Comprehensive Report of API Crude Oil Characterization Measurements

API TECHNICAL REPORT 997
FIRST EDITION, AUGUST 2000

American Petroleum Institute

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Downstream Segment

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FIRST EDITION, AUGUST 2000

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American Petroleum Institute
1220 L. Street, Northwest
Washington, DC 20005

Gene P. Sturm, Jr.
Johanna Y. Shay

TRW Inc.
TRW Petroleum Technologies
P.O. Box 2543
Bartlesville, OK 74005
(918) 338-4400

American Petroleum Institute

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ABSTRACT

A consortium of American Petroleum Institute member companies has sponsored a research program consisting of a series of projects on the characterization of crude oils. The goal of this program was to obtain complete sets of assay and thermophysical property data on a few widely varying crude oils to test the basic correlations and models typically used in the design of crude oil refining and related facilities. The crude oils chosen were Alaskan North Slope, Utah Altamont, and San Joaquin Valley. This report provides descriptions of the test procedures, discussions of their accuracy, and a comprehensive compilation of the data for the three crude oils measured under this program. The scope of this report is limited to discussion of the characterization tests and compilation of the data. Although the data were generated to allow for the evaluation of various correlations used for design purposes, such evaluation has been/will be done by API's Technical Data Committee and may be published later. It is important to note, however, that a number of these data have been utilized in the development of correlations that are included in the three most recent revisions of the API Technical Data Book, most notably Chapter 2 (Characterization) and Chapter 3 (Distillation Interconversions).

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Also, the authors and TRW Petroleum Technologies would like to express deep appreciation to the American Petroleum Institute Technical Data Committee member companies who sponsored the API crude oil characterization program conducted by TRW Petroleum Technologies and its predecessors. The sponsor companies and their years of sponsorship are listed below.

Sponsor Company	Years of Sponsorship
Amoco Oil Company	1989 – 98
Chevron Research and Technology	1993 – 98
Fluor Daniel	1989 – 98
M. W. Kellogg	1992 – 98
Mobil Research & Development	1989 – 97
Pennzoil Products	1989 – 98
Phillips Petroleum	1989 – 98
Shell Oil Company	1989 – 97
Sun Refining & Marketing	1989 – 90
Tesoro Petroleum	1989 – 90

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1. INTRODUCTION

The American Petroleum Institute (API), under the sponsorship of several members of the Technical Data Committee, has set up a subscription research program for the characterization of crude oils. The goal of this program was to obtain complete sets of characterization and thermophysical property data on a few widely varying crude oils to test the basic correlations utilized in the design of crude oil refining and related facilities. These correlations have been used regularly in the refining industry even though they are based on an old, incomplete data bank and, in many cases, on strictly pure component hydrocarbon data. Previous API sponsored studies have reported inconsistencies and serious gaps in the existing data. Also, new characterization methods, such as gas chromatographic simulated distillation, are being used without sufficient tie-in with the older methods used to estimate the required design properties. The data gaps and inconsistencies are particularly severe for the higher molecular weight fractions for which **new correlating parameters may be required**.

The crude oils selected by the sponsors were Alaska North Slope (ANS) crude, Utah Altamont (ALT) crude (very paraffinic), and San Joaquin Valley (SJV) crude (very aromatic). The program consisted of several research projects conducted by the National Institute for Petroleum and Energy Research (NIPER) operated by the IIT Research Institute (1983-1993) and BDM Oklahoma (1994-1998). Except for a few tasks that were subcontracted, the experimental work was conducted by NIPER personnel. Results from each of the previous projects in this program have been reported previously (1-12). This final comprehensive report was prepared by former NIPER personnel employed by TRW Petroleum Technologies, after TRW purchased BDM (1998).

1.1 SCOPE

Each crude was distilled into narrow boiling fractions and detailed characterization was performed on the whole crude, narrow boiling fractions, appropriate composites, and residues. The scope of NIPER's involvement in the program was to produce detailed assay and thermophysical property data. Although the rationale for obtaining the data was to evaluate various correlations used for design purposes, such evaluation was beyond the scope of NIPER's involvement. Hence, this final comprehensive report is in large part a collection of data without attempts to develop or evaluate correlations. Such development or evaluation of correlations falls within the purview of the project sponsors.

1.2 REPORT ORGANIZATION

Chapter 1 of the report is the Introduction. Chapter 2 covers distillation and gas chromatographic simulated distillation of the three crude oils and their fractions. Chapter 3 covers general physical properties and Chapter 4 covers chemical properties. Chapters 5 through 10 focus on thermophysical property data with separate chapters on vapor pressure, heat capacity, thermal conductivity, viscosity, gravity, and molecular weight. A brief summary is given in chapter 11. A list of references and the data tables follow Chapter 11.

Each chapter contains a brief description of the method(s) or procedure(s) and a discussion of the accuracy of each as appropriate. Discussion of accuracy generally includes references to the ASTM precision statements in each method. ASTM defines repeatability as the value (r) for which "the difference between successive results obtained by the same operator in the same laboratory with the same apparatus under constant operating conditions on identical test material would, in the long run, exceed only in one case in twenty." Reproducibility (R) is defined such that "the difference between two single and independent results obtained by different operators working in different laboratories on nominally identical test material would, in the long run, in the normal and correct operation of the test method, exceed the R value only in one case in twenty. ASTM tests performed by NIPER personnel were run according to the latest published methods (13) unless otherwise noted. Tests were generally run in duplicate when practical and when sample quantity permitted. When the results from duplicate runs were outside the ASTM repeatability, **a third run was made and the closest two results averaged.** In addition, standard reference materials were run periodically for most tests depending on availability of suitable standards. Two distillate fractions were run through a number of tests as blind samples as a further quality assurance check. Finally, a second set of vapor pressure measurements on one distillate was made by another laboratory.

The NIPER analytical laboratory has maintained and improved its quality program for many years and received accreditation under the API 1512 Petroleum Test Laboratory Accreditation Program in 1996 becoming the second lab to receive accreditation under that program. Heat capacity and vapor pressure data were provided by NIPER's Thermodynamics Laboratory, which has a long history and excellent reputation for production of highly accurate and precise data.

2. DISTILLATION AND SIMULATED DISTILLATION

2.1 Distillation

2.1.1 Preparative Crude Oil Distillation

The three crude oils characterized in this program were supplied by the project sponsors. Analyses were performed on both the whole crude and distillation fractions. This section describes the initial crude oil distillations to provide samples for further characterization.

It was necessary to distill a large quantity (80-90 gallons) of crude oil to obtain the quantities of material required for analyses and for distribution to project sponsors and other contractors. Because of the large amount of material to be distilled, the distillations to 950° F were subcontracted to the Pittsburgh Applied Research Center (PARC). Their initial distillation was conducted in a 150 gallon batch still with packed column, timed reflux, and vacuum to approximately 15 mm Hg. This distillation was carried out up to a corrected vapor temperature of 850° F. Bottoms from the 150 gallon still were charged to 10-liter Sarnia stills with no column packing, no reflux, and with vacuum to about 0.6 mm Hg. This distillation was terminated at a corrected vapor temperature of 950° F.

Results of these distillations are summarized in Table 1. Yields were determined in weight percent and then converted to volume percent using the specific gravities included in Table 1.

Production of the higher boiling cuts was performed at NIPER via short path distillation on a 6-inch Pope still. There were three passes through the short path still: 1) to produce a nominal 950-1050° F distillate and >1050° F resid, 2) to produce a nominal 1050-1150° F distillate and >1150° F resid, and 3) to produce a nominal 1150-1250° F distillate and >1250° F resid. Actual weights and recoveries from each pass are summarized in Table 2 and volume percent yields on a whole crude basis are summarized in Table 1 along with the data provided by PARC.

In addition to the individual cuts shown in Table 1 composites of certain wider boiling range cuts were made by back blending appropriate individual cuts in proportion to their weight percent yields in the distillations. The following composites were made:

- 450-650° F
- >650° F resid
- 650-950° F
- 950-1250° F

Including the whole crude and the four composites, 20 different samples from ANS and ALT crudes and 19 samples from SJV crude were measured in this program.

Precision of the distillations is dependent upon the distillation equipment and the care taken in performing the distillation. Important equipment parameters include proper column packing, temperature and pressure sensor locations and calibration, and distillation rate to avoid column flooding. Comparison of the preparative scale distillation results with the ASTM D 2892 and ASTM D 1160 results in Tables 4 and 7, respectively, can give some indication of the precision or at least consistency between the distillations. Also for comparison, simulated distillation data by ASTM D 5307 are included with the comparison data shown in Table 3. In general, the data agree reasonably well considering the different methods involved and the interpolations needed to obtain the directly comparable data. In particular, the preparative distillation data and the ASTM D 2892 data for the ANS crude showed very good agreement.

2.1.2 Analytical Crude Oil Distillation

In addition to the preparative distillations described above, each whole crude was also distilled by ASTM D 2892, Distillation of Crude Petroleum (15-Theoretical Plate Column). Results for these distillations are reported in Table 4. Repeatability for this method is under statistical review by ASTM. Reproducibility is 1.2% for both mass and volume percent for distillation at atmospheric pressure and 1.4 and 1.5%, respectively, for distillation under vacuum. No statement of bias is made for this method since there is no accepted reference material suitable for determination of bias.

2.1.3 Distillation of Fractions

Individual cuts or composites from the preparative distillation were distilled by various methods. Fractions were distilled on a 15-theoretical plate column by ASTM D 2892. This distillation procedure, which was carried out with an automated apparatus, was not designed for distillation of narrow range cuts and control of the distillations proved to be exceedingly difficult. Repeatability would be expected to be considerably higher than that published in the method. Results are summarized in Table 5.

ASTM D 86, Distillation of Petroleum Products, which is a simple atmospheric pressure distillation, was applied to cuts boiling below 750° F. Cuts from 650-750° F were run by both ASTM D 86 and ASTM D 1160 at the request of the project sponsors although these cuts are outside the scope of ASTM D 86. Thus, the ASTM D 86 precision and bias statements do not apply to the 650-750° F distillate cut data. Data for distillations of seven individual cuts and the 450-650° F composite are provided in Table 6 using an automated method. Repeatability for distillation of group 1 (gasoline range) materials is 7° F for the initial boiling point (IBP) and 8° F for the final boiling point (FBP) with values for intermediate temperatures a function of the slope of temperature versus volume percent distilled. Repeatability for group 4 (diesel/kerosine range) is 6.3° F for both IBP and FBP with intermediate values a function of slope. A much more extensive discussion is given in ASTM D 86 (13). No statement of bias is made for this method.

Higher boiling fractions and composites were distilled by ASTM D 1160, Distillation of Petroleum Products at Reduced Pressures. The distillations were conducted at either 10 mm Hg (650-750° F, 750-850° F, 850-950° F, 650-950° F composite, and >650° F resid) or 1 mm Hg (850-950° F, 950-1050° F, and >650° F resid). Data for the 10 mm and 1 mm Hg distillations are provided in Tables 7 and 8, respectively. Both the vapor temperatures and atmospheric equivalent temperatures are provided. Repeatability is again a complicated function of the slope of temperature versus volume percent distilled. For distillations conducted at 10 mm Hg, repeatability ranges between 3.4 and 11.7° F atmospheric equivalent temperature for volume recovered between 5 and 90 volume percent. For distillations conducted at 1 mm Hg, repeatability ranges between 4.3 and 10.3° F. Repeatabilities for IBP and FBP at 10 mm Hg are 27 and 12.8° F, respectively. For distillation at 1 mm Hg, the corresponding repeatabilities are 30.6 and 5.9° F, respectively. No statement of bias is made due to lack of a suitable reference material.

2.2 Simulated Distillation by Gas Chromatography

2.2.1 Boiling Range Distribution of Whole Crude by ASTM D 5307 (P 167)

The boiling range distribution of the whole crude oils was determined by the proposed ASTM P 167 which was subsequently approved and published in 1992 as ASTM D 5307, Boiling Range Distribution of Crude Petroleum by Gas Chromatography (GC). The method is applicable to whole crude oils that can be dissolved in a solvent for introduction by means of a microsyringe. The crude oil is normally diluted in carbon disulfide and injected into a GC column that separates hydrocarbons in boiling point order. Boiling points are assigned to the time axis by comparison to a calibration curve obtained under the same chromatographic conditions by running a mixture of n-paraffins of known boiling point through a temperature of 1000° F. The amount of material boiling above 1000° F is estimated from a second run of the sample containing an internal standard. Repeatability varies with percent eluted off the column ranging from 6.7° F for the IBP to 37.3° F for 90% off. No bias can be determined as the boiling range distribution can only be defined in terms of a test method. A more detailed description of precision is given in the method (13). The simulated distillation data are provided in Table 9.

2.2.2 Boiling Range Distribution of <500° F Fractions by ASTM D 3710

The IBP-320° F, 320-450° F, and 450-500° F fractions were analyzed by ASTM D 3710, Boiling Range Distribution of Gasoline and Gasoline Fractions by Gas Chromatography. This method is applicable to petroleum products and fractions with a final boiling point below 500° F. A GC column is employed under conditions that allow determination of isopentane and lighter saturates discretely. The time axis is calibrated using a known mixture of hydrocarbons covering the boiling range expected in the sample. Repeatability is a function of the volume percent recovered and the rate of change in temperature with percent recovered (dT/dV). Values for IBP and FBP are 2° F and 6° F, respectively. Values for 20 to 95 percent recovered range from 2° F to 19° F depending on dT/dV. A more complete description and a table are given in the method (13). Bias cannot be determined as there is no acceptable reference material for the method. Results are presented in Table 10.

2.2.3 Boiling Range Distribution of Fractions by ASTM D 2887

All distillate fractions and composites boiling between 320 and 850° F (7 distillate fractions and 1 composite) were analyzed by ASTM D 2887, Boiling Range Distribution of Petroleum Fractions by Gas Chromatography. This method is applicable to petroleum products with a final boiling point of 1000° F or lower. Repeatability for IBP by this method is 0.11 (X-32) where X is the average of two results in °F. Repeatability for 10-40% off is 1.4° F; for 50-90% off, r is 1.8° F; and for FBP, r is 5.8° F. Results are presented in Table 11.

2.2.4 Boiling Range Distribution of High Boiling Fractions and Resids by ASTM D 5307 and High Temperature Simulated Distillation

Three methods were used to determine boiling range distributions for the high boiling fractions and resids from the three crudes. The first, ASTM D 5307, has been discussed earlier. The second is a variation of the ASTM proposed high temperature method "Boiling Range Distribution of Heavy Petroleum Fractions by Gas Chromatography" that is analogous to ASTM D 2887. This method uses a high temperature GC and column to elute material boiling below

1350° F. An internal standard is not used, and complete sample elution by 1350° F is assumed. The third is the ASTM proposed high temperature method in a variation that uses an internal standard. This method is applicable to materials with an initial boiling point of at least 600° F, since elution of the internal standard (typically C_{14} and C_{16} *n*-paraffins) must be complete before the sample elution begins. Reproducibility and repeatability data on the two proposed methods are not available and bias has not been determined due to lack of an accepted reference material. Data for the fractions and resids from the three crudes are listed in Table 12. Most samples were run by the proposed high temperature method using an internal standard. Samples run by the proposed method without an internal standard and one sample run by ASTM D 5307 are indicated by footnotes.

3. GENERAL PHYSICAL PROPERTY CHARACTERIZATION DATA

3.1 Cloud Point

Cloud points were determined for all fractions distilling between 320 and 550° F by ASTM D 2500, Cloud Point of Petroleum Products. This method is applicable to petroleum products that are transparent in layers of 40 mm thickness, and with cloud points below 120° F. The cloud point is the temperature at which a cloud of wax crystals first appears in a liquid that is cooled at a specified rate. The repeatability for this test is 3.6° F. Reproducibility is 7.2° F. The procedure has no bias as the value of cloud point can be defined only in terms of a test method. Results are listed in Table 13.

3.2 Pour Point

Pour points on the whole crude and all distillate fractions above 450° F were determined by ASTM D 97, Pour Point for Petroleum Products. This method is applicable to any petroleum product. The pour point is the lowest temperature at which the sample shows movement after first being heated and then cooled at a specified rate and examined at 5° F intervals. Repeatability for this method is 5° F. Reproducibility is 10° F. No bias statement can be made since there are no criteria for measuring bias for the test-product combinations in the method. Results are provided in Table 13. Pour point determinations on samples of the 850-950° F distillates from ANS and ALT crude oils that were submitted with sample numbers without specific sample information (blind) were identical with the original sample determinations. A later repeat determination on the 1150-1250° F distillate from ANS crude deviated by 10° F from the original determination. This deviation is within the reproducibility limits of the method.

3.3 Freeze Point

Freeze points were determined for fractions distilling between 320 and 550° F by ASTM D 2386, Freezing Point of Aviation Fuels. This method is applicable to aviation turbine fuels and aviation gasolines, although the precision data were determined using only aviation turbine fuels. The method involves cooling the fuel until solid hydrocarbon crystals appear, and then noting the temperature at which the crystals disappear as the temperature is allowed to rise. The repeatability of the method is 1.4° F. Reproducibility is 4.1° F. Bias could not be established since no liquid hydrocarbon mixtures of known freezing point that simulate aviation fuels could be found. Results are listed in Table 13.

3.4 Refractive Index

Refractive indexes for the distillates boiling below 650° F were measured by ASTM D 1218, Refractive Index and Refractive Dispersion of Hydrocarbon Liquids using the sodium D line and at 20° C. Measurements for the higher boiling distillates (>650° F) were made by ASTM D 1747, Refractive Index of Viscous Materials. These measurements were also made with the sodium D line but at 80° C. ASTM D 1218 is applicable to transparent and light-colored hydrocarbon liquids that have refractive indexes in the range from 1.33 to 1.50, and at temperatures from 20 to 30° C. The method involves measuring the refractive index by the critical angle method with a Bausch & Lomb Precision Refractometer using monochromatic light. Prior to measurement of samples, a calibration was obtained with certified liquid standards (n-hexadecane, trans-decahydronaphthalene, and 1-methylnaphthalene). Repeatability and reproducibility are 0.00006 and bias is expected to be no more than 0.00006. ASTM D 1747 is applicable to transparent and light-colored viscous hydrocarbon liquids and melted solids which have a refractive index in the range between 1.33 and 1.60, and at temperatures from 80 to 100° C. In other respects, the method is similar to ASTM D 1218. Repeatability for successive results from this method is 0.00007. Reproducibility is 0.0006. Bias is under study by the ASTM subcommittee. Refractive index results are summarized in Table 13. Results obtained for the 850-950° F blind samples were well within the reproducibility of 0.0006 as compared to those obtained from the original samples.

3.5 Flash Point

Flash points were determined by ASTM D 93, Flash Point by Pensky-Martens Closed Cup Tester. The basic procedure (Method A) was used. This method is applicable to petroleum products with flash points in the range from 40 to 360° C, including fuel oils, lube oils, liquids with suspensions of solids, liquids that tend to form a surface film under test conditions, and other liquids with viscosities of 5.5 cSt or more at 40° C. Repeatability of Procedure A is given by the relationship: r = 0.035X where X is the average of two measurements in °C. Bias was not determined since there is no accepted reference material suitable for determination of bias. Results are listed in Table 13. The flash point determined on the ANS blind sample was identical to the original determination. Variation for the ALT flash points (220.5° C versus 220° C) was well within the repeatability (7.7° C). A later repeat determination of the flash point for the 850-950° F distillate from SJV crude deviated from the average of the two determinations by 4.0° C, which is within the repeatability (7.6° C)

3.6 Aniline Point

Aniline points were run by Method A of ASTM D 611, Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents. Method A is applicable to clear samples or to samples not darker than No. 6.5 ASTM color, as determined by Test Method ASTM D 1500, having an initial boiling point above room temperature and where the aniline point is below the bubble point and above the solidification point of the aniline-sample mixture. The method involves mixing specified volumes of aniline and sample, or aniline and sample plus *n*-heptane, in a tube while heating at a controlled rate until the two phases become miscible. The mixture is then cooled at a controlled rate and the temperature at which two phases separate is recorded as the aniline point, or mixed aniline point. Repeatability for aniline point and mixed aniline point in the method is 0.3° F for clear and light colored samples. Reproducibility is 0.9° F. A statement of bias is under development by the ASTM subcommittee. Results are provided in Table 13.

3.7 Smoke Point

Smoke points were run by ASTM D 1322, Smoke Point of Kerosine and Aviation Turbine Fuel. Smoke point is defined as the maximum height in millimeters, of a smokeless flame of fuel burned in a wick-fed lamp of specified design. The method involves burning the sample in an enclosed wick-fed lamp that is calibrated daily against pure hydrocarbon blends of known smoke point. The maximum height of flame attained without smoking is determined to the nearest 0.5 mm. Repeatability is 2 mm. Reproducibility is 3 mm. Bias cannot be determined since the value of the smoke point can only be defined in terms of a test method. Results are listed in Table 13.

3.8 Reid Vapor Pressure

The Reid vapor pressure of the whole crude was determined by ASTM D 5191, Vapor Pressure of Petroleum Products (Mini Method). This method, which uses automated total vapor pressure instruments, is suitable for testing samples with boiling points above 32° F that exert a vapor pressure between 1 and 18.6 psi at 100° F at a vapor-to-liquid ratio of 4:1. A known volume of chilled, air-saturated sample is introduced into an evacuated temperature controlled chamber that has a total volume of 5 times the volume of the injected sample. The test sample is allowed to reach thermal equilibrium at the test temperature of 100° F and the total pressure is measured with a pressure transducer sensor and indicator. The total pressure is then converted to a dry vapor pressure equivalent (DVPE) through use of a correlation equation. Previous interlaboratory studies with gasoline samples have shown no bias between the DVPE value and Reid vapor pressure measured by ASTM D 323. The repeatability of total pressure in method ASTM D 5191 is given by 0.00807(DVPE + 18.0 psi). Absolute bias cannot be determined for lack of a suitable reference material. Relative bias studies resulted in the correlation between total vapor pressure and DVPE. The Reid vapor pressures of the three crude oils are listed in Table 13.

3.9 Octane Numbers

Research and motor octane numbers were run by ASTM D 2699, Knock Characteristics of Motor Fuels by the Research Method, and ASTM D 2700, Knock Characteristics of Motor and Aviation Fuels by the Motor Method, respectively. These analyses were subcontracted to Phillips Petroleum Co. Results are included in Table 13. The research octane is applicable to motor gasolines intended for use in spark-ignition engines. The motor octane method is applicable to motor and aviation gasolines intended for use in spark ignition engines. In both methods the knocking tendency of the fuel is determined by comparison with the knocking tendencies for blends of ASTM reference fuels of known octane numbers under standard operating conditions in a single cylinder engine.

Precision data are not available for the range of octane numbers measured for these samples. Repeatability of the research method for gasolines with an average research octane number (RON) level of 90 is 0.2 RON. Reproducibility is 0.7 RON at the same level. For the motor method, repeatability for gasolines with average motor octane number (MON) level of 85 is 0.3 MON. Reproducibility for gasolines with average MON of 80.0 is 1.2 MON.

3.10 Water

Water contents of the three crudes were determined by ASTM D 4928, Water in Crude Oils by Coulometric Karl Fischer Titration. The method applies to crude oils with water content between 0.02 and 5 wt. %. Mercaptans and sulfides interfere at concentrations exceeding 500 ppm sulfur. A thoroughly homogenized aliquot of the crude oil is injected into the titration vessel of a Karl Fischer apparatus and titrated with iodine that is generated coulometrically at the anode. The end-point is determined when excess iodine is detected by an electrometric end-point detector. One mole of iodine reacts with one mole of water, and thus the quantity of water is proportional to the total integrated current according to Faraday's Law. Repeatability for a sample varies from 0.003 at 0.02 wt. % to 0.12 at 5.0 wt. % according to the relationship: $r = 0.040X^{2/3}$, where X is the sample mean from 0.005 to 5 wt. %. Reproducibility is $0.105X^{2/3}$. Determinations of samples with known quantities of added water showed no differences between observed and expected values. Water content results are summarized in Table 13.

3.11 Sediment

Sediment in the whole crudes was determined by ASTM D 473, Sediment in Crude Oils and Fuel Oils by the Extraction Method, in which the crude oil sample is extracted with refluxing toluene. Repeatability is given by the relationship: $r = 0.017 + 0.255X$, where X is the average result in percent. Reproducibility is given by $R = 0.033 + 0.255X$. Sediment results are summarized in Table 13.

4. CHEMICAL ANALYSIS DATA

4.1 Detailed Hydrocarbon Analysis

Detailed component analyses were performed on the whole crudes, the IBP-165° F, and the 165-320° F fractions. The method used and related methods are widely employed in the petroleum industry for detailed component analysis. These methods are often modifications and extensions of ASTM D 5134, Detailed Analysis of Petroleum Naphthas through *n*-Nonane by Capillary Gas Chromatography. When applied to a whole crude, an internal standard is used to provide concentrations on a whole crude basis. Repeatability of these methods may be similar to that of D 5134. Repeatability and reproducibility values for a number of individual compounds are given in Table 3 of ASTM D 5134. Some examples of repeatability are *n*-Butane ($r = 0.091X^{0.85}$), Benzene ($r = 0.037X^{0.67}$), and *n*-Nonane {$r = 0.017X$}. Bias cannot be determined since there is no accepted reference material suitable for determining bias. Results of the detailed hydrocarbon analyses are provided in Table 14. The first page for each sample in the table provides the total concentration for each compound class (paraffins, isoparaffins, etc.) and the concentration of each carbon number in each compound class. The following pages provide the concentrations of each identified compound in chromatographic order.

4.2 Hydrocarbon Types by Mass Spectrometry

Hydrocarbon type analyses were run on distillate fractions and composites distilling between 450 and 650° F by the mass spectrometric method of Richard M. Teeter (14). A type analysis does not yield information on individual components in a mixture, but rather it does supply information on the relative amounts of classes or types of compounds. Thus, the Teeter method determines the relative amounts of eight types of saturate hydrocarbons (zero through seven rings), ten types of aromatic hydrocarbons, and four types of sulfur-containing aromatic compounds. Although the type analysis does not yield results of high accuracy, the results can be very useful in comparisons to determine trends and in correlations with processing parameters, product quality, or any other property that is related to or determined by composition. The method is limited to low-olefin, petroleum distillate fractions in the boiling range 350 to 1050° F which contain less than 5% oxygen, nitrogen, or sulfur compounds. Only the 22 compound types listed in the method are determined; all others are ignored. Other factors that can produce erroneous results are large amounts of a single compound, any other unusual distribution of compounds, or thermally unstable components. The mass spectral resolution required for the method is 5,000 (10% valley definition). The main advantage over the standard ASTM methods that apply to fractions in the same boiling range is the absence of need for prior separation of the samples.

Another advantage for the Teeter method over ASTM Method D 2425 for middle distillates (or diesel fuels) is the determination of more compound types (up to 22 compared to 11 for ASTM D 2425). In particular, the determination of thiophenic types by the Teeter method could be a very important advantage for some samples in view of the forthcoming more stringent control of the level of sulfur species in gasoline and other petroleum products (the ASTM method determines only hydrocarbon types). For higher boiling samples in the gas-oil range, the combination of ASTM D 2786 (7 saturate and 1 aromatic types) and ASTM D 3239 (18 aromatic hydrocarbon and 3 aromatic sulfur-containing types) does determine more compound types than the Teeter method, but requires the prior separation and analysis of two samples. Overall, the precision and accuracy of the Teeter and various ASTM methods are comparable. A summary of the analytical results for a sample used for QA/QC purposes in our laboratory and in a client's laboratory (using a different mass spectrometric method [modified Robinson method similar to ASTM D 2425] and instrument [CEC 21-103]) are shown below:

Compound Type	Teeter Method on Our MS-50	Client's 21-103 data
Paraffins	16.01 ± 0.29	16.91 ± 0.43
Naphthenes	14.55 ± 0.47	16.06 ± 0.46
Aromatics	69.40 ± 0.56	67.03 ± 0.55

The error limits listed are plus or minus one standard deviation. The agreement between the results from the two methods is quite good, especially considering that the data were acquired by different operators using different methods and different instruments located in different laboratories. Results for the Teeter analysis are provided in Table 15.

4.3 Aromatic Carbon by Nuclear Magnetic Resonance Spectroscopy

Aromatic carbon contents of three fractions and one composite were determined using carbon-13 nuclear magnetic resonance (NMR) spectrometry. Results are listed in Table 16. The aromaticity, fa, is defined as the mole fraction of aromatic carbons in the sample, and is obtained by finding the ratio of the aromatic carbon signal integral to the total carbon signal integral from the NMR spectrum. The fastest procedure is to obtain the proton NMR spectrum of the sample, which is inherently quantitative. However, the underlying carbon structure of the sample must be inferred from the proton spectrum using some assumptions based on the nature of the sample, so the resulting aromaticity is subject to some uncertainty.

Because of the variable interaction of the carbon-13 nuclear spin with those of the attached protons during proton decoupling (nuclear Overhauser effect, NOE) and the long spin-lattice relaxation times of non-protonated carbons, care must be exercised to obtain quantitative carbon-13 NMR spectra. Gated decoupling is used where the proton decoupling field is applied only during signal acquisition and not during the longer delay between successive pulses to avoid the variable NOE. A long delay between successive pulses is used to allow complete relaxation of the different carbon types in the sample between pulses to achieve quantitative results. Because of the low isotopic ratio of carbon-13 in the sample, many successive signals must be added to achieve adequate signal/noise ratios, leading to long experiment times. The experiment can be shortened by adding a relaxation agent, such as chromium acetylacetonate, to the sample solution. This can shorten the time by a factor of four or more.

From the quantitative carbon-13 NMR spectrum, the integral of the aromatic carbon signal (105-160 ppm from TMS) and the total carbon-13 integral are obtained to calculate the aromaticity. If the sample contains olefinic material or water, the signals from olefinic carbon-13 are located in the same region as the aromatic carbon-13 signals and can lead to a larger value for the aromaticity. The proton spectrum usually will reveal whether there is significant olefinic material present in the sample, so the wise procedure is to do both experiments even though petroleum crude oils generally contain no olefinic material.

The aromatic carbon content method is essentially Procedure C of ASTM D 5292 which was approved and published by ASTM in 1993. Repeatability of ASTM D 5292 is given by the relationship: $r = 0.59X^{1/3}$ where X is the aromatic content determined in the method. Reproducibility is given by $R = 1.37X^{1/3}$. No bias was found for single pure hydrocarbons or a known mixture of pure aromatic compounds. Bias cannot be determined for typical petroleum fractions since there is no suitable accepted reference method available.

4.4 Elemental Analyses

Elemental analyses are provided in Table 17. Carbon, hydrogen and nitrogen were determined by Method B of ASTM D 5291, Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants, using a Perkin-Elmer 240C instrument. The sample is combusted to carbon dioxide, water, and nitrogen oxides. Oxygen is removed and the nitrogen oxides are reduced to nitrogen. The gases are separated on a column before quantitative determination. Good repeatability is typically obtained for carbon and hydrogen via this method but the nitrogen values are of questionable value. Repeatabilities published with the method are $r = 0.0072(X+48.48)$ for carbon in the range 75 to 87 wt. %, $r = 0.1162X^{0.5}$ for hydrogen in the range 9 to 16 wt. %, and $r = 0.1670$ for nitrogen in the range 0.75 to 2.5 wt. %, where X is the average wt. % value determined for each element, respectively. Reproducibilities are $R = 0.018(X+48.48)$, $R = 0.2314(X^{0.5})$, and $R = 0.4456$ for carbon, hydrogen, and nitrogen, respectively. Bias could not be determined for lack of a suitable petroleum based reference material.

Carbon contents for the two blind samples (850-950° F ANS and ALT distillates), were well within the repeatability ($r = 0.96$ wt. %) for the method as compared to the original samples. In like manner, the hydrogen contents were well within the repeatabilities for the two crude oil distillates (r = 0.4 wt. % for ANS, r = 0.45 wt. % for ALT). The nitrogen values repeated well, but both were outside the applicable range of the method.

Nitrogen values determined by chemiluminescence (ASTM D 4629 and ASTM D 5762 with a modification (15)), which are also reported in Table 17, are much more reliable. Method ASTM D 4629, Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection, is applicable to liquid hydrocarbons boiling in the range from approximately 122° F to 752° F, with viscosities between about 0.2 to 10 cSt at room temperature, and with total nitrogen contents from 0.3 to 100 mg/kg. In this method, the sample is injected into an inert gas stream, vaporized, and carried into a high temperature zone where oxygen is introduced to convert organic and bound nitrogen into nitric oxide. The nitric oxide is reacted with ozone to produce electronically excited nitrogen dioxide. The light emitted as the excited molecules decay is detected by a photomultiplier tube and the resulting signal is related to nitrogen content of the sample. Precision is given by $r = 0.15X^{0.54}$, where X is the average of two test results. Reproducibility is given by $R = 0.85X^{0.54}$. Bias for the method has not been determined. In the modified method ASTM D 5762, the neat sample is introduced into the instrument in the sample boat instead of a diluted sample. Results obtained with the modified method were essentially the same as those obtained by sample dilution before injection by syringe. Precision is expected to be comparable also. Repeatability for ASTM D 5762 is given by the relationship: $r = 0.099X$, where X is the average of two test results in μg/g. Reproducibility is given by $R = 0.291X$. Results for a NIST Standard Reference Material showed no significant bias. Nitrogen content of the ANS blind sample by modified ASTM D 5762 was identical to the original sample and was thus well within the repeatability (r = 0.025 wt. %). Deviation of the two results for the ALT 850-950° F distillate was 0.002 as compared to 0.002 for reproducibility.

Sulfur values, including results by three different methods, are also reported in Table 17. Sulfur contents were determined for the whole crude and its fractions through 950° F by ASTM D 4294, Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence (XRF) Spectrometry. ASTM D 1552, Sulfur in Petroleum Products (High-Temperature/Infrared (IR) Method), was used for sulfur determination on the >650° F samples. This method is more accurate than the XRF method for heavy samples. For the fractions containing trace sulfur levels, the microcoulometric method, ASTM D 3120, Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry, is more appropriate.

The XRF method is applicable to a wide range of samples with concentrations in the range from 0.0150 to 5.00 wt. % sulfur. In this method, the sample is placed in the beam emitted from an X-ray source and the resultant excited characteristic X radiation is measured. The accumulated count is compared to counts obtained previously from calibration samples to obtain sulfur concentration in wt. %. Repeatability for this ASTM method is given by the relationship: $r = 0.02894(X+0.1691)$ where X is the sulfur concentration in wt. %. Reproducibility is given by $R = 0.1215(X+0.05555)$. Bias was determined in a study of eight NIST reference materials with sulfur contents ranging from 0.0146 to 3.02 wt. %. Six samples showed small positive biases and two showed negative biases. Only one value, -0.0119 for the reference standard containing 0.381 wt. % sulfur, was considered to be significant. From the data in Table 17, the sulfur contents for the regular and blind 850-950° F ANS samples are identical. Values for the corresponding ALT samples deviated by 0.004 wt. % and thus the difference is well within the repeatability (0.006).

The high temperature method, ASTM D 1552, with resistance furnace and IR detection was used. The method is applicable to samples boiling above 177° C (350° F) and containing not less than 0.06 wt. % sulfur. Since only about 97% of sulfur is converted to sulfur dioxide after combustion at 2500° F, a calibration factor determined from standards is required. Repeatability for two test results from the procedure with IR detection used in this work varies from 0.04 for sulfur contents from 0.0 to 0.5 wt. %, 0.09 for sulfur contents from 1.0 to 2.0 wt. %, and 0.16 for sulfur contents from 4.0 to 5.0 wt. %. Corresponding reproducibility values are 0.13, 0.27, and 0.49, respectively. Although bias in the method is still under study, no statistically significant bias was found between the iodate and IR detector procedures. One sulfur analysis by this method was repeated at a later time. The difference of 0.11 wt. % between the two determinations for the 650-950° F composite SJV samples (1.19 and 1.30 wt. %) is considerably less than the reproducibility (0.27 wt. %).

Comparisons of values for samples analyzed by both the XRF and high temperature methods can also shed light on the accuracy of the analyses. Values for the 650-750° F (1.312 and 1.33), 750-850° F (1.210 and 1.22), 850-950° F (1.213 and 1.21), and 650-950° F composite (1.234 and 1.19 wt. %) SJV samples by ASTM D 4294 (XRF) and ASTM D 1552 (IR) methods, respectively, show excellent agreement, with the differences observed being within the repeatabilities of both methods.

The microcoulometric method, ASTM D 3120, is applicable to light liquid hydrocarbons boiling in the range from 26 to 274° C (80 to 525° F) with sulfur contents from 3.0 to 100 ppm by weight, or to higher sulfur contents with appropriate dilution. In this method, a liquid sample is injected into a combustion tube maintained at about 800° C having a flowing stream of 80% oxygen and 20% inert gas. The sulfur dioxide produced flows into a titration cell where it reacts with triiodide ion in the electrolyte. The triiodide consumed is coulometrically replaced and the total current required is a measure of the sulfur present in the sample injected. Repeatability of the method is 28% of the average value determined. Reproducibility is 38% of the average value. Bias is not available due to lack of a suitable accepted reference material. Method ASTM D 3120 was applied to the 165-320° F and 320-450° F distillates from all three crude oils. No repeat runs were made but XRF data were obtained on these samples also. Agreement between the values from the two methods for the SJV distillates was quite good and well within the repeatability of method ASTM D 3120. Results for the two distillates from ANS and ALT crude oils agree reasonably well considering three of the four values determined by XRF are outside the range of applicability.

4.5 Carbon Residue

Carbon Residue was determined by ASTM D 524, Ramsbottom Carbon Residue of Petroleum Products or by ASTM D 4530, Determination of Carbon Residue (Micro method). In the Ramsbottom method, a weighed sample in a special glass bulb having a capillary opening is placed in a metal furnace maintained at approximately 550° C. The volatile material is evaporated with or without decomposition and the heavier material undergoes cracking and coking reactions. After a specified heating period, the bulb is removed, cooled in a desiccator, and reweighed. The weight of the residue is expressed as a percentage of the original sample weight. Repeatability is given by a complex relationship expressed as a curve on a log/log plot of r versus average Ramsbottom Carbon Residue. Values of r vary from 0.02 wt. % for a residue value of 0.04 wt. %, to 2 wt. % for a residue value of 20 wt. %. Corresponding values for reproducibility are 0.026 and 3 wt. %, respectively. No bias was given for the method since the test is empirical. Comparison of results from the ANS and ALT blind sample with the original 850-950° F distillate results show one pair of results within repeatability (ALT) and one outside the reproducibility (ANS, R = 0.06, values 0.24 and 0.32 wt. %).

In the Micro Carbon Residue method, a weighed sample is placed in a glass vial and heated to 500° C under a nitrogen atmosphere in a controlled manner for a specific time. As the sample undergoes coking reactions, volatiles are swept away by the nitrogen. The carbonaceous-type residue remaining is reported as a percent of the original sample. Repeatability is given by the relationship: $r = 0.0770X^{2/3}$ where X is the percent micro carbon residue. Reproducibility is given by $R = 0.2451X^{2/3}$. No bias was reported for this method as the wt. % of carbon residue can be defined only in terms of the test method. Carbon residue results are listed in Table 18. The difference between determinations of Micro Carbon residue by ASTM D 4530 on the original and blind ANS 850-950° F distillate was 0.05 wt. % (0.36 - 0.31). This difference was well within the reproducibility (0.12 wt. %).

5. EBULLIOMETRIC VAPOR PRESSURE MEASUREMENTS

Prior to the ebulliometric vapor pressure measurements each fraction was carefully outgassed (degassed) on a vacuum line using freeze, pump, thaw cycles. Three cycles were used to remove dissolved air. Liquid nitrogen was used in the outgassing to prevent the loss of light ends. The outgassing procedure was undertaken to prevent thermal oxidation of the sample by small amounts of dissolved oxygen during the subsequent high-temperature vapor pressure measurements.

The platinum resistance thermometers used in these measurements were calibrated by comparison with standard thermometers whose constants were determined at the National Institute for Standards and Technology (NIST). All temperature measurements were made in terms of the ITS-90 (16,17) and subsequently converted to °F. Measurements of electric resistance and potential difference were made in terms of standards traceable to calibrations at NIST. Vapor pressures were determined in Pascals. Values reported in mm Hg were derived using the conversion factor 1 mm Hg = 133.322 Pa.

The vapor pressure measurements were made using twin comparative ebulliometry, wherein both the boiling and condensation temperatures are measured, and the pressure in the system is determined by comparison with standards. The ebulliometer is a one-stage total reflux boiler designed to minimize superheating of the boiling liquid. The essential features of the ebulliometric equipment and procedures for vapor-pressure measurements are described in the literature (18, 19, 20). The ASTM Standard Test Method E 1719-97 gives details of the methodology for ebulliometry (boiling temperature only). The ebulliometers were used to reflux the substance under study with a standard of known vapor pressure under a common helium atmosphere. In the pressure region from 25 to 270 kPa, water was used as the standard, and the pressures were derived using the internationally accepted equation of state for ordinary water revised to ITS-90 (21). In the pressure region from 2 to 25 kPa, decane was used as the standard. Pressures were calculated on ITS-90 for those measurements using the equation:

$$\mathrm{Ln}(p/\mathrm{kPa}) = 7.73165 + (1/T_r)\{-9.98917(1-T_r) + 5.28411(1-T_r)^{1.5} - 6.51326(1-T_r)^{2.5} - 2.68400(1-T_r)^5\}, \qquad (1)$$

where $T_r = T/(617.650\ \mathrm{K})$ and T denotes the condensation temperature for the decane.

The precision in the temperature measurements for the ebulliometric vapor-pressure studies was 0.001 K. Uncertainties in the pressures are adequately described by:

$$\sigma(p) = (0.001)\ \{(dp_{(ref)}/dT)^2 + (dp_{(x)}/dT)^2\}^{1/2} \qquad (2)$$

where $p_{(ref)}$ is the vapor pressure of the reference substance and $p_{(x)}$ is the vapor pressure of the sample under study.

Table 19 lists the vapor pressure measurements made on each of the fractions. The temperatures are in °F and the pressures in mm Hg. In table 19, T_{cond} is the condensation temperature for the corresponding pressure, p. T_{boil} is the temperature of the boiling liquid for the corresponding pressure and $\Delta T = T_{boil} - T_{cond}$. $\sigma(p)$ gives the precision of the measurements when a pure component sample is refluxed in the ebulliometer. For a pure component sample, ΔT usually averages less than 0.03° F. **Temperatures listed for the vapor pressure data are defined in terms of the ebulliometer system and do not correspond exactly with similar terms used in engineering practice. However, the condensation temperature should be within a few degrees of what is referred to in engineering terms as the bubble point.**

Vapor pressure measurements on the 600-650° F SJV distillate were also conducted by Wiltec Research Company. Table 19A gives the vapor pressure data from 144° C (292° F) to 330° C (627° F). The measured vapor pressure data was also correlated by the Antoine equation. The correlated pressures and the percent deviations between the two pressures are listed in the table also.

The vapor pressure data from Wiltec agreed very well with that measured by NIPER. For comparison, the NIPER data and the combined data were also correlated by the Antoine equation, lnP(mm Hg) = A – B/(T(K)-93.). The following values were found for A, B, R^2 for the correlation, and the average % deviation between calculated and measured pressures:

Data Set	A	B	R^2	Ave. % Dev. P
Wiltec	16.631	5186.4	0.9999	1.39
NIPER	16.659	5192.4	0.9999	0.78
Combined	16.645	5190.2	0.9999	1.33

The precision of the NIPER data as indicated by the average % deviation of 0.78% was very good.

6. TWO-PHASE HEAT CAPACITY AND PSEUDO-CRITICAL TEMPERATURE MEASUREMENTS

Several fractions of the ANS, ALT, and SJV crudes were selected for heat capacity measurements. The samples were carefully outgassed (degassed) on a vacuum line using freeze, pump, thaw cycles. Three cycles were used for each sample to remove dissolved air. Liquid nitrogen was used in the outgassing to prevent the loss of "light ends." The outgassing procedure was undertaken to prevent thermal oxidation of the samples during the subsequent high-temperature heat-capacity measurements.

Values of the heat capacity are reported in units of Btu/(lb °F). They were measured in units of J/(gK) and converted by multiplying by the factor 0.2390056. Temperature measurements were made in terms of the IPTS-68(22) or ITS = 90(16) and were subsequently converted to °F. Measurements of mass, time, electrical resistance, and potential difference were made in terms of standards traceable to calibrations at the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS).

Differential-scanning calorimetric measurements were made with a Perkin-Elmer DSC II which was fitted with a glove box to exclude air from the head. The calorimeter head was flushed with dry nitrogen. A Perkin-Elmer Intercooler II "freon" refrigeration unit was used to remove energy from the calorimetric head.

The samples were confined in high-pressure cells fabricated at NIPER.(23) The cells were made from 17-4 PH chromium nickel stainless steel (AISI#630), and had an internal volume of approximately 0.05 cm^3. The cells were sealed with gold gaskets in the form of washers. The internal volumes of the cells were determined from the masses of water held by the cells after they were immersed and sealed in distilled water. The heights of the cells were determined after sealing to correct the volumes for compression of the gold gaskets. It was practical to work with the cells filled in the range of 0.5 to 1.5 times the critical density. In that range, the saturation temperatures are typically within 20 K (36° F) of the critical temperature.

Oxygen is known to be a promoter for the formation of free radicals leading to sample decomposition at high temperatures. Therefore, care was used to exclude oxygen from both the samples and the cells. All cells were sealed in an atmosphere of dry nitrogen.

All measurements of the two-phase heat capacities (liquid plus vapor) were determined with a stepwise heating method described by Mraw and Naas.(24) Measurements were made in 20-K (36° F) increments at a heating rate of 5 $K \cdot min^{-1}$. An integrating voltmeter was used to give an almost continuous integration of the imbalance signal from the d.s.c. A computer was programmed to step through the heat-equilibration-heat cycles, collect the imbalance signals from the voltmeter, and monitor the temperature from the d.s.c.

The temperature scale of the d.s.c. was calibrated before each set of heat-capacity measurements by measurement of the melting temperatures of NIST Standard Reference Materials (SRM's) indium (429.78 K), tin (505.06 K), and lead (600.65 K). The energy scale was assumed to be dependent upon temperature, scanning rate, and the gain settings for the instrument. Imbalance signals were calibrated with sapphire using published heat-capacity values.(25)

None of the three heat capacities – heat capacity at constant volume (C_v), heat capacity at constant pressure (C_p), or heat capacity at saturated pressure (C_{sat}) — can be directly measured conveniently for a liquid along its saturation line. The third heat capacity, C_{sat}, is the most closely related to experiment, and could, in principle, be measured directly in a calorimeter whose volume was adjusted to be that of the saturated liquid at each temperature. This would, however, be difficult to realize experimentally. In practice the measurement is of the heat capacity at constant total volume of a liquid in equilibrium with a small amount of its vapor. The difference between the measured (liquid + vapor) heat capacities and C_{sat} is small at low vapor pressures ($p < 0.1$ MPa), but becomes significant as the vapor pressure increases. This difference was first discussed as a problem of practical importance when heat capacities were required in the refrigeration industry for compounds such as liquid ammonia, carbon dioxide, and methyl chloride. Osborne and van Dusen(26) and Babcock(27) gave full analyses of the heat capacity in the two-phase system and derived C_p and C_{sat}. Hoge(28) gave a clearer and more concise description, but he derived C_{sat} only.

Details of the theoretical background for the determination of heat capacities at vapor-saturation pressure, C_{sat}, with results obtained with a d.s.c. have been described previously(29). Although the theoretical analysis was derived assuming the substance in the d.s.c. cell was a pure compound, unpublished research at NIPER has shown it can be applied successfully to narrow-boiling fractions provided the boiling range of the fractions is 50° F or less. In this research the absence of vapor pressure measurements over a sufficient range of pressures (approximately 10 to 270 kPa), and density measurements over a range of temperature, precluded the derivation of C_{sat} values for each fraction.

The experimental two-phase heat capacities C_X^{II} for the selected fractions are listed in Table 20. As noted above, the absence of both vapor pressure measurements and density as a function of temperature precluded calculation of C_{sat} values for either fraction. To partially compensate for the missing data the fractions were studied with about 20 mg of sample in the cells to minimize the vaporization correction, thereby more closely approximating C_{sat}.

7. THERMAL CONDUCTIVITY

Thermal conductivity measurements by ASTM D 2717, Thermal Conductivity of Liquids, at three temperatures (40, 100 and 150° C) were carried out by Phoenix Chemical Laboratory, Inc. Data for fractions between 320 to 950° F are listed in Table 21. The method is applicable to nonmetallic liquids that are: 1) chemically compatible with borosilicate glass and platinum; 2) moderately transparent or absorbent to infrared radiation; and 3) have a vapor pressure less than 200 mm Hg at the temperature of the test. Materials with vapor pressures up to 50 psia can be tested in an appropriate pressurized cell. The thermal conductivity is determined by measurement of the temperature gradient produced across the liquid sample by a known amount of energy introduced into the cell by electrically heating the platinum element. The cell is constructed according to precise specifications given in the test method. Precision and bias have not been determined due to lack of sufficient volunteers for a cooperative laboratory study. A preliminary estimate of repeatability is 10% of the average of two results by the same operator.

8. VISCOSITY

Viscosities were run by ASTM D 445, Kinematic Viscosity of Transparent and Opaque Liquids and by modified ASTM D 4741, Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer, using a Haake viscometer. Method ASTM D 445 is applicable to transparent and opaque liquid petroleum products with viscosities in the range 0.2 to 300,000 cSt at all temperatures. In the method, time is measured for a fixed volume of liquid to flow under gravity through the capillary of a calibrated viscometer under a reproducible head and at a closely controlled and known temperature. The kinematic viscosity is the product of the measured flow time and the calibration constant of the viscometer.

Method ASTM D 4741 was modified to cover determination of the dynamic viscosity of oils using a Haake Rotovisco RV 12/RV 100 with the PK 100 cone and plate sensor system. Samples were run according to the Haake manual. The viscosity of a sample is given by the measured shear stress divided by the preset shear rate.

Kinematic viscosity measurements were made at a total of eight temperatures (0, 25, 40, 70, 100, 125, 150, and 175° C) with viscosities of all samples up to 950° F being made at two or more temperatures. Viscosities (in centistokes) are reported in Table 22. Dynamic viscosity (in centipoise) was measured on four fractions boiling above 950° F at four temperatures (70, 100, 125, and 150° C) by Haake viscometer. These dynamic viscosities were subsequently converted to kinematic viscosities by the following equation:

kinematic viscosity = dynamic viscosity / density

at the same temperature used for measuring the viscosity. Data are also shown in Table 22.

Precision for viscosity by ASTM D 445 is given for a number of petroleum fractions and products at a number of temperatures. Data appropriate for the fractions in this study are the following. Repeatability for ASTM D 445 viscosity of base oils at 104 and 212° F is 0.0011X, where X is the average of results being compared. Corresponding reproducibility is 0.0065X. For residual fuel oils at 176 and 212° F, repeatability for this method is 0.013 (X+8). Corresponding reproducibility is 0.04 (X+8). For gas oils, repeatability for measurement at 104° F is 0.0043 (X+1). Corresponding reproducibility is 0.0082 (X+1). Repeatability and reproducibility for petroleum wax at 212° F are $0.0141X^{1.2}$ and $0.0366X^{1.2}$, respectively. No statement of bias was made in the method.

Repeatability for ASTM D 4741 was 2.8 % of the mean of two test measurements being compared. Reproducibility was 5.0 % of the mean. Both were based on a 12 laboratory study of 12 ASTM engine oils in the range from 2.4 to 4.8 centipoise. No statement of bias could be made since all determinations are relative to the calibration fluid. Repeatability of test results using the Haake instrument is comparable to that of ASTM D 4741 according to the Haake manual.

Repeat measurements of kinematic viscosity by ASTM D 445 were made on several samples. Comparing precision data with the sample data is difficult as the sample type/temperatures for the precision data do not match the sample/temperature combinations for the ANS, ALT, and SJV data. With one exception, the data from the ANS and ALT 850-950° F distillate blind samples were well within the repeatability for gas oils at 104° F, although the measurements were made at 158, 180, 212, and 257° F. The exception was data for the ALT fraction measured at 158° F which were outside the repeatability (0.048) and reproducibility (0.09). Comparing this very waxy crude sample with repeatability and reproducibility for petroleum wax at 212° F shows the data are well within the reproducibility (0.60). Repeat runs for the SJV 450-650° F composite sample gave 6.747 and 6.750 cSt at 104° F; and 3.131 and 3.087 cSt at 158° F. The data at 104° F were within the repeatability (r = 0.007), but the data at 158° F were outside the reproducibility (R = 0.022), both using the precision data for gas oils at 104° F. Repeat runs for the ALT 650-950° F composite at 158° F (6.362/6.198) and 212° F (3.644/3.733) were outside the repeatability and reproducibility for gas oils, but were within the reproducibility and repeatability for petroleum wax (R = 0.332 and r = 0.068), respectively. The repeat run at 257° F (2.602/2.598) was well within the repeatability value for gas oils at 104° F (0.015) or petroleum wax at 212° F (0.044).

9. GRAVITY

Specific gravities and API gravities for the whole crude oils, their fractions, and resids are presented in Table 23. Specific gravities for the crude and fractions through 950° F were measured by ASTM D 4052, Density and Relative Density of Liquids by Digital Density Meter, when feasible. The API gravities were calculated from the specific gravities at 60/60° F. Specific gravities for the >650° F and >950° F resids and higher boiling fractions were determined by pycnometer, ASTM D 70, Specific Gravity of Semi-solid Bituminous Materials; or by hydrometer, ASTM D 1298, Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method, with the results corrected to 60° F and then recorrected to other temperatures by ASTM D 1250 using Volume X, Background, Development, and Implementation Procedures as needed.

ASTM Method D 4052 is applicable to petroleum distillates and viscous oils that can be handled in a normal manner as liquids at test temperatures between 60 and 95° F and that have vapor pressures below 600 mm Hg and viscosities below about 15,000 cSt at the test temperature. In this method about 0.7 mL of sample is injected into an oscillating sample tube and the change in oscillation frequency caused by the change in mass of the tube is used along with calibration data to determine the density of the sample. Specific gravity is calculated by dividing by the density of water at the same temperature. Repeatability for tests conducted at 60 and 68° F with samples in the range 0.68 to 0.97 g/mL was determined to be 0.0001. Reproducibility was 0.0005 g/mL. A study of four standard reference oils certified by pycnometry with densities ranging from 0.747 to 0.927 g/mL at 20° C and viscosities between 1 and 5,000 centipoise (also at 68° F) indicated that this method can be biased by up to 0.0006 g/mL.

ASTM Method D 1298 is applicable to crude petroleum, petroleum products, and mixtures of petroleum and nonpetroleum products normally handled as liquids, and having a Reid vapor pressure of 26 psi or less. Density, relative density (specific gravity), or API gravity is determined using a glass hydrometer at a temperature convenient for the sample. Density values are converted to 15° C, and specific gravity and API gravity to 60° F, by means of international standard tables. Repeatability for transparent, nonviscous samples measured in the temperature range 29 to 76° F is 0.0005 for density and specific gravity (0.1 for API gravity in temperature range 42 to 78° F). Reproducibility is 0.0012 and 0.3, respectively. For opaque samples, repeatability for measurements in the same temperature ranges is 0.0006 for density and specific gravity and 0.2 for API. Reproducibility is 0.0015 and 0.5, respectively.

ASTM Method D 70 is applicable to viscous, semi-solid bituminous materials. The method is gravimetric using a pycnometer of known volume. Repeatability at 60° F is 0.003 and reproducibility is 0.007.

Agreement between repeated specific gravity determinations by ASTM D 4052 is mixed although much of the comparison data is within or near the repeatability of 0.0001. For example, the original and repeat values for specific gravity of the 550-600° F fraction from SJV crude at 60° F were 0.8914 and 0.8913, respectively. A similar comparison for the ANS 750-850° F fraction with values of 0.9296 and 0.9303 was close to the reproducibility of 0.0005. Three determinations on the SJV 750-850° F fraction (0.9604, 0.9627, and 0.9625) showed good agreement between the latter two values, but not between the first and the latter two.

Agreement between specific gravity data determined by PARC (method unspecified) and those determined by NIPER on the same fractions was also mixed with some data being identical (0.8633 for the ANS 500-550° F fraction) and some data showing relatively large differences (0.9548 and 0.9437 for the ANS 850-950° F fraction, respectively). Most of the comparative data showed reasonable agreement with over half being within the reproducibility for the method.

Agreement between repeated specific gravity determinations by ASTM D 1298 at 60° F was mixed as well. Values for the original and blind ALT 850-950° F samples was within the repeatability of 0.0005 (0.8409 and 0.8405, respectively). Three runs of the ALT 750-850° F fraction showed fair agreement between the latter two, but not between the first and either of the latter two (0.8338, 0.8275, and 0.8264, respectively). This discrepancy may be due to difficulties in running waxy samples by this hydrometer method.

Agreement between results on the same samples at the same temperature but by different methods was mixed also.

10. MOLECULAR WEIGHT

Molecular weight for the 320-450° F fraction was subcontracted to Core Laboratories for determination by freezing point depression. Repeatability is given by r = 0.03X, where X is the average molecular weights. No value for reproducibility was available. Molecular weights for all higher boiling fractions were determined by ASTM D 2503, Molecular Weight (Relative Molecular Mass) of Hydrocarbons by Thermoelectric Measurement of Vapor Pressure using a Wescan Model 232A Molecular Weight Apparatus. This method is applicable to petroleum fractions with initial boiling point above 430° F and with molecular weights up to 3000, although precision has not been established above 800. A weighed portion of the sample is dissolved in a known quantity of a suitable solvent. A drop of the solution and a drop of the solvent are suspended, side by side, on separate thermistors in a closed chamber saturated with solvent vapor. Solvent condenses on the sample drop since the vapor pressure of the solution is lower than that of the solvent. This causes a temperature difference between the two drops. The resultant change in temperature is measured and used to determine the molecular weight of the sample by reference to a previously prepared calibration curve. Repeatability is 5 g/mol for molecular weights in the range 245 to 399, 12 in the range 400 to 599, and 30 in the range 600 to 800. Reproducibilities for the three ranges are 14, 32, and 94 g/mol, respectively. Molecular weight data are listed in Table 24.

Agreement between repeated molecular weight determinations by ASTM D 2503 was reasonably good except for the SJV 500-550° F fraction (228/246), which was outside the reproducibility. The data for the ANS and ALT 850-950° F fractions and blind samples showed excellent agreement as did the freezing point depression molecular weight determinations for the ANS and SJV 320-450° F fractions.

11. SUMMARY

Crude oil characterization and thermophysical property data from the twelve reports issued in the course of the API research program on characterization of crude oils are compiled in this comprehensive report. The goal of the API program was to obtain complete sets of property data on a few widely varying crude oils to test the basic correlations necessary to evaluate a crude oil for design purposes. The crude oils selected by the project sponsors were Alaska North Slope (a typical and important crude for a number of U.S. refineries), Utah Altamont (a very paraffinic crude), and San Joaquin Valley (an aromatic crude). In general, data obtained on the two blind samples and data from repeat runs on samples taken out of cold storage were in good agreement with original data. Reproducibility precision values apply more closely in the comparisons with repeat runs which were made two to four years after the original runs, and often by different operators. The scope of this report is limited to a discussion of the characterization tests and their accuracy, and to a comprehensive compilation of data for the three crudes. The thermodynamics and petroleum test laboratories at NIPER have a long history of producing high quality data and have always taken the utmost care and pride in their work. The vast majority of the data produced in this program are judged to be highly reliable. Nevertheless, every test method has its limitations. Data which are judged to be of particularly high quality, given the limitations of the particular method, are vapor pressure, heat capacity, refractive index, flash point, carbon, hydrogen, nitrogen, sulfur, hydrocarbon types by mass spectrometry, and aromatic carbon by nuclear magnetic resonance spectrometry. Some problems were encountered with the gravity and viscosity data, particularly with the waxy Altamont crude samples.

In addition, the ASTM D 86 distillation data for the 650-750° F distillates, run at the sponsors' request, should not be considered reliable as these distillates are outside the range covered by the method. Similarly, the ASTM D 2892 distillations of the narrow boiling range cuts are not reliable as the method applies to crude oils and the automated equipment is not designed for use on such narrow cuts. Finally, although the data were generated to allow evaluation of various correlations used for design purposes, such evaluation is beyond the scope of this report and have been/will be done by API Technical Data Committee participants.

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Table 1. Preparative Distillation of Alaska North Slope (ANS), Altamont (ALT), and San Joaquin Valley (SJV) Crudes[a]

	ANS								ALT		SJV	
	Vapor Temp.[b] °F	Pressure[b] mm Hg	AET[c] °F	Yield wt.%	Yield vol.%	Cumulative Yield vol.%	API Grav.	Spec. Grav.	Yield wt.%	Spec. Grav.	Yield[e] wt.%	Spec. Grav.
Crude							27.3	0.8911		0.8179		0.9772
Cut 1	163	740	165	3.0	4.1	4.1	85.6	0.6518	1.2	0.6578	--	--
Cut 2	318	740	320	9.6	11.3	15.4	55.8	0.7555	8.2	0.7328	0.9	0.8081
Cut 3	314	87	450	9.6	10.6	26.0	43.2	0.8100	8.7	0.7661	2.4	0.8529
Cut 4	328	48	500	4.7	4.9	30.9	35.6	0.8468	5.9	0.7861	3.1	0.8735
Cut 5	348	29	550	5.4	5.6	36.5	32.4	0.8633	4.3	0.7954	6.0	0.8849
Cut 6	375	22	600	4.4	4.5	41.0	31.2	0.8697	6.2	0.8008	4.6	0.9106
Cut 7	420	22	650	5.4	5.4	46.5	28.0	0.8871	4.4	0.8081	8.0	0.9340
Cut 8	478	12	750	10.5	10.3	56.8	24.8	0.9053	9.2	0.8212	9.6	0.9490
Cut 9	565	12	850	11.1	10.7	67.4	20.9	0.9285	13.4	0.8330	11.5	0.9600
Cut 10	526[d]	0.61[d]	950	6.5	6.1	73.5	16.7	0.9548	10.4	0.8403	17.9	0.9888
Bottoms			>950	28.1	24.7	98.3	8.0	1.0142	26.6	0.8644	31.8	1.0580
Cut 11			1050	4.0				[f]0.9603	4.5	[h]0.8577	4.1	[h]1.0034
Cut 12			1150	5.3				[f]0.9656	6.2	[h]0.8741	3.9	[h]1.0051
Cut 13			1250	5.7				[f]0.9812	6.9	[h]0.8848	5.7	[h]1.0183
>1250 Resid			>1250	12.9				[g]1.0029	8.9	[h]0.9172	17.9	[h]1.0436
Total Loss				1.9					1.6		4.4	

[a] Distillation to produce cuts 1 through 10 were performed by Pittsburgh Applied Research Center. Fractions 1-9 were obtained with a 150 gallon batch still charged with 90 gallons of crude and fraction 10 was obtained from 10-liter Sarnia stills. Cuts 11 through 13 were prepared by NIPER using short path distillation on a 6-inch Pope still.

[b] Data for ANS crude;similar data for ALT and SJV crudes are found in references 2 and 4, respectively.

[c] Atmospheric equivalent temperature.

[d] Average of 11 Sarnia still runs.

[e] First cut made at 320° F due to insufficient material boiling below 165° F.

[f] ASTM D 4052 @ 80/80° F.

[g] ASTM D 70 @ 180/180° F.

[h] ASTM D 70 @ 60/60° F.

Table 2. Short Path Distillation of ANS, ALT, and SJV >950° F Resids: Yields and Recoveries

	ANS		ALT		SJV	
	wt., kg	wt.%	wt., kg	wt.%	wt., kg	wt.%
First Pass (Nominal 950-1050° F)						
Total Charge	43.081		26.14		26.22	
Distillate	6.216	14.4	4.42	16.9	3.40	12.97
Resid	36.859	85.6	21.63	82.8	22.75	86.77
Total Recovered	43.075	99.9	26.05	99.7	26.15	99.74
Second Pass (Nominal 1050-1150° F)						
Total Charge	24.37		21.60		22.41	
Distillate	5.37	22.1	6.03	27.9	3.15	14.06
Resid	18.97	77.9	15.52	71.9	19.25	85.90
Total Recovered	24.34	99.88	21.55	99.8	22.40	99.96
Third Pass (Nominal 1150-1250° F)						
Total Charge	13.63		15.49		15.22	
Distillate	4.19	30.8	6.76	43.6	3.64	23.92
Resid	9.43	69.2	8.72	56.3	11.51	75.62
Total Recovered	13.62	99.93	15.48	99.9	15.15	99.54

Table 3. Comparison of Preparative Distillation Cut Yields with ASTM Distillation and Simulated Distillation Data (wt. %)

Distillation Cut	ANS			ALT			SJV		
	Prep	D 2892[a] D 1160[b]	D 5307[c]	Prep	D 2892[a] D 1160[b]	D 5307[c]	Prep	D 2892[a] D 1160[b]	D 5307[c]
IBP - 165° F	3.0	2.9	3.4	1.2	0.4	0.2	0.0	0.0	0.0
165 - 320° F	9.6	9.7	10.3	8.2	6.7	8.0	0.9	1.0	0.0
320 - 450° F	9.6	9.6	10.3	8.7	8.9	9.1	2.4	2.5	4.3
450 - 500° F	4.7	4.8	4.8	5.9	3.9	4.6	3.1	3.0	3.2
500 - 550° F	5.4	5.0	5.4	4.3	4.3	5.3	6.0	4.0	4.2
550 - 600° F	4.4	4.4	5.0	6.2	5.5	4.8	4.6	4.6	5.0
600 - 650° F	5.4	4.9	5.7	4.4	6.2	6.0	8.0	5.4	5.6
650 - 750° F	10.5	8.2	11.1	9.2	10.6	12.5	9.6	8.2	12.1
750 - 850° F	11.1	12.3	10.9	13.4	16.5	14.0	11.5	16.6	13.5
850 - 950° F	6.5	9.9	9.9	10.4	12.4	10.3	17.9	12.2	11.8
Cumulative Total	70.2	71.7	76.0	71.9	75.4	74.8	64.0	57.5	59.7

[a] Data obtained from Table 4 for cuts up to 650° F.
[b] Data for >650° F cuts obtained from Table 7 by linear interpolation or extrapolation and conversion to whole crude basis.
[c] Data obtained from Table 9 by linear interpolation.

Table 4. ASTM D 2892 Distillation of ANS, ALT, and SJV Crude Oils

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV
			Cumulative, wt. %		
<15 (59° F)	ATM	<15	0.52	0.04	
30	ATM	30	0.57	0.15	
40	ATM	40	1.09	0.16	
50	ATM	50	1.45	0.21	
60	ATM	60	1.97	0.25	
70	ATM	70	2.58	0.31	
73.9 (165° F)	ATM	73.9	2.93	0.42	0.01
90	ATM	90	4.38	0.99	0.13
100	ATM	100	6.30	1.49	0.25
110	ATM	110	7.50	2.08	0.33
120	ATM	120	8.28	3.02	0.43
130	ATM	130	9.17	3.91	0.53
140	ATM	140	10.07	4.93	0.61
150	ATM	150	11.34	5.96	0.84
160 (320° F)	ATM	160	12.61	7.09	1.01
170	99	104.3	14.17	8.45	1.07
180	99	113.2	15.21	9.38	1.25
190	99	122.1	16.33	10.38	1.42
200	100	131.1	17.59	11.62	1.57
210	99	140	18.85	12.76	1.88
220	99	149	20.17	14.25	2.60
230	100	158	21.63	15.57	3.31
232.2 (450° F)	100	160	22.21	15.96	3.52
240	99	167	24.36	17.26	4.38
250	100	176	25.49	18.71	5.43
260 (500° F)	100	185.1	26.96	19.86	6.56
270	99	194.1	29.10	21.37	8.03
280	100	203.2	30.53	23.49	9.46
287.8 (550° F)	100	210.3	31.95	24.15	10.55
295	10	154.9	34.21	25.55	11.57
300	10	159	34.27	27.09	12.40
310	10	167.4	35.30	28.28	14.19
315.6 (600° F)	10	172	36.31	29.61	15.20
320	10	175.7	37.33	31.22	16.02
330	10	184.1	38.86	33.66	17.91
340	10	192.5	40.55	35.33	19.91
343.3 (650° F)	10	195.3	41.25	35.77	20.65
Resid, wt%			57.07	64.03	77.85
Loss, wt%			1.68	0.19	1.50

[a] AET = Atmospheric equivalent temperature

[b] VT = Vapor temperature

[c] Data in these columns are from distillation of ANS crude; similar data for ALT and SJV crudes are found in references 2 and 4, respectively.

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892

165 - 320° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV
			Cumulative, wt. %		
60	ATM	60	0.54	0.42	
70	ATM	70	2.16	2.34	
80 (176° F)	ATM	80	7.54	6.50	
90	ATM	90	16.84	12.97	
100	ATM	100	32.11	31.60	1.72
110	ATM	110	44.14	41.96	3.40
120	ATM	120	54.76	52.38	5.56
130	ATM	130	67.98	68.78	8.92
140	ATM	140	80.41	80.22	13.30
150	ATM	150	90.49	90.52	19.70
153 (307° F)	ATM			93.92	
156.8 (314° F)	ATM		95.10		
160 (320° F)	ATM				28.82
170	ATM				46.30
180	ATM				62.81
190	ATM				73.49
200	ATM				83.27
210	ATM				90.09
215 (419° F)	ATM				93.07
Resid, wt. %			4.09	5.24	4.95
Loss, wt. %			0.80	0.51	1.98

[a] AET = Atmospheric equivalent temperature
[b] VT = Vapor temperature
[c] Data for ANS, similar data for ALT and SJV are found in references 2 and 4, respectively.

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892, continued

320 - 450° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV[d]
			Cumulative, wt. %		
130	ATM	130	1.39	1.20	
140	ATM	140	1.48	2.10	
150	ATM	150	1.88	6.40	
155	ATM	155	3.00		
160 (320° F)	ATM	160	5.87	13.24	
170	ATM	170	18.95	23.00	
180	ATM	180	32.07	42.32	1.03
190	ATM	190	44.98	50.68	17.75
200	ATM	200	57.84	63.96	27.34
210	ATM	210	71.07	75.04	37.10
220	ATM	220	83.34	88.80	65.85
230 (446° F)	ATM	230	93.54	93.16	86.80
231.1 (448° F)	ATM	231.1	95.21		
235	ATM				90.43
237 (459° F)	ATM				91.53
Resid, wt. %			4.79	5.74	7.82
Loss, wt. %			0.00	1.10	0.65

[d] Distillation at 100 mm Hg.

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892, continued

450 - 500° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV
			Cumulative, wt. %		
50	100	1.1	4.52		
70	100	16.3	7.61		
90	100	33.7	8.67		
110	100	51.3	9.08		
130	100	68.9	9.44		
150	100	86.6	9.81		
170	100	104.3	10.40		
180	100	113.2	10.72	0.14	0.98
190	100	122.1	10.98	0.55	1.83
200	100	131.1	11.25	1.45	2.64
210	100	140.0	11.48	3.36	5.06
220	100	149.0	11.70	10.07	12.16
230	100	158.0	19.16	22.03	22.82
235	100	162.5	26.67	25.78	30.96
240	100	167.0	37.95	43.25	37.11
245	100	171.5	51.57	58.24	51.14
250	100	176.0	69.55	64.77	58.86
255	100	180.6	82.42	79.00	66.80
260 (500° F)	100	185.1	92.81	87.70	74.52
265	100	189.6		90.64	81.97
270	100	194.1		93.78	88.12
271 (519° F)	100			94.83	
275	100	198.7			92.98
278 (532° F)	100	201.4			95.32
Resid, wt. %			7.19	4.73	3.96
Loss, wt. %			0.00	0.44	0.72

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892, continued

500 - 550° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV
			Cumulative, wt. %		
50	100	1.1	0.03		
70	100	16.3	0.19		
90	100	33.7	0.40		
110	100	51.3	0.59		
130	100	68.9	0.85		
150	100	86.6	1.12		
170	100	104.3	1.27		
180	100	113.2	1.35		
190	100	122.1	1.41		
195	100				0.05
200	100	131.1	1.53		0.15
210	100	140.0	1.57		0.48
220	100	149.0	1.67		1.07
230	100	158.0	1.71	0.03	2.44
235	100	162.5	1.80	0.32	4.06
240	100	167.0	1.81	0.61	5.66
245	100	171.5	2.51	1.25	8.79
250	100	176.0	4.85	2.96	12.19
255	100	180.6	10.47	7.37	17.19
260	100	185.1	19.33	13.31	21.23
265	100	189.6	29.97	21.78	26.81
270	100	194.1	41.95	35.52	35.31
275	100	198.7	57.71	51.72	42.95
280	100	203.2	70.21	60.39	60.27
285	100	207.8	82.63	70.70	71.65
290	100	212.3	92.37	81.74	78.06
292 (558° F)	100	214.2	94.81		
295	100	216.9		92.31	84.53
297 (567° F)	100	218.7			92.08
300 (572° F)	100	221.4		94.74	
Resid, wt. %			5.19	4.25	7.84
Loss, wt. %			0.00	0.41	0.08

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892, continued

550 - 600° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT[e]	SJV[e]
			Cumulative, wt. %		
50	100	1.1	0.03		
70	100	16.3	1.02		
90	100	33.7	3.51		
110	100	51.3	5.53		
130	100	68.9	6.61		
150	100	86.6	7.09		
170	100	104.3	7.37		
180	100	113.2	7.47		
190	100	122.1	7.58		
200	100	131.1	7.69		
210	100	140.0	7.75		
220	100	149.0	7.83		
230	100	158.0	7.93		
235	100	162.5	8.02		
240	100	167.0	8.05		
245	100	171.5	8.12		
250	100	176.0	8.17		0.02
255	100	180.6	8.22		
260	100	185.1	8.29	0.06	0.22
265	100	189.6	8.35		
270	100	194.1	8.41	1.09	0.64
275	100	198.7	8.47		
280	100	203.2	8.57	3.04	1.75
285	100	207.8	8.59		
290	100	212.3	18.03	9.60	6.08
295	100	216.9	27.74	14.91	
300	100	221.4	44.17	18.54	15.01
305	100	226.0	63.83	48.17	24.59
310	100	230.6	79.04	54.61	52.85
315	100	235.1	89.57	76.02	61.01
318.1 (604° F)	100	238.0	94.79		
320				91.33	72.87
325 (617° F)				94.89	81.18
330					88.54
335					91.79
337 (639° F)					92.54
Resid, wt. %			5.21	4.95	6.96
Loss, wt. %			0.00	0.16	0.50

[e] Distillation at 10 mm Hg.

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892, continued

600 - 650° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV
			Cumulative, wt. %		
140	10	29.6	0.53		
160 (320° F)	10	45.4	0.67		
180	10	61.3	0.82		
200	10	77.3	1.13		
220	10	93.4	2.28		
240	10	109.6	3.55		
250	10	117.8			0.73
260	10	126.0	5.31		0.87
270	10	134.2	5.89		1.03
280	10	142.4	6.53	0.03	1.23
290	10	150.7	7.14	0.30	1.58
295	10	154.9		0.54	
300	10	159.0	8.19	1.07	2.87
305	10	163.2		1.90	3.99
310	10	167.4	8.84	2.46	5.52
315	10	171.5		5.07	8.58
320	10	175.7	9.68	9.72	13.44
325	10	179.9	51.11	11.79	22.04
330	10	184.1	65.19	17.27	24.70
335	10	188.3	79.28	49.38	43.18
340	10	192.5	89.31	66.78	46.44
345	10	196.8		78.99	57.78
346.5 (656° F)	10	198.0	95.47		
350	10	201.0		90.12	60.93
355	10	205.2			76.06
360	10	209.5			82.22
365	10	213.7			87.67
370 (698° F)	10	218.0			91.33
Resid, wt. %			4.53	9.45	8.10
Loss, wt. %			0.00	0.43	0.57

Table 5. Distillation of ANS, ALT, and SJV Crude Oil Fractions by ASTM D 2892, continued

450 - 650° F Fractions

AET[a,c] °C	Pressure[c] mmHg	VT[b,c] °C	ANS	ALT	SJV
			Cumulative, wt. %		
130	100.0	68.9	0.33		
150	99.9	86.6	1.00		
160 (320° F)	100.0	95.4	2.79		
170	99.8	104.3	4.69		
180	100.0	113.2	5.73		
190	100.0	122.1	6.31	0.05	
200	99.9	131.1	6.55	0.47	0.32
210	100.0	140.0	6.97	1.22	0.99
220	100.0	149.0	7.17	2.88	2.15
230	99.9	158.0	7.30	6.33	3.80
240	99.9	167.0	10.17	12.39	7.72
250	100.0	176.0	23.13	20.54	11.12
260	100.0	185.1	28.45	26.80	17.02
270	99.9	194.1	35.40	33.63	22.91
280	99.8	203.2	43.73	39.44	32.42
287.8 (550° F)	99.9	210.3	49.18	46.94	37.84
290	10.0	150.7			40.33
297.8 (568° F)	9.9	157.2	49.30		
300	10.0	159.0		56.28	45.53
307.8 (586° F)	9.9	165.5	62.17		
310	10.0	167.4		67.10	53.12
312.8 (595° F)	9.9	169.7	79.21		
317.8 (604° F)	9.9	173.9	81.48		
320	10.1	175.7		76.27	62.60
322.8 (613° F)	9.9	178.1	85.68		
325.1 (617° F)	9.9	180.0	95.40		
330	10.0	184.1		84.80	71.51
340	10.0	192.5		90.79	78.71
346 (655° F)	10.0	197.6		95.00	
350	10.0	201.0			86.92
355	10.0	205.2			91.64
360	10.0	209.5			93.68
366 (691° F)	10.0	214.6			96.11
Resid, wt. %			4.60	4.17	2.98
Loss, wt. %			0.00	0.83	0.91

Table 6. ASTM D 86 Distillation of ANS, ALT, and SJV Fractions[a], °F

Distillate	165 - 320° F			320 - 450° F			450 - 500° F			500 - 550° F		
	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV
IBP	199	186.8	208.7	324.5	318.7	373.2	439	399.9	433.4	473	485.2	474.2
5%	208	205.1	271.5	337.2	334.9	395.0	449	439.1	447.8	499	503.7	498.7
10%	209	209.8	284.1	339.6	339.0	395.9	451	440.4	452.1	500	505.5	500.5
20%	213	217.0	296.2	344.3	345.0	402.4	454	445.8	456.9	503	508.1	507.3
30%	222	222.6	310.1	349.5	351.1	406.0	456	448.8	461.1	505	509.9	511.3
40%	228	229.6	320.1	355.2	357.4	411.8	459	452.3	465.6	507	512.2	515.6
50%	235	237.2	329.0	361.0	363.5	416.6	461	455.7	469.9	509	514.0	520.1
60%	244	246.2	338.1	368.6	371.1	422.0	463	459.3	474.2	512	516.2	524.6
70%	254	256.1	347.1	377.0	380.1	428.1	466	463.4	480.0	514	518.9	529.7
80%	267	267.8	357.9	387.3	390.5	435.7	470	468.5	486.3	518	522.1	535.6
90%	280	282.0	373.6	400.8	404.6	446.5	475	475.7	495.3	523	527.0	544.1
95%	292	293.3	388.5	411.4	415.9	455.0	479	481.2	501.9	527	530.4	551.3
End Point	309	308.4	413.7	426.3	428.7	467.9	486	491.1	509.5	532	538.5	556.7
Residue, vol. %	0	0.5	0.0	1.3	0.9	1.2	1.0	1.2	0.1	1.0	0.0	1.6
Loss, vol. %	0.5	1.0	0.3	0.9	1.3	0.5	0.0	0.7	1.6	0.5	0.6	0.8

[a] All readings corrected to 760 mm Hg.
Temperatures reported for the 165-320° F and 320-450° F distillates are based on percent evaporated.

Table 6. ASTM D 86 Distillation of ANS, ALT, and SJV Fractions[a], °F, continued

Distillate	550 - 600° F			600 - 650° F			450 - 650° F			650 - 750° F		
	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV[b]	ANS	ALT[c]	SJV[d]
IBP	528	550.2	562.2	582	590.0	578.4	469	462.0	467.4	534	645.9	467.7
5%	550	556.1	570.9	594	604.0	608.9	490	487.5	505.4	645	654.9	591.4
10%	552	557.4	573.0	597	605.8	615.3	496	494.9	515.8	655	657.8	632.8
20%	553	559.2	575.0	598	607.8	622.0	506	503.9	529.7	662	661.2	
30%	555	560.8	577.0	599	609.4	625.6	515	513.8	543.2	665	663.8	
40%	556	562.8	579.0	601	611.2	629.6	524	525.2	557.6	667	666.6	
50%	558	564.9	581.1	602	612.8	633.3	534	536.9	571.2	670	669.7	
60%	559	567.1	583.8	604	615.0	637.8	545	549.3	585.3	674	673.3	
70%	561	570.2	587.1	606	617.3	643.4	558	562.6	600.6	679	677.4	
80%	564	573.8	591.6	609	620.0	650.3	572	577.5	617.0	685	683.7	
90%	567	579.2	598.2	613	624.3	662.3	588	594.5	638.0	693	689.1	
95%	570	584.6	604.9	616	628.7	677.3	598	605.4	654.6	701		
End Point	573	588.9	609.8	620	631.2	677.8	608	616.8		707		
Residue, vol. %	0.5	--	1.1	1.0	1.9	1.5	1.0	1.3	0.6	1.5		
Loss, vol. %	0.5	--	1.4	0.5	1.0	1.5	0.5	0.0	4.4	0.5		

[b] Smoking (cracking) observed at 95%. Distillation discontinued.
[c] Smoking (cracking) observed at 92%. Distillation discontinued.
[d] Smoking (cracking) observed at 10%. Distillation discontinued.

Table 7. ASTM D 1160 Distillation of ANS, ALT, and SJV Fractions, (10 mm Hg)[d], °F

Fraction	650 - 750° F						750 - 850° F					
	ANS		ALT		SJV		ANS		ALT		SJV	
°F	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]
IBP	295.4	543.2	378.2	642.2	224.6	456.9	303.2	552.6	384.6	649.8	245.8	482.9
5%	405.6	674.5	409.0	678.5			489.4	772.1	480.2	761.5		
10%	410.8	680.6	411.8	681.8	386.2	651.7	496.0	779.7	485.2	767.3	443.6	719.7
20%	415.2	685.8	415.0	685.6	410.8	680.5	501.6	786.2	489.4	772.1	486.6	769.0
30%	418.4	689.6	416.9	687.2	420.4	691.9	507.0	792.4	493.6	777.0	492.6	781.7
40%	422.0	693.8	420.0	691.4	424.8	697.0	511.8	797.9	496.4	780.2	504.6	789.7
50%	426.0	698.5	424.6	696.8	433.0	706.7	517.4	804.3	502.2	786.9	512.2	798.4
60%	430.8	704.1	427.6	700.3	437.6	712.0	522.8	810.5	508.8	794.5	517.6	804.6
70%	436.4	710.6	431.6	705.0	443.6	719.1	532.8	821.9	514.0	800.4	526.6	814.9
80%	443.8	719.3	436.8	711.1	451.0	727.7	541.4	831.7	521.6	809.1	536.2	825.8
90%	449.6	726.0	444.4	720.0	458.6	736.5	555.0	847.2	535.2	824.7	550.2	841.8
95%	461.6	740.0	449.4	725.8	462.4	739.8			542.8	833.3		
End Point[c]	461.6	740.0	449.4	725.8	462.4	739.8	557.6	850.2	542.8	833.3	561.2	854.3
Residue, wt. %	6.5		8.2		7.3		10.6		14.2		4.7	
Loss, wt. %	0.3		0.4		0.2		0.2		0.1		0.2	

[a] VT = Vapor temperature at 10 mm Hg
[b] AET = Atmospheric equivalent temperature
[c] End point = The maximum temperature reading obtained during the distillation.
[d] Performed with a manual apparatus.

Table 7. ASTM D 1160 Distillation of ANS, ALT, and SJV Fractions, (10 mm Hg)[d], °F, continued

Fraction	850 - 950° F						650 - 950° F					
	ANS		ALT		SJV		ANS		ALT		SJV	
°F	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]
IBP	465.2	744.1	526.2	814.4	390.0	656.2	366.8	628.7	385.4	650.7	262.8	503.6
5%	570.2	864.5	548.4	839.7			427.0	699.6	439.2	713.9		
10%	577.8	873.0	553.8	845.9	579.0	874.4	437.4	711.8	448.0	724.1	431.6	705.0
20%	582.6	878.5	560.0	852.9	591.6	888.6	450.2	726.7	462.2	740.7	462.0	740.5
30%	589.8	886.6	564.2	857.7	601.2	899.4	463.2	741.8	476.4	757.1	486.2	768.4
40%	597.8	895.6	570.0	864.2	610.2	909.5	481.4	762.9	493.8	777.2	513.0	799.2
50%	604.2	902.8	577.4	872.6	620.2	920.8	502.8	787.6	511.6	797.7	534.0	823.3
60%	612.8	912.4	584.4	880.5	630.4	932.0	523.2	811.0	531.8	820.8	565.6	859.2
70%	622.6	923.4	595.0	892.4	641.8	944.9	544.6	835.4	549.4	840.9	591.2	888.2
80%	634.8	937.0	609.8	909.1	653.4	957.7	568.2	862.2	572.4	866.9	615.8	915.7
90%			630.4	932.1	670.6	976.8	598.4	896.3	603.8	902.3	651.0	955.8
95%			644.4	947.7			615.8	915.8	629.8	931.4		
End Point[c]	646.5	950.1	644.4	947.7	682.8	990.3	615.8	915.8	629.8	931.4	671.8	978.0
Residue, wt. %	14.8		9.6		7.2		7.6		4.5		5.1	
Loss, wt. %	0.1		0.2		0.3		0.3		0.2		0.4	

Table 7. ASTM D 1160 Distillation of ANS, ALT, and SJV Fractions, (10 mm Hg)[d], °F, continued

Fraction	>650° F					
	ANS		ALT		SJV	
°F	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]
IBP	388.2	654.0	393.0	659.7	338.6	595.0
5%	441.4	716.5	434.6	708.5		
10%	456.8	734.4	452.2	729.0	467.8	747.1
20%	487.6	770.1	481.6	763.1	506.6	792.0
30%	529.0	817.6	513.8	800.2	546.4	837.5
40%	575.4	870.3	548.4	839.7	603.2	901.6
50%	626.6	927.9	585.6	881.9		
60%	683.0	990.5	637.2	939.7		
70%						
80%						
90%						
95%						
End Point[c]	692.0	1000.4	657.0	961.7	627.2	930.2
Residue, wt. %	40.7		35.0		53.5	
Loss, wt. %	0.3		0.3		0.3	

Table 8. ASTM D 1160 Distillation of ANS, ALT, and SJV Fractions, (1 mm Hg), °F

Fraction	850 - 950° F								950 - 1050° F					
	ANS[d]				ALT[f]		SJV[f]		ANS[d]		ALT[f]		SJV[f]	
			Blind[e]											
°F	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]
IBP	356.9	726.3	403.8	784.7	438.4	827.1	393.8	772.4	457.5	850.1	466.0	860.5	545.8	955.5
5%	432.7	820.0	476.2	872.8	462.4	856.2			493.0	892.8	515.6	920.0		
10%	461.8	855.3	486.4	885.1	468.8	863.9	488.8	888.0	506.7	909.1	531.4	938.5	584.4	1000.7
20%	474.8	871.7	495.8	896.3	475.0	871.4	501.2	902.8	521.1	926.2	542.4	951.7	591.8	1009.2
30%	482.0	879.6	498.0	899.0	480.4	877.9	510.6	914.0	526.6	932.7	549.6	960.1	596.2	1014.2
40%	492.4	892.2	502.2	904.0	484.8	883.2	518.8	923.6	532.2	939.4	557.8	969.6	600.4	1019.2
50%	500.2	901.4	509.0	912.1	490.4	889.9	529.0	935.8	541.6	950.4	564.8	977.8	605.8	1025.4
60%	510.1	913.1	516.8	921.3	495.8	896.3	538.2	946.6	547.3	957.2	573.2	987.8	612.4	1032.9
70%	520.3	925.3	527.2	933.6	506.0	908.5	549.4	959.7	557.2	968.7	581.6	997.3	621.2	1043.0
80%	540.9	949.6	540.4	949.2	518.2	923.0	563.0	975.7	567.1	980.4	592.0	1009.4		
90%					538.4	946.9	585.2	1001.5	583.7	999.7	605.4	1025.0		
95%					551.8	962.6			601.2	1019.8	613.4	1034.1		
End Point[c]	541.2	950.0	541.0	950.0	551.8	962.6	601.6	1020.5	601.2	1019.8	627.2	1050.0	627.2	1050.0
Residue, wt. %	(19.1)[g]		19.4		9.3		5.4		(4.8)[g]		4.5		23.9	
Loss, wt. %	(0.2)[g]		0.1		0.2		0.2		(0.2)[g]		0.2		0.3	

[a] VT = Vapor temperature at 1 mm Hg
[b] AET = Atmospheric equivalent temperature
[c] End point = The maximum temperature reading obtained during the distillation.
[d] Automated apparatus except for the 850-950° F blind which was performed with a manual apparatus.
[e] A second ANS 850-950° F distillation was run as a blind sample.
[f] Performed with a manual apparatus.
[g] Loss value was estimated and residue was calculated by difference.

Table 8. ASTM D 1160 Distillation of ANS, ALT, and SJV Fractions, (1 mm Hg), °F, continued

Fraction	>650° F					
	ANS[d]		ALT[f]		SJV[f]	
° F	VT[a]	AET[b]	VT[a]	AET[b]	VT[a]	AET[b]
IBP	282.9	632.5	313.4	671.6	263.8	608.1
5%	318.9	678.6	363.0	734.1		
10%	338.7	703.6	375.4	749.5	375.4	749.6
20%	373.6	747.1	406.6	788.2	413.6	796.8
30%	416.3	799.9	430.0	816.8	453.4	845.3
40%	460.9	854.2	460.4	853.8	498.4	899.4
50%	522.3	927.7	510.0	913.3	562.0	974.5
60%	597.4	1015.5	558.0	969.9		
70%			626.4	1049.1		
80%						
90%						
95%						
End Point[c]	627.4	1050.1	627.2	1050.0	627.2	1050.0
Residue, wt. %	(36.1)[g]		33.0		39.4	
Loss, wt. %	(0.2)[g]		0.2		0.2	

Table 9. Boiling Range Distribution of ANS, ALT, and SJV Crudes by Gas Chromatography, ASTM P 167 and ASTM D 5307

% Off	ANS[a] Temp. °F	ALT[a] Temp. °F	SJV[b] Temp. °F	% Off	ANS[a] Temp. °F	ALT[a] Temp. °F	SJV[b] Temp. °F
IBP	31	158	328				
1	75	189	365	51	704	754	875
2	103	214	403	52	713	759	883
3	157	236	426	53	722	770	892
4	180	256	445	54	731	774	900
5	197	269	463	55	740	782	909
6	212	288	479	56	750	791	918
7	224	302	493	57	759	794	927
8	241	315	507	58	768	805	936
9	254	335	519	59	777	809	944
10	270	344	531	60	786	817	953
11	284	360	542	61	795	825	962
12	296	381	553	62	804	830	971
13	310	387	564	63	813	840	979
14	325	411	575	64	823	845	988
15	338	418	584	65	832	856	997
16	351	428	594	66	841	862	1006
17	367	448	603	67	851	872	1015
18	382	454	612	68	861	880	
19	393	469	621	69	872	889	
20	406	483	629	70	882	899	
21	416	487	638	71	892	908	
22	427	502	647	72	903	918	
23	440	515	655	73	914	929	
24	450	519	664	74	925	941	
25	460	532	672	75	937	953	
26	473	544	680	76	950	964	
27	483	547	689	77	962	976	
28	491	563	697	78	976	987	
29	503	574	705	79	990	1000	
30	513	577	714	80	1005	1014	
31	521	588	722	81			
32	531	600	730	82			
33	540	603	739	83			
34	548	616	747	84			
35	559	625	755	85			
36	570	629	764	86			
37	578	643	772	87			
38	587	650	780	88			
39	598	654	787	89			
40	606	670	795	90			
41	615	673	802	91			
42	624	681	809	92			
43	633	693	816	93			
44	642	697	823	94			
45	651	709	830	95			
46	660	716	837	96			
47	669	719	844	97			
48	677	732	851	98			
49	686	737	859	99			
50	695	746	867	FBP			

[a] ASTM P 167, approved and published as ASTM D 5307 in 1992.
[b] ASTM D 5307.

Table 10. Boiling Range Distribution of Fractions from ANS, ALT, and SJV Crude Oils by Gas Chromatography, ASTM D 3710

165 - 320° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV* Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV* Temp. °F
IBP	133	134	157				
1		138	168	51		244	332
2		155	191	52		245	333
3		157	196	53		246	334
4		158	210	54		247	335
5	161	159	214	55	246	248	336
6		162	224	56		249	337
7		164	229	57		251	338
8		169	232	58		256	339
9		177	238	59		260	340
10	177	179	241	60	256	261	342
11		180	246	61		261	343
12		188	251	62		262	344
13		191	255	63		263	345
14		193	261	64		263	347
15	189	195	266	65	264	264	348
16		197	268	66		264	349
17		198	271	67		265	351
18		201	274	68		265	353
19		209	276	69		266	354
20	195	211	280	70	271	266	356
21		212	283	71		267	358
22		213	286	72		269	360
23		214	289	73		271	361
24		214	291	74		274	363
25	208	215	293	75	280	276	365
26		215	295	76		279	367
27		216	297	77		281	368
28		216	299	78		282	370
29		216	301	79		282	372
30	212	217	303	80	285	283	374
31		217	305	81		285	375
32		217	306	82		288	378
33		218	308	83		289	380
34		218	309	84		290	382
35	214	219	311	85	292	292	384
36		219	312	86		293	386
37		219	313	87		297	388
38		220	315	88		303	390
39		220	316	89		304	392
40	229	222	318	90	302	305	394
41		227	319	91		306	396
42		231	320	92		306	398
43		232	322	93		307	401
44		233	323	94		308	404
45	233	234	324	95	317	308	406
46		235	326	96		311	410
47		238	327	97		316	415
48		240	328	98		322	424
49		242	329	99		329	439
50	241	243	331	FBP	355	344	454

* IBP - 320° F Fraction for SJV Crude.

Table 10. Boiling Range Distribution of Fractions from ANS, ALT, and SJV Crude Oils by Gas Chromatography, ASTM D 3710, continued

320 - 450° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	263	241	303				
1	273	256	313	51	378	374	413
2	284	275	324	52	379	377	414
3	290	283	330	53	381	381	415
4	298	288	335	54	383	383	416
5	302	295	339	55	385	385	416
6	305	297	342	56	386	386	417
7	309	300	345	57	387	387	418
8	310	302	349	58	388	387	419
9	312	303	352	59	388	388	420
10	315	304	356	60	389	388	421
11	317	305	359	61	390	389	422
12	318	306	361	62	391	389	423
13	320	309	363	63	392	390	424
14	322	313	366	64	393	390	425
15	324	316	368	65	394	390	426
16	326	319	370	66	395	391	427
17	328	322	372	67	396	391	429
18	329	325	374	68	397	391	430
19	331	327	376	69	398	392	431
20	332	329	378	70	399	392	432
21	333	330	380	71	401	394	433
22	334	331	382	72	402	395	434
23	336	333	384	73	403	398	436
24	338	336	385	74	404	401	437
25	339	337	387	75	406	403	438
26	340	339	388	76	407	405	439
27	341	341	389	77	408	408	440
28	343	342	390	78	409	410	442
29	345	343	391	79	410	412	443
30	346	344	393	80	411	413	444
31	347	344	394	81	412	414	446
32	348	345	395	82	414	415	447
33	350	346	396	83	415	416	449
34	351	347	397	84	416	416	451
35	352	348	398	85	417	417	452
36	353	348	400	86	417	417	454
37	355	349	401	87	418	418	456
38	356	349	402	88	420	418	457
39	357	349	403	89	422	419	459
40	358	350	404	90	424	419	461
41	360	350	404	91	427	420	464
42	361	351	405	92	429	422	466
43	363	353	406	93	431	427	469
44	365	355	407	94	433	432	472
45	367	356	408	95	435	436	475
46	369	358	409	96	437	441	479
47	371	362	410	97	440	446	483
48	372	366	410	98	443	447	488
49	374	369	411	99	447	449	497
50	376	371	412	FBP	459	456	506

Table 10. Boiling Range Distribution of Fractions from ANS, ALT, and SJV Crude Oils by Gas Chromatography, ASTM D 3710, continued

450 - 500° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	356	336	336				
1	375	361	353	51	470	470	470
2	390	380	369	52	471	472	472
3	397	385	380	53	472	474	473
4	402	395	388	54	473	475	474
5	407	403	392	55	474	477	475
6	410	408	396	56	475	479	477
7	413	411	399	57	476	480	478
8	415	412	402	58	477	482	479
9	418	413	404	59	477	483	480
10	420	414	407	60	478	484	481
11	422	414	409	61	478	485	483
12	425	415	411	62	479	486	484
13	427	416	413	63	480	487	485
14	428	417	415	64	481	488	486
15	429	418	417	65	481	489	488
16	430	420	418	66	482	489	489
17	432	424	420	67	483	490	490
18	433	429	421	68	484	491	491
19	435	432	423	69	484	491	492
20	436	435	423	70	485	492	494
21	438	438	427	71	486	492	495
22	439	440	429	72	487	493	496
23	440	443	430	73	488	494	497
24	442	444	432	74	489	494	498
25	443	446	434	75	489	495	500
26	444	447	435	76	490	495	501
27	446	448	437	77	491	495	502
28	447	449	438	78	492	496	504
29	448	450	440	79	492	496	505
30	449	451	441	80	493	497	506
31	450	452	443	81	494	497	508
32	452	453	444	82	494	498	509
33	453	453	446	83	495	498	510
34	454	454	447	84	495	499	512
35	454	455	449	85	496	500	513
36	455	455	450	86	496	501	514
37	456	456	452	87	497	503	516
38	457	456	453	88	498	506	517
39	458	457	454	89	499	508	519
40	459	457	456	90	500	510	520
41	460	458	457	91	501	512	522
42	461	458	458	92	503	516	523
43	462	459	460	93	504	520	525
44	463	459	461	94	505	521	526
45	464	460	462	95	507	522	528
46	465	460	464	96	508	522	530
47	466	461	465	97	510	523	533
48	467	463	466	98	514	524	538
49	468	465	468	99	517	528	544
50	469	467	469	FBP	535	540	557

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887

320 - 450° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	263	247	305				
1	274	260	319	51	381	384	420
2	284	280	332	52	382	385	421
3	291	288	338	53	384	386	422
4	298	294	343	54	385	386	423
5	302	301	347	55	386	386	424
6	306	302	351	56	387	387	425
7	309	303	354	57	387	387	426
8	313	304	357	58	388	387	427
9	316	305	360	59	389	388	428
10	318	307	363	60	390	388	429
11	320	311	366	61	392	388	430
12	321	316	368	62	393	389	432
13	323	319	370	63	394	389	433
14	325	323	372	64	396	389	434
15	327	326	374	65	397	390	435
16	329	328	376	66	398	390	436
17	330	331	378	67	399	392	437
18	332	332	379	68	401	394	438
19	333	334	381	69	402	397	439
20	334	336	383	70	403	401	440
21	336	339	384	71	405	404	441
22	338	341	386	72	406	407	442
23	339	342	388	73	407	409	444
24	341	343	389	74	409	413	445
25	342	345	390	75	410	416	446
26	343	345	392	76	412	418	447
27	344	346	393	77	413	418	448
28	345	346	394	78	415	419	450
29	346	346	396	79	416	419	451
30	347	347	397	80	417	419	453
31	349	347	398	81	418	420	454
32	351	348	400	82	419	420	456
33	352	348	401	83	420	421	457
34	354	348	402	84	421	421	459
35	355	349	404	85	423	422	461
36	357	349	405	86	425	422	462
37	358	350	406	87	427	424	464
38	359	350	407	88	429	425	466
39	361	353	408	89	432	427	468
40	362	356	409	90	434	430	471
41	364	358	410	91	436	436	473
42	366	360	411	92	438	441	476
43	368	363	412	93	440	445	478
44	369	366	413	94	442	449	481
45	371	370	414	95	445	452	485
46	372	372	415	96	448	454	488
47	374	374	416	97	450	455	493
48	376	378	417	98	454	457	499
49	378	381	418	99	461	461	509
50	380	382	419	FBP	469	473	519

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

450 - 500° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	362	341	343				
1	379	367	363	51	474	476	478
2	393	383	379	52	475	478	479
3	400	389	389	53	476	480	480
4	406	402	396	54	477	481	481
5	411	410	401	55	477	483	482
6	414	415	405	56	478	484	483
7	417	417	409	57	479	485	484
8	419	418	412	58	480	485	485
9	422	419	414	59	481	486	487
10	425	420	417	60	481	487	488
11	428	421	419	61	482	487	489
12	430	422	421	62	483	488	490
13	432	423	424	63	483	489	491
14	434	426	426	64	484	489	492
15	436	431	428	65	485	489	493
16	437	436	430	66	485	490	494
17	439	439	432	67	486	490	496
18	440	442	434	68	487	490	497
19	441	444	436	69	487	491	498
20	442	446	437	70	488	491	499
21	444	448	439	71	489	491	500
22	445	450	440	72	489	492	501
23	446	451	442	73	490	492	502
24	447	453	443	74	490	492	503
25	448	453	445	75	491	492	504
26	450	454	446	76	491	493	506
27	451	454	448	77	492	493	507
28	452	454	449	78	493	493	508
29	453	455	450	79	493	494	509
30	453	455	452	80	494	494	511
31	454	455	453	81	495	494	512
32	455	456	455	82	496	496	513
33	456	456	456	83	496	499	514
34	457	456	457	84	497	501	516
35	458	457	458	85	498	504	517
36	459	457	460	86	499	506	518
37	460	457	461	87	500	508	520
38	460	458	462	88	501	510	521
39	461	458	463	89	503	513	523
40	462	459	465	90	504	516	524
41	464	460	466	91	505	517	526
42	465	461	467	92	507	518	528
43	466	461	468	93	508	519	530
44	467	462	470	94	510	520	532
45	468	463	471	95	511	522	535
46	469	466	472	96	513	523	538
47	470	468	473	97	516	524	542
48	471	471	474	98	518	528	548
49	472	473	476	99	522	541	597
50	473	475	477	FBP	525	547	894

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

500 - 550° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	415	434	387				
1	432	450	407	51	528	528	532
2	443	457	422	52	528	529	533
3	452	473	432	53	529	529	534
4	459	480	439	54	529	530	535
5	466	484	445	55	530	532	536
6	471	485	450	56	531	534	536
7	474	486	454	57	532	536	537
8	477	487	459	58	532	537	538
9	480	488	462	59	533	538	539
10	482	489	466	60	534	539	540
11	484	491	469	61	534	541	541
12	485	492	472	62	535	543	542
13	487	493	475	63	536	545	543
14	489	495	477	64	537	545	544
15	490	499	480	65	537	546	545
16	492	503	482	66	538	547	546
17	494	505	484	67	539	548	546
18	496	507	487	68	539	548	547
19	498	509	489	69	540	549	548
20	500	510	491	70	541	550	549
21	501	512	493	71	541	550	550
22	503	514	495	72	542	550	551
23	505	516	496	73	543	550	553
24	506	517	498	74	543	551	554
25	507	517	500	75	544	551	555
26	509	518	501	76	545	551	556
27	510	519	503	77	546	552	557
28	511	520	505	78	547	552	558
29	512	521	506	79	547	552	559
30	513	521	508	80	548	552	561
31	514	521	509	81	549	553	562
32	515	521	510	82	550	553	563
33	516	521	512	83	551	553	565
34	517	522	513	84	551	554	566
35	518	522	514	85	552	554	567
36	519	522	516	86	553	554	569
37	520	522	517	87	554	554	570
38	520	523	518	88	554	556	572
39	521	523	519	89	555	559	573
40	522	523	520	90	557	561	575
41	522	523	522	91	558	563	577
42	523	524	523	92	559	565	579
43	523	524	524	93	561	569	581
44	524	524	525	94	562	572	584
45	524	524	526	95	564	575	587
46	525	525	527	96	565	577	590
47	526	525	528	97	568	578	595
48	526	525	529	98	571	580	602
49	527	526	530	99	576	582	633
50	527	527	531	FBP	580	587	820

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

550 - 600° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	473	481	484				
1	490	501	505	51	580	582	599
2	509	514	522	52	581	583	599
3	517	518	531	53	581	583	600
4	522	521	536	54	581	584	601
5	527	531	541	55	582	586	602
6	530	536	544	56	582	587	603
7	533	541	547	57	583	588	603
8	536	542	550	58	583	590	604
9	539	543	552	59	583	592	605
10	541	545	555	60	584	593	606
11	542	545	557	61	584	596	607
12	544	546	559	62	585	598	608
13	546	547	561	63	585	600	608
14	547	547	562	64	586	601	609
15	548	548	564	65	587	602	610
16	550	549	565	66	587	603	611
17	551	550	567	67	588	604	612
18	553	555	568	68	588	605	613
19	555	558	569	69	589	605	614
20	556	561	570	70	589	605	615
21	558	563	572	71	590	606	615
22	559	565	573	72	591	606	616
23	560	567	574	73	591	606	617
24	561	570	575	74	592	607	618
25	562	572	576	75	593	607	619
26	563	573	577	76	594	607	620
27	564	574	578	77	594	608	621
28	565	574	579	78	595	608	622
29	565	575	580	79	596	608	623
30	566	576	581	80	597	608	624
31	567	576	582	81	598	609	625
32	568	577	583	82	598	609	627
33	569	578	584	83	599	609	628
34	570	578	584	84	600	610	629
35	570	578	585	85	601	610	630
36	571	578	586	86	602	612	632
37	572	579	587	87	603	613	633
38	573	579	588	88	604	614	634
39	573	579	589	89	605	615	636
40	574	580	590	90	606	618	638
41	575	580	590	91	607	621	639
42	576	580	591	92	608	625	641
43	576	580	592	93	608	626	644
44	577	581	593	94	609	628	646
45	578	581	594	95	610	629	649
46	578	581	595	96	612	630	652
47	579	581	595	97	614	631	656
48	579	582	596	98	616	634	662
49	579	582	597	99	621	636	682
50	580	582	598	FBP	626	645	854

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

600 - 650° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	525	530	424				
1	545	550	492	51	632	638	652
2	561	572	545	52	633	640	653
3	569	576	560	53	634	642	654
4	574	579	569	54	634	643	655
5	578	584	575	55	635	645	656
6	582	592	579	56	636	646	657
7	585	598	583	57	636	648	658
8	588	601	587	58	637	649	659
9	590	602	590	59	637	651	660
10	592	603	593	60	638	652	662
11	595	604	595	61	638	653	663
12	597	605	598	62	639	653	664
13	599	606	600	63	639	654	665
14	600	606	602	64	640	654	666
15	602	607	604	65	641	654	667
16	603	609	606	66	641	655	668
17	604	610	608	67	642	655	670
18	606	612	610	68	642	656	671
19	607	615	611	69	643	656	672
20	608	618	613	70	644	656	673
21	609	620	615	71	644	657	674
22	610	623	616	72	645	657	676
23	610	625	618	73	646	658	677
24	611	626	619	74	647	658	678
25	612	628	621	75	647	658	679
26	613	628	622	76	648	659	680
27	614	629	623	77	649	659	682
28	615	629	625	78	650	660	683
29	616	629	626	79	650	660	685
30	616	630	627	80	651	661	686
31	617	630	629	81	652	661	687
32	618	631	630	82	653	661	689
33	619	631	631	83	654	662	691
34	620	632	632	84	655	662	692
35	620	632	634	85	655	663	694
36	621	633	635	86	656	664	696
37	622	633	636	87	657	667	697
38	623	633	637	88	658	669	699
39	624	634	638	89	659	671	701
40	624	634	640	90	659	673	704
41	625	634	641	91	660	674	706
42	626	635	642	92	661	675	708
43	627	635	643	93	662	676	711
44	627	635	644	94	663	677	714
45	628	636	645	95	665	678	718
46	629	636	647	96	666	680	722
47	629	636	648	97	668	681	727
48	630	637	649	98	671	682	735
49	631	637	650	99	675	689	760
50	632	637	651	FBP	679	695	890

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

450 - 650° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	391	381	362				
1	405	389	386	51	549	550	565
2	419	414	403	52	552	552	567
3	429	419	412	53	554	554	569
4	436	422	419	54	557	561	572
5	441	435	426	55	560	564	574
6	445	444	432	56	562	568	577
7	449	449	437	57	564	572	579
8	452	451	441	58	566	574	581
9	455	453	446	59	569	576	583
10	458	455	450	60	571	577	586
11	462	456	454	61	573	578	588
12	465	457	458	62	575	578	590
13	469	458	461	63	578	579	593
14	472	466	465	64	579	580	595
15	474	472	469	65	581	581	597
16	477	477	472	66	582	582	599
17	479	481	475	67	584	586	602
18	481	484	478	68	586	591	604
19	483	485	481	69	589	595	606
20	485	486	484	70	591	599	608
21	487	487	487	71	593	602	611
22	488	488	490	72	596	603	613
23	490	489	493	73	598	603	615
24	492	490	495	74	600	604	617
25	495	491	498	75	602	605	620
26	497	493	501	76	604	606	622
27	500	495	504	77	606	607	624
28	503	502	506	78	608	609	627
29	505	506	509	79	609	612	629
30	508	509	512	80	611	618	632
31	510	513	514	81	614	622	634
32	512	516	517	82	616	625	637
33	515	517	520	83	618	627	640
34	517	518	522	84	620	628	643
35	519	519	524	85	622	629	646
36	520	520	527	86	625	630	649
37	522	521	529	87	627	631	652
38	524	522	531	88	629	632	655
39	525	523	534	89	631	635	658
40	527	525	536	90	633	641	662
41	529	527	539	91	635	647	666
42	532	533	541	92	638	649	670
43	534	537	543	93	640	651	675
44	536	541	546	94	643	653	679
45	538	545	548	95	646	655	685
46	540	546	551	96	650	657	691
47	542	546	554	97	653	663	698
48	544	547	557	98	656	672	706
49	546	548	559	99	662	676	719
50	547	549	562	FBP	667	679	739

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

650 - 750° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	426	431	358				
1	539	481	417	51	705	695	708
2	603	529	462	52	706	695	709
3	618	558	493	53	707	696	710
4	628	581	518	54	708	697	712
5	634	600	540	55	709	698	713
6	639	609	560	56	710	700	714
7	644	621	577	57	711	701	715
8	647	624	590	58	712	703	716
9	650	627	602	59	713	705	718
10	652	632	611	60	715	706	719
11	654	638	618	61	716	707	720
12	656	642	625	62	717	709	721
13	658	645	630	63	718	710	722
14	660	646	635	64	720	711	723
15	662	647	639	65	721	711	725
16	664	648	643	66	722	712	726
17	665	650	647	67	723	713	727
18	667	652	650	68	724	714	728
19	668	654	653	69	725	714	729
20	670	657	655	70	726	715	731
21	671	661	658	71	727	716	732
22	673	663	660	72	729	717	733
23	674	665	663	73	730	718	734
24	675	666	665	74	731	719	735
25	676	667	668	75	732	720	737
26	678	668	670	76	734	722	738
27	679	669	672	77	735	724	739
28	680	670	674	78	737	726	741
29	681	671	676	79	738	728	742
30	682	672	677	80	740	729	744
31	683	673	679	81	741	731	745
32	684	673	681	82	742	732	747
33	685	674	682	83	744	733	748
34	686	675	684	84	745	734	750
35	687	677	686	85	747	735	752
36	688	679	687	86	748	736	754
37	689	681	689	87	750	738	756
38	691	683	690	88	752	740	758
39	692	685	692	89	754	743	761
40	693	686	693	90	756	746	764
41	694	687	695	91	758	748	767
42	695	688	696	92	760	751	772
43	696	689	697	93	763	753	778
44	697	690	699	94	765	756	786
45	699	691	700	95	768	761	798
46	700	691	701	96	771	767	817
47	701	692	703	97	775	776	847
48	702	693	704	98	779	790	892
49	703	693	705	99	786	818	947
50	704	694	707	FBP	793	847	974

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

750 - 850° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	501	642	416				
1	576	686	452	51	811	797	797
2	668	700	503	52	812	798	798
3	701	713	542	53	814	798	800
4	713	717	575	54	815	799	801
5	721	720	603	55	816	799	802
6	727	723	627	56	817	800	803
7	732	729	649	57	819	800	805
8	736	735	667	58	820	801	806
9	740	737	683	59	821	802	807
10	743	738	695	60	823	803	809
11	746	740	705	61	824	805	810
12	749	741	713	62	825	807	812
13	752	743	720	63	827	810	813
14	754	745	726	64	828	812	814
15	757	748	731	65	829	813	816
16	759	752	735	66	831	814	817
17	761	755	738	67	832	814	819
18	763	757	742	68	834	815	820
19	765	758	745	69	835	816	822
20	767	759	747	70	837	817	823
21	769	760	750	71	838	817	825
22	771	761	752	72	840	819	826
23	772	762	754	73	841	821	828
24	774	763	757	74	843	823	829
25	776	764	758	75	844	826	831
26	777	765	760	76	846	828	833
27	779	766	762	77	848	829	834
28	780	767	764	78	850	831	836
29	782	770	766	79	851	832	838
30	783	772	767	80	853	833	840
31	785	774	769	81	855	835	842
32	786	776	771	82	857	837	844
33	788	777	772	83	860	841	846
34	789	778	774	84	862	844	848
35	790	778	775	85	864	846	850
36	792	779	777	86	867	848	852
37	793	780	778	87	869	850	855
38	794	781	779	88	872	854	858
39	796	781	781	89	875	859	860
40	797	782	782	90	878	861	863
41	798	783	784	91	882	864	866
42	800	784	785	92	886	870	870
43	801	785	786	93	890	875	874
44	802	786	788	94	895	879	878
45	804	787	789	95	902	886	882
46	805	790	790	96	910	893	888
47	806	792	792	97	921	902	894
48	807	793	793	98	937	916	903
49	809	795	794	99	967	938	918
50	810	796	796	FBP	996	959	933

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

850 - 950° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	674	548	539				
1	753	756	648	51	915	879	925
2	787	776	758	52	916	880	927
3	802	788	783	53	918	882	928
4	811	792	797	54	919	884	930
5	818	797	806	55	920	885	931
6	824	803	814	56	921	887	933
7	829	806	820	57	923	888	935
8	834	809	825	58	924	889	936
9	838	811	830	59	925	890	938
10	842	812	834	60	927	892	940
11	845	815	838	61	928	894	941
12	848	818	842	62	929	895	943
13	851	821	845	63	931	897	944
14	854	824	849	64	932	899	946
15	857	825	852	65	933	901	948
16	859	826	855	66	935	902	949
17	862	827	857	67	936	903	951
18	864	829	860	68	938	905	953
19	866	830	863	69	939	907	954
20	868	832	865	70	941	909	956
21	870	834	868	71	942	911	958
22	873	836	870	72	944	913	960
23	875	839	873	73	945	915	961
24	876	840	875	74	947	916	963
25	878	841	877	75	948	918	965
26	880	843	879	76	950	920	967
27	881	844	881	77	952	923	969
28	883	845	884	78	953	925	971
29	885	846	886	79	955	927	973
30	886	848	888	80	957	929	975
31	888	849	890	81	959	932	977
32	889	851	891	82	961	934	979
33	891	853	893	83	963	937	982
34	892	855	895	84	965	940	984
35	894	857	897	85	967	943	987
36	895	858	899	86	970	946	989
37	896	859	901	87	972	950	992
38	898	860	903	88	975	953	995
39	899	861	905	89	978	957	998
40	901	863	906	90	981	962	1001
41	902	864	908	91	985	966	1005
42	903	865	910	92	988	972	1009
43	905	867	912	93	993	978	1013
44	906	870	913	94	997	984	1018
45	907	871	915	95	1003	993	1025
46	909	872	917	96	1009	1004	1033
47	910	874	918	97	1017		1044
48	911	875	920	98	1029		1060
49	912	876	922	99	1050		1090
50	914	877	923	FBP	1071		1117

Table 11. Boiling Range Distribution of ANS, ALT, and SJV Crude Oil Fractions by Gas Chromatography, ASTM D 2887, continued

650 - 950° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F
IBP	476	622	413				
1	576	628	456	51	789	792	822
2	624	647	513	52	792	793	825
3	639	651	558	53	794	794	828
4	648	665	591	54	797	795	832
5	654	669	614	55	800	799	835
6	658	670	631	56	803	804	839
7	663	672	643	57	806	806	842
8	667	679	652	58	809	807	845
9	670	687	660	59	812	809	849
10	674	688	668	60	814	810	852
11	676	690	674	61	817	812	856
12	679	692	679	62	820	814	859
13	682	693	684	63	823	818	862
14	685	695	689	64	826	822	866
15	688	699	694	65	829	823	869
16	691	706	698	66	832	825	873
17	693	710	702	67	835	826	876
18	696	711	706	68	838	827	880
19	699	712	710	69	841	830	883
20	702	713	714	70	844	834	886
21	704	714	718	71	847	838	890
22	707	715	721	72	850	840	893
23	710	721	725	73	853	842	896
24	713	727	728	74	857	843	900
25	715	730	732	75	860	845	903
26	718	732	735	76	863	850	906
27	721	733	738	77	866	855	910
28	723	735	742	78	870	856	913
29	726	736	745	79	873	858	916
30	729	738	749	80	877	860	920
31	732	742	752	81	880	864	923
32	735	748	756	82	884	869	927
33	738	750	759	83	887	872	930
34	741	753	763	84	891	875	933
35	743	754	766	85	895	877	937
36	746	755	770	86	899	880	941
37	749	756	773	87	903	885	944
38	752	757	777	88	908	888	948
39	755	762	780	89	912	890	952
40	758	767	784	90	917	894	955
41	760	770	787	91	922	899	960
42	763	772	791	92	928	902	964
43	766	773	794	93	934	906	968
44	769	774	798	94	941	912	973
45	772	775	801	95	948	916	979
46	775	776	805	96	956	923	984
47	777	781	808	97	967	929	991
48	780	785	811	98	980	937	998
49	783	788	815	99	1002	945	1007
50	786	790	818	FBP	1021	951	1007

[a] Run by ASTM Method D 5307, Boiling Range Distribution of Crude Petroleum by Gas Chromatography.

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography

950 - 1050° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F
IBP	838	784	670				
1	854	802	735	51	970	965	990
2	871	824	829	52	971	967	991
3	880	837	864	53	972	968	992
4	886	845	880	54	974	970	993
5	891	856	890	55	975	971	995
6	895	860	897	56	976	973	996
7	898	869	903	57	977	975	997
8	902	873	908	58	978	977	999
9	905	877	913	59	980	978	1000
10	908	882	917	60	981	980	1001
11	911	886	920	61	982	982	1002
12	913	888	923	62	983	984	1004
13	915	890	927	63	985	986	1005
14	917	894	929	64	986	988	1006
15	920	898	932	65	987	989	1007
16	922	900	935	66	988	991	1009
17	924	902	937	67	990	993	1010
18	925	904	939	68	991	996	1011
19	927	907	942	69	992	998	1013
20	929	910	944	70	994	1000	1014
21	931	912	946	71	995	1002	1015
22	932	914	948	72	997	1004	1017
23	934	916	950	73	998	1007	1018
24	935	918	952	74	1000	1009	1019
25	937	920	953	75	1001	1011	1021
26	938	922	955	76	1002	1014	1022
27	940	925	957	77	1004	1017	1023
28	941	926	958	78	1005	1020	1025
29	943	928	960	79	1007	1023	1026
30	944	930	961	80	1008	1026	1028
31	946	931	963	81	1010	1029	1029
32	947	933	964	82	1011	1033	1031
33	948	935	966	83	1013	1039	1033
34	950	938	967	84	1015	1045	1035
35	951	939	969	85	1017	1053	1037
36	952	941	970	86	1019	1063	1040
37	954	942	971	87	1021	1076	1043
38	955	944	973	88	1022	1093	1046
39	956	946	974	89	1025	1116	1049
40	957	947	975	90	1027		1052
41	958	949	977	91	1029		1056
42	960	951	978	92	1032		1060
43	961	953	979	93	1035		1065
44	962	954	981	94	1039		1071
45	963	956	982	95	1044		1080
46	964	957	983	96	1051		1093
47	965	959	984	97	1058		1124
48	967	960	986	98	1069		1216
49	968	962	987	99	1091		1284
50	969	964	988	FBP	1127		1295

[a] Proposed high temperature method without internal standard.

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography, continued

1050 - 1150° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F
IBP	890	790	645				
1	920	815	707	51	1043	1048	1035
2	941	867	811	52	1044	1050	1037
3	952	903	902	53	1046	1051	1038
4	959	928	931	54	1047	1052	1039
5	964	943	945	55	1048	1054	1040
6	969	953	954	56	1049	1056	1041
7	973	959	960	57	1051	1057	1042
8	977	965	966	58	1052	1058	1043
9	980	970	970	59	1053	1060	1044
10	983	974	974	60	1055	1062	1046
11	986	977	978	61	1056	1063	1047
12	988	981	981	62	1057	1065	1048
13	991	984	984	63	1058	1067	1049
14	993	987	986	64	1060	1068	1050
15	995	990	989	65	1061	1070	1051
16	997	992	991	66	1062	1072	1052
17	999	995	993	67	1064	1074	1053
18	1001	998	995	68	1065	1076	1054
19	1003	999	997	69	1067	1078	1055
20	1005	1001	999	70	1068	1080	1057
21	1006	1004	1001	71	1070	1083	1058
22	1008	1006	1003	72	1071	1085	1059
23	1009	1008	1004	73	1073	1087	1060
24	1011	1009	1006	74	1075	1088	1061
25	1012	1011	1007	75	1076	1092	1062
26	1014	1013	1009	76	1078	1095	1063
27	1015	1015	1010	77	1080	1098	1065
28	1017	1016	1012	78	1082	1102	1066
29	1018	1018	1013	79	1084	1106	1067
30	1019	1019	1014	80	1086	1110	1068
31	1020	1020	1015	81	1088	1116	1070
32	1021	1022	1017	82	1090	1122	1071
33	1022	1023	1018	83	1092	1130	1072
34	1023	1024	1019	84	1095	1141	1074
35	1025	1025	1020	85	1098	1158	1075
36	1026	1027	1021	86	1101	1180	1077
37	1027	1028	1022	87	1104	1207	1078
38	1028	1029	1023	88	1108	1237	1080
39	1029	1031	1024	89	1113	1263	1082
40	1030	1032	1025	90	1118	1291	1083
41	1031	1033	1026	91	1124	1325	1085
42	1032	1034	1027	92	1132	1386	1087
43	1033	1036	1028	93	1144	1463	1088
44	1034	1037	1029	94	1175		1090
45	1035	1039	1030	95	1259		1092
46	1037	1040	1030	96			1094
47	1038	1042	1031	97			1096
48	1039	1043	1032	98			1099
49	1040	1045	1033	99			1101
50	1042	1046	1034	FBP			1103

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography, continued

1150 - 1250° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F
IBP	942	797	658				
1	994	830	729	51	1145	1148	1117
2	1026	890	838	52	1147	1150	1119
3	1038	942	927	53	1148	1151	1121
4	1046	990	973	54	1150	1153	1122
5	1052	1023	994	55	1152	1155	1124
6	1057	1037	1006	56	1153	1157	1126
7	1061	1048	1015	57	1155	1158	1128
8	1065	1055	1021	58	1156	1160	1129
9	1069	1060	1026	59	1158	1162	1131
10	1072	1065	1030	60	1159	1164	1133
11	1075	1069	1034	61	1161	1166	1134
12	1078	1073	1038	62	1162	1168	1136
13	1080	1076	1042	63	1164	1170	1138
14	1083	1080	1046	64	1166	1172	1140
15	1085	1082	1049	65	1167	1174	1142
16	1087	1085	1052	66	1169	1176	1144
17	1089	1088	1055	67	1170	1179	1146
18	1091	1090	1057	68	1172	1181	1148
19	1093	1092	1060	69	1174	1184	1150
20	1095	1094	1062	70	1176	1187	1153
21	1096	1096	1064	71	1177	1190	1155
22	1098	1098	1066	72	1179	1195	1157
23	1100	1100	1069	73	1181	1199	1160
24	1102	1102	1071	74	1182	1203	1162
25	1104	1104	1073	75	1184	1208	1165
26	1106	1106	1075	76	1186	1214	1168
27	1107	1108	1077	77	1189	1222	1171
28	1109	1110	1079	78	1191	1234	1175
29	1111	1112	1081	79	1194		1178
30	1113	1113	1083	80	1197		1182
31	1114	1115	1084	81	1199		1187
32	1116	1117	1086	82	1202		1193
33	1118	1119	1088	83	1204		1200
34	1119	1120	1089	84	1207		1208
35	1121	1122	1091	85	1210		1221
36	1122	1124	1093	86	1213		1242
37	1124	1125	1094	87	1217		1267
38	1125	1127	1096	88	1222		1292
39	1127	1128	1097	89	1230		1314
40	1128	1130	1099	90	1240		1331
41	1130	1132	1101	91	1248		1346
42	1131	1133	1102	92	1257		1357
43	1133	1135	1104	93	1283		1368
44	1135	1136	1106	94	1307		1380
45	1136	1138	1107	95	1326		1391
46	1138	1139	1109	96			1403
47	1139	1141	1111	97			1415
48	1141	1143	1112	98			1428
49	1142	1144	1114	99			1442
50	1144	1146	1116	FBP			1450

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography, continued

950 - 1250° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV[a] Temp. °F
IBP	862	803	652				
1	881	827	721	51	1082	1078	1063
2	899	857	822	52	1085	1081	1065
3	911	876	877	53	1088	1084	1068
4	920	888	899	54	1091	1087	1070
5	927	899	913	55	1094	1090	1073
6	933	907	923	56	1097	1093	1076
7	939	916	931	57	1100	1096	1078
8	945	923	938	58	1103	1099	1081
9	950	929	945	59	1107	1102	1084
10	954	935	950	60	1110	1105	1086
11	959	941	955	61	1114	1108	1089
12	963	946	960	62	1117	1112	1091
13	967	952	964	63	1121	1115	1094
14	970	956	968	64	1125	1118	1097
15	974	961	972	65	1128	1121	1100
16	978	965	975	66	1132	1125	1103
17	981	969	979	67	1135	1129	1106
18	985	974	982	68	1139	1131	1109
19	988	977	985	69	1143	1135	1112
20	992	981	988	70	1147	1138	1116
21	995	985	991	71	1151	1142	1119
22	998	989	994	72	1155	1146	1122
23	1001	992	997	73	1159	1150	1126
24	1004	996	1000	74	1163	1154	1130
25	1007	1000	1003	75	1168	1158	1133
26	1010	1003	1005	76	1172	1162	1137
27	1013	1007	1008	77	1176	1166	1142
28	1016	1010	1010	78	1181	1171	1146
29	1019	1013	1012	79	1186	1176	1151
30	1021	1016	1015	80	1193	1182	1157
31	1023	1019	1017	81	1200	1189	1163
32	1026	1021	1019	82	1207	1199	1169
33	1028	1024	1021	83	1216	1210	1177
34	1031	1027	1023	84	1231	1229	1187
35	1033	1029	1025	85	1252	1266	1201
36	1036	1032	1027	86	1304	1394	1221
37	1039	1035	1029	87	1402		1253
38	1042	1038	1031	88			1284
39	1045	1041	1034	89			1312
40	1048	1044	1036	90			1332
41	1051	1047	1038	91			1346
42	1054	1051	1041	92			1357
43	1057	1054	1043	93			1366
44	1060	1057	1046	94			1376
45	1063	1060	1049	95			1386
46	1066	1062	1051	96			1398
47	1069	1066	1053	97			1410
48	1072	1068	1056	98			1424
49	1075	1072	1058	99			1439
50	1078	1075	1060	FBP			1448

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography, continued

>650° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV[b] Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV[b] Temp. °F
IBP	628	643	438				
1	641	648	493	51	930	931	932
2	653	660	567	52	938	940	939
3	661	669	613	53	945	949	946
4	668	673	639	54	953	958	952
5	673	683	655	55	961	966	959
6	678	691	668	56	969	975	966
7	683	693	678	57	977	985	973
8	689	697	687	58	985	994	980
9	694	707	695	59	993	1003	988
10	698	712	702	60	1001	1012	995
11	703	715	709	61	1009	1021	1002
12	708	718	715	62	1017	1028	1009
13	714	728	721	63	1024	1037	1017
14	718	734	727	64	1031	1047	
15	723	736	733	65	1040	1056	
16	728	739	738	66	1049	1066	
17	734	750	744	67	1058	1076	
18	738	754	749	68	1068	1086	
19	744	756	755	69	1077	1095	
20	750	761	760	70	1087	1106	
21	755	770	765	71	1097	1117	
22	760	773	771	72	1108	1128	
23	765	775	776	73	1119	1139	
24	771	781	781	74	1130	1152	
25	775	790	786	75	1142	1165	
26	781	792	792	76	1154	1179	
27	786	794	796	77	1166	1195	
28	791	801	801	78	1177	1211	
29	796	807	806	79	1190	1233	
30	801	810	811	80	1202	1249	
31	807	813	816	81	1214	1276	
32	811	821	821	82	1227		
33	817	824	826	83	1239		
34	822	827	831	84	1250		
35	827	833	836	85	1261		
36	832	840	841	86	1272		
37	838	843	846	87	1282		
38	843	848	851	88	1291		
39	850	855	856	89	1302		
40	856	859	862	90	1312		
41	862	866	868	91	1324		
42	869	873	874	92	1339		
43	876	877	880	93			
44	882	884	886	94			
45	888	889	892	95			
46	894	895	899	96			
47	901	901	905	97			
48	908	909	912	98			
49	915	916	919	99			
50	922	924	925	FBP			

[b] Run by ASTM Method D 5307, Boiling Range Distribution of Crude Petroleum by Gas Chromatography.

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography, continued

>950° F Fractions

% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F	% Off	ANS Temp. °F	ALT Temp. °F	SJV Temp. °F
IBP	814	867	674				
1	874	881	718	51	1185	1137	1155
2	905	899	782	52	1192	1142	1161
3	921	911	834	53	1199	1146	1166
4	932	921	876	54	1204	1151	1171
5	941	929	900	55	1210	1156	1176
6	950	938	918	56	1216	1161	1181
7	957	945	931	57	1223	1166	1187
8	963	952	942	58	1229	1171	1193
9	970	958	951	59	1236	1176	1199
10	976	964	959	60	1242	1181	1204
11	981	969	966	61	1248	1186	1209
12	987	974	972	62	1253	1193	1214
13	992	979	978	63	1259	1200	1219
14	997	985	984	64	1265	1205	1224
15	1002	989	990	65	1271	1211	1230
16	1007	994	995	66	1278	1217	1236
17	1012	999	1000	67	1283	1224	1241
18	1016	1004	1004	68	1288	1234	1246
19	1021	1007	1009	69	1295	1242	1250
20	1024	1012	1013	70	1300	1248	1255
21	1028	1016	1018	71	1306	1250	1260
22	1032	1020	1021	72	1312	1256	1265
23	1037	1023	1025	73	1319	1263	1271
24	1042	1027	1028	74	1328	1277	1277
25	1046	1030	1032	75	1341	1283	1282
26	1051	1033	1036	76	1352	1283	1287
27	1056	1038	1041	77		1288	1296
28	1061	1042	1045	78		1297	1302
29	1065	1046	1050	79		1303	1310
30	1070	1050	1054	80		1311	1319
31	1075	1055	1058	81		1318	1328
32	1080	1058	1062	82		1326	1340
33	1085	1062	1067	83		1333	1353
34	1090	1066	1071	84		1341	1369
35	1095	1070	1076	85			1396
36	1100	1074	1081	86			
37	1105	1079	1085	87			
38	1111	1083	1089	88			
39	1116	1087	1094	89			
40	1122	1090	1098	90			
41	1127	1094	1103	91			
42	1133	1098	1108	92			
43	1139	1102	1114	93			
44	1144	1107	1119	94			
45	1150	1111	1124	95			
46	1156	1116	1129	96			
47	1162	1120	1134	97			
48	1168	1124	1139	98			
49	1174	1128	1145	99			
50	1179	1133	1150	FBP			

Table 12. Boiling Range Distribution of ANS, ALT, and SJV High Boiling Fractions and Resids by High Temperature Gas Chromatography, continued

>1250° F Fractions

% Off	ANS Temp. °F	% Off	ANS Temp. °F
IBP	980		
1	1047	51	1314
2	1113	52	1316
3	1142	53	1319
4	1159	54	1321
5	1171	55	1324
6	1179	56	1327
7	1185	57	1331
8	1192	58	1335
9	1198	59	1341
10	1202	60	1348
11	1206	61	1357
12	1210	62	1368
13	1214	63	1386
14	1217	64	1426
15	1221	65	
16	1225	66	
17	1230	67	
18	1235	68	
19	1240	69	
20	1243	70	
21	1246	71	
22	1248	72	
23	1248	73	
24	1249	74	
25	1252	75	
26	1254	76	
27	1257	77	
28	1260	78	
29	1262	79	
30	1268	80	
31	1274	81	
32	1279	82	
33	1281	83	
34	1282	84	
35	1283	85	
36	1283	86	
37	1283	87	
38	1285	88	
39	1287	89	
40	1289	90	
41	1292	91	
42	1295	92	
43	1297	93	
44	1299	94	
45	1301	95	
46	1303	96	
47	1305	97	
48	1307	98	
49	1309	99	
50	1312	FBP	

Table 13. General Physical Property Data

	Cloud Point, °F			Pour Point, °F			Freeze Point, °F			[c]Refractive Index, N_D		
	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV
Whole Crude				5	115	40						
320 - 450° F	-72	-44	<-60				-74.2	-35	-79.6			
450 - 500° F	-32	8	<-60	-30	5	<-60	-33.7	7	-40.0	1.46916	1.43826	1.47441
500 - 550° F	-10	34	<-60	-15	35	<-60	-9.4	36	TD	1.47928	1.44254	1.48491
550 - 600° F				10	55	-50				1.48210	1.44557	1.49624
600 - 650° F				25	75	-35				1.49204	1.61733	1.51058
450 - 650° F (composite)	0	42	TD	0	40	<-60				1.48078	1.44358	1.49364
650 - 750° F				55	95	-10				1.47866	1.42989	1.49934
750 - 850° F				65	120	5				1.49177	1.43583	1.50433
850 - 950° F				105	135	65				1.50731	1.44162	1.51759
(Blind)[a]				105	135					1.50730	1.44176	
650 - 950° F (composite)				70	120	30				1.49024	1.43587	1.50891
950 - 1050° F				115	145	105				1.51752	1.4471	1.51904
1050 - 1150° F				120	165	125				1.52200	1.4491	1.52291
1150 - 1250° F				100 (110)[b]	185	155				1.53090[d]	1.4632[d]	1.52348
950 - 1250° F (composite)				110	175	125				1.52181[d]	1.4623[d]	1.52017

TD = Too dark.

[a] Samples of the 850-950° F distillates from ANS and ALT crudes were submitted for analysis as "blind" samples.

[b] Values in parentheses are from repeat tests conducted at a later time.

[c] Fractions boiling below 650° F were measured at 20° C; fractions boiling above 650° F were measured at 80° C.

[d] Measurement made on diluted samples and reported on a neat sample basis.

Table 13. General Physical Property Data, continued

	Flash Point, °C			Aniline Point, °F			Smoke Point, mm			Reid Vapor Pressure, psi @ 100° F		
	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV
Whole Crude										4.45	0.55	0.77
320 - 450° F	50.5	49.0	61.5 (66.5)				21.4	27.6	18.0			
450 - 500° F	92.5	91.0	86.5	134.0	178.5	131.5						
500 - 550° F	113.5	120.0	107.5	136.0	190.0	126.4						
550 - 600° F	130.5	141.0	142.5	149.0	201.0	123.2						
600 - 650° F	146.5	161.0	143.5	151.5	209.5	117.4						
450 - 650° F (composite)	106.5	109.0	108.5	142.5	194.5	123.3						
650 - 750° F	150.5	178.0	137.5									
750 – 850° F	173.5	210.0	150.5									
850 - 950° F	242.5	220.0	213.5 (221.5)									
(blind)	242.5	220.5										
650 - 950° F (composite)	169.5	197.5	150.5									

	Research Octane Number			Motor Octane Number			Water, wt. %			Sediment, wt. %		
	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV	ANS	ALT	SJV
Whole Crude							0.01	0.0004	0.23	0.04	0.02	0.039
IBP - 165° F	76.8	67.3		70.8	62.2							
165 - 320° F	58.4	37.3	68.0	52.2	36.1	68.0						

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions

Whole Crude

Component		ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
Total Paraffins		5.183	7.722	0.110
Total Iso-paraffins		4.152	2.781	0.475
Total Aromatics		4.365	2.112	0.596
Total Naphthenes		4.522	2.063	0.353
Total Olefins		0.000	0.000	0.000
Unknowns		1.598	0.253	1.518
Paraffins	C1	0.000	0.000	0.000
	C2	0.002	0.000	0.000
	C3	0.055	0.000	0.000
	C4	0.521	0.011	0.000
	C5	0.666	0.093	0.002
	C6	0.580	0.339	0.003
	C7	0.557	0.725	0.004
	C8	0.555	1.043	0.016
	C9	0.489	1.210	0.015
	C10	0.521	1.362	0.007
	C11	0.440	1.458	0.013
	C12	0.426	1.481	0.029
	C13	0.372	0.000	0.021
Iso-paraffins	C4	0.116	0.002	0.000
	C5	0.421	0.043	0.001
	C6	0.537	0.175	0.004
	C7	0.501	0.356	0.008
	C8	0.579	0.707	0.031
	C9	0.521	0.453	0.074
	C10	0.858	0.693	0.130
	C11	0.462	0.269	0.091
	C12	0.158	0.083	0.072
	C13	0.000	0.000	0.064
Aromatics	C6	0.344	0.059	0.000
	C7	0.614	0.295	0.005
	C8	0.909	0.553	0.017
	C9	0.858	0.466	0.044
	C10	0.756	0.292	0.206
	C11	0.505	0.184	0.182
	C12	0.378	0.263	0.141
Naphthenes	C5	0.104	0.020	0.001
	C6	0.795	0.250	0.010
	C7	1.210	0.618	0.035
	C8	1.116	0.383	0.052
	C9	0.700	0.480	0.109
	C10	0.392	0.170	0.076
	C11	0.173	0.126	0.056
	C12	0.031	0.015	0.014

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
ethane	0.002		
propane	0.055		
i-butane	0.116	0.002	
n-butane	0.521	0.011	0.000
2,2-dimethylpropane	0.011		
i-pentane	0.410	0.043	0.001
n-pentane	0.666	0.093	0.002
2,2-dimethylbutane		0.009	
2,3-dimethylbutane	0.044		0.001
cyclopentane	0.104	0.020	0.001
2-methylpentane	0.302	0.095	0.002
3-methylpentane	0.192	0.072	0.002
n-hexane	0.580	0.339	0.003
2,2-dimethylpentane	0.009	0.010	
methylcyclopentane	0.386	0.089	0.006
2,4-dimethylpentane	0.023	0.016	0.000
2,2,3-trimethylbutane	0.002	0.003	
benzene	0.344	0.059	
3,3-dimethylpentane	0.008	0.008	
cyclohexane	0.410	0.161	0.004
2-methylhexane	0.159	0.135	0.002
2,3-dimethylpentane	0.074	0.032	0.002
1,1-dimethylcyclopentane	0.036	0.024	0.001
3-methylhexane	0.207	0.143	0.003
1c,3-dimethylcyclopentane	0.084	0.023	0.005
1t,3-dimethylcyclopentane	0.081	0.024	0.005
3-ethylpentane	0.019	0.010	0.001
1t,2-dimethylcyclopentane	0.141	0.037	0.007
2,2,4-trimethylpentane	0.000		
n-heptane	0.557	0.725	0.004
methylcyclohexane	0.794	0.485	0.014
2,2-dimethylhexane	0.047	0.025	0.005
ethylcyclopentane	0.074	0.025	0.002
2,2,3-trimethylpentane	0.023		
2,4-dimethylhexane	0.030	0.058	0.001
1c,2t,4-trimethylcyclopentane	0.050	0.011	0.008
3,3-dimethylhexane	0.010	0.008	
1c,2t,3c-trimethylcyclopentane	0.068	0.011	0.011
2,3,4-trimethylpentane	0.009		0.001
toluene	0.614	0.295	0.005
2,3-dimethylhexane	0.049	0.024	0.003
1,1,2-trimethylcyclopentane	0.020		0.001
?			0.001
2-methylheptane	0.212	0.183	0.004
4-methylheptane	0.075	0.079	0.001
3,4-dimethylhexane	0.012		
1c,2c,4t-trimethylcyclopentane	0.005	0.012	0.000
3-methylheptane	0.112	0.165	0.014
1c,2t,3-trimethylcyclopentane	0.249		
3-ethylhexane		0.164	0.003

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
1t,4-dimethylcyclohexane	0.085	0.071	0.004
1,1-dimethylcyclohexane	0.036	0.029	0.002
2,2,5-trimethylhexane		0.004	
1t,3-ethylmethylcyclopentane	0.029	0.005	0.002
1c,3-ethylmethylcyclopentane	0.026	0.004	0.002
1t,2-ethylmethylcyclopentane	0.083		
1,1-ethylmethylcyclopentane	0.007		
1,1-methylethylcyclopentane			0.001
2,2,4-trimethylhexane		0.006	0.005
1t,2-dimethylcyclohexane	0.117	0.057	0.007
n-octane	0.555	1.043	0.016
i-propylcyclopentane	0.013		0.006
?			0.001
N			0.000
2,2,3,4-tetramethylpentane	0.003		0.004
?			0.001
2,3,4-trimethylhexane	0.008		
1c,2-dimethylcyclohexane	0.050	0.049	
2,3,5-trimethylhexane	0.004		
2,2-dimethylheptane	0.005	0.014	
1,1,4-trimethylcyclohexane		0.075	
2,4-dimethylheptane			0.001
4,4-dimethylheptane			0.009
ethylcyclohexane			0.003
n-propylcyclopentane	0.253	0.135	
2-methyl-4-ethylhexane	0.076		
1c,3c,5-trimethylcyclohexane		0.058	0.003
2,5-dimethylheptane	0.005		0.001
3,3-dimethylheptane	0.045	0.014	
2,6-dimethylheptane			0.017
1,1,3-trimethylcyclohexane	0.175	0.043	0.005
N	0.014		0.004
?	0.008		0.002
N	0.010		0.002
ethylbenzene	0.164	0.032	0.008
1c,2t,4t-trimethylcyclohexane	0.051	0.031	0.009
I3	0.007		
N			0.001
m-xylene	0.371	0.266	0.002
p-xylene	0.166	0.149	0.005
3,4-dimethylheptane	0.031	0.022	
3,5-dimethylheptane			0.002
2,3-dimethylheptane	0.003		0.003
N		0.018	
4-ethylheptane	0.009		
4-methyloctane	0.065	0.091	0.001
2-methyloctane	0.086	0.123	0.001
N	0.015		0.009
3-ethylheptane		0.006	0.005
3-methyloctane	0.113	0.127	0.003

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
1c,2t,4c-trimethylcyclohexane	0.036	0.025	0.003
3,3-diethylpentane	0.005		0.004
o-xylene	0.208	0.107	0.002
1,1,2-trimethylcyclohexane		0.003	0.002
I6			0.002
I7	0.054	0.004	
N	0.100	0.011	0.014
N	0.059	0.065	0.005
?	0.007		
I8		0.041	0.015
N			0.001
i-butylcyclopentane	0.005	0.002	0.004
N	0.009	0.010	0.008
N	0.004		
I9			0.002
N		0.004	0.001
n-nonane	0.489	1.210	0.015
1,1-methylethylcyclohexane	0.071	0.048	0.015
N	0.019	0.021	0.004
?	0.006		0.003
i-propylbenzene	0.031	0.008	0.004
N	0.082	0.021	0.015
i-propylcyclohexane	0.035	0.014	0.005
?	0.008		0.002
I11		0.007	0.003
?	0.010		
2,2-dimethyloctane	0.039	0.038	0.006
2,4-dimethyloctane	0.008	0.010	0.013
N		0.007	0.003
2,6-dimethyloctane	0.020		0.011
2,5-dimethyloctane	0.156	0.128	0.014
n-butylcyclopentane	0.040	0.025	0.005
I13	0.013	0.013	0.006
?			0.003
N		0.002	0.008
I14	0.121	0.080	0.011
?		0.011	
3,3-dimethyloctane		0.008	0.006
N	0.011		0.007
?	0.012		
n-propylbenzene	0.101	0.030	0.002
3-methyl-5-ethylheptane	0.055	0.011	0.003
?	0.011		0.009
N	0.015	0.008	
?	0.006		0.008
1,3-methylethylbenzene	0.146	0.062	0.009
1,4-methylethylbenzene	0.049	0.023	
N	0.057		
1,3,5-trimethylbenzene	0.106	0.110	0.006
2,3-dimethyloctane		0.022	0.005

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
?		0.025	
I15	0.010		
N	0.012	0.006	0.002
I17	0.044	0.046	
5-methylnonane	0.075	0.079	
?			0.002
2-methylnonane	0.084	0.115	0.004
1-methyl-2-ethylbenzene	0.069		0.010
?			0.006
3-ethyloctane	0.035	0.015	0.006
N			0.004
3-methylnonane	0.120	0.101	0.010
?			0.011
?			0.003
N	0.034	0.009	0.012
?			0.009
I18	0.008		0.004
I19	0.005		0.010
t-butylbenzene			0.008
1,2,4-trimethylbenzene	0.244	0.191	0.008
t-butylcyclohexane	0.051		0.008
i-butylcyclohexane	0.057	0.033	0.017
I21	0.019	0.004	0.007
?	0.008		
I22		0.002	0.004
I23	0.024	0.002	0.002
I24	0.022	0.011	0.005
?			0.004
1t-methyl-2-n-propylcyclohexane	0.030	0.006	
i-butylbenzene	0.017		0.019
sec-butylbenzene	0.007		
n-decane	0.521	1.362	0.007
?			0.022
?			0.011
I26	0.016	0.005	
N	0.026	0.005	0.015
1,2,3-trimethylbenzene	0.098	0.026	0.006
1,3-methyl-i-propylbenzene	0.033	0.017	0.009
N			0.014
1,4-methyl-i-propylbenzene	0.021	0.008	0.007
?			0.004
I27	0.020		0.012
?	0.002	0.014	0.009
?			0.011
?			0.005
I28		0.005	
I29	0.036	0.004	
2,3-dihydroindene	0.015	0.017	
sec-butylcyclohexane	0.125	0.106	0.026
1,2-methyl-i-propylbenzene	0.007		0.008

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
3-ethylnonane	0.027	0.020	0.023
N	0.079	0.076	0.010
I31	0.007	0.008	
I32	0.036	0.025	
?	0.020		0.003
?			0.016
?			0.005
1,3-diethylbenzene	0.019	0.004	0.007
?	0.010		
1,3-methyl-n-propylbenzene	0.086	0.032	0.010
I33	0.011		0.001
1,4-diethylbenzene	0.004	0.004	
1,4-methyl-n-propylbenzene	0.025	0.013	0.001
n-butylbenzene	0.045	0.030	0.003
1,3-dimethyl-5-ethylbenzene	0.046		0.010
1,2-diethylbenzene	0.010	0.008	0.003
?	0.005		
I34	0.016		0.010
N	0.068	0.013	0.016
N		0.032	
1,2-methyl-n-propylbenzene	0.041	0.003	0.005
?			0.009
I35		0.054	0.007
I36	0.047		
I37	0.043	0.053	0.013
I38	0.073		
?			0.003
?			0.008
1,4,dimethyl-2-ethylbenzene	0.046	0.076	0.023
?		0.003	0.008
?		0.003	
1,3-dimethyl-4-ethylbenzene	0.038		0.012
I39	0.055	0.068	0.011
1,2-dimethyl-4-ethylbenzene	0.058	0.019	0.025
?	0.012	0.007	0.027
I40	0.034		
?	0.020		
?		0.003	
1,3-dimethyl-2-ethylbenzene	0.025		0.013
I41	0.010		
?	0.026		0.039
I42	0.032	0.028	0.014
?	0.005	0.015	0.003
?	0.038		
?	0.017		
1,4-methyl-t-butylbenzene	0.039	0.010	0.028
?		0.009	0.008
1,2-dimethyl-3-ethylbenzene	0.063	0.002	0.006
1,2-ethyl-i-propylbenzene	0.017	0.014	0.004
n-undecane	0.440	1.458	0.013

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
?	0.019		0.025
?	0.009		
1,4-ethyl-i-propylbenzene	0.008	0.005	
1,2,4,5-tetramethylbenzene	0.017	0.020	0.009
?	0.023		0.013
1,2-methyl-n-butylbenzene	0.004		0.006
?			0.013
1,2,3,5-tetramethylbenzene	0.024	0.017	0.003
?	0.054	0.024	0.015
?	0.003	0.012	0.019
?	0.015	0.022	0.009
?	0.031	0.006	0.024
?	0.009		0.007
1,2-methyl-t-butylbenzene	0.003	0.010	0.015
?			0.015
5-methylindan		0.003	0.006
A2	0.011	0.025	0.015
I43	0.048	0.021	0.009
A3	0.051		0.027
?	0.021		0.017
?			0.011
4-methylindan		0.005	
?		0.007	
1,2-ethyl-n-propylbenzene	0.010	0.069	0.006
A4	0.083		
1,3-methyl-n-butylbenzene	0.036	0.008	0.008
?			0.010
1,3-di-i-propylbenzene	0.066	0.007	0.004
?	0.011		
s-pentylbenzene		0.009	
n-pentylbenzene	0.020	0.005	0.014
?	0.005		0.012
?			0.006
1t-M-2-(4-MP)cyclopentane	0.031	0.015	0.014
?		0.011	0.014
?			0.012
1,2-di-i-propylbenzene	0.031	0.028	0.005
?	0.035	0.041	0.006
?		0.002	
1,4-di-i-propylbenzene	0.039		
?	0.032		
1,2,3,4-tetrahydronaphthalene	0.036	0.036	0.014
?	0.074		0.016
?	0.024		0.013
?	0.010	0.009	0.009
naphthalene	0.126	0.004	0.024
?			0.017
1-t-butyl-3,5-dimethylbenzene		0.080	
1,4-ethyl-t-butylbenzene			0.028
?		0.004	

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
I44	0.010	0.065	0.010
I45	0.009	0.001	
?	0.009		0.021
?	0.008		0.008
I46	0.019	0.005	0.011
I47	0.037	0.008	0.033
?			0.043
I48	0.036	0.003	0.019
?	0.023		
1,3-di-n-propylbenzene	0.087	0.037	0.013
?	0.010	0.022	
A5	0.015		0.022
?	0.033	0.004	0.013
?	0.016		0.012
?			0.002
n-dodecane	0.426	1.481	0.029
?	0.016	0.004	0.031
?	0.053	0.003	0.038
?	0.014		0.003
?	0.019		0.010
?	0.131		0.038
1t-butyl-4-n-pentylbenzene	0.017	0.110	0.012
?	0.018		0.012
?	0.005		0.014
?	0.001		0.019
?	0.016		0.030
?	0.012		0.028
?	0.022		0.017
1,3,5-triethylbenzene		0.001	
1,2,4-triethylbenzene	0.035		
?	0.020		0.028
?	0.030		0.014
?	0.016		0.012
?	0.048		0.025
1,4-methyl-n-pentylbenzene	0.050		0.036
?	0.008		0.023
?	0.018		0.012
n-hexylbenzene	0.038		0.020
?	0.042		0.029
?	0.091		0.055
?	0.005		0.008
?	0.058		0.010
?	0.014		0.011
?	0.040		0.031
?	0.067		0.016
?	0.016		0.041
I49	0.086		0.064
?	0.000		0.012
?	0.014		0.014
?			0.014

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

Whole Crude

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
?			0.014
2-methylnaphthalene	0.185		0.028
?	0.009		0.007
?	0.028		0.020
?	0.029		0.018
?	0.015		0.013
?	0.025		0.013
1-methylnaphthalene			0.006
?			0.012
?			0.014
n-tridecane	0.372		0.021
?			0.021
?			0.014
?			0.033
?			0.014
?			0.007
?			0.025
?			0.017
?			0.009
?			0.019
?			0.015

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

IBP - 165° F Fraction

Component		ANS wt. % in sample	ALT wt. % in sample
Total Paraffins		47.671	51.506
Total Iso-paraffins		32.895	35.108
Total Aromatics		4.255	3.333
Total Naphthenes		15.179	10.053
Total Olefins		0.000	0.000
Unknowns		0.000	0.000
Paraffins	C1	0.000	0.000
	C2	0.000	0.000
	C3	0.097	0.047
	C4	9.213	2.340
	C5	23.824	19.839
	C6	14.304	28.538
	C7	0.232	0.743
	C8	0.000	0.000
Iso-paraffins	C4	1.311	0.308
	C5	13.871	9.134
	C6	16.699	22.901
	C7	1.014	2.718
	C8	0.000	0.048
	C9	0.000	0.000
Aromatics	C6	4.161	3.245
	C7	0.094	0.088
	C8	0.000	0.000
Naphthenes	C5	5.242	1.325
	C6	9.270	7.997
	C7	0.667	0.731
	C8	0.000	0.000

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

IBP - 165° F Fraction

Component	ANS wt. % in sample	ALT wt. % in sample
propane	0.097	0.047
i-butane	1.311	0.308
n-butane	9.213	2.340
2,2-dimethylpropane		0.026
i-pentane	13.871	9.107
n-pentane	23.824	19.839
2,3-dimethylbutane		2.427
cyclopentane	5.242	1.325
2-methylpentane	10.635	12.553
3-methylpentane	6.064	7.891
n-hexane	14.304	28.538
2,2-dimethylpentane	0.093	0.286
methylcyclopentane	6.602	4.732
2,4-dimethylpentane	0.232	0.408
2,2,3-trimethylbutane		0.073
benzene	4.161	3.245
3,3-dimethylpentane		0.082
cyclohexane	2.669	3.265
2-methylhexane	0.292	0.850
2,3-dimethylpentane	0.140	0.214
1,1-dimethylcyclopentane	0.103	0.258
3-methylhexane	0.256	0.761
1c,3-dimethylcyclopentane	0.113	0.066
1t,3-dimethylcyclopentane	0.086	0.044
3-ethylpentane		0.045
1t,2-dimethylcyclopentane	0.157	0.144
2,2,4-trimethylpentane		0.048
n-heptane	0.232	0.743
methylcyclohexane	0.207	0.220
toluene	0.094	0.088

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component		ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
Total Paraffins		19.492	40.518	6.777
Total Iso-paraffins		21.859	24.045	28.518
Total Aromatics		20.111	13.462	19.016
Total Naphthenes		37.910	21.975	26.765
Total Olefins		0.000	0.000	0.000
Unknowns		0.629	0.000	18.924
Paraffins	C1	0.000	0.000	0.000
	C2	0.000	0.000	0.000
	C3	0.000	0.000	0.000
	C4	0.017	0.000	0.004
	C5	0.209	0.181	0.093
	C6	2.934	3.968	0.292
	C7	6.027	11.820	0.565
	C8	5.899	14.264	1.619
	C9	3.940	9.454	2.141
	C10	0.467	0.829	1.527
	C11	0.000	0.000	0.366
	C12	0.000	0.000	0.123
	C13	0.000	0.000	0.046
Iso-paraffins	C4	0.000	0.027	0.000
	C5	0.074	0.072	0.040
	C6	1.392	1.418	0.359
	C7	5.290	5.688	0.882
	C8	6.088	9.542	3.272
	C9	5.781	4.928	7.337
	C10	3.200	2.371	11.726
	C11	0.033	0.000	4.337
	C12	0.000	0.000	0.528
	C13	0.000	0.000	0.039
Aromatics	C6	2.115	0.746	0.028
	C7	6.528	4.738	1.396
	C8	8.676	6.530	1.974
	C9	2.699	1.085	5.133
	C10	0.094	0.363	7.216
	C11	0.000	0.000	2.678
	C12	0.000	0.000	0.591
Naphthenes	C5	0.151	0.037	0.048
	C6	6.576	3.398	0.836
	C7	13.343	9.323	3.273
	C8	11.466	4.706	5.132
	C9	5.819	4.390	10.067
	C10	0.529	0.099	5.369
	C11	0.025	0.022	1.873
	C12	0.000	0.000	0.166

[a] IBP - 320° F fraction for SJV

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
n-butane	0.017	0.027	0.004
i-pentane	0.074	0.072	0.040
n-pentane	0.209	0.181	0.093
2,3-dimethylbutane	0.085	0.119	0.048
cyclopentane	0.151	0.037	0.048
2-methylpentane	0.691	0.683	0.166
3-methylpentane	0.615	0.616	0.146
n-hexane	2.934	3.968	0.292
2,2-dimethylpentane	0.085	0.140	0.016
methylcyclopentane	2.660	1.123	0.500
2,4-dimethylpentane	0.219	0.235	0.041
2,2,3-trimethylbutane	0.019	0.041	0.029
?			0.002
benzene	2.115	0.746	0.028
3,3-dimethylpentane	0.069	0.088	0.024
cyclohexane	3.916	2.275	0.336
2-methylhexane	1.677	2.192	0.184
2,3-dimethylpentane	0.791	0.492	0.205
1,1-dimethylcyclopentane	0.408	0.334	0.123
3-methylhexane	2.212	2.333	0.300
1c,3-dimethylcyclopentane	0.890	0.376	0.483
1t,3-dimethylcyclopentane	0.865	0.373	0.486
3-ethylpentane	0.218	0.167	0.083
1t,2-dimethylcyclopentane	1.767	0.582	0.692
2,2,4-trimethylpentane			0.009
n-heptane	6.027	11.820	0.565
1c,2-dimethylcyclopentane		0.009	
methylcyclohexane	8.609	7.432	1.254
2,2-dimethylhexane	0.516	0.366	0.454
ethylcyclopentane	0.805	0.216	0.235
2,5-dimethylhexane	0.253		
2,2,3-trimethylpentane		0.324	0.087
2,4-dimethylhexane	0.342	0.375	0.088
1c,2t,4-trimethylcyclopentane	0.536	0.190	0.706
3,3-dimethylhexane	0.092	0.125	0.043
?			0.017
1c,2t,3c-trimethylcyclopentane	0.713	0.168	0.999
2,3,4-trimethylpentane	0.076		0.117
?			0.007
toluene	6.528	4.738	1.396
2,3-dimethylhexane	0.488	0.326	0.218
1,1,2-trimethylcyclopentane			0.082
?			0.064
2-methylheptane	2.227	2.588	0.404
4-methylheptane	0.831	1.018	0.116
3-methyl-3-ethylpentane			0.030
3,4-dimethylhexane	0.073		0.036
1c,2c,4t-trimethylcyclopentane	0.077	0.035	0.111
3-methylheptane	1.189	2.189	1.345
1c,2t,3-trimethylcyclopentane	2.665		

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
3-ethylhexane		2.230	0.324
1t,4-dimethylcyclohexane	0.904	0.895	0.401
1,1-dimethylcyclohexane	0.387	0.417	0.158
2,2,5-trimethylhexane		0.057	0.013
1t,3-ethylmethylcyclopentane	0.309	0.074	0.206
1c,3-ethylmethylcyclopentane	0.269	0.066	0.186
1t,2-ethylmethylcyclopentane	0.891		
1,1-ethylmethylcyclopentane	0.080		
1,1-methylethylcyclopentane		0.040	0.046
2,2,4-trimethylhexane		0.095	0.428
1t,2-dimethylcyclohexane	1.240	0.747	0.553
1c,2c,3-trimethylcyclopentane			0.028
n-octane	5.899	14.264	1.619
?			0.015
i-propylcyclopentane	0.145		0.546
?			0.082
N			0.043
2,2,3,4-tetramethylpentane	0.037	0.032	0.358
2,3,4-trimethylhexane	0.092		
N			0.037
?			0.075
?			0.024
1c,2-dimethylcyclohexane	0.233	0.437	
2,3,5-trimethylhexane	0.056		0.026
2,2-dimethylheptane	0.059	0.150	
?			0.148
1,1,4-trimethylcyclohexane		0.916	0.189
2,2,3-trimethylhexane	0.342		0.023
2,4-dimethylheptane	0.018	0.029	0.105
4,4-dimethylheptane			0.832
ethylcyclohexane			0.298
n-propylcyclopentane	2.665	1.621	0.226
2-methyl-4-ethylhexane	0.876		1.492
1c,3c,5-trimethylcyclohexane		0.715	
2,5-dimethylheptane	0.104	0.175	0.162
3,3-dimethylheptane	0.653		
2,6-dimethylheptane	0.049		
1,1,3-trimethylcyclohexane	1.805	0.481	0.516
?	0.142		0.155
N	0.241		0.373
?	0.155		
1c,1t,3c-trimethylcyclohexane			0.051
N	0.112	0.016	0.133
?			0.031
?			0.312
ethylbenzene	1.666	0.430	0.807
1c,2t,4t-trimethylcyclohexane	0.499	0.313	0.908
I3	0.092		0.076
N	0.024	0.025	0.044
m-xylene	3.592	3.706	0.279

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
p-xylene	1.647	1.234	0.569
3,4-dimethylheptane	0.292	0.146	0.060
3,5-dimethylheptane		0.287	0.202
2,3-dimethylheptane	0.028	0.055	0.328
N		0.139	
4-ethylheptane	0.117		0.150
?	0.026		0.089
4-methyloctane	0.615	0.935	0.168
2-methyloctane	0.809	1.261	0.199
N	0.123		0.784
?			0.131
3-ethylheptane		0.065	0.443
1c,3c,5c-trimethylcyclohexane			0.376
3-methyloctane	1.026	1.281	0.413
1c,2t,4c-trimethylcyclohexane	0.290	0.252	
3,3-diethylpentane	0.032		0.357
o-xylene	1.770	1.159	0.318
1,1,2-trimethylcyclohexane	0.029	0.038	0.186
?	0.036		0.047
I6	0.027		0.134
I7	0.457	0.032	
N	0.800	0.085	1.226
N	0.462	0.529	0.474
?			0.180
?			0.041
?			0.388
I8		0.328	1.273
N			0.048
?	0.062		0.056
i-butylcyclopentane	0.121	0.016	0.074
N	0.067	0.081	0.666
N	0.032		
I9			0.097
N		0.034	0.186
?			0.307
n-nonane	3.940	9.454	2.141
1,1-methylethylcyclohexane	0.466	0.288	1.436
N	0.123	0.116	0.436
?			0.041
?			0.388
i-propylbenzene	0.233	0.063	
N	0.533	0.131	1.355
i-propylcyclohexane	0.201	0.079	0.438
?	0.055		0.180
I11	0.052	0.035	0.329
2,2-dimethyloctane	0.236	0.210	0.610
2,4-dimethyloctane	0.035	0.049	1.040
N		0.034	0.196
2,6-dimethyloctane	0.070	0.032	1.046
2,5-dimethyloctane	0.827	0.670	1.151

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
?			0.017
n-butylcyclopentane	0.244	0.118	0.479
I13	0.097	0.057	0.538
?			0.144
N			0.582
I14	0.646	0.386	1.125
?	0.062		
3,3-dimethyloctane		0.022	0.425
N	0.066		0.443
?			0.344
n-propylbenzene	0.518	0.140	0.204
3,6-dimethyloctane		0.036	
3-methyl-5-ethylheptane	0.275	0.043	0.379
?	0.054		0.603
N	0.066	0.009	
?	0.038		
1,3-methylethylbenzene	0.656	0.273	0.982
1,4-methylethylbenzene	0.234	0.122	0.223
N	0.148		
1,3,5-trimethylbenzene	0.309	0.422	0.526
2,3-dimethyloctane	0.084	0.057	0.366
I15	0.042		0.564
N	0.031		0.401
I16			0.158
?			0.306
I17	0.107	0.109	0.233
5-methylnonane	0.216	0.184	0.268
?			0.118
1,2-methylethylbenzene			1.156
2-methylnonane	0.206	0.263	
1-methyl-2-ethylbenzene	0.206		
3-ethyloctane	0.045	0.037	0.357
N			0.261
3-methylnonane	0.214	0.182	0.609
?			0.897
?			0.195
N	0.031	0.018	0.765
?			0.566
I18	0.011		0.222
I19			0.613
t-butylbenzene		0.363	0.424
1,2,4-trimethylbenzene	0.457	0.042	1.066
t-butylcyclohexane	0.075	0.035	
i-butylcyclohexane	0.058		1.210
I21	0.014		0.577
I22			0.374
I23	0.014		0.469
N			0.308
I24	0.010		0.273
?			0.270

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
1t-methyl-2-n-propylcyclohexane	0.015	0.020	0.080
?			0.222
i-butylbenzene	0.006		0.832
n-decane	0.467	0.829	1.527
I26	0.004		
?			0.882
?			0.627
N	0.006		0.802
1,2,3-trimethylbenzene	0.085	0.023	0.976
1,3-methyl-i-propylbenzene	0.031		0.611
1,4-methyl-i-propylbenzene	0.017		0.380
?			0.254
I27	0.011		0.673
I29	0.013		0.182
?			0.282
?			0.587
?			0.260
sec-butylcyclohexane	0.040	0.017	1.320
1,2-methyl-i-propylbenzene			0.402
3-ethylnonane			0.993
N	0.018	0.022	0.514
?			0.149
?			0.323
?			0.307
?			0.305
I32	0.006		
1,3-diethylbenzene	0.006		0.385
1,3-methyl-n-propylbenzene	0.019		0.611
I33			0.344
1,4-diethylbenzene			0.123
1,4-methyl-n-propylbenzene	0.002		0.158
n-butylbenzene			0.185
1,3-dimethyl-5-ethylbenzene	0.006		0.481
1,2-diethylbenzene			0.179
I34			0.394
N			0.556
1,2-methyl-n-propylbenzene	0.006		0.169
?			0.273
I35			0.262
I37			0.438
?			0.097
I38			0.276
1,4,dimethyl-2-ethylbenzene			0.722
?			0.288
1,3-dimethyl-4-ethylbenzene			0.404
I39			0.412
1,2-dimethyl-4-ethylbenzene			0.733
?			0.191
?			0.534
1,3-dimethyl-2-ethylbenzene			0.339

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
?			0.977
I42			0.362
?			0.069
?			0.185
1,4-methyl-t-butylbenzene			0.431
?			0.188
1,2-dimethyl-3-ethylbenzene			0.095
1,2-ethyl-i-propylbenzene			0.086
n-undecane			0.366
?			0.468
1,4-ethyl-i-propylbenzene			0.169
?			0.249
1,2-methyl-n-butylbenzene			0.116
?			0.203
1,2,3,5-tetramethylbenzene			0.051
?			0.230
?			0.352
?			0.150
?			0.390
?			0.109
1,2-methyl-t-butylbenzene			0.259
?			0.279
5-methylindan			0.095
A2			0.231
I43			0.126
A3			0.405
?			0.253
?			0.172
1,2-ethyl-n-propylbenzene			0.081
1,3-methyl-n-butylbenzene			0.105
?			0.135
1,3-di-i-propylbenzene			0.046
n-pentylbenzene			0.169
?			0.158
?			0.052
?			0.086
1t-M-2-(4-MP)cyclopentane			0.166
?			0.158
?			0.145
1,2-di-i-propylbenzene			0.061
?			0.068
1,2,3,4-tetrahydronaphthalene			0.159
?			0.175
?			0.139
1-t-butyl-ethylbenzene			0.269
?			0.080
naphthalene			0.177
?			0.117
I44			0.079
?			0.174

Table 14. Detailed Hydrocarbon Analysis, ANS, ALT, and SJV Whole Crude, IBP-165° F and 165-320° F Fractions, continued

165 - 320° F Fraction[a]

Component	ANS wt. % in sample	ALT wt. % in sample	SJV wt. % in sample
?			0.058
I46			0.087
I47			0.247
?			0.264
I48			0.114
1,3-di-n-propylbenzene			0.077
?			0.138
?			0.069
?			0.046
n-dodecane			0.123
?			0.088
?			0.140
?			0.054
?			0.145
1t-butyl-4-ethlybenzene			0.035
?			0.021
?			0.077
?			0.068
?			0.041
?			0.068
?			0.031
?			0.036
1,4-methyl-n-pentylbenzene			0.070
?			0.047
?			0.023
n-hexylbenzene			0.034
?			0.046
?			0.088
?			0.011
?			0.011
?			0.034
?			0.017
I49			0.039
?			0.039
?			0.004
?			0.003
?			0.013
n-tridecane			0.046
?			0.031
?			0.032
?			0.030

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method)

		450 - 500° F					
		ANS		ALT		SJV	
		vol. %	wt. %	vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	29.2	26.1	72.3	69.9	1.3	1.1
C_nH_{2n}	Monocycloparaffins	24.8	23.8	15.8	16.2	20.8	19.3
C_nH_{2n-2}	Dicycloparaffins	17.2	17.8	5.9	6.6	50.0	50.0
C_nH_{2n-4}	Tricycloparaffins	7.2	7.9	1.8	2.1	17.7	18.6
C_nH_{2n-6}	Tetracycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
Total Saturates		78.4	75.6	95.8	94.8	89.7	89.0
Monoaromatics							
C_nH_{2n-6}	Alkylbenzenes	5.2	5.3	1.2	1.3	2.6	2.6
C_nH_{2n-8}	Benzocycloparaffins	4.6	5.1	0.8	1.0	4.4	4.7
C_nH_{2n-10}	Benzodicycloparaffins	1.6	1.8	0.4	0.5	1.9	2.0
Diaromatics							
C_nH_{2n-12}	Naphthalenes	9.2	10.8	1.5	1.9	1.2	1.4
C_nH_{2n-14}		0.5	0.7	0.3	0.4	0.0	0.0
C_nH_{2n-16}		0.3	0.4	0.1	0.1	0.0	0.0
Triaromatics							
C_nH_{2n-18}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-22}		0.0	0.0	0.0	0.0	0.0	0.0
Tetraaromatics							
C_nH_{2n-24}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-28}		0.0	0.0	0.0	0.0	0.0	0.0
Total Aromatics		21.4	24.1	4.2	5.2	10.1	10.8
$C_nH_{2n-4}S$	Thiophenes	0.0	0.0	0.0	0.0	0.1	0.1
$C_nH_{2n-10}S$	Benzothiophenes	0.2	0.3	0.0	0.0	0.1	0.2
$C_nH_{2n-16}S$	Dibenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
Total Sulfur Compounds		0.2	0.3	0.0	0.0	0.2	0.3

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		500 - 550° F					
		ANS		ALT		SJV	
		vol. %	wt. %	vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	25.7	22.6	76.4	74.3	1.7	1.5
C_nH_{2n}	Monocycloparaffins	21.1	19.8	14.2	14.7	22.3	20.6
C_nH_{2n-2}	Dicycloparaffins	16.4	16.5	4.6	5.1	35.1	34.7
C_nH_{2n-4}	Tricycloparaffins	8.4	8.9	1.1	1.3	20.9	21.8
C_nH_{2n-6}	Tetracycloparaffins	0.0	0.0	0.0	0.0	1.1	1.1
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
Total Saturates		71.6	67.8	96.4	95.5	81.1	79.7
Monoaromatics							
C_nH_{2n-6}	Alkylbenzenes	5.0	5.0	0.8	0.9	3.8	3.7
C_nH_{2n-8}	Benzocycloparaffins	3.8	4.1	0.3	0.4	5.1	5.4
C_nH_{2n-10}	Benzodicycloparaffins	2.9	3.1	0.6	0.7	5.3	5.6
Diaromatics							
C_nH_{2n-12}	Naphthalenes	11.4	13.3	1.2	1.5	2.7	3.0
C_nH_{2n-14}		2.1	2.6	0.5	0.6	0.7	0.9
C_nH_{2n-16}		1.6	2.0	0.2	0.4	0.6	0.7
Triaromatics							
C_nH_{2n-18}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-22}		0.0	0.0	0.0	0.0	0.0	0.0
Tetraaromatics							
C_nH_{2n-24}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-28}		0.0	0.0	0.0	0.0	0.0	0.0
Total Aromatics		26.8	30.1	3.7	4.5	18.0	19.2
$C_nH_{2n-4}S$	Thiophenes	0.0	0.0	0.0	0.0	0.2	0.2
$C_nH_{2n-10}S$	Benzothiophenes	1.6	2.1	0.0	0.0	0.7	0.9
$C_nH_{2n-16}S$	Dibenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
Total Sulfur Compounds		1.6	2.1	0.0	0.0	0.9	1.1

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		550 - 600° F					
		ANS		ALT		SJV	
		vol. %	wt. %	vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	29.1	25.7	79.5	77.7	1.3	1.1
C_nH_{2n}	Monocycloparaffins	19.4	18.3	13.2	13.7	20.4	18.6
C_nH_{2n-2}	Dicycloparaffins	14.0	14.0	3.2	3.5	26.2	25.3
C_nH_{2n-4}	Tricycloparaffins	8.1	8.6	0.9	1.1	17.2	17.6
C_nH_{2n-6}	Tetracycloparaffins	0.7	0.8	0.2	0.2	4.5	4.7
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
Total Saturates		71.3	67.4	97.1	96.2	69.7	67.3
Monoaromatics							
C_nH_{2n-6}	Alkylbenzenes	5.0	4.9	0.5	0.6	4.0	3.9
C_nH_{2n-8}	Benzocycloparaffins	2.6	2.7	0.1	0.2	5.4	5.6
C_nH_{2n-10}	Benzodicycloparaffins	2.8	3.0	0.4	0.5	6.3	6.5
Diaromatics							
C_nH_{2n-12}	Naphthalenes	7.5	8.4	0.5	0.6	3.9	4.2
C_nH_{2n-14}		3.2	3.9	0.4	0.6	4.7	5.4
C_nH_{2n-16}		3.9	4.9	0.6	0.8	3.5	4.1
Triaromatics							
C_nH_{2n-18}		1.0	1.4	0.3	0.5	0.4	0.6
C_nH_{2n-22}		0.0	0.0	0.0	0.0	0.0	0.0
Tetraaromatics							
C_nH_{2n-24}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-28}		0.0	0.0	0.0	0.0	0.0	0.0
Total Aromatics		26.0	29.2	2.9	3.8	28.3	30.3
$C_nH_{2n-4}S$	Thiophenes	0.0	0.1	0.0	0.0	0.3	0.3
$C_nH_{2n-10}S$	Benzothiophenes	2.7	3.4	0.0	0.0	1.9	2.2
$C_nH_{2n-16}S$	Dibenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
Total Sulfur Compounds		2.7	3.4	0.0	0.0	2.2	2.5

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		600 - 650° F					
		ANS		ALT		SJV	
		vol. %	wt. %	vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	24.3	21.1	78.8	77.1	0.7	0.6
C_nH_{2n}	Monocycloparaffins	21.0	19.3	14.3	14.7	19.5	17.5
C_nH_{2n-2}	Dicycloparaffins	11.4	11.1	2.9	3.2	23.8	22.7
C_nH_{2n-4}	Tricycloparaffins	6.7	7.0	1.0	1.2	12.3	12.4
C_nH_{2n-6}	Tetracycloparaffins	1.6	1.6	0.0	0.0	4.3	4.3
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
Total Saturates		65.0	60.1	97.0	96.2	60.7	57.5
Monoaromatics							
C_nH_{2n-6}	Alkylbenzenes	4.6	4.5	0.7	0.8	4.7	4.4
C_nH_{2n-8}	Benzocycloparaffins	3.0	3.1	0.2	0.2	5.6	5.6
C_nH_{2n-10}	Benzodicycloparaffins	2.6	2.7	0.2	0.3	4.4	4.5
Diaromatics							
C_nH_{2n-12}	Naphthalenes	3.5	3.8	0.1	0.2	3.3	3.5
C_nH_{2n-14}		4.8	5.5	0.3	0.3	6.8	7.5
C_nH_{2n-16}		7.2	8.6	0.8	1.1	7.3	8.3
Triaromatics							
C_nH_{2n-18}		2.9	3.8	0.6	0.9	2.7	3.3
C_nH_{2n-22}		0.0	0.0	0.0	0.0	0.8	1.1
Tetraaromatics							
C_nH_{2n-24}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-28}		0.0	0.0	0.0	0.0	0.0	0.0
Total Aromatics		28.6	31.9	2.9	3.7	35.6	38.1
$C_nH_{2n-4}S$	Thiophenes	0.0	0.0	0.0	0.0	0.4	0.4
$C_nH_{2n-10}S$	Benzothiophenes	4.4	5.4	0.1	0.2	2.7	3.1
$C_nH_{2n-16}S$	Dibenzothiophenes	2.0	2.6	0.0	0.0	0.7	0.9
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
Total Sulfur Compounds		6.4	8.0	0.1	0.2	3.8	4.5

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		450 - 650° F					
		ANS		ALT		SJV	
		vol. %	wt. %	vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	26.8	23.6	75.9	74.0	1.0	0.9
C_nH_{2n}	Monocycloparaffins	22.0	20.6	15.5	16.1	18.7	17.0
C_nH_{2n-2}	Dicycloparaffins	15.0	15.1	4.0	4.4	30.1	29.2
C_nH_{2n-4}	Tricycloparaffins	7.4	7.8	1.5	1.7	18.4	18.8
C_nH_{2n-6}	Tetracycloparaffins	0.1	0.1	0.0	0.0	3.9	4.0
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0	0.0	0.0
Total Saturates		71.3	67.2	96.9	96.2	72.2	69.8
Monoaromatics							
C_nH_{2n-6}	Alkylbenzenes	5.2	5.2	0.8	0.9	3.6	3.4
C_nH_{2n-8}	Benzocycloparaffins	3.4	3.7	0.2	0.4	5.4	5.6
C_nH_{2n-10}	Benzodicycloparaffins	2.4	2.6	0.4	0.5	5.5	5.7
Diaromatics							
C_nH_{2n-12}	Naphthalenes	8.3	9.2	0.8	1.1	3.2	3.5
C_nH_{2n-14}		2.7	3.3	0.2	0.3	3.5	4.0
C_nH_{2n-16}		3.2	4.1	0.4	0.6	3.1	3.7
Triaromatics							
C_nH_{2n-18}		0.7	1.0	0.0	0.0	1.0	1.3
C_nH_{2n-22}		0.0	0.0	0.0	0.0	0.3	0.4
Tetraaromatics							
C_nH_{2n-24}		0.0	0.0	0.0	0.0	0.0	0.0
C_nH_{2n-28}		0.0	0.0	0.0	0.0	0.0	0.0
Total Aromatics		25.9	29.1	3.1	3.7	25.7	27.6
$C_nH_{2n-4}S$	Thiophenes	0.0	0.0	0.0	0.0	0.3	0.3
$C_nH_{2n-10}S$	Benzothiophenes	2.1	2.7	0.0	0.0	1.7	2.0
$C_nH_{2n-16}S$	Dibenzothiophenes	0.7	1.0	0.0	0.0	0.2	0.3
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0	0.0	0.0
Total Sulfur Compounds		2.8	3.7	0.0	0.0	2.2	2.6

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		650 - 750° F			
		ANS		ALT	
		vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	19.3	16.8	79.5	78.5
C_nH_{2n}	Monocycloparaffins	20.0	18.1	15.0	15.4
C_nH_{2n-2}	Dicycloparaffins	9.9	9.5	2.6	2.8
C_nH_{2n-4}	Tricycloparaffins	6.2	6.3	1.0	1.1
C_nH_{2n-6}	Tetracycloparaffins	3.0	3.0	0.0	0.0
C_nH_{2n-8}	Pentacycloparaffins	0.1	0.1	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0
Total Saturates		58.5	53.8	98.1	97.8
Monoaromatics					
C_nH_{2n-6}	Alkylbenzenes	4.5	4.2	0.8	0.9
C_nH_{2n-8}	Benzocycloparaffins	3.0	3.0	0.1	0.1
C_nH_{2n-10}	Benzodicycloparaffins	2.4	2.4	0.2	0.2
Diaromatics					
C_nH_{2n-12}	Naphthalenes	3.1	3.2	0.1	0.2
C_nH_{2n-14}		3.5	3.7	0.1	0.1
C_nH_{2n-16}		6.6	7.4	0.3	0.4
Triaromatics					
C_nH_{2n-18}		5.1	5.9	0.2	0.2
C_nH_{2n-22}		2.1	2.7	0.0	0.0
Tetraaromatics					
C_nH_{2n-24}		0.2	0.2	0.0	0.0
C_nH_{2n-28}		0.0	0.0	0.0	0.0
Total Aromatics		30.5	32.7	1.7	2.2
$C_nH_{2n-4}S$	Thiophenes	0.0	0.0	0.0	0.0
$C_nH_{2n-10}S$	Benzothiophenes	4.5	5.2	0.1	0.1
$C_nH_{2n-16}S$	Dibenzothiophenes	6.5	8.3	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0
Total Sulfur Compounds		11.0	13.5	0.1	0.1

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		750 - 850° F			
		ANS		ALT	
		vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	12.0	10.6	76.5	75.5
C_nH_{2n}	Monocycloparaffins	18.9	17.0	17.8	18.2
C_nH_{2n-2}	Dicycloparaffins	13.8	13.2	2.8	3.0
C_nH_{2n-4}	Tricycloparaffins	7.5	7.5	1.1	1.2
C_nH_{2n-6}	Tetracycloparaffins	2.5	2.5	0.0	0.0
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.8	0.8	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.3	0.3	0.0	0.0
Total Saturates		55.8	51.9	98.2	97.9
Monoaromatics					
C_nH_{2n-6}	Alkylbenzenes	7.2	6.7	0.9	0.9
C_nH_{2n-8}	Benzocycloparaffins	4.7	4.6	0.3	0.3
C_nH_{2n-10}	Benzodicycloparaffins	2.6	2.6	0.2	0.2
Diaromatics					
C_nH_{2n-12}	Naphthalenes	2.6	2.6	0.1	0.2
C_nH_{2n-14}		3.1	3.3	0.0	0.0
C_nH_{2n-16}		4.1	4.4	0.0	0.0
Triaromatics					
C_nH_{2n-18}		3.0	3.3	0.1	0.1
C_nH_{2n-22}		4.6	5.6	0.2	0.2
Tetraaromatics					
C_nH_{2n-24}		2.6	3.3	0.1	0.1
C_nH_{2n-28}		1.5	2.1	0.0	0.0
Total Aromatics		36.0	38.5	1.9	2.0
$C_nH_{2n-4}S$	Thiophenes	0.4	0.3	0.0	0.0
$C_nH_{2n-10}S$	Benzothiophenes	3.9	4.4	0.0	0.0
$C_nH_{2n-16}S$	Dibenzothiophenes	2.8	3.5	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	1.1	1.4	0.0	0.0
Total Sulfur Compounds		8.2	9.6	0.0	0.0

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		850 - 950° F			
		ANS		ALT	
		vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	4.4	3.8	69.5	68.5
C_nH_{2n}	Monocycloparaffins	21.1	19.1	23.9	24.3
C_nH_{2n-2}	Dicycloparaffins	13.3	12.6	3.2	3.3
C_nH_{2n-4}	Tricycloparaffins	7.8	7.8	1.5	1.7
C_nH_{2n-6}	Tetracycloparaffins	4.5	4.5	0.0	0.0
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0
Total Saturates		51.1	47.8	98.0	97.8
Monoaromatics					
C_nH_{2n-6}	Alkylbenzenes	6.6	6.2	1.2	1.3
C_nH_{2n-8}	Benzocycloparaffins	4.6	4.5	0.4	0.4
C_nH_{2n-10}	Benzodicycloparaffins	3.4	3.4	0.2	0.2
Diaromatics					
C_nH_{2n-12}	Naphthalenes	3.4	3.4	0.1	0.1
C_nH_{2n-14}		3.6	3.7	0.0	0.0
C_nH_{2n-16}		4.4	4.5	0.0	0.0
Triaromatics					
C_nH_{2n-18}		2.4	2.5	0.0	0.1
C_nH_{2n-22}		4.6	5.2	0.0	0.1
Tetraaromatics					
C_nH_{2n-24}		3.3	3.9	0.0	0.0
C_nH_{2n-28}		3.3	4.3	0.1	0.1
Total Aromatics		39.6	41.6	1.9	2.2
$C_nH_{2n-4}S$	Thiophenes	0.4	0.4	0.0	0.0
$C_nH_{2n-10}S$	Benzothiophenes	4.9	5.3	0.0	0.0
$C_nH_{2n-16}S$	Dibenzothiophenes	2.4	2.9	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	1.6	2.0	0.0	0.0
Total Sulfur Compounds		9.3	10.6	0.0	0.0

Table 15. Hydrocarbon Types in ANS, ALT, and SJV Fractions by High Resolution Mass Spectrometry (Teeter Method), continued

		650 - 950° F			
		ANS		ALT	
		vol. %	wt. %	vol. %	wt. %
C_nH_{2n+2}	Paraffins	14.1	12.4	72.0	71.0
C_nH_{2n}	Monocycloparaffins	21.7	19.8	21.5	21.9
C_nH_{2n-2}	Dicycloparaffins	13.0	12.6	3.2	3.4
C_nH_{2n-4}	Tricycloparaffins	6.4	6.5	1.2	1.4
C_nH_{2n-6}	Tetracycloparaffins	4.3	4.3	0.2	0.2
C_nH_{2n-8}	Pentacycloparaffins	0.0	0.0	0.0	0.0
C_nH_{2n-10}	Hexacycloparaffins	0.0	0.0	0.0	0.0
C_nH_{2n-12}	Heptacycloparaffins	0.0	0.0	0.0	0.0
Total Saturates		59.5	55.6	98.1	97.8
Monoaromatics					
C_nH_{2n-6}	Alkylbenzenes	5.1	4.8	1.0	1.0
C_nH_{2n-8}	Benzocycloparaffins	3.6	3.6	0.4	0.4
C_nH_{2n-10}	Benzodicycloparaffins	3.2	3.2	0.2	0.2
Diaromatics					
C_nH_{2n-12}	Naphthalenes	3.2	3.4	0.1	0.1
C_nH_{2n-14}		3.7	4.0	0.0	0.0
C_nH_{2n-16}		4.8	5.2	0.0	0.1
Triaromatics					
C_nH_{2n-18}		3.4	3.8	0.2	0.3
C_nH_{2n-22}		2.9	3.5	0.1	0.1
Tetraaromatics					
C_nH_{2n-24}		0.9	1.2	0.0	0.0
C_nH_{2n-28}		0.8	1.1	0.0	0.0
Total Aromatics		31.6	33.8	2.0	2.1
$C_nH_{2n-4}S$	Thiophenes	0.1	0.1	0.0	0.0
$C_nH_{2n-10}S$	Benzothiophenes	4.0	4.6	0.0	0.0
$C_nH_{2n-16}S$	Dibenzothiophenes	4.7	5.9	0.0	0.0
$C_nH_{2n-22}S$	Naphthobenzothiophenes	0.0	0.0	0.0	0.0
Total Sulfur Compounds		8.8	10.6	0.0	0.0

Table 16. Aromatic Carbon by Nuclear Magnetic Resonance Spectroscopy

	Aromatic Carbon, mol. %		
	ANS	ALT	SJV
650 - 750° F		1.85	24.3
750 – 850° F		1.66	24.6
850 - 950° F		1.45	27.4
650 - 950° F (composite)		1.72	25.4
950 - 1050° F	23.8	1.65	30.4
1050 – 1150° F	24.1	1.50	29.9
1150 - 1250° F	26.1	1.19	30.9
950 - 1250° F (composite)	24.2	1.38	30.0
>1250° F Resid	37.0		

Table 17. Elemental Analyses of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids

		ANS	ALT	SJV
Whole Crude				
CHN D 5291 (TCD)	Carbon, wt. %	85.30	[c]84.92	85.96
	Hydrogen, wt. %	12.48	[c]14.64	11.20
	Nitrogen, wt. %	0.48	<0.01	0.86
[a] Nitrogen, D 5762 (Chemiluminescence), wt. %		0.232	<0.001	0.714
Sulfur, D 4294 (XRF), wt. %		1.07	0.014	1.094
IBP - 165° F				
Sulfur, D 4294 (XRF), wt. %		0.015	0.017	
[b] 165 - 320° F				
Sulfur, D 4294 (XRF), wt. %		0.011	0.006	0.126
Sulfur, D 3120 (Microcoulometer), wt. %		0.0031	0.0032	0.11
320 - 450° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.07	85.15	86.44
	Hydrogen, wt. %	13.7	14.26	13.50
	Nitrogen, wt. %	<0.01	<0.01	<0.01
Nitrogen, D 4629 (Chemiluminescence), wt. %		0.0001	<0.0001	0.002
Sulfur, D 4294 (XRF), wt. %		0.05	0.003	0.193
Sulfur, D 3120 (Microcoulometer), wt. %		0.0358	0.0017	0.18
450 - 500° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.18	84.32	86.89
	Hydrogen, wt. %	13.28	14.75	13.12
	Nitrogen, wt. %	<0.01	<0.01	<0.01
Nitrogen, D 4629 (Chemiluminescence), wt. %		0.0002	<0.0001	0.014
Sulfur, D 4294 (XRF), wt. %		0.17	0.005	0.292
500 - 550° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.64	84.65	86.26
	Hydrogen, wt. %	13.02	14.74	12.76
	Nitrogen, wt. %	<0.01	<0.01	0.02
Nitrogen, D 4629 (Chemiluminescence), wt. %		0.002	0.0001	0.031
Sulfur, D 4294 (XRF), wt. %		0.36	0.004	0.444
550 - 600° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.20	84.52	86.62
	Hydrogen, wt. %	13.06	14.72	12.38
	Nitrogen, wt. %	<0.01	<0.01	0.02
Nitrogen, D 4629 (Chemiluminescence), wt. %		0.004	0.0003	0.082
Sulfur, D 4294 (XRF), wt. %		0.55	0.013	0.633

TCD Thermal Conductivity Detector

[a] Modified ASTM D 5762 method was used.

[b] San Joaquin Valley IBP-320° F

[c] Calculated as weighted average of IBP-450° F, 450-650° F, and >650° F resid fraction data. 320-450° F data used for IBP-450° F.

Table 17. Elemental Analyses of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids, continued

		ANS	ALT	SJV
600 - 650° F				
CHN, D 5291 (TCD)	Carbon, wt. %	85.94	84.38	86.50
	Hydrogen, wt. %	12.75	14.58	11.94
	Nitrogen, wt. %	0.05	<0.01	0.04
Nitrogen, D 4629 (Chemiluminescence), wt. %		0.013	<0.001	0.152
Sulfur, D 4294 (XRF), wt. %		0.88	0.030	0.835
450 - 650° F (composite)				
CHN, D 5291 (TCD)	Carbon, wt. %	86.24	84.66	86.23
	Hydrogen, wt. %	13.08	14.86	12.41
	Nitrogen, wt. %	0.06	<0.01	0.04
Nitrogen, D 4629 (Chemiluminescence), wt. %		0.005	<0.001	0.094
Sulfur, D 4294 (XRF), wt. %		0.50	0.013	0.613
>650° F Resid				
CHN, D 5291 (TCD)	Carbon, wt. %	86.02	84.81	87.4
	Hydrogen, wt. %	11.60	14.66	10.70
	Nitrogen, wt. %	0.56	<0.01	1.05
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.405	0.007	1.086
Sulfur, D 4294 (XRF), wt. %		1.94	0.025	1.064
650 - 750° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.25	84.28	86.50
	Hydrogen, wt. %	12.64	13.82	11.48
	Nitrogen, wt. %	0.30	<0.01	0.28
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.075	<0.001	0.356
Sulfur, D 4294 (XRF), wt. %		1.15	0.029	1.312
Sulfur, D 1552 (IR), wt. %				1.33
750 - 850° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.00	85.15	87.08
	Hydrogen, wt. %	12.40	14.66	11.52
	Nitrogen, wt. %	0.46	<0.01	0.44
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.148	0.003	0.516
Sulfur, D 4294 (XRF), wt. %		1.31	0.026	1.210
Sulfur, D 1552 (IR), wt. %				1.22

Table 17. Elemental Analyses of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids, continued

		ANS	ALT	SJV
850 - 950° F				
CHN, D 5291 (TCD)	Carbon, wt. %	85.62	84.54	87.18
	Hydrogen, wt. %	11.94	14.66	10.97
	Nitrogen, wt. %	0.61	<0.01	0.68
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.256	0.006	0.830
Sulfur, D 4294 (XRF), wt. %		1.59	0.023	1.213
Sulfur, D 1552 (IR), wt. %				1.21
850 - 950° F (Blind)				
CHN, D 5291 (TCD)	Carbon, wt. %	85.17	84.81	
	Hydrogen, wt. %	12.02	14.81	
	Nitrogen, wt. %	0.50	<0.01	
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.256	0.008	
Sulfur, D 4294 (XRF), wt. %		1.59	0.027	
650 - 950° F (composite)				
CHN, D 5291 (TCD)	Carbon, wt. %	85.58	84.94	87.10
	Hydrogen, wt. %	12.35	15.00	11.19
	Nitrogen, wt. %	0.46	<0.01	0.56
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.146	0.003	0.629
Sulfur, D 4294 (XRF), wt. %		1.32	0.025	1.234
Sulfur, D 1552 (IR), wt. %				1.19 (1.30)[d]
>950° F Resid				
CHN, D 5291 (TCD)	Carbon, wt. %		84.98	87.64
	Hydrogen, wt. %		14.36	9.91
	Nitrogen, wt. %		0.06	1.58
Nitrogen, D 5762 (Chemiluminescence), wt. %			0.020	1.660 (1.480)[d]
Sulfur, D 1552 (IR), wt. %			0.17	1.35
950 - 1050° F				
CHN, D 5291 (TCD)	Carbon, wt. %	86.09	85.52	86.64
	Hydrogen, wt. %	11.61	14.42	10.68
	Nitrogen, wt. %	0.63	<0.01	1.22
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.344	0.013	1.211
Sulfur, D 4294 (XRF), wt. %		1.83		
Sulfur, D 1552 (IR), wt. %			<0.06	1.26

[d] Values in parentheses are from repeat tests conducted at a later time.

Table 17. Elemental Analyses of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids, continued

		ANS	ALT	SJV
1050 - 1150° F				
CHN, D 5291 (TCD)	Carbon, wt. %	85.78	85.24	86.53
	Hydrogen, wt. %	11.34	14.50	10.53
	Nitrogen, wt. %	0.80	<0.01	1.22
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.550	0.008	1.306
Sulfur, D 4294 (XRF), wt. %		1.95		
Sulfur, D 1552 (IR), wt. %			<0.06	1.30
1150 - 1250° F				
CHN, D 5291 (TCD)	Carbon, wt. %	85.47	85.76	86.76
	Hydrogen, wt. %	11.10	14.61	10.46
	Nitrogen, wt. %	1.08	<0.01	1.33
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.648	0.010	1.362
Sulfur, D 4294 (XRF), wt. %		2.21		
Sulfur, D 1552 (IR), wt. %			<0.06	1.33
950 - 1250° F (composite)				
CHN, D 5291 (TCD)	Carbon, wt. %	85.70	85.55	86.64
	Hydrogen, wt. %	11.28	14.59	10.48
	Nitrogen, wt. %	0.83	<0.01	1.18
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.578	0.009	1.306
Sulfur, D 4294 (XRF), wt. %		2.04		
Sulfur, D 1552 (IR), wt. %			<0.06	1.31
>1250° F Resid				
CHN, D 5291 (TCD)	Carbon, wt. %	85.90	85.69	86.58
	Hydrogen, wt. %	9.82	14.32	10.25
	Nitrogen, wt. %	1.18	<0.01	1.71
Nitrogen, D 5762 (Chemiluminescence), wt. %		0.933	0.016	1.609
Sulfur, D 1552 (IR), wt. %		2.72	0.20	1.39

Table 18. Ramsbottom and Micro-carbon Residues of ANS and ALT Crude Oil Distillate Cuts and Resids

	Ramsbottom Carbon Residue, wt. %		Micro-Carbon Residue, wt. %	
	ANS	ALT	ANS	ALT
>650° F Resid	8.40	0.16	8.99	0.18
650 - 750° F	0.10	0.03	0.05	0.05
750 - 850° F	0.12	0.06	<0.01	0.04
850 - 950° F	0.24	0.06	0.36	0.05
(Blind)	(0.32)	(0.05)	(0.31)	
650 - 950° F (composite)	0.20	0.05	0.13	0.05
950 - 1050° F	0.90		1.28	
1050 - 1150° F	3.37		3.96	
1150 - 1250° F	8.83		10.32	
950 - 1250° F (composite)	4.98		5.37	
>1250° F Resid	32.07[a]		33.09	

[a] Determined using modified metal crucibles.

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions

	320 - 450° F			
	ANS			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	14.983	145.27	155.09	9.82
decane	29.989	173.16	183.55	10.39
decane	39.983	185.73	196.29	10.56
decane	60.041	203.37	214.94	11.57
decane	79.997	218.00	229.11	11.11
decane	99.945	229.54	240.44	10.90
decane	124.98	242.37	252.54	10.17
decane	149.42	252.91	262.61	9.70
water	187.78	266.51	275.51	9.00
water	233.86	279.85	288.48	8.63
water	289.27	293.01	301.71	8.71
water	355.39	306.73	315.00	8.27
water	433.62	319.93	328.20	8.27
water	525.96	333.38	341.72	8.34
water	633.88	347.24	355.09	7.85
water	760.04	360.28	368.85	8.58
water	905.96	374.22	382.69	8.47
water	1074.4	388.09	396.50	8.41
water	1267.6	401.69	410.60	8.91
water	1488.7	415.99	424.74	8.75
water	1740.1	429.60	439.05	9.44
water	2025.1	443.67	453.18	9.51

[a] Water or decane refers to which material was used as the standard in the reference ebulliometer.

[b] The pressure p was calculated from the condensation temperature of the reference substance (decane or water).

[c] T_{cond} is the condensation temperature of the fraction.

[d] T_{boil} is the boiling temperature of the fraction.

[e] ΔT is the difference between the boiling and condensation temperatures (T_{boil}-T_{cond}) for the fraction.

NOTE: Temperatures listed for the vapor pressure data are defined in terms of the ebulliometer system and do not correspond exactly with similar terms used in engineering practice. However, the condensation temperature should be within a few degrees of what is referred to in engineering terms as the bubble point.

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	450 - 650° F			
	SJV			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	15.083	253.46	285.60	32.14
decane	29.972	289.16	319.95	30.80
decane	40.021	305.34	335.41	30.07
decane	60.045	328.87	358.51	29.64
decane	80.029	346.91	375.76	28.85
decane	99.979	361.78	389.36	27.58
decane	124.94	376.58	403.62	27.04
decane	149.55	391.61	415.63	24.02
water	187.67	408.14	431.43	23.30
water	233.82	425.02	447.23	22.21
water	289.23	441.69	463.40	21.71
water	355.19	457.75	479.39	21.63
water	433.65	474.07	495.67	21.61
water	525.89	489.95	512.43	22.47
water	633.80	504.81	528.73	23.92

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	500 - 550° F			
	SJV			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	14.958	271.19	282.46	11.27
decane	29.993	303.78	314.46	10.68
decane	40.025	319.82	328.88	9.07
decane	60.007	341.55	350.16	8.61
decane	79.987	358.27	365.99	7.72
decane	99.956	371.86	379.20	7.34
decane	125.02	386.02	392.80	6.79
decane	149.48	398.34	404.12	5.78
water	187.66	413.41	419.10	5.68
water	233.78	428.64	434.13	5.49
water	289.20	444.07	449.21	5.15
water	355.39	459.76	464.39	4.63
water	433.53	474.98	479.53	4.55
water	525.84	490.51	494.93	4.42
water	633.98	506.22	510.49	4.27
water	759.86	521.84	526.10	4.25
water	905.99	537.29	541.90	4.62
water	1074.3	552.87	557.83	4.96
water	1267.7	568.75	573.95	5.20
water	1488.7	584.48	590.16	5.68
water	1740.0	600.49	606.56	6.07
water	2025.1	616.35	623.05	6.70

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	550 - 600° F			
	ANS			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	14.998	322.07	329.53	7.46
decane	29.991	356.43	362.45	6.02
decane	40.029	371.42	376.91	5.50
decane	60.005	393.88	398.65	4.77
decane	79.925	410.85	414.90	4.06
decane	100.00	424.09	428.18	4.09
decane	124.99	437.74	441.77	4.04
decane	149.32	449.08	453.08	4.00
water	187.74	463.99	468.16	4.17
water	233.82	479.27	483.15	3.88
water	289.27	494.50	498.32	3.82
water	355.31	509.92	513.52	3.60
water	733.64	525.29	528.90	3.60
water	525.90	540.41	544.37	3.95
water	633.92	555.84	559.88	4.03
water	459.90	571.89	575.55	3.66
water	905.92	587.61	591.32	3.71
water	1074.3	603.07	607.23	4.15
water	1267.7	618.82	623.27	4.45
water	1488.6	634.84	639.39	4.56
water	1740.2	650.96	655.55	4.59

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	550 - 600° F			
	ALT			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	15.017	329.37	338.43	9.06
decane	29.937	363.44	370.32	6.88
decane	40.009	378.34	384.89	6.55
decane	59.991	400.57	406.26	5.69
decane	79.939	416.64	422.11	5.47
decane	99.914	429.76	434.95	5.19
decane	124.93	443.20	448.44	5.24
decane	149.59	454.57	459.64	5.08
water	187.68	469.48	474.43	4.96
water	233.82	484.66	489.16	4.50
water	289.34	499.71	504.19	4.47
water	355.32	514.66	519.16	4.50
water	433.56	529.31	534.29	4.98
water	525.86	544.37	549.52	5.15
water	634.07	559.76	564.87	5.10
water	759.88	574.81	580.24	5.42

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	600 - 650° F			
	SJV			
Standard[a]	p, mmHg[b]	σ(p), mmHg[f]	T_{cond}, °F[c]	ΔT, °F[e]
decane	14.932	0.001	377.46	9.12
decane	20.022	0.002	393.09	8.39
decane	29.976	0.002	412.77	8.10
decane	39.969	0.002	427.78	8.00
decane	60.026	0.003	450.68	7.51
decane	79.920	0.004	468.11	6.88
decane	100.044	0.005	482.76	6.59
decane	125.070	0.005	497.95	6.09
decane	149.464	0.007	509.55	6.54
water	187.719	0.008	526.10	6.09
water	233.96	0.01	542.37	6.14
water	289.29	0.01	558.39	6.43
water	355.28	0.02	574.95	6.30

[f] σ(p) is the precision in pressure. See text.

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	650 - 750° F			
	ALT			
Standard[a]	p, mmHg[b]	σ(p), mmHg[f]	T_{cond}, °F[c]	ΔT, °F[e]
decane	14.958	0.001	420.008	12.541
decane	29.991	0.002	454.690	11.956
decane	40.006	0.002	471.529	10.386
decane	60.161	0.003	494.438	10.379
decane	80.192	0.004	511.795	10.346
decane	99.803	0.005	525.819	9.695
decane	124.97	0.01	540.786	9.263
decane	149.34	0.01	553.482	8.501
decane	187.55	0.01	569.080	8.599
water	233.73	0.01	585.307	8.237
water	289.21	0.01	600.701	8.851
water	355.34	0.02	616.312	9.320
water	433.65	0.02	631.812	9.950

	650 - 750° F			
	SJV			
Standard[a]	p, mmHg[b]	σ(p), mmHg[f]	T_{cond}, °F[c]	ΔT, °F[e]
decane	15.016	0.001	364.152	36.522
decane	29.947	0.002	402.208	33.374
decane	39.909	0.002	420.071	31.019
decane	59.973	0.003	443.651	29.482
decane	79.988	0.004	467.361	23.872
decane	99.908	0.008	477.037	28.118
decane	124.77	0.01	496.625	24.192
decane	149.29	0.01	508.050	25.155
water	187.66	0.01	527.540	22.954
water	233.91	0.01	535.860	30.163
water	289.21	0.01	547.313	36.724
water	355.18	0.02	560.170	41.758
water	433.55	0.02	561.587	60.257

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	750 - 850° F			
	ANS			
Standard[a]	p, mmHg[b]	σ(p), mmHg[f]	T_{cond}, °F[c]	ΔT, °F[e]
decane	14.985	0.001	512.508	12.256
decane	29.794	0.002	542.458	11.574
decane	39.793	0.002	558.477	12.469
decane	59.933	0.003	582.179	13.712
decane	79.801	0.004	600.550	14.063
decane	99.991	0.006	614.098	15.701
decane	125.04	0.01	629.920	15.190

	750 - 850° F			
	ALT			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	15.019	487.67	512.98	25.31
decane	19.939	508.06	528.84	20.78
decane	29.907	528.61	549.44	20.83
decane	39.917	546.13	565.89	19.74
decane	49.924	559.86	578.94	19.08
decane	59.927	572.19	590.01	17.82
decane	69.925	581.44	599.49	18.06
decane	79.968	590.65	608.16	17.51
decane	89.944	598.09	615.72	17.62
decane	99.940	605.33	622.72	17.39

	750 - 850° F			
	SJV			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	14.959	411.06	480.04	68.98
decane	19.967	429.83	493.08	63.24
decane	29.971	452.74	513.43	60.69
decane	39.915	468.92	527.92	59.00
decane	49.979	489.19	540.84	51.66
decane	59.992	502.21	550.91	48.70
decane	69.910	516.65	560.12	43.47
decane	79.910	533.45	569.38	35.93
decane	90.033	543.55	577.95	34.40

Table 19. Vapor Presssure Measurements on ANS, ALT, and SJV Distillate Fractions, continued

	850 - 950° F			
	ANS			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	15.007	579.44	611.80	32.35
decane	19.986	594.80	626.76	31.96
decane	24.833	609.32	638.93	29.61
decane	29.951	620.43	649.88	29.45

	850 - 950° F			
	ALT			
Standard[a]	p, mmHg[b]	σ(p), mmHg[f]	T_{cond}, °F[c]	ΔT, °F[e]
decane	14.949	0.001	572.396	18.189
decane	29.836	0.002	606.596	19.822
decane	39.844	0.002	623.547	19.265

	850 - 950° F			
	SJV			
Standard[a]	p, mmHg[b]	T_{cond}, °F[c]	T_{boil}, °F[d]	ΔT, °F[e]
decane	15.026	567.40	605.36	37.96
decane	20.014	581.33	621.91	40.58
decane	24.964	596.02	635.12	39.11
decane	29.926	608.24	644.63	36.39

Table 19A. Vapor Presssure Measurements on the SJV 600-650° F Distillate Fraction

Temperature		Pressure, mm Hg		% Dev
°C	°F	Measured	Correlation	
144.48	292.06	1.877	1.923	-2.47
154.93	310.87	3.125	3.166	-1.30
164.95	328.91	5.074	4.962	2.21
175.00	347.00	7.773	7.592	2.33
185.52	365.94	11.770	11.556	1.82
195.07	383.13	16.778	16.580	1.18
204.56	400.21	23.561	23.316	1.04
214.95	418.91	33.292	33.237	0.16
225.03	437.05	45.859	46.073	-0.47
235.54	455.97	62.74	63.680	-1.50
244.77	472.59	82.20	83.503	-1.59
255.93	492.67	111.49	114.120	-2.36
247.00	476.60	86.72	88.997	-2.63
255.84	492.51	111.68	113.840	-1.93
264.31	507.76	142.86	142.806	0.04
273.99	525.18	183.55	183.134	0.23
283.96	543.13	236.30	234.053	0.95
294.84	562.71	310.97	302.330	2.78
304.01	579.22	375.21	371.789	0.91
314.16	597.49	470.24	463.260	1.48
323.96	615.12	565.52	568.079	-0.45
330.66	627.19	645.43	650.152	-0.73

InP(mm Hg) = 16.6306 - 5186.44/ (T (K) - 93.)

Table 20. Experimental two-phase heat capacities C^{II}_x for ANS, ALT, and SJV Fractions[a,b]

	320 - 450° F		450 - 500° F	
	ANS	ALT	ANS	ALT
m/g	0.019704	0.020791	0.020861	0.021506
Volume of cell/cm^3	0.05292	0.05272	0.05288	0.05339
T/°F	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})
107.33	0.490	0.508	0.465	0.525
143.33	0.508	0.527	0.482	0.532
179.33	0.528	0.547	0.502	0.555
215.33	0.548	0.567	0.521	0.572
251.33	0.569	0.587	0.540	0.593
287.33	0.590	0.608	0.560	0.613
323.33	0.611	0.629	0.580	0.633
359.33	0.633	0.654	0.598	0.653
395.33	0.654	0.669	0.620	0.671
431.33	0.676	0.690	0.637	0.693
467.33	0.697	0.714	0.656	0.713
503.33	0.717	0.731	0.674	0.734
539.33	0.737	0.748	0.694	0.754
575.33	0.758	0.775	0.714	0.772
611.33	0.781	0.802	0.734	0.796
647.33	0.811	0.777	0.750	0.814
		T_c = (680±20)°F		
683.33	0.838	0.685	0.767	0.822
	T_c = (700±10)°F			
719.33	0.720		0.787	0.858
755.33	0.695		0.820	0.727
			T_c = (790±5)°F	
791.33	0.691		0.770	
827.33	0.693		0.685	

[a] Volume of cell measured at 298.15K (77°F).
[b] The pseudo-critical temperature, T_c, determined from measurements. See text.
Values below T_c refer to the fluid (supercritical) phase.

Table 20. Experimental two-phase heat capacities C^{II}_x for ANS, ALT, and SJV Fractions[a,b], continued

	500 - 550° F		550 - 600° F	
	ANS	ALT	ANS	ALT
m/g	0.019682	0.021777	0.01769	0.021209
Volume of cell/cm^3	0.05292	0.05272	0.05288	0.05339
T/°F	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})
107.33	0.470	0.498	0.468	0.511
143.33	0.487	0.532	0.486	0.535
179.33	0.507	0.542	0.505	0.549
215.33	0.527	0.560	0.524	0.569
251.33	0.543	0.581	0.540	0.586
287.33	0.562	0.600	0.561	0.605
323.33	0.587	0.622	0.580	0.623
359.33	0.602	0.640	0.599	0.645
395.33	0.623	0.657	0.621	0.660
431.33	0.641	0.681	0.637	0.680
467.33	0.658	0.698	0.656	0.697
503.33	0.675	0.718	0.675	0.714
539.33	0.694	0.734	0.690	0.735
575.33	0.716	0.750	0.708	0.744
611.33	0.734	0.768	0.726	0.766
647.33	0.754	0.787	0.742	0.778
683.33	0.769	0.798	0.758	0.793
719.33	0.788	0.820	0.776	0.814
755.33	0.807	0.842	0.788	0.828
791.33	0.806	0.717	0.788	0.834
		T_c = (810±20)°F		
827.33	0.906	0.725	0.926	0.778
	T_c = (830±5)°F		T_c = (860±5)°F	T_c = (860±20)°F
863.33	0.720		0.984	1.068

Table 20. Experimental two-phase heat capacities C^{II}_x for ANS, ALT, and SJV Fractions[a,b], continued

	600 - 650° F			
	ANS	ALT	SJV	
m/g	0.018119	0.021648	m/g	0.02233
Volume of cell/cm^3	0.05292	0.05339	Volume of cell/cm^3	0.0545
T/°F	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	T/°F	C^{II}_x /(btu.lb^{-1}.°F^{-1})
35.33		1.011[d,e]		
71.33		1.367[d,e]		
107.33	0.465	0.516	98.33	0.441
143.33	0.480	0.532	134.33	0.459
179.33	0.499	0.549	170.33	0.477
215.33	0.518	0.567	206.33	0.495
251.33	0.534	0.585	242.33	0.513
287.33	0.553	0.604	278.33	0.532
323.33	0.571	0.621	314.33	0.543
359.33	0.590	0.639	350.33	0.563
395.33	0.608	0.657	386.33	0.582
431.33	0.627	0.677	422.33	0.596
467.33	0.645	0.693	458.33	0.616
503.33	0.661	0.710	494.33	0.631
539.33	0.682	0.726	530.33	0.646
575.33	0.694	0.742	566.33	0.665
611.33	0.711	0.767	602.33	0.681
647.33	0.730	0.773	638.33	0.696
683.33	0.742	0.786	674.33	0.712
719.33	0.759	0.803	710.33	0.760[c]
755.33	0.768	0.817	746.33	0.756[c]
791.33	0.766[c]	0.819[c]		
827.33	0.873[c]			
863.33	1.095[c]			

[c] Sample decomposition. See text.

Table 20. Experimental two-phase heat capacities C^{II}_x for ANS, ALT, and SJV Fractions[a,b], continued

	650 - 750° F		750 - 850° F	
	ANS	ALT	ANS	ALT
m/g	0.018852	0.027083	0.026815	0.021648
Volume of cell/cm^3	0.05292	0.05272	0.05288	0.05339
T/°F	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})
35.33		0.636[d,e]		0.578[d,e]
71.33		1.441[d,e]		0.600[d,e]
107.33	0.463	1.017[d,e]	0.457	1.700[d,e]
143.33	0.478	0.533	0.472	0.649[d,e]
179.33	0.495	0.549	0.492	0.555
215.33	0.513	0.566	0.508	0.571
251.33	0.531	0.584	0.526	0.589
287.33	0.548	0.602	0.542	0.605
323.33	0.565	0.618	0.561	0.626
359.33	0.585	0.636	0.578	0.642
395.33	0.601	0.652	0.594	0.655
431.33	0.618	0.668	0.613	0.671
467.33	0.634	0.683	0.628	0.693
503.33	0.649	0.700	0.644	0.706
539.33	0.668	0.718	0.661	0.720
575.33	0.683	0.732	0.674	0.737
611.33	0.7	0.743	0.691	0.751
647.33	0.712	0.763	0.706	0.768
683.33	0.729	0.773	0.718	0.789
719.33	0.739	0.791	0.730	0.793
755.33	0.744	0.782[c]	0.735	0.803
791.33	0.749	0.705[c]	0.754[c]	0.804[c]
827.33	0.877[c]			
863.33	1.134[c]			

[d] Sample partially solid. See text.
[e] Includes "heat of fusion"/"heat of solution." See text.

Table 20. Experimental two-phase heat capacities C^{II}_x for ANS, ALT, and SJV Fractions[a,b], continued

	850 - 950° F	
	ANS	ALT
m/g	0.018852	0.027083
Volume of cell/cm^3	0.05292	0.05272
T/°F	C^{II}_x /(btu.lb^{-1}.°F^{-1})	C^{II}_x /(btu.lb^{-1}.°F^{-1})
35.33	0.444[d]	0.520[d,e]
71.33	0.469[d]	0.644[d,e]
107.33	0.521[d,e]	1.115[d,e]
143.33	0.472	1.177[d,e]
179.33	0.487	0.547
215.33	0.498	0.564
251.33	0.515	0.581
287.33	0.532	0.602
323.33	0.548	0.618
359.33	0.565	0.635
395.33	0.582	0.652
431.33	0.601	0.668
467.33	0.612	0.685
503.33	0.628	0.702
539.33	0.643	0.718
575.33	0.658	0.733
611.33	0.674	0.752
647.33	0.685	0.774
683.33	0.694	0.780
719.33	0.704	0.792
755.33	0.720	0.816
791.33	0.749	0.816[c]
827.33	0.910[c]	
863.33	0.996[c]	

Table 21. Thermal Conductivity of ANS, ALT, and SJV Fractions

	Thermal Conductivity[a] cal/sec $(cm)^2(°C/cm) \times 10^5$				
	ANS	ALT	SJV	SJV	SJV
Distillate °F	40° C	40° C	40° C	100° C	150° C
320 - 450° F	27.3	30.7	27.2	26.2	25.4
450 - 500° F	27.7	31.3	26.6	26.3	26.0
500 - 550° F	26.3	32.0	28.0	26.3	25.0
550 - 600° F	25.9	32.3	28.7	27.4	26.3
600 - 650° F	25.3	34.4	28.2	27.2	26.3
650 - 750° F	28.2		28.7	27.2	25.9
750 - 850° F	28.5		29.6	27.8	26.3
850 - 950° F	31.2[b]		30.9	29.1	27.5

[a] Data produced by Phoenix Chemical Laboratory, Inc.
[b] Measured at 100° C

Table 22. Viscosity of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids[a]

	ANS	ALT	SJV
Whole Crude			
60° F	31.54		
104° F	12.33		1424
158° F		9.962	144.1
212° F		3.228	34.59
257° F		2.414	14.32
320 - 450° F			
32° F	2.134	1.890	3.988
77° F			2.318
104° F	1.15	1.102	1.779
158° F		0.7865	1.170
212° F	(0.632)[b]		
450 - 500° F			
77° F			3.635
104° F	2.04	1.925	2.618
158° F		1.256	1.583
212° F	0.936	1.084	1.092
302° F	(0.586)		
500 - 550° F			
77° F			6.072
104° F	2.94	2.720	4.020
158° F		1.630	2.166
212° F	1.17	1.158	1.447
302° F	(0.707)		
550 - 600° F			
77° F			16.28
104° F	4.66	3.764	9.085
158° F		2.208	3.694
212° F	1.53	1.454	2.072
302° F	(1.019)		

[a] Viscosities by ASTM D445 in centistokes at the temperature listed.
[b] Values in parentheses are from tests (or repeat tests) run at a later time.

Table 22. Viscosity of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids[a], continued

	ANS	ALT	SJV
600 - 650° F			
77° F			37.98
104° F	6.85	5.178	17.71
158° F		2.827	6.009
212° F	2.00	1.821	2.940
302° F	(1.028)		
450 - 650° F (composite)			
77° F			11.36 (11.63)
104° F	3.54	3.029	6.747 (6.740)
158° F		1.813	3.131 (3.087)
212° F	1.33	1.253	1.838
302° F	(0.784)		(1.903)
>650° F (Resid)			
104° F	956.9		
158° F		187.7 [c](20.7cP)	1143
212° F	36.58	8.252 [c](7.3cP)	148.0
257° F		5.328 [c](4.3cP)	48.74
302° F			20.64
650 - 750° F			
104° F	14.81	7.296	32.53
158° F		3.822	8.985
212° F	3.14	2.323	4.020
257° F			2.523
302° F	(1.488)		
750 - 850° F			
104° F	62.56		
158° F		6.400	28.12
212° F	6.88	3.399	8.892
257° F		2.612	4.776
302° F	(2.665)		
347° F			2.418

[c] Viscosity by modified ASTM D 4741 (Haake) in centipoise.

Table 22. Viscosity of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids[a], continued

	ANS	ALT	SJV
850 - 950° F			
158° F		10.09	306.01
180° F	33.34		
212° F	17.07	5.442	49.34
257° F		3.720	18.85
302° F	(4.489)		
347° F			4.937
850 - 950° F (blind)			
158° F		10.46	
180° F	33.38		
212° F	17.03	5.456	
257° F		3.706	
650 - 950° F (composite)			
104° F	45.29		
158° F		6.362 (6.198)	49.88
212° F	5.76	3.644 (3.733)	13.65
257° F		2.602 (2.598)	6.792
302° F	(2.368)		
347° F			2.819
950 - 1050° F			
158° F		15.78	1784
212° F	32.47	7.931 [c](10.1cP)	211.4
257° F		5.022 [c](6.6cP)	51.03
302° F	7.56	3.534 [c](4.6cP)	23.09
347° F	[c](4.5cP)	[c](3.2cP)	

Table 22. Viscosity of ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids[a], continued

	ANS	ALT	SJV
1050 - 1150° F			
158° F			5591
212° F	66.89	11.57	466.4
257° F		7.406	98.04
302° F	12.66	5.086	39.40
347° F	[c](6.6cP)	3.704	
1150 - 1250° F			
158° F			38780
212° F	232.6	19.07	1581
257° F		11.36	263.4
302° F	30.10	7.552	92.72
347° F	[c](13.9cP)	5.428	
950 - 1250° F (composite)			
158° F			8929
212° F	81.43	16.76	598.5
257° F		8.010	114.2
302° F	14.77	5.427	45.90
347° F	[c](7.6cP)	3.941	

Table 23. Gravity Data for ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids

	Specific Gravity*			Gravity, °API		
	ANS	ALT	SJV	ANS	ALT	SJV
Whole Crude	0.8911	0.8179	0.9772			
D4052 @ 60/60° F	0.8932		0.9800	26.9		12.9
D4052 @ 80/80° F			0.9746			
D4052 @ 100/100° F			0.9702			
D1298 @ 60/60° F		0.8166			41.8	
IBP - 165° F	0.6518	0.6578				
165 - 320° F[a]	0.7555	0.7328	0.8081			
D4052 @ 60/60° F	0.7582	0.7369	0.8074	55.1	60.5	43.8
D4052 @ 80/80° F			0.8026			
D4052 @ 100/100° F			0.7970			
320 - 450° F	0.8100	0.7661	0.8529			
D4052 @ 60/60° F	0.8095 (0.8098)[b]	0.7649	0.8532	43.3 (43.2)	53.5	34.3
D4052 @ 80/80° F			0.8471			
D4052 @ 100/100° F			0.8423			
450 - 500° F	0.8468	0.7861	0.8735			
D4052 @ 60/60° F	0.8456	0.7853	0.8745	35.8	48.7	30.3
D4052 @ 80/80° F			0.8687			
D4052 @ 100/100° F			0.8642			
500 - 550° F	0.8633	0.7954	0.8849			
D4052 @ 60/60° F	0.8633	0.7945	0.8914 (0.8913)	32.4	46.6	27.2 (27.3)
D4052 @ 80/80° F			0.8857			
D4052 @ 100/100° F			0.8814			
550 - 600° F	0.8697	0.8008	0.9106			
D4052 @ 60/60° F	0.8696 (0.8698)	0.8003 (0.8003)	0.9124	31.2 (31.2)	45.3 (45.3)	23.6
D4052 @ 80/80°			0.9071			
D4052 @ 100/100° F	0.8867	0.8081	0.9029			

* Specific gravity data for the whole crude and distillate cuts with no method specified were determined by Pittsburgh Applied Research Center in preparation of distillate cuts up to 950° F.

a IBP-320° F for SJV.

b Values in parentheses are from tests (or repeat tests) conducted at a later time.

Table 23. Gravity Data for ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids, continued

	Specific Gravity			Gravity, °API		
	ANS	ALT	SJV	ANS	ALT	SJV
600 - 650° F	0.8871	0.8081	0.9340			
D4052 @ 60/60° F	0.8867		0.9317	28.1		20.4
			(0.9318)			
D4052 @ 80/80°			0.9265			
D4052 @ 100/100° F			0.9225			
D1298 @ 60/60° F		0.8044			44.4	
450 - 650° F Composite						
D4052 @ 60/60° F	0.8667	0.7964	0.9079	31.8	46.2	24.4
D4052 @ 80/80° F			0.9025			
D4052 @ 100/100° F			0.8983			
>650° F Resid						
D4052 @ 60/60° F	0.9665			14.9		
D1298 @ 60/60° F		0.8366			37.6	
D70 @ 60/60° F		(0.8618)	1.0086			8.8
D70 @ 100/100° F			0.9806			
D70 @ 160/160° F			0.9345			
650 - 750° F	0.9053	0.8212	0.9490			
D4052 @ 60/60° F	0.9021	(0.8203)	0.9483	25.4	(41.0)	17.7
			(0.9484)			(17.7)
D4052 @ 100/100° F			0.9392			
D4052 @ 160/160° F			0.9316			
D4052 @ 180/180° F	0.8835					
D1298 @ 60/60° F		0.8208			41.0	
750 - 850° F	0.9285	0.8333	0.9600			
D4052 @ 60/60° F	0.9296		0.9604	20.7		15.8
	(0.9303)		(0.9627)	(20.6)		
			(0.9625)			
D4052 @ 100/100° F			0.9533			
D4052 @ 160/160° F			0.9467			
D4052 @ 180/180° F	0.9084					
D1298 @ 60/60° F		0.8338			38.2	
		(0.8275)			(39.6)	
		(0.8264)				

Table 23. Gravity Data for ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids, continued

	Specific Gravity			Gravity, °API		
	ANS	ALT	SJV	ANS	ALT	SJV
850 - 950° F	0.9548	0.8403	0.9888			
D4052 @ 60/60° F	0.9437	(0.8413)	0.9872	18.4	(36.7)	11.8
	0.9433[c]		(0.9898)			(11.5)
	(0.9459)		(0.9897)	(18.1)		
D4052 @ 100/100° F			0.9811			
D4052 @ 160/160° F			0.9754			
D4052 @ 180/180° F	0.9334					
	0.9337[c]					
D1298 @ 60/60° F		0.8409			36.8	
		0.8405[c]			36.9[c]	
650 - 950° F Composite						
D4052 @ 60/60° F	0.9242		0.9698	21.6		14.4
D4052 @ 100/100° F			0.9620			
D4052 @ 160/160° F			0.9562			
D4052 @ 180/180° F	0.9046					
D1298 @ 60/60° F		0.8312			38.7	
>950° F Resid	1.0142	0.8644	1.058	8.0		
D70 @ 60/60° F		0.8772	1.0414		29.8	4.4
D70 @ 100/100° F			1.0229			
D70 @ 160/160° F		0.7734	0.9913			
950 - 1050° F						
D4052 @ 80/80° F	0.9603					
D4052 @ 180/180° F	0.9479					
D70 @ 60/60° F		0.8577	1.0034		33.5	9.5
D1298 @ 60/60° F			1.0053			9.3
D1298 @ 100/100° F			0.9900			
D1298 @ 160/160° F		0.8160	0.9680			
1050 - 1150° F						
D4052 @ 80/80° F	0.9656					
D4052 @ 180/180° F	0.9544					
D70 @ 60/60° F		0.8741	1.0051		30.4	
D1298 @ 60/60° F			1.0150			7.9
D1298 @ 100/100° F			1.0000			
D1298 @ 160/160° F		0.8340	0.9770			

[c] Values from blind sample.

Table 23. Gravity Data for ANS, ALT, and SJV Crude Oils, Distillate Cuts, and Resids, continued

	Specific Gravity			Gravity, °API		
	ANS	ALT	SJV	ANS	ALT	SJV
1150 - 1250° F						
D4052 @ 80/80° F	0.9812					
D4052 @ 180/180° F	0.9720					
D70 @ 60/60° F		0.8848	1.0183		28.5	
D1298 @ 60/60° F			1.0274			6.2
D1298 @ 100/100° F			1.0120			
D1298 @ 160/160° F		0.8430	0.9900			
950 - 1250° F Composite						
D4052 @ 80/80° F	0.9707					
D4052 @ 180/180° F	0.9600					
D70 @ 60/60° F		0.8804	1.0143		29.3	
D1298 @ 60/60° F			1.0201			7.2
D1298 @ 100/100° F			1.0050			
D1298 @ 160/160° F		0.8410	0.9820			
>1250° F Resid						
D70 @ 60/60° F		0.9172	1.0436		22.8	4.1
D70 @ 180/180° F	1.0029					
D1298 @ 60/60° F			1.0341			
D1298 @ 100/100° F			1.0190			
D1298 @ 160/160° F			0.9970			

Table 24. Molecular Weight of ANS, ALT, and SJV Distillate Fractions and Resids, g/mol

	ANS	ALT	SJV
320 - 450° F[a]	152	148	171
	(148)[b]		(171)
450 - 500° F	245	225	207
	(235)	(231)	
500 - 550° F	248	231	228
			(246)
550 - 600° F	263	264	244
600 - 650° F	271	289	272
450 - 650° F	251	243	245
(composite)			
>650° F Resid	477	509	468
650 - 750° F	434	338	283
750 - 850° F	442	401	335
850 - 950° F	518	457	432
(Blind)	(519)	(454)	
650 - 950° F	438	384	364
(composite)			
950 - 1050° F	573	551	540
1050 - 1150° F	683	750	640
			(666)
1150 - 1250° F	850	1018	718
950 - 1250° F	672	767	626
(composite)	(631)		
>1250° F Resid	1509	2037	1616

[a] Data for 320-450° F distillates by Freezing Point Depression, all others by ASTM D 2503 (VPO)

[b] Values in parentheses are from repeat tests conducted at a later time.

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