01 | 70 | 2.7E+00 | 7.3E-01 | 1.1E+03 | 2 | 3 |
| 15 | 6.1E+03 | 0.91 | 7.9E+05 | 1.2E-01 | 7% | 2.7E+00 | 7.1E-01 | 1.1E+03 | 2 | 3 |
| 16 | 6.1E+03 | 0.91 | 8.0E+05 | 1.2E-01 | 70 | 2.6E+00 | 6.9E-01 | 1.1E+03 | 2 | 3 |
| 17 | 6.1E+03 | 0.91 | 8.1E+05 | 1.2E-01 | 70 | 2.6E+00 | 6.8E-01 | 1.1E+03 | 2 | 3 |
| 18 | 6.0E+03 | 0.91 | 8.1E+05 | 1.2E-01 | 70 | 2.5E+00 | 6.6E-01 | 1.1E+03 | 2 | 3 |
| 19 | 6.0E+03 | 0.91 | 8.2E+05 | 1.2E-01 | 70 | 2.5E+00 | 6.5E-01 | 1.1E+03 | 2 | 3 |
| 20 | 6.0E+03 | 0.91 | 8.3E+05 | 1.2E-01 | 70 | 2.5E+00 | 6.3E-01 | 1.1E+03 | 2 | 3 |
| 21 | 6.0E+03 | 0.91 | 8.3E+05 | 1.1E-01 | 70 | 2.4E+00 | 6.2E-01 | 1.0E+03 | 2 | 3 |
| 22 | 6.0E+03 | 0.91 | 8.4E+05 | 1.1E-01 | 70 | 2.4E+00 | 6.1E-01 | 1.0E+03 | 2 | 3 |
| 23 | 6.0E+03 | 0.91 | 8.4E+05 | 1.1E-01 | 70 | 2.3E+00 | 6.0E-01 | 1.0E+03 | 2 | 3 |

Table 17.--(Continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 5.9E+03 | 0.91 | 8.5E+05 | 1.1E-01 | 70 | 2.3E+00 | 5.8E-01 | 1.0E+03 | 2 | 4 |
| 26 | 5.9E+03 | 0.91 | 8.6E+05 | 1.1E-01 | 70 | 2.2E+00 | 5.7E-01 | 9.9E+02 | 2 | 4 |
| 27 | 5.9E+03 | 0.91 | 8.7E+05 | 1.1E-01 | 70 | 2.2E+00 | 5.5E-01 | 9.8E+02 | 2 | 4 |
| 29 | 5.9E+03 | 0.91 | 8.7E+05 | 1.1E-01 | 70 | 2.2E+00 | 5.4E-01 | 9.7E+02 | 2 | 4 |
| 30 | 5.8E+03 | 0.91 | 8.8E+05 | 1.1E-01 | 70 | 2.1E+00 | 5.3E-01 | 9.6E+02 | 2 | 4 |
| 31 | 5.8E+03 | 0.91 | 8.9E+05 | 1.0E-01 | 70 | 2.1E+00 | 5.2E-01 | 9.5E+02 | 2 | 4 |
| 32 | 5.8E+03 | 0.91 | 8.9E+05 | 1.0E-01 | 70 | 2.0E+00 | 5.0E-01 | 9.4E+02 | 2 | 4 |
| 34 | 5.8E+03 | 0.91 | 9.0E+05 | 1.0E-01 | 70 | 2.0E+00 | 4.9E-01 | 9.3E+02 | 3 | 4 |
| 35 | 5.8E+03 | 0.91 | 9.1E+05 | 1.0E-01 | 70 | 2.0E+00 | 4.8E-01 | 9.2E+02 | 3 | 4 |
| 36 | 5.7E+03 | 0.91 | 9.1E+05 | 1.0E-01 | 70 | 1.9E+00 | 4.7E-01 | 9.1E+02 | 3 | 4 |
| 37 | 5.7E+03 | 0.91 | 9.2E+05 | 9.9E-02 | 70 | 1.9E+00 | 4.6E-01 | 9.0E+02 | 3 | 4 |
| 39 | 5.7E+03 | 0.91 | 9.3E+05 | 9.8E-02 | 70 | 1.9E+00 | 4.5E-01 | 8.9E+02 | 3 | 4 |
| 40 | 5.7E+03 | 0.91 | 9.3E+05 | 9.7E-02 | 70 | 1.8E+00 | 4.4E-01 | 8.8E+02 | 3 | 4 |
| 41 | 3.7E+03 | 0.91 | 9.4E+05 | 9.6E-02 | 70 | 1.8E+00 | 4.3E-01 | 8.7E+02 | 3 | 4 |
| 42 | 5.6E+03 | 0.91 | 9.4E+05 | 9.SE-%12 | 70 | 1.8E+00 | 4.2E-01 | 8.7E+02 | 3 | 4 |
| 44 | 5.6E+03 | 0.91 | 9.5E+05 | 9.4E-02 | 70 | 1.7E+00 | 4.1E-01 | 8.6E+02 | 3 | 4 |
| 45 | 5.6E+03 | 0.91 | 9.6E+05 | 9.3E-02 | 70 | 1.7E+00 | 4.1E-01 | 8.5E+02 | 3 | 4 |
| 46 | 5.6E+03 | 0.91 | 9.6E+05 | 9.2E-02 | 70 | 1.7E+00 | 4.0E-01 | 8.4E+02 | 3 | 4 |
| 47 | 5.6E+03 | 0.91 | 9.7E+05 | 9.2E-02 | 70 | 1.6E+00 | 3.9E-01 | 8.3E+02 | 3 | 4 |
| 49 | 5.6E+03 | 0.91 | 9.7E+05 | 9.1 E-02 | 70 | 1.6E+00 | 3.8E-01 | 8.3E+02 | 3 | 4 |
| 50 | 5.5E+03 | 0.91 | 9.8E+05 | 9.0E-02 | 70 | 1.6E+00 | 3.7E-01 | 8.2E+02 | 3 | 4 |
| 51 | 5.5E+03 | 0.91 | 9.8E+05 | 8.9E-02 | 70 | 1.6E+00 | 3.7E-01 | 8.1E+02 | 3 | 4 |
| 62 | 5.4E+03 | 0.91 | 1.0E+06 | 8.3E-02 | 70 | 1.4E+00 | 3.1E-01 | 7.6E+02 | 3 | 4 |
| 72 | 5.3E+03 | 0.91 | 1.1E+06 | 7.8E-02 | 70 | 1.2E+00 | 2.7E-01 | 7.1E+02 | 3 | 4 |
| 82 | 5.2E+03 | 0.91 | 1.1E+06 | 7.4E-02 | 70 | 1.1E+00 | 2.4E-01 | 6.8E+02 | 3 | 4 |
| 92 | 3.1E+03 | 0.91 | 1.1E+06 | 7.0E-02 | 70 | 9.4E-01 | 2.1E-01 | 6.4E+02 | 3 | 5 |
| 102 | 5.0E+03 | 0.91 | 1.2E+06 | 6.7E-02 | 70 | 8.4E-01 | 1.9E-01 | 6.1E+02 | 3 | 5 |
| 112 | 4.9E+03 | 0.91 | 1.2E+06 | 6.4E-02 | 70 | 7.6E-01 | 1.7E-01 | 5.9E+02 | 3 | 5 |
| 122 | 4.8E+03 | 0.91 | 1 .2E+06 | 6.2E-02 | 70 | 6.9E-01 | 1.6E-01 | 5.6E+02 | 4 | 5 |
| 132 | 4.7E+03 | 0.91 | 1.3E+06 | 5.9E-02 | 70 | 6.3E-01 | 1.5E-01 | 5.4E+02 | 4 | 5 |
| 14 2 | 4.7E+03 | 0.91 | 1.3E+06 | 5.7E-02 | 70 | 5.7E-01 | 1.4E-01 | 5.2E+02 | 4 | 5 |
| 152 | 4.6E+03 | 0.91 | 1.3E+06 | 5.5E-02 | 70 | 5.3E-01 | 1.3E-01 | 5.1E+02 | 4 | 5 |
| 162 | 4.5E+03 | 0.91 | 1.3E+06 | 5.4E-02 | 70 | 4.8E-01 | 1.2E-01 | 4.9E+02 | 4 | 5 |
| 172 | 4.5E+03 | 0.92 | 1.4E+06 | 5.2E-02 | 70 | 4.5E-01 | 1.1E-01 | 4.7E+02 | 4 | 5 |
| 18 2 | 4.4E+03 | 0.92 | 1.4E+06 | 5.0E-02 | 70 | 4.1E-01 | 1.0E-01 | 4.6E+02 | 4 | 5 |
| 192 | 4.4E+03 | 0.92 | 1.4E+06 | 4.9E-02 | 70 | 3.8E-01 | 9.7E-02 | 4.5E+02 | 4 | 5 |
| 202 | 4.3E+03 | 0.92 | 1 .4E+06 | 4.8E-02 | 70 | 3.6E-01 | 9.0E-02 | 4.4E+02 | 4 | 5 |
| 212 | 4.3E+03 | 0.92 | 1.5E+06 | 4.6E-02 | 70 | 3.3E-01 | 8.5E-02 | 4.3E+02 | 4 | 5 |
| 222 | 4.2E+03 | 0.92 | 1 .5E+06 | 4.5E-02 | 70 | 3.1E-01 | 7.9E-02 | 4.2E+02 | 4 | 5 |
| 232 | 4.2E+03 | 0.92 | 1.5E+06 | 4.4E-02 | 70 | 2.9E-01 | 7.5E-02 | 4.1E+02 | 4 | 5 |

output in Table 17 is essentially a condensed, self-contained, version of the calculated results in Table 16.

Table 18 presents the results of the calculations of the input parameters for the Mackay evaporation equation

$$\frac{dF}{d\Theta} = \frac{V_{\ell}}{RT} \exp \left[\frac{\Delta Hv}{R} \left( \frac{1}{T_b} - \frac{1}{T_1} \right)\right]$$

which is described in detail in Mackay (1982). The constraints required as input to the Mackay model are calculated, if requested> using the TBP data which are input to the ocean-ice oil-weathering code.

Page 75 represents the beginning of the results of a one-plate batch distillation of Prudhoe Bay crude oil. The results of this distillation are data for fraction distilled vs. temperature as presented on page 81. A linear correlation of these data plus values for bulk oil density, bulk molar volume, and mean Trouton's Rule constant are all combined to give the final Mackay evaporation model equation (all on page 81).

## COMPUTER INSTALLATION/ACCESS

Currently the ocean-ice oil-weathering code resides on a VAX 8650 computer at SAIC in San Diego, CA and has been delivered to the NOAA OCSEAP office in Anchorage. Due to frequent changes in operating commands and software upgrades, it is not practical to set up open access to the model. Interested parties can call SAIC to obtain username, password, and code execution information.

Table 18.--Illustration of Output From Ocean-Ice Oil-Weathering Code: Mackay Parameter Calculations, Beginning of One-Plate Batch Distillation Results Using TBP Data as Input.

```
**************** MACKAY PARAMETER CALCULATIONS *****************

THE MACKAY EVAPORATION MODEL IS DESCRIBED IN
(MACKAY, 1982 )
THE FOLLOWING ARE THE RESULTS OF A CALCULATION OF THE
INPUT PARAMETERS FOR THE MACKAY MODEL FOR PRUDHOE BAY, ALASKA
AT 3.200E+01 DEGREES F

SIMULATED ONE-PLATE BATCH DISTILLATION:
```

| F | TEMP(F) | Y SUM |
|---|---|---|
| 0.000E+00 | 2.918E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 2.740E+04 | 8.107E+00 | 4.128E-01 |
| 2 | 3.148E+04 | 4.589E+00 | 2.685E-01 |
| 3 | 3.907E+04 | 2.378E+00 | 1.727E-01 |
| 4 | 3.668E+04 | 1.202E+00 | 8.197E-02 |
| 5 | 3.433E+04 | 5.857E-01 | 3.736E-02 |
| 6 | 2.923E+04 | 2.710E-01 | 1.472E-02 |
| 7 | 3.304E+04 | 1.189E-01 | 7.300E-03 |
| 8 | 3.414E+04 | 4.918E-02 | 3.120E-03 |
| 9 | 3.340E+04 | 1.937E-02 | 1.202E-03 |
| 10 | 1.741E+04 | 6.130E-03 | 1.983E-04 |
| 11 | 3.576E+04 | 1.363E-03 | 9.054E-05 |
| 12 | 3.412E+04 | 2.932E-04 | 1.859E-05 |
| 13 | 2.745E+04 | 5.957E-05 | 3.039E-06 |
| 14 | 3.042E+04 | 9.128E-06 | 5.160E-07 |

| F | TEMP(F) | Y suFi |
|---|---|---|
| 2.334E-02 | 3.088E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 1.734E+04 | 9.879E+00 | 3.390E-01 |
| 2 | 2.418E+04 | 5.681E+00 | 2.687E-01 |
| 3 | 3.398E+04 | 3.002E+00 | 1.995E-01 |
| 4 | 3.414E+04 | 1.552E+00 | 1.037E-01 |
| 5 | 3.313E+04 | 7.762E-01 | 5.030E-02 |
| 6 | 2.874E+04 | 3.704E-01 | 2.082E-02 |
| 7 | 3.279E+04 | 1.680E-01 | 1.078E-02 |
| 8 | 3.403E+04 | 7.201E-02 | 4.793E-03 |
| 9 | 3.335E+04 | 2.940E-02 | 1.918E-03 |
| 10 | 1.740E+04 | 1.014E-02 | 3.449E-04 |
| 11 | 3.575E+04 | 2.381E-03 | 1.665E-04 |
| 12 | 3.412E+04 | 5.414E-04 | 3.614E-05 |
| 13 | 2.745E+04 | 1.166E-04 | 6.264E-06 |
| 14 | 3.042E+04 | 1.919E-05 | 1.142E-06 |

| F | TEMP(F J | Y SUM |
|---|---|---|
| 4.734E-02 | 3.295E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 9.992E+03 | 1.240E+01 | 2.539E-01 |

Table 18.--Mackay Parameter Calculations (Continued): One-Plate Batch Distillation Results.

| | | | |
|---|---|---|---|
| 2 | 1.703E+04 | 7.262E+00 | 2.554E-01 |
| 3 | 2.807E+04 | 3.921E+00 | 2.272E-01 |
| 4 | 3.087E+04 | 2.080E+00 | 1.325E-01 |
| 5 | 3.147E+04 | 1.071E+00 | 6.956E-02 |
| 6 | 2.803E+04 | 5.287E-01 | 3.060E-02 |
| 7 | 3.241E+04 | 2.490E-01 | 1.666E-02 |
| 8 | 3.385E+04 | 1.111E-01 | 7.769E-03 |
| 9 | 3.328E+04 | 4.730E-02 | 3.250E-03 |
| 10 | 1.738E+04 | 1.740E-02 | 6.245E-04 |
| 11 | 3.575E+04 | 4.511E-03 | 3.329E-04 |
| 12 | 3.412E+04 | 1.093E-03 | 7.698E-05 |
| 13 | 2.745E+04 | 2.517E-04 | 1.427E-05 |
| 14 | 3.042E+04 | 4.492E-05 | 2.821E-06 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 7.226E-02 | 3.538E+02 | 1.000E+00 |

| 1 | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 5.011E+03 | 1.597E+01 | 1.750E-01 |
| 2 | 1.058E+04 | 9.536E+00 | 2.206E-01 |
| 3 | 2.139E+04 | 5.272E+00 | 2.465E-01 |
| 4 | 2.662E+04 | 2.872E+00 | 1.672E-01 |
| 5 | 2.910E+04 | 1.526E+00 | 9.706E-02 |
| 6 | 2.694E+04 | 7.816E-01 | 4.603E-02 |
| 7 | 3.179E+04 | 3.831E-01 | 2.663E-02 |
| 8 | 3.355E+04 | 1.787E-01 | 1.311E-02 |
| 9 | 3.315E+04 | 7.964E-02 | 5.772E-03 |
| 10 | 1.736E+04 | 3.089E-02 | 1.172E-03 |
| 11 | 3.573E+04 | 9.123E-03 | 7.127E-04 |
| 12 | 3.411E+04 | 2.370E-03 | 1.768E-04 |
| 13 | 2.745E+04 | 5.878E-04 | 3.528E-05 |
| 14 | 3.042E+04 | 1.148E-04 | 7.632E-06 |

| F | TEMP(F) | Y sum |
|---|---|---|
| 9.848E-02 | 3.807E+02 | 1.000E+00 |

| 1 | MOLES I | VP([) | Y(I) |
|---|---|---|---|
| 1 | 2.442E+03 | 2.079E+01 | 1.179E-01 |
| 2 | 5.586E+03 | 1.266E+01 | 1.643E-01 |
| 3 | 1.439E+04 | 7.173E+00 | 2.398E-01 |
| 4 | 2.125E+04 | 4.016E+00 | 1.983E-01 |
| 5 | 2.573E+04 | 2.200E+00 | 1.315E-01 |
| 6 | 2.324E+04 | 1.169E+00 | 6.856E-02 |
| 7 | 3.076E+04 | 5.966E-01 | 4.263E-02 |
| 8 | 3.302E+04 | 2.911E-01 | 2.233E-02 |
| 9 | 3.290E+04 | 1.359E-01 | 1.039E-02 |
| 10 | 1.731E+04 | 5.573E-02 | 2.240E-03 |
| 11 | 3.570E+04 | 1.818E-02 | 1.507E-03 |
| 12 | 3.410E+04 | 5.275E-03 | 4.179E-04 |
| 13 | 2.745E+04 | 1.412E-03 | 9.005E-05 |
| 14 | 3.042E+04 | 3.025E-04 | 2.138E-05 |

| F | TEMP(F) | Y sun |
|---|---|---|
| 1.261E-01 | 4.117E+02 | 1.000E+00 |

Table 18.--Mackay Parameter Calculations (Continued): One-plate Batch Distillation Results.

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 8.534E+02 | 2.739E+01 | 5.848E-02 |
| 2 | 2.646E+03 | 1.710E+01 | 1.126E-01 |
| 3 | 8.239E+03 | 9.980E+00 | 2.042E-01 |
| 4 | 1.520E+04 | 5.748E+00 | 2.165E-01 |
| 5 | 2.127E+04 | 3.232E+00 | 1.713E-01 |
| 6 | 2.273E+04 | 1.795E+00 | 1.011E-01 |
| 7 | 2.910E+04 | 9.540E-01 | 6.879E-02 |
| 8 | 3.211E+04 | 4.873E-01 | 3.877E-02 |
| 9 | 3.246E+04 | 2.389E-01 | 1.922E-02 |
| 10 | 1.720E+04 | 1.039E-01 | 4.429E-03 |
| 11 | 3.562E+04 | 3.660E-02 | 3.231E-03 |
| 12 | 3.408E+04 | 1.235E-02 | 1.043E-03 |
| 13 | 2.744E+04 | 3.588E-03 | 2.440E-04 |
| 14 | 3.042E+04 | 8.484E-04 | 6.394E-05 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 1.556E-01 | 4.437E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 6.865E+01 | 3.680E+01 | 6.706E-03 |
| 2 | 1.131E+03 | 2.341E+01 | 7.031E-02 |
| 3 | 4.014E+03 | 1.396E+01 | 1.487E-01 |
| 4 | 9.233E+03 | 8.271E+00 | 2.032E-01 |
| 5 | 1.579E+04 | 4.827E+00 | 2.024E-01 |
| 6 | 1.917E+04 | 2.764E+00 | 1.407E-01 |
| 7 | 2.630E+04 | 1.528E+00 | 1.075E-01 |
| 8 | 3.036E+04 | 8.162E-01 | 6.621E-02 |
| 9 | 3.165E+04 | 4.197E-01 | 3.527E-02 |
| 10 | 1.701E+04 | 1.934E-01 | 8.734E-03 |
| 11 | 3.547E+04 | 7.364E-02 | 6.934E-03 |
| 12 | 3.403E+04 | 2.687E-02 | 2.427E-03 |
| 13 | 2.743E+04 | 9.139E-03 | 6.669E-04 |
| 14 | 3.041E+04 | 2.392E-03 | 1.931E-04 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 1.874E-01 | 4.794E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(1) |
|---|---|---|---|
| 1 | 0.000E+00 | 4.794E+01 | 0.000E+00 |
| 2 | 1.833E+02 | 3.112E+01 | 1.648E-02 |
| 3 | 2.003E+03 | 1.899E+01 | 1.088E-01 |
| 4 | 4.648E+03 | 1.135E+01 | 1.334E-01 |
| 5 | 9.969E+03 | 6.931E+00 | 1.975E-01 |
| 6 | 1.432E+04 | 4.099E+00 | 1.702E-01 |
| 7 | 2.261E+04 | 2.347E+00 | 1.517E-01 |
| 8 | 2.799E+04 | 1.303E+00 | 1.042E-01 |
| 9 | 3.020E+04 | 6.983E-01 | 6.029E-02 |
| 10 | 1.663E+04 | 3.388E-01 | 1.610E-02 |
| 11 | 3.314E+04 | 1.383E-01 | 1.389E-02 |
| 12 | 3.391E+04 | 5.412E-02 | 5.245E-03 |
| 13 | 2.739E+04 | 2.041E-02 | 1.598E-03 |
| 14 | 3.040E+04 | 6.125E-03 | 5.323E-04 |

| F | TEMP(F) | Y SUM |
|---|---|---|

Table 18.--Mackay Parameter Calculations (Continued): One-Plate Batch Distillation Results.

| | | |
|---|---|---|
| 2.213E-01 | 5.145E+02 | 1.000E+00 |

| I | MOLES [ | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 6.194E+01 | 0.000E+00 |
| 2 | 0.000E+00 | 4.100E+01 | 0.000E+00 |
| 3 | 5.399E+02 | 2.560E+01 | 4.280E-02 |
| 4 | 2.206E+03 | 1.595E+01 | 1.089E-01 |
| 5 | 5.207E+03 | 9.833E+00 | 1.586E-01 |
| 6 | 9.468E+03 | 5.995E+00 | 1.758E-01 |
| 7 | 1.749E+04 | 3.545E+00 | 1.920E-01 |
| 8 | 2.416E+04 | 2.039E+00 | 1.526E-01 |
| 9 | 2.784E+04 | 1.136E+00 | 9.791E-02 |
| 10 | 1.596E+04 | 5.778E-01 | 2.855E-02 |
| 11 | 3.433E+04 | 2.518E-01 | 2.692E-02 |
| 12 | 3.366E+04 | 1.053E-01 | 1.098E-02 |
| 13 | 2.731E+04 | 4.260E-02 | 3.603E-03 |
| 14 | 3.037E+04 | 1.482E-02 | 1.394E-03 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 2.577E-01 | 5.506E+02 | 1.000E+00 |

| I | MOLES I | VP([) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 7.918E+01 | 0.000E+00 |
| 2 | 0.000E+00 | 5.340E+01 | 0.000E+00 |
| 3 | 0.000E+00 | 3.407E+01 | 0.000E+00 |
| 4 | 7.403E+02 | 2.173E+01 | 5.433E-02 |
| 5 | 2.436E+03 | 1.374E+01 | 1.131E-01 |
| 6 | 5.072E+03 | 8.622E+00 | 1.477E-01 |
| 7 | 1.167E+04 | 5.252E+00 | 2.070E-01 |
| 8 | 1.894E+04 | 3.123E+00 | 1.998E-01 |
| 9 | 2.421E+04 | 1.801E+00 | 1.472E-01 |
| 10 | 1.482E+04 | 9.564E-01 | 4.789E-02 |
| 11 | 3.338E+04 | 4.428E-01 | 4.992E-02 |
| 12 | 3.316E+04 | 1.970E-01 | 2.207E-02 |
| 13 | 2.714E+04 | 8.512E-02 | 7.802E-03 |
| 14 | 3.030E+04 | 3.202E-02 | 3.277E-03 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 2.967E-01 | 5.878E+02 | 1.000E+00 |

| I | MOLES I | VP([) | Y(I) |
|---|---|---|---|
| 1 | e.000E+00 | 1.001E+02 | 0.000E+00 |
| 2 | 0.000E+00 | 6.873E+01 | e.000E+00 |
| 3 | 0.000E+00 | 4.476E+01 | 0.000E+00 |
| 4 | 9.394E+00 | 2.920E+01 | 1.019E-03 |
| s | 9.150E+02 | 1.891E+01 | 6.429E-02 |
| 6 | 2.359E+03 | 1.219E+01 | 1.069E-01 |
| 7 | 6.341E+03 | 7.637E+00 | 1.799E-01 |
| a | 1.276E+04 | 4.681E+00 | 2.219E-01 |
| 9 | 1.910E+04 | 2.786E+00 | 1.977E-01 |
| 10 | 1.301E+04 | 1.539E+00 | 7.443E-02 |
| 11 | 3.134E+04 | 7.532E-01 | 8.770E-02 |
| 12 | 3.220E+04 | 3.542E-01 | 4.245E-02 |
| 13 | 2.678E+04 | 1.630E-01 | 1.621E-02 |
| 14 | 3.013E+04 | 6.601E-02 | 7.391E-03 |

Table 18.--Mackay Parameter Calculations (Continued): One-plate Batch Distillation Results.

| F | TEMP(F) | Y SUM |
|---|---|---|
| 3.386E-01 | 6.266E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 1.257E+02 | 0.000E+00 |
| 2 | 0.000E+00 | 8.782E+01 | 0.000E+00 |
| 3 | 0.000E+00 | 5.836E+01 | 0.000E+00 |
| 4 | 0.000E+00 | 3.890E+01 | 0.000E+00 |
| 5 | 5.004E+01 | 2.579E+01 | 5.327E-03 |
| 6 | 9.216E+02 | 1.707E+01 | 6.492E-02 |
| 7 | 2.921E+03 | 1.098E+01 | 1.324E-01 |
| 8 | 6.901E+03 | 6.925E+00 | 1.973E-01 |
| 9 | 1.284E+04 | 4.246E+00 | 2.250E-01 |
| 10 | 1.035E+04 | 2.433E+00 | 1.039E-01 |
| 11 | 2.787E+04 | 1.254E+00 | 1.443E-01 |
| 12 | 3.039E+04 | 6.230E-01 | 7.816E-02 |
| 13 | 2.604E+04 | 3.031E-01 | 3.258E-02 |
| 14 | 2.977E+04 | 1.317E-01 | 1.618E-02 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 3.839E-01 | 6.670E+02 | 1.000E+00 |

| I | MOLES 1 | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 1.567E+02 | 0.000E+00 |
| 2 | 0.000E+00 | 1.113E+02 | 0.000E+00 |
| 3 | 0.000E+00 | 7.540E+01 | 0.000E+00 |
| 4 | 0.000E+00 | 5.132E+01 | 0.000E+00 |
| 5 | 0.000E+00 | 3.480E+01 | 0.000E+00 |
| 6 | 4.814E+01 | 2.361E+01 | 5.278E-03 |
| 7 | 1.140E+03 | 1.558E+01 | 8.248E-02 |
| 8 | 3.129E+03 | 1.010E+01 | 1.467E-01 |
| 9 | 6.783E+03 | 6.369E+00 | 2.006E-01 |
| 10 | 6.931E+03 | 3.776E+00 | 1.215E-01 |
| 11 | 2.241E+04 | 2.042E+00 | 2.125E-01 |
| 12 | 2.714E+04 | 1.066E+00 | 1.343E-01 |
| 13 | 2.458E+04 | 5.470E-01 | 6.244E-02 |
| 14 | 2.900E+04 | 2.538E-01 | 3.417E-02 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 4.328E-01 | 7.083E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 1.933E+02 | 0.000E+00 |
| 2 | 0.000E+00 | 1.395E+02 | 0.000E+00 |
| 3 | 0.000E+00 | 9.629E+01 | 0.000E+00 |
| 4 | 0.000E+00 | 6.686E+01 | 0.000E+00 |
| 5 | 0.000E+00 | 4.632E+01 | 0.000E+00 |
| 6 | 0.000E+00 | 3.219E+01 | 0.000E+00 |
| 7 | 3.032E+01 | 2.176E+01 | 3.501E-03 |
| 8 | 1.135E+03 | 1.447E+01 | 8.868E-02 |
| 9 | 3.056E+03 | 9.367E+00 | 1.519E-01 |
| 10 | 3.617E+03 | 5.732E+00 | 1.100E-01 |
| 11 | 1.517E+04 | 3.240E+00 | 2.608E-01 |
| 12 | 2.192E+04 | 1.770E+00 | 2.058E-01 |

Table 18.--Mackay Parameter Calculations (Continued): End of One-plate Batch Distillation, Heat of Vaporization and Trouton's Rule Calculations.

| | | | |
|---|---|---|---|
| 13 | 2.192E+04 | 9.541E-01 | 1.110E-01 |
| 14 | 2.742E+04 | 4.705E-01 | 6.843E-02 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 4.853E-01 | 7.524E+02 | 1.000E+00 |

| I | MOLES I | VP( I ) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 2.380E+02 | 0.000E+00 |
| 2 | 0.000E+00 | 1.745E+02 | 0.000E+00 |
| 3 | 0.000E+00 | 1.227E+02 | 0.000E+00 |
| 4 | 0.000E+00 | 8.688E+01 | 0.000E+00 |
| 5 | 0.000E+00 | 6.147E+01 | 0.000E+00 |
| 6 | 0.000E+00 | 4.374E+01 | 0.000E+00 |
| 7 | 0.000E+00 | 3.029E+01 | 0.000E+00 |
| 8 | 0.000E+00 | 2.066E+01 | 0.000E+00 |
| 9 | 1.013E+03 | 1.372E+01 | 8.594E-02 |
| 10 | 1.631E+03 | 8.654E+00 | 8.730E-02 |
| 11 | 7.922E+03 | 5.107E+00 | 2.503E-01 |
| 12 | 1.483E+04 | 2.913E+00 | 2.672E-01 |
| 13 | 1.758E+04 | 1.646E+00 | 1.790E-01 |
| 14 | 2.446E+04 | 8.604E-01 | 1.302E-01 |

| F | TEMP(F) | Y SUM |
|---|---|---|
| 5.413E-01 | 8.052E+02 | 1.000E+00 |

| I | MOLES I | VP(I) | Y(I) |
|---|---|---|---|
| 1 | 0.000E+00 | 2.995E+02 | 0.000E+00 |
| 2 | 0.000E+00 | 2.235E+02 | 0.000E+00 |
| 3 | 0.000E+00 | 1.603E+02 | 0.000E+00 |
| 4 | 0.000E+00 | 1.161E+02 | 0.000E+00 |
| 5 | 0.000E+00 | 8.406E+01 | 0.000E+00 |
| 6 | 0.000E+00 | 6.140E+01 | 0.000E+00 |
| 7 | 0.000E+00 | 4.365E+01 | 0.000E+00 |
| 8 | 0.000E+00 | 3.062E+01 | 0.000E+00 |
| 9 | 0.000E+00 | 2.091E+01 | 0.000E+00 |
| 10 | 4.561E+02 | 1.364E+01 | 4.612E-02 |
| 11 | 3.467E+03 | 8.433E+00 | 2.168E-01 |
| 12 | 7.013E+03 | 5.038E+00 | 2.620E-01 |
| 13 | 1.094E+04 | 2.995E+00 | 2.429E-01 |
| 14 | 1.880E+04 | 1.666E+00 | 2.322E-01 |

| | DELTAH | DELTAH/TB |
|---|---|---|
| 1 | 1.203E+04 | 1.976E+01 |
| 2 | 1.324E+04 | 2.040E+01 |
| 3 | 1.448E+04 | 2.086E+01 |
| 4 | 1.564E+04 | 2.117E+01 |
| 5 | 1.678E+04 | 2.141E+01 |
| 6 | 1.791E+04 | 2.160E+01 |
| 7 | 1.904E+04 | 2.179E+01 |
| 8 | 2.019E+04 | 2.197E+01 |
| 9 | 2.098E+04 | 2.176E+01 |

WHERE:
DELTAH IS THE ENTHALPY OF VAPORIZATION IN BTU/LBMOLE
DELTAH/TB IS TEE TROUTONS RULE CONSTANT IN BTU/LBMOLE*DEG R

Table 18.--Mackay Parameter Calculations (Continued): Distillation Curve Correlation, Bulk Oil Properties, Final Mackay Evaporation Equation.

```
LEAST SQUARES OF B.P.VS. FRACTION EVAPORATED:

   SLOPE:   9.690E+02 DEG R/FRACTION EVAPORATED
   INITIAL B.P.:   2.912E+02 DEG F
   CORRELATION COEFFICIENT:   9.991E-01

BULK OIL DENSITY:  8.820E-01 GRAMS/CC
BULK MOLAR VOLUME OF OIL:  2.940E+02 CC/MOLE
MEAN TROUTONS RULE CONSTANT:  2.119E+01 BTU/LBMOLE*DEG R

AFTER SIMPLIFICATION AND COMBINING TERMS, THE
MACKAY EVAPORATION MODEL BECOMES:

DELTA-F = DELTA-THETA * EXP(  6.400E+00 -  2.324E-02 ( 7.502E+02  +  9.690E+02(F))

     OR

DELTA-F = DELTA-THETA  *  EXP( -1.103E+01 - 2.251E+01(F))
```

REFERENCES


API. 1965. 108 Technical Data Book--Petroleum Refining. American Petroleum Institute, Washington, D.C.

ASTM . 1977. Method D2892-73: Standard Test Method for Distillation of Crude Petroleum (150 Theoretical Plate Column, American Society for Testing and Materials, Philadelphia, PA.)

Coleman, H. J., E. M. Shelton, D. T. Nichols, and C. J. Thompson. 1978. Analyses of 800 Crude Oils from United States Oil Fields, BETC/RI-78/14, Bartlesville Energy Technology Center, Department of Energy, Bartlesville, Oklahoma.

Edmister, W. C., and K. K. Okamoto. 1959. Applied hydrocarbon thermodynamics part 13: equilibrium flash vaporizations correlations for petroleum fractions. Petroleum Refiner. 38:117-129.

Elliot, A. J. 1966. Shear diffusion and the spread of oil in the surface layers of the North Sea. Dtsch. Hydrogr. Z. 39, H.3.

Garratt, J. R. 1977. Review of drag coefficients over oceans and continents. Monthly Weather Rev. 105:915-929.

Gold, P. I., and G. Olge. 1969. Estimating thermophysical properties of liquids, part 10: viscosity. Chemical Engineering, July 14.

Hougen, O. A., K. M. Watson, and R. A. Ragatz. 1965. Chemical Process Principles. Part 1. Material and Energy Balances, 2nd edition. John Wiley & Sons, Inc.

Liss, P. S., and P. G. Slater. 1974. Flux of gases across the air-sea interface. Nature 247:181-184.

Mackay, D., and R. S. Matsugu. 1973. Evaporation rates of liquid hydrocarbon spills on land and water. Can. J. Chemical Engineering 51:434-439.

Mackay, D., I. Buist, R. Mascarenhas, and S. Paterson. 1980. Oil Spill Processes and Models. Research and Development Division, Environmental Emergency Branch, Environmental Impact Control Directorate, Environmental Protective Service, Environment Canada, Ottawa, Ontario, KIA 1C8.

Mackay, D., W. Y. Shiv, K. Hossain, W. Stiver, D. McCurdy, S. Patterson, and P. Tebeau. 1982. Development and Calibration of an Oil Spill Behavior Model. Unpublished report, Department of Chemical Engineering and Applied Science, University of Toronto.

Mackay, D., W. Stiver, and P. Tebeau. 1983. Testing of crude oils and petroleum productions for environmental purposes. In: Proceedings of the 1983 Oil Spill Conference. American Petroleum Institute, Washington, D.C.

Mooney, M. 1951. The viscosity of a concentrated suspension of spherical particles. J. Colloid Sci. 10:162-170.

Murray, D. A. J., W. L. Lockhart, and G. R. B. Webster. 1984. Oil and Petrochemical Pollution 2(1):39.

O&GJ . 1973. Evaluations of World's important crudes. Oil and Gas Journal, Petroleum Publishing Co., Tulsa, Oklahoma.

Payne, J. R., B. E. Kirstein, G. D. McNabb, Jr., J. L. Lambach, C, de Oliveira, R. E. Jordan, and W. Horn. 1983. Multivariate analysis of petroleum hydrocarbon weathering in the subarctic-marine environment. Pages 423-434 in Proceedings of the 1983 Oil Spill Conference. American Petroleum Institute, Washington, D.C.

Payne, J. R. , B. E. Kirstein, G. D. McNabb, Jr., J. L. Lambach, R. Redding, R. E. Jordan, W. Horn, C. De Oliveira, G. S. Smith, D. M. Baxter, and R. Geagel. 1984a. Multivariate analysis of petroleum in the marine environment--Subarctic. U.S. Dep. Comber. , NOAA, OCSEAP Final Rep. 21 and 22.

Payne, J. R., J. R. Clayton, Jr., G. D. McNabb, Jr., C. R. Phillips, L. E. Hachmeister, B. E. Kirstein, R. T. Redding, C. C. Clay, G. S. Smith, and G. H. Farmer. 1987. Development of a predictive model for the weathering of oil in the presence of sea ice. U.S. Dep. Comber. , NOAA, OCSEAP Final Rep. 58:147-465.

Reid, R. C., J. M. Pransintz, and T. K. Sherwood. 1977. The Properties of Gases and Liquids, 3rd edition. McGraw-Hill.

Tebeau, P. A., D. Mackay, W. R. Shin, W. Stiver, K. Hossain, D. McCurdy, and S. Paterson. 1982. Oil Weathering Under Arctic Conditions. Department of Chemical Engineering and Applied Sciences, University of Toronto, Toronto, Canada.

Treybal, R. E. 1955. Mass Transfer. McGraw-Hill.

Van Winkle, M. 1967. Distillation. McGraw-Hill.

# APPENDIX

## CODE LISTING FOR OCEAN-ICE OIL-WEATHERING MODEL

```
C       ***** OILICE.FOR *****
      INCLUDE 'VARI.FOR'
C
C       THIS IS THE OPEN-OCEAN OIL-WEATHERING CODE AND
C       THE OIL PHASE IS CONSIDERED WELL-STIRRED ALL THE
C       TIME.
C
C       THIS CODE ALSO ALLOWS FOR WEATHERING IN THE PRESENCE OF
C       SEA ICE.
C
C       ANOTHER OPTION AVAILABLE IN THIS CODE IS THE CALCULATION
C       OF THE INPUT PARAMETERS FOR THE MACKAY EVAPORATION
C       MODEL.
C
C       AUGUST, 1986
C
C       GET YOUR OUTPUT FROM OILICE.OUT/FILE:FORTRAN
C       THE PLOT FILE IS OILICE.PLT
C       THE TYPE FILE IS OILICE.TYP/FILE:FORTRAN
C       THE MACKAY CONSTANTS GO INTO MACKAY.DAT
C
      DIMENSION FMF(30)
      DATA (ANAMEL(1,J),J=1,5)/'PRUDH','OE BA','Y, AL','ASKA '
     1,'     '/
      DATA (ANAMEL(2,J),J=1,5)/'COOK ','INLET',', ALA','SKA  '
     1,'     '/
      DATA (ANAMEL(3,J),J=1,5)/'WILMI','NGTON',', CAL','IFORN'
     1,'IA   '/
      DATA (ANAMEL(4,J),J=1,5)/'MURBA','N, AB','U DHA','BI   '
     1,'     '/
      DATA (ANAMEL(5,J),J=1,5)/'LAKE ','CHICO','T, LO','UISIA'
     1,'NA   '/
      DATA (ANAMEL(6,J),J=1,5)/'LIGHT',' DIES','EL CU','T    ',
     1'     '/
      DATA APIBL/27.,35.4,19.4,40.5,54.7,38.9/
      DATA ITEML/9,7,94,99999,221,1/
      DATA ISAMPL/71011,72025,71052,99999,54062,2/
      DATA NCTS/15,16,13,16,16,11/
C
C       FOR CRUDE OIL THE RESIDUUM CUT IS ASSIGNED A NORMAL
C       BOILING POINT OF .
C
      DATA (TBL(1,J),J=1,30)/150.,190.,235.,280.,325.,370.
     1,415.,460.,505.,554.,609.,662.,712.,764.,850.,15*0./
      DATA (TBL(2,J),J=1,20)/110.,145.,190.,235.,280.,325.
     1,370.,415.,460.,505.,554.,609.,662.,712.,764.,850.
     2,4*0./
      DATA (TBL(3,J),J=1,20)/195.,235.,280.,325.,370.,415.
     1,460.,505.,554.,609.,662.,712.,850.,7*0./
      DATA (TBL(4,J),J=1,20)/110.,145.,190.,235.,280.,325.
     1,370.,415.,460.,505.,554.,609.,662.,712.,764.,850.
     2,4*0./
      DATA (TBL(5,J),J=1,20)/110.,145.,190.,235.,280.,325.
     1,370.,415.,460.,505.,554.,609.,662.,712.,764.,850.
     2,4*0./
      DATA (TBL(6,J),J=1,11)/313.,342.,366.,395.,415.,438.,461.
     1,479.,501.,518.,538./
      DATA (APIL(1,J),J=1,30)/72.7,64.2,56.7,51.6,47.6,45.2
     1,41.5,37.8,34.8,30.6,29.1,26.2,24.,22.5,11.4,15*0./
      DATA (APIL(2,J),J=1,20)/89.2,77.2,65.,59.5,55.4,50.8
```

```
 6100          1,46.5,43.,39.6,37.,32.8,31.3,28.7,26.6,25.,11.6,4*0./
 6200           DATA (APIL(3,J),J=1,20)/68.6,58.7,53.,48.1,43.2,38.8
 6300          1,35.4,32.3,26.8,24.5,22.3,20.3,8.9,7*0./
 6400           DATA (APIL(4,J),J=1,20)/96.7,86.2,70.6,62.3,55.7,51.6
 6500          1,48.5,45.6,43.,40.,35.8,34.,30.,28.4,26.6,16.7,4*0./
 6600           DATA (APIL(5,J),J=1,20)/92.4,81.,68.9,62.1,57.2,52.5
 6700          1,48.8,45.2,41.7,38.2,34.4,33.2,30.6,28.9,26.1,18.1,4*0./
 6800           DATA (APIL(6,J),J=1,11)/49.6,47.3,46.,44.,38.6,38.8,37.2
 6900          1,35.4,33.9,33.1,32.2/
 7000           DATA (VOLL(1,J),J=1,30)/2.1,2.6,3.5,3.6,3.7,3.5,4.3,4.8
 7100          1,5.,2.8,6.5,6.8,6.0,7.4,36.3,15*0./
 7200           DATA (VOLL(2,J),J=1,20)/2.4,2.5,5.9,6.1,5.1,5.2,4.9
 7300          1,5.1,5.2,5.,3.3,5.2,7.,4.2,4.2,25.6,4*0./
 7400           DATA (VOLL(3,J),J=1,20)/2.3,2.4,2.4,2.5,2.8,3.6,4.4
 7500          1,5.3,4.7,6.3,4.1,5.5,53.3,7*0./
 7600           DATA (VOLL(4,J),J=1,20)/1.7,2.9,4.9,6.,6.8,6.5,5.7
 7700          1,5.6,6.,4.9,5.7,5.6,6.5,6.,5.6,19.3,4*0./
 7800           DATA (VOLL(5,J),J=1,20)/7.5,8.2,9.7,11.,9.1,8.3,7.2
 7900          1,7.2,7.4,6.9,3.5,3.,1.6,1.4,1.9,2.,4*0./
 8000           DATA (VOLL(6,J),J=1,11)/4.78,9.57,9.09,9.57,9.57,9.57
 8100          1,9.57,9.57,9.57,9.57,9.57/
 8200    C
 8300    C        C1L, C2L, AND C4L ARE THE MOUSSE FORMATION CONSTANTS.
 8400    C        C1L IS THE VISCOSITY CONSTANT.
 8500    C        C2L IS THE INVERSE OF THE MAXIMUM WATER IN OIL WEIGHT
 8600    C        FRACTION.  C4L IS THE WATER INCORPORATION RATE.
 8700    C
 8800           DATA C1L/0.62,0.62,0.63,0.64,0.65,0.65/
 8900           DATA C2L/1.42,3.33,1.43,5.,-1.,-1./
 9000           DATA C4L/0.001,0.001,0.01,0.001,0.,0./
 9100    C
 9200    C        FOR THE DISPERSION PROCESS, KA IS THE CONSTANT IN THE
 9300    C        SEA SURFACE DISPERSION EQUATION, KB IS THE CONSTANT IN
 9400    C        THE DROPLET FRACTION EQUATION.  STENL(6) IS THE LIBRARY
 9500    C        OIL-WATER SURFACE TENSION IN DYNES/CM.
 9600    C
 9700           DATA KA,KB,STENL/0.108,50.,30.,30.,30.,30.,30.,30./
 9800           DATA VISZL/35.,35.,195.,15.,13.5,11.5/
 9900           DATA MK3L/9000.,9000.,9000.,9000.,9000.,3000./
10000           DATA MK4L/10.5,7.4,15.3,10.5,2.,2./
10100           OPEN(UNIT=32,file='OILICE.OUT',status='new')
10200
10300           OPEN(UNIT=34,file='OILICE.PLT',status='new')
10400           OPEN(UNIT=35,file='OILICE.TYP',status='new')
10500           IOU=32
10600           IPU=34
10700           ITY=35
10800    C
10900    C        FILL IN SOME LIBRARY IDENTIFICATIONS.
11000    C
11100    10     TYPE 20
11200    20     FORMAT(1X,'ENTER THE NUMBER OF TBP CUTS TO BE CHARACTERIZED
11300          1 ON I2')
11400           TYPE 30
11500    30     FORMAT(1X,'IF YOU HAVE NO INPUT DATA JUST ENTER 99')
11600           TYPE 40
11700    40     FORMAT(1X,'A 99 ENTRY WILL USE A LIBRARY EXAMPLE')
11800           ICODE=1
11900           ACCEPT 50, NCUTS
12000    50     FORMAT(I2)
```

```
12100          LSWTCH=NCUTS
12200    C
12300    C       LSWTCH=99 IS USED TO INDICATE THAT A LIBRARY CRUDE WAS
12400    C       CHOSEN.
12500    C
12600          IF(NCUTS.NE.99) GO TO 120
12700    C
12800    C       USING A LIBRARY CRUDE.
12900    C
13000          IFLE=2
13100          TYPE 60
13200    60    FORMAT(1X,'CHOOSE A CRUDE ACCORDING TO:')
13300          DO 80 I=1,6
13400          TYPE 70, I,(ANAMEL(I,J),J=1,5)
13500    70    FORMAT(1X,I1,' = ',5A5)
13600    80    CONTINUE
13700          ACCEPT 90, IC
13800    90    FORMAT(I1)
13900          APIB=APIBL(IC)
14000          ITEM=ITEML(IC)
14100          ISAMP=ISAMPL(IC)
14200          NCUTS=NCTS(IC)
14300          ICODE=2
14400          DO 100 J=1,5
14500          ANAME(J)=ANAMEL(IC,J)
14600    100   CONTINUE
14700          TYPE 110, (ANAME(J),J=1,5)
14800    110   FORMAT(/,1X,'YOU CHOSE: ',5A5)
14900          GO TO 250
15000    C
15100    C       USER IS ENTERING THE CRUDE DATA OR READING HIS OWN FILE
15200    C
15300    120   TYPE 130
15400    130   FORMAT(1X,'IS THE CRUDE ON A FILE ?')
15500          IFLE=1
15600          ACCEPT 140, ANS
15700    140   FORMAT(A1)
15800          IF(ANS.EQ.'N') GO TO 170
15900          TYPE 150
16000    150   FORMAT(1X,'WHAT IS THE FILE NAME?')
16050          ACCEPT 151,FNAME
16075    151   FORMAT(A10)
16100          OPEN(UNIT=36, file=FNAME,STATUS='OLD')
16200          IFLE=2
16300          READ (36,550) (ANAME(J),J=1,5)
16400          READ (36,560) ITEM,ISAMP,NCUTS
16500          READ (36,570) APIB
16600          DO 160 J=1,NCUTS
16700          READ (36,580) TB(J),API(J),VOL(J)
16800    160   CONTINUE
16900          GO TO 330
17000    C
17100    170   TYPE 180
17200    180   FORMAT(1X,'ENTER THE NAME OF THE CRUDE')
17300          ACCEPT 190, (ANAME(I),I=1,5)
17400    190   FORMAT(10A5)
17500          TYPE 200
17600    200   FORMAT(1X,'ENTER AN IDENTIFICATION NUMBER FOR
17700         1 THIS CRUDE ON I5')
17800          ACCEPT 210, ITEM
```

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17900   210   FORMAT(I5)
18000         TYPE 220
18100   220   FORMAT(1X,'ENTER A SAMPLE NUMBER ON I5')
18200         ACCEPT 210, ISAMP
18300         TYPE 230
18400   230   FORMAT(1X,'ENTER THE BULK API GRAVITY')
18500         ACCEPT 280, APIB
18600         TYPE 240
18700   240   FORMAT(/,1X,'YOU MUST ENTER THE TRUE BOILING POINT
18800        1 CUT DATA STARTING',/,1X,'WITH THE MOST VOLATILE CUT
18900        2 AND GOING TO THE BOTTOM OF THE BARREL',/)
19000   C
19100   C       CALCULATE THE BULK DENSITY OF THE CRUDE AT 60/60.
19200   C
19300   250   DCRUDE=141.5/(APIB+131.5)
19400         DCRUDE=0.983*DCRUDE
19500   C
19600   C       TRANSFER CRUDE INPUT DATA TO THE VARIABLES USED IN
19700   C       THE CALCULATIONS.
19800   C
19900         DO 320 I=1,NCUTS
20000         GO TO (260,310), ICODE
20100   260   TYPE 270, I
20200   C
20300   C       ENTER THE CRUDE CUT DATA.
20400   C
20500   270   FORMAT(1X,'ENTER THE BOILING POINT AT 1 ATM IN DEG F
20600        1 FOR CUT',I3)
20700         ACCEPT 280, TB(I)
20800   280   FORMAT(F10.0)
20900         TYPE 290, I
21000   290   FORMAT(1X,'ENTER API GRAVITY FOR CUT',I3)
21100         ACCEPT 280, API(I)
21200         TYPE 300, I
21300   300   FORMAT(1X,'ENTER VOLUME PER CENT FOR CUT',I3)
21400         ACCEPT 280, VOL(I)
21500         GO TO 320
21600   C
21700   C       TRANSFER CRUDE CUT INPUT DATA FROM THE LIBRARY.
21800   C
21900   310   TB(I)=TBL(IC,I)
22000         API(I)=APIL(IC,I)
22100         VOL(I)=VOLL(IC,I)
22200   320   CONTINUE
22300   C
22400   C       DISPLAY THE CUTS BACK TO THE USER.
22500   C
22600   330   TYPE 340
22700   340   FORMAT(/,1X,'CUT',5X,'TB',10X,'API',8X,'VOL')
22800         DO 360 I=1,NCUTS
22900         TYPE 350, I,TB(I),API(I),VOL(I)
23000   350   FORMAT(1X,I2,5X,F5.1,7X,F4.1,6X,F5.1)
23100   360   CONTINUE
23200         TYPE 370
23300   370   FORMAT(1X,'DO YOU WANT TO CHANGE ANY?')
23400   380   ACCEPT 390, ANS
23500   390   FORMAT(A1)
23600         IF(ANS.EQ.'N') GO TO 470
23700   C
23800   C       ALLOW THE INPUT TO BE CHANGED.
```

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23900   C
24000          TYPE 400
24100   400    FORMAT(1X,'ENTER THE CUT NUMBER TO BE CHANGED ON I2')
24200          ACCEPT 50, N
24300          TYPE 410
24400   410    FORMAT(1X,'ENTER 1 TO CHANGE TB, 2 FOR API, 3 FOR VOL%')
24500          ACCEPT 420, IC
24600   420    FORMAT(I1)
24700          TYPE 430
24800   430    FORMAT(1X,'ENTER THE CHANGED DATA')
24900          GO TO (440,450,460), IC
25000   440    ACCEPT 280, TB(N)
25100          GO TO 330
25200   450    ACCEPT 280, API(N)
25300          GO TO 330
25400   460    ACCEPT 280, VOL(N)
25500          GO TO 330
25600   470    DO 480 I=2,NCUTS
25700          IM1=I-1
25800          IF(TB(I).LT.TB(IM1)) GO TO 490
25900   480    CONTINUE
26000          GO TO 510
26100   490    TYPE 500, I,IM1
26200   500    FORMAT(/,1X,'THE BOILING POINT OF CUT ',I2
26300         1,' IS LESS THAN CUT ',I2,/,1X,'AND THIS ORDER IS NOT
26400         2 ACCEPTABLE, SO START OVER',/)
26500          GO TO 10
26600   C
26700   C        ALWAYS RENORMALIZE THE INPUT VOLUMES TO 100%.
26800   C
26900   510    VTOTAL=0.
27000          DO 520 I=1,NCUTS
27100          VTOTAL=VTOTAL+VOL(I)
27200   520    CONTINUE
27300          DO 530 I=1,NCUTS
27400          VOL(I)=100.*VOL(I)/VTOTAL
27500   530    CONTINUE
27600   C
27700   C        IF YOU READ IT IN, DO NOT RESAVE IT
27800   C
27900          IF(IFLE.EQ.2) GO TO 590
28000          TYPE 540
28100   540    FORMAT(1X,'THIS CRUDE WILL NOW BE WRITTEN TO A FILE. WHAT
28200         1 WOULD YOU LIKE TO CALL IT?')
28250           ACCEPT 541,FNAME
28275   541    FORMAT(A10)
28300          OPEN(UNIT=38,file=FNAME,STATUS='NEW')
28400          WRITE (38,550) (ANAME(J),J=1,5)
28500   550    FORMAT(5A5)
28600          WRITE (38,560) ITEM,ISAMP,NCUTS
28700   560    FORMAT(3I5)
28800          WRITE (38,570) APIB
28900   570    FORMAT(1X,F6.1)
29000          DO 590 J=1,NCUTS
29100          WRITE (38,580) TB(J),API(J),VOL(J)
29200   580    FORMAT(3(1X,1PE10.3))
29300   590    CONTINUE
29400   C
29500   C        NOW CHARACTERIZE THE PARENT OIL
29600   C
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29700          CALL DOCHAR
29800    C
29900    C       CALCULATE THE INITIAL MASS, MOLES, DENSITY FOR EACH CUT
30000    C
30100          BBL=1000.
30200          BM=0.159*BBL
30300          TMOLES=0.
30400          DO 600 I=1,NCUTS
30500          AMASS=1582.*SPGR(I)*BBL*VOL(I)
30600          MOLES(I)=AMASS/MW(I)
30700          MOLS(I)=MOLES(I)
30800          TMOLES=TMOLES+MOLES(I)
30900          RHO(I)=100*MOLES(I)/(BM*VOL(I))
31000    600   CONTINUE
31100          WTMOLE=0.
31200          DO 610 I=1,NCUTS
31300          WTMOLE=WTMOLE+MW(I)*MOLES(I)/TMOLES
31400    610   CONTINUE
31500          TYPE 620
31600    620   FORMAT(1X,'DO YOU WANT THE MACKAY CONSTANTS?')
31700          ACCEPT 390, ANS
31800          IF(ANS.EQ.'N') GO TO 650
31900          TYPE 630
32000    630   FORMAT(1X,'AT WHAT TEMPERATURE, DEG F?')
32100          ACCEPT 280,TE
32200          TE=TE+459.
32300          CALL VPIF(TE,NC1)
32400          OPEN(UNIT=40,file='MACKAY.DAT',STATUS='NEW')
32500          TYPE 640
32600    640   FORMAT(/,1X,'PLEASE WAIT')
32700    C
32800    C       SUBROUTINE MACK CALCULATES THE PARAMETERS NEEDED FOR INPUT
32900    C       INTO THE EVAPORATION MODEL DEVELOPED BY DR. MACKAY
33000    C       THIS DATA IS PUT INTO A FILE CALLED MACKAY.DAT
33100    C
33200          CALL MACK
33300    650   CONTINUE
33400    C
33500    C       NZSWI=0 INDICATES THAT NO PREVIOUS WEATHERING HAS TAKEN
33600    C       PLACE SO A NEW INITIAL OIL THICKNESS IS NEEDED.
33700    C       NZSWI=1 INDICATES THAT PREVIOUS WEATHERING HAS TAKEN
33800    C       PLACE SO THE PREVIOUS THICKNESS CAN BE CARRIED OVER
33900    C
34000          NZSWI=0
34100    C
34200    C       NIP=0 INDICATES ICE POOL WEATHERING HAS NOT TAKEN PLACE
34300    C       NIP=1 INDICATES ICE POOL WEATHERING HAS TAKEN PLACE
34400    C
34500    C       NBI=0 INDICATES THAT BROKEN ICE FIELD WEATHERING HAS NOT
34600    C       TAKEN PLACE
34700    C       NBI=1 INDICATES THAT BROKEN ICE FIELD WEATHERINT HAS
34800    C       TAKEN PLACE
34900    C
35000          NIP=0
35100          NBI=0
35200    C
35300    C       NG COUNTS THE NUMBER OF CUTS THAT HAVE BEEN WEATHERED AWAY
35400    C
35500          NG=0
35600    C
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35700   C       NQUIT=0 MEANS SLICK HAS NOT DECREASED TO 10% OF ORIGINAL MOLES
35800   C       NQUIT=1 MEANS SLICK HAS DECREASED TO 10% OF ORIGINAL MOLES
35900   C
36000         NQUIT=0
36100         TYPE 660
36200   660   FORMAT(1X,'DO YOU WANT TO WEATHER THIS OIL?')
36300         ACCEPT 390,ANS
36400         IF(ANS.EQ.'N') GO TO 4550
36500         TYPE 670
36600   670   FORMAT(1X,'WHAT IS THE SPILL SIZE IN BARRELS?')
36700         ACCEPT 280,BBL
36800   C
36900   C       CALCULATE AND SAVE INITIAL MASSES FOR OVERALL MASS BALANCE
37000   C
37100         BM=.159*BBL
37200         MOLSAV=0.
37300         TMASAV=0.
37400         DO 680 I=1,NCUTS
37500         MASSAV(I)=1582.*SPGR(I)*BBL*VOL(I)
37600         MLSAV(I)=MASSAV(I)/MW(I)
37700         MOLSAV=MOLSAV+MLSAV(I)
37800         TMASAV=TMASAV+MASSAV(I)
37900   680   CONTINUE
38000   C
38100   C       DELMAS IS THE MASS OF CUTS THAT ARE DELETED BECAUSE THEY
38200   C       EVAPORATE TOO QUICKLY
38300   C
38400         DELMAS=0.
38500   C
38600   C       TME IS THE TOTAL MASS EVAPORATED
38700   C       TMD IS THE TOTAL MASS DISPERSED
38800   C
38900         TME=0.
39000         TMD=0.
39100   C
39200   C       FE IS THE FRACTION (BASED ON MASS) EVAPORATED
39300   C
39400         FE=0.
39500   C
39600   C       MOUSWI=0 INDICATES THAT MOUSSE FORMATION HAS NOT BEEN STARTED
39700   C       MOUSWI=1 INDICATES THAT MOUSSE FORMATION HAS STARTED SUCH THAT
39800   C       NEW MOUSSE CONSTANTS MUST MATCH THE EXISTING CONDITIONS
39900   C
40000         MOUSWI=0
40100   C
40200   C       HOUMOU IS THE NUMBER OF HOURS THAT MOUSSE FORMATION HAS BEEN
40300   C       IN EFFECT
40400   C
40500         HOUMOU=0.
40600         TYPE 690
40700   690   FORMAT(1X,'WILL THE WEATHERING SCENARIO INCLUDE SEA ICE?')
40800         ACCEPT 390,ANS
40900         IF (ANS.EQ.'N') GO TO 3060
41000         TYPE 700
41100   700   FORMAT(1X,'WHEN THE OIL REACHES THE OIL SURFACE,')
41200         TYPE 710
41300   710   FORMAT(1X,'WILL IT WEATHER IN POOLS ON TOP OF THE ICE?')
41400         ACCEPT 390,ANS
41500         IF(ANS.EQ.'N') GO TO 1660
41600         TYPE 720
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720   FORMAT(1X,'AT WHAT TEMPERATURE, DEG F?')
      ACCEPT 280,XSAVE
      SPRFAC=1.
      NIP=1
      NCC1=NC1
      TK=(XSAVE-32.)/1.8+273.
      XPRINT=XSAVE
      XSAVE=XSAVE+459.
C
C       SUBROUTINE VPIF CALCULATES THE VAPOR PRESSURE OF EACH CUT
C       AT A SPECIFIED TEMPERATURE
C
      CALL VPIF(XSAVE,NCC1)
      TYPE 730
730   FORMAT(1X,'FOR HOW MANY HOURS?')
      ACCEPT 280,X2
C
C       NHIP IS THE NUMBER OF HOURS OF ICE POOL WEATHERING
C
      NHIP=X2
      TYPE 740
740   FORMAT(1X,'HOW DEEP WILL THE POOLS BE IN CM?  TRY 2')
      ACCEPT 280,Z
      NZSWI=1
      Z=Z/100
C
C       SET C2=-1. SINCE MOUSSE CANNOT BE FORMED
C
      C2=-1.
C
C       SET STEN TO 1. TO AVOID DIVIDE BY ZERO PROBLEMS LATER
C
750   STEN=1.0
760   TYPE 770
770   FORMAT(1X,'ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1
     1, 2, OR 3 WHERE:')
      TYPE 780
780   FORMAT(1X,'1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEF
     1FICIENT')
      TYPE 790
790   FORMAT(1X,'2=CORRELATION MASS-TRANSFER COEFFICIENT BY
     1 MACKAY & MATSUGU')
      TYPE 800
800   FORMAT(1X,'3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS')
      ACCEPT 420, KMTC
C
C       NOW ENTER THE WIND SPEED IN KNOTS AND CONVERT TO METER/SEC
C       AND METER/HOUR.
C
      TYPE 810
810   FORMAT(1X,'ENTER THE WIND SPEED IN KNOTS')
      ACCEPT 280, WINDS
C
C       NEVER LET THE WIND SPEED DROP BELOW 2 KNOTS.  A ZERO WIND
C       SPEED DESTROYS THE MASS-TRANSFER CALCULATION AND WILL
C       YIELD A ZERO MASS-TRANSFER COEFFICIENT.
C
      IF(WINDS.LT.2.) WINDS=2.
      WINDMS=0.514*WINDS
      WINDMH=1853.*WINDS
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C
C       NOW CALCULATE THE INITIAL GRAM MOLES FOR EACH COMPONENT TO
C       GET THE INTEGRATION STARTED.
C
820   BM=0.159*BBL
      TMOLES=0.
      DO 830 I=1,NCUTS
      AMASS=1582.*SPGR(I)*BBL*VOL(I)
      MOLES(I)=AMASS/MW(I)
      MOLS(I)=MOLES(I)
      TMOLES=TMOLES+MOLES(I)
C
C       RHO IS THE DENSITY IN GM MOLES/CUBIC METER.
C
      RHO(I)=100.*MOLES(I)/(BM*VOL(I))
830   CONTINUE
C
C       CALCULATE THE MEAN MOLECULAR WEIGHT OF THE CRUDE
C
      WTMOLE=0.
      DO 840 I=1,NCUTS
      WTMOLE=WTMOLE+MW(I)*MOLES(I)/TMOLES
840   CONTINUE
      WRITE (IOU,850) WTMOLE
850   FORMAT(/,1X,'MEAN MOLECULAR WEIGHT OF THE CRUDE = ',1PE10.3)
C
C       SET SPREADING TO ZERO.
C
860   SPREAD=0.
C
C       CALCULATE AN AREA IN SAME WAY IT WILL BE CALCULATED
C       AS THE SLICK WEATHERS.  Z=THICKNESS IN METERS.
C
870   VOLUM=0.
      DO 880 I=1,NCUTS
      VOLUM=VOLUM+MOLES(I)/RHO(I)
880   CONTINUE
C
C       CALCULATE THE INITIAL AREA AND DIAMETER.
C
      AREA=VOLUM/Z
      DIA=SQRT(AREA/0.785)
C
C       THE MASS-TRANSFER COEFFICIENT CAN BE CALCULATED ACCORDING TO:
C
C            1.  A USER-SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
C
C            2.  THE MASS-TRANSFER COEFFICIENT CORRELATION ACCORDING
C                TO MACKAY AND MATSUGU, 1973, CAN. J. CHE, V51,
C                P434-439.
C
C            3.  INDIVIDUAL OIL- AND AIR-PHASE MASS-TRANSFER COEFFI-
C                CIENTS BASED ON SOME REAL ENVIRONMENTAL DATA SUCH
C                AS THAT OF LISS AND SLATER.  SCALE THE AIR-PHASE
C                VALUE WITH RESPECT TO WIND SPEED ACCORDING TO
C                GARRATT, 1977, MONTHLY WEATHER REVIEW, V105,
C                P915-920.
C
C      TEMP IS R*T AND USED TO CHANGE THE UNITS ON THE MASS-
C      TRANSFER COEFFICIENT.
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53700   C
53800   890   TEMP=(8.2E-05)*TK
53900         GO TO (900,950,1040), KMTC
54000   C
54100   C       USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
54200   C
54300   900   TYPE 910
54400   910   FORMAT(1X,'ENTER THE OVER-ALL MASS-TRANSFER COEFFICIENT
54500        1, CM/HR, TRY 10')
54600         ACCEPT 280, UMTC
54700         WRITE(IOU,920)
54800   920   FORMAT(1H1,'DATA FOR WEATHERING OF OIL IN POOLS ON ICE')
54900         WRITE (IOU,930) UMTC
55000   930   FORMAT(/,'OVER-ALL MASS-TRANSFER COEFFICIENT WAS USER
55100        1-SPECIFIED AT ',1PE10.3,' CM/HR BY INPUT CODE 1')
55200   C
55300   C       CONVERT CM/HR TO GM-MOLES/(HR)(ATM)(M**2) SINCE VAPOR
55400   C       PRESSURE IS THE DRIVING FORCE FOR MASS TRANSFER.
55500   C
55600         UMTC=UMTC/TEMP/100.
55700         DO 940 I=1,NC1
55800         MTC(I)=UMTC
55900   940   CONTINUE
56000         GO TO 1120
56100   C
56200   C       USE THE MACKAY AND MATSUGU MASS-TRANSFER COEFFICIENT.
56300   C
56400   950   TERM1=0.015*WINDMH**0.78
56500   C
56600   C       THE SLICK DOES NOT SPREAD, SO BASE THE DIAMETER DEPENDENCE
56700   C       ON 1000 METERS AND DIVIDE THE RESULT BY 0.7
56800   C
56900   960   TERM2=0.65
57000   C
57100   C       KH INCLUDES THE SCHMIDT NUMBER FOR CUMENE.
57200   C
57300   970   KH=TERM1*TERM2
57400         WRITE(IOU,980)
57500   980   FORMAT(1H1,'WEATHERING OF OIL IN POOLS ON TOP OF ICE')
57600         WRITE (IOU,990) KMTC
57700   990   FORMAT(/,1X,'OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT
57800        1 CODE',I2)
57900         WRITE (IOU,1000) KH
58000   1000  FORMAT(/,1X,'OVER-ALL MASS-TRANSFER COEFFICIENT FOR CUMENE = '
58100        1,1PE10.3,' M/HR',/)
58200         WRITE (IOU,1010)
58300   1010  FORMAT(3X,'CUT',12X,'M/HR',7X,'GM-MOLES/(HR)(ATM)(M**2)')
58400         DO 1030 I=1,NC1
58500   C
58600   C       THE MASS-TRANSFER COEFFICIENT IS CORRECTED FOR THE
58700   C       DIFFUSIVITY OF COMPONENT I IN AIR.  THE SQRT IS USED
58800   C       (I.E. LISS AND SLATER), BUT THE 1/3 POWER COULD ALSO
58900   C       BE USED (I.E. THE SCHMIDT NUMBER).
59000   C
59100         MTCA(I)=KH*0.93*SQRT((MW(I)+29.)/MW(I))
59200   C
59300   C       MTC(I) IS THE OVER-ALL MASS-TRANSFER COEFFICIENT DIVIDED
59400   C       BY R*T.  R=82.06E-06 (ATM)(M**3)/(G-MOLE)(DEG K)
59500   C
59600         MTC(I)=MTCA(I)/TEMP
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59700          WRITE (IOU,1020) I,MTCA(I),MTC(I)
59800    1020  FORMAT(2X,I3,2(10X,1PE10.3))
59900    1030  CONTINUE
60000          GO TO 1120
60100    C
60200    C       USER SPECIFIED INDIVIDUAL-PHASE MASS-TRANSFER
60300    C       COEFFICIENTS.
60400    C
60500    1040  TYPE 1050
60600    1050  FORMAT(1X,'ENTER THE OIL-PHASE MASS-TRANSFER COEFFICIENT
60700         1 IN CM/HR, TRY 10')
60800          ACCEPT 280, KOIL
60900          TYPE 1060
61000    1060  FORMAT(1X,'ENTER THE AIR-PHASE MASS-TRANSFER COEFFICIENT
61100         1 IN CM/HR, TRY 1000')
61200          ACCEPT 280, KAIR
61300          TYPE 1070
61400    1070  FORMAT(1X,'ENTER THE MOLECULAR WEIGHT OF THE COMPOUND
61500         1 FOR K-AIR ABOVE, TRY 200')
61600          ACCEPT 280, DATAMW
61700    C
61800    C       SCALE K-AIR ACCORDING TO WIND SPEED (GARRATT, 1977),
61900    C       SO THAT AS THE WIND SPEED GOES UP THE MASS TRANSFER
62000    C       GOES UP, I.E., THE CONDUCTANCE INCREASES.
62100    C
62200          KAIR=KAIR*(1.+0.089*WINDMS)
62300          RKAIR=1./KAIR
62400    C
62500    C       CALCULATE R*T IN ATM*CM**3/GM-MOLE
62600    C
62700          RT=82.06*TK
62800          HTERM=WTMOLE/(DCRUDE*RT)
62900          WRITE (IOU,990) KMTC
63000    C
63100    C       WRITE THE USERS INPUT, WIND SPEED, AND HENRYS LAW
63200    C       TERM TO THE OUTPUT.
63300    C
63400          WRITE (IOU,1080) KAIR,KOIL,DATAMW
63500    1080  FORMAT(/,1X,'K-AIR = ',1PE10.3,', AND K-OIL = ',1PE10.3
63600         1,' CM/HR, BASED ON A MOLECULAR WEIGHT OF ',1PE10.3)
63700          WRITE (IOU,1090) WINDMS
63800    1090  FORMAT(1X,'WIND SPEED = ',1PE10.3,' M/S')
63900          WRITE (IOU,1100) HTERM
64000    1100  FORMAT(1X,'THE HENRYS LAW CONVERSION TERM FOR OIL = '
64100         1,1PE10.3,' 1/ATM')
64200          WRITE (IOU,1010)
64300    C
64400    C       CALCULATE THE OVER-ALL MASS-TRANSFER COEFFICIENT BASED
64500    C       ON GAS-PHASE CONCENTRATIONS FOR EACH CUT.
64600    C
64700          DO 1110 I=1,NC1
64800          HLAW(I)=HTERM*VP(I)
64900          MTCA(I)=RKAIR+HLAW(I)/KOIL
65000    C
65100    C       NOW TAKE THE INVERSE TO OBTAIN CM/HR AND THEN MULTIPLY
65200    C       BY 0.01 TO GET M/HR.
65300    C
65400          MTCA(I)=0.01/MTCA(I)
65500    C
65600    C       CORRECT FOR MOLECULAR WEIGHT ACCORDING TO LISS & SLATER,
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C       1974, NATURE, V247, P181-184.
C
      MTCA(I)=MTCA(I)*SQRT(DATAMW/MW(I))
      MTC(I)=MTCA(I)/TEMP
C
C       AND WRITE THE OVER-ALL MASS-TRANSFER COEFFICIENT
C       IN M/HR AND MOLE/HR*ATM*M*M.
C
      WRITE (IOU,1020) I,MTCA(I),MTC(I)
1110  CONTINUE
1120  SPGRB=141.5/(APIB+131.5)
      MASS=0.1582*BBL*SPGRB
      WRITE (IOU,1130) BBL,MASS
1130  FORMAT(/,1X,'FOR THIS SPILL OF ',1PE10.3,' BARRELS, THE
     1 MASS IS ',1PE10.3,' METRIC TONNES')
      VOLUMB=VOLUM/0.159
      WRITE (IOU,1140) VOLUM,VOLUMB
1140  FORMAT(/,1X,'VOLUME FROM SUMMING THE CUTS = ',1PE8.1,' M**3
     1, OR ',1PE10.3,' BARRELS')
      GO TO (1170,1150,1170), KMTC
1150  WRITE (IOU,1160) WINDS,WINDMH
1160  FORMAT(/,1X,'WIND SPEED = ',1PE10.3,' KNOTS, OR ',1PE10.3
     1,' M/HR')
1170  WRITE (IOU,1180) DIA,AREA
1180  FORMAT(/,1X,'INITIAL SLICK DIAMETER = ',1PE10.3,' M, OR AREA
     1 = ',1PE10.3,' M**2')
      WRITE (IOU,1190)
1190  FORMAT(/,1X,'THIS SLICK DOES NOT SPREAD FOR THIS CALCULATION')
C
C       CALCULATE THE KINEMATIC VISCOSITY OF THE CRUDE AT 122
C       DEG F AND THE ENTERED ENVIRONMENTAL TEMPERATURE.
C       USE THE VISCOSITY MIXING RULE OF (MOLE FRACTION)*(LOG).
C       SEE PAGE 460 OF REID, PRAUSNITZ & SHERWOOD IN
C       THE BOOK 'THE PROPERTIES OF GASES AND LIQUIDS'
C
1200  VISMIX=0.
      DO 1210 I=1,NCUTS
      VISMIX=VISMIX+MOLES(I)*VLOGK(I)/TMOLES
1210  CONTINUE
      VISMIX=EXP(VISMIX)
      WRITE (IOU,1220) VISMIX
1220  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
      XSAVE=XSAVE+459.
      EXPT=EXP(1923.*(1./XSAVE-0.001721))
      DO 1230 I=1,NCUTS
      VIS(I)=VISK(I)*EXPT
      VLOG(I)=ALOG(VIS(I))
      VISMIX=VISMIX+MOLES(I)*VLOG(I)/TMOLES
1230  CONTINUE
      XPRINT=32.
      VISMIX=EXP(VISMIX)
      WRITE (IOU,1240) VISMIX,XPRINT,EXPT
1240  FORMAT(/,1X,'KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE
     1 CUTS = ',1PE8.1,' AT T = ',0PF5.1,' DEG F, SCALE
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6100          2 FACTOR = ',1PE8.1)
6200    C
6300    C        IMPORTANT NOTE:  THE VISCOSITY PREDICTION OF THE WHOLE
6400    C        CRUDE FROM CUT INFORMATION IS NOT GOOD AT ALL.  SO THE
6500    C        VISCOSITY INFOMATION CALCULATED ABOVE IS NOT USED IN
6600    C        THIS VERSION OF THE CODE, BUT IT COULD BE IF A GOOD
6700    C        MIXING RULE IS EVER DETERMINED.
6800    C        THEREFORE, FOR THE TIME BEING, THE VISCOSITY OF THE WHOLE
6900    C        WEATHERED CRUDE IS CALCULATED ACCORDING TO MACKAY.
7000    C
7100    C        NOW LOAD THE VISCOSITY INFORMATION IN THE FORM
7200    C        OF THREE CONSTANTS:
7300    C             1.  THE VISCOSITY IN CP AT 25 DEG C
7400    C             2.  THE ANDRADE-VISCOSITY-SCALING CONSTANT
7500    C                 WITH RESPECT TO TEMPERATURE, SEE GOLD &
7600    C                 OGLE, 1969, CHEM. ENG., JULY 14, P121-123
7700    C             3.  THE VISCOSITY AS AN EXPONENTIAL FUNCTION OF
7800    C                 THE FRACTION OF OIL WEATHERED
7900    C
8000          IF(LSWTCH.EQ.99) GO TO 1260
8100          TYPE 1250
8200    1250  FORMAT(1X,'SINCE A LIBRARY CRUDE WAS NOT USED
8300         1,',/,1X,'ENTER THE FOLLOWING THREE VISCOSITY CONSTANTS')
8400          GO TO 1280
8500    1260  TYPE 1270
8600    1270  FORMAT(1X,'DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?')
8700          ACCEPT 390, ANS
8800          IF(ANS.EQ.'N') GO TO 1320
8900    1280  TYPE 1290
9000    1290  FORMAT(1X,'1. ENTER THE BULK CRUDE VISCOSITY
9100         1 AT 25 DEG C, CENTIPOISE, TRY 35.')
9200          ACCEPT 280, VISZ
9300          TYPE 1300
9400    1300  FORMAT(1X,'2. ENTER THE VISCOSITY TEMPERATURE SCALING
9500         1 CONSTANT (ANDRADE), TRY 9000.')
9600          ACCEPT 280, MK3
9700          TYPE 1310
9800    1310  FORMAT(1X,'3. ENTER THE VISCOSITY-FRACTION-OIL
9900         1-WEATHERED CONSTANT, TRY 10.5')
10000         ACCEPT 280, MK4
10100         GO TO 1330
10200   C
10300   C        USE THE LIBRARY VISCOSITY DATA
10400   C
10500   1320  VISZ=VISZL(IC)
10600         MK3=MK3L(IC)
10700         MK4=MK4L(IC)
10800   C
10900   C        INSERT VISCOSITY CALCULATION ACCORDING TO MASS
11000   C        FRACTION EVAPORATED.  THIS IS THE VISCOSITY
11100   C        MODIFICATION RELATIVE TO CUTVP1
11200   C
11300   1330  VSLEAD=VISZ*EXP(MK3*(1./TK-0.003357))
11400         WRITE (IOU,1340) VISZ,MK3,MK4,VSLEAD
11500   1340  FORMAT(/,1X,'VISCOSITY ACCORDING TO MASS EVAPORATED:
11600         1 VIS25C =',1PE9.2,', ANDRADE =',1PE9.2
11700         2,', FRACT WEATHERED =',1PE9.2', VSLEAD =',1PE9.2
11800         3,' CP')
11900         C2P=1./C2
12000         WRITE (IOU,1500) C1,C2P,C4
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      NEQ=NCUTS
      FRACTS=0.
C
C       SPECIFY NO DISPERSION
C
1350  WRITE (IOU,1360) FRACTS
1360  FORMAT(/,1X,'THE FRACTIONAL SLICK AREA SUBJECT TO
     1 DISPERSION IS ',1PE8.1,' PER HOUR')
C
C       PRINT EVERY XP TIME INCREMENT (HOURS).
C       X1 IS THE STARTING TIME = 0.
C       X2 IS THE NUMBER OF HOURS FOR WEATHERING TO OCCUR.
C
1370  XP=1.
      X1=0.
      MOLS(NCUTS+1)=AREA
C
C       PRINT AN OUTPUT FILE FOR 80 COLUMN OUTPUT, THIS IS
C       THE OILICE.TYP FILE.
C
      WRITE(ITY,1380)
1380  FORMAT(1X,'WEATHERING OF OIL IN POOLS ON TOP OF ICE')
      WRITE (ITY,1390) (ANAME(J),J=1,5)
1390  FORMAT(/,1X,'OIL: ',5A5)
      WRITE (ITY,1400) XPRINT,WINDS
1400  FORMAT(1X,'TEMPERATURE= ',F5.1,' DEG F, WIND SPEED= '
     1,F5.1,' KNOTS')
      WRITE (ITY,1410) BBL
1410  FORMAT(1X,'SPILL SIZE= ',1PE10.3,' BARRELS')
      WRITE (ITY,1420) KMTC
1420  FORMAT(1X,'MASS-TRANSFER COEFFICIENT CODE=',I3)
      WRITE (ITY,1430)
1430  FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS, MOLES
     1=GRAM MOLES')
      WRITE (ITY,1440)
1440  FORMAT(1X,'GMS=GRAMS, VP=VAPOR PRESSURE IN ATMOSPHERES')
      WRITE (ITY,1450)
1450  FORMAT(1X,'BP=BOILING POINT IN DEG F, API=GRAVITY')
      WRITE (ITY,1460)
1460  FORMAT(1X,'MW=MOLECULAR WEIGHT')
      WRITE (ITY,1470)
1470  FORMAT(/,2X,'CUT',3X,'MOLES',6X,'GMS',8X,'VP',8X,'BP'
     1,7X,'API',5X,'MW')
      DO 1490 I=1,NCUTS
      GMS=MOLES(I)*MW(I)
      IMW=MW(I)
      WRITE (ITY,1480) I,MOLES(I),GMS,VP(I),TB(I),API(I),IMW
1480  FORMAT(3X,I2,5(1X,1PE9.2),1X,I3)
1490  CONTINUE
      WRITE (ITY,1500) C1,C2P,C4
1500  FORMAT(/,1X,'MOUSSE CONSTANTS: MOONEY=',1PE9.2
     1,', MAX H20=',0PF5.2,', WIND**2=',1PE9.2)
      WRITE (ITY,1510) KA,KB,STEN
1510  FORMAT(1X,'DISPERSION CONSTANTS: KA=',1PE9.2
     1,', KB=',1PE9.2,', S-TENSION=',1PE9.2)
      WRITE (ITY,1520) VISZ,MK3,MK4
1520  FORMAT(1X,'VIS CONSTANTS: VIS25C=',1PE9.2
     1,', ANDRADE =',1PE9.2,', FRACT =',1PE9.2)
      WRITE (ITY,1530)
1530  FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS, TIME=HOURS')
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18100          WRITE (ITY,1540)
18200    1540  FORMAT(1X,'BBL=BARRELS, SPGR=SPECIFIC GRAVITY, AREA=M*M')
18300          WRITE (ITY,1550)
18400    1550  FORMAT(1X,'THICKNESS=CM, W=PERCENT WATER IN OIL (
18500         1MOUSSE)')
18600          WRITE (ITY,1560)
18700    1560  FORMAT(1X,'DISP=DISPERSION RATE IN GMS/M*M/HR')
18800          WRITE (ITY,1570)
18900    1570  FORMAT(1X,'ERATE=EVAPORTION RATE IN GMS/M*M/HR')
19000          WRITE (ITY,1580)
19100    1580  FORMAT(1X,'M/A=MASS PER M*M OF OIL IN THE SLICK')
19200          WRITE (ITY,1590)
19300    1590  FORMAT(1X,'I=FIRST CUT WITH GREATER THAN  1% (MASS)
19400         1 REMAINING')
19500          WRITE (ITY,1600)
19600    1600  FORMAT(1X,'J=FIRST CUT WITH GREATER THAN 50% (MASS)
19700         1 REMAINING')
19800          WRITE (ITY,1610)
19900    1610  FORMAT(1X,'DISPERSION WAS TURNED OFF')
20000          WRITE (ITY,1620)
20100    1620  FORMAT(1X,'SPREADING WAS TURNED OFF')
20200    1630  TCODE=KMTC
20300          TYPE 1640
20400    1640  FORMAT(/,1X,'PLEASE WAIT')
20500   C
20600   C        SUBROUTINE BRKG4 DOES THE INTEGRATION
20700   C
20800          CALL BRKG4(MOLS,X1,X2,XP,NEQ,NDEL)
20900   C
21000   C        ND IS THE NUMBER OF CUTS THAT WEATHERED COMPLETELY AWAY
21100   C
21200          ND=0
21300          DO 1650 I=1,NEQ
21400          IF (YM(I).NE.0.) GO TO 1650
21500          ND=ND+1
21600    1650  CONTINUE
21700   C
21800   C        NDEL IS THE NUMBER OF CUTS THAT WERE DELETED BECAUSE THEY
21900   C        EVAPORATE TO QUICKLY
22000   C
22100          NEW=NDEL+ND
22200          IF(NQUIT.EQ.1) GO TO 4460
22300    1660  TYPE 1670
22400    1670  FORMAT(1X,'WILL THE OIL NOW WEATHER IN THE BROKEN ICE FIELD?')
22500          ACCEPT 390,ANS
22600          IF(NIP.EQ.0) GO TO 1710
22700          TV=0.
22800   C
22900   C        NOW CALCULATE NEW VALUES FOR VOLUME PERCENT FOR EACH
23000   C        CUT AND SHIFT THE ARRAYS FOR VOLUME PERCENT, BOILING POINT,
23100   C        AND API TO ELIMINATE CUTS THAT ARE GONE
23200   C
23300          DO 1680 I=1,NEQ-ND
23400          TV=TV+(YM(ND+I)*YMSAVE(ND+I)/SPGR(NEW+I))
23500          VOL(I)=YM(ND+I)*MOLES(NEW+I)*MW(NEW+I)/(SPGR(NEW+I)
23600         1*(BBL*1582.))
23700          TB(I)=TB(NEW+I)
23800          API(I)=API(NEW+I)
23900    1680  CONTINUE
24000          BBL=TV/158200.
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24100          NCUTS=NCUTS-(ND+NDEL)
24200          NEQ=NCUTS
24300    C
24400    C       ALWAYS RENORMALIZE THE INPUT VOLUMES TO 100%.
24500    C
24600          VTOTAL=0.
24700          DO 1690 I=1,NCUTS
24800          VTOTAL=VTOTAL+VOL(I)
24900    1690  CONTINUE
25000          DO 1700 I=1,NCUTS
25100          VOL(I)=100.*VOL(I)/VTOTAL
25200    1700  CONTINUE
25300          IS=0
25400          APISWI=1
25500          CALL DOCHAR
25600    1710  IF(ANS.EQ.'N') GO TO 3060
25700          NG=NG+NEW
25800          NBI=1
25900          TYPE 1720
26000    1720  FORMAT(1X,'FOR HOW MANY HOURS?')
26100          ACCEPT 280,X2
26200    C
26300    C       NHBI IS THE NUMBER OF HOURS OF BROKEN ICE FIELD WEATHERING
26400    C
26500          NHBI=X2
26600          TYPE 1730
26700    1730  FORMAT(1X,'AT WHAT TEMPERATURE, DEG F?')
26800          ACCEPT 280,XSAVE
26900          TYPE 1740
27000    1740  FORMAT(1X,'ENTER THE FRACTION OF ICE COVER, I.E. 0.7')
27100          ACCEPT 280,FRACIC
27200          TK=(XSAVE-32.)/1.8+273.
27300          XPRINT=XSAVE
27400          XSAVE=XSAVE+459.
27500          NCC1=NC1
27600          CALL VPIF(XSAVE,NCC1)
27700          TEMP=(8.2E-05)*TK
27800          FACMOU=1.
27900    C
28000    C       THE FUNCTIONAL DEPENDENCE OF MOUSSE FORMATION RATE WITH
28100    C       FRACTION OF ICE COVER IS NOT KNOWN. FOR NOW THE VARIABLE
28200    C       FACMOU WILL BE THE FACTOR WHICH WILL DETERMINE THE
28300    C       AMOUNT OF INCREASE OF FORMATION RATE. IF MOUSSE
28400    C       CONSTANTS ARE NOT INPUT BY THE USER, FACMOU=10
28500    C
28600          IF(LSWTCH.EQ.99) GO TO 1770
28700          TYPE  1750
28800    1750  FORMAT(1X,'SINCE YOU DID NOT USE A LIBRARY CRUDE,')
28900          TYPE 1760
29000    1760  FORMAT(1X,'YOU MUST ENTER THE FOLLOWING FOUR MOUSSE
29100         1 FORMATION CONSTANTS')
29200          GO TO 1790
29300    1770  TYPE 1780
29400    1780  FORMAT(1X,'DO YOU WANT TO ENTER NEW MOUSSE FORMATION CONS
29500         1TANTS?')
29600          ACCEPT 390, ANS
29700          IF(ANS.EQ.'N') GO TO 1860
29800    C
29900    C       TO SPECIFY NO MOUSSE, ENTER C2  = 0
30000    C
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```
1790  TYPE 1800
1800  FORMAT(1X,'1. ENTER THE MAXIMUM WEIGHT FRACTION WATER
     1 IN OIL')
      ACCEPT 280, C2
      IF(C2.GT.0.) GO TO 1820
C
C       SET C2=-1. IF A MOUSSE CANNOT BE FORMED AND LOOP OUT.
C
      C2=-1.
      TYPE 1810
1810  FORMAT(/,1X,'SINCE A 0% WATER CONTENT WAS SPECIFIED
     1, THE REMAINING THREE MOUSSE',/,1X,'CONSTANTS ARE NOT
     2 NEEDED')
      GO TO 1870
1820  C2=1./C2
      TYPE 1830
1830  FORMAT(1X,'2. ENTER THE MOUSSE-VISCOSITY CONSTANT
     1, TRY 0.65')
      ACCEPT 280, C1
      TYPE 1840
1840  FORMAT(1X,'3. ENTER THE WATER INCORPORATION RATE CONSTANT
     1, TRY 0.001')
      ACCEPT 280, C4
      TYPE 1850
1850  FORMAT(1X,'4. ENTER THE BROKEN ICE FIELD MULTIPLIER FOR MOUSSE
     1 FORMATION')
      ACCEPT 280,FACMOU
      GO TO 1870
1860  C1=C1L(IC)
      C2=C2L(IC)
      C4=C4L(IC)
      FACMOU=10.
1870  CONTINUE
      C4=C4*FACMOU
      IF(LSWTCH.EQ.99) GO TO 1900
      TYPE 1880
1880  FORMAT(/,1X,'YOU MUST ALSO ENTER AN OIL-WATER SURFACE
     1 TENSION (DYNES/CM')
      TYPE 1890
1890  FORMAT(1X,'FOR DISPERSION, TRY 30.')
      GO TO 1930
1900  TYPE 1910
1910  FORMAT(1X,'DO YOU WANT TO ENTER A NEW OIL-WATER SURFACE
     1 TENSION (DYNES/CM)?')
      ACCEPT 390, ANS
      IF(ANS.EQ.'N') GO TO 1940
      TYPE 1920
1920  FORMAT(1X,'TRY 30.')
1930  ACCEPT 280, STEN
      GO TO 1950
1940  STEN=STENL(IC)
C
C       START THE MASS-TRANSFER COEFFICIENT SPECIFICATION.
C
1950  TYPE 1960
1960  FORMAT(1X,'ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1
     1, 2, OR 3 WHERE:')
      TYPE 1970
1970  FORMAT(1X,'1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEF
     1FICIENT')
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36100          TYPE 1980
36200    1980  FORMAT(1X,'2=CORRELATION MASS-TRANSFER COEFFICIENT BY
36300         1 MACKAY & MATSUGU')
36400          TYPE 1990
36500    1990  FORMAT(1X,'3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS')
36600          ACCEPT 420, KMTC
36700    C
36800    C       NOW ENTER THE WIND SPEED IN KNOTS AND CONVERT TO METER/SEC
36900    C       AND METER/HOUR.
37000    C
37100          TYPE 2000
37200    2000  FORMAT(1X,'ENTER THE WIND SPEED IN KNOTS')
37300          ACCEPT 280, WINDS
37400    C
37500    C       NEVER LET THE WIND SPEED DROP BELOW 2 KNOTS.  A ZERO WIND
37600    C       SPEED DESTROYS THE MASS-TRANSFER CALCULATION AND WILL
37700    C       YIELD A ZERO MASS-TRANSFER COEFFICIENT.
37800    C
37900          IF(WINDS.LT.2.) WINDS=2.
38000          WINDMS=0.514*WINDS
38100          WINDMH=1853.*WINDS
38200    C
38300    C       NOW CALCULATE THE INITIAL GRAM MOLES FOR EACH COMPONENT TO
38400    C       GET THE INTEGRATION STARTED.
38500    C
38600    2010  BM=0.159*BBL
38700          TMOLES=0.
38800          DO 2020 I=1,NCUTS
38900          AMASS=1582.*SPGR(I)*BBL*VOL(I)
39000          MOLES(I)=AMASS/MW(I)
39100          MOLS(I)=MOLES(I)
39200          TMOLES=TMOLES+MOLES(I)
39300    C
39400    C       RHO IS THE DENSITY IN GM MOLES/CUBIC METER.
39500    C
39600          RHO(I)=100.*MOLES(I)/(BM*VOL(I))
39700    2020  CONTINUE
39800    C
39900    C       CALCULATE THE MEAN MOLECULAR WEIGHT OF THE CRUDE
40000    C
40100          WTMOLE=0.
40200          DO 2030 I=1,NCUTS
40300          WTMOLE=WTMOLE+MW(I)*MOLES(I)/TMOLES
40400    2030  CONTINUE
40500          WRITE (IOU,2040) WTMOLE
40600    2040  FORMAT(/,1X,'MEAN MOLECULAR WEIGHT OF THE CRUDE = ',1PE10.3)
40700    C
40800    C       SPECIFY SLICK SPREADING.
40900    C
41000    2050  SPREAD=0.
41100          TYPE 2060
41200    2060  FORMAT(1X,'DO YOU WANT THE SLICK TO SPREAD?')
41300          ACCEPT 390, ANS
41400          IF(ANS.EQ.'N') GO TO 2070
41500          SPREAD=1.
41600          GO TO 2100
41700    C
41800    C       CALCULATE AN AREA IN SAME WAY IT WILL BE CALCULATED
41900    C       AS THE SLICK WEATHERS.  Z=THICKNESS IN METERS.
42000    C
```

```
2070  IF (NZSWI.EQ.1) GO TO 2090
      TYPE 2080
2080  FORMAT(1X,'SINCE THE SLICK DOES NOT SPREAD, ENTER
     1 A STARTING THICKNESS IN CM')
      ACCEPT 280, Z
2090  Z=Z/100.
      GO TO 2110
C
C       THE SLICK ALWAYS STARTS AT 2-CM THICKNESS.
C
2100  IF (NZSWI.NE.0) GO TO 2110
      Z=0.02
2110  VOLUM=0.
      DO 2120 I=1,NCUTS
      VOLUM=VOLUM+MOLES(I)/RHO(I)
2120  CONTINUE
      NZSWI=1
C
C       CALCULATE THE INITIAL AREA AND DIAMETER.
C
      AREA=VOLUM/Z
      DIA=SQRT(AREA/0.785)
C
C       THE FUNCTIONAL DEPENDENCE OF SPREADING WITH FRACTION OF ICE
C       COVER IS NOT KNOWN.  FOR NOW, A LINEAR DEPENDENCE IS ASSUMMED
C
      SPRFAC=1.-FRACIC
C
C       THE MASS-TRANSFER COEFFICIENT CAN BE CALCULATED ACCORDING TO:
C
C            1.  A USER-SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
C
C            2.  THE MASS-TRANSFER COEFFICIENT CORRELATION ACCORDING
C                TO MACKAY AND MATSUGU, 1973, CAN. J. CHE, V51,
C                P434-439.
C
C            3.  INDIVIDUAL OIL- AND AIR-PHASE MASS-TRANSFER COEFFI-
C                CIENTS BASED ON SOME REAL ENVIRONMENTAL DATA SUCH
C                AS THAT OF LISS AND SLATER.  SCALE THE AIR-PHASE
C                VALUE WITH RESPECT TO WIND SPEED ACCORDING TO
C                GARRATT, 1977, MONTHLY WEATHER REVIEW, V105,
C                P915-920.
C
C      TEMP IS R*T AND USED TO CHANGE THE UNITS ON THE MASS-
C      TRANSFER COEFFICIENT.
C
2130  TEMP=(8.2E-05)*TK
      GO TO (2140,2180,2290), KMTC
C
C       USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
C
2140  TYPE 2150
2150  FORMAT(1X,'ENTER THE OVER-ALL MASS-TRANSFER COEFFICIENT
     1, CM/HR, TRY 10')
      ACCEPT 280, UMTC
      WRITE (IOU,2160) UMTC
2160  FORMAT(1H1,'OVER-ALL MASS-TRANSFER COEFFICIENT WAS USER
     1-SPECIFIED AT ',1PE10.3,' CM/HR BY INPUT CODE 1')
C
C       CONVERT CM/HR TO GM-MOLES/(HR)(ATM)(M**2) SINCE VAPOR
```

```
C       PRESSURE IS THE DRIVING FORCE FOR MASS TRANSFER.
C
      UMTC=UMTC/TEMP/100.
      DO 2170 I=1,NC1
      MTC(I)=UMTC
2170  CONTINUE
      GO TO 2370
C
C       USE THE MACKAY AND MATSUGU MASS-TRANSFER COEFFICIENT.
C
2180  TERM1=0.015*WINDMH**0.78
      IF(SPREAD.EQ.0.) GO TO 2190
      TERM2=DIA**(-0.11)
      GO TO 2200
C
C       IF THE SLICK DOES NOT SPREAD BASE THE DIAMETER DEPENDENCE
C       ON 1000 METERS AND DIVIDE THE RESULT BY 0.7
C
2190  TERM2=0.65
C
C       KH INCLUDES THE SCHMIDT NUMBER FOR CUMENE.
C
2200  KH=TERM1*TERM2
      WRITE(IOU,2210)
2210  FORMAT(1H1,'WEATHERING DATA FOR OIL IN A BROKEN ICE FIELD')
      IF(NIP.NE.1) GO TO 2230
      WRITE(IOU,2220)NHIP
2220  FORMAT(1X,'AFTER ICE POOL WEATHERING FOR ',1PE9.3,' HOURS')
2230  WRITE (IOU,2240) KMTC
2240  FORMAT(/,1X,'OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT
     1 CODE',I2)
      WRITE (IOU,2250) KH
2250  FORMAT(/,1X,'OVER-ALL MASS-TRANSFER COEFFICIENT FOR CUMENE = '
     1,1PE10.3,' M/HR',/)
      WRITE (IOU,2260)
2260  FORMAT(3X,'CUT',12X,'M/HR',7X,'GM-MOLES/(HR)(ATM)(M**2)')
      DO 2280 I=1,NC1
C
C       THE MASS-TRANSFER COEFFICIENT IS CORRECTED FOR THE
C       DIFFUSIVITY OF COMPONENT I IN AIR.  THE SQRT IS USED
C       (I.E. LISS AND SLATER), BUT THE 1/3 POWER COULD ALSO
C       BE USED (I.E. THE SCHMIDT NUMBER).
C
      MTCA(I)=KH*0.93*SQRT((MW(I)+29.)/MW(I))
C
C       MTC(I) IS THE OVER-ALL MASS-TRANSFER COEFFICIENT DIVIDED
C       BY R*T.  R=82.06E-06 (ATM)(M**3)/(G-MOLE)(DEG K)
C
      MTC(I)=MTCA(I)/TEMP
      WRITE (IOU,2270) I,MTCA(I),MTC(I)
2270  FORMAT(2X,I3,2(10X,1PE10.3))
2280  CONTINUE
      GO TO 2370
C
C       USER SPECIFIED INDIVIDUAL-PHASE MASS-TRANSFER
C       COEFFICIENTS.
C
2290  TYPE 2300
2300  FORMAT(1X,'ENTER THE OIL-PHASE MASS-TRANSFER COEFFICIENT
     1 IN CM/HR, TRY 10')
```

```
54100          ACCEPT 280, KOIL
54200          TYPE 2310
54300    2310  FORMAT(1X,'ENTER THE AIR-PHASE MASS-TRANSFER COEFFICIENT
54400         1 IN CM/HR, TRY 1000')
54500          ACCEPT 280, KAIR
54600          TYPE 2320
54700    2320  FORMAT(1X,'ENTER THE MOLECULAR WEIGHT OF THE COMPOUND
54800         1 FOR K-AIR ABOVE, TRY 200')
54900          ACCEPT 280, DATAMW
55000    C
55100    C       SCALE K-AIR ACCORDING TO WIND SPEED (GARRATT, 1977),
55200    C       SO THAT AS THE WIND SPEED GOES UP THE MASS TRANSFER
55300    C       GOES UP, I.E., THE CONDUCTANCE INCREASES.
55400    C
55500          KAIR=KAIR*(1.+0.089*WINDMS)
55600          RKAIR=1./KAIR
55700    C
55800    C       CALCULATE R*T IN ATM*CM**3/GM-MOLE
55900    C
56000          RT=82.06*TK
56100          HTERM=WTMOLE/(DCRUDE*RT)
56200          WRITE (IOU,2240) KMTC
56300    C
56400    C       WRITE THE USERS INPUT, WIND SPEED, AND HENRYS LAW
56500    C       TERM TO THE OUTPUT.
56600    C
56700          WRITE (IOU,2330) KAIR,KOIL,DATAMW
56800    2330  FORMAT(/,1X,'K-AIR = ',1PE10.3,', AND K-OIL = ',1PE10.3
56900         1,' CM/HR, BASED ON A MOLECULAR WEIGHT OF ',1PE10.3)
57000          WRITE (IOU,2340) WINDMS
57100    2340  FORMAT(1X,'WIND SPEED = ',1PE10.3,' M/S')
57200          WRITE (IOU,2350) HTERM
57300    2350  FORMAT(1X,'THE HENRYS LAW CONVERSION TERM FOR OIL = '
57400         1,1PE10.3,' 1/ATM')
57500          WRITE (IOU,2260)
57600    C
57700    C       CALCULATE THE OVER-ALL MASS-TRANSFER COEFFICIENT BASED
57800    C       ON GAS-PHASE CONCENTRATIONS FOR EACH CUT.
57900    C
58000          DO 2360 I=1,NC1
58100          HLAW(I)=HTERM*VP(I)
58200          MTCA(I)=RKAIR+HLAW(I)/KOIL
58300    C
58400    C       NOW TAKE THE INVERSE TO OBTAIN CM/HR AND THEN MULTIPLY
58500    C       BY 0.01 TO GET M/HR.
58600    C
58700          MTCA(I)=0.01/MTCA(I)
58800    C
58900    C       CORRECT FOR MOLECULAR WEIGHT ACCORDING TO LISS & SLATER,
59000    C       1974, NATURE, V247, P181-184.
59100    C
59200          MTCA(I)=MTCA(I)*SQRT(DATAMW/MW(I))
59300          MTC(I)=MTCA(I)/TEMP
59400    C
59500    C       AND WRITE THE OVER-ALL MASS-TRANSFER COEFFICIENT
59600    C       IN M/HR AND MOLE/HR*ATM*M*M.
59700    C
59800          WRITE (IOU,2270) I,MTCA(I),MTC(I)
59900    2360  CONTINUE
60000    2370  SPGRB=141.5/(APIB+131.5)
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60100          MASS=0.1582*BBL*SPGRB
60200          WRITE (IOU,2380) BBL,MASS
60300    2380  FORMAT(/,1X,'FOR THIS SPILL OF ',1PE10.3,' BARRELS, THE
60400         1 MASS IS ',1PE10.3,' METRIC TONNES')
60500          VOLUMB=VOLUM/0.159
60600          WRITE (IOU,2390) VOLUM,VOLUMB
60700    2390  FORMAT(/,1X,'VOLUME FROM SUMMING THE CUTS = ',1PE8.1,' M**3
60800         1, OR ',1PE10.3,' BARRELS')
60900          GO TO (2420,2400,2420), KMTC
61000    2400  WRITE (IOU,2410) WINDS,WINDMH
61100    2410  FORMAT(/,1X,'WIND SPEED = ',1PE10.3,' KNOTS, OR ',1PE10.3
61200         1,' M/HR')
61300    2420  WRITE (IOU,2430) DIA,AREA
61400    2430  FORMAT(/,1X,'INITIAL SLICK DIAMETER = ',1PE10.3,' M, OR AREA
61500         1 = ',1PE10.3,' M**2')
61600          IF(SPREAD.GT.0.) GO TO 2450
61700          WRITE (IOU,2440)
61800    2440  FORMAT(/,1X,'THIS SLICK DOES NOT SPREAD FOR THIS CALCULATION')
61900    C
62000    C       CALCULATE THE KINEMATIC VISCOSITY OF THE CRUDE AT 122
62100    C       DEG F AND THE ENTERED ENVIRONMENTAL TEMPERATURE.
62200    C       USE THE VISCOSITY MIXING RULE OF (MOLE FRACTION)*(LOG),
62300    C       SEE PAGE 460 OF REID, PRAUSNITZ & SHERWOOD IN
62400    C       THE BOOK 'THE PROPERTIES OF GASES AND LIQUIDS'
62500    C
62600    2450  VISMIX=0.
62700          DO 2460 I=1,NCUTS
62800          VISMIX=VISMIX+MOLES(I)*VLOGK(I)/TMOLES
62900    2460  CONTINUE
63000          VISMIX=EXP(VISMIX)
63100          WRITE (IOU,2470) VISMIX
63200    2470  FORMAT(/,1X,'KINEMATIC VISCOSITY OF THE BULK CRUDE FROM
63300         1 THE CUTS = ',1PE8.1,' CENTISTOKES AT 122 DEG F')
63400          VISMIX=0.
63500    C
63600    C       SCALE THE VISCOSITY WITH TEMPERATURE ACCORDING TO
63700    C       ANDRADE.
63800    C
63900          EXPT=EXP(1923.*(1./XSAVE-0.001721))
64000          DO 2480 I=1,NCUTS
64100          VIS(I)=VISK(I)*EXPT
64200          VLOG(I)=ALOG(VIS(I))
64300          VISMIX=VISMIX+MOLES(I)*VLOG(I)/TMOLES
64400    2480  CONTINUE
64500          VISMIX=EXP(VISMIX)
64600          WRITE (IOU,2490) VISMIX,XPRINT,EXPT
64700    2490  FORMAT(/,1X,'KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE
64800         1 CUTS = ',1PE8.1,' AT T = ',0PF5.1,' DEG F, SCALE
64900         2 FACTOR = ',1PE8.1)
65000    C
65100    C       IMPORTANT NOTE:  THE VISCOSITY PREDICTION OF THE WHOLE
65200    C       CRUDE FROM CUT INFORMATION IS NOT GOOD AT ALL.  SO THE
65300    C       VISCOSITY INFOMATION CALCULATED ABOVE IS NOT USED IN
65400    C       THIS VERSION OF THE CODE, BUT IT COULD BE IF A GOOD
65500    C       MIXING RULE IS EVER DETERMINED.
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C       THEREFORE, FOR THE TIME BEING, THE VISCOSITY OF THE WHOLE
C       WEATHERED CRUDE IS CALCULATED 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-SCALING CONSTANT
C                WITH RESPECT TO TEMPERATURE, SEE GOLD &
C                OGLE, 1969, CHEM. ENG., 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 2510
      TYPE 2500
 2500 FORMAT(1X,'SINCE A LIBRARY CRUDE WAS NOT USED
     1,',/,1X,'ENTER THE FOLLOWING THREE VISCOSITY CONSTANTS')
      GO TO 2530
 2510 TYPE 2520
 2520 FORMAT(1X,'DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?')
      ACCEPT 390, ANS
      IF(ANS.EQ.'N') GO TO 2570
 2530 TYPE 2540
 2540 FORMAT(1X,'1. ENTER THE BULK CRUDE VISCOSITY
     1 AT 25 DEG C, CENTIPOISE, TRY 35.')
      ACCEPT 280, VISZ
      TYPE 2550
 2550 FORMAT(1X,'2. ENTER THE VISCOSITY TEMPERATURE SCALING
     1 CONSTANT (ANDRADE), TRY 9000.')
      ACCEPT 280, MK3
      TYPE 2560
 2560 FORMAT(1X,'3. ENTER THE VISCOSITY-FRACTION-OIL
     1-WEATHERED CONSTANT, TRY 10.5')
      ACCEPT 280, MK4
      GO TO 2580
C
C       USE THE LIBRARY VISCOSITY DATA
C
 2570 VISZ=VISZL(IC)
      MK3=MK3L(IC)
      MK4=MK4L(IC)
C
C       INSERT VISCOSITY CALCULATION ACCORDING TO MASS
C       FRACTION EVAPORATED.  THIS IS THE VISCOSITY
C       MODIFICATION RELATIVE TO CUTVP1
C
 2580 VSLEAD=VISZ*EXP(MK3*(1./TK-0.003357))
      WRITE (IOU,2590) VISZ,MK3,MK4,VSLEAD
 2590 FORMAT(/,1X,'VISCOSITY ACCORDING TO MASS EVAPORATED:
     1 VIS25C =',1PE9.2,', ANDRADE =',1PE9.2
     2,', FRACT WEATHERED =',1PE9.2', VSLEAD =',1PE9.2
     3,' CP')
      C2P=1./C2
      WRITE (IOU,2850) C1,C2P,C4
      NEQ=NCUTS
C
C       SET UP THE DISPERSION PROCESS CONSTANTS.
C       CALCULATE THE FRACTION OF THE SEA SURFACE SUBJECT TO
C       DISPERSIONS/HOUR.
C
C       THE FUNCTIONAL DEPENDENCE OF DISPERSION RATE WITH FRACTION
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```
C       OF ICE COVER IS NOT KNOWN. FOR NOW, THE VARIABLE FACDIS WILL
C       BE USED TO INCREASE THE DISPERSION RATE.  ITS DEFAULT VALUE
C       WILL BE 10.
C
      FACDIS=10.
      TYPE 2600
 2600 FORMAT(1X,'DO YOU WANT THE WEATHERING TO OCCUR WITH
     1 DISPERSION?')
      ACCEPT 390, ANS
      FRACTS=0.
      IF(ANS.EQ.'N') GO TO 2670
      IF (LSWTCH.NE.99) GO TO 2620
      TYPE 2610
 2610 FORMAT(1X,'DO YOU WANT TO ENTER NEW DISPERSION
     1 CONSTANTS?')
      ACCEPT 390, ANS
      IF(ANS.EQ.'N') GO TO 2660
 2620 TYPE 2630
 2630 FORMAT(1X,'ENTER THE WIND SPEED CONSTANT, TRY 0.1')
      ACCEPT 280, KA
      TYPE 2640
 2640 FORMAT(1X,'ENTER THE CRITICAL DROPLET SIZE CONSTANT
     1, TRY 50')
      ACCEPT 280, KB
      TYPE 2650
 2650 FORMAT(1X,'ENTER THE BROKEN ICE FIELD DISPERSION MULTIPLIER')
      ACCEPT 280,FACDIS
 2660 FRACTS=KA*(1.+WINDMS)**2
 2670 CONTINUE
      FRACTS=FRACTS*FACDIS
      WRITE (IOU,2680) FRACTS
 2680 FORMAT(/,1X,'THE FRACTIONAL SLICK AREA SUBJECT TO
     1 DISPERSION IS ',1PE8.1,' PER HOUR')
      IF(ANS.EQ.'N') GO TO 2700
      WRITE (IOU,2690) KA,KB,STEN
 2690 FORMAT(1X,'THE DISPERSION PARAMETERS USED:  KA = '
     1,1PE9.2,', KB = ',1PE9.2,', SURFACE TENSION = ',1PE9.2
     2,' DYNES/CM')
C
C       PRINT EVERY XP TIME INCREMENT (HOURS).
C       X1 IS THE STARTING TIME = 0.
C       X2 IS THE NUMBER OF HOURS FOR WEATHERING TO OCCUR.
C
 2700 XP=1.
      X1=0.
      MOLS(NCUTS+1)=AREA
C
C       PRINT AN OUTPUT FILE FOR 80 COLUMN OUTPUT, THIS IS
C       THE CUTVP2.TYP FILE.
C
      WRITE(ITY,2710)
 2710 FORMAT(1H1,'WEATHERING OF OIL IN A BROKEN ICE FIELD')
      IF(NIP.NE.1) GO TO 2730
      WRITE(ITY,2720) NHIP
 2720 FORMAT(1X,'AFTER ICE POOL WEATHERING FOR ',1PE9.3,' HOURS')
 2730 WRITE (ITY,2740) (ANAME(J),J=1,5)
 2740 FORMAT(/,1X,'OIL: ',5A5)
      WRITE (ITY,2750) XPRINT,WINDS
 2750 FORMAT(1X,'TEMPERATURE= ',F5.1,' DEG F, WIND SPEED= '
     1,F5.1,' KNOTS')
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      WRITE (ITY,2760) BBL
 2760 FORMAT(1X,'SPILL SIZE= ',1PE10.3,' BARRELS')
      WRITE (ITY,2770) KMTC
 2770 FORMAT(1X,'MASS-TRANSFER COEFFICIENT CODE=',I3)
      WRITE (ITY,2780)
 2780 FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS, MOLES
     1=GRAM MOLES')
      WRITE (ITY,2790)
 2790 FORMAT(1X,'GMS=GRAMS, VP=VAPOR PRESSURE IN ATMOSPHERES')
      WRITE (ITY,2800)
 2800 FORMAT(1X,'BP=BOILING POINT IN DEG F, API=GRAVITY')
      WRITE (ITY,2810)
 2810 FORMAT(1X,'MW=MOLECULAR WEIGHT')
      WRITE (ITY,2820)
 2820 FORMAT(/,2X,'CUT',3X,'MOLES',6X,'GMS',8X,'VP',8X,'BP'
     1,7X,'API',5X,'MW')
      DO 2840 I=1,NCUTS
      GMS=MOLES(I)*MW(I)
      IMW=MW(I)
      WRITE (ITY,2830) I,MOLES(I),GMS,VP(I),TB(I),API(I),IMW
 2830 FORMAT(3X,I2,5(1X,1PE9.2),1X,I3)
 2840 CONTINUE
      WRITE (ITY,2850) C1,C2P,C4
 2850 FORMAT(/,1X,'MOUSSE CONSTANTS: MOONEY=',1PE9.2
     1,', MAX H20=',0PF5.2,', WIND**2=',1PE9.2)
      WRITE(ITY,2860) FACMOU
 2860 FORMAT(20X,'K4=',1PE9.3)
      WRITE (ITY,2870) KA,KB,STEN
 2870 FORMAT(1X,'DISPERSION CONSTANTS: KA=',1PE9.2
     1,', KB=',1PE9.2,', S-TENSION=',1PE9.2)
      WRITE(ITY,2880)FACDIS
 2880 FORMAT(24X,'KC=',1PE9.3)
      WRITE(ITY,2890)FRACIC
 2890 FORMAT(1X,'FRACTION OF ICE COVER=',1PE9.3)
      WRITE (ITY,2900) VISZ,MK3,MK4
 2900 FORMAT(1X,'VIS CONSTANTS: VIS25C=',1PE9.2
     1,', ANDRADE =',1PE9.2,', FRACT =',1PE9.2)
      WRITE (ITY,2910)
 2910 FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS, TIME=HOURS')
      WRITE (ITY,2920)
 2920 FORMAT(1X,'BBL=BARRELS, SPGR=SPECIFIC GRAVITY, AREA=M*M')
      WRITE (ITY,2930)
 2930 FORMAT(1X,'THICKNESS=CM, W=PERCENT WATER IN OIL (
     1MOUSSE)')
      WRITE (ITY,2940)
 2940 FORMAT(1X,'DISP=DISPERSION RATE IN GMS/M*M/HR')
      WRITE (ITY,2950)
 2950 FORMAT(1X,'ERATE=EVAPORTION RATE IN GMS/M*M/HR')
      WRITE (ITY,2960)
 2960 FORMAT(1X,'M/A=MASS PER M*M OF OIL IN THE SLICK')
      WRITE (ITY,2970)
 2970 FORMAT(1X,'I=FIRST CUT WITH GREATER THAN  1% (MASS)
     1 REMAINING')
      WRITE (ITY,2980)
 2980 FORMAT(1X,'J=FIRST CUT WITH GREATER THAN 50% (MASS)
     1 REMAINING')
      IF(FRACTS.NE.0.) GO TO 3000
      WRITE (ITY,2990)
 2990 FORMAT(1X,'DISPERSION WAS TURNED OFF')
 3000 IF(SPREAD.NE.0.) GO TO 3020
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18100          WRITE (ITY,3010)
18200    3010  FORMAT(1X,'SPREADING WAS TURNED OFF')
18300    3020  TCODE=KMTC
18400          TYPE 3030
18500    3030  FORMAT(/,1X,'PLEASE WAIT')
18600          CALL BRKG4(MOLS,X1,X2,XP,NEQ,NDEL)
18700          IF (C3.EQ.-1.) GO TO 3040
18800    C
18900    C       CHECK TO SEE IF MOUSSE HAS BEEN MADE.  IF IT HAS, SAVE THE
19000    C       RATE CONSTANT SO THAT FURTHER WEATHERING CAN TAKE THIS INTO
19100    C       ACCOUNT
19200    C
19300          MOUSWI=1
19400          C3SAVE=C3
19500    3040  CONTINUE
19600          ND=0
19700          DO 3050 I=1,NEQ
19800          IF (YM(I).NE.0.) GO TO 3050
19900          ND=ND+1
20000    3050  CONTINUE
20100          NEW=NDEL+ND
20200          IF(NQUIT.EQ.1) GO TO 4460
20300    3060  TYPE 3070
20400    3070  FORMAT(1X,'WILL OPEN OCEAN WEATHERING NOW OCCUR?')
20500          ACCEPT 390,ANS
20600          IF(NBI.EQ.0) GO TO 3110
20700          TV=0.
20800          DO 3080 I=1,NEQ-ND
20900          TV=TV+(YM(ND+I)*YMSAVE(ND+I)/SPGR(NEW+I))
21000          VOL(I)=YM(ND+I)*MOLES(NEW+I)*MW(NEW+I)/(SPGR(NEW+I)
21100         1*(BBL*1582.))
21200          TB(I)=TB(NEW+I)
21300          API(I)=API(NEW+I)
21400    3080  CONTINUE
21500          BBL=TV/158200.
21600          NCUTS=NCUTS-(ND+NDEL)
21700          NEQ=NCUTS
21800    C
21900    C       ALWAYS RENORMALIZE THE INPUT VOLUMES TO 100%.
22000    C
22100          VTOTAL=0.
22200          DO 3090 I=1,NCUTS
22300          VTOTAL=VTOTAL+VOL(I)
22400    3090  CONTINUE
22500          DO 3100 I=1,NCUTS
22600          VOL(I)=100.*VOL(I)/VTOTAL
22700    3100  CONTINUE
22800          IS=0
22900          APISWI=1
23000          CALL DOCHAR
23100    3110  CONTINUE
23200          SPRFAC=1.
23300          IF(ANS.EQ.'N') GO TO 4460
23400          NG=NG+NEW
23500          TYPE 3120
23600    3120  FORMAT(1X,'FOR HOW MANY HOURS?')
23700          ACCEPT 280,X2
23800          TYPE 3130
23900    3130  FORMAT(1X,'AT WHAT TEMPERATURE, DEG F?')
24000          ACCEPT 280,XSAVE
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24100          XPRINT=XSAVE
24200          XSAVE=XSAVE+459.
24300          NCC1=NC1
24400          CALL VPIF(XSAVE,NCC1)
24500          TK=(XSAVE-491.)/1.8+273.
24600          IF(LSWTCH.EQ.99) GO TO 3160
24700          TYPE  3140
24800    3140  FORMAT(1X,'SINCE YOU DID NOT USE A LIBRARY CRUDE,')
24900          TYPE 3150
25000    3150  FORMAT(1X,'YOU MUST ENTER THE FOLLOWING THREE MOUSSE
25100         1 FORMATION CONSTANTS')
25200          GO TO 3180
25300    3160  TYPE 3170
25400    3170  FORMAT(1X,'DO YOU WANT TO ENTER NEW MOUSSE FORMATION CONS
25500         1TANTS?')
25600          ACCEPT 390, ANS
25700          IF(ANS.EQ.'N') GO TO 3240
25800    C
25900    C       TO SPECIFY NO MOUSSE, ENTER C2  = 0
26000    C
26100    3180  TYPE 3190
26200    3190  FORMAT(1X,'1. ENTER THE MAXIMUM WEIGHT FRACTION WATER
26300         1 IN OIL')
26400          ACCEPT 280, C2
26500          IF(C2.GT.0.) GO TO 3210
26600    C
26700    C       SET C2=-1. IF A MOUSSE CANNOT BE FORMED AND LOOP OUT.
26800    C
26900          C2=-1.
27000          TYPE 3200
27100    3200  FORMAT(/,1X,'SINCE A 0% WATER CONTENT WAS SPECIFIED
27200         1, THE REMAINING TWO MOUSSE',/,1X,'CONSTANTS ARE NOT
27300         2 NEEDED')
27400          GO TO 3250
27500    3210  C2=1./C2
27600          TYPE 3220
27700    3220  FORMAT(1X,'2. ENTER THE MOUSSE-VISCOSITY CONSTANT
27800         1, TRY 0.65')
27900          ACCEPT 280, C1
28000          TYPE 3230
28100    3230  FORMAT(1X,'3. ENTER THE WATER INCORPORATION RATE CONSTANT
28200         1, TRY 0.001')
28300          ACCEPT 280, C4
28400          GO TO 3250
28500    3240  C1=C1L(IC)
28600          C2=C2L(IC)
28700          C4=C4L(IC)
28800    3250  IF(LSWTCH.EQ.99) GO TO 3280
28900          TYPE 3260
29000    3260  FORMAT(/,1X,'YOU MUST ALSO ENTER AN OIL-WATER SURFACE
29100         1 TENSION (DYNES/CM')
29200          TYPE 3270
29300    3270  FORMAT(1X,'FOR DISPERSION, TRY 30.')
29400          GO TO 3310
29500    3280  TYPE 3290
29600    3290  FORMAT(1X,'DO YOU WANT TO ENTER A NEW OIL-WATER SURFACE
29700         1 TENSION (DYNES/CM)?')
29800          ACCEPT 390, ANS
29900          IF(ANS.EQ.'N') GO TO 3320
30000          TYPE 3300
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30100   3300  FORMAT(1X,'TRY 30.')
30200   3310  ACCEPT 280, STEN
30300         GO TO 3330
30400   3320  STEN=STENL(IC)
30500   C
30600   C       START THE MASS-TRANSFER COEFFICIENT SPECIFICATION.
30700   C
30800   3330  TYPE 3340
30900   3340  FORMAT(1X,'ENTER THE MASS-TRANSFER COEFFICIENT CODE: 1
31000        1, 2, OR 3 WHERE:')
31100         TYPE 3350
31200   3350  FORMAT(1X,'1=USER SPECIFIED OVER-ALL MASS-TRANSFER COEF
31300        1FICIENT')
31400         TYPE 3360
31500   3360  FORMAT(1X,'2=CORRELATION MASS-TRANSFER COEFFICIENT BY
31600        1 MACKAY & MATSUGU')
31700         TYPE 3370
31800   3370  FORMAT(1X,'3=INDIVIDUAL-PHASE MASS-TRANSFER COEFFICIENTS')
31900         ACCEPT 420, KMTC
32000   C
32100   C       NOW ENTER THE WIND SPEED IN KNOTS AND CONVERT TO METER/SEC
32200   C       AND METER/HOUR.
32300   C
32400         TYPE 3380
32500   3380  FORMAT(1X,'ENTER THE WIND SPEED IN KNOTS')
32600         ACCEPT 280, WINDS
32700   C
32800   C       NEVER LET THE WIND SPEED DROP BELOW 2 KNOTS.  A ZERO WIND
32900   C       SPEED DESTROYS THE MASS-TRANSFER CALCULATION AND WILL
33000   C       YIELD A ZERO MASS-TRANSFER COEFFICIENT.
33100   C
33200         IF(WINDS.LT.2.) WINDS=2.
33300         WINDMS=0.514*WINDS
33400         WINDMH=1853.*WINDS
33500   C
33600   C       NOW CALCULATE THE INITIAL GRAM MOLES FOR EACH COMPONENT TO
33700   C       GET THE INTEGRATION STARTED.
33800   C
33900   3390  BM=0.159*BBL
34000         TMOLES=0.
34100         DO 3400 I=1,NCUTS
34200         AMASS=1582.*SPGR(I)*BBL*VOL(I)
34300         MOLES(I)=AMASS/MW(I)
34400         MOLS(I)=MOLES(I)
34500         TMOLES=TMOLES+MOLES(I)
34600   C
34700   C       RHO IS THE DENSITY IN GM MOLES/CUBIC METER.
34800   C
34900         RHO(I)=100.*MOLES(I)/(BM*VOL(I))
35000   3400  CONTINUE
35100   C
35200   C       CALCULATE THE MEAN MOLECULAR WEIGHT OF THE CRUDE
35300   C
35400         WTMOLE=0.
35500         DO 3410 I=1,NCUTS
35600         WTMOLE=WTMOLE+MW(I)*MOLES(I)/TMOLES
35700   3410  CONTINUE
35800         WRITE (IOU,3420) WTMOLE
35900   3420  FORMAT(/,1X,'MEAN MOLECULAR WEIGHT OF THE CRUDE = ',1PE10.3)
36000   C
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36100   C       SPECIFY SLICK SPREADING.
36200   C
36300   3430  SPREAD=0.
36400         TYPE 3440
36500   3440  FORMAT(1X,'DO YOU WANT THE SLICK TO SPREAD?')
36600         ACCEPT 390, ANS
36700         IF(ANS.EQ.'N') GO TO 3450
36800         SPREAD=1.
36900         GO TO 3480
37000   C
37100   C       CALCULATE AN AREA IN SAME WAY IT WILL BE CALCULATED
37200   C       AS THE SLICK WEATHERS.  Z=THICKNESS IN METERS.
37300   C
37400   3450  IF (NZSWI.EQ.1) GO TO 3470
37500         TYPE 3460
37600   3460  FORMAT(1X,'SINCE THE SLICK DOES NOT SPREAD, ENTER
37700        1 A STARTING THICKNESS IN CM')
37800         ACCEPT 280, Z
37900   3470  Z=Z/100.
38000         GO TO 3490
38100   C
38200   C       THE SLICK ALWAYS STARTS AT 2-CM THICKNESS.
38300   C
38400   3480  IF (NZSWI.NE.0) GO TO 3490
38500         Z=0.02
38600   3490  VOLUM=0.
38700         DO 3500 I=1,NCUTS
38800         VOLUM=VOLUM+MOLES(I)/RHO(I)
38900   3500  CONTINUE
39000   C
39100   C       CALCULATE THE INITIAL AREA AND DIAMETER.
39200   C
39300         AREA=VOLUM/Z
39400         DIA=SQRT(AREA/0.785)
39500   C
39600   C       THE MASS-TRANSFER COEFFICIENT CAN BE CALCULATED ACCORDING TO:
39700   C
39800   C            1.  A USER-SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
39900   C
40000   C            2.  THE MASS-TRANSFER COEFFICIENT CORRELATION ACCORDING
40100   C                TO MACKAY AND MATSUGU, 1973, CAN. J. CHE, V51,
40200   C                P434-439.
40300   C
40400   C            3.  INDIVIDUAL OIL- AND AIR-PHASE MASS-TRANSFER COEFFI-
40500   C                CIENTS BASED ON SOME REAL ENVIRONMENTAL DATA SUCH
40600   C                AS THAT OF LISS AND SLATER.  SCALE THE AIR-PHASE
40700   C                VALUE WITH RESPECT TO WIND SPEED ACCORDING TO
40800   C                GARRATT, 1977, MONTHLY WEATHER REVIEW, V105,
40900   C                P915-920.
41000   C
41100   C      TEMP IS R*T AND USED TO CHANGE THE UNITS ON THE MASS-
41200   C      TRANSFER COEFFICIENT.
41300   C
41400   3510  TEMP=(8.2E-05)*TK
41500         GO TO (3520,3560,3710), KMTC
41600   C
41700   C       USER SPECIFIED OVER-ALL MASS-TRANSFER COEFFICIENT.
41800   C
41900   3520  TYPE 3530
42000   3530  FORMAT(1X,'ENTER THE OVER-ALL MASS-TRANSFER COEFFICIENT
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42100          1, CM/HR, TRY 10')
42200           ACCEPT 280, UMTC
42300           WRITE (IOU,3540) UMTC
42400    3540   FORMAT(1H1,'OVER-ALL MASS-TRANSFER COEFFICIENT WAS USER
42500          1-SPECIFIED AT ',1PE10.3,' CM/HR BY INPUT CODE 1')
42600    C
42700    C        CONVERT CM/HR TO GM-MOLES/(HR)(ATM)(M**2) SINCE VAPOR
42800    C        PRESSURE IS THE DRIVING FORCE FOR MASS TRANSFER.
42900    C
43000           UMTC=UMTC/TEMP/100.
43100           DO 3550 I=1,NC1
43200           MTC(I)=UMTC
43300    3550   CONTINUE
43400           GO TO 3790
43500    C
43600    C        USE THE MACKAY AND MATSUGU MASS-TRANSFER COEFFICIENT.
43700    C
43800    3560   TERM1=0.015*WINDMH**0.78
43900           IF(SPREAD.EQ.0.) GO TO 3570
44000           TERM2=DIA**(-0.11)
44100           GO TO 3580
44200    C
44300    C        IF THE SLICK DOES NOT SPREAD BASE THE DIAMETER DEPENDENCE
44400    C        ON 1000 METERS AND DIVIDE THE RESULT BY 0.7
44500    C
44600    3570   TERM2=0.65
44700    C
44800    C        KH INCLUDES THE SCHMIDT NUMBER FOR CUMENE.
44900    C
45000    3580   KH=TERM1*TERM2
45100           WRITE(IOU,3590)
45200    3590   FORMAT(1H1,'WEATHERING DATA FOR OIL ON THE OPEN OCEAN')
45300           IF(NIP.NE.1.AND.NBI.NE.1) GO TO 3650
45400           WRITE(IOU,3600)
45500    3600   FORMAT(1X,'AFTER:')
45600           IF(NIP.NE.1) GO TO 3620
45700           WRITE(IOU,3610) NHIP
45800    3610   FORMAT(9X,'ICE POOL WEATHERING FOR ',1PE9.3,' HOURS')
45900    3620   CONTINUE
46000           IF(NBI.NE.1) GO TO 3640
46100           WRITE(IOU,3630) NHBI
46200    3630   FORMAT(9X,'BROKEN ICE FIELD WEATHERING FOR ',1PE9.3,' HOURS')
46300    3640   CONTINUE
46400    3650   WRITE (IOU,3660) KMTC
46500    3660   FORMAT(/,1X,'OVER-ALL MASS-TRANSFER COEFFICIENTS BY INPUT
46600          1 CODE',I2)
46700           WRITE (IOU,3670) KH
46800    3670   FORMAT(/,1X,'OVER-ALL MASS-TRANSFER COEFFICIENT FOR CUMENE = '
46900          1,1PE10.3,' M/HR',/)
47000           WRITE (IOU,3680)
47100    3680   FORMAT(3X,'CUT',12X,'M/HR',7X,'GM-MOLES/(HR)(ATM)(M**2)')
47200           DO 3700 I=1,NC1
47300    C
47400    C        THE MASS-TRANSFER COEFFICIENT IS CORRECTED FOR THE
47500    C        DIFFUSIVITY OF COMPONENT I IN AIR.  THE SQRT IS USED
47600    C        (I.E. LISS AND SLATER), BUT THE 1/3 POWER COULD ALSO
47700    C        BE USED (I.E. THE SCHMIDT NUMBER).
47800    C
47900           MTCA(I)=KH*0.93*SQRT((MW(I)+29.)/MW(I))
48000    C
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C       MTC(I) IS THE OVER-ALL MASS-TRANSFER COEFFICIENT DIVIDED
C       BY R*T.  R=82.06E-06 (ATM)(M**3)/(G-MOLE)(DEG K)
C
      MTC(I)=MTCA(I)/TEMP
      WRITE (IOU,3690) I,MTCA(I),MTC(I)
3690  FORMAT(2X,I3,2(10X,1PE10.3))
3700  CONTINUE
      GO TO 3790
C
C       USER SPECIFIED INDIVIDUAL-PHASE MASS-TRANSFER
C       COEFFICIENTS.
C
3710  TYPE 3720
3720  FORMAT(1X,'ENTER THE OIL-PHASE MASS-TRANSFER COEFFICIENT
     1 IN CM/HR, TRY 10')
      ACCEPT 280, KOIL
      TYPE 3730
3730  FORMAT(1X,'ENTER THE AIR-PHASE MASS-TRANSFER COEFFICIENT
     1 IN CM/HR, TRY 1000')
      ACCEPT 280, KAIR
      TYPE 3740
3740  FORMAT(1X,'ENTER THE MOLECULAR WEIGHT OF THE COMPOUND
     1 FOR K-AIR ABOVE, TRY 200')
      ACCEPT 280, DATAMW
C
C       SCALE K-AIR ACCORDING TO WIND SPEED (GARRATT, 1977),
C       SO THAT AS THE WIND SPEED GOES UP THE MASS TRANSFER
C       GOES UP, I.E., THE CONDUCTANCE INCREASES.
C
      KAIR=KAIR*(1.+0.089*WINDMS)
      RKAIR=1./KAIR
C
C       CALCULATE R*T IN ATM*CM**3/GM-MOLE
C
      RT=82.06*TK
      HTERM=WTMOLE/(DCRUDE*RT)
      WRITE (IOU,3660) KMTC
C
C       WRITE THE USERS INPUT, WIND SPEED, AND HENRYS LAW
C       TERM TO THE OUTPUT.
C
      WRITE (IOU,3750) KAIR,KOIL,DATAMW
3750  FORMAT(/,1X,'K-AIR = ',1PE10.3,', AND K-OIL = ',1PE10.3
     1,' CM/HR, BASED ON A MOLECULAR WEIGHT OF ',1PE10.3)
      WRITE (IOU,3760) WINDMS
3760  FORMAT(1X,'WIND SPEED = ',1PE10.3,' M/S')
      WRITE (IOU,3770) HTERM
3770  FORMAT(1X,'THE HENRYS LAW CONVERSION TERM FOR OIL = '
     1,1PE10.3,' 1/ATM')
      WRITE (IOU,3680)
C
C       CALCULATE THE OVER-ALL MASS-TRANSFER COEFFICIENT BASED
C       ON GAS-PHASE CONCENTRATIONS FOR EACH CUT.
C
      DO 3780 I=1,NC1
      HLAW(I)=HTERM*VP(I)
      MTCA(I)=RKAIR+HLAW(I)/KOIL
C
C       NOW TAKE THE INVERSE TO OBTAIN CM/HR AND THEN MULTIPLY
C       BY 0.01 TO GET M/HR.
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C
      MTCA(I)=0.01/MTCA(I)
C
C       CORRECT FOR MOLECULAR WEIGHT ACCORDING TO LISS & SLATER,
C       1974, NATURE, V247, P181-184.
C
      MTCA(I)=MTCA(I)*SQRT(DATAMW/MW(I))
      MTC(I)=MTCA(I)/TEMP
C
C       AND WRITE THE OVER-ALL MASS-TRANSFER COEFFICIENT
C       IN M/HR AND MOLE/HR*ATM*M*M.
C
      WRITE (IOU,3690) I,MTCA(I),MTC(I)
3780  CONTINUE
3790  SPGRB=141.5/(APIB+131.5)
      MASS=0.1582*BBL*SPGRB
      WRITE (IOU,3800) BBL,MASS
3800  FORMAT(/,1X,'FOR THIS SPILL OF ',1PE10.3,' BARRELS, THE
     1 MASS IS ',1PE10.3,' METRIC TONNES')
      VOLUMB=VOLUM/0.159
      WRITE (IOU,3810) VOLUM,VOLUMB
3810  FORMAT(/,1X,'VOLUME FROM SUMMING THE CUTS = ',1PE8.1,' M**3
     1, OR ',1PE10.3,' BARRELS')
      GO TO (3840,3820,3840), KMTC
3820  WRITE (IOU,3830) WINDS,WINDMH
3830  FORMAT(/,1X,'WIND SPEED = ',1PE10.3,' KNOTS, OR ',1PE10.3
     1,' M/HR')
3840  WRITE (IOU,3850) DIA,AREA
3850  FORMAT(/,1X,'INITIAL SLICK DIAMETER = ',1PE10.3,' M, OR AREA
     1 = ',1PE10.3,' M**2')
      IF(SPREAD.GT.0.) GO TO 3870
      WRITE (IOU,3860)
3860  FORMAT(/,1X,'THIS SLICK DOES NOT SPREAD FOR THIS CALCULATION')
C
C       CALCULATE THE KINEMATIC VISCOSITY OF THE CRUDE AT 122
C       DEG F AND THE ENTERED ENVIRONMENTAL TEMPERATURE.
C       USE THE VISCOSITY MIXING RULE OF (MOLE FRACTION)*(LOG),
C       SEE PAGE 460 OF REID, PRAUSNITZ & SHERWOOD IN
C       THE BOOK 'THE PROPERTIES OF GASES AND LIQUIDS'
C
3870  VISMIX=0.
      DO 3880 I=1,NCUTS
      VISMIX=VISMIX+MOLES(I)*VLOGK(I)/TMOLES
3880  CONTINUE
      VISMIX=EXP(VISMIX)
      WRITE (IOU,3890) VISMIX
3890  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 3900 I=1,NCUTS
      VIS(I)=VISK(I)*EXPT
      VLOG(I)=ALOG(VIS(I))
      VISMIX=VISMIX+MOLES(I)*VLOG(I)/TMOLES
3900  CONTINUE
      VISMIX=EXP(VISMIX)
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60100          WRITE (IOU,3910) VISMIX,XPRINT,EXPT
60200    3910  FORMAT(/,1X,'KINEMATIC VISCOSITY OF THE BULK CRUDE FROM THE
60300         1 CUTS = ',1PE8.1,' AT T = ',0PF5.1,' DEG F, SCALE
60400         2 FACTOR = ',1PE8.1)
60500    C
60600    C       IMPORTANT NOTE:  THE VISCOSITY PREDICTION OF THE WHOLE
60700    C       CRUDE FROM CUT INFORMATION IS NOT GOOD AT ALL.  SO THE
60800    C       VISCOSITY INFOMATION CALCULATED ABOVE IS NOT USED IN
60900    C       THIS VERSION OF THE CODE, BUT IT COULD BE IF A GOOD
61000    C       MIXING RULE IS EVER DETERMINED.
61100    C       THEREFORE, FOR THE TIME BEING, THE VISCOSITY OF THE WHOLE
61200    C       WEATHERED CRUDE IS CALCULATED ACCORDING TO MACKAY.
61300    C
61400    C       NOW LOAD THE VISCOSITY INFORMATION IN THE FORM
61500    C       OF THREE CONSTANTS:
61600    C            1.  THE VISCOSITY IN CP AT 25 DEG C
61700    C            2.  THE ANDRADE-VISCOSITY-SCALING CONSTANT
61800    C                WITH RESPECT TO TEMPERATURE, SEE GOLD &
61900    C                OGLE, 1969, CHEM. ENG., JULY 14, P121-123
62000    C            3.  THE VISCOSITY AS AN EXPONENTIAL FUNCTION OF
62100    C                THE FRACTION OF OIL WEATHERED
62200    C
62300          IF(LSWTCH.EQ.99) GO TO 3930
62400          TYPE 3920
62500    3920  FORMAT(1X,'SINCE A LIBRARY CRUDE WAS NOT USED
62600         1,',/,1X,'ENTER THE FOLLOWING THREE VISCOSITY CONSTANTS')
62700          GO TO 3950
62800    3930  TYPE 3940
62900    3940  FORMAT(1X,'DO YOU WANT TO ENTER NEW VISCOSITY CONSTANTS?')
63000          ACCEPT 390, ANS
63100          IF(ANS.EQ.'N') GO TO 3990
63200    3950  TYPE 3960
63300    3960  FORMAT(1X,'1. ENTER THE BULK CRUDE VISCOSITY
63400         1 AT 25 DEG C, CENTIPOISE, TRY 35.')
63500          ACCEPT 280, VISZ
63600          TYPE 3970
63700    3970  FORMAT(1X,'2. ENTER THE VISCOSITY TEMPERATURE SCALING
63800         1 CONSTANT (ANDRADE), TRY 9000.')
63900          ACCEPT 280, MK3
64000          TYPE 3980
64100    3980  FORMAT(1X,'3. ENTER THE VISCOSITY-FRACTION-OIL
64200         1-WEATHERED CONSTANT, TRY 10.5')
64300          ACCEPT 280, MK4
64400          GO TO 4000
64500    C
64600    C       USE THE LIBRARY VISCOSITY DATA
64700    C
64800    3990  VISZ=VISZL(IC)
64900          MK3=MK3L(IC)
65000          MK4=MK4L(IC)
65100    C
65200    C       INSERT VISCOSITY CALCULATION ACCORDING TO MASS
65300    C       FRACTION EVAPORATED.  THIS IS THE VISCOSITY
65400    C       MODIFICATION RELATIVE TO CUTVP1
65500    C
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 4000  VSLEAD=VISZ*EXP(MK3*(1./TK-0.003357))
       WRITE (IOU,4010) VISZ,MK3,MK4,VSLEAD
 4010  FORMAT(/,1X,'VISCOSITY ACCORDING TO MASS EVAPORATED:
      1 VIS25C =',1PE9.2,', ANDRADE =',1PE9.2
      2,', FRACT WEATHERED =',1PE9.2', VSLEAD =',1PE9.2
      3,' CP')
       C2P=1./C2
       WRITE (IOU,4300) C1,C2P,C4
       NEQ=NCUTS
C
C        SET UP THE DISPERSION PROCESS CONSTANTS.
C        CALCULATE THE FRACTION OF THE SEA SURFACE SUBJECT TO
C        DISPERSIONS/HOUR.
C
       TYPE 4020
 4020  FORMAT(1X,'DO YOU WANT THE WEATHERING TO OCCUR WITH
      1 DISPERSION?')
       ACCEPT 390, ANS
       FRACTS=0.
       IF(ANS.EQ.'N') GO TO 4080
       IF(LSWTCH.NE.99) GO TO 4040
       TYPE 4030
 4030  FORMAT(1X,'DO YOU WANT TO ENTER NEW DISPERSION
      1 CONSTANTS?')
       ACCEPT 390, ANS
       IF(ANS.EQ.'N') GO TO 4070
 4040  TYPE 4050
 4050  FORMAT(1X,'ENTER THE WIND SPEED CONSTANT, TRY 0.1')
       ACCEPT 280, KA
       TYPE 4060
 4060  FORMAT(1X,'ENTER THE CRITICAL DROPLET SIZE CONSTANT
      1, TRY 50')
       ACCEPT 280, KB
 4070  FRACTS=KA*(1.+WINDMS)**2
 4080  WRITE (IOU,4090) FRACTS
 4090  FORMAT(/,1X,'THE FRACTIONAL SLICK AREA SUBJECT TO
      1 DISPERSION IS ',1PE8.1,' PER HOUR')
       IF(ANS.EQ.'N') GO TO 4110
       WRITE (IOU,4100) KA,KB,STEN
 4100  FORMAT(1X,'THE DISPERSION PARAMETERS USED:  KA = '
      1,1PE9.2,', KB = ',1PE9.2,', SURFACE TENSION = ',1PE9.2
      2,' DYNES/CM')
C
C        PRINT EVERY XP TIME INCREMENT (HOURS).
C        X1 IS THE STARTING TIME = 0.
C        X2 IS THE NUMBER OF HOURS FOR WEATHERING TO OCCUR.
C
 4110  XP=1.
       X1=0.
       MOLS(NCUTS+1)=AREA
C
C        PRINT AN OUTPUT FILE FOR 80 COLUMN OUTPUT, THIS IS
C        THE CUTVP2.TYP FILE.
C
       WRITE(ITY,4120)
 4120  FORMAT(1H1,'OPEN OCEAN WEATHERING')
       IF(NIP.NE.1.AND.NBI.NE.1) GO TO 4180
       WRITE(ITY,4130)
 4130  FORMAT(1X,'AFTER:')
       IF(NIP.NE.1) GO TO 4150
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      WRITE(ITY,4140) NHIP
 4140 FORMAT(9X,'ICE POOL WEATHERING FOR ',1PE9.3,' HOURS')
 4150 CONTINUE
      IF(NBI.NE.1) GO TO 4170
      WRITE(ITY,4160) NHBI
 4160 FORMAT(9X,'BROKEN ICE FIELD WEATHERING FOR ',1PE9.3,' HOURS')
 4170 CONTINUE
 4180 WRITE (ITY,4190) (ANAME(J),J=1,5)
 4190 FORMAT(/,1X,'OIL: ',5A5)
      WRITE (ITY,4200) XPRINT,WINDS
 4200 FORMAT(1X,'TEMPERATURE= ',F5.1,' DEG F, WIND SPEED= '
     1,F5.1,' KNOTS')
      WRITE (ITY,4210) BBL
 4210 FORMAT(1X,'SPILL SIZE= ',1PE10.3,' BARRELS')
      WRITE (ITY,4220) KMTC
 4220 FORMAT(1X,'MASS-TRANSFER COEFFICIENT CODE=',I3)
      WRITE (ITY,4230)
 4230 FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS, MOLES
     1=GRAM MOLES')
      WRITE (ITY,4240)
 4240 FORMAT(1X,'GMS=GRAMS, VP=VAPOR PRESSURE IN ATMOSPHERES')
      WRITE (ITY,4250)
 4250 FORMAT(1X,'BP=BOILING POINT IN DEG F, API=GRAVITY')
      WRITE (ITY,4260)
 4260 FORMAT(1X,'MW=MOLECULAR WEIGHT')
      WRITE (ITY,4270)
 4270 FORMAT(/,2X,'CUT',3X,'MOLES',6X,'GMS',8X,'VP',8X,'BP'
     1,7X,'API',5X,'MW')
      DO 4290 I=1,NCUTS
      GMS=MOLES(I)*MW(I)
      IMW=MW(I)
      WRITE (ITY,4280) I,MOLES(I),GMS,VP(I),TB(I),API(I),IMW
 4280 FORMAT(3X,I2,5(1X,1PE9.2),1X,I3)
 4290 CONTINUE
      WRITE (ITY,4300) C1,C2P,C4
 4300 FORMAT(/,1X,'MOUSSE CONSTANTS: MOONEY=',1PE9.2
     1,', MAX H20=',0PF5.2,', WIND**2=',1PE9.2)
      WRITE (ITY,4310) KA,KB,STEN
 4310 FORMAT(1X,'DISPERSION CONSTANTS: KA=',1PE9.2
     1,', KB=',1PE9.2,', S-TENSION=',1PE9.2)
      WRITE (ITY,4320) VISZ,MK3,MK4
 4320 FORMAT(1X,'VIS CONSTANTS: VIS25C=',1PE9.2
     1,', ANDRADE =',1PE9.2,', FRACT =',1PE9.2)
      WRITE (ITY,4330)
 4330 FORMAT(/,1X,'FOR THE OUTPUT THAT FOLLOWS, TIME=HOURS')
      WRITE (ITY,4340)
 4340 FORMAT(1X,'BBL=BARRELS, SPGR=SPECIFIC GRAVITY, AREA=M*M')
      WRITE (ITY,4350)
 4350 FORMAT(1X,'THICKNESS=CM, W=PERCENT WATER IN OIL (
     1MOUSSE)')
      WRITE (ITY,4360)
 4360 FORMAT(1X,'DISP=DISPERSION RATE IN GMS/M*M/HR')
      WRITE (ITY,4370)
 4370 FORMAT(1X,'ERATE=EVAPORTION RATE IN GMS/M*M/HR')
      WRITE (ITY,4380)
 4380 FORMAT(1X,'M/A=MASS PER M*M OF OIL IN THE SLICK')
      WRITE (ITY,4390)
 4390 FORMAT(1X,'I=FIRST CUT WITH GREATER THAN  1% (MASS)
     1 REMAINING')
      WRITE (ITY,4400)
```

```
12100   4400  FORMAT(1X,'J=FIRST CUT WITH GREATER THAN 50% (MASS)
12200        1 REMAINING')
12300         IF(FRACTS.NE.0.) GO TO 4420
12400         WRITE (ITY,4410)
12500   4410  FORMAT(1X,'DISPERSION WAS TURNED OFF')
12600   4420  IF(SPREAD.NE.0.) GO TO 4440
12700         WRITE (ITY,4430)
12800   4430  FORMAT(1X,'SPREADING WAS TURNED OFF')
12900   4440  TCODE=KMTC
13000         TYPE 4450
13100   4450  FORMAT(/,1X,'PLEASE WAIT')
13200         CALL BRKG4(MOLS,X1,X2,XP,NEQ,NDEL)
13300   4460  CONTINUE
13400         WRITE(IOU,4470)
13500   4470  FORMAT(//,1X,'********* FINAL OVERALL MASS BALANCE FOR PARENT
13600        1 OIL ***********')
13700         CHECK=TMASS+TME+TMD+DELMAS
13800         DO 4480 I=1,NG
13900         FMF(I)=0.
14000   4480  CONTINUE
14100         DO 4490 I=1,NEQ
14200         FMF(I+NG)=YM1(I)/MASSAV(I+NG)
14300   4490  CONTINUE
14400         WRITE(IOU,4500)
14500   4500  FORMAT(/,1X,'FINAL MASS FRACTIONS OF CUTS:')
14600         WRITE (IOU,4510) (FMF(I),I=1,NEQ+NG)
14700   4510  FORMAT(11(1X,1PE10.3))
14800         FR=TMASS/TMASAV
14900         WRITE(IOU,4520)FR
15000   4520  FORMAT(1X,'FRACTION (BASED ON MASS) REMAINING= ',1PE10.3)
15100         WRITE(IOU,4530) TMASS,TMD,TME,DELMAS,CHECK
15200   4530  FORMAT(1X,'MASS REMAINING= ',1PE9.3,1X,'MASS DISPERSED= ',1PE9.3,
15300        11X,'MASS EVAPORATED= ',1PE9.3,1X,'MASS DELETED= '
15400        2,1PE9.3,1X,'TOTAL= ',1PE9.3)
15500         WRITE(IOU,4540) TMASAV
15600   4540  FORMAT(1X,'ORIGINAL MASS= ',1PE9.3)
15700   4550  END
  100         REAL*4 MW,MOLS,KA,KB,MOLES,MTC,MWU,K,K0,MK,MW1,K11,MK4
  200        1,MK3L,MK4L,MTCA,KH,KOIL,KAIR,MASS,MK3,MOLSAV,MLSAV,MASSAV
  300        2,NHIP,NHBI
  350           CHARACTER*5 ANAMEL,ANAME
  375           CHARACTER*10 FNAME
  400         COMMON /LIST1/TBL(6,30),APIL(6,30),VOLL(6,30),ANAMEL(6,5)
  500        1,DESC(30,5),VOL(30),APIBL(6),ANAME(5)
  600        2,C1L(6),C2L(6),C4L(6),STENL(6),VISZL(6),MK3L(6)
  700        3,MK4L(6),TB(30)
  800        4,API(30),SPGR(30),MW(30),MOLES(30),RHO(30),MTC(30),MTCA(30)
  900        5,HLAW(30),VLOGK(30),VLOG(30),VP(30),VISK(30),VIS(30),YM(30)
 1000        6,GONE(30),T10(30),MLSAV(30),MASSAV(30)
 1100        7,UOP(30),CI(30),OSPGR(30),OAPI(30),OUOP(30)
 1200        8,TC(30),VC(30),PC(30),HVAP1(30),A(30),B(30)
 1300        9,HVAPZ(30),CNUM(30),DELH(30),DELHTB(30),EM(30)
 1400        1,MWU(30),VPI(30),VFRAC(100),WYI(30),TBNN(100),K0(30),MK(30)
 1500        2,TMPVP(30),TMPDS(30),YM1(30),MOLS(30)
 1600        3,K(30),YSAVE(30),YMSAVE(30),YF(30)
 1700        4,FRACTS,DISPER,Z,TERM2,SPREAD,KB,WINDS,C1,C2,C3,C4,K11,MK4
 1800        5,APISWI,APIB,KH,KOIL,KAIR,MASS,MK3,MW1,TC1,VC1,PC1,CNUM1,VIS1
 1900        6,VSLEAD,STEN,DCRUDE,BM,TMOLES,WTMOLE,MOLSAV,TME,TMD,FE,HOUMOU
 2000        7,TMASAV,C3SAVE,NHIP,NHBI,TMASS,DELMAS,SPRFAC,TE
 2100         COMMON /LIST2/ NCTS(6),ITEML(6),ISAMPL(6),NC(30)
 2200        1,NS(30),NEQ1,NEQ2,NEQ3,IOU,IPU,ITY,NC1,NCUTS,KMTC,MOUSWI
 2300        2,LINE,NIP,NBI,NQUIT,ITEM,ISAMP
```

```
      SUBROUTINE DOCHAR
      INCLUDE 'VARI.FOR'
C
C       THIS SUBROUTINE CHARACTERIZES THE CUTS.  IF THE LAST CUT IS
C       RESIDUUM DO NOT CHARACTERIZE IT BUT USE A VAPOR
C       PRESSURE OF 0. AND A MOLECULAR WEIGHT OF 600.
C
10    MW(NCUTS)=600.
      VP(NCUTS)=0.
C
C       NV=1 MEANS NO RESIDUUM CUT PRESENT.
C       NV=2 MEANS A RESIDUUM IS PRESENT.
C
      NV=1
      NC1=NCUTS
      DO 90 I=1,NCUTS
      SPGR(I)=141.5/(API(I)+131.5)
      SPGR(I)=0.983*SPGR(I)
C
C       IF APISWI=1 (PREVIOUS WEATHERING HAS OCCURED), CALCULATE
C       A NEW BULK API GRAVITY
C
      DCRUDE=0.
      DO 20 J=1,NCUTS
      DCRUDE=((VOL(J)*SPGR(J))/100)+DCRUDE
20    CONTINUE
      APIB=(141.5/DCRUDE)-131.5
      TBN=TB(I)
C
C       CALCULATE U.O.P. K-FACTOR AND CORRELATION INDEX
C
      UOP(I)=((TB(I)+459.)**.33333)/SPGR(I)
      CI(I)=(473.7*SPGR(I))-456.8+(49339/(((TB(I)-32.)/1.8)+273.))
      APIN=API(I)
C
C       THE RESIDUUM CUT IS IDENTIFIED BY A NORMAL BOILING
C       POINT OF 850.  LOOP AROUND THE NV=2 SWITCH IF A
C       RESIDUUM IS PRESENT.  NC1 IS THE NUMBER OF PSEUDO COMPONENTS
C       WITH FINITE VAPOR PRESSURES.
C
      IF(TBN.LT.850.) GO TO 30
      NV=2
      NC1=NCUTS-1
30    CALL CHAR(APIN,TBN,AN,BN,NSN,NV)
C
C       THE CHARACTERIZATION SUBROUTINE RETURNS THE LOG10 OF THE
C       KINEMATIC VISCOSITY (CENTISTOKES) AT 122 DEG F.
C
      VISK(I)=10.**VIS1
      VLOGK(I)=ALOG(VISK(I))
      GO TO (40,90), NV
C
C       STORE THE CUT INFORMATION FOR A NON-RESIDUUM CUT.
C
40    NS(I)=NSN
      A(I)=AN
      B(I)=BN
      MW(I)=MW1
      TC(I)=TC1
      TC(I)=TC(I)+459.
```

```
      VC(I)=VC1
      PC(I)=PC1
      CNUM(I)=CNUM1
C
C       FIND THE TEMPERATURE AT WHICH THE VAPOR PRESSURE IS 10 MMHG
C       BY USING NEWTON-RAPHSON WITH TB AS THE FIRST GUESS.
C
      NC(I)=0
      YTEN=ALOG10(0.01315/PC(I))
      X=(TB(I)+459.)/TC(I)
50    EX=EXP(-20.*(X-B(I))**2)
      Y=-A(I)*(1.-X)/X-EX
      YOBJ=Y-YTEN
      VP(I)=PC(I)*10.**Y
      TEST=ABS(VP(I)-0.01315)
      IF(TEST.LT.0.001315) GO TO 80
      NC(I)=NC(I)+1
      IF(NC(I).GT.20) GO TO 60
      DY=A(I)/(X*X)+40.*(X-B(I))*EX
      BI=YOBJ-DY*X
      X=-BI/DY
      GO TO 50
C
C       UNSUCCESSFUL EXIT FROM NEWTON-RAPHSON
C
60    TYPE 70, I,X,Y
70    FORMAT(1X,'T10 FAILURE FOR',I4,' AT T = ',1PE10.3,' WHERE
     1 LOG10(P) = ',1PE10.3)
      GO TO 460
C
C       SUCCESSFUL EXIT FROM NEWTON-RAPHSON
C
80    T10(I)=X*TC(I)
C
C       CALCULATE THE HEAT OF VAPORIZATION AT 10 MMHG WITH THE
C       CLAPEYRON EQUATION AND USE WATSONS METHOD FOR THE
C       VAPOR PRESSURE BELOW 10 MMHG.  SEE GAMSON AND WATSON,
C       1944, NATIONAL PETROLEUM NEWS, R-258 TO R-264.
C
      TR2=T10(I)/TC(I)
      EX=92.12*(TR2-B(I))*EXP(-20.*(TR2-B(I))**2)
      HVAP=1.987*T10(I)*T10(I)*(2.303*A(I)/(TR2*TR2)+EX)/TC(I)
      HVAP1(I)=HVAP/MW(I)
      HVAPZ(I)=HVAP/(1.-TR2)**0.38
90    CONTINUE
C
C       END OF TRUE-BOILING-POINT CUTS CHARACTERIZATION
C
      WRITE (IOU,100) (ANAME(I),I=1,5)
100   FORMAT(1H1,'SUMMARY OF TBP CUTS CHARACTERIZATION FOR: '
     1,5A5)
      IF(NIP.NE.1.AND.NBI.NE.1) GO TO 150
      WRITE(IOU,110)
110   FORMAT(1X,'AFTER:')
      IF(NIP.NE.1) GO TO 130
      WRITE(IOU,120) NHIP
120   FORMAT(8X,'ICE POOL WEATHERING FOR ',1PE9.3,' HOURS')
130   CONTINUE
      IF(NBI.NE.1) GO TO 150
      WRITE(IOU,140) NHBI
```

```
140   FORMAT(8X,'BROKEN ICE FIELD WEATHERING FOR ',1PE9.3,' HOURS')
150   CONTINUE
      WRITE (IOU,160)
160   FORMAT(/,1X,'CODE VERSION IS CUTICA OF MAY 84')
      WRITE (IOU,170) ITEM,ISAMP
170   FORMAT(1X,'ITEM ',I5,', SAMPLE ',I5)
180   CONTINUE
      WRITE (IOU,190)
190   FORMAT(/,8X,'TB',7X,'API',6X,'SPGR',7X,'VOL',8X,'MW',8X
     1,'TC',8X,'PC',8X,'VC',8X,'A',9X,'B',8X,'T10',7X,'VIS'
     2,4X,'NC NS')
      DO 210 I=1,NCUTS
      WRITE (IOU,200) I,TB(I),API(I),SPGR(I),VOL(I),MW(I),TC(I)
     1,PC(I),VC(I),A(I),B(I),T10(I),VISK(I),NC(I),NS(I)
200   FORMAT(1X,I2,12(1X,1PE9.2),2(1X,I2))
210   CONTINUE
      WRITE(IOU,220)
220   FORMAT(//,7X,'UOP K',4X,'CORRELATION INDEX')
      DO 240 I=1,NCUTS
      WRITE(IOU,230) I,UOP(I),CI(I),(DESC(I,J), J=1,5)
230   FORMAT(1X,I2,1X,1PE9.2,7X,1PE9.2,7X,5A5)
240   CONTINUE
      WRITE (IOU,250) APIB
250   FORMAT(//,1X,'BULK API GRAVITY = ',F5.1)
      WRITE (IOU,260)
260   FORMAT(//,1X,'TB = NORMAL BOILING TEMPERATURE, DEG F')
      WRITE (IOU,270)
270   FORMAT(1X,'API = API GRAVITY')
      WRITE (IOU,280)
280   FORMAT(1X,'VOL = VOLUME PER CENT OF TOTAL CRUDE')
      WRITE (IOU,290)
290   FORMAT(1X,'MW = MOLECULAR WEIGHT')
      WRITE (IOU,300)
300   FORMAT(1X,'TC = CRITICAL TEMPERATURE, DEG RANKINE')
      WRITE (IOU,310)
310   FORMAT(1X,'PC = CRITICAL PRESSURE, ATMOSPHERES')
      WRITE (IOU,320)
320   FORMAT(1X,'VC = CRITICAL VOLUME, CC/MOLE')
      WRITE (IOU,330)
330   FORMAT(1X,'A AND B ARE PARAMETERS IN THE VAPOR PRESSURE
     1 EQUATION')
      WRITE (IOU,340)
340   FORMAT(1X,'T10 IS THE TEMPERATURE IN DEG R WHERE THE VAPOR
     1 PRESSURE IS 10 MM HG')
      WRITE (IOU,350)
350   FORMAT(1X,'VIS IS THE KINEMATIC VISCOSITY IN CENTISTOKES
     1 AT 122 DEG F')
      WRITE(IOU,360)
360   FORMAT(1X,'UOP K IS THE U.O.P. K CHARACTERIZATION FACTOR')
      WRITE(IOU,370)
370   FORMAT(1X,'CORRELATION INDEX IS DEFINED IN (COLEMAN, 1978)')
      WRITE (IOU,380)
380   FORMAT(1X,'NC = ERROR CODE, SHOULD BE LESS THAN 20')
      WRITE (IOU,390)
390   FORMAT(1X,'NS = ERROR CODE, SHOULD BE EQUAL TO 1')
      WRITE (IOU,400) NCUTS
400   FORMAT(1X,'IGNORE THE ERROR CODES FOR COMPONENT NUMBER ',I2
     1,' IF IT IS A RESIDUUM')
410   WRITE (IPU,420) ITEM,ISAMP
420   FORMAT(2I5)
```

```
      WRITE (IPU,430) (ANAME(I),I=1,5)
430   FORMAT(5A5)
C
C       THE CUTVP2.PLT PLOT FILE IS WRITTEN AS:
C            1.  ITEM AND SAMPLE NUMBER ON 2I5
C            2.  THE CRUDE NAME ON 5A5
C            3.  NCUTS ON I5
C            4.  BOILING POINT IN DEG F OF EACH CUT ON
C                10(1X,1PE10.3).
C            5.  TEMPERATURE IN DEG F OF EVAPORATION, XPRINT
C                WIND SPEED IN KNOTS, WINDS
C                KA AND KB IN THE DISPERSION EQUATION,
C                SURFACE TENSION IN DYNES/CM, STEN
C                VOLUME OF THE SPILL IN BARRELS, BBL
C                C1, C2, AND C4 IN THE MOUSSE EQUATION,
C                KMTC, MASS TRANSFER COEFFICIENT CODE (FLOATED).
C                ALL ON 10(1X,1PE10.3).
C            6.  NUMBER OF CUTS+1 ON I5
C            7.  TIME, MASS OF CUTS, AREA ON 10(1X,1PE10.3)
C            8.  TOTAL MASS FRACTION REMAINING IN THE OIL
C                SLICK FOR EACH TIME STEP PRINTED ON
C                10(1X,1PE10.3)
C
C       ITEMS 6 AND 7 ABOVE ARE WRITTEN FOR EACH TIME STEP
C       WITH THE FIRST TIME STEP BEING ZERO.  WHEN THE
C       VERY LAST TIME STEP IS WRITTEN THEN ITEM 8 IS WRITTEN.
C
C       THE NUMBER OF LINES WRITTEN ON THE CUTVP2.PLT PLOT FILE
C       REFERS TO THE NUMBER OF 'TIMES' WRITTEN THROUGH
C       ITEMS 6 AND 7 ABOVE.
C
      WRITE (IPU,440) NCUTS
440   FORMAT(I5)
      WRITE (IPU,450) (TB(I),I=1,NCUTS)
450   FORMAT(10(1X,1PE10.3))
460   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CHAR(API1,TB1,A1,B1,NS1,NV)
      INCLUDE 'VARI.FOR'
      DIMENSION T(2,6),C(2,6),P(4),V(2,6)
      DATA ((C(I,J),J=1,6),I=1,2)/6.241E+01,-4.595E-02,-2.836E-01
     1,3.256E-03,4.578E-04,5.279E-04
     2,4.268E+02,-1.007,-7.449,1.38E-02,1.047E-03,2.621E-02/
      DATA ((T(I,J),J=1,6),I=1,2)/4.055E+02,1.337,-2.662,-2.169E-03
     1,-4.943E-04,1.454E-02
     2,412.2,1.276,-2.865,-2.888E-03,-3.707E-04,2.888E-02/
      DATA P/1.237E-02,0.2516,4.039E-02,-4.024E-02/
      DATA ((V(I,J),J=1,6),I=1,2)/ -0.4488,-9.344E-04,0.01583
     1,-5.219E-05,5.268E-06,1.536E-04
     2,-0.6019,1.793E-03,-3.159E-03,-5.1E-06,9.067E-07,3.522E-05/
C
C       THIS SUBROUTINE CHARACTERIZES A CUT OF CRUDE OIL WITH RESPECT
C       TO VAPOR PRESSURE.  THE INPUT REQUIRED IS API GRAVITY AND THE
C       BOILING POINT AT 1 ATMOSPHERE.  THE OUTPUT IS A SWITCH NS
C       WHERE NS1=1 MEANS THE VAPOR PRESSURE EQUATION CAN BE USED DOWN T
C       10MM HG AND NS=2 MEANS THE CLAPEYRON EQUATION SHOULD BE USED.
C
C       THE VAPOR PRESSURE EQUATION IS:
C
C       LOG10(PR) = -A*(1.-TR)/TR - EXP(-20*(TR-B)**2)
C
C       WHERE PR = REDUCED PRESSURE, TR = REDUCED TEMPERATURE AND
C       A AND B ARE RETURNED BY THIS SUBROUTINE.
C
C       API = GRAVITY, TB = BOILING POINT AT 1 ATMOSPHERE IN DEG F.
C       CALCULATE CRITICAL TEMPERATURE AND MOLECULAR WEIGHT.
C
      API2=API1*API1
      TB2=TB1*TB1
      CROSS=API1*TB1
      I=1
      IF(API1.GT.35.) I=2
      VIS1=V(I,1)+V(I,2)*TB1+V(I,3)*API1+V(I,4)*CROSS+V(I,5)*TB2
     1+V(I,6)*API2
      GO TO (10,30), NV
10    I=1
      IF(TB1.GT.500.) I=2
      MW1=C(I,1)+C(I,2)*TB1+C(I,3)*API1+C(I,4)*CROSS+C(I,5)*TB2
     1+C(I,6)*API2
      TC1=T(I,1)+T(I,2)*TB1+T(I,3)*API1+T(I,4)*CROSS+T(I,5)*TB2
     1+T(I,6)*API2
      TCK=(TC1+459.)/1.8
C
C       CALCULATE THE VISCOSITY OF THE CUT.
C
      I=1
      IF(API1.GT.35.) I=2
      VIS1=V(I,1)+V(I,2)*TB1+V(I,3)*API1+V(I,4)*CROSS+V(I,5)*TB2
     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)))
      B1=BPRIME-0.02
C
C       CALCULATE THE CRITICAL VOLUME, CC/GMOLE
C
      VW=1.88+2.44*CNUM1
      VC1=VW/0.044
C
C       CALCULATE THE CRITICAL PRESSURE IN ATMOSPHERES
C
      PCP=20.8*TCK/(VC1-8.)
      PC1=PCP+10.
      TR=(TB1+459.)/(TC1+459.)
      PR=1./PC1
      NS1=1
      IF(TR.LE.B1) GO TO 20
      A1=(ALOG10(PR)+EXP(-20.*(TR-B1)**2))*TR/(TR-1.)
      GO TO 30
20    NS1=2
30    RETURN
      END
```

```
      SUBROUTINE MACK
      REAL*4 KAY,KAY0,MID,MOLEFT,MDH,MVO,L0,LH
      INCLUDE 'VARI.FOR'
      DIMENSION KAY(30),KAY0(30)
C
C       THIS SUBROUTINE CALCULATES THE INPUT PARAMETERS FOR THE
C       MACKAY EVAPORATION MODEL
C
C       THE MACKAY EVAPORATION EQUATION IS:
C
C             DF = DTHETA * H
C
C       WHERE DF IS THE CHANGE IN THE VOLUME FRACTION EVAPORATED
C       IN ONE TIME INCREMENT,  H IS THE HENRY'S LAW COEFFICIENT, AND
C       DTHETA IS THE INCREASE IN THE "EVAPORATIVE EXPOSURE", WHICH
C       IS DEFINED AS:
C
C           DTHETA = K*A*DT/V
C
C       WHERE A IS THE SLICK AREA, DT IS THE TIME INCREMENT, V IS
C       THE SLICK VOLUME AT THE BEGINNING OF THE TIME INCREMENT,
C       AND K IS THE MASS TRANSFER COEFFICIENT.
C
C       FIRST DETERMINE WHICH CUTS EVAPORATE.  FOR NOW USE CUTS WHICH
C       HAVE VAPOR PRESSURES GREATER THEN 1X10E-07 AT
C       ENVIRONMENTAL TEMPERATURE.
C
      MAC=40
      CUTOFF=1.0E-07
      ICNT=0
10    ICNT=ICNT+1
      IF (VP(ICNT).GT.CUTOFF) GO TO 10
      ICNT=ICNT-1
C
C       CALCULATE HEAT OF VAPORIZATION USING RESULTS OF
C       FALLON AND WATSON
C
      DO 20 I=1,ICNT
      API2=API(I)*API(I)
      TB2=TB(I)*TB(I)
      CROSS=API(I)*TB(I)
      DELH(I)=232.2-(0.2441*TB(I))-(0.6937*API(I))
     1-(3.583E-04*CROSS)+(1.024E-04*TB2)+(1.037E-04*API2)
      DELH(I)=DELH(I)*MW(I)
      DELHTB(I)=DELH(I)/(TB(I)+459.)
20    CONTINUE
C
C       CALCULATE MEAN (DELTAH/TB) FOR "TROUTON'S RULE"
C
      SDH=0
      DO 30 I=1,ICNT
      SDH=SDH+DELHTB(I)
30    CONTINUE
      MDH=SDH/ICNT
C
C       CALCULATE MOLAR VOLUME OF OIL
C
      MVO=WTMOLE/DCRUDE
C
C       NOW PERFORM A SIMPLE (ZERO PLATE) BATCH
```

```
C       DISTILLATION IN ORDER TO FIND THE BUBBLE POINT VERSUS
C       VOLUME FRACTION DISTILLED CURVE.  THE INTEGRATION IS
C       CARRIED OUT USING A FIRST ORDER RUNGA-KUTTA NUMERICAL
C       INTEGRATION SCHEME (SEE GREENSPAN, 1971).
C
C       TVOL IS THE TOTAL VOLUME OF THE BATCH (INITIALLY) IN METERS
C       CUBED.  VOLU IS THE REMAINING VOLUME OF THE BATCH.
C       EM(I) IS THE NUMBER OF GRAM-MOLES REMAINING
C       IN EACH CUT.  MOLEFT IS THE TOTAL NUMBER OF MOLES LEFT.
C       L0 IS THE TOTAL INITIAL NUMBER OF MOLES IN THE BATCH.
C
      WRITE(MAC,40)
40    FORMAT(1H1,2X,'**************** MACKAY PARAMETER CALCULATIONS
     1 *******************')
      WRITE(MAC,50)
50    FORMAT(/,2X,'THE MACKAY EVAPORATION MODEL IS DESCRIBED IN')
      WRITE(MAC,60)
60    FORMAT(2X,'(MACKAY,1982)')
      WRITE(MAC,70)
70    FORMAT(2X,'THE FOLLOWING ARE THE RESULTS OF A CALCULATION OF THE')
      WRITE(MAC,80) (ANAME(I),I=1,5)
80    FORMAT(2X,'INPUT PARAMETERS FOR THE MACKAY MODEL FOR ',5A5)
      TT=TE-459.
      WRITE(MAC,90) TT
90    FORMAT(2X,'AT ',1PE9.3,' DEGREES F')
      WRITE(MAC,100)
100   FORMAT(//,2X,'SIMULATED ONE-PLATE BATCH DISTILLATION:')
      TVOL=BM
      VOLU=BM
      DO 110 I=1,NCUTS
      EM(I)=MOLES(I)
110   CONTINUE
      J=1
      L0=TMOLES
C
C       LH AND RH ARE THE ENDPOINTS FOR THE INTERVAL HALVING TRIAL AND
C       ERROR THAT IS USED TO CALCULATE THE BUBBLE POINT OF THE
C       REMAINING LIQUID.
C
      LH=TB(1)+459.
      RH=TB(NC1)+459.
120   CONTINUE
      MOLEFT=0.
      DO 130 I=1,NCUTS
      MOLEFT=MOLEFT+EM(I)
130   CONTINUE
C
C       BEGIN TRIAL AND ERROR TO GET BUBBLE POINT
C
      DO 160 L=1,20
      YTOT=0.
      MID=(RH+LH)/2.
C
C       THE SUBROUTINE VPIF RETURNS THE VAPOR PRESSURE OF THE
C       NON-RESIDUUM CUTS IN ATMOSPHERES AT THE TEMPERATURE
C       MID.  MID IS THE CENTER OF THE INTERVAL OF INTERVAL HALVING.
C
      CALL VPIF(MID,NC1)
C
C       WYI(I) IS THE THE MOLE FRACTION OF EACH CUT
```

```
C       IN THE VAPOR PHASE.  YTOT IS THE TOTAL MOLE FRACTION OF CUTS.
C
      DO 140 I=1,NC1
      WYI(I)=(VP(I)*EM(I)/MOLEFT)
      YTOT=YTOT+WYI(I)
140   CONTINUE
      IF(YTOT.GT.1.) GO TO 150
      LH=MID
      GO TO 160
150   CONTINUE
      RH=MID
160   CONTINUE
C
C       VFRAC IS THE VOLUME FRACTION DISTILLED.  TBNN(J) IS THE
C       BUBBLE POINT OF THE CURRENT FRACTION.
C
      VFRAC(J)=1.-(VOLU/TVOL)
      TBNN(J)=MID-459.
      WRITE(MAC,170)
170   FORMAT(///,8X,'F',7X,'TEMP(F)',5X,'Y SUM')
      WRITE(MAC,180) VFRAC(J),TBNN(J),YTOT
180   FORMAT(2X,3(1X,1PE10.3))
      WRITE (MAC,190)
190   FORMAT(//4X,'I',3X,'MOLES I',5X,'VP(I)',5X,'Y(I)',/)
      DO 210 I=1,NC1
      WRITE(MAC,200) I,EM(I),VP(I),WYI(I)
200   FORMAT(2X,I2,3(1X,1PE10.3))
210   CONTINUE
C
C       IF ALL OF THE LAST CUT WITH VAPOR PRESSURE (AT ENVIRONMENTAL
C       TEMPERATURE) GREATER THAN 1X10E-7 IS GONE THEN STOP INTEGRATION.
C
      IF (EM(ICNT).EQ.0.) GO TO 310
      TMK=0.
C
C       K0 AND MK ARE INTERMEDIATE VALUES FOR THE RUNGA KUTTA.
C
      DO 230 I=1,NC1
      KAY0(I)=-(0.05*L0)*(VP(I)*EM(I)/MOLEFT)
      MK(I)=EM(I)+KAY0(I)
C
C       ZERO MK IF IT GOES NEGATIVE.
C
      IF (MK(I).GT.0.) GO TO 220
      MK(I)=0.
220   CONTINUE
      TMK=TMK+MK(I)
230   CONTINUE
      IF(TMK.EQ.0.) GO TO 310
      IF (NC1.EQ.NCUTS) GO TO 240
      TMK=TMK+EM(NCUTS)
240   CONTINUE
C
C       RESET ENDPOINTS FOR SECOND HALF OF INTEGRATION.
C
      RH=MID+100.
      LH=MID-100.
      DO 270 L=1,20
      YTOT=0.
      MID=(RH+LH)/2.
```

```
      CALL VPIF(MID,NC1)
      DO 250 I=1,NC1
      YTOT=YTOT+(VP(I)*MK(I)/TMK)
250   CONTINUE
      IF (YTOT.GT.1.) GO TO 260
      LH=MID
      GO TO 270
260   CONTINUE
      RH=MID
270   CONTINUE
      VOLU=0.
      DO 290 I=1,NC1
      KAY(I)=-(0.05*L0)*(VP(I)*MK(I)/TMK)
      EM(I)=EM(I)+0.5*(KAY0(I)+KAY(I))
C
C       ZERO EM IF IT GOES NEGATIVE
C
      IF(EM(I).GT.0.) GO TO 280
      EM(I)=0.
280   CONTINUE
C
C       CALCULATE THE REMAINING VOLUME.  RHO IS THE DENSITY IN
C       GRAM MOLES PER METER CUBED.
C
      VOLU=VOLU+EM(I)/RHO(I)
290   CONTINUE
      IF(NC1.EQ.NCUTS) GO TO 300
      VOLU=VOLU+MOLES(NCUTS)/RHO(NCUTS)
300   CONTINUE
C
C       RESET THE ENDPOINTS AND RETURN FOR ANOTHER "TIME" STEP
C
      LH=TBNN(J)+459.
      RH=LH+100.
      J=J+1
      GO TO 120
310   CONTINUE
C
C       NOW LEAST SQUARES THE TBNN VS. VFRAC DATA.
C
      SX=0
      SY=0
      SX2=0
      SXY=0
      SY2=0
      DO 320 I=1,J
      SX=SX+VFRAC(I)
      SY=SY+TBNN(I)
      SX2=SX2+VFRAC(I)*VFRAC(I)
      SY2=SY2+TBNN(I)*TBNN(I)
      SXY=SXY+TBNN(I)*VFRAC(I)
320   CONTINUE
      XM=SX/J
      YMM=SY/J
      BNUM=SXY-(SX*SY/J)
      BDEN=SX2-(SX*SX/J)
      BEE=BNUM/BDEN
      AA=YMM-BEE*XM
C
C       CALCULATE CORRELATION COEFFICIENT
```

```
C
      FAC1=(SX2-SX*SX/J)
      FAC2=(SY2-SY*SY/J)
      RDEN=(FAC1*FAC2)**0.5
      R=BNUM/RDEN
C
C       PRINT OUT MACKAY PARAMETERS
C
      WRITE (MAC,330)
330   FORMAT (/,6X,'DELTAH',
     14X,'DELTAH/TB')
      DO 350 I=1,ICNT
      WRITE (MAC,340) I,DELH(I),DELHTB(I)
340   FORMAT(1X,I2,5(1X,1PE10.3))
350   CONTINUE
      WRITE (MAC,360)
360   FORMAT(//,2X,'WHERE:')
      WRITE (MAC,370)
370   FORMAT (2X,'DELTAH IS THE ENTHALPY OF VAPORIZATION IN BTU/LBMOLE')
      WRITE (MAC,380)
380   FORMAT(2X,'DELTAH/TB IS THE TROUTONS RULE CONSTANT IN BTU/LBMOLE
     1*DEG R')
390   CONTINUE
      WRITE (MAC,400)
400   FORMAT(//,2X,'LEAST SQUARES OF B.P. VS. FRACTION EVAPORATED:')
      WRITE (MAC,410)BEE
410   FORMAT(/,5X,'SLOPE: ',1PE10.3,' DEG R/FRACTION EVAPORATED')
      WRITE (MAC,420) AA
420   FORMAT(5X,'INITIAL B.P.: ',1PE10.3,' DEG F')
      WRITE (MAC,430) R
430   FORMAT(5X,'CORRELATION COEFFICIENT: ',1PE10.3)
      WRITE (MAC,440) DCRUDE
440   FORMAT (/,2X,'BULK OIL DENSITY: ',1PE10.3,' GRAMS/CC')
      WRITE (MAC,450) MVO
450   FORMAT(2X,'BULK MOLAR VOLUME OF OIL: ',1PE10.3,' CC/MOLE')
      WRITE (MAC,460) MDH
460   FORMAT(2X,'MEAN TROUTONS RULE CONSTANT: ',1PE10.3,' BTU/LBMOLE
     1*DEG R')
      WRITE (MAC,470)
470   FORMAT(//,2X,'AFTER SIMPLIFICATION AND COMBINING TERMS, THE '
     1)
      WRITE (MAC,480)
480   FORMAT(2X,'MACKAY  EVAPORATION MODEL BECOMES:')
      AAA=MVO*0.01219/(((XPRINT-32.)/1.8)+273.)
      AAA=ALOG(AAA)
      BBB=MDH/1.987
      CCC=BBB/(XPRINT+459.)
      BBB=BBB+AAA
      DDD=AA+459.
      WRITE (MAC,490)BBB,CCC,DDD,BEE
490   FORMAT(/,10X,'DELTA-F = DELTA-THETA * EXP( ',1PE10.3
     1,' - ',1PE10.3,' ( ',1PE10.3,' + ',1PE10.3,'(F)))')
      EEE=CCC*DDD
      FFF=BBB-EEE
      GGG=CCC*BEE
      WRITE (MAC,500)
500   FORMAT(/,15X,'OR')
      WRITE(MAC,510)FFF,GGG
510   FORMAT(/,10X,'DELTA-F = DELTA-THETA * EXP( ',1PE10.3,' - ',1PE10.3
     1,'(F))')
520   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BRKG4(Y,X1,X2,XP,NEQ,NDEL)
      INCLUDE 'VARI.FOR'
      REAL*4 K1,K2,K3,K4
      DIMENSION Y(30),YARG(30),K2(30),K1(30),K3(30),K4(30)
C
C       RUNGA-KUTTA 4-TH ORDER NUMERICAL INTEGRATION FOR SIMULTANEOUS
C       DIFFERENTIAL EQUATIONS, SEE C.R. WYLIE, PAGES 108-117 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.  INTEGRATION 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) IS 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.
C
      INT=1
      ITYP=1
      LINE=0
      NEQ1=NEQ+1
      NEQ2=NEQ+2
      NEQ3=NEQ+3
      NSS=1
      IN=1
      IKEEP=1
      GONE(1)=1.
      DISPER=0.
C
C       TOTAL IS THE INITIAL NUMBER OF MOLES.
C       TSAVE IS THE INITIAL MASS.
C
      TOTAL=0.
      TSAVE=0.
      DO 10 I=1,NEQ
C
C       CALCULATE AND SAVE THE INITIAL CONDITIONS.
C
      YSAVE(I)=Y(I)
      YMSAVE(I)=Y(I)*MW(I)
      MWU(I)=MW(I)
      TSAVE=TSAVE+YMSAVE(I)
      TOTAL=TOTAL+Y(I)
```

```
10    CONTINUE
C
C       SAVE THE INITIAL AREA.
C
      YMSAVE(NEQ1)=Y(NEQ1)
C
C       INITIALIZE THE MASS LOST BY DISPERSION ALONE AND
C       EVAPORATION ALONE.
C
      Y(NEQ2)=0.
      Y(NEQ3)=0.
C
C       NDEL IS THE NUMBER OF COMPONENTS DELETED BECAUSE THEY
C       EVAPORATE TOO FAST.  NFAST IS THE CURRENT ARRAY LOCATION
C       OF THE FASTEST MOVING COMPONENT.
C
      NDEL=0
      NFAST=0
      X=X1
C
C       INITIALIZE THE PRINT SWITCH TO FORCE A PRINT AND
C       SUBSEQUENT CALCULATIONS THE FIRST TIME THROUGH.
C
      XW=-1.
      WRITE (IOU,20)
20    FORMAT(/,1X,'COUNT THE CUTS IN THE FOLLOWING OUTPUT FROM LEFT
     1 TO RIGHT',/)
      WRITE (IOU,30)
30    FORMAT(1X,'THE INITIAL GRAM MOLES IN THE SLICK ARE:')
      WRITE (IOU,40) (Y(I),I=1,NEQ)
40    FORMAT(11(1X,1PE10.3))
      WRITE (IOU,50)
50    FORMAT(/,1X,'THE INITIAL MASSES (GRAMS) IN THE SLICK ARE
     1:')
      WRITE (IOU,40) (YMSAVE(I),I=1,NEQ)
      WRITE (IOU,60) TSAVE
60    FORMAT(1X,'THE TOTAL MASS FROM THESE CUTS IS '
     1,1PE10.3,' GRAMS')
      WRITE (IOU,70)
70    FORMAT(/)
C
C       CALCULATE DY/DX AND SET THE STEP SIZE TO APPROXIMATE
C       A 5% CHANGE IN THE MOST RAPIDLY CHANGING Y.  WHEN THIS
C       Y DECREASES BY A FACTOR OF 20, RESET THE STEP SIZE
C       ACCORDING TO THE NEXT Y.
C       SOME Y'S WILL CHANGE SO FAST THAT THEY WILL BE GONE
C       IN A FEW MINUTES.  THESE ARE DELETED BEFORE INTEGRATION
C       STARTS AND NOTED ON THE PRINTED RESULTS.
C
C       INITIALIZE OR INCREMENT NFAST.
C
80    NFAST=NFAST+1
90    CALL FXYZ(X,Y,K1,NEQ)
C
C       THE TIME UNIT IS HOUR.
C       SET THE STEP SIZE TO H=0.05*Y/(DY/DX).
C
      H=0.05*Y(NFAST)/K1(NFAST)
      YOLD=Y(NFAST)
      H=ABS(H)
```

```
      H2=H/2.
      GO TO (100,170), IN
C
C       IF THERE IS A RAPIDLY MOVING COMPONENT AT THE BEGINNING
C       ITS STEP SIZE WILL BE VERY SMALL, DO NOT LET THE
C       STEP SIZE BE LESS THAN 0.05 HOUR.
C
100   IF(H.GT.0.05) GO TO 130
C
C       Y(NFAST) CHANGES TOO FAST TO CALCULATE, DELETE IT AND MOVE
C       EVERYBODY ONE SPACE TO THE LEFT.
C
C       WHEN YOU MOVE THE AREA BE SURE TO SUBTRACT THE CONTRIBUTION
C       OF THE CUT JUST DELETED.
C
      ISTART=1
      NFAST=1
      NDEL=NDEL+1
C
C       DECREASE THE NUMBER OF COMPONENTS BY 1
C
C       DELMAS IS THE TOTAL MASS OF DELETED CUTS
C
      DELMAS=DELMAS+(Y(NDEL)*MW(NDEL))
      NEQ=NEQ-1
      NEQ1=NEQ+1
      NEQ2=NEQ+2
      NEQ3=NEQ+3
      NEQ4=NEQ+4
      AD=Y(1)/RHO(1)/Z
      DO 110 I=1,NEQ
C
C       SHIFT THE ARRAYS.
C
      I1=I+1
      Y(I)=Y(I1)
      VP(I)=VP(I1)
      MTC(I)=MTC(I1)
      YSAVE(I)=YSAVE(I1)
      VLOG(I)=VLOG(I1)
      RHO(I)=RHO(I1)
      MWU(I)=MWU(I1)
      YMSAVE(I)=YMSAVE(I1)
110   CONTINUE
C
C       BE SURE AND DO THE LAST THREE POSITIONS WHEN SHIFTING
C
      Y(NEQ1)=Y(NEQ2)-AD
      Y(NEQ2)=Y(NEQ3)
      Y(NEQ3)=Y(NEQ4)
      WRITE (IOU,120) NDEL
120   FORMAT(1X,'CUT ',I2,' GOES AWAY IN MINUTES, THEREFORE IT WAS
     1 DELETED AND THE CUTS RENUMBERED',/)
      WRITE (ITY,120) NDEL
      GO TO 90
130   IN=2
      GO TO (140,160) ITYP
140   ITYP=2
      WRITE (ITY,150)
150   FORMAT(/,1X,'TIME',2X,'BBL',3X,'SPGR',2X,'AREA',2X
```

```
     1,'THICKNESS  W',2X,'DISP',4X,'ERATE',4X,'M/A   I  J')
C
C       THE COMPONENTS THAT MOVE TOO FAST TO CONSIDER (AT TIME
C       ZERO) HAVE BEEN DELETED AND THE ARRAYS SHIFTED.
C
160   NEQ1=NEQ+1
      NEQ2=NEQ+2
      NEQ3=NEQ+3
C
C       NEVER LET THE STEP SIZE BE GREATER THAN 0.5
C
170   IF(H.GT.0.5) H=0.5
      WRITE (IOU,180) H,NFAST
180   FORMAT(/,2X,'STEP SIZE OF ',1PE10.3,' IS BASED ON CUT ',I3,/)
C
C       CHECK THE PRINT SWITCH.
C
190   IF(X.LT.XW) GO TO 400
C
C       INCREMENT THE PRINT SWITCH AND CALCULATE INTERMEDIATE
C       RESULTS NOT CARRIED WITH THE INTEGRATION.
C
      XW=X+XP
      YTOT=0.
      TMASS=0.
      DO 200 I=1,NEQ
      YF(I)=Y(I)/YSAVE(I)
      YTOT=YTOT+Y(I)
      YM(I)=Y(I)*MWU(I)
      YM1(I)=YM(I)
      TMASS=TMASS+YM(I)
      YM(I)=YM(I)/YMSAVE(I)
200   CONTINUE
      YM1(NEQ1)=Y(NEQ1)
C
C       CALCULATE THE MEAN MOLECULAR WEIGHT OF THE SLICK.
C
      WMEANS=0.
      DO 210 I=1,NEQ
      WMEANS=WMEANS+MWU(I)*Y(I)/YTOT
210   CONTINUE
      LINE=LINE+1
      WRITE (IOU,220) X,LINE
220   FORMAT(2X,'TIME = ',1PE8.1,' HOURS, MASS FRACTION OF EACH
     1 CUT REMAINING:',65X,I3)
      WRITE (IOU,230) (YM(I),I=1,NEQ)
230   FORMAT(14(1X,1PE8.1))
      CHECK=TMASS+Y(NEQ2)+Y(NEQ3)
      WRITE (IOU,240) TMASS,Y(NEQ2),Y(NEQ3),CHECK
240   FORMAT(2X,'MASS REMAINING = ',1PE10.3,', MASS DISPERSED
     1 = ',1PE10.3,', MASS EVAPORATED = ',1PE10.3,'
     2, SUM = ',1PE10.3)
      WRITE (IPU,250) NEQ1
250   FORMAT(I5)
      WRITE (IPU,260) X,(YM1(I),I=1,NEQ1)
260   FORMAT(10(1X,1PE10.3))
C
C       WHEN THE FRACTION REMAINING OF COMPONENT I GETS LOW,
C       SET ITS VAPOR PRESSURE AND MOLES EQUAL TO ZERO.
C
```

```
      DO 270 I=ISTART,NEQ
      IF(YF(I).GT.1.0E-08) GO TO 270
      IKEEP=I+1
      VP(I)=0.
      Y(I)=0.
270   CONTINUE
      ISTART=IKEEP
      NFAST=IKEEP
      GONE(LINE)=TMASS/TSAVE
      ZP=Z*100.
      WRITE (IOU,280) GONE(LINE),Y(NEQ1),ZP,WMEANS
280   FORMAT(2X,'FRACTION (BASED ON MASS) REMAINING IN THE SLICK
     1=',1PE8.1,', AREA=',1PE8.1,' M**2, THICKNESS='
     2,1PE8.1,' CM, MOLE WT=',0PF5.1)
C
C       WIO IS THE MOUSSE CALCULATION.
C
C       FIRST CHECK TO SEE IF MOUSSE HAS ALREADY BEEN FORMED.
C       IF IT HAS, CALCULATE XMOU, WHICH IS A FAKE
C       TIME. THIS WILL MATCH THE MOUSSE AND VISCOSITY DATA TO
C       THE PREVIOUS CONDITIONS
C
C       IF NOT, PROCEED IN THE NORMAL MANNER
C
      IF (MOUSWI.NE.1) GO TO 290
      C3NEW=C4*WINDS*WINDS
      XMOU=X+(HOUMOU*C3SAVE)/C3NEW
      CALL WIO(XMOU,W,VTERM)
      GO TO 300
290   CALL WIO(X,W,VTERM)
C
C       VISCP1 IS THE VISCOSITY OF THE PARENT OIL WITH NO WATER
C       INCORPORATED.
C       VISCP1 IS IN CENTIPOISE, FEVAP IS THE FRACTION OF OIL
C       EVAPORATED.  NOTE THAT FEVAP IS NOT
C       1 - (FRACTION REMAINING) BECAUSE DISPERSION LOSSES
C       WOULD BE INCLUDED.  THE FRACTION EVAPORATED MUST
C       CORRECT FOR THE LOSS DUE TO DISPERSION.
C
C
C       ********************
C       WE MIGHT WANT TO CHANGE TO A BETTER FEVAP
C       CALCULATION LATER.
C       ********************
C
300   FEVAP=(1.-GONE(LINE))/YM(NEQ)+FE
      VISCP1=VSLEAD*EXP(MK4*FEVAP)
C
C       VTERM IS THE VISCOSITY MULTIPLIER FROM THE MOUSSE
C       CALCULATION.
C
      VISCP=VISCP1*VTERM
C
C       CALCULATE THE BULK SPGR.
C
      BSPGR=0.
      DO 310 I=ISTART,NEQ
      BSPGR=BSPGR+SPGR(I)*Y(I)/YTOT
310   CONTINUE
      VISQT=SQRT(VISCP/10.)
```

```
C
C       CALCULATE THE DISPERSION FACTOR.
C
      FB=1./(1.+KB*VISQT*Z*STEN/0.024)
      DISPER=FRACTS*FB
      WRITE (IOU,320) W,VISCP,DISPER
320   FORMAT(2X,'WEIGHT FRACTION WATER IN OIL = ',1PE8.1,', VIS
     1COSITY = ',1PE8.1,' CENTIPOISE, DISPERSION TERM = '
     2,1PE8.1,' WEIGHT FRACTION/HR')
      CVOLUM=Y(NEQ1)*Z
      TBBL=CVOLUM/0.159
      CVOLUM=(1.0E+06)*CVOLUM
      CSPGR=TMASS/CVOLUM
      WAREA=(1.0E+06)*Z*CSPGR
      WDISP=WAREA*DISPER
      IF(INT.EQ.1) ERATE=0.
      ERATE=ERATE/Y(NEQ1)
      WRITE (IOU,330) WAREA,CSPGR,TBBL,WDISP,ERATE
330   FORMAT(2X,'MASS/AREA=',1PE8.1,' GMS/M*M, SPGR='
     1,1PE8.1,', TOTAL VOLUME=',1PE8.1,' BBL, DISPERSION='
     2,1PE8.1,' GMS/M*M/HR, EVAP RATE=',1PE8.1,' GMS/M*M/HR')
C
C       PRINT AN OUTPUT FILE FOR 80 COLUMN OUTPUT.
C
      DO 340 J=1,NEQ
      JCUT=J
      IF(YM(J).GT.0.5) GO TO 350
340   CONTINUE
350   DO 360 I=1,NEQ
      ICUT=I
      IF(YM(I).GT.0.01) GO TO 370
360   CONTINUE
370   IX=X
      IW=W*100.
      WRITE (ITY,380) IX,TBBL,CSPGR,Y(NEQ1),ZP,IW,WDISP
     1,ERATE,WAREA,ICUT,JCUT
380   FORMAT(1X,I3,1PE8.1,0PF5.2,2(1PE8.1),1X,I3
     1,3(1PE8.1),I2,I3)
      WRITE (IOU,70)
C
C       INCREASE XP TO 10 HOURS AFTER 50 HOURS OF WEATHERING.
C
      GO TO (390,400), NSS
390   IF(X.LT.50.) GO TO 400
      NSS=2
      XP=10.
C
C       TAKE A STEP IN TIME
C
400   XARG=X
      DO 410 I=1,NEQ3
      YARG(I)=Y(I)
410   CONTINUE
C
C       INT IS A SWITCH TO INDICATE THAT THE INTEGRATION WAS
C       INITIATED.
C
      INT=2
      CALL FXYZ(XARG,YARG,K1,NEQ)
      XARG=X+H2
```

```
      DO 420 I=1,NEQ3
      YARG(I)=Y(I)+H*K1(I)/2.
420   CONTINUE
C
C       SAVE THE EVAPORATION RATE FROM THE FIRST TIME
C       THE DERIVATIVES ARE CALCULATED.
C
      ERATE=K1(NEQ3)
      CALL FXYZ(XARG,YARG,K2,NEQ)
      DO 430 I=1,NEQ3
      YARG(I)=Y(I)+H*K2(I)/2.
430   CONTINUE
      CALL FXYZ(XARG,YARG,K3,NEQ)
      XARG=X+H
      DO 440 I=1,NEQ3
      YARG(I)=Y(I)+H*K3(I)
440   CONTINUE
      CALL FXYZ(XARG,YARG,K4,NEQ)
      DO 450 I=1,NEQ3
      Y(I)=Y(I)+H*(K1(I)+2.*(K2(I)+K3(I))+K4(I))/6.
450   CONTINUE
C
C       IF 10 PER CENT BY MOLES OR LESS OF THE SLICK IS LEFT, STOP
C       THE CALCULATION BECAUSE STRANGE THINGS HAPPEN CLOSE TO
C       ZERO OIL.
C
      REMAIN=0.
      DO 460 I=1,NEQ
      REMAIN=REMAIN+Y(I)
460   CONTINUE
      TEST=REMAIN/MOLSAV
      IF(TEST.GT.0.1) GO TO 510
      NQUIT=1
      TYPE 470
470   FORMAT(1X,'THE SLICK HAS DECREASED TO 10% OF THE ORIGINAL MOLES.')
      TYPE 480
480   FORMAT(1X,'THE INTEGRATION WILL BE STOPPED HERE.')
      WRITE (IOU,490)
490   FORMAT(/,1X,'THE SLICK (MOLES) HAS DECREASED TO 10%
     1 OR LESS, THEREFORE THE CALCULATION WAS STOPPED.')
      WRITE (ITY,500)
500   FORMAT(/,1X,'SLICK DECREASED TO 10% MASS **STOP**')
      GO TO 550
C
C       RECALCULATE THE OVER-ALL MASS-TRANSFER COEFFICIENTS OUTSIDE
C       THE DERIVATIVE SUBROUTINE.  THE DIAMETER DEPENDENCE IS VERY
C       SLOW.  TERM2 IS THE OLD DIA**(-0.11).  SO DIVIDE THE OLD
C       COEFFICIENT BY TERM2 AND MULTIPLY IN THE NEW ONE.
C
C       WHEN YOU CHANGE THE WIND SPEED WITH RESPECT TO TIME,
C       CHANGE THE MASS-TRANSFER COEFFICIENT HERE.  DIVIDE
C       OUT THE OLD WIND TERM AND MULTIPLY IN THE NEW ONE.
C       ALSO, IF THE TEMPERATURE CHANGES, RECALCULATE THE
C       VAPOR PRESSURE HERE.  THIS APPLIES ONLY TO MACKAY
C       AND MATSUGU.
C
510   GO TO (540,520,540), KMTC
520   DIA=SQRT(Y(NEQ1)/0.785)
      TNEW=DIA**(-0.11)
      ADJUST=TNEW/TERM2
```

```
      DO 530 I=1,NEQ
      MTC(I)=MTC(I)*ADJUST
530   CONTINUE
      TERM2=TNEW
C
C       CHECK TO SEE IF THE INTEGRATION IS COMPLETED.
C
540   IF(X.GE.X2) GO TO 550
      X=XARG
C
C       CHECK TO SEE IS THE FIRST NON-ZERO MOLES HAS FALLEN TO
C       0.01 OF ITS STARTING VALUE.  IF IT HAS, RECALCULATE THE
C       STEP SIZE ON THE NEXT NON-ZERO COMPONENT.  NOTE THAT
C       A COMPONENT IS NOT ZEROED UNTIL ITS MOLE NUMBER HAS
C       FALLEN TO LESS THAN 1.0E-08.
C
      TEST=ABS(Y(NFAST)/YOLD)
      IF(TEST.LT.0.01) GO TO 80
      GO TO 190
550   NSTART=NDEL+1
      WRITE (IOU,560) NSTART
560   FORMAT(/,1X,'THE CUT NUMBERING BEGINS WITH',I3,' BASED ON
     1 THE ORIGINAL CUT NUMBERS',/)
      LINE=LINE+1
      WRITE (IOU,570) X,LINE
570   FORMAT(1X,'THE FINAL MASS FRACTIONS FOR THE SLICK AT '
     1,1PE8.1,' HOURS ARE:',65X,I3)
      HOUMOU=X
      TMASS=0.
      DO 580 I=1,NEQ
      YM(I)=Y(I)*MWU(I)
      TMASS=TMASS+YM(I)
      YM1(I)=YM(I)
      YM(I)=YM(I)/YMSAVE(I)
580   CONTINUE
      YM1(NEQ1)=Y(NEQ1)
      GONE(LINE)=TMASS/TSAVE
      WRITE (IOU,40) (YM(I),I=1,NEQ)
      WRITE (IPU,250) NEQ1
      WRITE (IPU,260) X,(YM1(I),I=1,NEQ1)
      WRITE (IPU,260) (GONE(I),I=1,LINE)
      ZP=Z*100.
      WRITE (IOU,280) GONE(LINE),Y(NEQ1),ZP,WMEANS
      CHECK=TMASS+Y(NEQ2)+Y(NEQ3)
      WRITE (IOU,240) TMASS,Y(NEQ2),Y(NEQ3),CHECK
      TME=TME+Y(NEQ3)
      TMD=TMD+Y(NEQ2)
      FE=(Y(NEQ3)/TMASAV)+FE
      WRITE (IOU,590)
590   FORMAT(/,1X,'****************************************
     1*************************',/)
      RETURN
      END
```

```
      SUBROUTINE VPIF(TEES,N)
      INCLUDE 'VARI.FOR'
C
C       THIS SUBROUTINE CALCULATES THE VAPOR PRESSURE OF THE CUTS AT
C       A SPECIFIED TEMPERATURE, TEES. IT USES A SIMPSONS RULE
C       INTEGRATION WITH 21 POINTS
C
      YI(X)=((1.-X)**0.38)/(X*X)
      DO 30 I=1,N
      TEE=TEES
      IF (TEE.LT.T10(I)) GO TO 10
      TEE=TEE/TC(I)
      EX=EXP(-20*(TEE-B(I))**2)
      Y=-A(I)*(1.-TEE)/TEE-EX
      VP(I)=PC(I)*10.**Y
      GO TO 30
10    CONTINUE
      TR1=TEE/TC(I)
      TR2=T10(I)/TC(I)
      DH=(TR2-TR1)/20.
      RESULT=YI(TR1)
      TR=TR1
      DO 20 L=1,10
      TR=TR+DH
      RESULT=RESULT+4.*YI(TR)
      TR=TR+DH
      RESULT=RESULT+2.*YI(TR)
20    CONTINUE
      TR=TR+DH
      RESULT=RESULT+4.*YI(TR)
      TR=TR+DH
      RESULT=DH*(RESULT+YI(TR))/3.
      P1=-4.33-HVAPZ(I)*RESULT/(1.987*TC(I))
      VP(I)=EXP(P1)
30    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FXYZ(XARG,MOLES1,KK,NEQ)
      REAL*4 MOLES1,KK
      INCLUDE 'VARI.FOR'
      DIMENSION KK(30),MOLES1(30)
C
C       THE VECTOR BEING INTEGRATED RESIDES IN MOLES1(I).
C       POSITIONS I=1 THROUGH I=NEQ ARE THE PSEUDO COMPONENTS,
C       POSITION NEQ1=NEQ+1 IS THE AREA.
C       POSITION NEQ2=NEQ+2 IS THE MASS LOST BY DISPERSION ALONE.
C       POSITION NEQ3=NEQ+3 IS THE MASS LOST BY EVAPORATION ALONE.
C
C
      SUM=0.
      DO 10 I=1,NEQ
      SUM=SUM+MOLES1(I)
10    CONTINUE
      DO 20 I=1,NEQ
C
C       CALCULATE THE MOLE DERIVATIVES.
C
      TMPVP(I)=MTC(I)*MOLES1(NEQ1)*VP(I)*MOLES1(I)/SUM
      TMPDS(I)=DISPER*MOLES1(I)
      KK(I)=TMPVP(I)+TMPDS(I)
      KK(I)=-KK(I)
20    CONTINUE
      VOLLU=0.
      DO 30 I=1,NEQ
      VOLLU=VOLLU+MOLES1(I)/RHO(I)
30    CONTINUE
C
C       CALCULATE THE AREA DERIVATIVE.
C
      Z=VOLLU/MOLES1(NEQ1)
      KK(NEQ1)=(5.4E+05)*(Z**1.33)*MOLES1(NEQ1)**0.33
      KK(NEQ1)=SPREAD*KK(NEQ1)*SPRFAC
C
C       CALCULATE THE MASS LOST FROM THE SLICK DUE TO
C       EVAPORATION ALONE AND THEN DISPERSION ALONE.
C
      KK(NEQ2)=0.
      KK(NEQ3)=0.
      DO 40 I=1,NEQ
      KK(NEQ3)=KK(NEQ3)+TMPVP(I)*MWU(I)
      KK(NEQ2)=KK(NEQ2)+TMPDS(I)*MWU(I)
40    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WIO(TIME,W,VTERM)
      INCLUDE 'VARI.FOR'
      WFUNC(W)=(1.0-C2*W)*EXP(-2.5*W/(1.0-C1*W))
      VIS(W)=EXP(2.5*W/(1.0-C1*W))
      DATA WSAVE,C4SAVE/-1.,-1./
C
C       THIS IS THE WATER-IN-OIL (MOUSSE) ROUTINE.
C       W IS THE FRACTIONAL WATER CONTENT IN THE OIL.
C       WINDS IS THE WIND SPEED IN KNOTS.
C       TIME IS IN HOURS.
C       C1 IS A VISCOSITY CONSTANT = 0.65
C       C2 IS AN OIL-COALESCING CONSTANT AND IS OIL
C       DEPENDENT, AND IS THE INVERSE OF THE MAXIMUM WEIGHT
C       FRACTION WATER IN OIL.
C       C3 IS A WATER INCORPORATION RATE (1./HR), USUALLY 0.01*U*U
C
C       THE PREDICTION EQUATION FOR W IS IMPLICIT AND IS
C       SOLVED BY TRIAL AND ERROR.
C
C       REFERENCE:  CHAPTER 4 BY MACKAY IN OIL SPILL PROCESSES
C       AND MODELS.
C
C       DECEMBER, 1981
C
C       IERR IS THE ERROR CODE.
C       IERR=1 IS A NORMAL EXIT, IERR=2 IS A PROBLEM IN THE
C       TRIAL-AND-ERROR ROUTINE, IERR=3 IS A STEADY-STATE
C       MOUSSE EXIT.
C
C       IF THE OIL DOES NOT FORM MOUSSE, C2 WAS SET TO -1.
C
      IF(C2.GT.0.) GO TO 10
C
C       NO MOUSSE FOR THIS OIL, SET TERMS AND RETURN.
C
      W=0.
      VTERM=1.
      GO TO 90
10    IERR=1
C
C       CHECK TO SEE IF THE WIND OR INCORPORATION RATE CONSTANT
C       CHANGED.
C
      IF(WINDS.EQ.WSAVE.AND.C4.EQ.C4SAVE) GO TO 20
      WSAVE=WINDS
      C4SAVE=C4
      U2=WINDS*WINDS
      C3=C4*U2
20    EX=C3*TIME
      IF(EX.GT.20.) GO TO 80
      TEST=EXP(-EX)
C
C       BRACKET THE TIME WITH TWO VALUES OF W.
C
      W=0.
      WMAX=1./C2
      WSTEP=WMAX/10.
30    W=W+WSTEP
      TRY=WFUNC(W)
      IF(TRY.LT.TEST) GO TO 40
```

```
      IF(W.LT.WMAX) GO TO 30
      IERR=2
      GO TO 90
C
C       NOW DO INTERVAL HALVING TO FIND W.
C
40    NTRY=0
      WR=W
      WL=W-WSTEP
50    W=(WR+WL)/2.
      TRY=WFUNC(W)
      IF(TRY.LT.TEST) GO TO 60
      WL=W
      GO TO 70
60    WR=W
70    NTRY=NTRY+1
      IF(NTRY.LT.10) GO TO 50
      VTERM=VIS(W)
      GO TO 90
80    IERR=3
90    CONTINUE
      RETURN
      END
```