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**PHYSICAL AND CHEMICAL CHARACTERIZATION
OF MILITARY SMOKES**

12

Part II - Fog Oils and Oil Fogs
Final Report

By

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EXECUTIVE SUMMARY

The present inventory of military obscuration smokes includes the oil fogs generated by the thermal evaporation and condensation of SGF-2 hydrocarbon oils. The field operation employs a gasoline powered M3-A3 fog generator which uses about 1 gallon of oil per minute to generate a dense aerosol cloud. The present study has been concerned with the characterization of the fog oil and the product fogs to determine the particle size and physical stability of the product fog and also to identify both oil and oil fog composition of possible biological significance.

Fog oils from three different sources and three fog generators were used in the tests. Oil fogs were generated with all nine oil-generator combinations and samples were collected for particle size determination, aerosol aging and chemical composition.

The physical appearances of the three oils varied considerably from clear light amber to dark black-brown. All three oils contained very small traces of copper and zinc at the parts per billion level, 40 ppb of zinc and 20-100 ppb of copper. The oil densities were in the $0.89-0.93 \text{ g}\cdot\text{ml}^{-1}$ range.

The oil fogs were generated using the recommended military procedure. A fraction of the aerosol in the exhaust was collected for chemical analysis. A second fraction was led into a 14 cu.m. (512 cf) cubical holding tank for aging studies. The remainder of the aerosol was incinerated.

Varying the generators appeared to have little effect on either the physical or chemical properties of the aerosols; additionally the physical properties of the aerosols were not greatly altered from one oil to the next. An average initial mass diameter for all oil fogs was $1.16 \mu\text{m}$ with a standard deviation of $0.14 \mu\text{m}$. The size distributions were all close to log normal and the particle content above the $10 \mu\text{m}$ size was negligible. A number count assessment indicated a bimodal distribution caused by a high level of very small

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This report describes a study of U.S. Army SGF-2 Fog Oils and the corresponding Oil Fogs using the Army M3-A3 Fog Generator to produce the fogs. The investigation included studies of the generation process, physical and chemical analysis of the oils and their fogs, and observations of the fog stability and persistence. It was noted that fog oil compositions varied from source to source and that this was reflected in the fog compositions. The generators did not appear to contribute significantly to fog variations.		

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The fog oils and the fogs contained almost equal amounts of aliphatic and aromatic hydrocarbons with acids, alcohols and esters at the 1st percent level or less and nitrogen derivatives in the parts per million range. Both the oils and their fogs proved to be too complex for complete chemical resolution by gas chromatography and mass spectrometry. Of the several hundred identifiable chemical species, aliphatic hydrocarbons were in the C₁₁ - C₂₂ range. The observed aromatics included one- through four-membered ring structures.

microscopic

The fogs were examined to determine size and stability. Size determinations indicated a mass median diameter of 1.16 μ m with a standard deviation of 0.14 μ m. On the basis of single particle counting, a bimodal distribution was observed with high levels of submicron particles. The aerosols were relatively stable; after aging for one hour, typical systems showed median particle size increases of the order of 12 percent with a decrease in the mass of suspended particles of about 30 percent.

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particles in the low submicron region. Aerosol aging consistently involved particle growth caused by collision, accompanied by a decrease in particle concentration, although median particle growths rarely exceeded 10% over a one-hour interval.

Chemical analysis of the oil fogs was based on liquid and gas chromatography fractionation and gas chromatography and mass spectrometry identification. The gas chromatography traces consistently indicated the presence of very large numbers of unresolved components with a relatively small number of identifiable structures. Initially the oils and oil fogs were separated into class fractions of aliphatics, aromatics, alcohols, acids and esters. The aliphatic and aromatic fractions predominated in both the oils and the fogs, at 95-99% of the total, with aromatics and aliphatics in near equal amounts. In general, the aliphatic, aromatic and ester fractions of the oil fogs appear to parallel the parent oil compositions, suggesting only moderate alteration in the fog-forming processes, with however, a tendency toward a slightly increased aromatic content in the oil fogs.

The aliphatic fractions contain identifiable straight and branched chain saturated hydrocarbons in the C_{14} - C_{22} range. The aromatic fractions were in a similar molecular weight range but many more species were identified including substituted benzenes, naphthalenes, anthracenes, phenanthrenes, fluorenes, phenalenes, ionols and others. No cyclic structures beyond tetracyclic groups were observed among the identifiable compounds.

A considerable number of nitrogen base materials was identified in the oils and oil fogs, including quinoline, benzoquinoline and indole derivatives. It should be noted that these nitrogen compounds are present at parts per million levels.

It must again be stated that the several hundred species identified with reasonable assurance are only a small fraction of the total number which were resolved but not identified or which could not be detected against the massive background of unresolved material.

The high aromatics contents of both oils and oil fogs, approximately 50% of the total, may represent a potential hazard.

FOREWORD

This report on the physical and chemical characterization of oil fogs and their precursor oils is the second in a series of investigations of military smokes. This investigation was started on October 1, 1978 and the experimental work was completed on February 29, 1980.

Other studies in the series include the Physical and Chemical Characterization of Hexachloroethane Smokes, completed on May 31, 1979 and the Physical and Chemical Characterization of White Phosphorus Smoke, presently in progress. These studies are phases of a program titled "Physical and Chemical Characterization of Military Smokes," U.S. Army Contract No. DAMD-17-78-C-8085 .

Citation of trade names in this report does not constitute an official Department of the Army endorsement or approval of the use of such items.

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SYMBOLS AND ABBREVIATIONS

Å	Angstrom unit; (10^{-10} meter)
AREA	area under a MS chart peak
ASAS	Active Scattering Aerosol Spectrometer
b	constant term in the linear regression equation, $y = mt + b$
BTU	British Thermal Unit
Bz	benzene
c	intercept in aerosol growth correlation equation
C_i	aerosol mass concentration in Stage i (P/Z counter)
C, °C	Celsius, degrees Celsius
cf	cubic feet
cm	centimeter
cc	cubic centimeter
d_i	midrange diameter (ASAS particle counter)
\bar{d}_m	mass median diameter
DMSO	dimethyl sulfoxide
d_p	particle diameter
$D_p 50$	50% cutoff size (diameter) for a P/Z counter
et ac	ethyl acetate
F, °F	Fahrenheit, degrees Fahrenheit
F/D	flame ionization detection (GC)
Δf_i	frequency shift for stage i (P/Z counter)
ft	foot
g	gram
GC	gas chromatography
GC/MS	gas chromatograph-mass spectrometer
HPLC	high pressure liquid chromatograph
hr	hour
I.D.	internal diameter compound identification (MS)

SYMBOLS AND ABBREVIATIONS (cont.)

in	inches
K, K*	particle agglomeration coefficient
k_i	P/Z counter stage constant
ln	natural logarithm
m	meter
	slope in linear regression equation $Y = mt + b$
M_i	between-stage midpoint particle diameter (P/Z counter)
min	minutes
ml	milliliter
MS	mass spectrometer
n	aerosol number concentration per ml
N	normal (concentration)
n_i	number of particles in the i th level
nm	nanometer (10^{-9} m)
n_0	aerosol number concentration at t_0 .
N/P	nitrogen-phosphorus selective detection (GC)
PK #	arbitrary peak number (MS)
ppb	parts per billion
P/Z	Piezo-electric Particle Cascade Impactor Counter
R	correlation coefficient
sec	second
SPEC	spectrum number (MS)
t	time in aerosol time history correlation
t_0	time zero of an experiment
Δt	sampling time (P/Z counter)
TIC	total ion current (MS)
TICRAT	percentage peak after correction for background (MS)
TSP	total suspended particles
UV	ultraviolet
V	volume rate of air flow
X_i	mass fraction per stage (PZ counter)
μm	micrometer (10^{-6} m)
σ_i	sensitivity factor for stage i (P/Z counter)

1. INTRODUCTION

This investigation is a study of a number of military obscuration smokes currently in the inventory of the U.S. Army. The investigation consisted of the examination of the generating materials, the generating process and the physical and chemical properties of the product smokes. Since physiological consequences of smoke exposure are believed to be primarily a result of inhalation, interest in the product smoke has been limited to particle sizes below 10 μm .

Part 1 of this series, dated January 1, 1980, was a report on smokes produced by the Army HC smoke generator in a process involving the thermal interaction of hexachloroethane, zinc oxide and aluminum.

The present report, Part 2 of the series, describes an investigation of oil fogs.

Oil fogs are formed by the thermal evaporation of hydrocarbon oils and the subsequent condensation of the vapor to form a fog. Physical characterization of the fog involved its generation followed by successive sampling to determine the size distribution and the number concentration of the smoke particles as well as the effects of aging, concentration and variations in the generation process. Chemical studies were used in attempts to identify representative members of the vast number of constituents of both the oil and the fog and where possible, to identify possible hazardous materials. As noted above, sampling was limited to particle sizes below 10 μm .

The standard oil fog generator yields a very large volume of oil fog. Initial experiments were conducted in a remote rural area. Several problems arose including the severe environmental consequences of the generation even far from the urban environment. In addition, the heated vapor and smoke rose rapidly in a manner that made sampling very difficult and almost certainly

of dubious reproducibility. It was therefore decided to conduct all subsequent experiments in a controllable laboratory environment.

2. CONCLUSIONS

2.1 Fog Oil Compositions

The fog oils were all almost pure hydrocarbons, predominantly mixtures of aliphatic and aromatic components in almost equal amounts with small amounts of alcohols, organic acids and esters and very small traces of organic nitrogen derivatives. Aliphatic hydrocarbons were in the C₁₂-C₂₂ range and aromatics consisted of one- through four-member rings, also in the C₁₂-C₂₂ range. All oils contained traces of copper and zinc, the former near 40 ppb and the latter varying between 20 and 100 ppb.

The oils were physically distinct ranging from light yellow to almost black with densities between 0.89 and 0.93 g ml.

2.2 Reaction Products

The generated aerosols were very similar in composition to their parent oils and indicated very little dependence on the different generators.

The aerosols from all sources and generators were closely similar on a weight distribution basis with a log normal distribution and a mass mean size of 1.16 μm and a standard deviation of 0.14 μm . Over a period of about one hour, the median sizes increased very slightly, ranging from virtually no increase to as much as 50%, and averaging about 12%.

On a number basis, the size distributions were bimodal with very large numbers of particles in the submicron range below 0.08 μm , the lower limit of the counter. These large numbers represented a very small fraction of the total aerosol weight.

3. OIL FOG GENERATION

3.1 Fog Oils

The fog oils used in this study are designated as "petroleum oil for use in mechanical smoke generators" of the class Type SGF-2. They are described in Military Specification MIL-F-12070A*. The chemical and physical standards are given in Table 1.

Three lots of fog oil were used in the investigation. Each lot was delivered in two steel drums. They were identified initially as SGF-No. 2 Lots No. 1, 2 and 3. Initially each drum in a lot was characterized by the designation 1-1, 1-2, etc., but this differentiation was discontinued when the oils from each source were found to be indistinguishable in all tests. The oils are identified by producer and identification code in Table 2.

3.2 Oil Fog Generators and Fog Generation

Three U.S. Army M3A3 fog generators were supplied to IIT Research Institute. They are listed and described by serial number in Table 3. Each generator was equipped with a tool kit and spare parts, principally replacement butterfly valves. Figure 1 shows the fog generator and Figure 2 shows the generator controls and the three exhaust nozzles from which the smoke emerges.

The M3A3 smoke generator consists of a small gasoline powered ram jet engine. The fog oil is metered into the exhaust manifold of this engine at a predetermined rate partially controlled by a manually operated valve. The heat of the exhaust vaporizes the oil and ejects it through the three nozzles shown in Figure 2 into the atmosphere where rapid condensation of the oil to dense fog occurs. The U.S. Army demonstrated the operation of the smoke generator to IITRI personnel and provided copies of the "Operator and Organizational Maintenance Manual Generator, Smoke, Mechanical, Pulse Jet, M3A3,"

*Appendix 1. Fog Oil Military Specifications

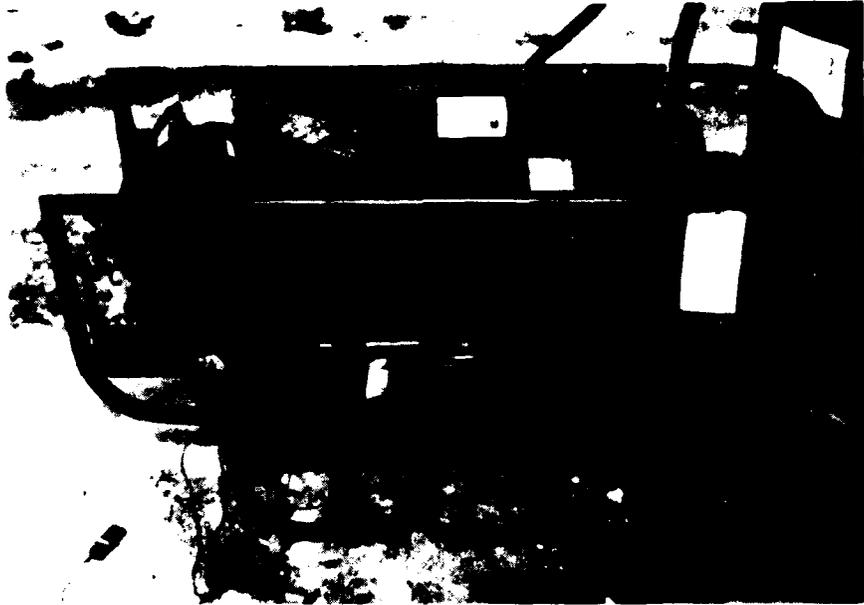


Figure 1. Army M3A3 Oil Fog Generator



Figure 2. Oil Fog Generator
Generator Controls (above)
Fog Exhaust Ports (below)

TABLE 1. PHYSICAL AND CHEMICAL REQUIREMENTS FOR
TYPE SGF-2 FOG OIL

Property	Maximum	Minimum
Flash point, °F (°C)	-	320 (160)
Viscosity, Saybolt Universal, at 100°F (38°C), sec.	110	100
Carbon residue, Conradson, %	0.1	-
Neutralization number	0.1	-
Pour point, °F (°C)	-40 (-40)	-

TABLE 2. SGF-2 FOG OIL SOURCE IDENTIFICATION

IITRI Lot No.	1	2	3
Source	Delta Petroleum Co.	Witco Chemical Co.	Phipps Product Corp.
Source Lot No.	-	DLA 600-78-C1088	DLA 800-78-C-1087
Batch	3580	8050	78208
Date	May 1978	May 1978	May 1978

TABLE 3. M3A3 OIL FOG GENERATORS

Generator	IITRI Identification		Government Identity Number	
	Serial No.	Tag	Serial No.	
A	US 1500 4	M3A3-1722	EUR 800 535	
B	US 1500 5	M3A3-1305	EUR 800 364	
C	US 1500 6	M3A3-1278	EUR 800 472	

Department of the Army Technical Manual, TM-3-1040-202-12. Except where otherwise noted in this report, the M3A3 generators were operated in the designated "normal mode", using about 40 gallons of fog oil and 3 gallons of gasoline per hour.

3.3 Experiment Designation

The experimental program required a comparison of the oil fogs formed by each oil in conjunction with each generator. Thus a minimum of 9 oil-fog generator combinations were required. Each run was designated by a sequential run number and was further identified by the oil batch number and the generator letter. For example, the run designated No. 1 (B-2) was the first run of the series, and involved Fog Oil No. 2 and Generator B.

Oil Fog Generation Field Test

Preliminary field tests were conducted at IIT Research Institute's Kingsbury "field" facility to evaluate equipment performance, to study the smoke cloud and, hopefully, to obtain some preliminary data.

The field tests were made using Fog Oil Lot No. 1 and Generator B. The first test was on December 18, 1979, a winter day with overcast sky and 2°C temperature. The cloud was very large but it lifted rapidly and attempts to sample at a station about 200 yards downwind failed.

The following day the test was repeated and the cloud was sampled with a Royco optical particle counter and an Anderson impactor. A small amount of 5 µm fog material was detected but nothing larger. It was evident that the particle content of the fog in the 10 µm and larger range was negligible.

The oil fog cloud formed during the December 18 field test, is shown in Figure 3.

Oil Fog Dispersed

It was not considered feasible to conduct the experimental program in open terrain because of the instability of the field environment, both for smoke generation and sampling. The large quantities of fog produced in the field emphasized the magnitude of the fog disposal problem that would be encountered in the laboratory.



Figure 3. Oil Fog Generation

Under normal operating conditions the M3A3 generator converts about 2/3 gallon of oil fog per minute into a highly visible dense white cloud. In order to sample a typical fog for analytical purposes, it was deemed desirable to allow the smoke generators to attain thermal equilibrium. Preliminary tests in which a thermocouple was inserted a distance of about 8 in. into one of the fog generating nozzles indicated steady temperature conditions after approximately 10 minutes of operation. Assuming that an analytical sampling period of 10 to 15 minutes was necessary, a minimum of about 13 gallons of oil would be converted to fog and would have to be disposed of in an acceptable manner.

The oil fog disposal problem was the subject of a detailed study. The preliminary particle size measurements made on the oil fog generated at the Kingsbury Ordnance facility indicated a mean particle size considerably less than 5 μ m and theoretical considerations led to similar conclusions.

The possibility that a filter/impaction collection technique might be suitable was considered even though the sheer volume of material involved might present a problem. Discussions with several industrial suppliers of particle air filtration systems indicated that this approach might be viable. Arrangements were made to obtain on loan, pending proof of satisfactory operation, of a large capacity industrial Balston Filter Unit. A few short duration trial runs with this unit connected to the smoke generator showed less than satisfactory operation and after a total running time of less than 5 minutes the filter units were plugged, restricting air flow through the unit almost completely.

In light of the above experience the filtering concept was abandoned and a decision was made to burn off the excess oil fog in a large incinerator rated at 7×10^6 BTU/hr situated in an open area 30 meters from the aerosol chamber laboratory. The room air conditioning ducting system was modified to carry the oil fog from the generator to the incinerator. Some preliminary tests involving about 5 minutes of generator operation indicated that the incinerator was able to burn off completely the smoke generator's output.

Unfortunately, on the first full scale test an explosion occurred causing moderate damage to the ducting system and blowers. The cause of the explosion

was not ascertained with certainty but considerable fog was observed swirling around the heated parts of the smoke generator and it seemed possible that the exhaust blower capacity may have been inadequate for its removal, and that the ignition might have started in this way. It was established that ignition had not occurred at the incinerator with the flame front travelling back down the ducting to the generator area.

Although the incineration approach itself was feasible, modification of the building's air conditioning system to increase its blower capacity to ensure that no oil fog would contact the hot parts of the smoke generator would have been a substantial undertaking. Based on cost and safety considerations it was deemed preferable to move the smoke generator with its own blower and ducting system as close to the incinerator as possible. A blower of 450 cu ft min⁻¹ was found adequate to handle the generator's smoke output. This approach was implemented successfully. A schematic drawing of the arrangement is shown in Figure 4.

Fog Collection for Analytical Procedures

a. General

With the arrangement for disposal of the oil fog aerosol from the M3A3 generator resolved, it was possible to run the generators for an indefinite period of time. To collect oil fog samples for the chemical and physical characterization of the aerosol, the generators were run under standard operating conditions until steady temperature conditions were attained in the exhaust manifold of the generators as indicated by a thermocouple inserted into one of the three fog exhaust nozzles. A total of twelve runs were made. In all experiments but one, Experiment 11, thermal equilibrium was attained in less than 10 minutes with a mean operating temperature of 375°C. All temperatures are included in the tabulation of all runs in Table 4.

In Experiment No. 11, a generator was deliberately run under conditions designed to increase the normal operating temperature. This was done with the object of magnifying any effects that the generator operating temperature might have on oil degradation or aerosol size characteristics. The increase in operating temperature was achieved by reducing the rate of fog oil feed to

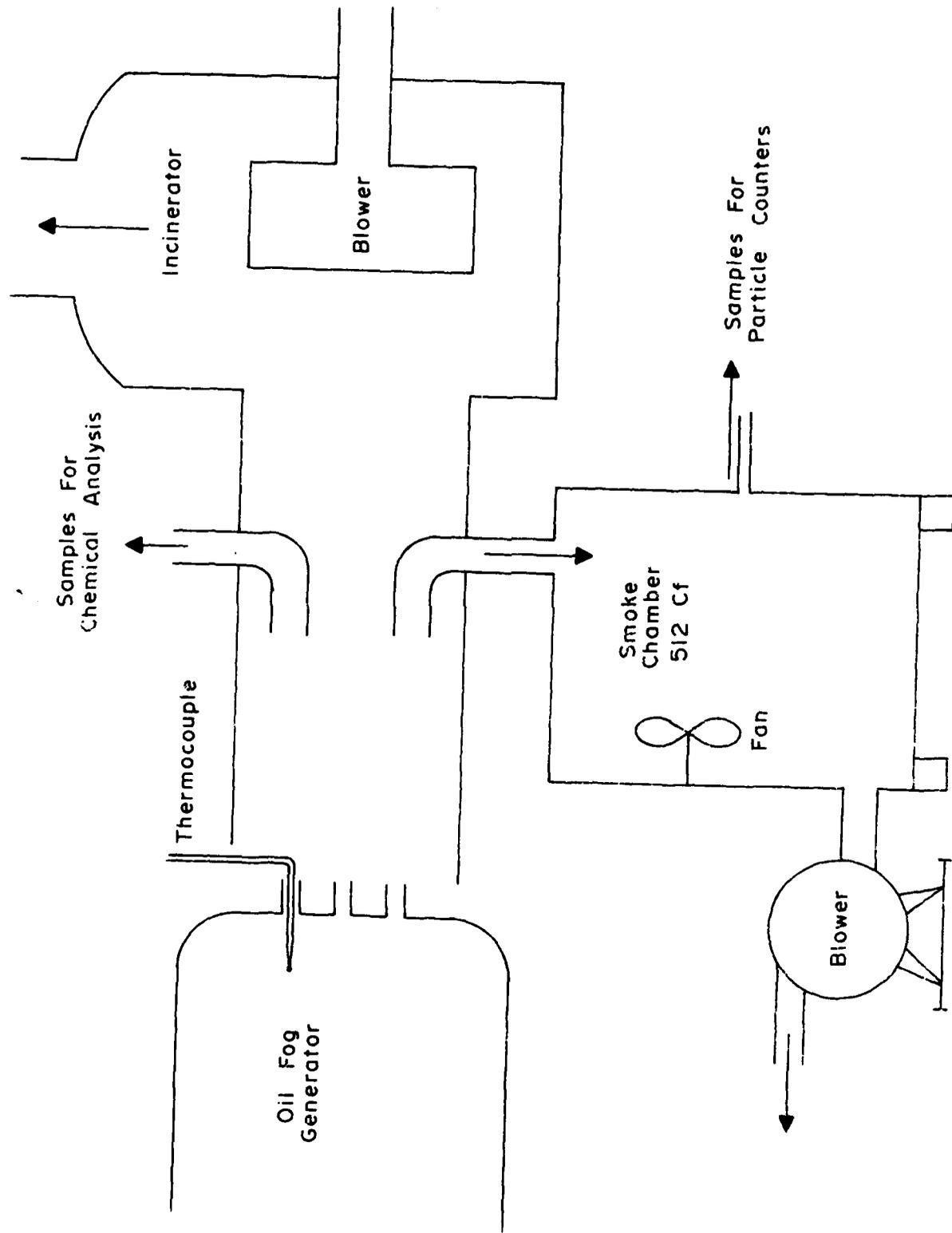


Fig. 4 FOG GENERATION AND SAMPLING SYSTEM

TABLE 4. AEROSOL GENERATOR EXHAUST TEMPERATURES. THERMOCOUPLE
 PROBE INSERTED ABOUT 6 IN INTO GENERATOR EXHAUST

Experiment No.	Generator - Oil	Time to equilibrium, min.	Average temperature, C
1	B-2	7½	350
2	B-1	8	375
3	B-3	9	360
4	B-2	6½	359
5	C-2	4	390
6	C-1	3½	371
7	C-3	4	370
8	A-3	6½	399
9	A-2	6	380
10	A-1	6	366
11*	B-1	5	572
12	B-1	5	410

* High temperature experiment

the generator, and reducing the gasoline supply to the ram jet motor. The resulting operating temperature was 572°C, almost 200° higher than the average of the other 11 "normal" runs.

b. Sampling for Chemical Analysis

To obtain analytical samples, the oil fog was collected using a simple impaction filter technique. A "high volume" filter pump (approximately 50 cu ft min⁻¹) was used to draw a sample of oil fog from the manifold on the low pressure side of the blower connected to the incinerator, (Fig. 4) through a 5 liter glass flask packed with glass wool. To keep the collection flask cool it was set in a bucket filled with ice. With this arrangement, between 50 and 100 cm³ of the oil was collected in 10 minutes. The oil in the flask was then subjected to the analytical procedures to be described shortly.

c. Sampling for Aerosol Analyses

The original intent in the program was to use IITRI's 6 meter (18 ft) diameter spherical chamber to contain the oil fog aerosol for particle size measurements. However, the arrangements necessary for disposal of the excess oil fog precluded use of this facility. Instead a "mobile" aerosol holding tank was constructed, consisting essentially of a 2 meter cubic wooden structure mounted on casters. This holding tank was moved close to the smoke generator and was connected to the up stream side of the blower unit for collection of the aerosol sample via a valved duct of 5 cm diameter. A small suction blower attached to the chamber provided the necessary negative pressure required for sample collection. As in sample collection for chemical analysis, aerosol was sampled after attainment of thermal equilibrium in the smoke generator exhaust manifold. An aerosol sample was collected by opening the sampling valve for about 1 sec. The holding tank was then disconnected from the generator and was moved into an adjacent building for aerosol particle size analyses. Elapsed time from sample collection to the start of aerosol measurement was approximately 3 minutes.

Table 5 is a generator-fog oil matrix correlating the experiments with the corresponding M3A3 generator and fog oil.

TABLE 5. FOG OIL EXPERIMENTS

M3A3 Generator	Fog Oil		
	1	2	3
A	#10	#9	#8
B	#2; #11; #12	#1, #4	#3
C	#6	#5	#7

4. CHEMICAL ANALYSIS

4.1 Discussion

The chemical analysis of natural hydrocarbon oils is a problem of extreme complexity. Even relatively simple oil fractions may be composed of many thousands of species. In the present investigation it was of interest to identify potentially toxic or hazardous constituents. These might be, for example, polycyclic aromatic hydrocarbons or their derivatives.

The analytical procedures were similar for both the oils and their derivative fogs. The methods used are described as follows:

- 1) separate the oil or oil fog sample into classes using either chemical separation or liquid chromatography or a combination of both,
- 2) analyze the resulting fractions using high resolution gas chromatography,
- 3) analyze selected fractions by gas chromatography/mass spectrometry, and
- 4) subject the oils and fogs to gel permeation liquid chromatography to determine size distribution.

This method is summarized as a flow chart in Figure 5. The details of the chemical analysis are presented in the following sections.

4.2 Sample Preparation

The oils were withdrawn from their metal containers and were delivered to the laboratory with no prior preparation.

The oil fogs were received for analysis as liquid condensates on glass wool in 5 liter glass round bottom flasks. Each oil fog was separated from the glass wool by three successive extractions with 300 ml aliquots of methylene dichloride, CH_2Cl_2 . The extracts were combined and the solvents were removed with a rotary evaporator. Prior to liquid chromatographic fractionation the oils and oil fogs were filtered using a Millipore Corporation filter with 0.2 μm pore size.

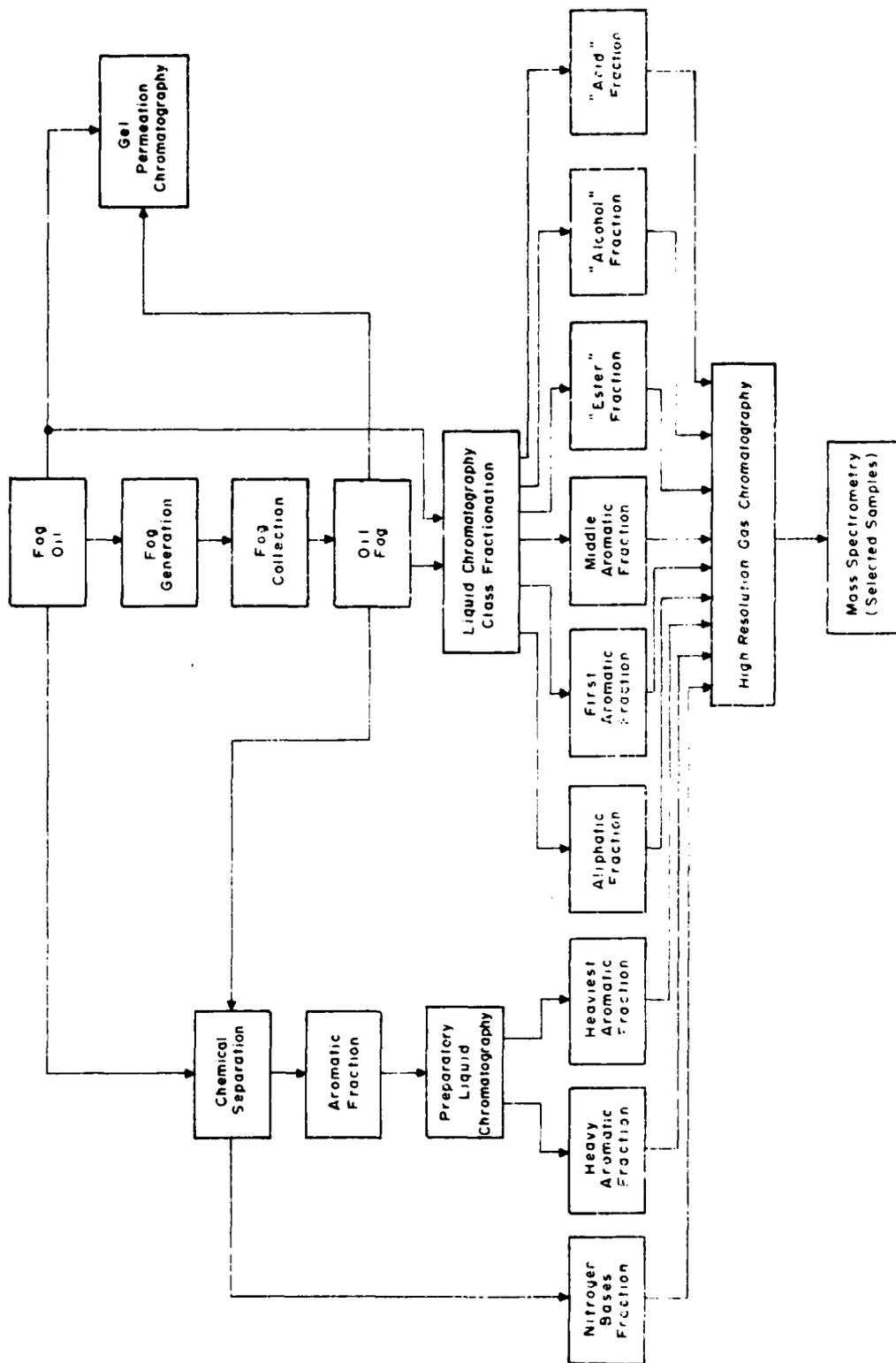


Fig 5 FLOW CHART OF CHEMICAL ANALYSIS

4.3 High Pressure Liquid Chromatography Class Fractionation

Compound class fractionation was performed by normal phase high pressure liquid chromatography (HPLC). This was accomplished by utilizing the Waters Associates Liquid Chromatograph, described in Table 6. The mobile phase flow rate was 2 ml/min at ambient temperature. The mobile phase, Burdick and Jackson solvent, was initially n-hexane but after 8 minutes a linear gradient was established with the second solvent consisting of ethyl acetate/methanol/benzene in the volume ratio 50/25/25. The gradient was set so as to achieve 80% of the second solvent in 1 hour, however, after 31.5 minutes the gradient was interrupted and the mobile phase was switched to 100% of the second solvent.

For each run 200 μ l of oil or oil fog were injected into the HPLC using a 250 μ l Precision Sampling Pressure Lock syringe. 2 μ l fractions of the elutant were continually collected up to a total of 30 fractions. The 31st fraction was collected until it totalled 20 ml. At that point each run was terminated. During the run, the elutant was monitored by both the absorbance detector (set at 254 nm) and the refractometer. The detectors were connected in series, with the absorbance detector being the first to "see" the elutant. Using this system the chemical classes were separated and given initial classification as follows:

<u>Fraction</u>	<u>Class</u>
4-6	Aliphatic
4-10	Aromatic
19-22	Ester
26-28	Alcohol
31	Acid

After fractionation and collection, each fraction was blown down with a nitrogen stream until all of the solvent was evaporated. At this point the fractions were weighed using the following method. First, the fractions were examined visually and those containing the largest amounts of material were

TABLE 6. HIGH PRESSURE LIQUID CHROMATOGRAPH (HPLC)

Units:	Waters Associates Model 244 HP Liquid Chromatograph.
Modules:	Model 6000A Solvent Delivery System (2 units). Model 660 Solvent Programmer. Model 440 Absorbance Detector. Model R401 Differential Refractometer.
Columns:	25 cm x 6.2 mm I.D., 10 μ m particle size and 60 Å pore size Lichtrosorb column.

diluted with 1.0 ml of CH_2Cl_2 . The remaining fractions were diluted with 100 μl of CH_2Cl_2 . Second, weighing pans were constructed out of one inch square sections of aluminum foil. The pans were rinsed with CH_2Cl_2 and dried thoroughly before use. Third, a pan was selected and weighed on a Mettler balance. Immediately after weighing, one quarter of the volume (either 25 or 250 μl) of the fraction to be weighed was removed with a Hamilton syringe and placed in the pan. The CH_2Cl_2 was allowed to evaporate, the pan was weighed again and the weight was determined by differences. Lastly, the measured weight was multiplied by four to give the total weight of the fraction.

In Fractions 4, 5 and 6 both the aliphatic and aromatic components eluted. In order to separate the two classes it was necessary to repeat the separation. To accomplish this the liquid chromatograph was set up as before with the following two exceptions: First, no gradient was necessary and the separation was accomplished isocratically using hexane as the mobile phase. Second, the chromatograph was operated in the recycle mode in order to pass the components through the column as many times as necessary to achieve separation. For these runs 20 μl volumes were injected using a 100 μl Precision Sampling syringe. In the case of Fraction 6, not enough material was present to provide for a 20 μl injection so the fraction was diluted to 20 μl using hexane. To achieve separation of the aliphatic and aromatic components it was never necessary to recycle the samples through the column more than twice. Once the components were deemed separated they were collected, blown down, and weighed as described previously. The aliphatic and aromatic components of Fractions 4-6 were designated -A and -B, respectively (e.g., 4-A, 4-B).

4.4 Chemical Separation, Liquid Chromatography - Heavy Aromatics

The liquid chromatography technique described previously did not yield a large enough quantity of heavy aromatics to provide for good chemical characterization. To correct this situation it was necessary to extract the aromatics chemically from a comparatively large volume of oil or condensed oil fog, and then separate the heavy aromatics using preparatory liquid chromatography.

To initiate the chemical separation, 30 ml of the oil or condensed oil fog was dissolved in 75 ml of n-pentane and then extracted three times with

105 ml portions of dimethyl sulfoxide. The dimethyl sulfoxide extracts were then combined in a large separating funnel followed by the addition of 300 ml of Millipore Milli-Q purified H₂O. The aromatics were then extracted twice from the dimethyl sulfoxide/aqueous mixture using two 600 ml portions of n-hexane. The extracts were combined, concentrated to ~5 ml using a rotary evaporator, washed three times with 5 ml portions of Milli-Q water and dried over anhydrous Na₂SO₄. The resulting aromatic fraction was then blown down with nitrogen to remove the solvent and filtered with a Millipore 0.2 μm pore filter. This extraction procedure would typically yield an aromatic extract with a volume of 1 to 3 ml, the volume depending on both initial aromatic content and extraction efficiency.

At this point, the extract was subjected to preparatory liquid chromatography in which two late fractions were collected to obtain the heavy aromatics. For this purpose the Dupont Liquid Chromatograph described in Table 7 was used. The chromatograph was run isocratically with n-hexane as the mobile phase. The flow rate was 28 ml/min. For each run 400 μl of extract was injected using a Precision Sampling 1.0 ml syringe. Collection was begun 21 minutes into the run. At an elapsed time of 27 minutes collection of the first fraction was terminated and collection of the second fraction was initiated. Collection was stopped at the end of the run which was allowed to proceed until the detector trace showed a flat baseline (usually about 60 min elapsed time). The collected fractions were concentrated using a rotary evaporator and were then blown down with nitrogen to evaporate the remaining solvent. Unlike previous fractions, these fractions were not weighed as uncertainties in both extraction efficiency and reproducibility precluded meaningful quantitative significance. The first fraction in each run was designated DMSO-1 and the second fraction DMSO-2.

A mixture of benzene/naphthalene/anthracene in the approximate ratio of 1:1:1 was injected into the chromatograph under the same conditions as the oils and oil fogs. Anthracene was the last component to elute with a retention time of 19.5 minutes. This indicated that fraction DMSO-1 contained aromatics with more than three rings with DMSO-2 containing even larger aromatic groups.

TABLE 7. PREPARATORY LIQUID CHROMATOGRAPH

Unit:	DuPont Model 830 Liquid Chromatograph.
Modules:	254 μ m UV absorbance detector.
	Columns: 50 cm x 20 mm i.d. packed with 10 μ m Spherosil. (2 columns in series)

4.5 Chemical Separation - Nitrogen Bases

Chemical separation of the nitrogen bases was achieved using the following extraction technique. 10 ml of oil or condensed oil fog were dissolved in 250 ml of CHCl_3 and were extracted three times with 200 ml of 0.5 N HCl. The extracts were combined and washed once with 250 ml of CHCl_3 . The aqueous acidic extracts were then made basic to pH 11 with 2.5 N NaOH and extracted three times with 250 ml of CH_2Cl_2 . The combined extracts were dried over Na_2CO_3 , filtered, concentrated with a rotary evaporator and finally the solvent was evaporated using a stream of dry nitrogen. As with the heavy aromatics these fractions were not weighed because of the many uncertainties in separation reproducibility.

4.6 High Resolution Gas Chromatography

All fractions obtained from liquid chromatographic and chemical separations were analyzed using high resolution capillary column gas chromatography. This was accomplished with a Hewlett-Packard Model 5840 A chromatograph equipped with a flame ionization detector and a capillary column carrier gas inlet system described in Table 8. The inlet system was operated in the "splitless" mode for greater sensitivity. In this mode the dissolved sample is injected into a hot (180°C) injector block from which the column protrudes into a cool (30°C) column oven. After injection the components of the sample with high boiling points condense into the column while most of the solvent remains in the vapor phase in the injector block. After a designated time period valves are switched to allow the vaporized solvent to be flashed from the injector into the atmosphere. During this time the carrier gas pressure is maintained at the head of the column to insure that carrier gas flow down the column remains continuous and stable. With this system virtually all of the sample ends up in the column while a large portion of the solvent is purged away. The "splitless" system was particularly suitable for the oil/fog analysis as all of the components were high boiling oils.

The aromatic, aliphatic, nitrogen base and ester fractions were analyzed under the conditions described in Table 8-A and the polar alcohols and acids as described in Table 8-B.

TABLE 8. HIGH RESOLUTION GAS CHROMATOGRAPHY UNIT
HEWLETT-PACKARD MODEL 5840 GAS CHROMATOGRAPH

A. Analytical Procedures for Aliphatics, Aromatics, Nitrogen Base and Ester Fractions

Column	= 12 meter x 0.25 mm I.D. glass capillary column coated with SE-30 (chrompak)
Carrier Flow	= 1.0 ml/min (He)
Purge Flow	= 30 ml/min (He)
Make-up Flow	= 24 ml/min (He)
Injector Temp.	= 180°C
Detector Temp.	= 280°C
Oven Temp.	= 30°C for 7 min, program at 30°C/min for 3 mins, then program at 6°C/min to 270°C, hold until elapsed time reaches 60 mins.

Purge Initiation = 2 mins after injection

B. Analytical Procedures for Polar Alcohol and Acid Fractions

Column	= 25 meter x 0.2 mm I.D. fused quartz capillary column coated with Carbowax 20M (Hewlett-Packard)
Carrier Flow	= 1.0 ml/min (He)
Purge Flow	= 30 ml/min (He)
Make-up Flow	= 24 ml/min (He)
Injector Temp.	= 180°C
Detector Temp.	= 275°C
Oven Temp.	= 30°C for 7 mins, program at 30°C for 3 mins then program at 5°C/min to 225°C, hold until elapsed time reaches 60 mins.

Purge Initiation = 1 min after injection

Three standard mixtures were prepared for the purpose of determining the retention times of characteristic compounds under the analytical conditions employed. These standards also served the purpose of periodically checking instrument performance and reproducibility. The compositions of these standards are listed in Table 9. The normal hydrocarbon standard was used in conjunction with the SE-30 column while the alcohol and acid standards were used with the Carbowax 20M column.

Before gas chromatographic analysis, the ester fractions were combined into one fraction as were the alcohol fractions. Although both the esters and alcohols were collected over several fractions, no resolution was observed

TABLE 9. COMPOSITIONS OF STANDARD MIXTURES
USED IN GC INSTRUMENT CALIBRATION

<u>Standard Hydrocarbon Mixture in n-hexane</u>	
n-C ₁₀ H ₂₂	104 µg/ml
n-C ₁₂ H ₂₆	101 µg/ml
n-C ₁₄ H ₃₀	104 µg/ml
n-C ₁₆ H ₃₄	103 µg/ml
n-C ₁₈ H ₃₈	78 µg/ml
n-C ₂₀ H ₄₂	95 µg/ml
n-C ₂₂ H ₄₆	104 µg/ml
n-C ₂₄ H ₅₀	100 µg/ml
n-C ₂₆ H ₅₄	100 µg/ml
n-C ₂₈ H ₆₀	94 µg/ml
n-C ₃₂ H ₆₆	101 µg/ml
<u>Standard Alcohol Mixture in CH₂Cl₂</u>	
C ₁₁ H ₂₃ OH	84.5 µg/ml
C ₁₂ H ₂₅ OH	73.5 µg/ml
C ₁₄ H ₂₉ OH	74.0 µg/ml
C ₁₆ H ₃₃ OH	89.5 µg/ml
C ₁₈ H ₃₇ OH	101.5 µg/ml
<u>Standard Acid Mixture in CH₃OH</u>	
C ₇ H ₁₃ COOH	71.5 µg/ml
C ₉ H ₁₉ COOH	54.5 µg/ml
C ₁₁ H ₂₃ COOH	46.5 µg/ml
C ₁₃ H ₂₇ COOH	85.5 µg/ml
C ₁₅ H ₃₁ COOH	88.0 µg/ml
C ₁₇ H ₃₅ COOH	107.0 µg/ml
C ₁₉ H ₃₉ COOH	70.0 µg/ml

among fractions of the same class. Therefore, the fractions were combined to provide a larger amount of material for analysis.

Prior to injection, the fractions were diluted with solvent. The aliphatic and aromatic fractions were diluted with n-hexane while the remaining fractions were diluted with CH_2Cl_2 . The fractions obtained from the liquid chromatographic separations were diluted with either 50 or 100 μl of solvent depending on the amount of material collected in the fraction. Those fractions collected during chemical separation required up to 3 ml of solvent as some of those fractions contained considerably larger amounts of material.

Injection was accomplished using a 1.0 μl Hamilton syringe. The size of each injection varied from 0.1 to 0.5 μl depending on the concentration of material in the fraction being analyzed. In some cases two or three injections were necessary before the gas chromatogram was acceptable for visual inspection and comparison with chromatograms of other oils and oil fogs. To be acceptable, the chromatogram had to exhibit peaks well above the baseline but not run off the top of the chart.

In addition to flame ionization detection, the nitrogen bases were subjected to GC analysis using a nitrogen/phosphorus selective detector. Conversion to the N/P mode required only replacement of the F/D collector with the N/P collector and an adjustment in the hydrogen and air flow rates. All other run parameters were retained.

4.7 Gel Permeation Chromatography

Gel permeation chromatography was utilized to determine the size-molecular weight distribution of the components making up the unfractionated oils and oil fogs. The Waters Associates HPLC described in Table 6 was used for this purpose. The chromatograph was fitted with a Waters 30 cm x 0.78 cm I.D. Styragel column with a particle size of 10 μm and a pore size of 100 \AA . Analysis was performed isocratically with CH_2Cl_2 used as the mobile phase. Flow rate was 1.0 ml/min at ambient temperature. Prior to injection the sample was filtered through the 0.2 μm filter previously described. A Precision Sampling 1.0 μl syringe was used to inject from 0.1 to 0.4 μl of sample. The actual volume of injection was adjusted so that the peak U.V.

absorbance had a value between one and two absorbance units. Before each analysis 10 μ l of a standard test mixture was injected. The standard mixture had the composition listed in Table 10 and it also was used with CH_2Cl_2 as the solvent phase.

TABLE 10. GEL PERMEATION STANDARD TEST MIXTURE

Component	Molecular Weight	Concentration
polyethylene 23 lauryl ether	1200	10 mg/ml
cholesteryl stearate	653	10 mg/ml
eicosanoic acid	313	10 mg/ml
cholesterol	386	10 mg/ml
eicosane	285	10 mg/ml
decane	142	10 mg/ml
anthracene	178	1 mg/ml

4.8 Gas Chromatography/Mass Spectrometry

For GC/MS analysis of selected fractions, the following system was used. A Varian MAT 311A mass spectrometer was used featuring a double-focusing analyzer system with Nier-Johnson geometry and a differentially pumped vacuum system utilizing two high-speed turbomolecular pumps. For sample introduction the system used a Varian Aerograph Model 2740 gas chromatograph equipped with a Hewlett-Packard Model 18835A injection system for splitless capillary column analysis. The capillary column was directly interfaced with the mass spectrometer via a microneedle valve regulator and glass lined tube.

The ion source of the mass spectrometer consisted of a combined electron impact/electron impact ionization detector for simultaneous registration of electron impact mass spectra and total ion current (TIC) gas chromatograms. The TIC signal was fed to an electronic integrator to monitor the progress of the chromatogram in real time.

The capillary column and the gas chromatographic parameters were identical to those used earlier in the high resolution gas chromatographic analysis. As in the earlier analysis, the column and parameters were matched to the particular class being analyzed.

In a typical analysis run, the magnet of the mass spectrometer was set to scan repetitively over a preset mass range. Data were acquired on a disk by the data system and stored on magnetic tape for subsequent examination. The raw GC/MS data was then routinely processed through a data-enhancement algorithm. Program "Clean-up"* automatically extracted mass spectra free of background and of contributions of unresolved (overlapping) GC peaks by the application of a tabular peak-modeling technique to mass chromatograms in the data file (Rindfleisch deconvolution). The resolved spectra were then identified by means of a library-matching search algorithm. Compounds which did not yield acceptable identifications in this way were sought manually by comparison of their spectra with published compendia of mass spectral data.

* Developed at Stanford University Medical School and modified at IITRI

5. RESULTS

5.1 Class Fractionation

A representation of a typical HPLC class fractionation run is shown in Figure 6. The severe overlap of the aromatic and aliphatic fractions is quite clear and demonstrates the need of the recycling technique used to separate these two classes. For completeness, the mobile phase gradient profile is presented at the top of the page.

The complete results of the HPLC class fractionation are presented in Table 11. The calculated percentages are based on the total amount of material eluted from the HPLC. For Oil #2, three identical runs were performed to determine the reproducibility. From these three runs the means and standard deviations were calculated. The error quoted in Table 11 represents one

TABLE 11. RESULTS OF HPLC CLASS FRACTIONATION

Sample	% Aliphatics	% Aromatics	% Esters	% Alcohols	% Acids
Oil #1	58.2	40.0	0.7	1.1	0.0
Run #10 (1-A)	55.1	42.0	1.1	1.2	0.6
Run #2 (1-B)	59.7	37.5	0.9	1.0	0.8
Run #6 (1-C)	57.8	39.4	1.0	1.3	0.6
Run #11 (1-BHT)	57.7	39.8	0.9	1.1	0.4
Oil #2	42.7 ± 5.7	50.0 ± 6.4	4.1 ± 0.7	2.7 ± 1.2	0.5 ± 0.1
Run #9 (2-A)	43.1	52.5	2.8	1.3	0.4
Run #4 (2-B)	54.6	41.0	2.9	1.1	0.3
Run #5 (2-C)	44.4	50.9	3.3	1.0	0.4
Oil #3	54.1	43.5	0.9	0.7	0.7
Run #8 (3-A)	42.4	55.2	1.4	0.6	0.4
Run #3 (3-B)	47.5	50.4	1.0	0.6	0.6
Run #7 (3-C)	54.5	43.8	1.1	0.3	0.2

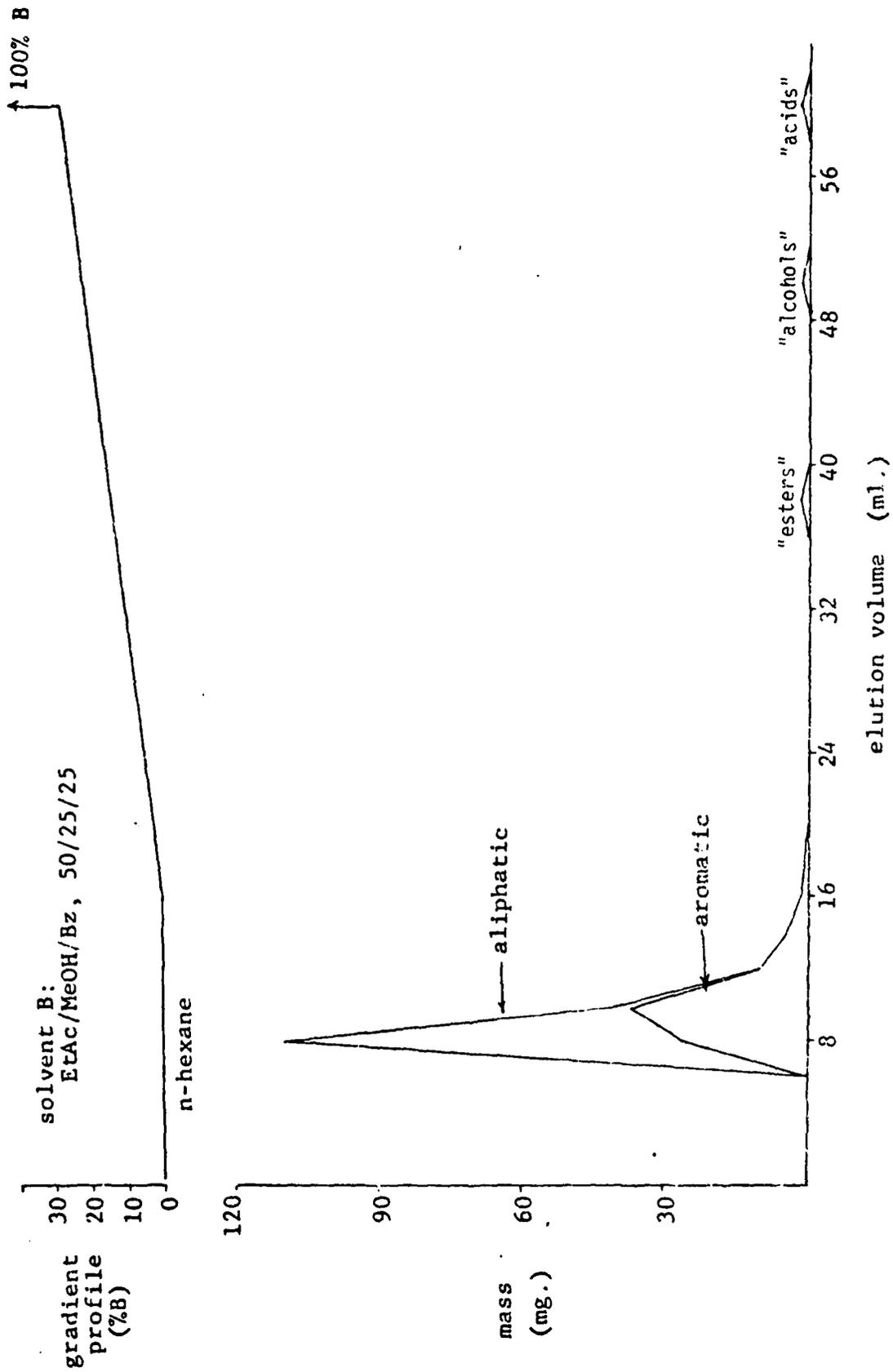


Figure 6. HPLC Class Fractionation of Fog 011 No. 3.

standard deviation. The primary source of error in the aliphatic and aromatics fractions was probably the failure to separate absolutely the two classes. Although the three oils vary in composition, the production of the fogs seemed to have very little significance on the oils' class compositions.

5.2 Gel Permeation Liquid Chromatography

The results of the gel permeation chromatography are presented in Table 12. The results are presented in two ways, as a ratio between absorbance units and refractive index units and as the retention time of the peak maximum using the refractive index detector. The data presented as a ratio give an indication of the relative quantities of U.V. absorbing materials (aromatics) in the oils and fogs. An increase in the value of the ratio could indicate a real increase in the relative concentration of aromatics or it could indicate an increase in the sizes of the aromatics or both. The peak maximum column is an indication of the average size of the compounds contained in the oils. For comparison, the retention times of decane and eicosane are presented at the bottom of the table. As with the HPLC fractionation, Oil #2 was run

TABLE 12. RESULTS OF GEL PERMEATION LIQUID CHROMATOGRAPHY

Sample	Absorbance/Refractive Index Units	Peak Maximum for Refractive Index (minutes)
Oil #1	$1.96 \pm 0.09 \times 10^4$	7.7
Run #10 (1-A)	2.26×10^4	7.7
Run #2 (1-B)	2.31×10^4	7.8
Run #6 (1-C)	2.33×10^4	7.8
Run #11 (1-BHT)	7.54×10^4	7.9
Oil #2	$3.88 \pm 0.02 \times 10^4$	8.4 ± 0.1
Run #9 (2-A)	3.95×10^4	8.3
Run #4 (2-B)	4.08×10^4	8.3
Run #4 (2-C)	3.94×10^4	8.4
Oil #3	2.56×10^4	8.1
Run #8 (3-A)	3.16×10^4	8.1
Run #3 (3-A)	2.97×10^4	8.1
Run #7 (3-C)	2.98×10^4	8.1
	Eicosane (M.W.295)	7.6
	Decane (M.W.142)	9.0

three times to determine the reproducibility with the quoted error being equal to one standard deviation.

All of the oil fog runs show a slight increase in the ratio column over the values for the corresponding oils with the exception of run #11 which shows a dramatic increase. These increases are not reflected in the peak maximum column.

5.3 Metal Analysis

Trace metals in the oils were determined by atomic absorption using a Perkin Elmer Model 403 Spectrometer. The analysis is summarized in Table 13 which includes the detection limits for each metal.

TABLE 13. RESULTS OF METAL ANALYSIS

	Oil #1 (PPB)	Oil #2 (PPB)	Oil #3 (PPB)	Detection Limit (PPB)
Cd	ND	ND	ND	9
Cr	ND	ND	ND	9
Co	ND	ND	ND	9
Cu	46 ($\pm 25\%$)	46	48	
Pb	ND	ND	ND	93
Mn	ND	ND	ND	9
Mo	ND	ND	ND	95
Ni	ND	ND	ND	9
Sr	ND	ND	ND	9
Sn	ND	ND	ND	93
V	ND	ND	ND	95
Zn	55 ($\pm 25\%$)	19	104	
As	ND	ND	ND	95
Hg	ND	ND	ND	2

ND - Not Detected

5.4 High Resolution Gas Chromatography

The gas chromatographic data are presented in Appendix B in Charts No. 2-31. Charts No. 2-23 present gas chromatograms of each class fraction of each oil along with those of the corresponding oil fogs. In most cases three oil fog chromatograms appear with each oil chromatogram, corresponding to the three generators used in the study. In the case of the heavy aromatics, heaviest aromatics, and nitrogen bases, only one oil fog chromatogram appears

with that of the oil. This results from the fact that the chemical extraction techniques were applied to only one fog from each oil. In the case of the heavy and heaviest aromatics, the fog from generator B was used and in the case of the nitrogen bases only the fog from generator A was used. For the nitrogen bases fraction only the chromatogram from Oil #2 is included in the data as it was the only one of the three oils to contain enough nitrogen bases to produce a meaningful chromatogram.

The second section of Appendix B, Charts No. 24 to 31, contains chromatograms of oil fogs obtained from high temperature Run #11. Along with each of these chromatograms is a chromatogram obtained from a normal run (#2) and a chromatogram obtained from the starting oil. No nitrogen bases fractions were included in the section because of the lack of material (condensed oil fog) to make the necessary chemical extraction.

Preceding the two sections is Chart No. 1 containing three typical qualitative calibration runs, one for each of the calibration standards described previously.

Portions of the class fractions from each oil and many of the oil fogs were selected for gas chromatograph/mass spectrometry (GC/MS) analysis. Where possible the results were used to make positive identification of some of the larger peaks present in the chromatograms. Complete matching of mass spectrometric data to gas chromatographic data was not possible because of sample complexity and some loss of resolution in the GC/MS interface. However, where identification was positive it is indicated with alphabetically labelled peaks and accompanying compound listings.

In the section of Appendix B containing the normal runs it is clear that the chromatogram of the aliphatic, aromatic and ester fractions of the oil fogs differ very little if any from their corresponding oil chromatograms. The chromatograms of the alcohol and acid fractions of the oil fogs show some difference from those of the starting oils, particularly in the early section of the chromatograms. To a large degree these differences are characterized by sharp individual peaks rather than a gross change in chromatographic pattern. Because of this it is probable that these peaks represent impurities concentrated from the solvents used in separation rather than representing

real differences. The acid and alcohol fractions were particularly vulnerable to contamination because of their relatively small masses compared to the other fractions. The nitrogen base fraction from the fog shows some difference from the oil and can be presumed to be real.

In the section of Appendix B devoted to the high temperature run (#1) many differences appear in comparing the aromatic fractions to the corresponding oil and the corresponding normal run (#2). These differences are almost certainly real and may represent changes in concentrations, composition or both.

5.5 Gas Chromatography/Mass Spectrometry

The 17 Tables presented in Appendix C are summaries of all the GC/MS data for the aliphatic, aromatic and nitrogen bases fractions selected for analysis. Several ester, alcohol and acid fractions were selected and analyzed, but failed to provide useful data. The class identification of these three groups must still be regarded as tentative.

The tables themselves contain an arbitrary peak number (PK#), an arbitrary spectrum number (SPEC), the compound identification (ID), the total ion current (TIC) which is equivalent to peak height in gas chromatography, the area under each peak in arbitrary units (AREA) (this column is not always included), and the percentage of each peak remaining after computer subtraction of the background (TICRAT). The last three columns (RELCON, RETIND, and TYPE) were not used in this study.

The ID column contains both the formula and the compound name of peaks which have been positively identified. Identifications enclosed in parenthesis indicate tentative identification. Those compounds identified as "silanated" are the result of GC column bleed and are not components of the sample itself. In some cases broad obvious peaks are missed by the clean-up program as they fail to meet peak model criteria. These compounds identified as "silanated" are noted at the end of each Table. Additional explanations of some of the data are also noted at the ends of the corresponding Table.

It should be stressed that the absence of any compound in the Tables does not preclude its presence in the sample. Low concentrations or lack of GC separation may mask a peak and make its identification impossible.

6. OIL FOG AEROSOL CHARACTERIZATION

6.1 Procedure and Instrumentation

Oil fog generation and collection were described in Section 3 with tabulations of the experimental runs in Tables 4 and 5. During both Experiments No. 1 and 2, aerosol collection was prolonged for 2 to 3 minutes, resulting in an excessively dense aerosol in the holding chamber. Experiment No. 11 was run at a low oil feed rate to observe the effects of high temperatures on the chemical and physical characteristics of the aerosol.

The aerosol was drawn from the holding chamber with dilution at successive intervals to observe particle size and concentration and the effects of aging on the aerosols. The aerosol dilution system is shown in Figure 7. An important function of this system was the reduction of the chamber aerosol concentration to a level suitable for measurement by the two aerosol monitors. A dilution of 1000(\pm 10):1 was used with a total transit time from chamber to detector of somewhat less than 1 min. A feature of the system is the use of recirculated air for dilution to preserve the physical characteristics of the sample. The aerosol particles were analyzed using the two instruments described below.

A California Measurements, Inc. Piezo Electric (P/Z) Particle Cascade Impactor Model PC-Z was used for the direct measurement of the mass concentration of air-suspended particles between 0.05 and 25 μm . The aerosol-laden air stream, sampled at 240 ml/min, is impacted sequentially on 10 quartz crystal impactor stages. The mass accumulated by each stage causes a proportional frequency shift on each impactor crystal, which is electronically compared to a matching clean reference crystal. Table 14 lists the 50% cutoff sizes ($D_p 50$) for the ten stages for a particle density of 2 g cm^{-3} . The values of M_i are the between-stage midpoint diameters used to compute the aerodynamic equivalent mass median diameters for each distribution.

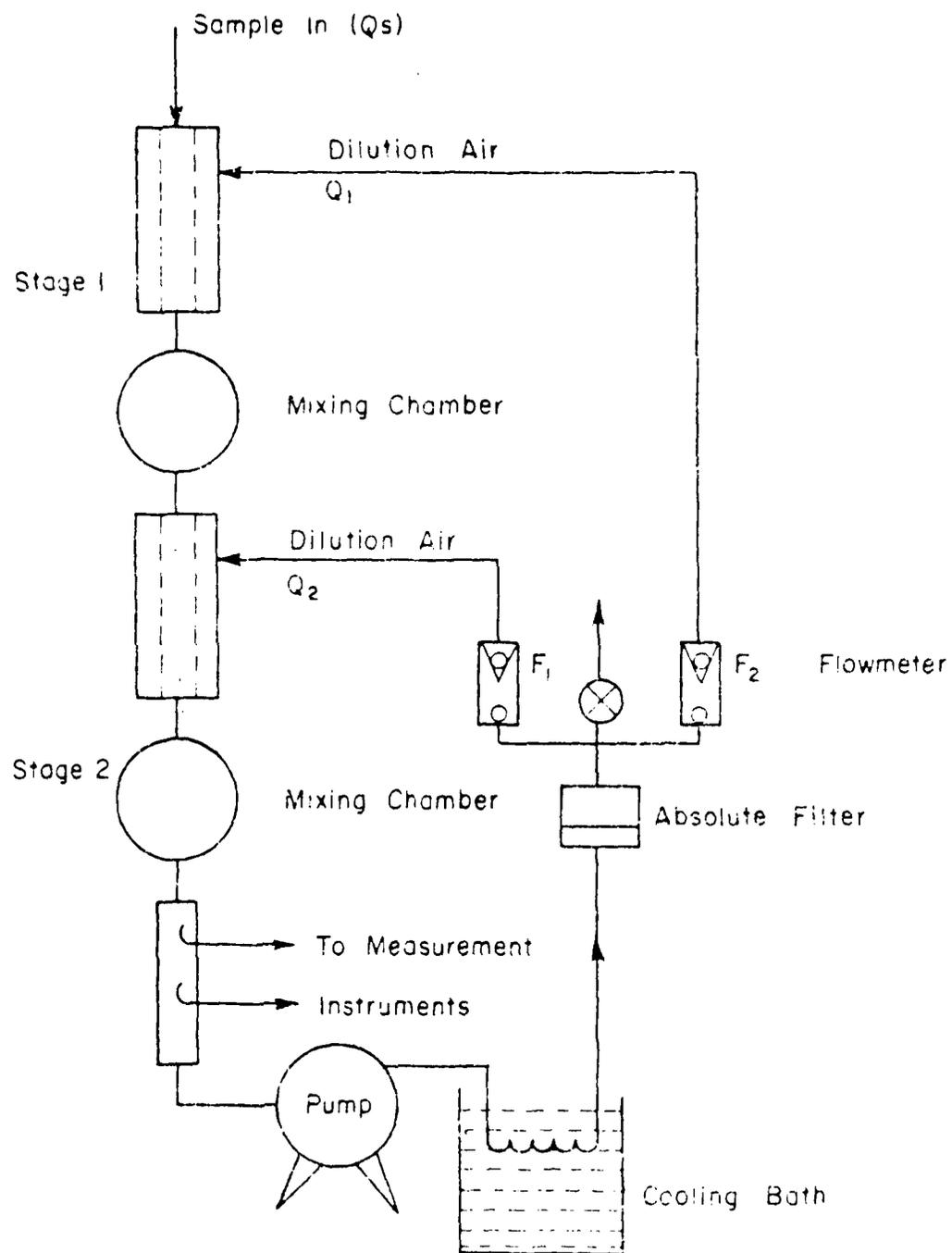


Figure 7. Aerosol sampling line and dilution system.

TABLE 14. PIEZOELECTRIC COUNTER STAGES

Stage	D_p μm	M_i μm
1	25.0	-
2	12.5	18.75
3	6.4	9.6
4	3.2	4.8
5	1.6	2.4
6	0.80	1.20
7	0.40	0.60
8	0.20	0.30
9	0.10	0.15
10	0.05	0.075

After passing through the 10th, lowest, stage, the air flows through a flowmeter to a pump where it is exhausted to the atmosphere. The rate of frequency shift in each stage is related to the mass concentration of aerosol particles captured in that stage, and can be expressed by the following equation:

$$\frac{\Delta f_i}{\Delta t} = \sigma_i V C_i$$

where

Δf_i = frequency shift for stage i, Hz

Δt = sample time, min

σ_i = sensitivity factor for stage i

V = volume flow rate of air sample, 240 ml/min

C_i = aerosol mass concentration in stage i, $\mu\text{g}/\text{m}^3$

The sensitivity factor, σ_i , depends on the resonant frequency of the crystal and the area of the sensitive portion of the crystal compared to the area of the impinging air jet, but is otherwise a constant for each stage. The concentration may therefore be calculated from the measured frequency shift by the equation:

$$C_i = k_i \frac{\Delta f_i}{\Delta t}$$

where

k_j = stage constant

The data reported from the P/Z cascade impactor are the total suspended particles (TSP) in mg/m^3 and the mass median diameter, \bar{d}_m , in μm . The TSP is determined by adding the masses per stage and multiplying by the dilution factor:

$$\text{TSP} = 1000 \sum C_j$$

The \bar{d}_m are computed by summing the products of the mass fractions per stage, X_j , times the midpoint cutoff size between stages, M_j :

$$\bar{d}_m = \sum X_j M_j$$

where

$$X_j = C_j / \sum C_j$$

M_j = as indicated in Table 14

The Particle Measuring Systems, Inc. Active Scattering Aerosol Spectrometer (ASAS) Model ASAS-300-PMT was used for sizing particles within the size range of 0.083 to 3.00 μm . Particles passing through the laser cavity of a continuous He-Ne laser produce pulses of light proportional only to their size and position in the beam. A pair of photomultiplier detectors image the light impulses and select pulses produced by particles in the correct sample space. A pulse height analyzer then determines the particle sizes.

The output of the ASAS is grouped into size classes as shown in Table 15.

TABLE 15. ASAS SIZE RANGE DATA

ASAS Range	Channel	Size Interval μm	Interval Width μm	d_i , Midrange Diameter, μm
3	1-7	0.088-0.144	0.056	0.116
3	8-15	0.144-0.208	0.064	0.176
2	4-15	0.210-0.390	0.180	0.300
1	4-8	0.388-0.503	0.115	0.445
1	9-15	0.508-0.676	0.168	0.592
0	2	0.690-0.855	0.165	0.772
0	3	0.855-1.020	0.165	0.938
0	4	1.020-1.185	0.165	1.102
-	-	-	-	-
0	15	2.835-3.000	0.165	2.918

7. RESULTS AND DISCUSSION

A summary of the analysis data is given in Table 16. In experiments 1 and 2 the dense smoke concentrations overloaded both the P/Z cascade impactor and the aerosol spectrometer and the data are not reliable. Even with a dilution of approximately 10,000 to 1 the smoke samples were still too concentrated for the aerosol spectrometer, making the number concentration measurements erroneous. Since large numbers of particles are present in the lower range, Range 3, of the spectrometer, counting errors are most severe in the lower channels. However the mass contribution from particles in lower ranges to the total mass distribution is small and the error is also minimal. Therefore the data from the aerosol spectrometer are presented as a mass distribution. From the rest of the data the following conclusions can be made:

1) The use of different generators or different oils does not affect the particle size characteristics of the oil fogs. The average mass mean diameter as determined by the P/Z cascade impactor for Runs No. 3 through 10 and 12 is $1.16 \mu\text{m}$ with a standard deviation of $0.14 \mu\text{m}$.

2) Running the oil fog generator at the low oil feed rate of 0.5 gpm, half the normal rate (Experiment No. 11) decreases the TSP and also the particle size. Reduction in TSP is attributed simply to the reduction in oil feed rate and is in approximately the same ratio to oil feed as in the TSP of oil fogs generated under normal operating conditions (Experiment No. 12). The smaller particle size is probably due to less agglomeration at the reduced particle concentration.

3) Very little effect on the fog characteristics seems attributable to the oil. For a given generator, for example generator B, changing the oil from Oil 3 to oil 1 changed the TSP from 0.62 gm/m^3 to 0.70 gm/m^3 and the mean diameter from $1.42 \mu\text{m}$ to $1.05 \mu\text{m}$.

4) Generator C produces fewer TSP compared to the other two generators for all three oils. The particle size does not show any trend.

TABLE 16. SUMMARY OF INITIAL PARTICLE SIZE AND CONCENTRATION MEASUREMENTS

Experiment No.	Generator	Oil	Time at Measurement (min)	TSP (mg/m ³)	mass mean diameter \bar{d}_m (μm)	
					P/Z Impactor**	ASAS
1*	B	2	10	740	1.68	1.10
2*	B	1	10	650	1.64	0.99
3	B	3	30	620	1.42	1.24
4	B	2	10	740	1.25	0.81
5	C	2	13	240	1.21	0.93
6	C	1	9	430	0.98	0.87
7	C	3	6	460	1.14	0.99
8	A	3	12	750	1.14	0.89
9	A	2	4	380	1.00	0.90
10	A	1	4	590	1.25	0.92
11	B	1	4	300	0.74	0.75
12	B	1	6	700	1.05	0.88

* The samples were too concentrated and the monitoring instruments were overloaded.

** P/Z Impactor diameters are calculated using Table 11 corrected for the oil density (0.9 g/cm³)

5) The mass mean diameter \bar{d}_m , calculated from light scattering measurements by the ASAS is consistently lower than the measured value by the P/Z cascade impactor.

The following assumptions involved in the transformation of number distribution to mass distribution may be the causes of the difference.

- The particles are assumed to be spherical.
- The refractive index of the oil fog particles is presumed to be uniform.
- All the particles are of uniform density. The coarseness in the cutpoints of the impactor stages also may contribute to error in mass mean diameter measurements.

Figures 8 and 9 show typical histogram and cumulative log probability plots of the particle size distribution obtained in Experiment 6. Except for the extreme ends of the distribution the data follow log normal behavior very well. This was true for all experimental runs.

Figure 10 shows the cumulative plot for the high temperature run (Experiment 11). The mass median diameter for this run (0.70 μm) is smaller than the mass median diameter obtained under normal operating conditions.

Time histories of mass mean diameter and TSP were obtained for Experiments 3 through 12. As an example, the complete data obtained up to one hour after the generation of smoke in Experiment 4 are given in Table 17. The decrease in mass concentration and the growth in particle mass mean diameter are plotted versus time in Figure 11. The mean diameter increases and the mass concentration decreases linearly. Table 17 also gives the slope, m , intercept b , and correlation coefficient R for the equation

$$y = mt + b$$

where

$$y = \bar{d}_m \text{ in } \mu\text{m} \text{ or TSP in mg/m}^3 \text{ as appropriate}$$

$$t = \text{time}$$

Table 14 and the corresponding data for Experiments 3-14 are given in Appendix D.

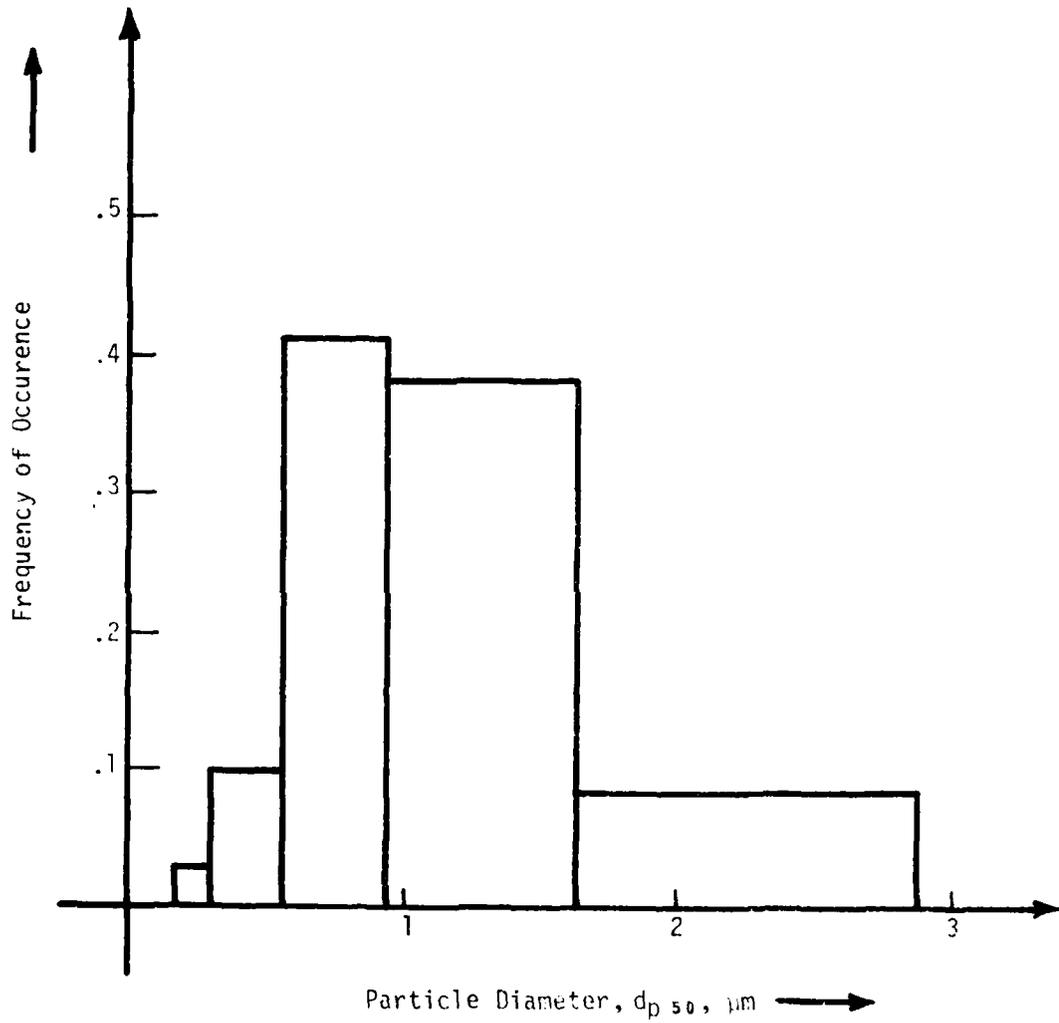


Figure 8. Histogram of Mass Median Particle Size Distribution. Experiment No. 6. 16 minutes after t_0 .

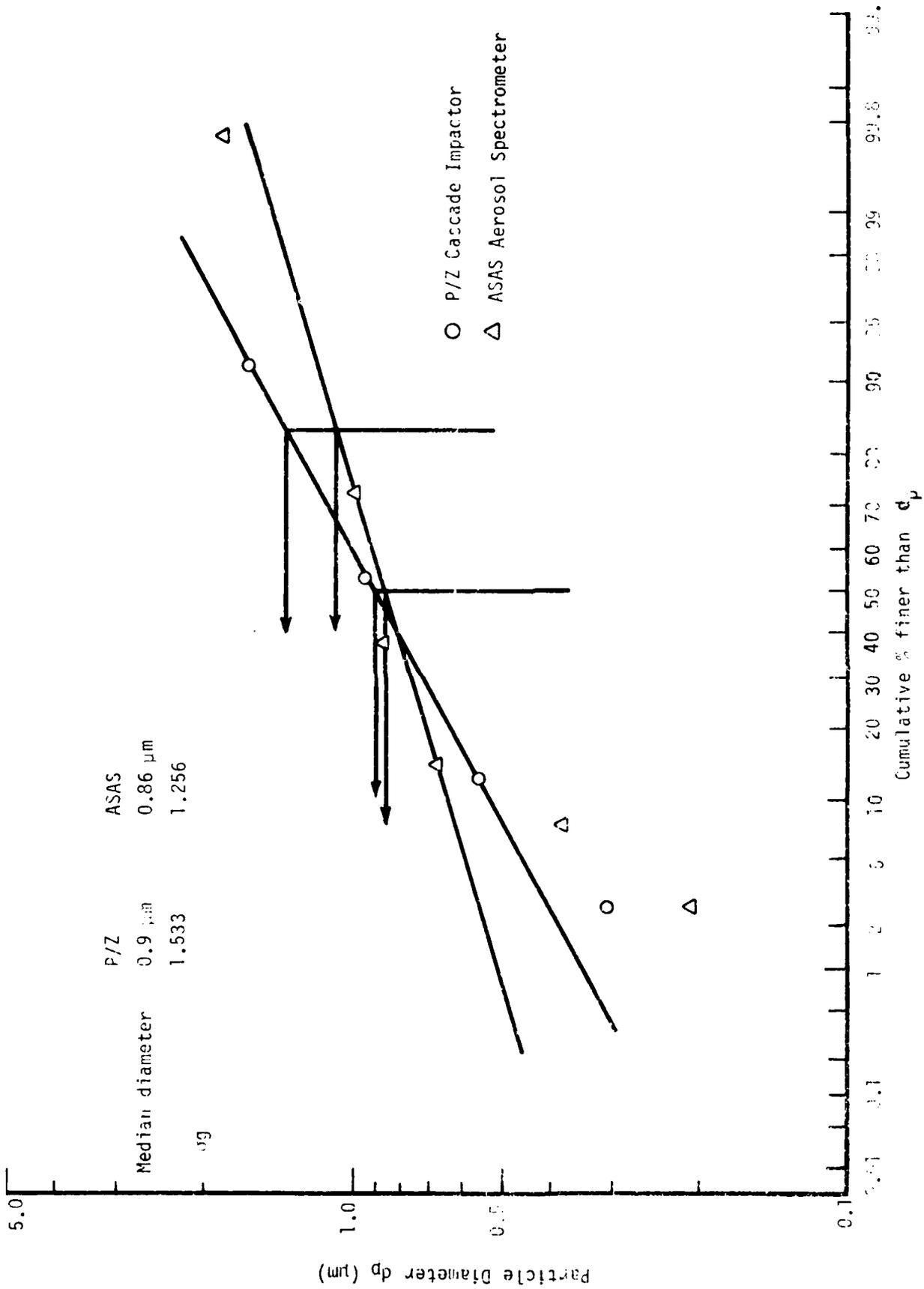


Figure 3. Log Probability plot for Experiment No. 6.

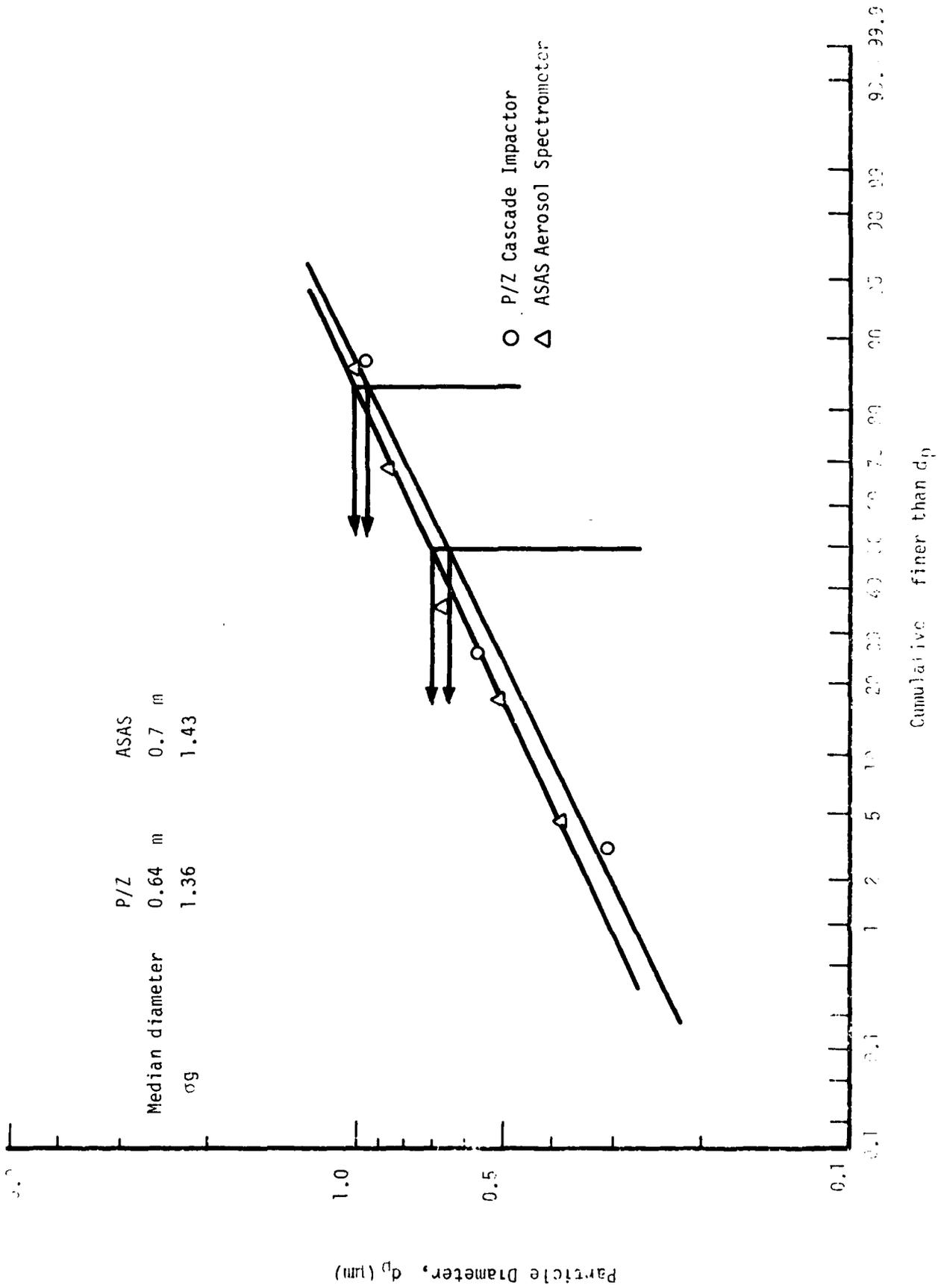


Figure 10. Log Probability Plot for Experiment No. 11.

TABLE 17. DEPENDENCE OF TSP, \bar{d}_m AND n ON TIME t .

EXPERIMENT NO. 4

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μ m)	Time (t) min	\bar{d}_m μ m	No. of Particles (n)
2	144	.686	2	.776	45622
10	739	.842	4	.853	52368
18	667	.876	10	.813	46992
36	634	.824	15	.823	42884
44	566	.831	36	.846	33718
52	598	.878	44	.850	31352
60	506	1.00	52	.888	22506
			60	.893	13774

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION:</p> <p>1) TSP vs t slope = - 3.9 intercept = 763 correlation coef. = -.944</p> <p>2) \bar{d}_m vs t slope = .00313 intercept = .749 correlation coef. = .744</p> <p>Equation: $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 55826$ $K = .0184$ correlation coef. = -0.93</p> <p>Equation: $n = 55826 e^{-.0184t}$ $\ln n = 10.93 - .0184t$ 95% significance level</p>
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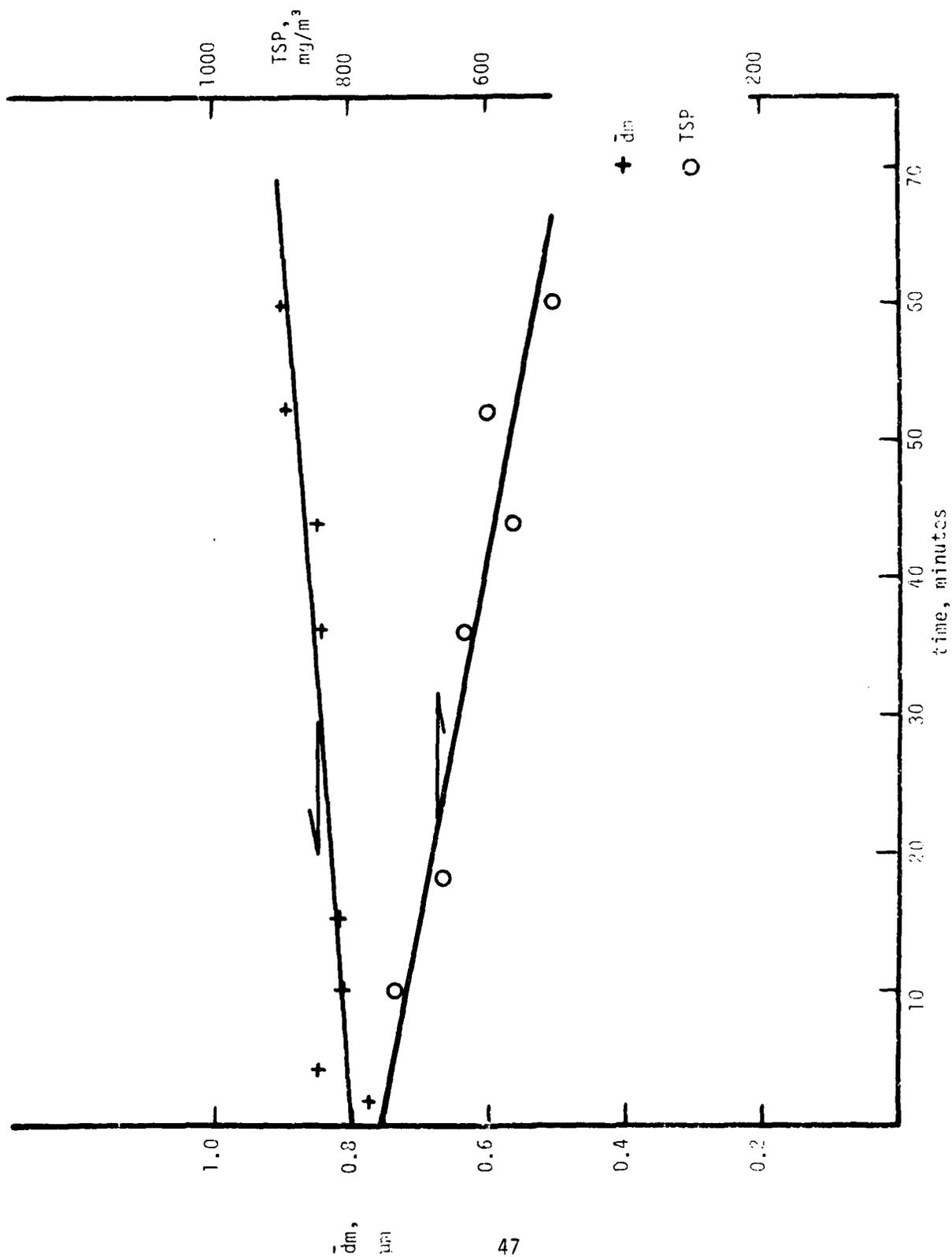


Figure 11. Experiment No. 4. Oil Fog Particle Size (\bar{d}_m) and Concentration (TSP) Variation With Time.

The number concentration n of the aerosols in the holding chamber will decrease exponentially due to coagulation. The rate of change of n is governed by the equation

$$\frac{dn}{dt} = -Kn \quad (1)$$

where K is the effective agglomeration coefficient. Integration of Equation 1 yields

$$\ln n = \ln n_0 - Kt$$

where n_0 is the number concentration at time $t = 0$. Use of regression equations of the above type to correlate the data obtained from the aerosol spectrometer provided good correlation coefficients. The regression coefficient, K , has a physical significance and denotes the effective agglomeration constant of the polydispersed aerosol under study. In order to compare the agglomeration constants obtained from various experiments it is necessary to normalize K with respect to initial concentration. The normalized constant K^* , determined by

$$K^* = \text{vol} \cdot n^{-1} \cdot t^{-1}$$

is given for all experiments in Table 18.

Figure 12 shows the particle concentration change with time for Experiment 4.

TABLE 18. CALCULATED VALUES OF
AGGLOMERATION COEFFICIENT

Experiment	Agglomeration Coefficient, K^* $\text{cm}^{-1} \times 10^{-7}$
3	1.4
4	3.29
6	4.38
7	5.98
8	12.0
9	3.37
10	12.0
11	1.03
12	5.82

Because of the overloading of the aerosol spectrometer the fine details of the number distribution were not observed. From those experimental runs which involved aerosol concentrations within the operating limit of the spectrometer it appears that the size distribution is bimodal with fine and coarse modes. The fine mode extends below the low limit of the spectrometer. Figures 13 and 14 show the number distributions of fog in Experiments 5 and 11. The bimodal nature of the aerosol is due to the dual fog forming processes of combustion and condensation. The fine mode corresponds to the excess condensation nuclei and the coarse mode corresponds to the nucleated aerosol. Under normal generator operation the modal value of the coarse mode is approximately $0.93 \mu\text{m}$. For high temperature runs the modal diameter of the coarse mode decreases to $0.45 \mu\text{m}$.

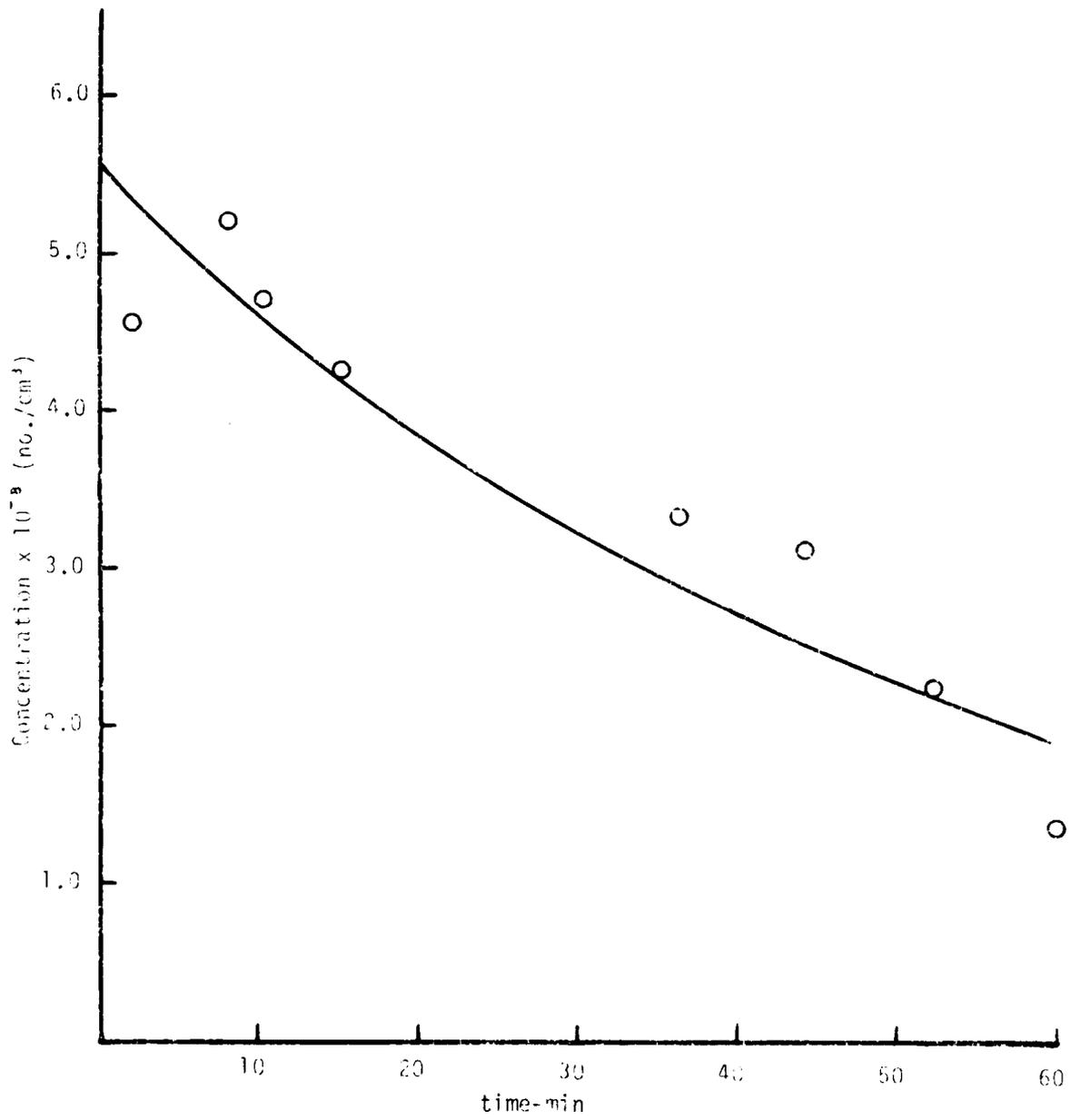


Figure 12. Experiment No. 4. Particle Number Concentration Change vs. Time.

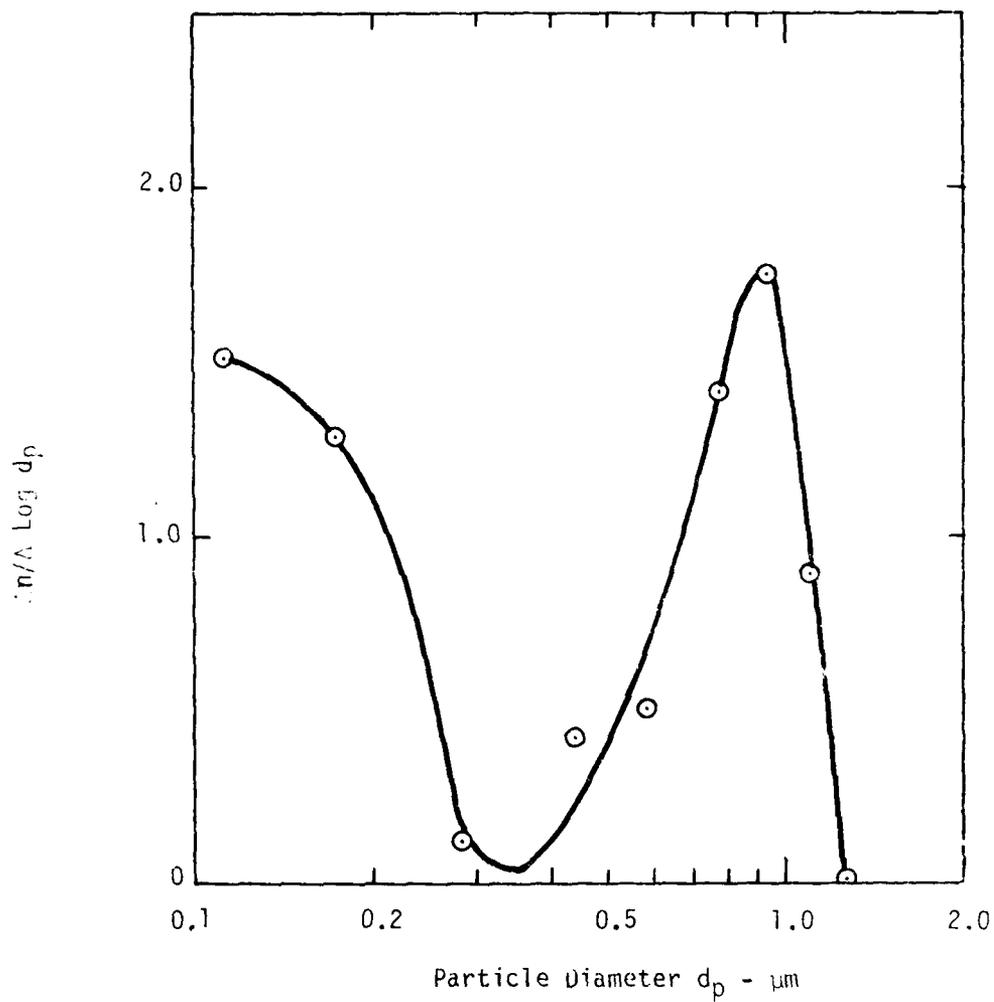


Figure 13. Experiment No. 5 (C-2) Particle Size Distribution by ASAS Aerosol Spectrometer.

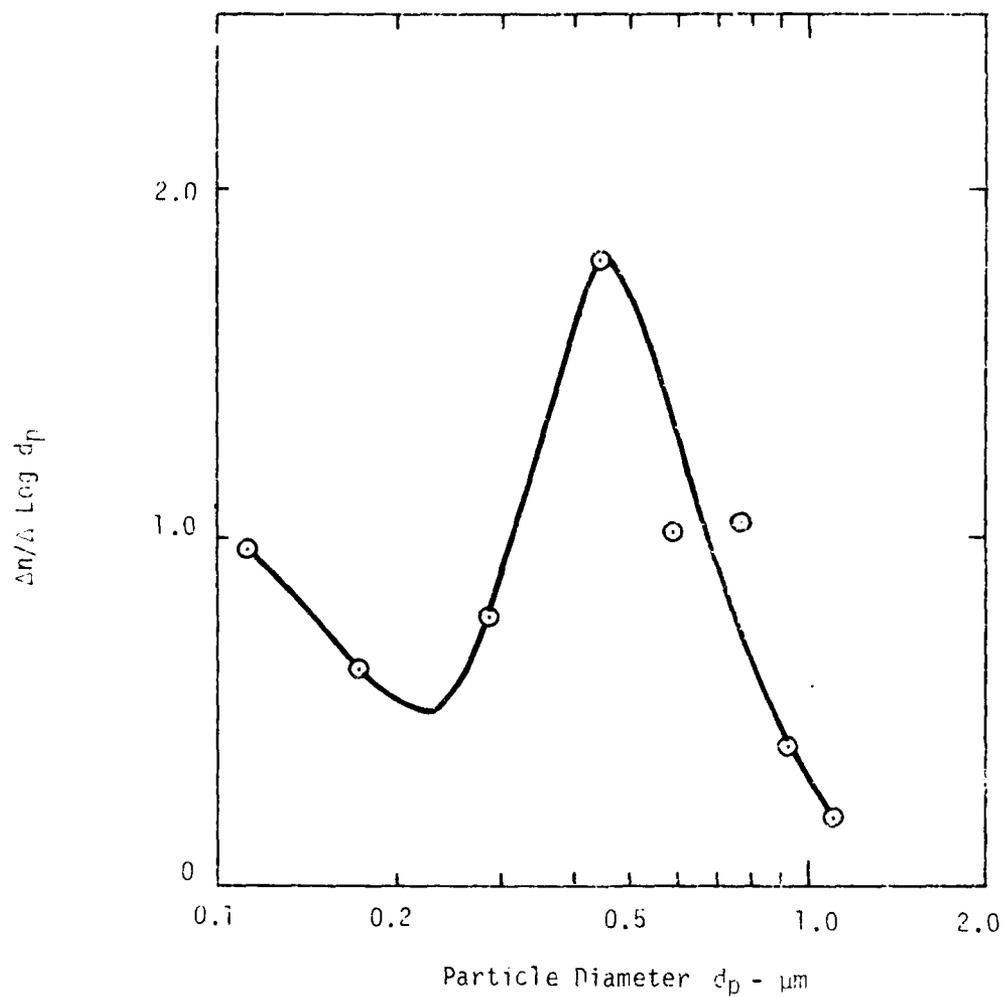


Figure 14. Experiment No. 11 (D-1, IIT) Particle Size Distribution by ASAS Aerosol Spectrometer.

APPENDIX A
FOG OIL
MILITARY SPECIFICATION MIL-F-12070A

MIL-F-12070A

6 JANUARY 1954

SUPERSEDING
MIL-F-12070 (CmlC)
5 June 1952
Navy 14F3
1 June 1946

MILITARY SPECIFICATION

FOG OIL

This specification has been approved by the Department of Defense for use by the Departments of the Army, the Navy, and the Air Force

1. SCOPE

1.1 Scope.—This specification covers petroleum oil for use in mechanical smoke generators.

1.2 Classification.—Fog oil shall be of the following types, as specified (see 6.1):

Type SGF1—For use at temperatures above 40° F.

Type SGF2—For use at 40° F. or lower.

2. APPLICABLE DOCUMENTS

2.1 The following specifications and standard, of the issue in effect on date of invitation for bids, form a part of this specification:

SPECIFICATIONS

FEDERAL

FF-W-556—Wool; Steel.

VV-L-791—Lubricants, Liquid Fuels, and Related Products; Methods of Sampling and Testing.

STANDARDS

MILITARY

MIL-STD-129—Marking of Shipments.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

2.2 Other publications.—The following document forms a part of this specification; unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

INTERSTATE COMMERCE COMMISSION

Regulations for Transportation of Explosives and Other Dangerous Articles, etc.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.)

3. REQUIREMENTS

3.1 Material.—The material shall be an overhead petroleum fraction and shall contain no additives. The material shall be free from water, sediment, grit, or other foreign matter.

3.2 Chemical and physical.—The material shall conform to Table I.

4. QUALITY ASSURANCE PROVISIONS

4.1 Lot.—A lot shall consist of the fog oil produced by one manufacturer with no change in process or materials in no more than 24 consecutive hours.

4.2 Sampling.—The Government inspector shall take a representative one-liter specimen from each of 5 containers selected at random or 5 representative one-liter specimens during the filling operations. The specimens shall be placed in clean, dry containers and labeled to identify the container with the lot represented. Each specimen shall be separately tested as specified in 4.4.

4.3 Inspection.

4.3.1 Packing and marking.—The inspector shall inspect the packing and marking for compliance with Section 5.

4.3.2 Certificate.—The inspector shall ascertain by certification or other approved means that the oil is an overhead petroleum fraction containing no additives.

4.3.3 Impurities.—The inspector shall inspect the material for the presence of water, sediment, grit, or other foreign matter.

Table I.—Chemical and physical

Property	Type SGF1		Type SGF2	
	Maximum	Minimum	Maximum	Minimum
Flash point, °F.....				320
Viscosity, Saybolt Universal				
At 100° F. (seconds).....			110	100
At 210° F. (seconds).....	*60			
Carbon residue (Conradson), percent.....	0.1		0.1	
Neutralization number.....	0.1		0.1	
Pour point, °F.....	0		-40	
Vapor temperature, °F. at:				
10 percent distillation.....		390		
50 percent distillation.....		490		
90 percent distillation.....	610			

*A viscosity of 65 sec., at 210° F. will be the maximum permissible for oils having a viscosity index of 50 or more.

4.4 Tests.

4.4.1 *Methods.*—The following tests shall be conducted in accordance with the applicable method of Specification VV-L-791 specified in Table II.

Table II.—Test methods

Test	Method
Flash point.....	110. 3. 4
Viscosity, Saybolt Universal.....	30. 4. 5
Carbon residue (Conradson).....	500. 1. 5
Neutralization number.....	510. 4. 1
Pour point.....	20. 1. 7

4.4.2 Distillation.

4.4.2.1 *Apparatus.*—The apparatus shall conform to this paragraph and figures 1 and 2.

4.4.2.1.1 *Distillation flask.*—The distillation flask shall be a 250-milliliter (ml.), Saybolt flask, of borosilicate glass, conforming to Specification VV-L-791, Method 100.2.1, except that the outlet tube internal diameter shall be 3.0 ± 0.5 millimeter (mm.).

4.4.2.1.2 *Shield.*—The flask shall be encased in a shield constructed of "Sil-O-Cel" brick as shown in figure 2 (see 6.3).

4.4.2.1.3 *Board or support.*—The flask shall rest on a transite or hard asbestos board. 5

inches by 5 inches by $\frac{1}{4}$ inch, having a hole in the center $2\frac{3}{4}$ inches in diameter.

4.4.2.1.4 *Condenser.*—The condenser (a Friederichs- or Hopkins-type condenser is satisfactory) shall be as shown in figure 2.

4.4.2.1.5 *Receiver.*—The receiver shall be a 100-ml. graduated cylinder constricted at the top to receive a stopper. The cylinder shall be calibrated at all points to within ± 0.5 ml.

4.4.2.1.6 *Suction flask.*—The suction flask shall be a 1000-ml., borosilicate glass flask.

4.4.2.1.7 *Pressure gauge.*—The pressure gauge shall be a Dubrovin Vacuum Gauge, or equivalent.

4.4.2.1.8 *Vacuum pump.*—The vacuum pump may be of any design capable of securing and maintaining the reduced pressure desired.

4.4.2.1.9 *Vacuum control apparatus.*—An automatic vacuum control apparatus or a hand-controlled bleeder valve shall be used to maintain a steady pressure.

4.4.2.1.10 *Thermometer.*—The thermometer shall be an ASTM High Distillation Thermometer, 30° to 760° F. or 0° to 400° C.

4.4.2.1.11 *Heater.*—An electric heater shall be used for the distillation (see 6.4).

4.4.2.1.12 *Connections.*—The connections shall be made by means of metal or glass tubing having an inside diameter of 8 to 9 mm. All joints shall be tight and shall be sealed with a

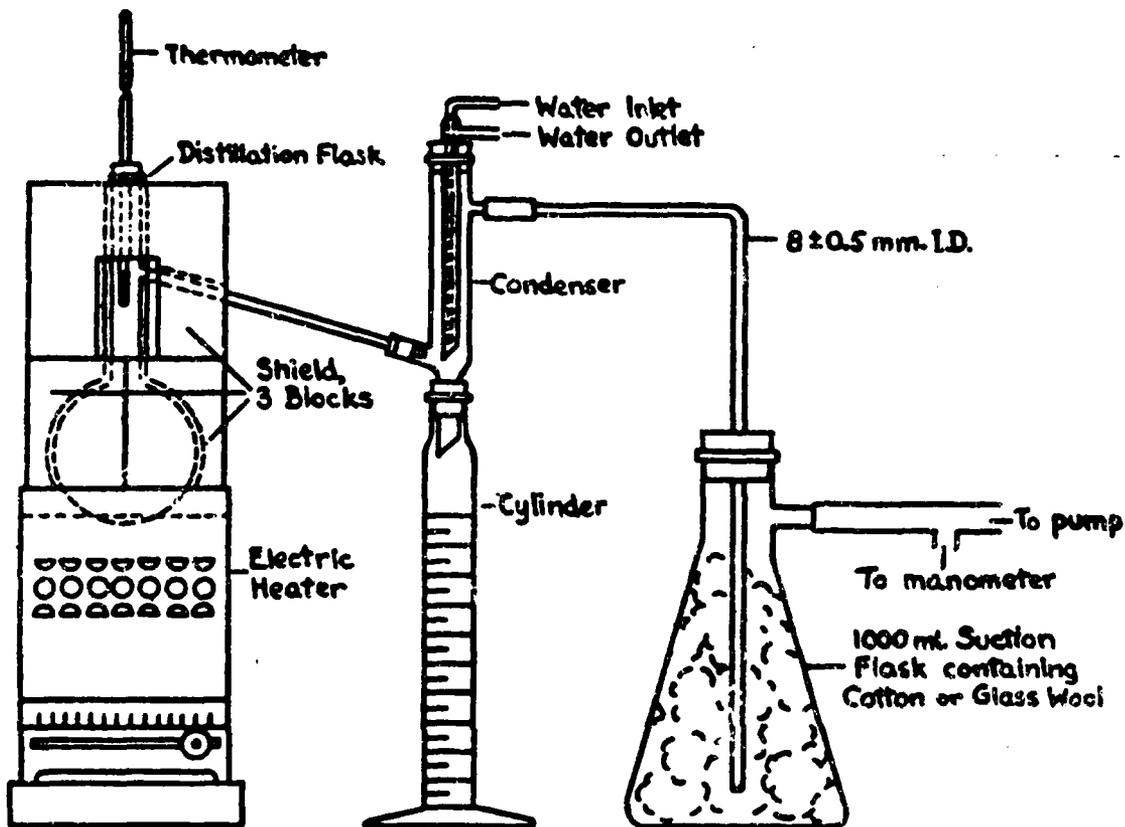


Figure 1. Distillation apparatus.

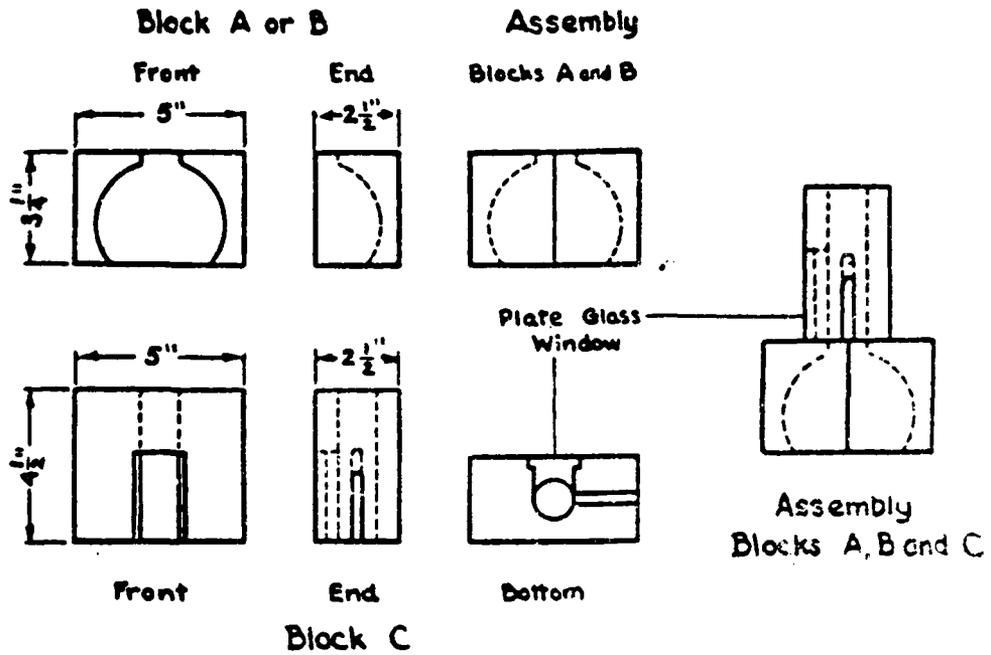
cement such as water glass (sodium silicate) or a mixture of 75 percent collodion and 25 percent castor oil.

4.4.2.2 Procedure.—Place approximately 10 gram (gm.) of dry, clean, grade No. 1 steel wool conforming to Specification FF-W-556 in the bulb of the distillation flask, and spread to nearly fill the bulb. Measure exactly 100 ml. of the specimen into the graduated cylinder. Pour the specimen from the graduated cylinder into the distillation flask. Allow the specimen to drain from the cylinder into the flask until not more than 1 ml. of oil remains in the cylinder. The same graduated cylinder, without being cleaned, shall be used for receiving the distillate. Assemble the apparatus as shown on figure 1. Fit the thermometer tightly into the flask, center properly in the neck with the lower end of the capillary tube on a level with the inside of the bottom of the vapor outlet tube where

it joins the neck of the flask. Evacuate the apparatus and maintain the absolute pressure at 10 ± 2 mm. by means of the vacuum control apparatus. Apply heat to the distillation flask at a rate sufficient to start the distillation within 20 to 30 minutes. Thereafter distillation should proceed at a uniform rate of 4 to 5 ml. per minute. Record the temperatures registered by the distillation thermometer when the quantity of distillate in the receiving flask amounts to 10, 50, and 90 percent respectively of the charge (see 6.5). With proper care and attention to detail, duplicate results should check within 10° F.

4.5 Rejection and resubmission.—If any specimen fails to conform to this specification, the lot shall be rejected. The contractor, at no expense to the Government, shall have the option of having an analysis made on each container in the lot, removing the nonconforming

Shield



Condenser

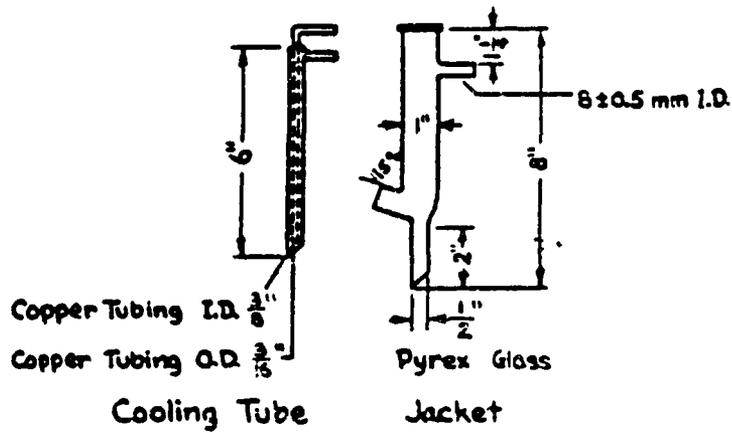


Figure 2. Shield and condenser.

material, and resubmitting the remaining portion of the lot for acceptance testing. If any specimen taken from the resubmitted portion of the lot fails to conform to this specification, the lot shall be finally rejected.

5. PREPARATION FOR DELIVERY

5.1 Packing.

5.1.1 For domestic shipment.—Fog oil shall be packed in drums conforming to Specification 37E of the Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles, etc.

5.1.2 For overseas shipment.—Fog oil shall be packed in drums conforming to Specification 37D of the Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles, etc.

5.2 Marking.—In addition to any special marking required by the contract or order, all shipping containers shall be marked in accordance with Standard MIL-STD-129.

6. NOTES

6.1 Ordering data.—Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Type of material required (see 1.2 and 3.2).
- (c) Type of packing required (see 5.1).

6.2 Sampling and testing.—When the contractor consistently produces high-quality material and operates under a system of quality control acceptable to the Government, the Government, at its discretion, may modify, in whole or in part, the sampling and testing procedures specified herein. However, the Government reserves the right to return at any time, without previous notice to the contractor, to the sam-

pling and testing procedures specified in this specification.

6.3 Shield brick.—The brick is obtainable from Johns Manville Co., New York.

6.4 Electric heater.—The 500-watt electric heater of the Precision Scientific Co., or equivalent, is satisfactory.

6.5 Distillation.—The distillation should not be continued beyond 620° F. because of the danger involved to the apparatus and the operator due to the possible softening of the bottom of the distillation flask and the existing low pressure in the apparatus.

6.6 Stock numbers.—SGF1 and SGF2 are Quartermaster Corps items of supply and carry the following Quartermaster Corps stock numbers:

Type	16-Gage drum	18-Gage drum
SGF1	14-0-875-50	14-0-875-55
SGF2	14-0-880-50	14-0-880-55

Notice.—When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodians:

Army—Chemical Corps
Navy—Bureau of Ordnance
Air Force

Other interest:

Army—M
Navy—Sh S.

MIL-F-12070A

AMENDMENT 1

10 MAY 1956

MILITARY SPECIFICATION

FOG OIL

This amendment forms a part of Military Specification MIL-F-12070A, 8 January 1954, and has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

Page 3, paragraph 4.4.2.2, line 20: Delete "10 ± 2 mm." and substitute "16 ± 0.2 mm."

Custodians:

Army—Chemical Corps
Navy—Bureau of Ordnance
Air Force

Other interests:

Army—M
Navy—ShS

FED. SUP. CLASS.
9150

APPENDIX B
GAS CHROMATOGRAPHY DATA

GAS CHROMATOGRAPHY DATA

Gas chromatograms of 27 oil fractions and their related oil fogs are included in this section. Preceding the oil/oil fog charts is a "Chromatographic Standards" chart, obtained with synthetic mixtures of alcohols, acids and hydrocarbons.

The standard chart is preceded by a Table describing the compositions of the three mixtures.

Oil/oil fog Chart Nos. 2-23 show the GC's of the oil fractions together with charts of the corresponding oil fog fraction. Where compositions have been identified, they are indicated on the chart and listed on the accompanying Table.

Chart Nos. 24-31 show representative oil fractions compared with corresponding normal and high temperature generated oil fog fractions.

CHART 1. GAS CHROMATOGRAPHY STANDARDS

Key

Alcohol Standard

A.	$C_{11}H_{23}OH$	1-undecanol
B.	$C_{12}H_{25}OH$	1-dodecanol
C.	$C_{14}H_{29}OH$	1-tetradecanol
D.	$C_{16}H_{33}OH$	1-hexadecanol
E.	$C_{18}H_{37}OH$	1-octadecanol

Acid Standard

A.	$C_7H_{15}COOH$	octanoic acid	(caprylic acid)
B.	$C_9H_{19}COOH$	decanoic acid	(capric acid)
C.	$C_{11}H_{23}COOH$	dodecanoic acid	(lauric acid)
D.	$C_{13}H_{27}COOH$	tetradecanoic acid	(myristic acid)
E.	$C_{15}H_{31}COOH$	hexadecanoic acid	(palmitic acid)
F.	$C_{17}H_{35}COOH$	octadecanoic acid	(stearic acid)

Hydrocarbon Standard

A.	$C_{10}H_{22}$	n-decane
B.	$C_{12}H_{26}$	n-dodecane
C.	$C_{14}H_{30}$	n-tetradecane
D.	$C_{16}H_{34}$	n-hexadecane
E.	$C_{17}H_{36}$	n-heptadecane
F.	$C_{18}H_{38}$	n-octadecane
G.	$C_{19}H_{40}$	n-nonadecane
H.	$C_{20}H_{42}$	n-eicosane
I.	$C_{21}H_{44}$	n-heneicosane
J.	$C_{22}H_{46}$	n-docosane
K.	$C_{23}H_{48}$	n-tricosane
L.	$C_{24}H_{50}$	n-tetracosane
M.	$C_{28}H_{58}$	n-octacosane
N.	$C_{29}H_{60}$	n-nonacosane

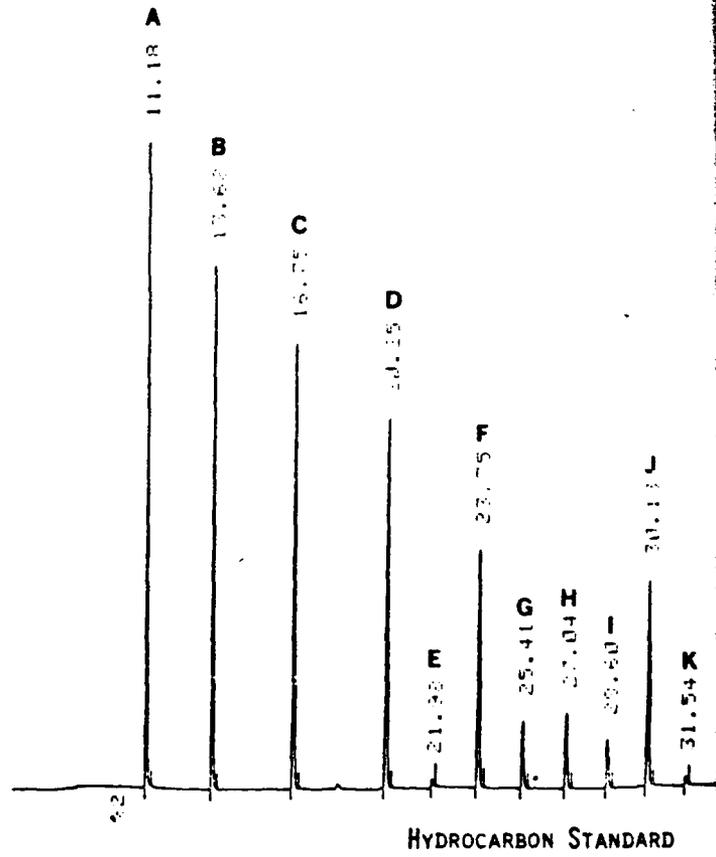
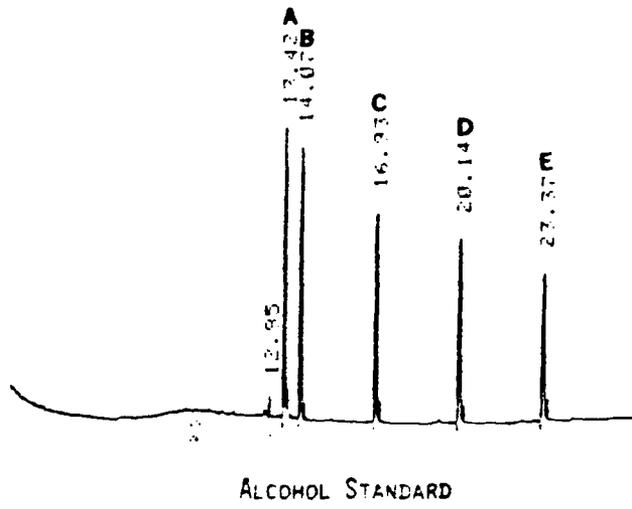
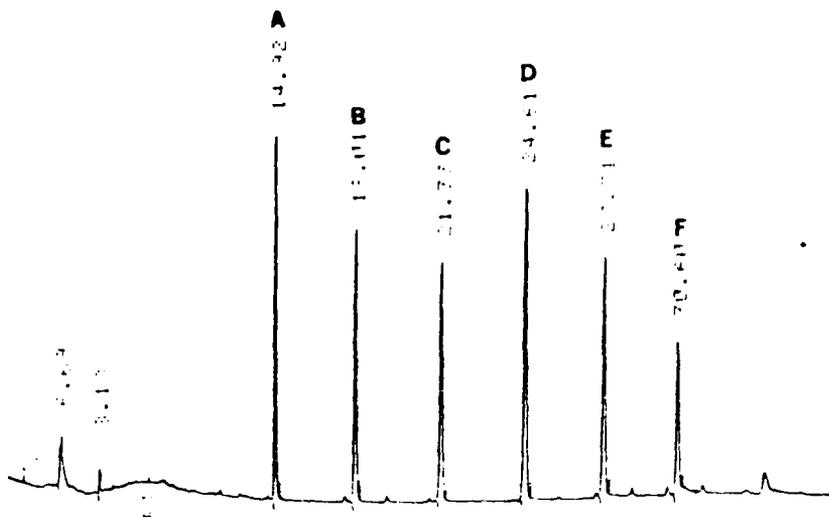
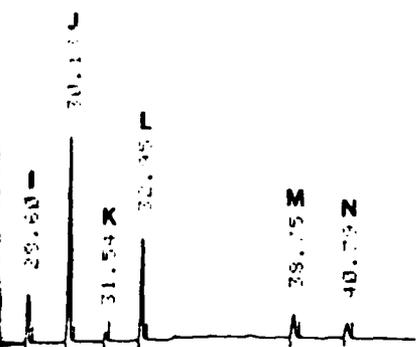


CHART 1. GAS CHROMATOGRAPHY STA



ACID STANDARD



STANDARD

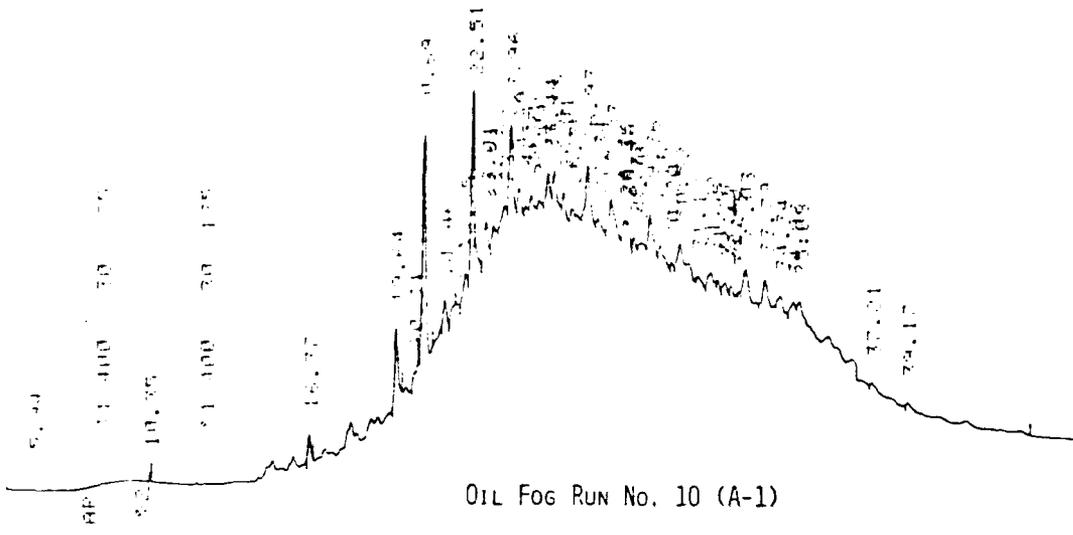
GRAPHY STANDARDS

W

CHART 2. ALIPHATIC FRACTION; OIL NO. 1 AND CORRESPONDING OIL FOGS

Key

- A. $C_{14}H_{30}$ n-tetradecane
- B. $C_{16}H_{34}$ n-hexadecane
- C. $C_{17}H_{36}$ branched alkane
- D. $C_{18}H_{38}$ n-octadecane
- E. $C_{19}H_{40}$ n-nonadecane
- F. $C_{20}H_{42}$ n-eicosane
- G. $C_{21}H_{44}$ branched alkane
- H. $C_{21}H_{44}$ n-heneicosane
- I. $C_{22}H_{46}$ branched alkane



OIL FOG RUN No. 10 (A-1)

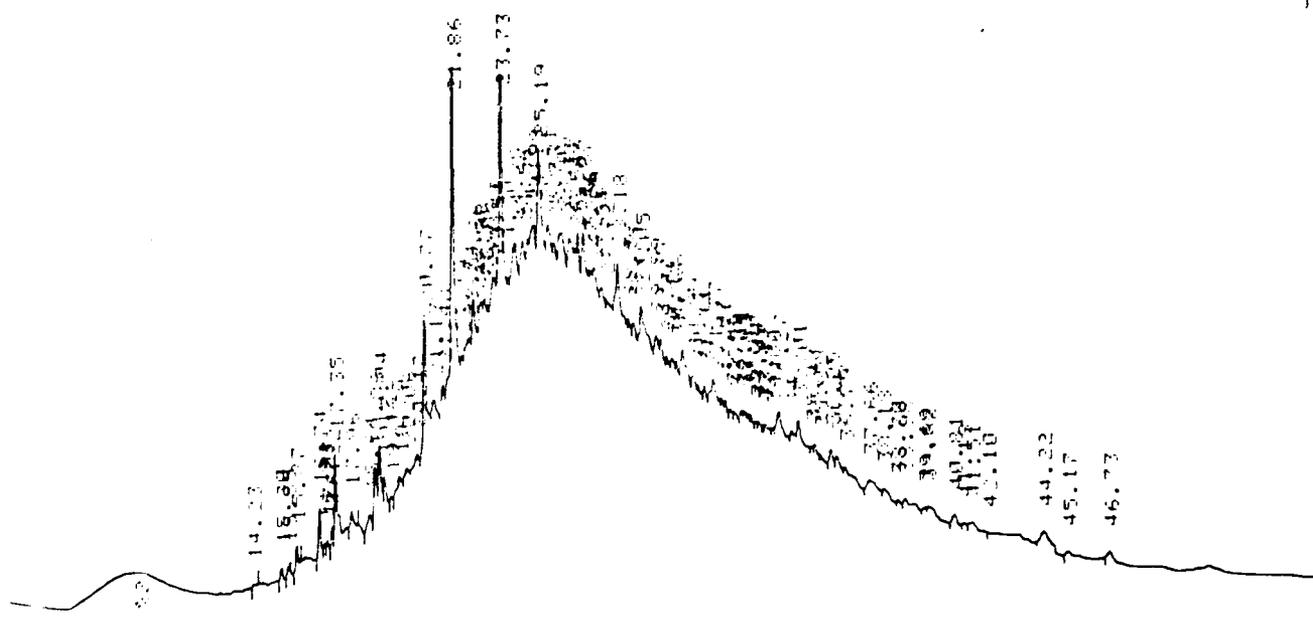


CHART 3. ALIPHATIC FRACTION; OIL NO. 2 AND CORRESPONDING OIL FOGS

Key

A. $n\text{-C}_{19}\text{H}_{40}$ n-nonadecane

CHART 4. ALIPHATIC FRACTION; OIL NO. 3 AND CORRESPONDING OIL FOGS

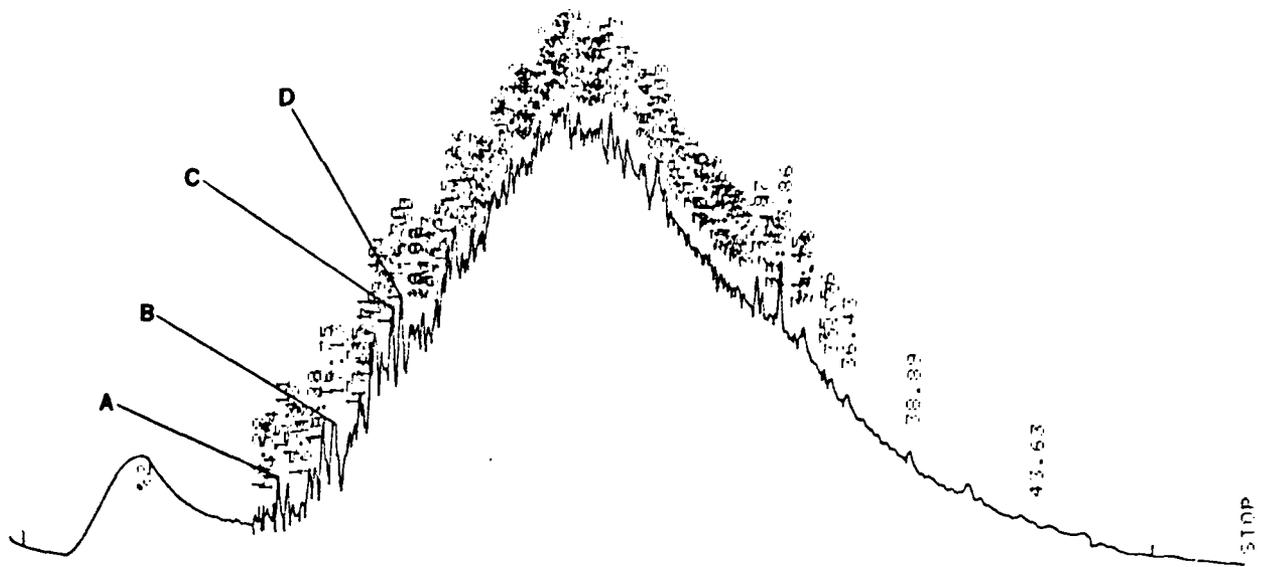
Key

- A. $C_{14}H_{30}$ n-tetradecane
- B. $C_{17}H_{36}$ n-heptadecane
- C. $C_{20}H_{42}$ n-eicosane
- D. $C_{21}H_{44}$ n-heneicosane

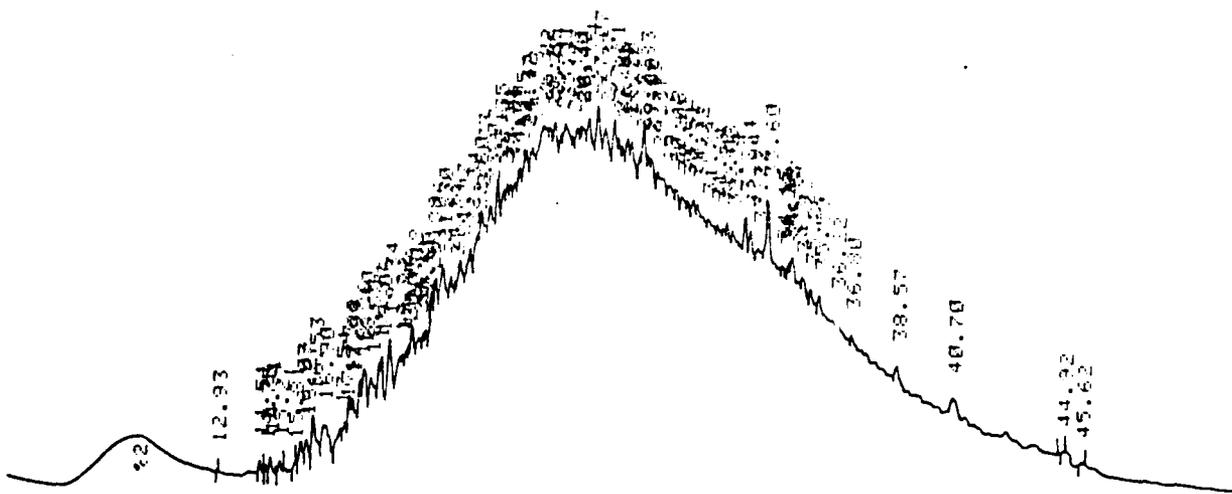
CHART 5. FIRST AROMATIC FRACTION: OIL NO. 1 AND CORRESPONDING OIL FOGS

Key

- A. $C_{12}H_{16}$ 2,6-dimethyl-1,2,3,4-tetrahydronaphthalene
- B. $C_{13}H_{16}$
- C. $C_{13}H_{14} + C_{14}H_{20} + C_{15}H_{24}$
- D. $C_{13}H_{16}O$ or $C_{14}H_{20}$

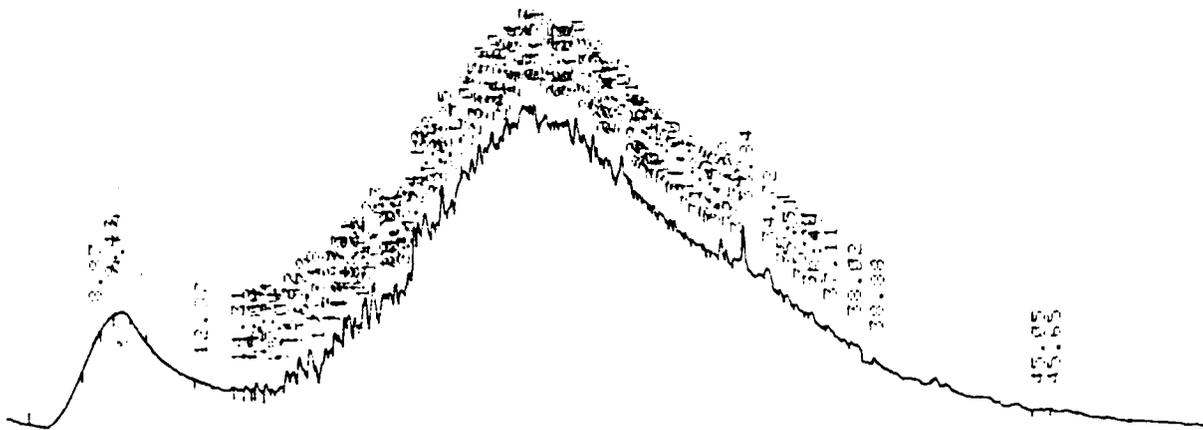


OIL No. 1



OIL FOG RUN No. 2 (B-1)

CHART 5. FIRST AROMATIC FRACTION:



OIL FOG RUN No. 10 (A-1)

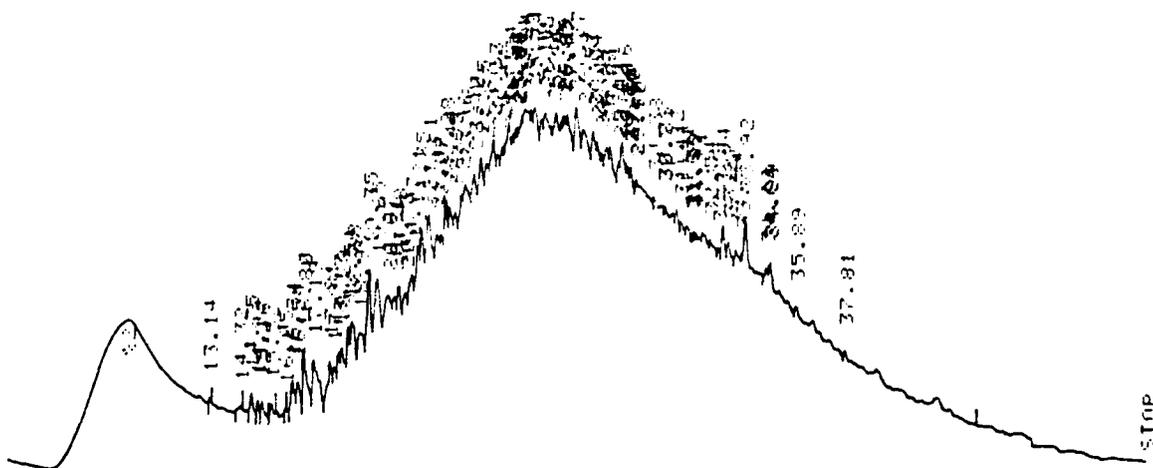
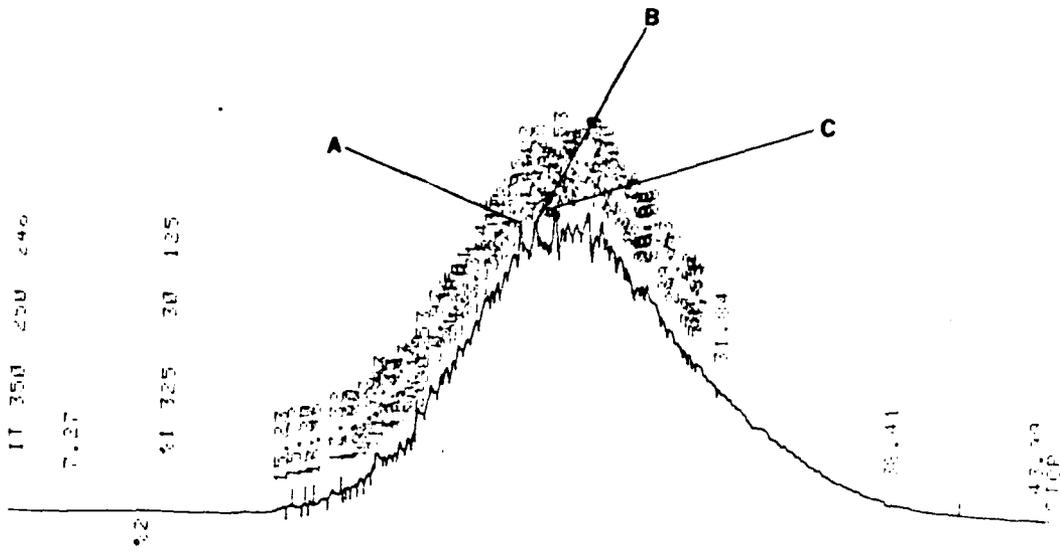


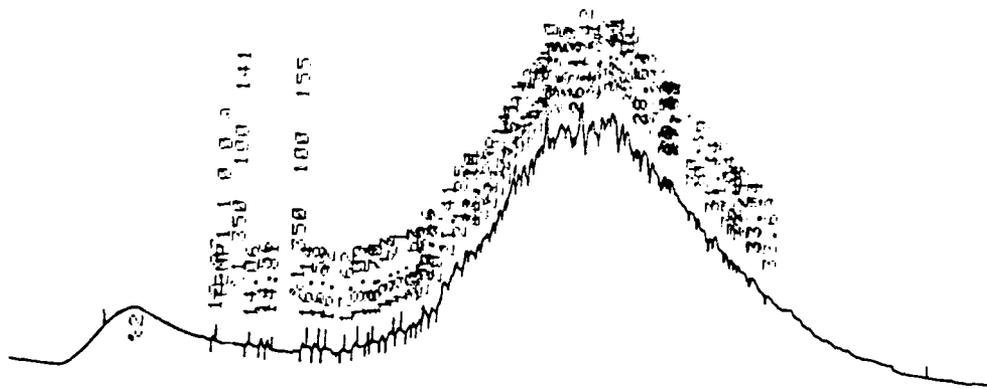
CHART 6. FIRST AROMATIC FRACTION: OIL NO. 2 AND CORRESPONDING OIL FOCS

Key

- A. $C_{20}H_{24}$ 3,6,9,9,10,10-hexamethyl-9,10-dihydrophenanthrene
- B. $C_{20}H_{32}$
- C. $C_{16}H_{18}$



OIL No. 2



OIL FOG RUN No. 4 (B-2)

CHART 6. AROMATIC FRACTION: OIL NO. 2 AND

CHART 7. FIRST AROMATIC FRACTION; OIL NO. 3 AND CORRESPONDING OIL FOGS

Key

- A. $C_{15}H_{22}$
- B. $C_{15}H_{18}$ dimethyl isopropylnaphthalene
- C. $C_{14}H_{16}$

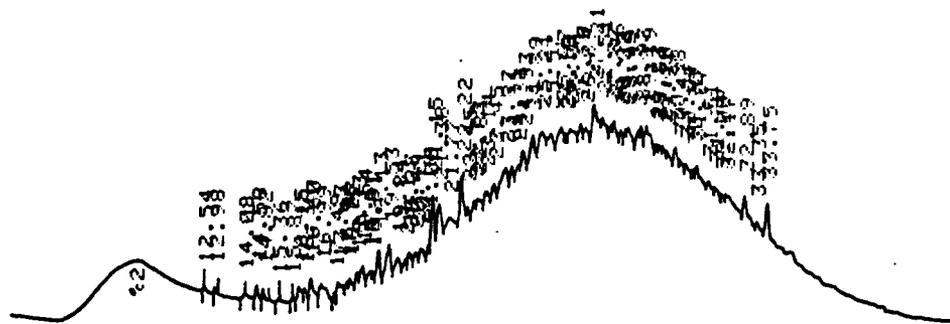
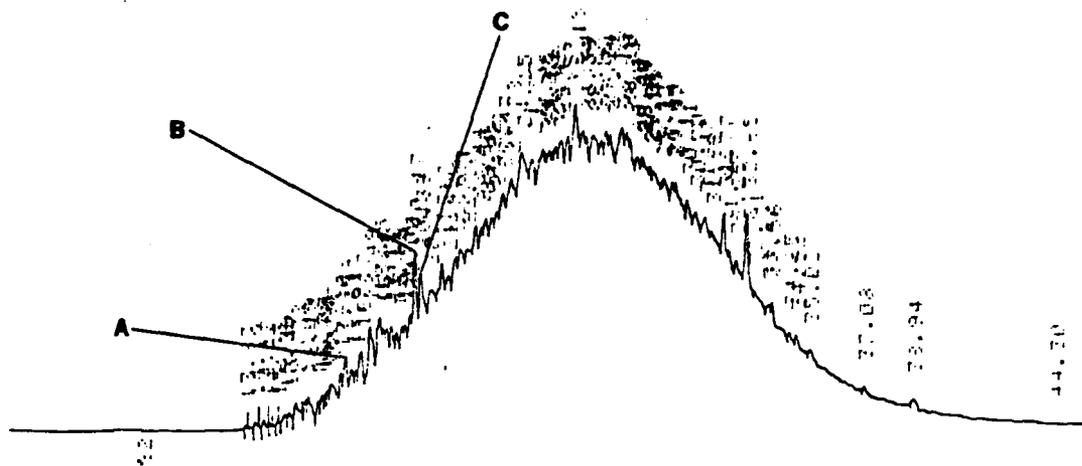
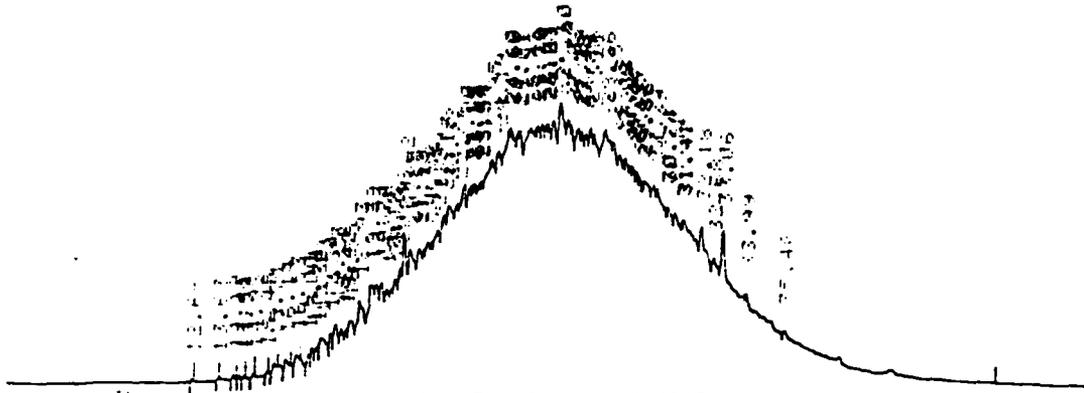
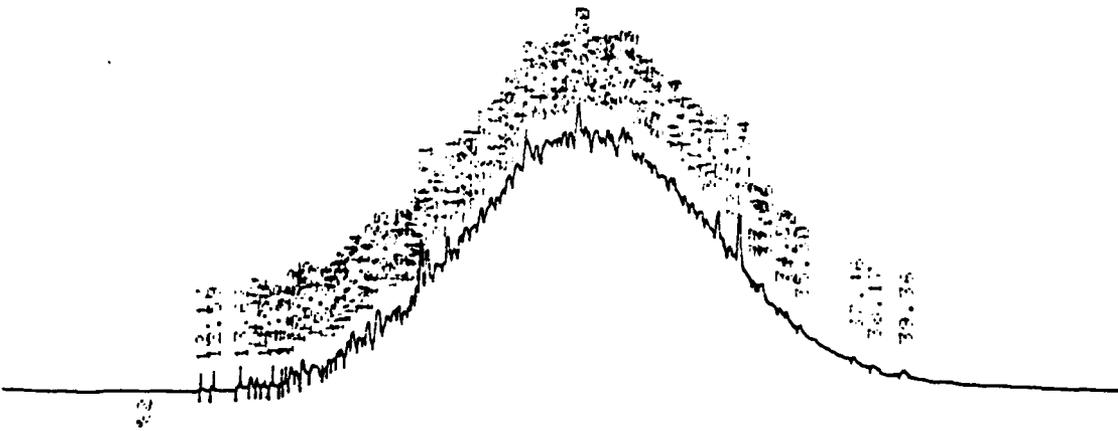


CHART 7. FIRST AROMATIC FRACTION: OIL



OIL FOG RUN No. 8 (A-3)



OIL FOG RUN No. 7 (C-3)

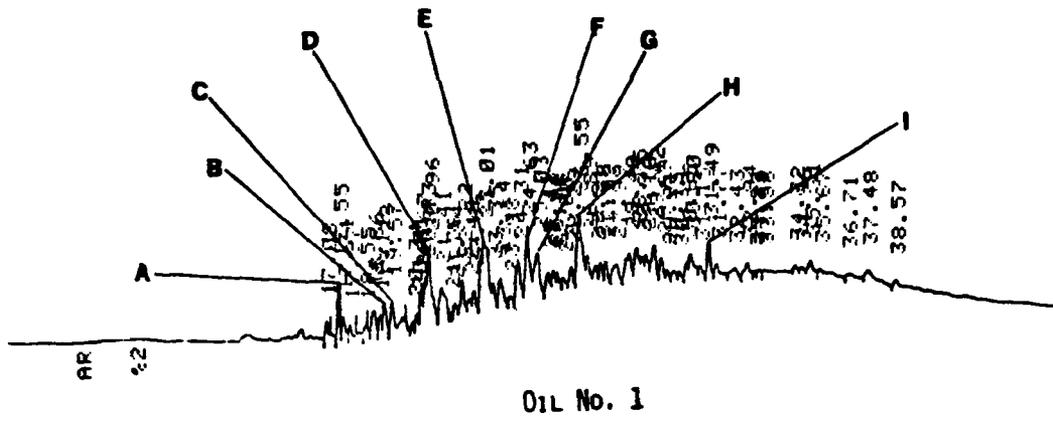
OIL NO. 3 AND CORRESPONDING OIL FOGS

2

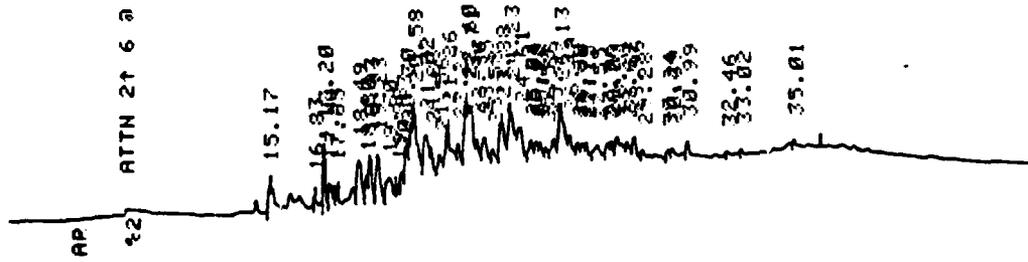
CHART 8. MIDDLE AROMATIC FRACTION; OIL NO. 1 AND CORRESPONDING OIL FOGS

Key

- A. $C_{15}H_{24}O$ methyl-di-tert-butylphenol
- B. $C_{16}H_{34}$ n-hexadecane
- C. $C_{14}H_{14}$ dimethylbiphenyl + $C_{15}H_{16}$ dimethylbenzylbenzene
- D. $C_{14}H_{12}$ methylfluorene
- E. $C_{15}H_{14}$ dimethylfluorene
- F. $C_{15}H_{12}$ methylphenanthrene
- G. $C_{15}H_{12}O$ 9-methoxyanthracene or $C_{18}H_{16}$
- H. $C_{16}H_{14}$ dimethylphenanthrene
- I. $C_{20}H_{32}$ n-butyl-n-hexyl tetrahydronaphthalene

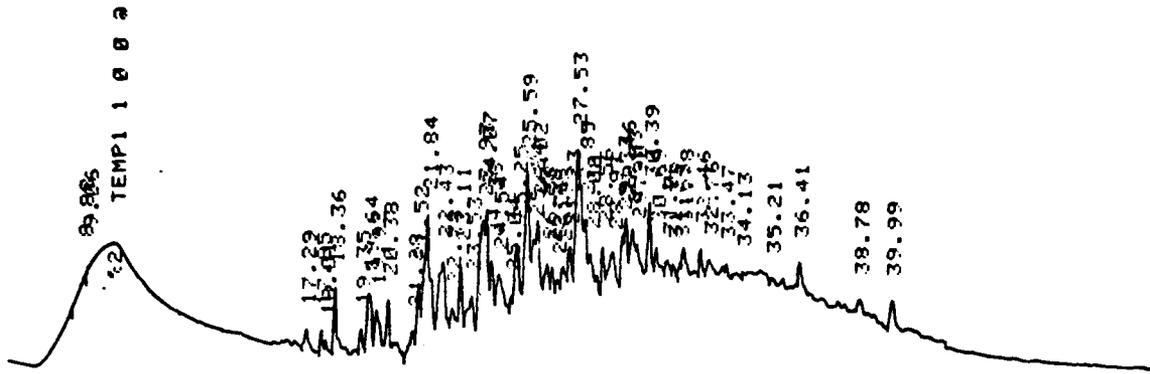


OIL No. 1



OIL FOG RUN No. 2 (B-1)

CHART 8. MIDDLE AROMATIC FRACTION: OIL NO.



OIL FOG RUN No. 10 (A-1)



OIL FOG RUN No. 6 (C-1)

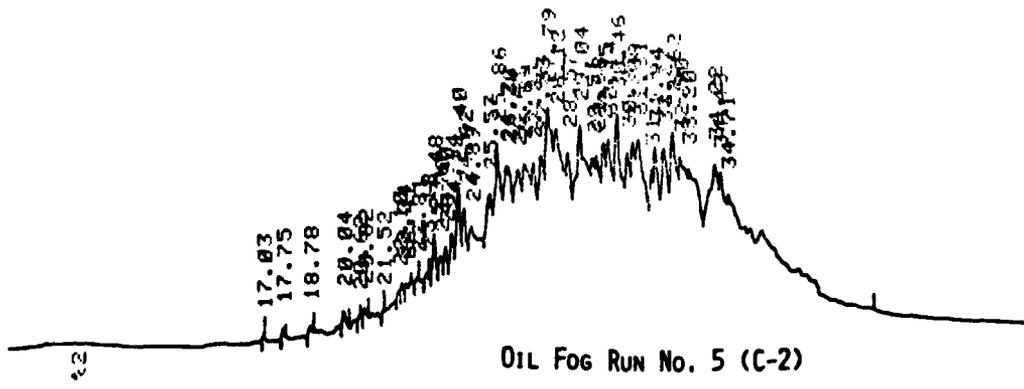
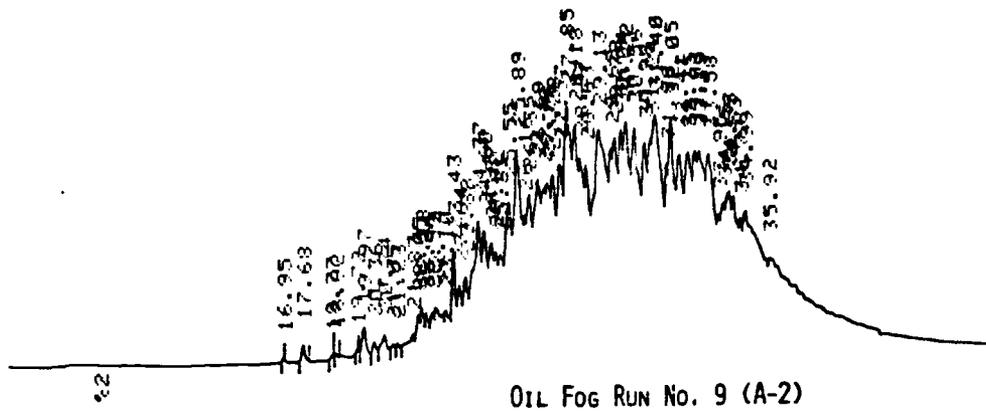
OIL NO. 1 AND CORRESPONDING OIL FOGS

2

CHART 9. MIDDLE AROMATIC FRACTION; OIL NO. 2 AND CORRESPONDING OIL FOGS

Key

- A. $C_{16}H_{14}$ dimethylphenanthrene + $C_{15}H_{14}$ dimethylfluorene
- B. $C_{17}H_{16}$ trimethylphenanthrene
- C. $C_{18}H_{18}$ alkylphenanthrene



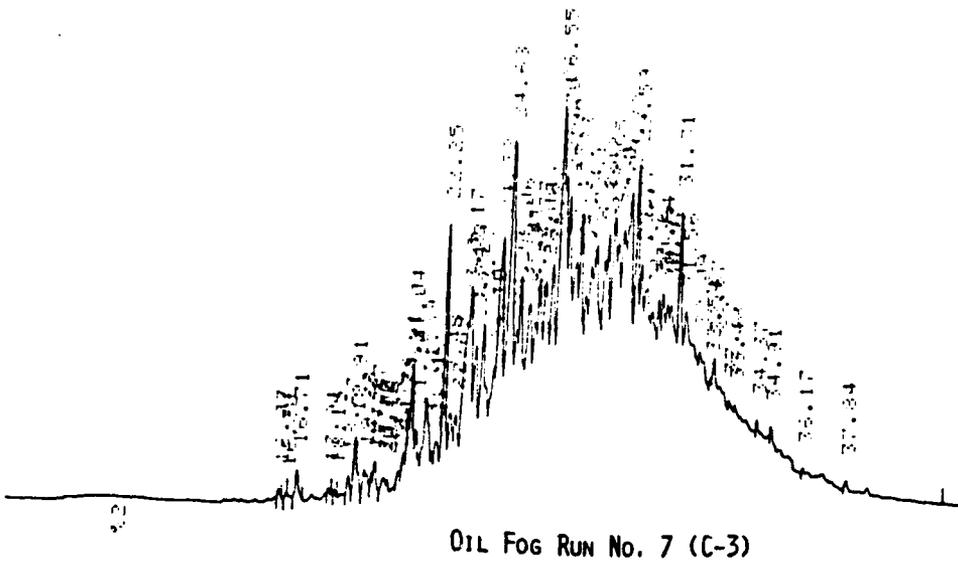
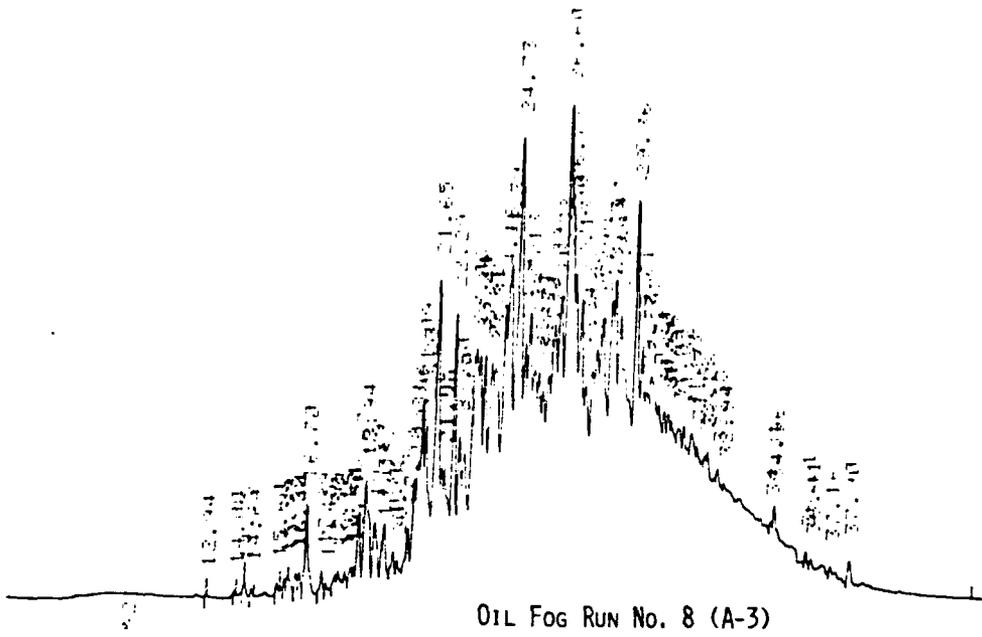
OIL NO. 2 AND CORRESPONDING OIL FOGS
 B-20

2

CHART 10. MIDDLE AROMATIC FRACTION; GIL NO. 3 AND CORRESPONDING OIL FOCS

Key

- A. $C_{14}H_{12}$ methylfluorene
- B. $C_{14}H_{10}$ phenanthrene or anthracene
- C. $C_{15}H_{14}$ dimethylfluorene
- D. $C_{15}H_{12}$ methylphenanthrene or methylanthracene
- E. $C_{15}H_{12}$ methylphenanthrene or methylanthracene
- F. $C_{15}H_{12}O$ 9-methoxyanthracene
- G. $C_{18}H_{18}$ 1-methyl-7-isopropylphenanthrene
- H. $C_{20}H_{32}$ probably n-butyl-n-hexyltetrahydronaphthalene



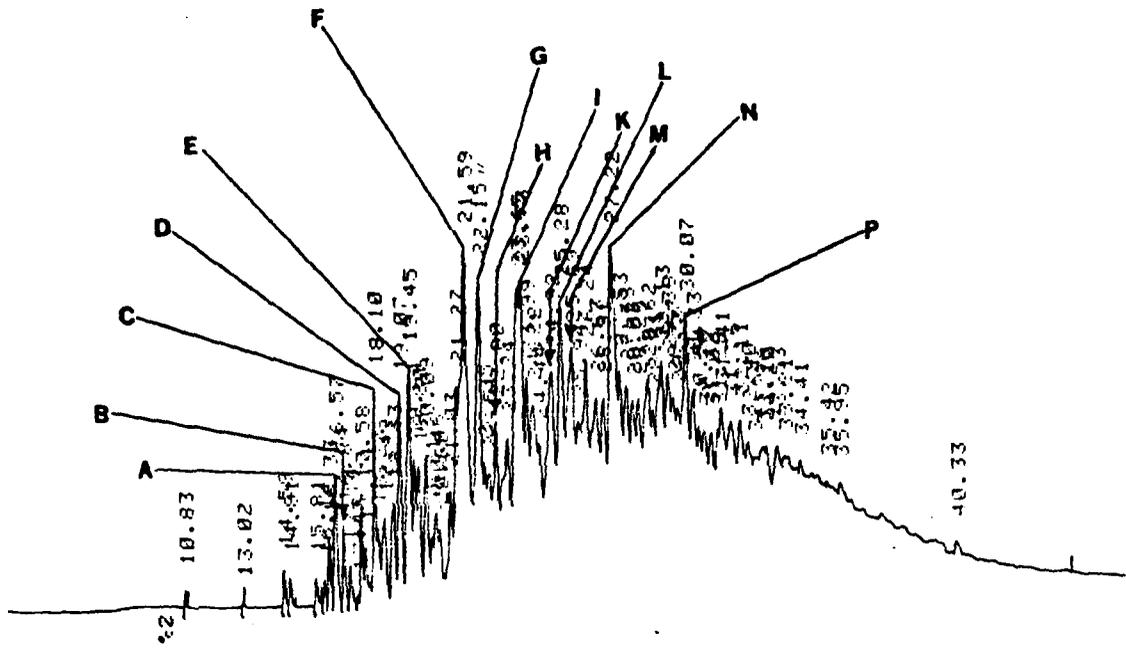
OIL NO. 3 AND CORRESPONDING OIL FOGS

2

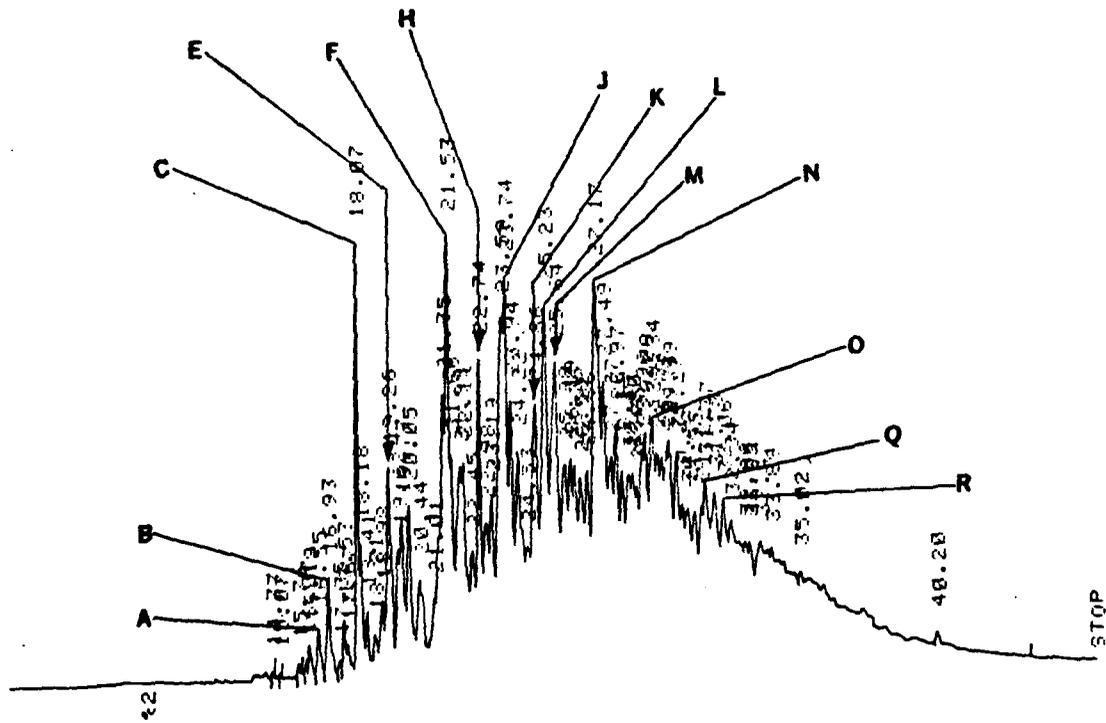
CHART 11. HEAVY AND HEAVIEST AROMATIC FRACTIONS: OIL NO. 1 AND CORRESPONDING OIL FUGS

Key

A.	$C_{12}H_{12}$	dimethylnaphthalene
B.	$C_{12}H_8$	acenaphthalene
C.	$C_{15}H_{24}O$	2,6-di-t-butyl-4-methylphenol (ionol)
D.	$C_{13}H_{14}$	trimethylnaphthalene
E.	$C_{13}H_{10}$	fluorene or phenalene
F.	$C_{14}H_{12}$	1-methyl fluorene
G.	$C_{14}H_{16}$	C_4 -alkylnaphthalene
H.	$C_{14}H_{10}$	anthracene or phenanthrene
I.	$C_{15}H_{14}$	dimethylfluorene
J.	$C_{15}H_{14}$	alkenyl dibenzene
K.	$C_{15}H_{12}$	methylphenanthrene or methylanthracene
L.	$C_{15}H_{12}$	methylphenanthrene or methylanthracene
M.	$C_{15}H_{12}O$	methoxyanthracene or $C_{16}H_{16}$ isomer
N.	$C_{16}H_{14}$	dimethylphenanthrene
O.	$C_{16}H_{14}$	ethyl or dimethylantracene
P.	$C_{18}H_{18}$	C_4 -alkylphenanthrene or C_4 -alkylantracene
Q.	$C_{18}H_{18}$	C_4 -alkylphenanthrene or C_4 -alkylantracene
R.	$C_{19}H_{30}$	2-n-butyl-5-hexylindan

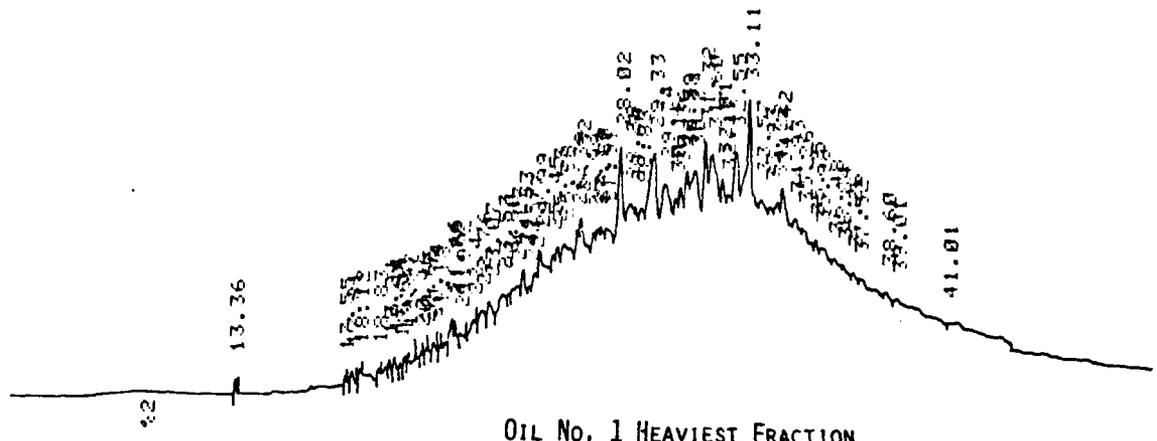


OIL No. 1 HEAVY FRACTION

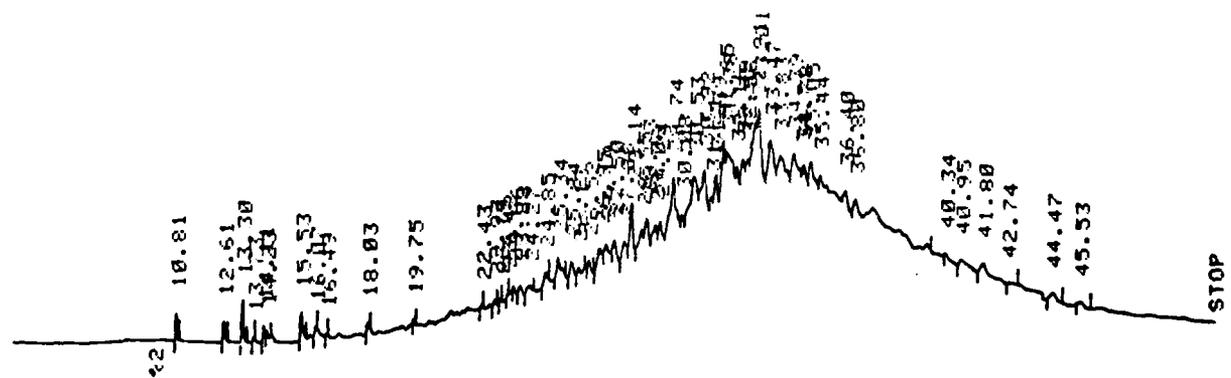


OIL FOG RUN No. 2 (B-1) HEAVIEST FRACTION

CHART 11. HEAVY AND HEAVIEST AROMATIC FRACTIONS: (



OIL No. 1 HEAVIEST FRACTION



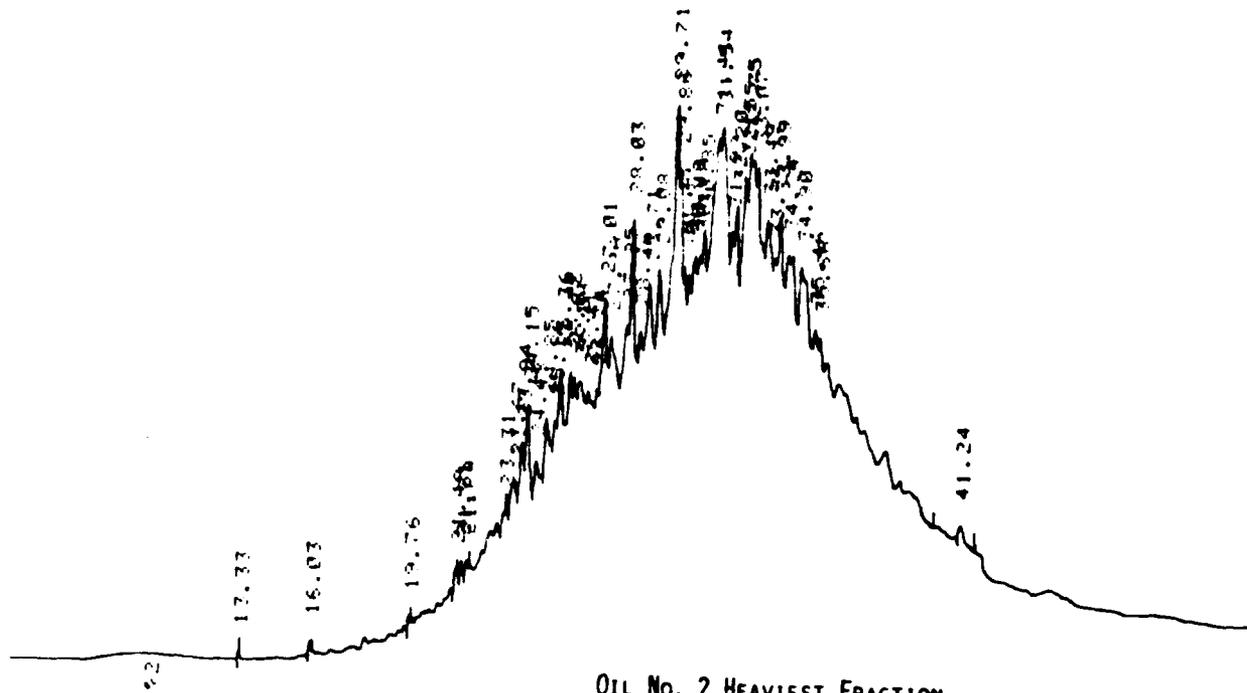
OIL FOG RUN No. 2 (B-1) HEAVY FRACTION

S: OIL NO. 1 AND CORRESPONDING OIL FOGS

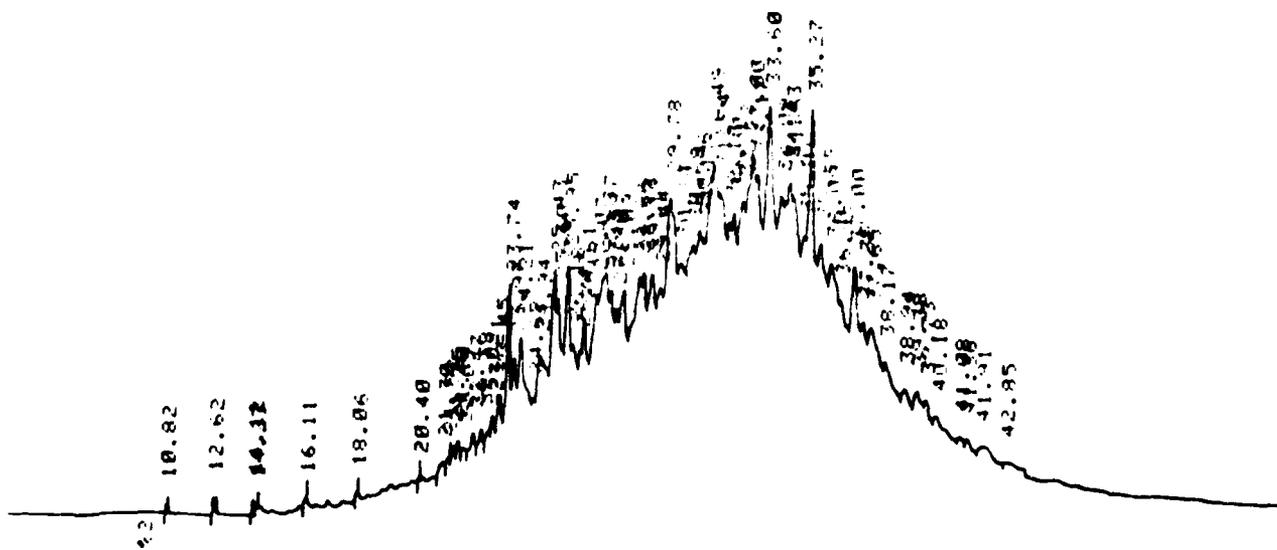
CHART 12. HEAVY AND HEAVIEST AROMATIC FRACTIONS; OIL NO. 2 AND CORRESPONDING OIL FOGS

Key

- A. $C_{13}H_{10}$ fluorene or phenalene
- B. $C_{14}H_{12}$ 1-methylfluorene
- C. $C_{14}H_{10}$ phenanthrene or anthracene
- D. $C_{15}H_{14}$ dimethylfluorene
- E. $C_{15}H_{12}$ methylphenanthrene or methylanthracene
- F. $C_{15}H_{12}O$ methoxyanthracene or $C_{17}H_{16}$ trimethylphenanthrene
- G. $C_{15}H_{12}O$ methoxyanthracene or other isomer
- H. $C_{10}H_{14}$ C_2 -alkylphenanthrene or C_2 -alkylanthracene
- I. $C_{17}H_{16}$ C_3 -alkylphenanthrene or C_3 -alkylanthracene
- J. $C_{17}H_{14}$ 2-benzyl-naphthalene or $C_{18}H_{18}$ C_4 -alkylphenanthrene
- K. $C_{18}H_{18}$ C_4 -alkylphenanthrene or C_4 -alkylanthracene

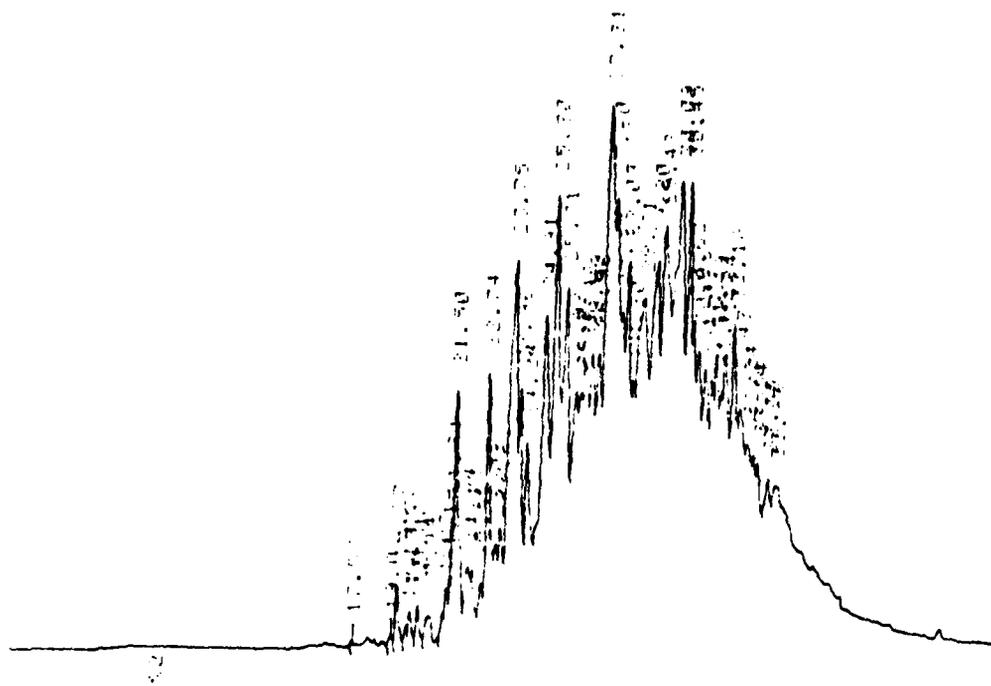


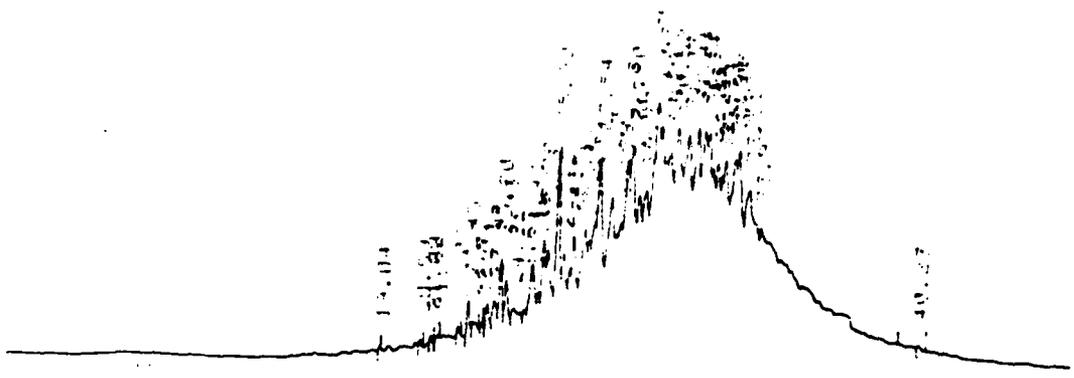
OIL NO. 2 HEAVIEST FRACTION



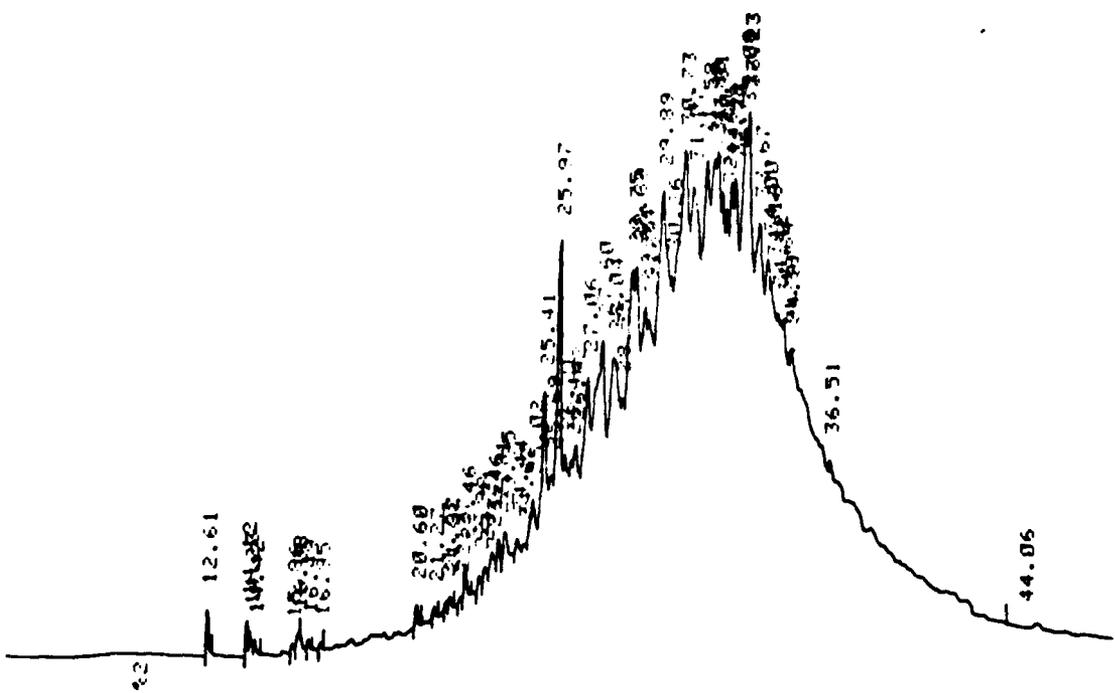
OIL FOG RUN NO. 4 (B-2) HEAVIEST FRACTION

FRACTION: OIL NO. 2 AND CORRESPONDING OIL FOGS



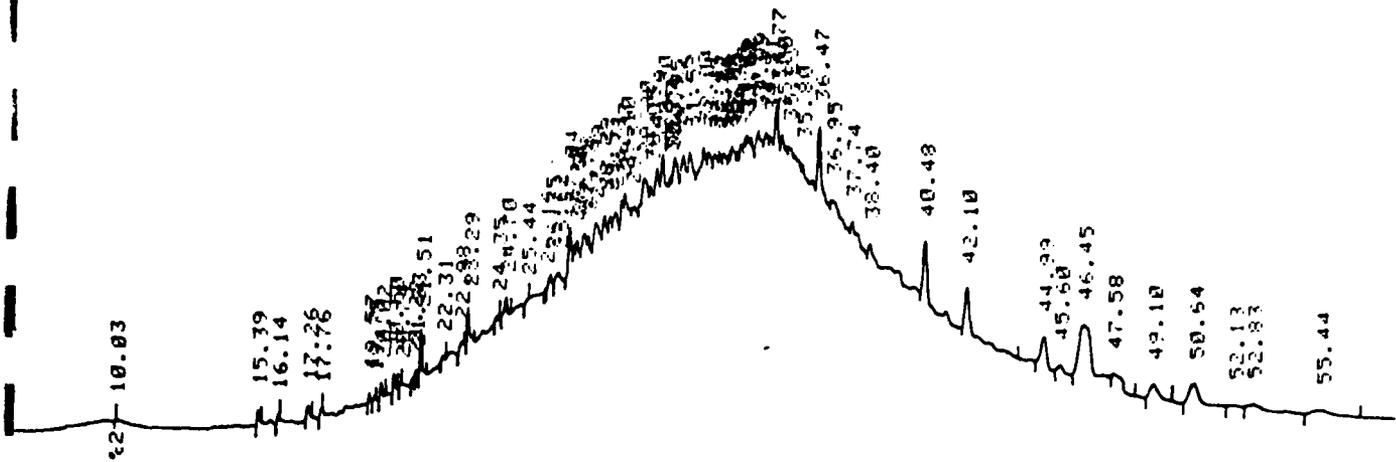


OIL NO. 3 HEAVIEST FRACTION

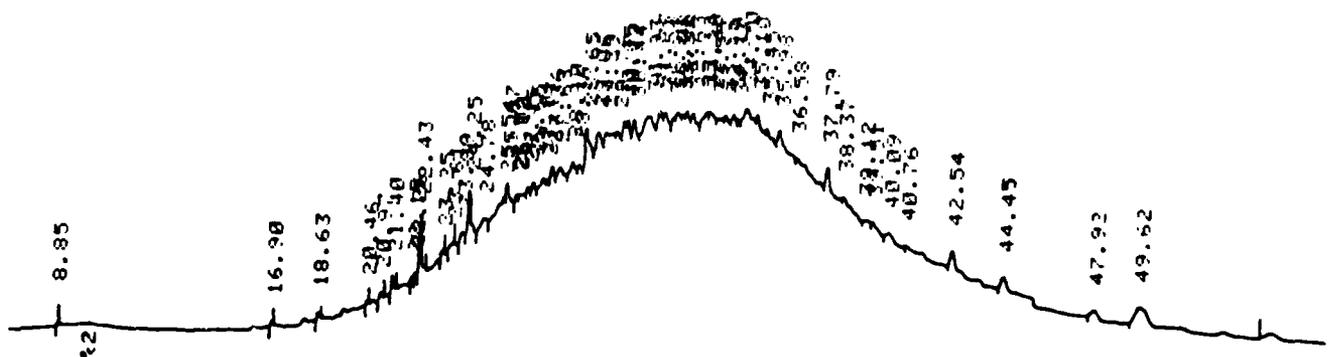


OIL FOG RUN NO. 3 (B-3) HEAVIEST FRACTION

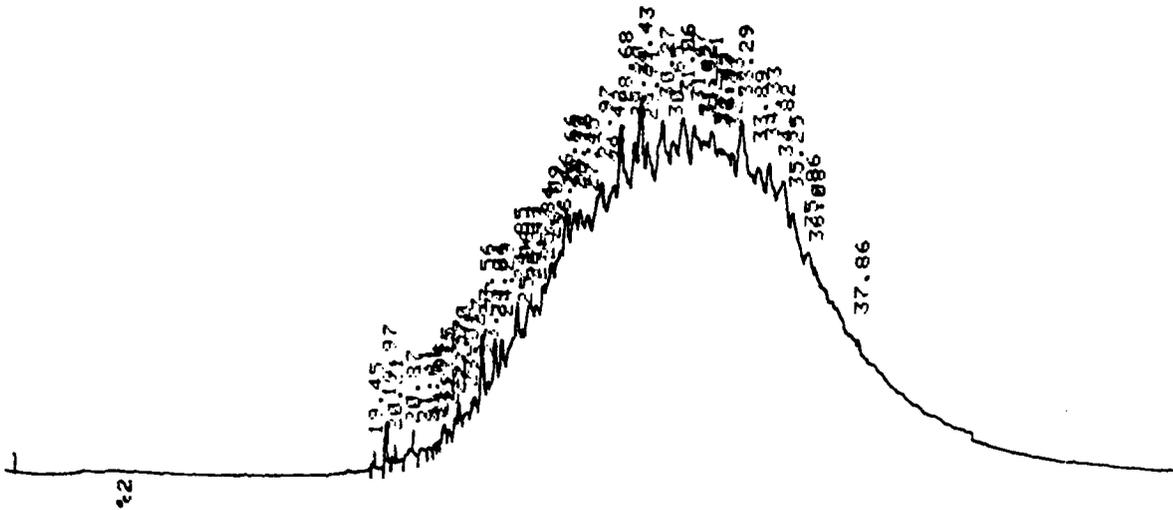
COMPARISONS: OIL NO. 3 AND CORRESPONDING OIL FOGS



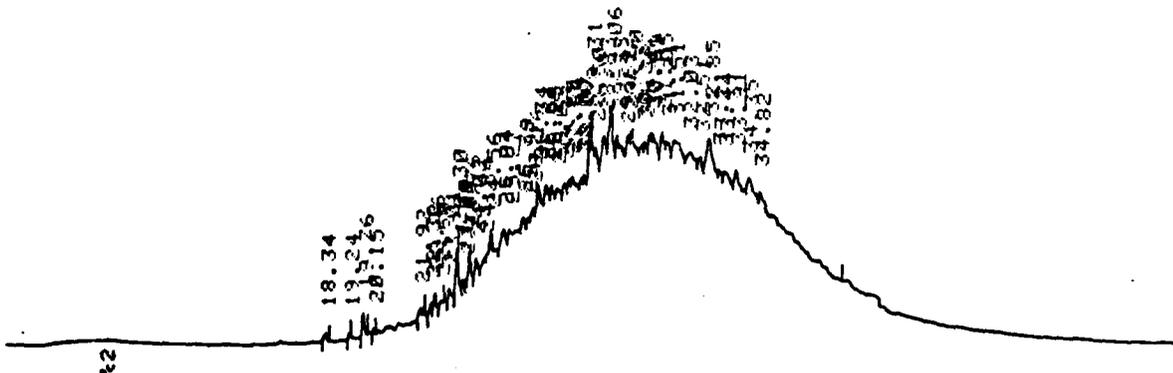
OIL No. 1



OIL FOG RUN No. 2 (B-1)

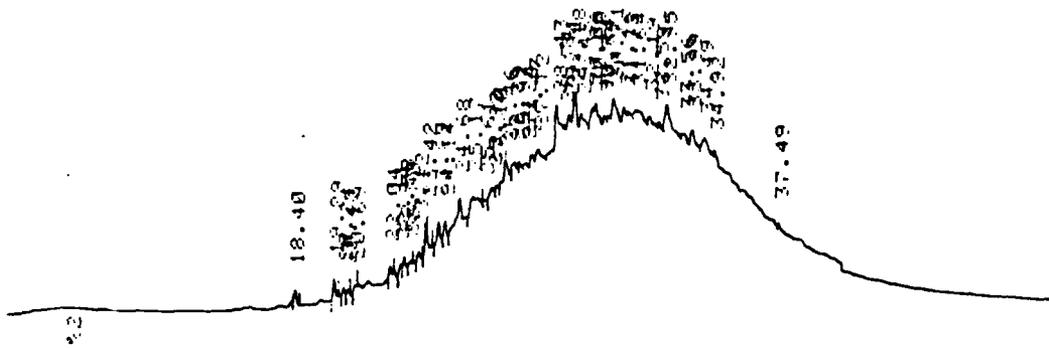


OIL No. 2

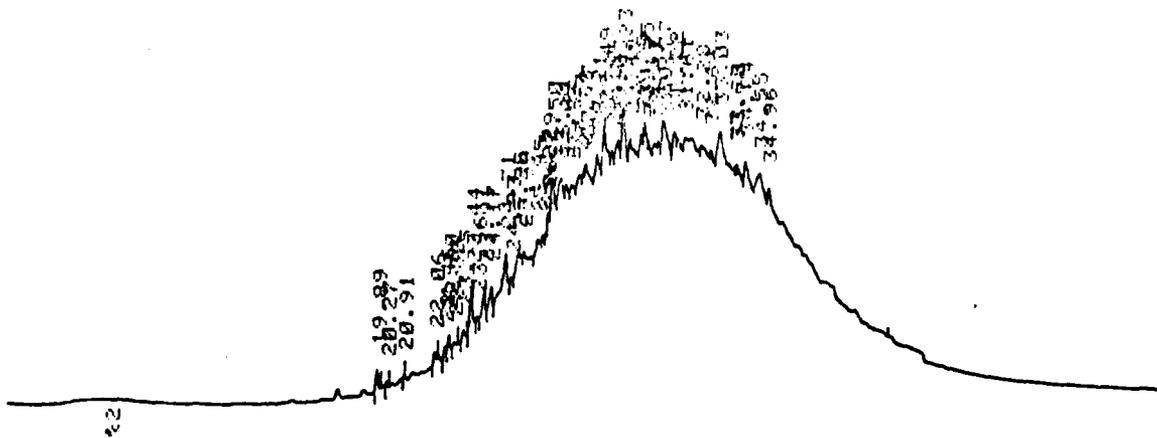


OIL FOG RUN No. 4 (B-2)

CHART 15. ESTER FRACTION: OIL NO. 2 AM

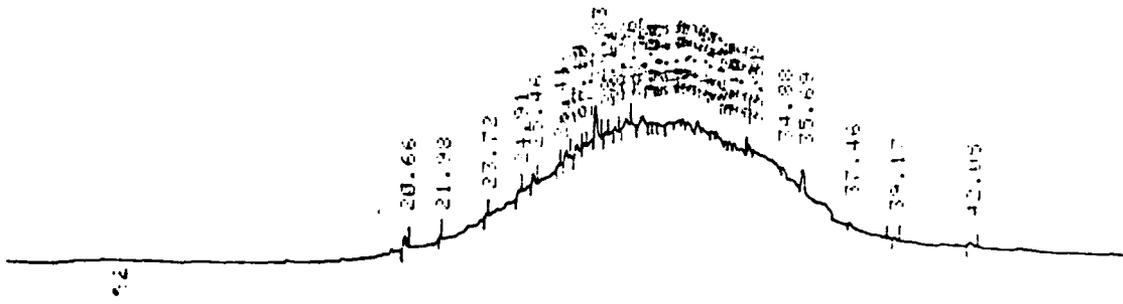


OIL FOG RUN No. 9 (A-2)

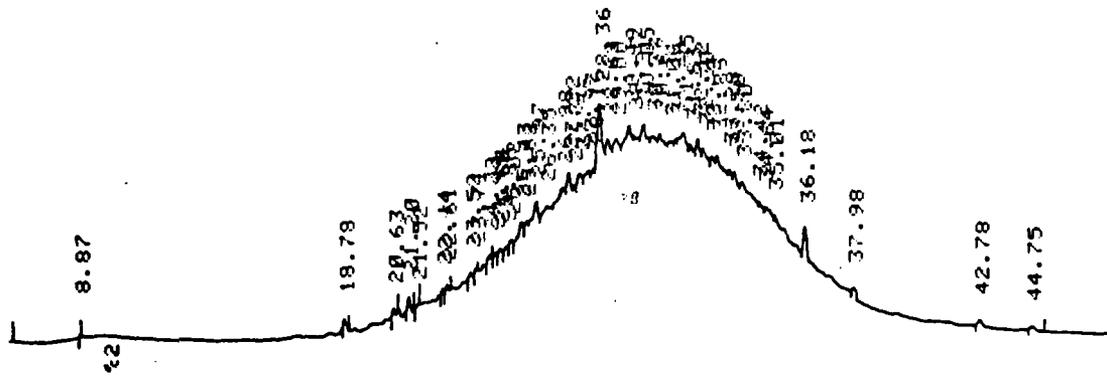


OIL FOG RUN No. 5 (C-2)

2 AND CORRESPONDING OIL FOGS

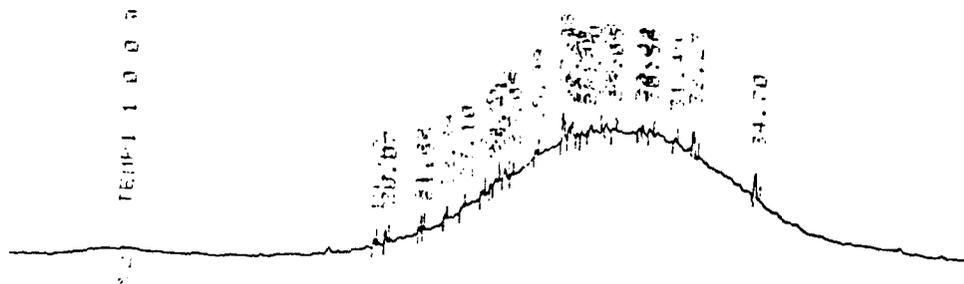


OIL No. 3

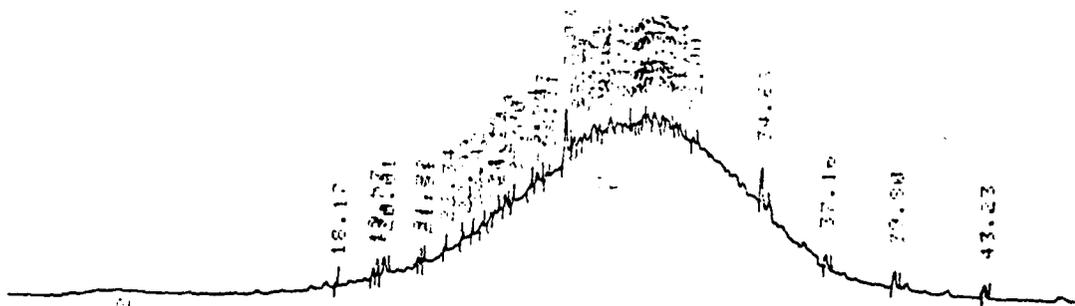


OIL FOG RUN No. 3 (B-3)

CHART 16. ESTER FRACTION: OIL NO. 3



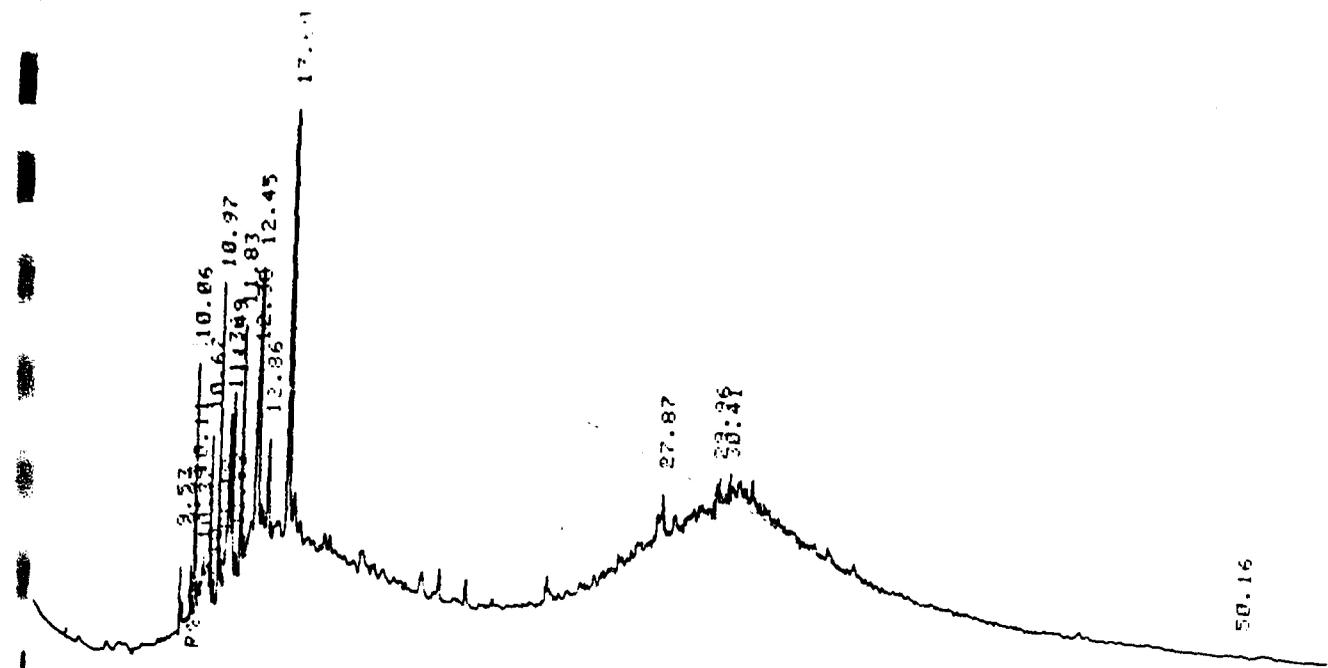
OIL FOG RUN No. 8 (A-3)



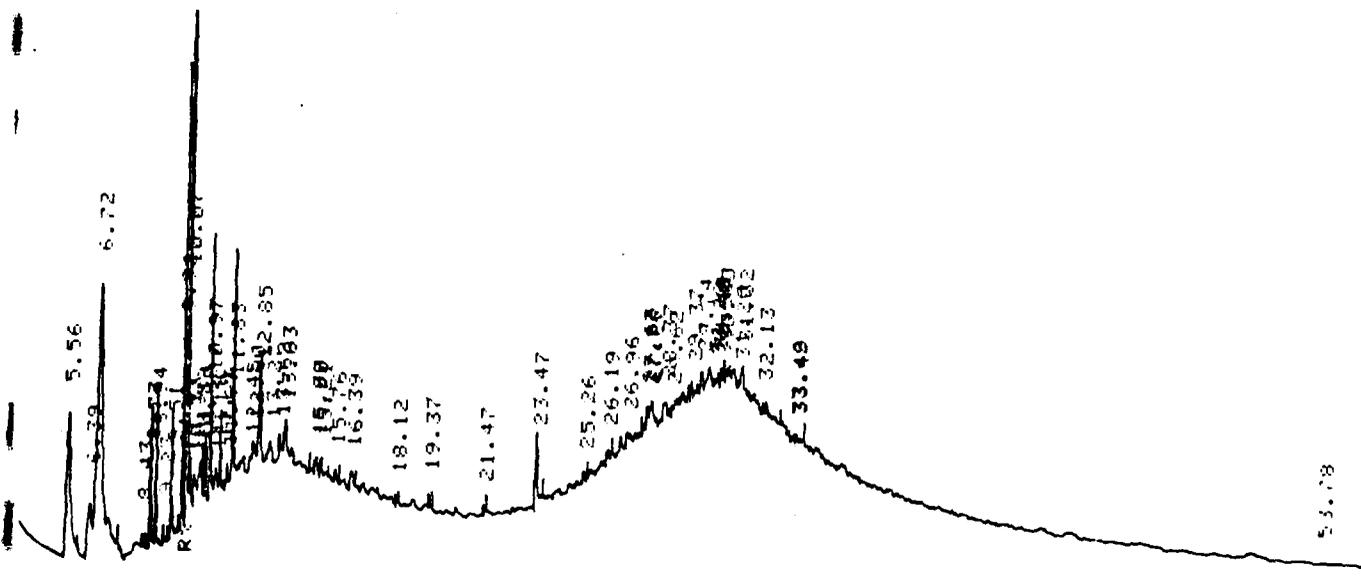
OIL FOG RUN No. 7 (C-3)

NO. 3 AND CORRESPONDING OIL FOGS

0

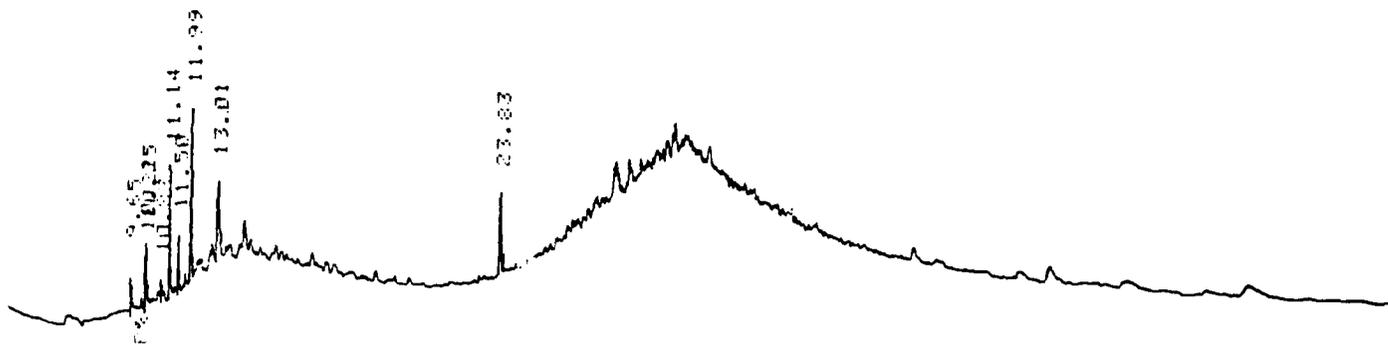


OIL No. 1

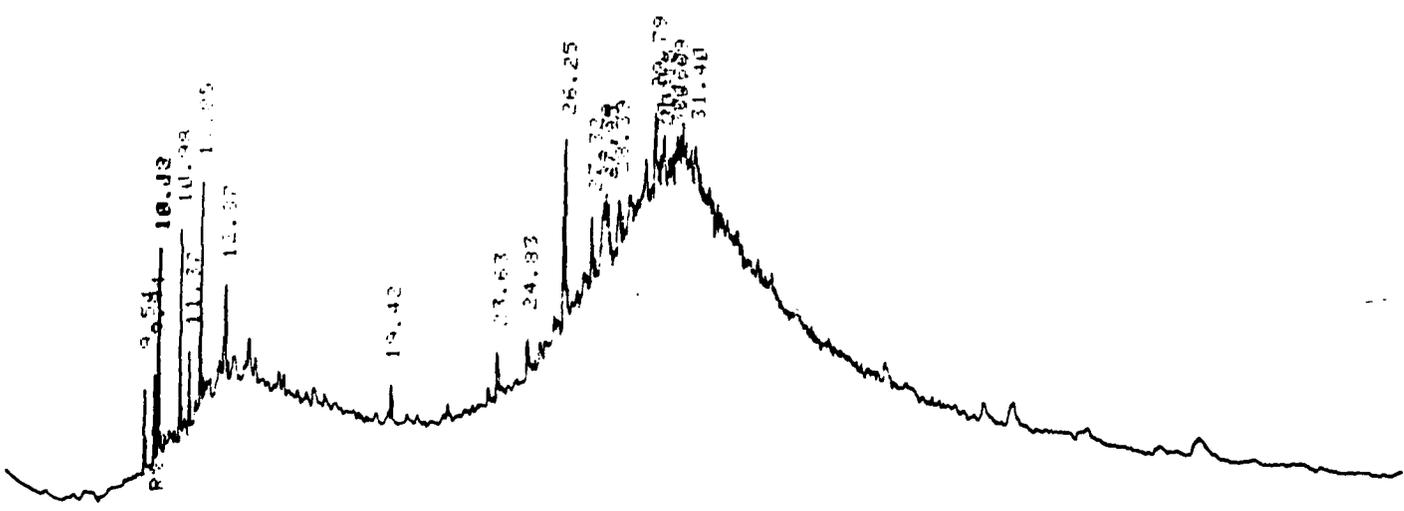


OIL FOG RUN No. 2 (B-1)

CHART 17. ALCOHOL FRACTION: OIL NO. 1



OIL FOG RUN No. 10 (A-1)



OIL FOG RUN No. E (C-1)

OIL NO. 1 AND CORRESPONDING OIL FOGS

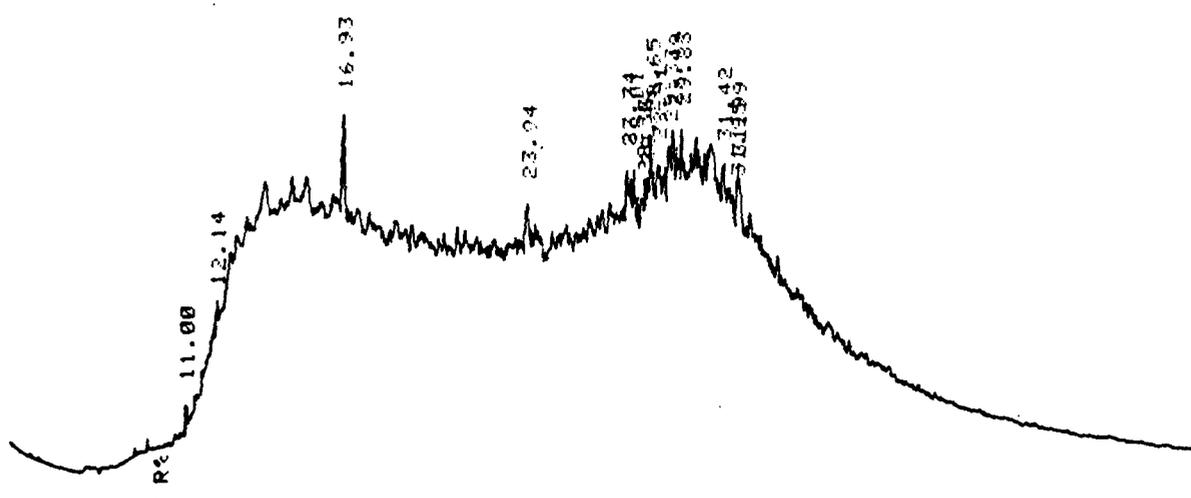
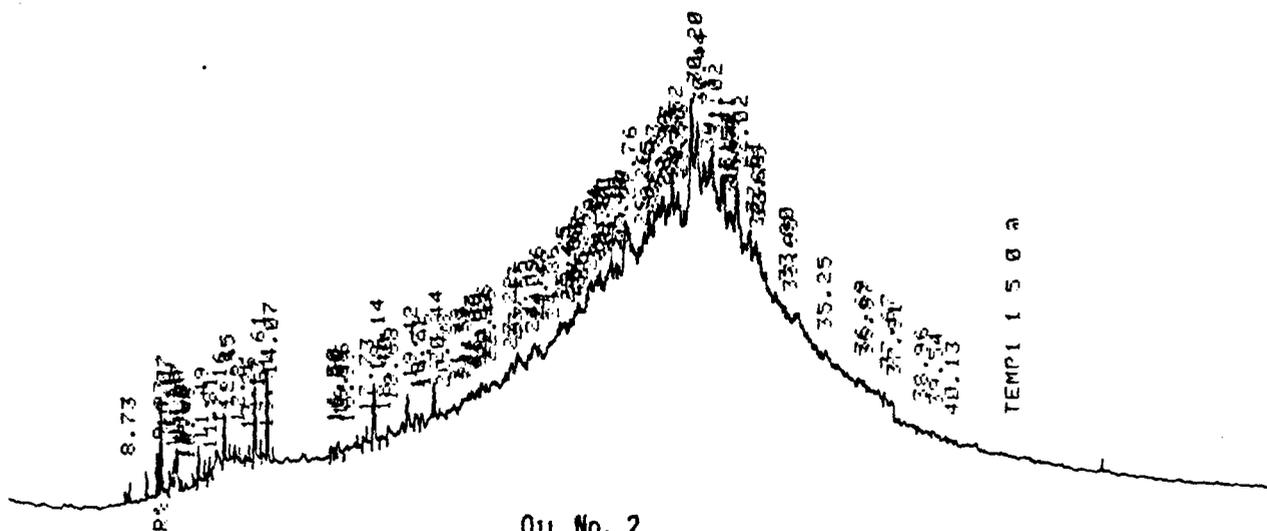
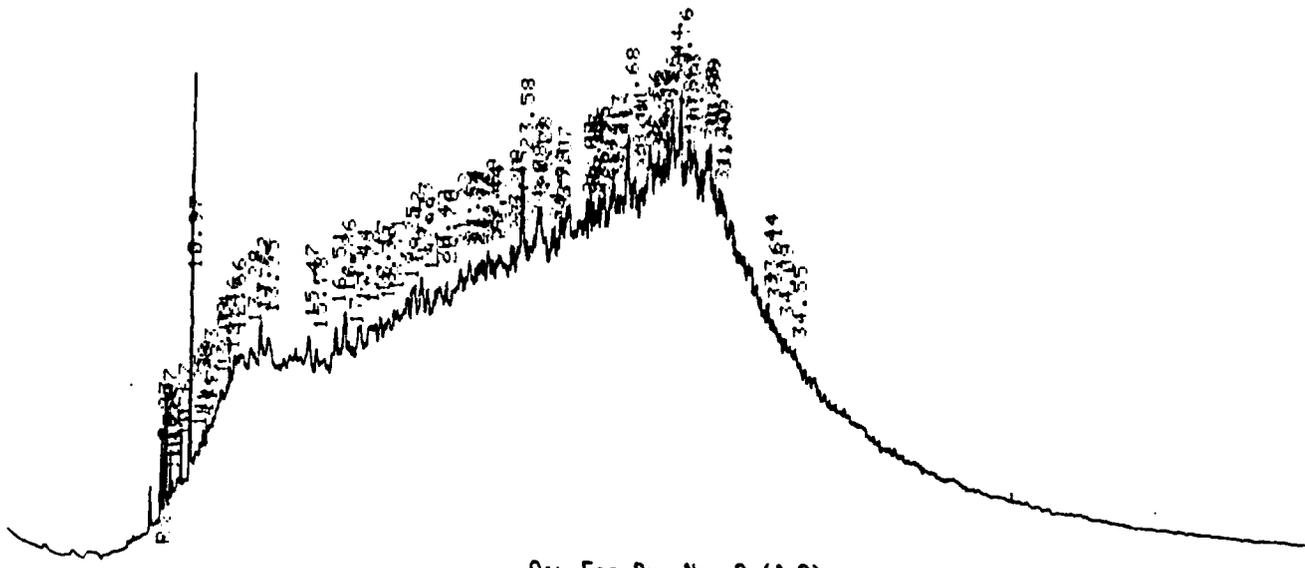
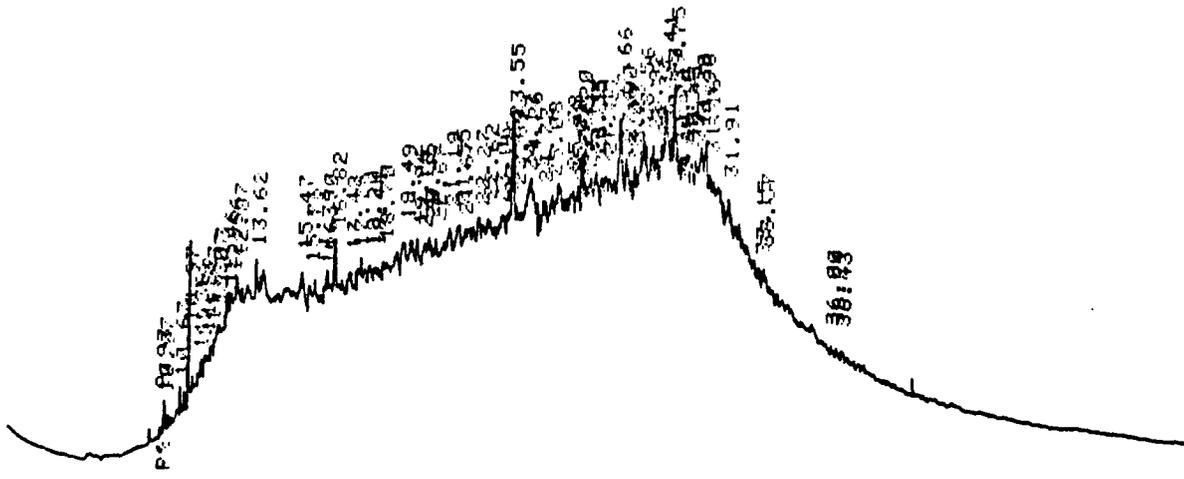
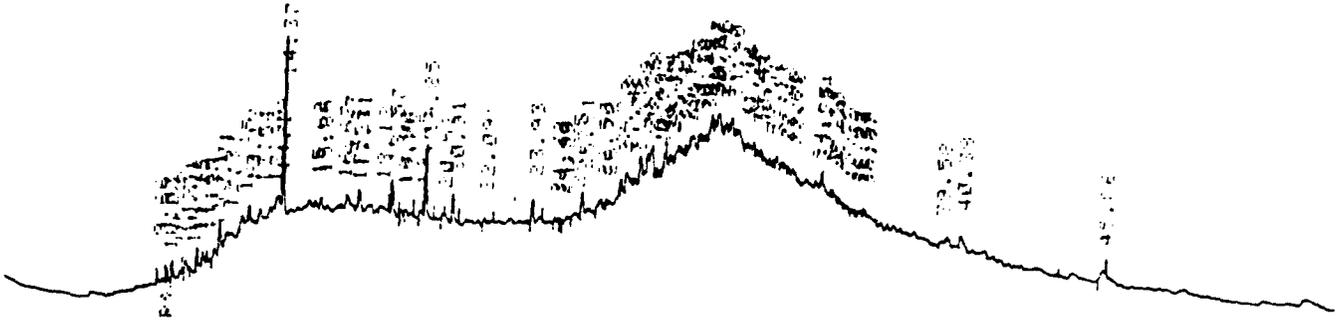


CHART 18. ALCOHOL FRACTION: OIL NO. 2

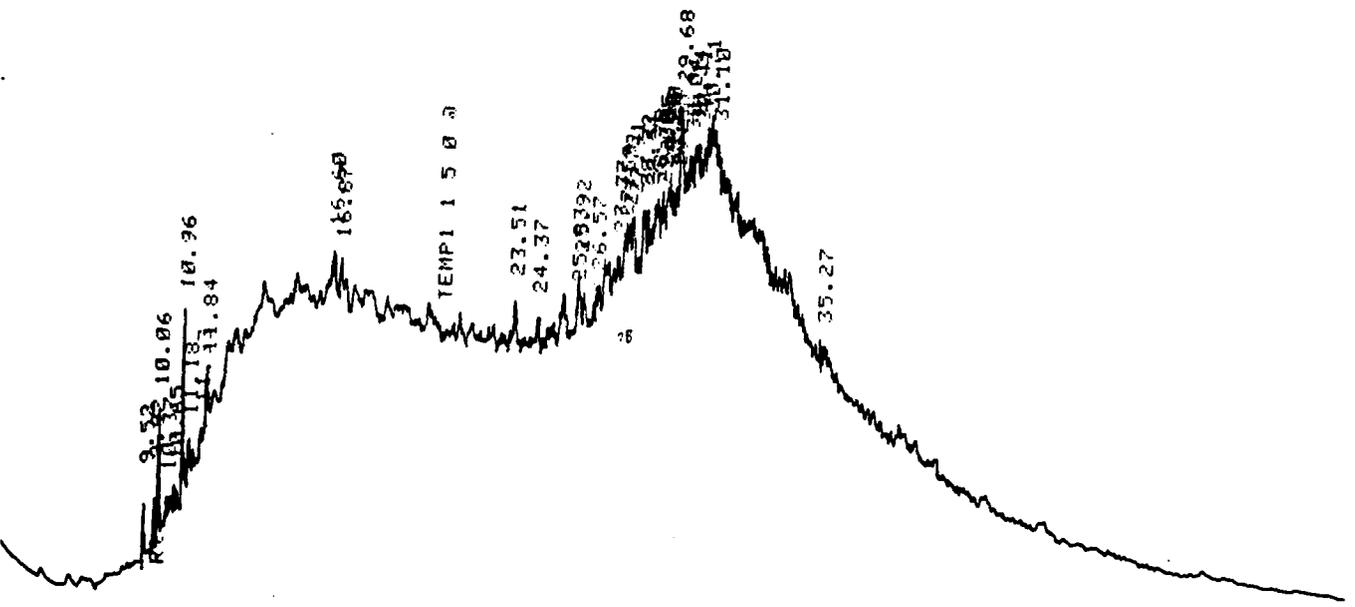


OIL FOG RUN No. 9 (A-2)



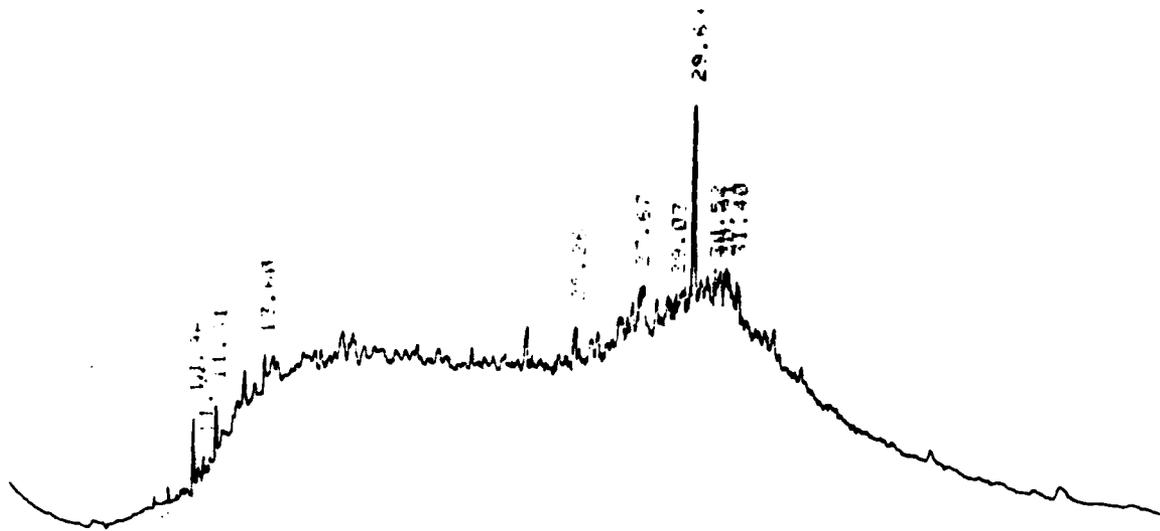


OIL No. 3

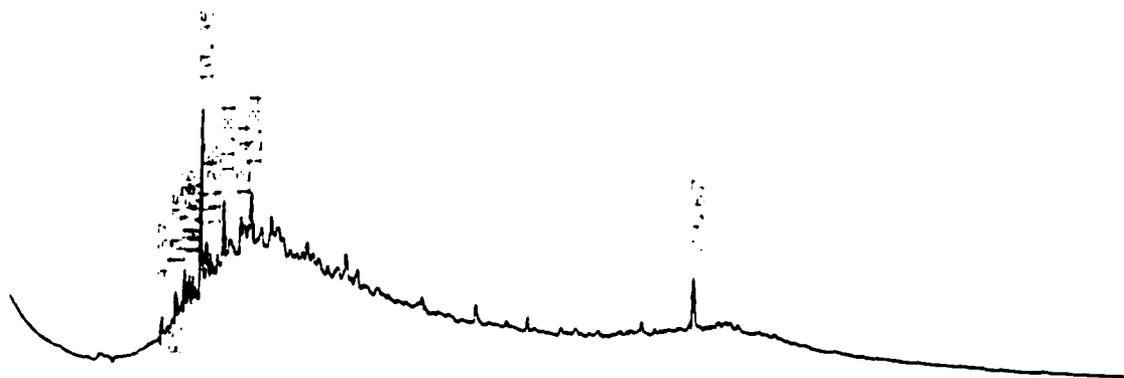


OIL FOG RUN No. 3 (B-3)

CHART 19. ALCOHOL FRACTION: OIL NO.



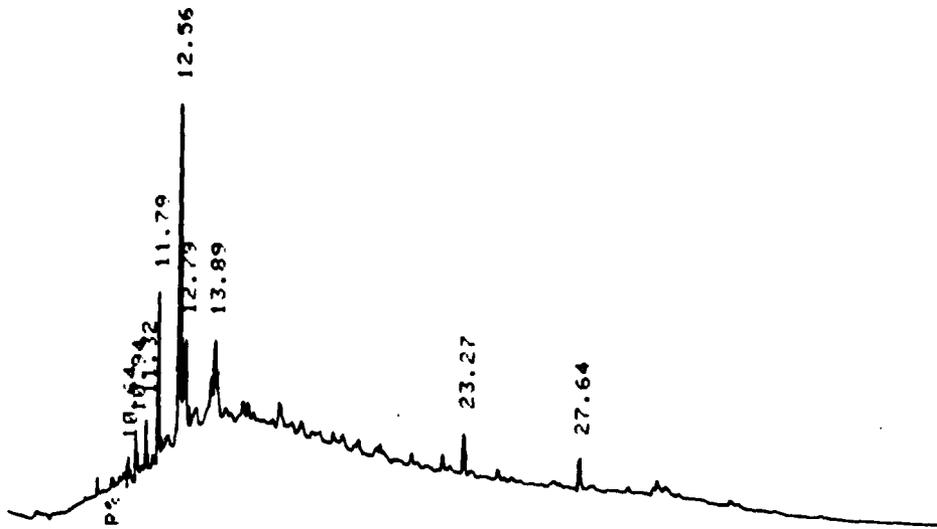
OIL FOG RUN No. 8 (A-3)



OIL FOG RUN No. 7 (C-3)

3 AND CORRESPONDING OIL FOGS

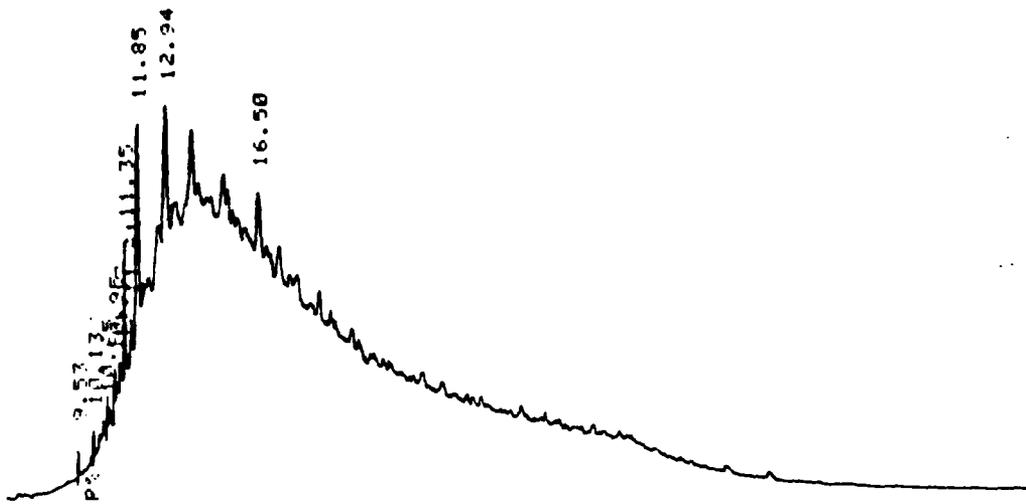
2



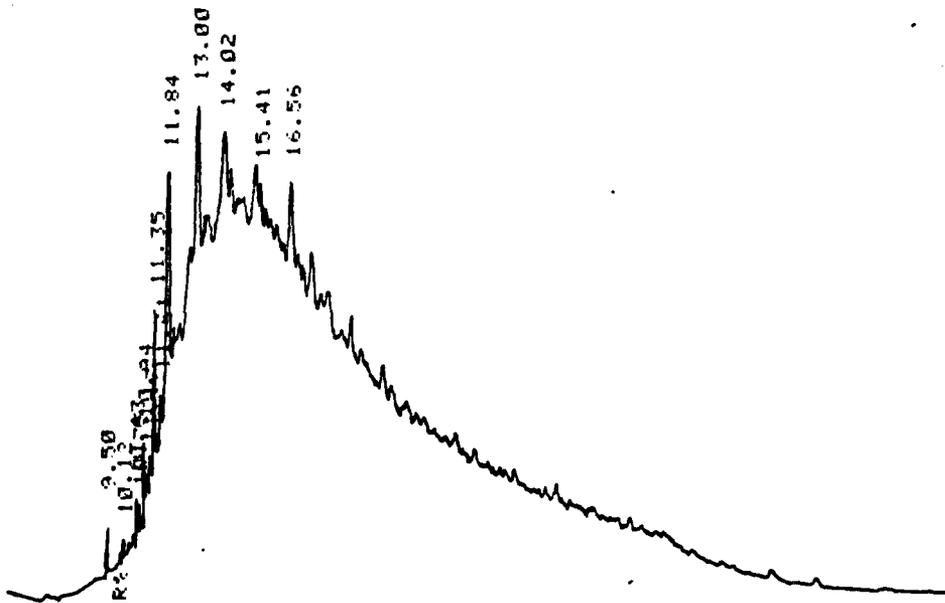
OIL No. 1



OIL FOG RUN No. 2 (B-1)



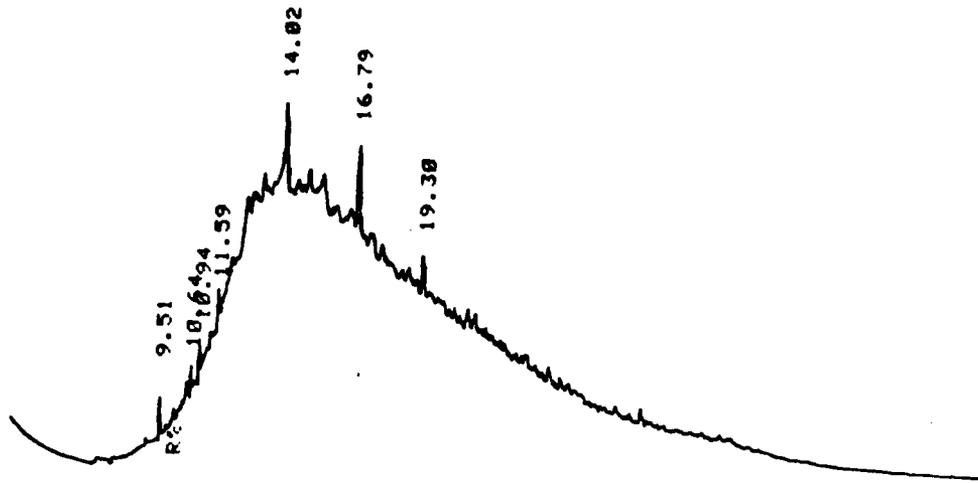
OIL FOG RUN No. 10 (A-1)



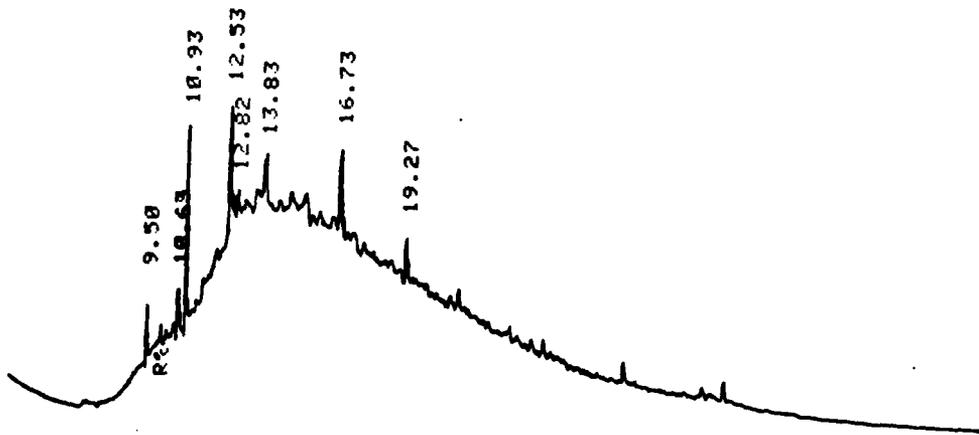
OIL FOG RUN No. 6 (C-1)

OIL NO. 1 AND CORRESPONDING OIL FOGS

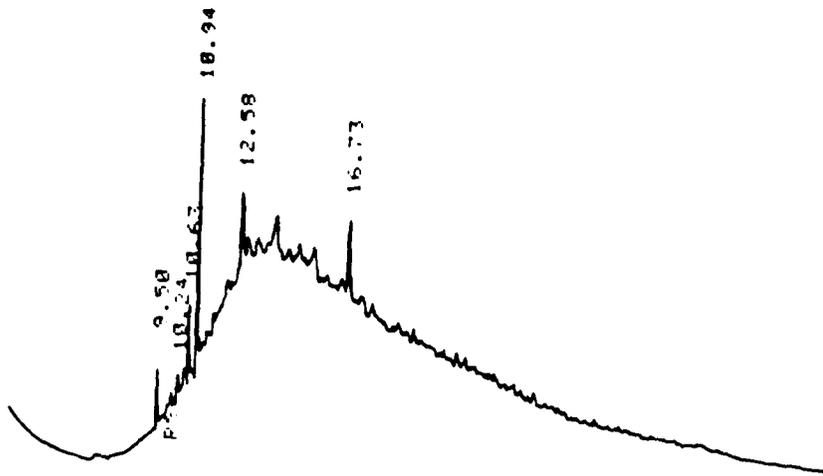
2



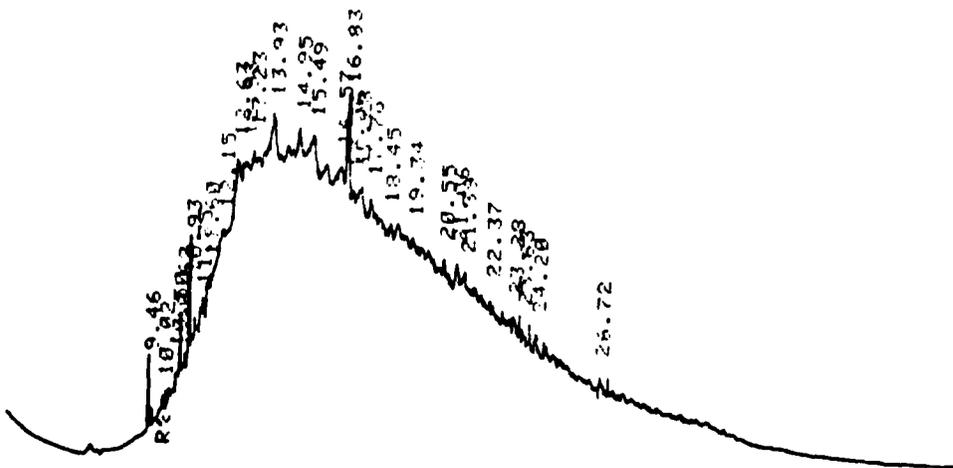
OIL No. 2



OIL Fos Run No. 4 (B-2)

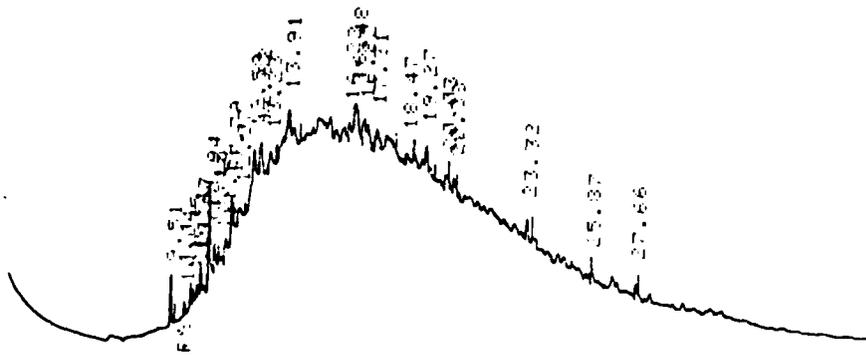


OIL FOG RUN No. 9 (A-2)



OIL FOG RUN No. 5 (C-2)

NO. 2 AND CORRESPONDING OIL FOGS



OIL FOG RUN No. 8 (A-3)

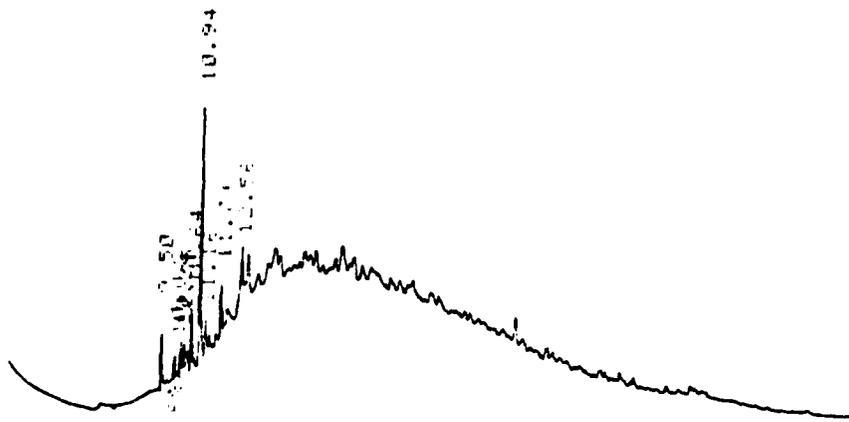


CHART 23. NITROGEN BASE FRACTION; OIL NO. 2 AND CORRESPONDING OIL FOGS

Key

- A. $C_{10}H_9N$ methylquinoline
- B. $C_{11}H_{11}N$ dimethylquinoline
- C. $C_{11}H_{11}N$ dimethylquinoline
- D. $C_{12}H_{13}N$ trimethylquinoline
- E. $C_{13}H_{15}N$ probably tetramethylquinoline
- F. $C_{13}H_{15}N$ probably tetramethylquinoline
- G. $C_{14}H_{17}N$ probably pentamethylquinoline
- H. $C_{15}H_{19}N$ probably hexamethylquinoline
- I. $C_{15}H_{19}N$ probably C6-alkylquinoline with at least one ethyl group
- J. $C_{15}H_{15}N$ probably dimethyl-9,10-dimethylbenzoquinoline
- K. $C_{15}H_{13}N$ methylphenylindole or dimethylbenzoquinoline
- L. $C_{16}H_{15}N$ or $C_{15}H_{11}NO$

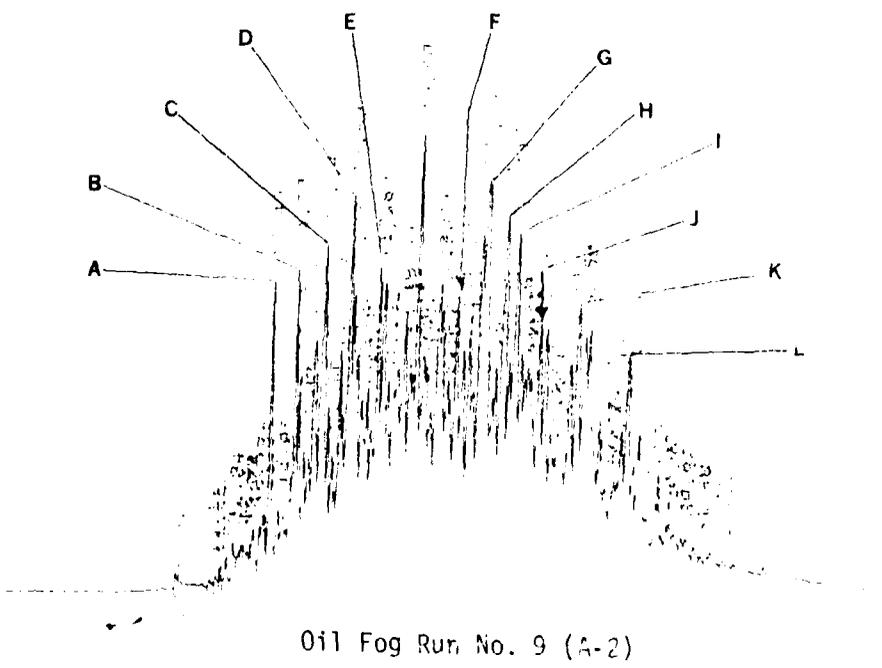
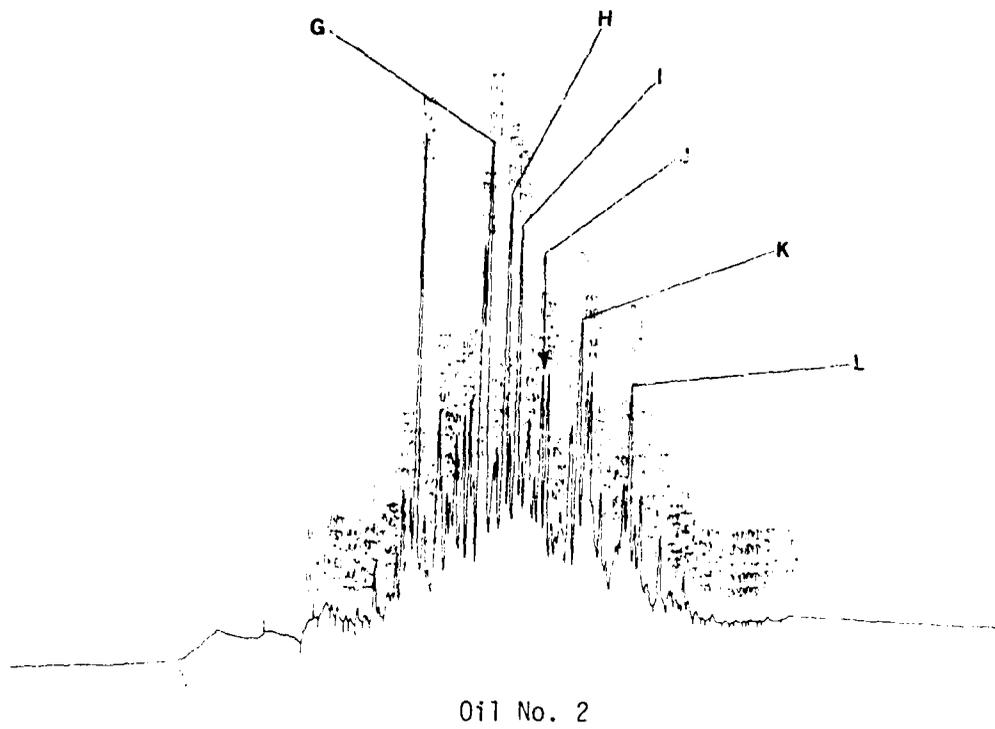
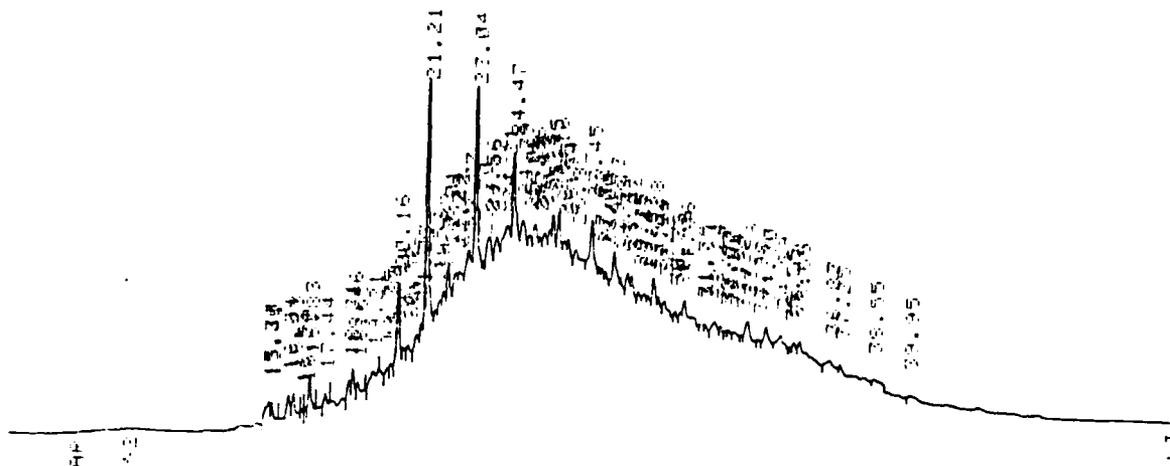


CHART 23. NITROGEN BASE FRACTION: OIL NO. 2 AND CORRESPONDING OIL FOSS

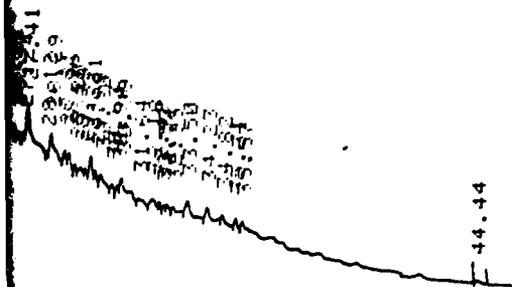
CHART 24. ALIPHATIC FRACTION; OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

Key

- A. $C_{14}H_{30}$ n-tetradecane
- B. $C_{16}H_{34}$ n-hexadecane
- C. $C_{17}H_{36}$ branched alkane
- D. $C_{18}H_{38}$ n-octadecane
- E. $C_{19}H_{40}$ n-nonadecane
- F. $C_{20}H_{42}$ n-eicosane
- G. $C_{21}H_{44}$ branched alkane
- H. $C_{21}H_{44}$ n-heneicosane
- I. $C_{22}H_{46}$ branched alkane



OIL FOG RUN No. 2 (B-1)



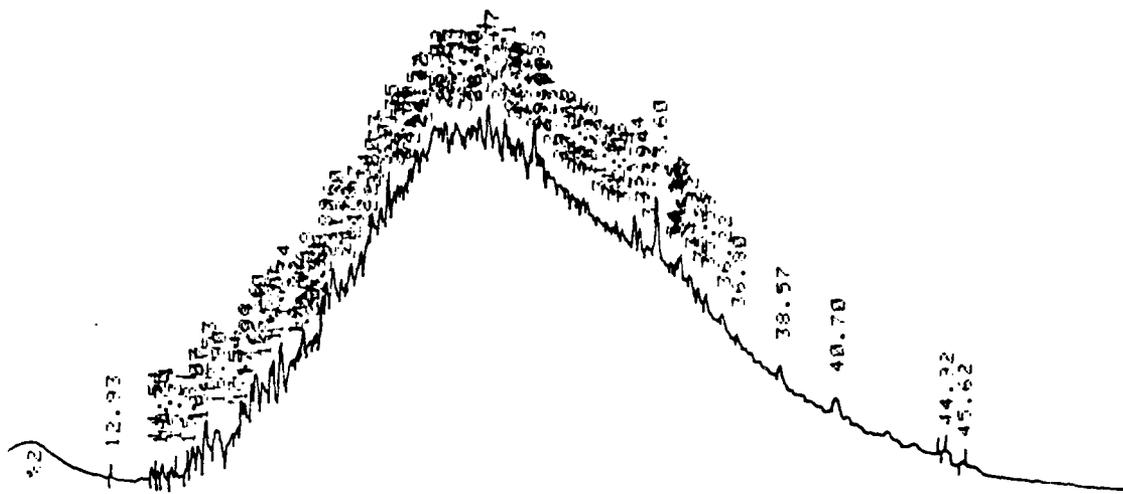
(B-1)(HT)

NORMAL RUN, HIGH TEMPERATURE RUN

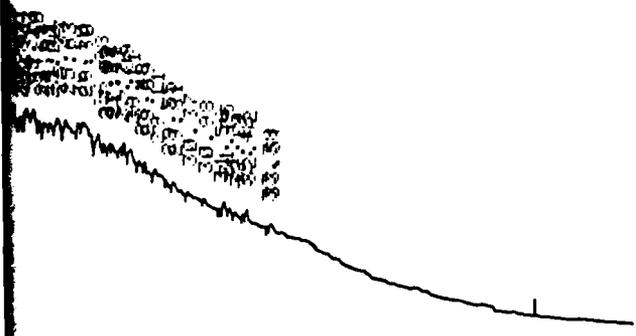
CHART 25. FIRST AROMATIC FRACTION; OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

Key

- A. 2,6-dimethyl-1,2,3,4-tetrahydronaphthalene
- B. $C_{13}H_{16}$
- C. $C_{13} + C_{14}H_{20} + C_{15}H_{24}$
- D. $C_{13}H_{16}O$ or $C_{14}H_{20}$



OIL FOG RUN No. 2 (B-1)



No. 11 (B-1(HT))

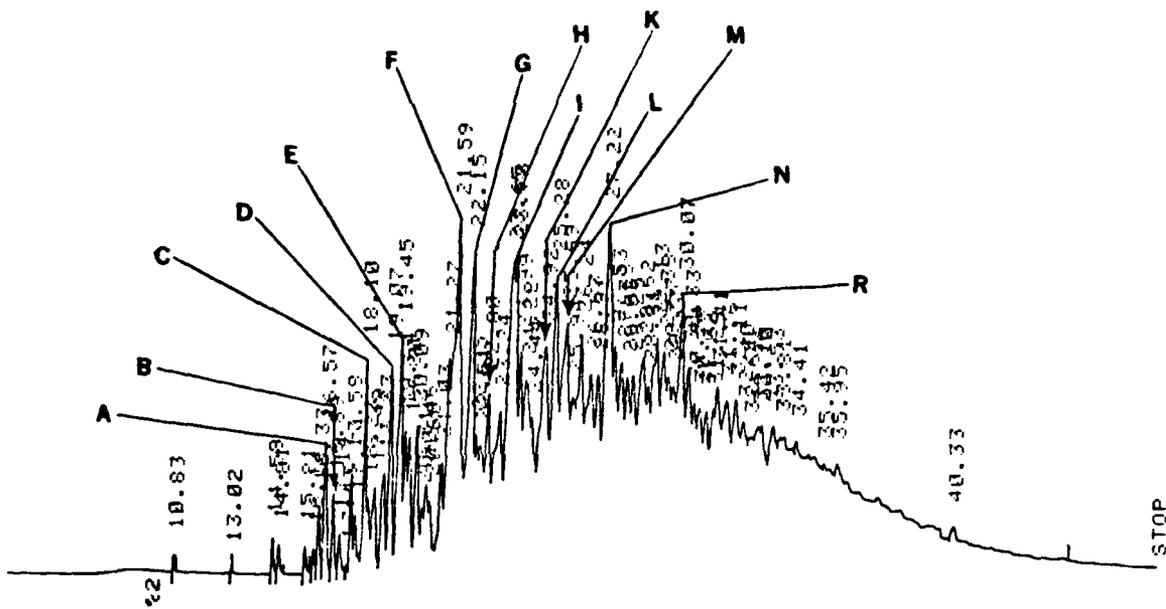
OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

2

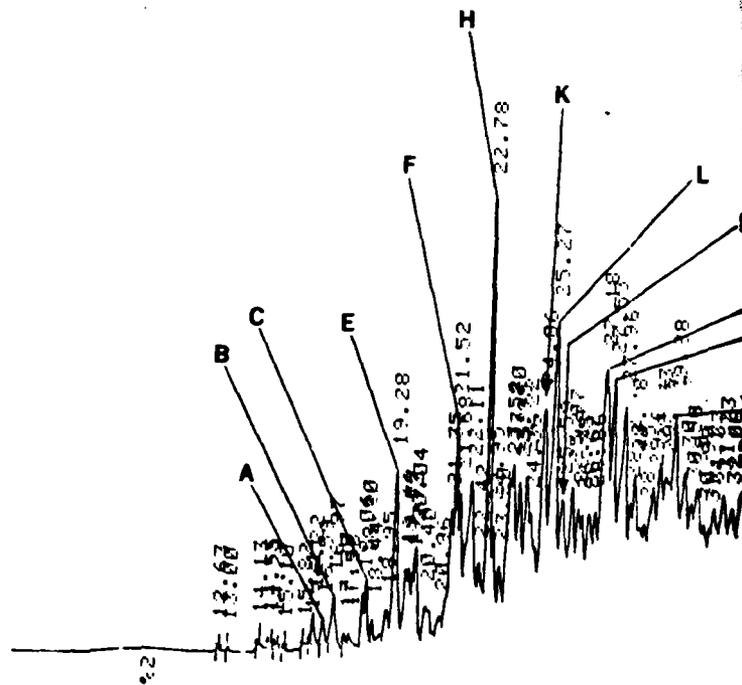
CHART 26. MIDDLE AROMATIC FRACTION; OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

Key

- A. $C_{15}H_{24}O$ methyl-di-tert-butylphenol
- B. $C_{16}H_{34}$ n-hexadecane
- C. $C_{14}H_{14}$ dimethylbiphenyl + $C_{15}H_{16}$ dimethylbenzylbenzene
- D. $C_{14}H_{12}$ methylfluorene
- E. $C_{15}H_{14}$ dimethylfluorene
- F. $C_{15}H_{12}$ methylphenanthrene
- G. $C_{15}H_{12}O$ 9-methoxyanthracene or $C_{16}H_{18}$
- H. $C_{16}H_{14}$ dimethylphenanthrene
- I. $C_{20}H_{32}$ n-butyl-n-hexyltetrahydronaphthalene?

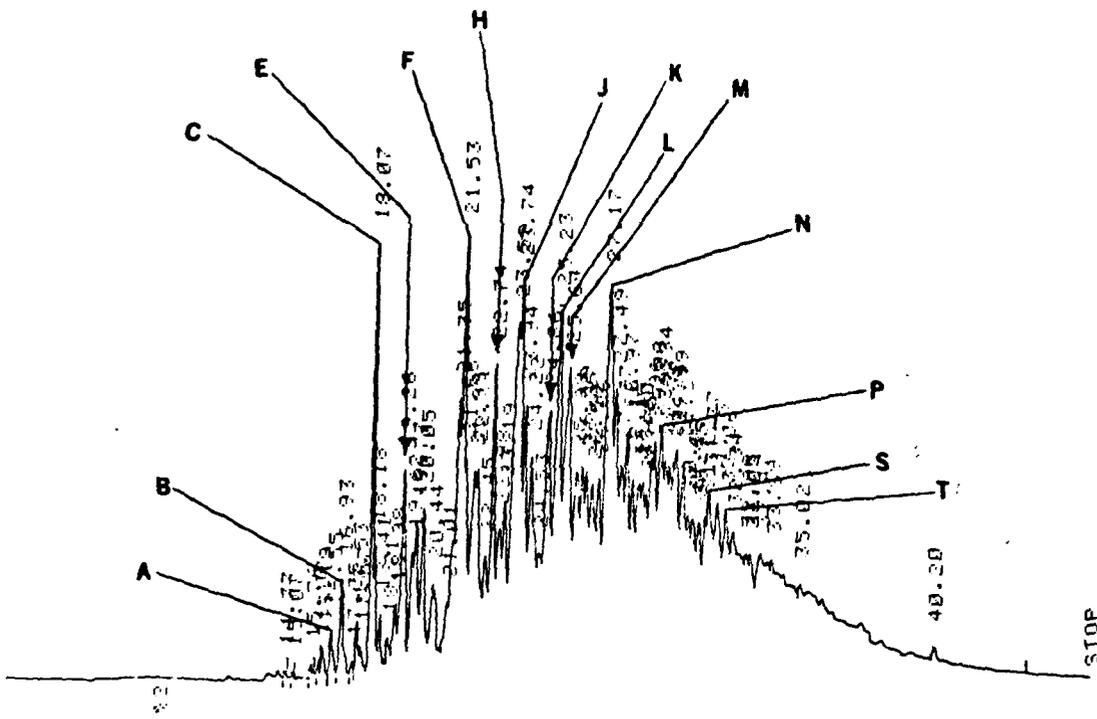


OIL No. 1

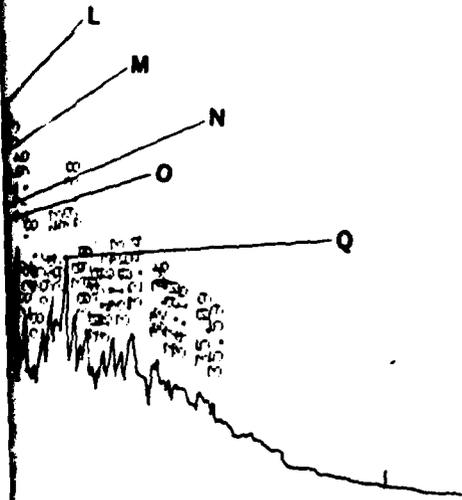


OIL FOG RUN No. 11 (B-11HT)

CHART 27. HEAVY AROMATIC FRACTION: OIL NO. 1, NORMAL



OIL FOG RUN No. 2 (B-1)



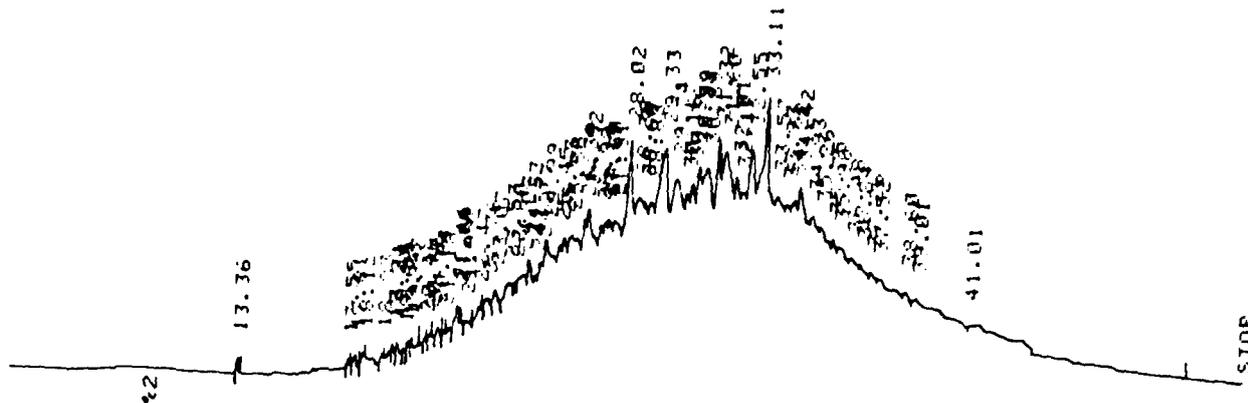
(B-1(HT))

NORMAL RUN, HIGH TEMPERATURE RUN

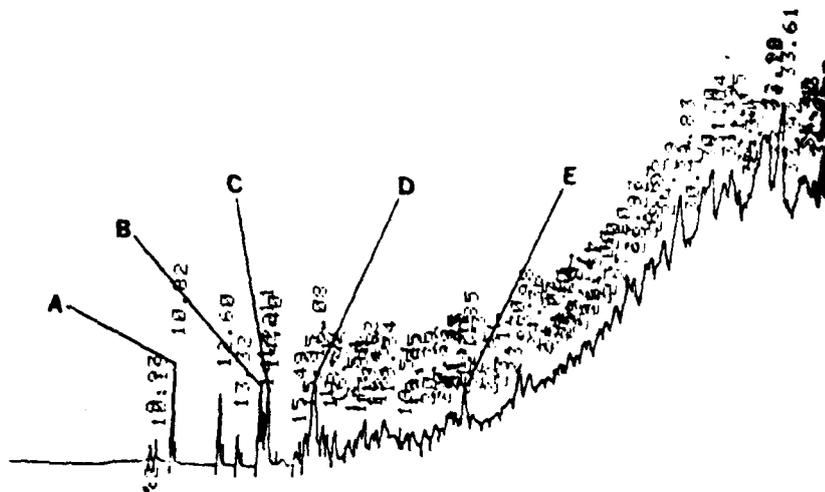
CHART 27. HEAVY AROMATIC FRACTION; OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

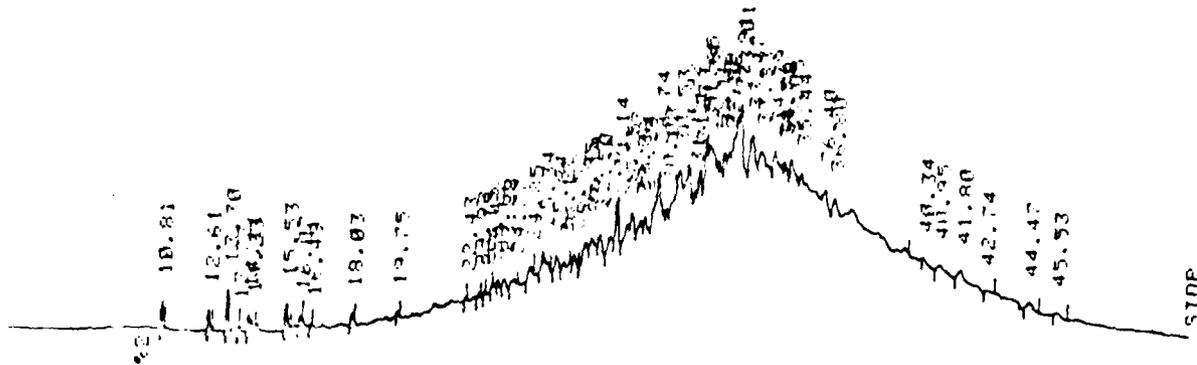
Key

A.	$C_{12}H_{12}$	dimethylnaphthalene
B.	$C_{12}H_8$	acenaphthalene
C.	$C_{15}H_{24}O$	2,6-di-t-butyl-4-methyl phenol (ionol)
D.	$C_{13}H_{14}$	trimethylnaphthalene
E.	$C_{13}H_{10}$	fluorene or phenalene
F.	$C_{14}H_{12}$	1-methylfluorene
G.	$C_{14}H_{16}$	C_4 -alkylnaphthalene
H.	$C_{14}H_{10}$	anthracene or phenanthrene
I.	$C_{15}H_{14}$	dimethylfluorene
J.	$C_{15}H_{14}$	alkenyl dibenzene
K.	$C_{15}H_{12}$	methylphenanthrene or methylanthracene
L.	$C_{15}H_{12}$	methylphenanthrene or methylanthracene
M.	$C_{15}H_{12}O$	methoxyanthracene or $C_{16}H_{16}$ isomer
N.	$C_{16}H_{14}$	dimethylphenanthrene
O.	$C_{16}H_{14}$	ethyl or dimethylantracene
P.	$C_{17}H_{16}$	C_3 -alkylphenanthrene or C_3 -alkylantracene
Q.	$C_{17}H_{12}$	methylpyrene or benz [α] anthracene
R.	$C_{18}H_{18}$	C_4 -alkylphenanthrene or C_4 -alkylantracene
S.	$C_{18}H_{18}$	C_4 -alkylphenanthrene or C_4 -alkylantracene
T.	$C_{19}H_{30}$	2-n-butyl-5-n-hexyl indan?

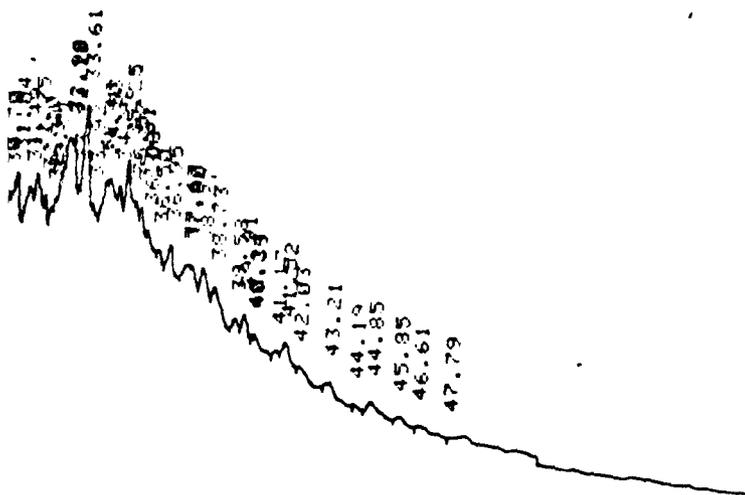


OIL No. 1





OIL FOG RUN No. 2 (B-1)



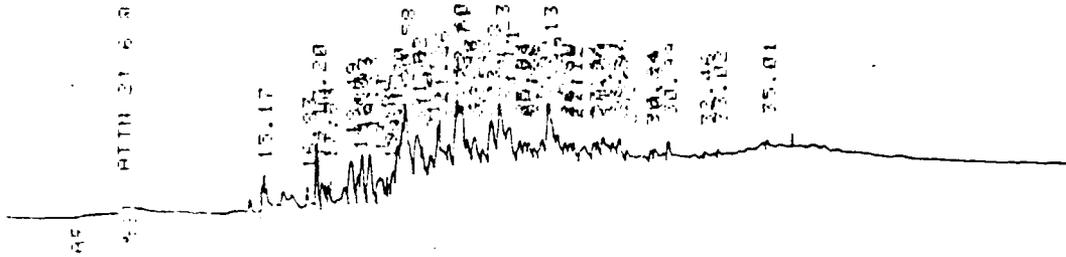
No. 11 (B-1HT)

DIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

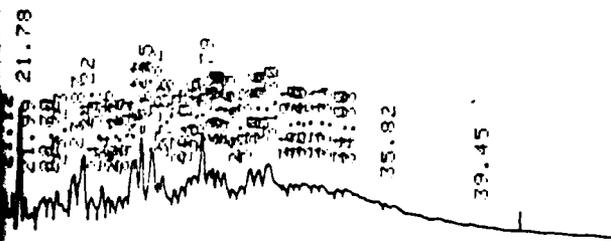
CHART 28. HEAVIEST AROMATIC FRACTION; OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

Key

- A. $C_{10}H_8$ naphthalene
- B. $C_{11}H_{10}$ methylnaphthalene
- C. $C_{11}H_{10}$ methylnaphthalene
- D. $C_{12}H_{12}$ dimethylnaphthalene
- E. $C_{14}H_{10}$ phenanthrene or anthracene

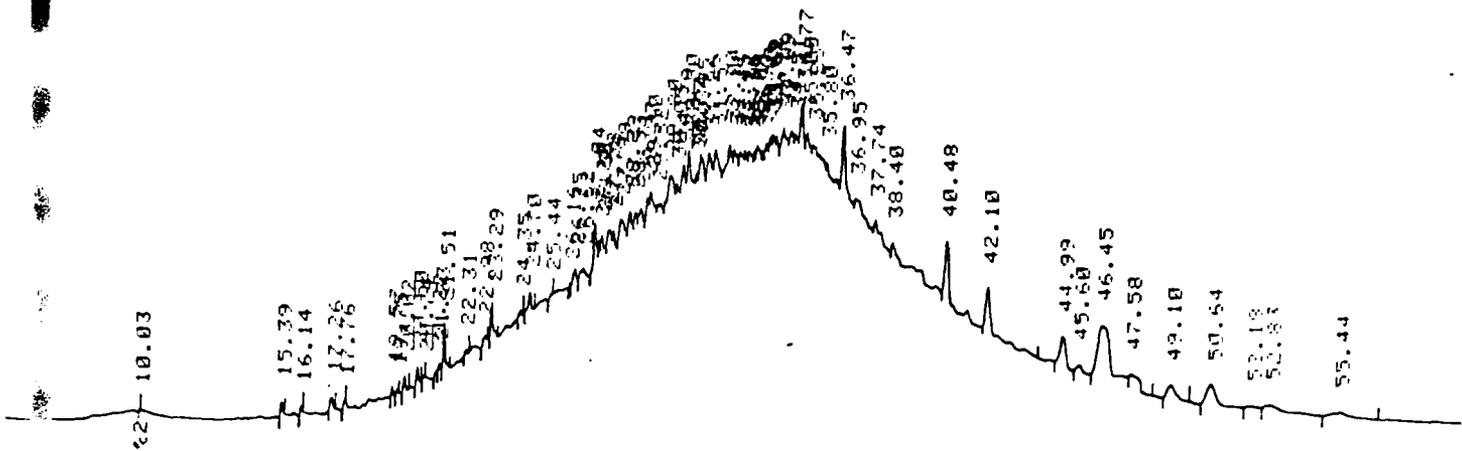


OIL FOG RUN No. 2 (B-1)

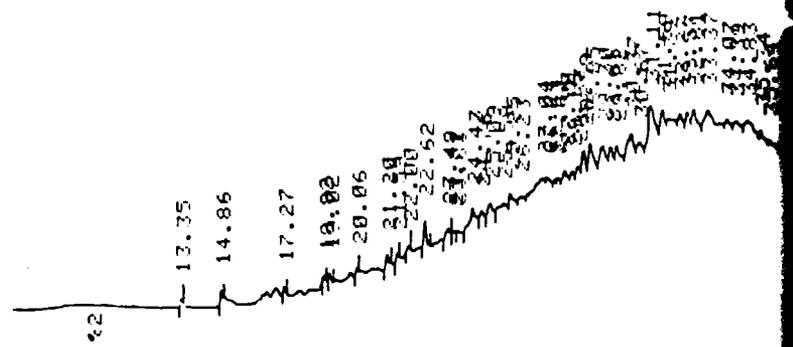


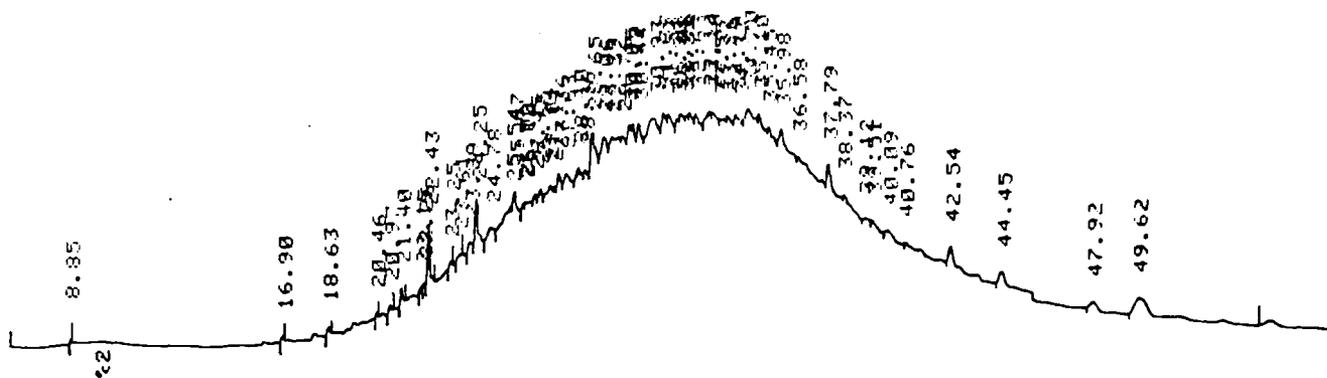
RUN No. 11 (B-1(HT))

OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

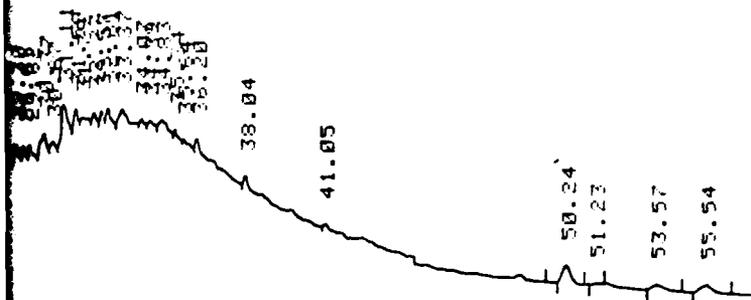


OIL No. 1



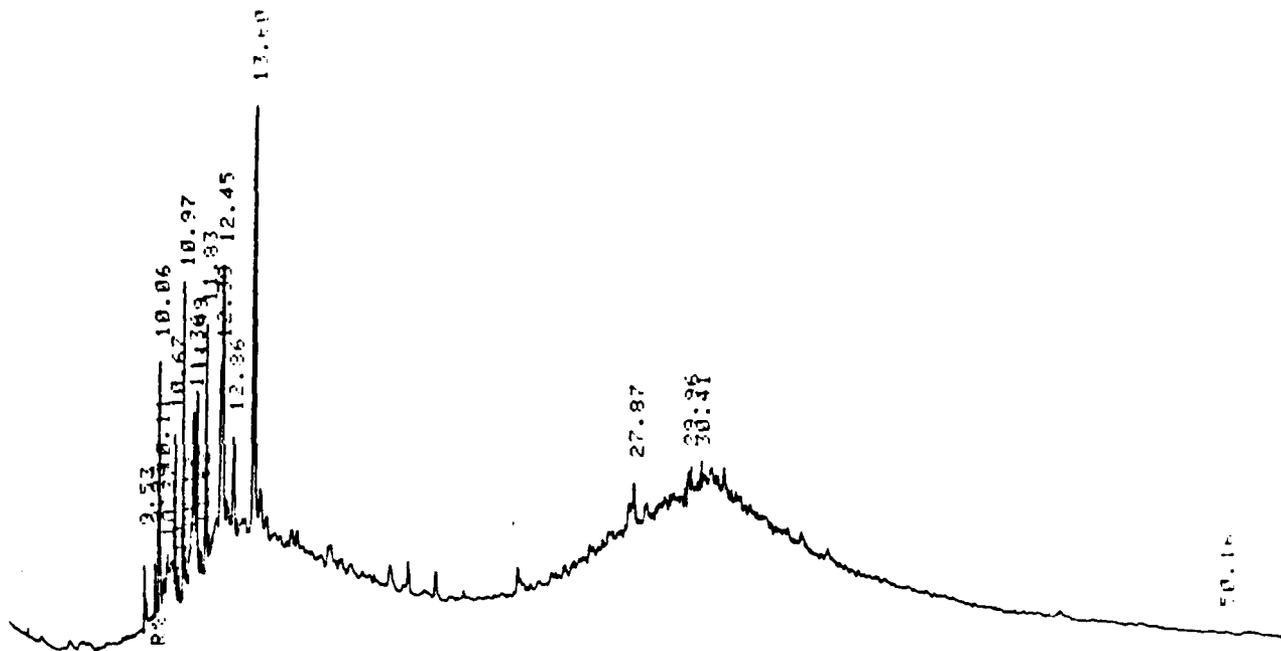


OIL FOG RUN No. 2 (B-1)

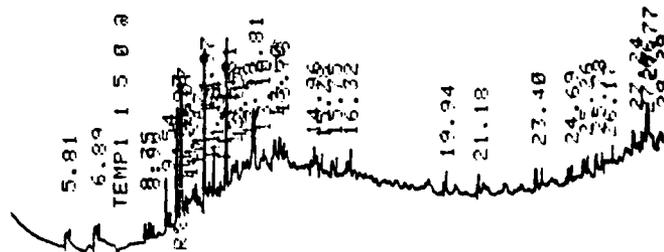


RUN No. 11 (B-1(HT))

OIL NO. 1, NORMAL RUN, HIGH TEMPERATURE RUN

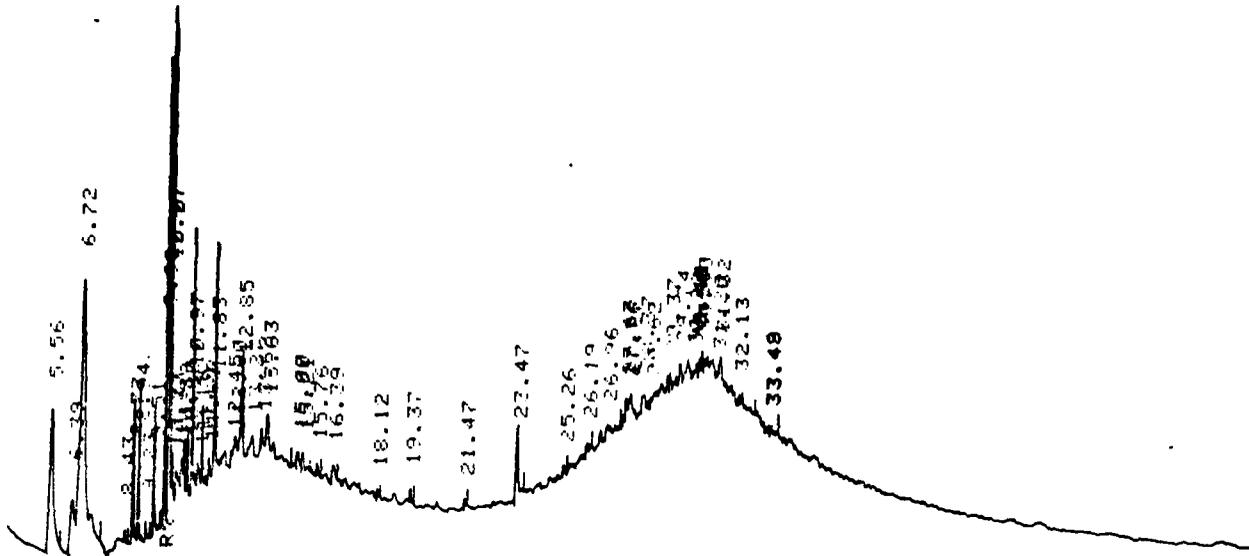


OIL No. 1

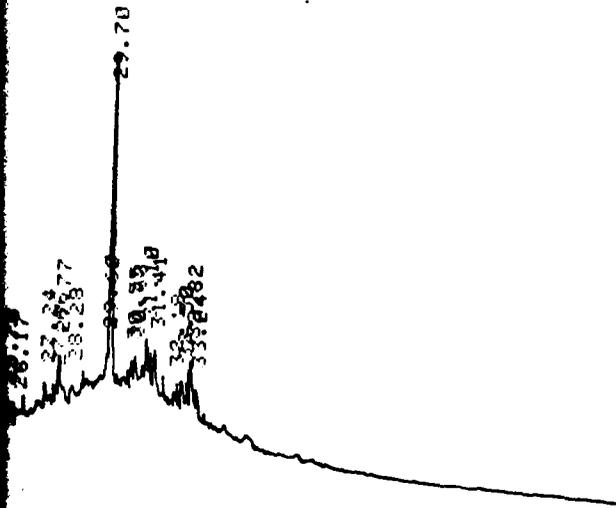


OIL FOG RUN No. 11

CHART 30. ALCOHOL FRACTION. OIL No. 1.

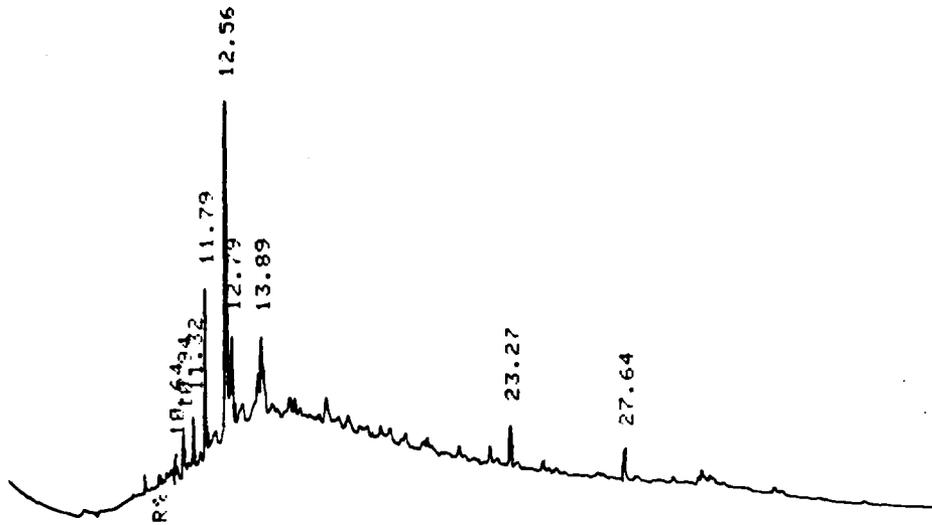


OIL FOG RUN No. 2 (B-1)

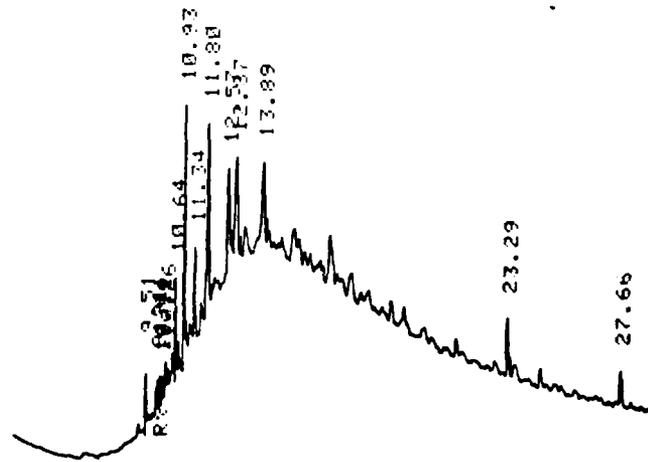


11 (B-1(HT))

1. NORMAL RUN, HIGH TEMPERATURE RUN

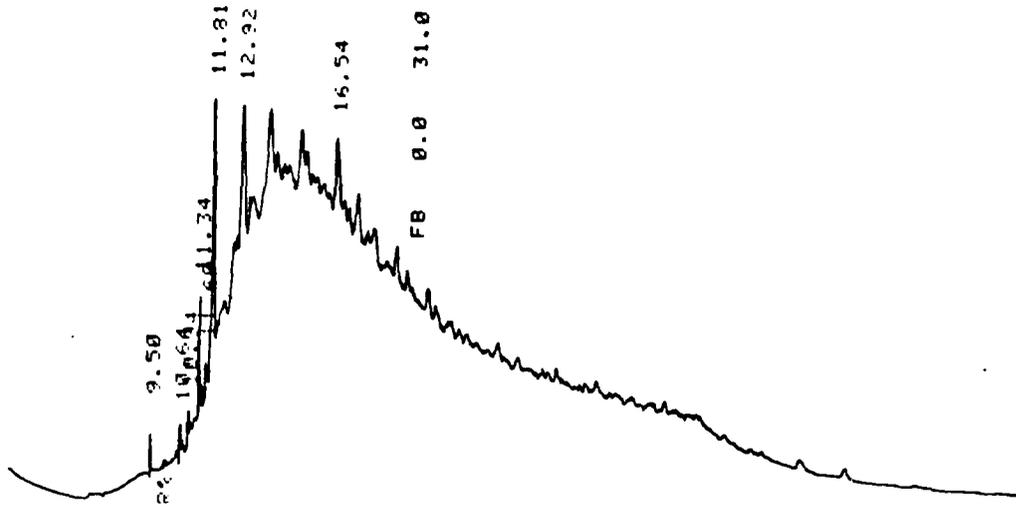


OIL No. 1



OIL FOG RUN No. 11 (B-1)

CHART 31. ACID FRACTION: OIL NO. 1, NORMAL



OIL FOG RUN No. 2 (B-1)

23.29

27.60

Run No. 11 (B-1(HT))

Run No. 1, NORMAL RUN, HIGH TEMPERATURE RUN

B-51

2

APPENDIX C
MASS SPECTROMETRY DATA

MASS SPECTROMETRY DATA

Seventeen oil and oil fog fractions were analyzed using gas chromatography separation followed by mass spectrometry (GC/MS). The fractions are listed below and are followed by the MS tabulations of the identifiable components.

As noted in the text, the tables show the following headings, an arbitrary peak number (PK#), an arbitrary spectrum number (SPEC), the compound identification (ID), the total ion current (TIC) which corresponds to the peak height in gas chromatography and is a qualitative indication of relative concentration, the area under each peak (AREA) (this column is not always included) and the percentage of each peak remaining after computer subtraction of the background (TICRAT). The last three columns of the table were not used in this study.

"Silanated" compounds are of column origin rather than from the compound.

Where additional compounds were identified by further processing of the data, they are listed on data sheets accompanying many of the charts.

A number of characteristic families of ion peaks whose identities were not established are also listed on the data sheets.

OIL AND OIL FOG FRACTIONS SELECTED FOR MASS SPECTROMETRY

Table C-1	Oil No. 1, Aliphatic Fraction
Table C-2	Oil No. 2, Aliphatic Fraction
Table C-3	Oil No. 3, Aliphatic Fraction
Table C-4	Oil No. 1, First Aromatic Fraction
Table C-5	Oil No. 2, First Aromatic Fraction
Table C-6	Oil No. 3, First Aromatic Fraction
Table C-7	Oil No. 1, Middle Aromatic Fraction
Table C-8	Oil No. 2, Middle Aromatic Fraction
Table C-9	Oil No. 3, Middle Aromatic Fraction
Table C-10	Oil No. 1, Heavy Aromatic Fraction
Table C-11	Oil Fog Run No. 2 (B-1), Heavy Aromatic Fraction
Table C-12	Oil Fog Run No. 11 (B-1[HT]), Heavy Aromatic Fraction
Table C-13	Oil No. 2, Heavy Aromatic Fraction
Table C-14	Oil Fog Run No. 4 (B-2), Heavy Aromatic Fraction
Table C-15	Oil Fog Run No. 11 (B-1[HT]), Heaviest Aromatic Fraction
Table C-16	Oil No. 2, Nitrogen Bases Fraction
Table C-17	Oil Fog Run No. 9 (A-2), Nitrogen Bases Fraction

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TABLE C-1. MS OF OIL NO. 1, ALIPHATIC FRACTION

PEAK #	SPEC	ID	TIC	TICRAT	RETIND	RELCON	TYPE
1	1010	UNIDENTIFIED	10271	28	-733	14	
2	1013	UNIDENTIFIED	*****	92	-706	1582	
3	1016	ALKANE	169205	25	680	238	
4	1035	UNIDENTIFIED	509627	43	599	639	
5	1026	ALKANE	*****	89	591	2905	
6	1221	UNIDENTIFIED	1840	1	1145	2	
7	1224	C14 H26 METHYLDICYCLOHEXYLMETHANE	3500	2	1172	5	*
8	1231	C14 H26 DICYCLOHEXYLETHANE	7222	5	1228	10	
9	1235	C14 H30 BR ALKANE + (193,123)	8796	6	1265	12	*
10	1240	(193,123,137,109)	3578	2	1295	5	
11	1247	C14 H26 DICYCLOHEXYLALKANE + (193,123,137,109)	17512	11	1346	25	*
12	1251	C14 H30 BR ALKANE + C14 H28 CYCLOHEXYLOCTANE + (193,123)	10014	7	1376	14	
13	1254	C14 H30 N-TETRADECANE	73874	34	1398	100	
14	1263	C15 H32 BR ALKANE + (97)	3933	2	1437	6	
15	1264	UNIDENTIFIED	2214	1	1441	3	
16	1267	C15 H28 DICYCLOHEXYLPROPANE + SILANATED	4175	3	1454	6	
17	1277	C15 H32 N-PENTADECANE + C15 H28 DICYCLOHEXYLALKANE + (123)	34245	17	1497	49	
18	1281	C16 H34 BR ALKANE	7145	4	1514	10	*
19	1284	PURIFIED COMPOUND	4936	2	1527	7	*
20	1290	C16H34 BR ALK + C16H32 ALKYL(CYCLOALK + C16 H30 DICYCLOHEXYLALK	5803	3	1552	8	*
21	1292	C16 H34 BR ALKANE	4433	2	1561	7	*
22	1293	C16 H32 ALKYL(CYCLOALKANE	4915	2	1565	7	*
23	1295	C16 H34 BR ALKANE	2234	1	1574	3	*
24	1307	C16 H34 N-HEXADECANE + C15 H32 ALKYL(CYCLOALKANE	19288	52	1621	261	
25	1312	(ALCANE)	21231	9	1639	31	*
26	1313	C16H34	7524	3	1644	11	
27	1314	C16H34	21231	9	1639	31	*
28	1315	C16H34	7524	3	1644	11	
29	1316	C16H34	21231	9	1639	31	*
30	1317	C16H34	7524	3	1644	11	

Table C-1

29	1332	UNIDENTIFIED	4507	1709	5
29	1339	C18 H38 BR ALKANE	5779	1730	7
30	1340	C18 H36 ALKYL CYCLOALKANE OR C18 H34 DICYCLOHEXYLHEXANE	12315	1715	17
31	1345	UNIDENTIFIED	3766	1751	5
32	1361	C18 H38 N-OCTADECANE	297632	1803	422
33	1370	SILANATED	2259	1830	4
34	1373	SILANATED	2474	1843	5
35	1375	C19 H38 ALKYL CYCLOALKANE OR C17 H16 DICYCLOHEXYLALKANE	5541	1848	11
36	1390	N-C19 H40	69024	1877	172
37	1419	N-C20 H42	10676	1921	21
38	1423	C21 H44 BR ALKANE	4373	2004	9
39	1425	SILANATED	1099	2011	2
40	1438	C21 H44 BR ALKANE	5921	2034	10
41	1450	N-C21 H44	15674	2094	27
42	1468	C22 H46 BR ALKANE	18275	2154	36
43	1495	ALKANE	1353	2247	2
44	1499	ALKANE	12226	2262	20
45	1522	SILANATED	1094	2345	2
46	1523	ALKANE	2493	2360	5
47	1575	ALKANE	3826	2547	10

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TABLE C-2 OIL NO. 2, A: PHASE 1 FRACTION

PEAK #	SPEC	ID	TIC	TICRAT	RETIND	RELCON	TYPE
1	4010		1107	12	549	0	
2	4015		812343	78	506	0	
3	4019		20119	3	472	0	
4	4027		*****	89	403	0	
5	4028		496622	51	395	0	
6	4029		*****	84	386	0	
7	4041		245422	59	284	0	
8	4243	UNKN*	4707	4	1400	0	
9	4254	SILANATED + UNKN*	1559	1	1445	0	
10	4264	ALKANE (N-C15) + (125 ALKYL CYCLOALKANE) + SILANATED	4354	3	1486	0	
11	4274	UNKN*	2840	2	1527	0	
12	4323	N-C17 H36 + (125 ALKYL CYCLOALKANE)	2775	0	1706	0	
13	4330	UNIDENTIFIED	1306	0	1724	0	
14	4344	ALKANE	1064	0	1771	0	
15	4348	UNIDENTIFIED	1278	0	1784	0	
16	4366	ALKANE	3183	0	1840	0	
17	4367	PART OF ABOVE PEAK	2510	0	1843	0	
18	4369	SILANATED + UNKN*	1244	0	1849	0	
19	4396	UNIDENTIFIED	1639	0	1934	0	
20	4402	UNIDENTIFIED	2232	0	1952	0	
21	4411	ALKANE	35554	8	1979	0	
22	4422	SILANATED	1218	0	2014	0	
23	4425	N-C20 H42	24697	6	2024	0	
24	4426	PART OF ABOVE PEAK	2414	0	2027	0	
25	4437	ALKANE	1286	0	2062	0	
26	4447	UNIDENTIFIED	1772	0	2094	0	
27	4453	N-C21 H44	110886	27	2113	0	
28	4475	UNIDENTIFIED	4090	1	2184	0	

29	4486	UNIDENTIFIED	1416	0	2221	0
30	4502	UNIDENTIFIED	1313	0	2275	0
31	4571	ALKANE	1303	1	3324	0
32	4615	ALKANE	1761	2	2691	0

TABLE C-2. OIL NO. 2, ALIPHATIC FRACTION

Key

UNK* Spectra with this designation contain some or all of the runs of the followings masses whose parent structures have not been resolved: 41, 42, 55, 67, 69, 81, 83, 95, 109, 123, 137, 165, 179, 193.

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TABLE C-3. D11 MS. 3. ALIPHATIC FRACTION

PEAK #	SPEC	ID	TIC	TICRAT	RETIND	RELCON	TYPE
1	5015		*****	92	-632	0	
2	5019		20233	4	-597	0	
3	5025		152174	17	-544	0	
4	5026		*****	96	-535	0	
5	5027		*****	84	-526	0	
6	5229	UNK*	7282	12	1246	0	
7	5235	UNK*	7071	11	1290	0	
8	5239	UNK*	1479	2	1319	0	
9	5245	N-C14H30 + UNK*	57901	48	1363	0	
10	5254	ALKANE + UNK*	50833	40	1416	0	
11	5255	PART OF ABOVE PEAK	10624	10	1420	0	
12	5259	UNIDENTIFIED	1296	1	1437	0	
13	5261	UNK*	2468	2	1446	0	
14	5262	ALKANE (C15)	3544	4	1450	0	
15	5266	ALKANE + (125.69 CYCLOALKYLALKANE) + SILANATED	4221	5	1467	0	
16	5272	UNK*	4626	4	1492	0	
17	5276	UNK*	45369	31	1509	0	
18	5279	UNIDENTIFIED	1817	1	1522	0	
19	5293	UNIDENTIFIED	2321	1	1581	0	
20	5307	ALKANE	2539	1	1634	0	
21	5317	SILANATED	1509	0	1669	0	
22	5325	N-C17 H36	27710	11	1697	0	
23	5331	UNIDENTIFIED	1757	0	1717	0	
24	5360	(N-C18 H38)	4365	1	1810	0	
25	5382	UNIDENTIFIED	2355	0	1880	0	
26	5393	UNIDENTIFIED	1120	0	1884	0	
27	5399	N-C19 H40	2357	6	1903	0	
28	5396	UNIDENTIFIED	1060	0	1925	0	

29	5401	UNIDENTIFIED	2877	0	1941	0
30	5403	UNIDENTIFIED	1821	0	1948	0
31	5413	UNIDENTIFIED	1880	0	1980	0
32	5422	N-C20 H42	23728	5	2009	0
33	5437	UNIDENTIFIED	1012	0	2059	0
34	5447	N-C21 H44	2059	0	2092	0
35	5454	UNIDENTIFIED	1054	0	2115	0
36	5455	UNIDENTIFIED	1927	0	2118	0
37	5466	UNIDENTIFIED	1550	0	2135	0
38	5466	UNIDENTIFIED	2209	0	2155	0
39	5496	UNIDENTIFIED	1015	0	2258	0
40	5512	UNIDENTIFIED	1085	0	2315	0
41	5518	UNIDENTIFIED	2016	0	2337	0
42	5597	UNIDENTIFIED	1054	1	2638	0

TABLE C-3. OIL NO. 3, ALIPHATIC FRACTION

Key

UNK* Spectra with this designation contain some or all the runs of the following masses whose parent structures have not been resolved: 41, 43, 55, 67, 69, 81, 83, 95, 109, 123, 137, 165, 179, 193.

Additional alkanes (not found by the cleanup) were present at spectra numbers 5352 and 5417.

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TABLE 4 - MS SPLIT NO. 1, FIRST AROMATIC FRACTION

PEAK #	SPEC	ID	TIC	TICRAT	RETIND	RELCON	TYPE
1	10035	C H2 CL2 DICHLOROMETHANE	16938	9	0	0	
2	10193	C10 H22 N-DECANE	6640	33	0	0	
3	10218	N-C12H26 + C11H14 (2)-METHYL-1,2,3,4-TETRAHYDRONAPHTHALENE	17235	48	0	0	
4	10226	C11H14 (5 OR 6)METHYL-1,2,3,4-TETRAHYDRONAPHTHALENE + SILANATED	2535	8	0	0	*
5	10230	C11H14 METHYL-1,2,3,4-TETRAHYDRONAPHTHALENE	2280	6	0	0	
6	10231	C12H16 (OR C11H12 O) 2,6-DIMETHYL-1,2,3,4-TETRAHYDRONAPHTHALENE	30449	35	0	0	*
7	10233	•	2408	6	0	0	
8	10234	•	11497	19	0	0	
9	10242	•	3493	5	0	0	*
10	10243	•	20993	23	0	0	*
11	10244	•	2011	2	0	0	*
12	10246	N-C14H30 + C12H12 DIMETHYLNAPHTHALENE	19709	16	0	0	
13	10249	•	36653	27	0	0	*
14	10253	C13H16 SEE 10233	29177	22	0	0	*
15	10254	•	20062	13	0	0	*
16	10258	•	7134	6	0	0	*
17	10261	C13H18 TRIMETHYL-1,2,3,4-TETRAHYDRONAPHTHALENE + (C13H32)ALKANE	20436	14	0	0	
18	10264	C13H18 SEE ABOVE + C14H16 BUTYLNAPHTHALENE	9466	6	0	0	
19	10265	C14H20 TETRAMETHYL-1,2,3,4-TETRAHYDRONAPHTHALENE	5315	3	0	0	
20	10266	C13H16O OR C14H20 (145,173,188,143) + C13H22 (187,202,129)	28332	16	0	0	*
21	10267	•	4080	2	0	0	*
22	10268	C13H14 ISOPROPYLNAPHTHALENE + C14H18 (186) + C15H22 (106,129,202)	5475	3	0	0	
23	10270	(132,131,120)	4800	2	0	0	*
24	10271	C14H20 OR C13H16O (173,188,174,158) SEE 10243	24860	13	0	0	
25	10274	•	37791	19	0	0	
26	10275	C13H14 TRIMETHYLNAPHTHALENE + C14H20 OR C13H16O (173,188)	13674	7	0	0	*
27	10276	C14 H18 (171, 186)	2503	1	0	0	
28	10277	C15H22 OR C14H18O (143,146,141,167,202) + C13H24 (133,134,119,20	13700	7	0	0	*

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29	10280	C15 H22 HEXAMETHYLINDAN	8502	4	0	0
30	10282	C13H14 (155,170) + C14H20 (173,188) + C15H24 (133,119,134,204)	29469	13	0	0
31	10284	C14 H16 1-METHYL-7-ISOPROPYLNAPHTHALENE	9129	5	0	0
32	10285	UNIDENTIFIED (95,109,123)	4094	2	0	0
33	10287	(C13H160 OR C14H20) (173,145,174)	24231	11	0	0
34	10288	e	14792	7	0	0
35	10289	C13 H14 + C15 H22 (187,202)	6112	3	0	0
36	10292	BUTYRATED COMPOUND (71,43) + (C14 H16) (155,184)	1812	0	0	0
37	10295	C14H20 OR C13H160 (145,173,188) + (143,157,171,(200))	7841	3	0	0
38	10296	e	9421	4	0	0
39	10297	C14H20 OR C13H160 (173,188,174,(155))	3659	1	0	0
40	10300	ALKANE (N-C16 H34)	23277	10	0	0
41	10301	e	6688	3	0	0
42	10302	C14H16 (169,184) + (C16H24) (133,160,(216),199)	2364	1	0	0
43	10305	C15 H18 (183,198) + C15 H22 (187,202)	2761	1	0	0
44	10310	C14 H16 OR C15 H18 (155,198,169,184)	12848	5	0	0
45	10315	C16 H26 OR C15 H22 0 (133,134,218)	5828	2	0	0
46	10316	ALKANE + (C16 H22) (214)	6423	2	0	0
47	10318	C15 H18 DIMETHYL ISOPROPYLNAPHTHALENE	12904	5	0	0
48	10321	C14H16 OR C15H18 (169,184) + C16H26 (105,119,106,91,92,218)	11875	4	0	0
49	10327	SILANATED	8146	3	0	0
50	10333	UNIDENTIFIED	1314	0	0	0
51	10336	ALKANE	15984	5	0	0
52	10344	C17 H28 (119,120,232,91,92)	1892	0	0	0
53	10346	C16 H26 (133,134,218)	1269	0	0	0
54	10349	(C18 H28) (159,244)	1650	0	0	0
55	10350	(C18 H26) (106,242)	3008	0	0	0
56	10356	C17 H28 (105,106,92,232)	3937	1	0	0
57	10360	C18 H30 (119,120,246)	5095	1	0	0
58	10365	UNIDENTIFIED	1003	0	0	0
59	10371	ALKANE	7456	2	0	0
60	10379	C18 H30 (120,(241),246)	3442	0	0	0
61	10382	SILANATED	8013	7	0	0

Table
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62	10384	C19 H30 (145, 159, 131, 258)	4082	1	0	0	*
63	10386	C19 H30 (106, 109, 202, 298)	1240	0	0	0	*
64	10391	C19 H32 (133, 134, (210), 260)	4453	1	0	0	
65	10392	C18 H30 (109, 106, 246)	5944	1	0	0	
66	10393	C20 H34 (119, 274)	7343	1	0	0	
67	10400	ALKANE (N-C19H40 ?)	1097	0	0	0	
68	10404	C19 H32 (134, 133, 119, 260)	1661	0	0	0	*
69	10407	C20 H32 (145, 131, 199, 272)	5953	1	0	0	*
70	10414	C19 H32 (120, 260)	2502	0	0	0	
71	10420	(C19 H32)	1747	0	0	0	
72	10425	C20 H32 (145, 146)	6896	1	0	0	
73	10427	C19 H32 OR C20 H34 (106, 260)	2575	0	0	0	
74	10430	C21 H34 (159, 181, 171) + (C17 H20) (224, 238)	3577	0	0	0	*
75	10431	UNIDENTIFIED	1394	0	0	0	
76	10436	SILANATED	5400	1	0	0	
77	10438	C21 H36 (134, 288)	1178	0	0	0	
78	10442	(255, 69, 159, 173, 185, (270))	8309	2	0	0	*
79	10447	C21 H36 (119, 120, 92, (241), 288)	5177	1	0	0	
80	10451	UNIDENTIFIED	1139	0	0	0	
81	10459	C20 H28 N-BUTYL N-HEXYL NAPHTHALENE	4985	1	0	0	*
82	10460	UNIDENTIFIED	1267	0	0	0	
83	10464	UNIDENTIFIED	1126	0	0	0	
84	10466	(257, 195, 252)	6130	1	0	0	*
85	10469	UNIDENTIFIED	1380	0	0	0	
86	10470	UNIDENTIFIED	1373	0	0	0	
87	10473	UNIDENTIFIED	1817	0	0	0	
88	10486	SILANATED	4604	1	0	0	
89	10517	UNIDENTIFIED	1108	0	0	0	
90	10523	UNIDENTIFIED	1983	0	0	0	
91	10528	UNIDENTIFIED	1402	0	0	0	
92	10530	UNIDENTIFIED	2224	0	0	0	
93	10532	SILANATED	1168	0	0	0	
94	10534	UNIDENTIFIED	1247	0	0	0	

95	10540	(145, 146, 157, 296, 310)	2094	0	0	0
96	10549	(159, 160, 185)	2144	1	0	0
97	10551	UNIDENTIFIED	3879	1	0	0
98	10557	(213, 295, 310, (326))	2924	1	0	0
99	10558	PART OF ABOVE PEAK	5560	2	0	0
100	10561	UNIDENTIFIED	1866	0	0	0
101	10568	UNIDENTIFIED	1764	0	0	0
102	10574	UNIDENTIFIED	2117	1	0	0
103	10575	SILANATED	1902	0	0	0
104	10578	(159, 171)	2923	1	0	0
105	10584	UNIDENTIFIED	1365	0	0	0
106	10592	UNIDENTIFIED	1042	0	0	0
107	10594	(106, 103, 51)	1812	1	0	0
108	10597	UNIDENTIFIED	1746	0	0	0
109	10598	UNIDENTIFIED	1031	0	0	0
110	10603	UNIDENTIFIED	1061	0	0	0
111	10605	UNIDENTIFIED	1061	0	0	0
112	10609	UNIDENTIFIED	1572	0	0	0
113	10610	UNIDENTIFIED	1613	0	0	0
114	10615	UNIDENTIFIED	1452	0	0	0
115	10617	UNIDENTIFIED	1245	0	0	0
116	10620	UNIDENTIFIED	1913	1	0	0
117	10640	UNIDENTIFIED	1079	0	0	0
118	10642	UNIDENTIFIED	1360	1	0	0
119	10646	UNIDENTIFIED	1355	1	0	0
120	10664	UNIDENTIFIED	1188	1	0	0

TABLE C-4. MS OF OIL NO. 1, FIRST AROMATIC FRACTION

Key

@ in the ID column are identified below by the Spectrum No.
Structures shown are compounds with similar spectra

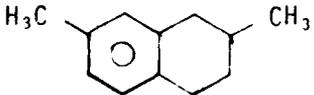
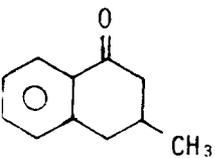
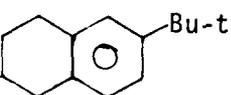
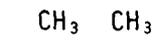
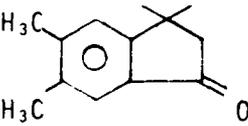
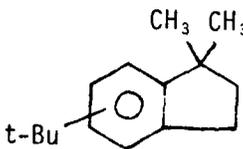
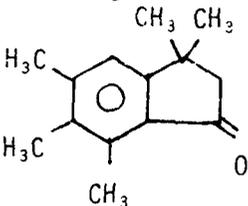
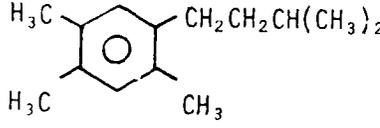
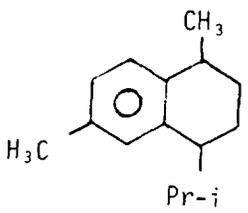
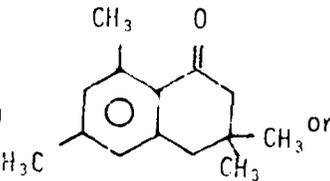
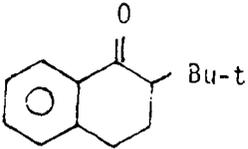
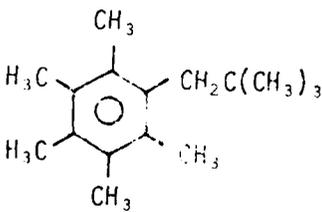
10233	$C_{13}H_{16}$	(such as 2-heptynyl benzene)
10234	$C_{12}H_{16}$	 1,7-dimethyl tetralin
	or	
	$C_{11}H_{12}O$	 3-methyl-3,4-dihydro naphthalenone
	and	
	$C_{13}H_{18}$	Trimethyl tetralin
10242	$C_{13}H_{16}$	(similar to 10233)
10243	$C_{12}H_{16}$	Dimethyl tetralin
	and	
	$C_{12}H_{12}$	Dimethyl naphthalene
	and	
	$C_{14}H_{20}$	 
	or	
	$C_{13}H_{16}O$	
10244	$C_{12}H_{16}O$	Cyclohexyl phenol
10249	$C_{12}H_{12}$	Dimethyl naphthalene
	and	
	$C_{14}H_{20}$ or $C_{13}H_{16}O$	(see 10243)

TABLE C-4 (cont.)

10254	$C_{13}H_{18}$	Trimethyl tetralin	
	and		
	$C_{15}H_{22}$		
	or		
	$C_{14}H_{18}O$		
10258	$C_{15}H_{22}$	or $C_{14}H_{18}O$ (see 10254)	
	and		
	$C_{14}H_{22}$	Alkylbenzene	
	and		
		Alkene or alkylcycloalkane	
10267	$C_{14}H_{22}$		
10274	$C_{15}H_{22}$		
10283	$C_{14}H_{18}O$	 or 	
10296	$C_{16}H_{26}$		
10301	$C_{15}H_{22}$	(similar to 10274)	

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TABLE C-5. MS OF OIL NO. 2, FIRST AROMATIC FRACTION

PEAK #	SPEC	ID	TIC	TICRAT	RETIND	RELCON	TYPE
1	11037	C H2 CL2 DICHLOROMETHANE	100555	40	0	0	
2	11193	C10 H22 N-DECANE	3159	29	0	0	
3	11220	C12 H26 N-DODECANE	3106	25	0	0	
4	11247	C14 H30 N-TETRADECANE	7093	37	0	0	
5	11274	SILANATED	2638	11	0	0	
6	11284	C13 H18 (159, 174) + C14 H18 (171, 186)	2785	9	0	0	
7	11291	BUTYRATED COMPOUND + C14 H20 (173, 188, 198, 174)	9006	18	0	0	
8	11298	C16 H34 N-HEXADECANE	7052	15	0	0	
9	11300	C17 H20 (209, 224)	1709	4	0	0	
10	11308	C14 H16 METHYL ISOPROPYLNAPHTHALENE	6672	13	0	0	
11	11316	C15 H16 (DIMETHYL BENZYL)BENZENE	1927	3	0	0	
12	11317	C15 H20 (171, 186, 158, 132, 200)	2134	3	0	0	
13	11319	C14 H16 SEE 11308	3114	5	0	0	
14	11326	SILANATED	12512	15	0	0	
15	11328	C15 H18 (183, 171, 198)	1583	2	0	0	
16	11330	ALKANE + C16 H18 (195, 210) + C14 H20 (173, 188)	1781	2	0	0	
17	11332	e	3564	4	0	0	*
18	11335	e	3787	4	0	0	*
19	11340	C16 H18 (195, 210) + C15 H16 (181, 196) + C15 H18 (185, 198)	1776	2	0	0	
20	11344	C18 H26 SEE 11332 + (131, 133, 157, 169)	1129	1	0	0	*
21	11345	C16 H18 (195, 210) + (C13 H18) (159)	1831	1	0	0	*
22	11347	C15 H18 (183, 198)	1489	1	0	0	
23	11349	(197, 213, 226, (242))	1612	1	0	0	*
24	11353	C18 H26 SEE 11332 + C16 H20 (183, 212)	2208	2	0	0	
25	11356	e	4474	4	0	0	e
26	11360	UNIDENTIFIED	1781	1	0	0	
27	11362	C19 H30 (173, 159, 258)	2177	1	0	0	*
28	11363	C16 H18 (195, 210) + C16 H20 (183, 212, (165)) + (ALKANE)	4410	3	0	0	*

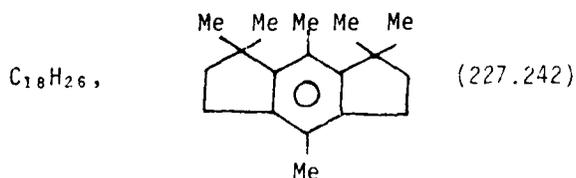
29	11366	ALKANE + C15 H18 (181, 183, 198, (254, C19 H26 ?))	2100	1	0	0	*
30	11369	(C19 H30) (145, 146)	1779	1	0	0	*
31	11370	C16 H18 (195, 210)	3039	2	0	0	*
32	11373	(213, 228, 242) SEE 11349	1660	1	0	0	
33	11376	UNIDENTIFIED	2006	1	0	0	
34	11377	UNIDENTIFIED	1145	0	0	0	
35	11378	(C19 H30) (145, 159, 146) + C16 H18 (195, 210)	1512	1	0	0	*
36	11380	SILANATED	14893	10	0	0	
37	11385	C20 H24 3,6,9,10,10-HEXAMETHYL-9,10-DIHYDROPHENANTHRENE	10945	7	0	0	*
38	11387	C19 H32 (133, 134, 260)	1128	0	0	0	
39	11389	(119)	2169	1	0	0	
40	11396	(C20 H32) (145, 146, 272) + (263, 264, 278) SEE 11411	3884	2	0	0	
41	11397	ALKANE	1374	1	0	0	
42	11398	C19 H32 (133, 134, 260)	1181	0	0	0	
43	11403	(145, 146) + (263, 264, 278) SEE 11411	1577	1	0	0	
44	11404	UNIDENTIFIED	1466	1	0	0	
45	11411	(C16 H18) (195, 210) + C18 H14 O3 (263, 278, 249, 235, 264, 250)	10628	7	0	0	
46	11416	UNIDENTIFIED	1787	1	0	0	
47	11420	(C20 H30) (133) + (224)	1865	1	0	0	
48	11421	(145, 146)	2041	1	0	0	
49	11423	(C20 H30) (119, 133, 120)	2277	1	0	0	
50	11427	UNIDENTIFIED	1444	1	0	0	
51	11433	SILANATED	12577	9	0	0	
52	11444	(C18 H24 O2) (162, 161, 272, 236, 155, 187)	2427	2	0	0	
53	11454	(119, 187, 120, 298)	2144	2	0	0	
54	11458	UNIDENTIFIED	1773	1	0	0	
55	11464	UNIDENTIFIED	1074	1	0	0	
56	11484	SILANATED	7646	8	0	0	
57	11493	(C23 H40) (120, 119, 133, 316)	1039	1	0	0	
58	11530	SILANATED	4689	8	0	0	
59	11574	SILANATED	3660	8	0	0	
60	11615	SILANATED	2204	5	0	0	

TABLE C-5. MS OF OIL NO. 2, FIRST AROMATIC FRACTION

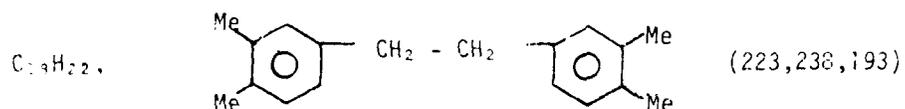
KEY

- 1) Numbers in parentheses indicate ions which seem to peak simultaneously.
- 2) @ in the ID column are explained below according to Spectrum Number. The structures shown are compounds which exhibit similar spectra.

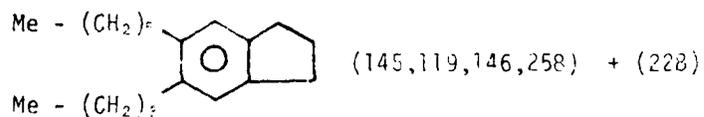
11332. alkane + C₁₄H₁₈ (171,186) or C₁₅H₂₀ (186,200) + C₁₄H₁₆ (169,184) +



11335. C₁₇H₂₀ (209,224) + C₁₆H₁₈ (195,210) + C₁₄H₁₆ (171,186) + C₁₈H₂₂ (195,210) +



11356. C₁₅H₁₈ (195,210) + C₁₃H₂₀



NFO115.MAS

TABLE C-6. MS OF OIL NO. 3, FIRST AROMATIC FRACTION

PEAK #	SPEC	ID	TIC	TICRAT	RETIND	RELCON	TYPE
1	12036	C H2 CL2 DICHLOROMETHANE	102556	39	0	0	
2	12245	C13 H18 OR C12 H14 D [10234]	3262	17	0	0	*
3	12253	C13 H16 + C12 H16 D [10242]	1955	8	0	0	
4	12256	C12 H12 + C12 H16 + C14 H20 OR C13 H16 D [10243]	3810	13	0	0	
5	12298	N-C14 H30 + C12 H12 [10246]	4405	13	0	0	
6	12261	C12 H12 + C15 H22 (187,202) [10249]	8050	19	0	0	
7	12252	C14 H20 OR C13 H16 D [10249]	3494	8	0	0	
8	12254	C13 H16 [10253] + C12 H12 + UNK*	11666	25	0	0	
9	12266	C13 H18 [10254]	12404	23	0	0	
10	12267	C14 H18 + C15 H22 [10254] + C14 H22 (119,190,120)	4603	12	0	0	
11	12273	C13 H18 + ALKANE [10261] + UNK*	9898	18	0	0	
12	12276	C14 H20 [10265]	5633	8	0	0	*
13	12278	C14 H20 + C15 H22 [10266]	6425	9	0	0	*
14	12281	C13 H14 + C15 H22 + (132) [10268,10270]	2360	3	0	0	*
15	12284	C14 H20 OR C13 H16 D [10271]	10462	13	0	0	
16	12286	C15 H22 [10274]	19059	20	0	0	
17	12287	C13 H14 + C14 H20 OR C13 H16 D [10275]	5072	6	0	0	
18	12289	C15 H22 [10277]	6728	7	0	0	*
19	12293	C15 H22 [10280]	6752	5	0	0	
20	12295	C15 H24 [10282]	9267	9	0	0	*
21	12296	C13 H14 [10282] + C14 H16 [10284] + C15 H22	9094	9	0	0	
22	12297	UNK* [10285]	5201	6	0	0	
23	12300	C14H20 OR C13H16D [10287] + C14H18U +(157,200,126,142) [10288]	18816	16	0	0	*
24	12302	C13 H14 [10289] + C14 H16 (169,184)	13650	13	0	0	
25	12303	C15 H22 OR C14 H18 D [10289]	6789	7	0	0	*
26	12306	BUTYRATED COMPOUND + C14 H16 [10292]	2061	1	0	0	*
27	12307	C13 H16 D OR C14 H20 + (143,157,200,171) [10295]	8848	7	0	0	*
28	12309	C16 H26 [10296]	5276	4	0	0	*

29	12312	ALKANE (10300) + C14 H16	4981	4	0	0
30	12314	C15 H22 OR C14 H18 O (10301)	4463	3	0	0
31	12315	C14 H16 + C16 H24 (10302)	5000	5	0	0
32	12318	C15 H22 + C15 H18 (10305)	4337	3	0	0
33	12323	C14 H16 OR C15 H18 (10310)	7403	5	0	0
34	12324	C15 H22 (187, 145, 202)	3421	2	0	0
35	12325	C16 H24 (173, 145, 187, 216) + (C17 H22) (157, 171, 226)	1502	1	0	0
36	12328	C16 H26 OR C15 H22 O (10315) + C16 H22 (199, 214, (155))	3760	2	0	0
37	12331	C15 H18 (10318)	39341	22	0	0
38	12334	C14 H16 + C16 H26 (10321)	12680	7	0	0
39	12339	UNIDENTIFIED	1926	1	0	0
40	12341	SILANATED (10327)	7972	5	0	0
41	12346	(C18 H28) (159, (229, 244))	2616	1	0	0
42	12349	UNIDENTIFIED	2785	1	0	0
43	12352	UNIDENTIFIED	1862	1	0	0
44	12358	C17 H28 (10344)	1904	1	0	0
45	12359	C16 H26 (10346)	1470	0	0	0
46	12363	(C18 H28) (159) (10349)	1481	0	0	0
47	12371	C17 H28 (10356)	1141	0	0	0
48	12373	C18 H30 (10360) + (145)	6871	3	0	0
49	12379	UNIDENTIFIED (10365)	1592	0	0	0
50	12384	C18 H30 (134, 246)	1086	0	0	0
51	12387	(145, 146)	2137	0	0	0
52	12391	UNIDENTIFIED	1336	0	0	0
53	12393	(131, 120)	3023	1	0	0
54	12395	SILANATED (10382)	6912	2	0	0
55	12400	(C19 H30) (145, 146) (10384)	6308	2	0	0
56	12405	UNIDENTIFIED	2461	0	0	0
57	12408	(C18 H30) (167, 106, 105, 195, 266)	3536	1	0	0
58	12409	C20 H34 + (C20 H32) (145, 131, 159, (272)) (10393)	7789	2	0	0
59	12415	(119, 120)	1034	0	0	0
60	12416	(145, 155)	2394	0	0	0
61	12420	C17 H20 (209, 224) + (133, 134) (10404)	2538	0	0	0

52	12425	(C18 H28) (145,146,131) [10407]	7413	2	0	0	*
53	12426	UNIDENTIFIED	1158	0	0	0	0
54	12430	(C19 H32) (120,119) [10414]	2483	0	0	0	*
55	12434	UNIDENTIFIED	1502	0	0	0	0
56	12438	(195,119,210,270) [10420]	1361	0	0	0	*
57	12443	(145,146,169) [10425]	8298	2	0	0	*
58	12446	(120,106) [10427]	2415	0	0	0	0
59	12449	(224,155,156,181) [10430,10431]	7161	2	0	0	*
60	12455	SILANATED [10436]	2884	0	0	0	0
61	12466	(C21 H36) (119,120,106,288) [10447]	3242	1	0	0	*
62	12468	(159,183)	2542	0	0	0	*
63	12473	UNIDENTIFIED	1223	0	0	0	0
64	12474	UNIDENTIFIED	1094	0	0	0	0
65	12479	C20 H28 [10459]	3079	1	0	0	*
66	12485	(C19 H26) (183,254) [10464]	4004	1	0	0	*
67	12486	(C13 H16 O5) (237,252,195) [10466]	4989	1	0	0	*
68	12489	(C18 H22 OR C16 H14 O2) (223,238) [10468]	4162	1	0	0	*
69	12491	(239,253,267,285) [10470]	2667	1	0	0	*
70	12495	(267)	2379	0	0	0	*
71	12502	C20 H26 O2 (283,298)	1467	0	0	0	*
72	12503	PART OF ABOVE PEAK	4361	1	0	0	0
73	12508	SILANATED [10486]	9432	2	0	0	0
74	12510	UNIDENTIFIED	1174	0	0	0	0
75	12512	UNIDENTIFIED	1339	0	0	0	0
76	12519	UNIDENTIFIED	2117	0	0	0	0
77	12520	UNIDENTIFIED	1646	0	0	0	0
78	12524	UNIDENTIFIED	1807	0	0	0	0
79	12526	(145,146,131)	4387	1	0	0	*
80	12529	(C23 H40) (119,120,133,134)	4958	2	0	0	*
81	12537	(C20 H24) (249)	1792	0	0	0	*
82	12543	(309,299,252) [10517]	1727	0	0	0	0
83	12544	UNIDENTIFIED	1166	0	0	0	0
84	12549	UNIDENTIFIED	2153	1	0	0	0

95	12531	(294,322,326,298) [10333]	5928	3	0	0
96	12552	UNIDENTIFIED	2062	1	0	0
97	12555	(C18 H14 O5 OR C21 H26 O2) [10530]	3551	1	0	0
98	12556	SILANATED [10532]	3664	1	0	0
99	12562	UNIDENTIFIED	2360	1	0	0
100	12564	(145,197,146) [10940]	13128	6	0	0
101	12570	UNIDENTIFIED	1297	0	0	0
102	12575	SEE 12583 [10531]	2874	1	0	0
103	12582	(195,306,336,136) [10537]	2211	1	0	0
104	12583	(C21 H26 O2) (213,295,225,214,310) [10558]	16334	9	0	0
105	12586	(229,230,241) + (159,160) [10561]	3682	2	0	0
106	12600	UNIDENTIFIED [10574]	2719	2	0	0
107	12602	SILANATED [10575]	4817	3	0	0
108	12604	(199) [10578]	3966	3	0	0
109	12623	(209) [10579]	1924	1	0	0
110	12625	(195) [10598]	1259	1	0	0
111	12638	(187,143,171,199,193) [10640]	20315	2	0	0
112	12645	SILANATED [10617]	1668	2	0	0

Table C-6

TABLE C-6. MS OF OIL NO. 3, FIRST AROMATIC FRACTION

KEY

- 1) UNK* These spectra contain some or all of the following ions: 41, 43, 55, 67, 69, 81, 83, 95, 109, 123, 137, 165, 179, 193, 207 structures have not been determined.
- 2) Numbers in brackets [] indicate the corresponding spectra numbers in Table C-4, Oil No. 1, First Aromatic Fraction.
- 3) Numbers in parentheses indicate ions which seem to peak together.
- 4) Additional peaks not included by the Cleanup program are:

12243	$C_{12}H_{16}$ or $C_{11}H_{12}O$ [10234]
12291	$C_{13}H_{14}$
12347	$C_{15}H_{18}$

TABLE C-7. MS OF OIL NO. 1, MIDDLE AROMATIC FRACTION

Retention Time (min)	Identification	TIC	Total Peak Count
7033	UNIDENTIFIED	107446	40
7209	C10 H22 N DECANE	56723	85
7245	C12 H26 N DODECANE	42951	81
7261	C14 H30 N TETRADECANE	66213	79
7264	C15 H17 METHYLBIPHENYL + C12 H12 DIMETHYLNAPHTHALENE	6808	29
7275	ALKANE	4399	17
7277	C13 H12 METHYLBIPHENYL OR C14 H14 DIMETHYLBIPHENYL	9232	41
7282	C15 H24 3 METHYL 6-TERT-BUTYLPHENOL	93234	84
7293	PHENYLALKANE (91, 92)	3549	5
7295	C14 H14 DIMETHYLBIPHENYL	4496	9
7281	C13 H14 TRIMETHYLNAPHTHALENE + PHENYLALKANE	2914	11
7295	C14 H14 TRIMETHYLNAPHTHALENE	5435	17
7297	C15 H15 DIMETHYLBENZENE	3354	6
7299	C13 H10 FLUORENE + C15 H14 DIMETHYLFLORENE	6592	17
7302	C14 H14 DIMETHYLBIPHENYL + C13 H14 TRIMETHYLNAPHTHALENE	12732	23
7305	C14 H14 DIMETHYLBIPHENYL + BUTYRATED COMPOUND	17645	30
7307	PHENYLALKANE	3874	6
7308	C15 H15 DIMETHYLBENZENE	12301	19
7310	C16 H14 N PENTADECANE	62317	56
7312	C14 H14 DIMETHYLBIPHENYL + C15 H14 DIMETHYLBENZENE + C11H9	12716	15
7318	C16 H16 DIPHENYLALKANE	10354	12
7325	ALKANE	7185	11
7327	C16 H16 DIPHENYLALKANE	4829	7
7329	C14 H14 OR C15 H12 D	2718	4
7331	C16 H16 DIPHENYLALKANE	2443	3
7333	C15 H15 DIMETHYLBENZENE	1553	15
7335	C12 H12 METHYLENE + C16 H18	2503	8

Retention Time	Peak Label	Retention Time	Peak Label
7347	UNIDENTIFIED	18017	15 1937 17
7348	UNIDENTIFIED	2046	2 1840
7349	UNIDENTIFIED	3478	3 1875 11
7350	UNIDENTIFIED	3794	2 1888 10
7351	UNIDENTIFIED	18514	13 1891 25
7352	UNIDENTIFIED	4917	3 1900 16
7353	UNIDENTIFIED	15331	10 1915 55
7354	UNIDENTIFIED	1746	1 1928 6
7355	UNIDENTIFIED	1501	1 1944 5
7356	UNIDENTIFIED	3040	2 1997 11
7357	UNIDENTIFIED	44295	24 2012 122
7358	UNIDENTIFIED	3372	2 2001 12
7359	UNIDENTIFIED	1206	0 2062 5
7360	UNIDENTIFIED	2399	1 2071 10
7361	UNIDENTIFIED	2914	2 2093 14
7362	UNIDENTIFIED	1202	0 2099 4
7363	UNIDENTIFIED	2045	1 2130
7364	UNIDENTIFIED	2311	
7365	UNIDENTIFIED		
7366	UNIDENTIFIED		
7367	UNIDENTIFIED		
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7496	UNIDENTIFIED		
7497	UNIDENTIFIED		
7498	UNIDENTIFIED		
7499	UNIDENTIFIED		
7500	UNIDENTIFIED		

Table
C

Sample	Retention Time (min)	Identification	1820	2183	B
63	7501	UNIDENTIFIED	1820	1	2183
64	7506	(15 HIB)	1342	0	2195
65	7518	(20 HIB ON BUTYL N-HEXYL TETRAHYDRONAPHTHALENE)	2667	2	2277
66	7541	(20 HIB)	7370	4	2322
67	7548	UNIDENTIFIED	9677	4	2332
68	7568	UNIDENTIFIED	1129	0	2356
69	7603	UNIDENTIFIED	1195	1	2425
70	7614	UNIDENTIFIED	1282	1	2553
71	7620	UNIDENTIFIED	3027	3	2595
72	7639	UNIDENTIFIED	1166	1	2516
			1364	1	2648

TABLE C-7. MS OF OIL NO. 1, MIDDLE AROMATIC FRACTION

KEY

Peaks not included by CLEANUP program:

7246	$C_{11} H_{10}$	Methylnaphthalene
7247	$C_{12} H_{18}$	
7257	$C_{12} H_{10}$	Biphenyl
7258	$C_{13} H_{12}$	Methylbiphenyl + $C_{12} H_{18}$
7267	$C_{12} H_{12}$	Dimethylnaphthalene
7287	$C_{13} H_{14}$	Trimethylnaphthalene
7419	$C_{15} H_{12}$ or $C_{16} H_{16}$	
7479	$C_{17} H_{16}$	Trimethylphenanthrene

If the "Identification" slot is empty, then no specific compound could be identified, although a definite peak exists.

MIDDLE MAS

TABLE 5-8. MS OF OIL NO. 2, MIDDLE AROMATIC FRACTION

PEAK #	SPEC.	ID	UV	TIC RAT	RET TIME	COLON	TEMP
1	8027	C 12 1,2-DICHLOROMETHANE	317305	65	219	17	
2	8036	UNIDENTIFIED	99590	41	152	13	
3	8192	C10 H22 N-DECANE	34793	24	134	41	
4	8217	C12 H24 N DODECANE	4221	66	139	22	
5	8246	C14 H30 N-TETRADECANE	87711	32	141	30	
6	8267		1376	13	141	2	
7	8284		1122	5	142	7	
8	8292	C16 H32 O4 TRIMETHYLPENTADECADIENESULFONATE	4350	17	145	7	
9	8299	C16 H34 N-HEXADECANE	58773	14	144	13	
10	8320		1015	6	146	7	
11	8323	C14 H12 METHYLFLUORENE	2607	5	145	4	
12	8327	SILANATED	5024	9	168	20	
13	8337		1102	1	157	5	
14	8340	C16 H14 DIMETHYLPHENANTHRENE	2159	3	157	3	
15	8345	C18 H30 (TENT)	1458	2	142	7	
16	8347	C14 H10 PHENANTHRENE	2409	3	148	10	
17	9354	C17 H18 TRIMETHYLPHENANTHRENE	4258	4	169	18	
18	8356	[REDACTED]	6243	6	175	27	
19	8364	C16 H14 DIMETHYLPHENANTHRENE + C15 H14 DIMETHYLFLUORENE	29659	23	149	80	
20	8367		1446	1	148	4	
21	8368	C17 H16 TRIMETHYLPHENANTHRENE	6292	5	1811	15	
22	8371	UNIDENTIFIED	1705	1	1819	4	
23	9376	ALKANE	2173	2	1834	5	
24	8381	SILANATED	2396	2	1848	6	
25	8386	C20 H24 (TENT)	2410	2	1862	3	
26	8387	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	2944	2	1845	7	
27	8389	C19 H18 TETRAMETHYL OR ALKYLPHENANTHRENE	2776	2	1871	7	
28	8390	UNIDENTIFIED	1550				

Table
C-8

29	8393	C15 H12 METHYLPHENANTHRENE	6178	4	1882	13
30	8395	C17 H16 ALKYLDIHYDRONAPHTHALENE	2203	1	1888	5
31	8399	PART OF PEAK BELOW	2970	2	1899	7
32	8401	C17 H16 TRIMETHYLPHENANTHRENE	10975	7	1909	26
33	8402	C16 H16 + UNIDENTIFIED	2564	1	1908	7
34	8405	C18 H20	1281	0	1917	3
35	8406	C17 H16 ISOMER(S)	3142	2	1920	8
36	8407	UNIDENTIFIED	1468	1	1923	4
37	8409	C16 H16	2040	1	1929	5
38	8415	C16 H16	3954	2	1947	10
39	8418	C16 H16 + C18 H16	2237	1	1955	5
40	8422	UNIDENTIFIED	2193	1	1967	5
41	8423	C20 H42 ALKANE + UNIDENTIFIED	2635	1	1970	7
42	8434	UNIDENTIFIED	1217	0	2002	6
43	8435	UNIDENTIFIED	1831	1	2005	8
44	8436	C18 H18 ALKYLPHENANTHRENE + C16 H14	2306	1	2008	11
45	8437	C16 H10 FLUORANTHENE (TENT)	3699	2	2011	17
46	8441	UNIDENTIFIED	1827	1	2023	8
47	8442	C18 H18 ALKYLPHENANTHRENE	2185	1	2026	10
48	8448	UNIDENTIFIED	1439	1	2044	7
49	8452	UNIDENTIFIED	1485	1	2055	7
50	8455	C16 H12 DIBENZOHEPTAFLUENE	3416	2	2064	16
51	8460	UNIDENTIFIED	1403	1	2079	6
52	8462	UNIDENTIFIED	1401	1	2085	6
53	8467	C21 H44 ALKANE	3442	2	2100	14
54	8470	C17 H16 TRIMETHYLPHENANTHRENE	1981	1	2109	9
55	8478	UNIDENTIFIED	1983	1	2132	9
56	8481	UNIDENTIFIED	1511	1	2141	7
57	8484	C17 H12 BENZOFLUORENE OR METHYLPIRENE	5714	4	2190	37
58	8490	UNIDENTIFIED	1223	0	2167	6
59	8500	C17 H12 BENZOFLUORENE OR METHYLPIRENE	3037	2	2197	13
60	8516	UNIDENTIFIED	2926	2	2248	14
61	8521	C18 H18 (TENT)	2504	2	2265	11

Table
C-8

	829	C18 M14			
62			3252	2	2291
63	8941	C18 M18	1723	1	2329
					7

TETRAMETHYLPHENANTHRENE OR METHYLISOPROPYLPHENANTHRENE

TABLE C-8. MS OF OIL NO. 2, MIDDLE AROMATIC FRACTION

KEY

Peaks not included by CLEANUP program

8431 $C_{18} H_{14}$ Dimethylphenanthrene

8563 $C_{19} H_{16}$ Isomer

If the "Identification" slot is empty, then no specific compound could be identified, although a definite peak exists.

TABLE C-9. MS OF MIDDLE AROMATIC FRACTION, OIL NO. 3

ME0115 MAS

PEAK #	SPEC	ID	TIC	TIC(RAT)	RETIND	RELCON	TYPE
1	9010	UNIDENTIFIED	2461	45	367	45	
2	9016	UNIDENTIFIED	812484	74	322	14783	
3	9023	UNIDENTIFIED	435892	73	269	8214	
4	9036	UNIDENTIFIED	12017	9	172	226	
5	9194	C10 H20 N DECANE	1786	20	1016	26	
6	9219	C12 H26 N-DODECANE	2730	22	1204	33	
7	9247	C14 H30 N TETRADECANE	6688	43	1400	100	
8	9274	SILANATED	6507	33	1503	61	
9	9283	C13 H14 TRIMETHYLNAPHTHALENE	2862	15	1538	30	
10	9288	C13 H10 FLUORENE	9621	32	1557	101	
11	9290	C13 H14 TRIMETHYLNAPHTHALENE + C14 H14 DIMETHYLDIPHENYL	5011	18	1565	53	
12	9291	BUYRATED COMPOUND	15164	42	1569	157	
13	9297	C15 H16 DIMETHYLBENZYL BENZENE + PHENYLALKANE	2664	9	1592	28	
14	9299	C16 H24 N HEXADECANE	8780	26	1599	84	
15	9301	C14 H14 DIMETHYLDIPHENYL + C15 H16 DIMETHYLBENZYL BENZENE	2383	7	1608	30	*
16	9302	C15 H16 DIMETHYLBENZYL BENZENE	5889	17	1608	61	
17	9304	PART OF ABOVE PEAK	2045	8	1615	25	
18	9307	C16 H18 DIPHENYLALKANE	3290	12	1624	35	*
19	9308		2044	7	1627	21	*
20	9309	PART OF ABOVE PEAK	3334	11	1630	35	*
21	9316	C16 H18 DIPHENYLALKANE	7052	15	1631	74	*
22	9318	C16 H16 (4,5)DIMETHYL (9,10)DIHYDROPHENANTHRENE	3486	7	1637	37	*
23	9320	C15 H16 OR C16 H18	6361	9	1663	66	*
24	9321	PHENYLALKANE	3758	5	1667	39	*
25	9324	C14 H12 METHYLFLUORENE	45590	52	1676	487	*
26	9326	PART OF ABOVE PEAK	12150	12	1682	126	*

Table
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27	9327	SILANATED	19772	34	1689	211
28	9331		6856	9	1697	71 *
29	9334	C14 H16 1-METHYL-7-ISOPROPYLNAPHTHALENE	35689	36	1706	443 *
30	9336		4961	6	1712	62 *
31	9338	PHENYLALKANE	2871	4	1719	54
32	9342		6137	8	1731	115 *
33	9345	UNIDENTIFIED	3171	4	1740	57
34	9347	C14 H10 PHENANTHRENE OR ANTHRACENE	56666	43	1746	1033 *
35	9349	UNIDENTIFIED	3028	3	1752	54
36	9351	SILANATED	1243	1	1758	22
37	9354		6081	6	1767	111 *
38	9357	UNIDENTIFIED	2299	2	1777	43
39	9359	C15 H14 DIMETHYLFLUORENE	7568	7	1783	138 *
40	9365	C15 H14 DIMETHYLFLUORENE	19722	12	1801	374 *
41	9368		4432	3	1810	83 *
42	9369	ALKANE	5013	3	1812	96 *
43	9371	C16 H12 1-PHENYLNAPHTHALENE OR DIBENZOHEPTAFLUORENE	4436	3	1818	85 *
44	9373	UNIDENTIFIED	3829	3	1824	71
45	9376	C16 H18 DIPHENYLALKANE	18873	13	1833	337 *
46	9380	UNIDENTIFIED	2584	2	1844	49
47	9382	SILANATED	23044	15	1850	440
48	9383		12451	9	1853	232 *
49	9389	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	18473	10	1870	344 *
50	9390	UNIDENTIFIED	7729	4	1873	148
51	9395	UNIDENTIFIED	3185	1	1887	59
52	9396	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	7921	32	1890	1320
53	9398	ALKANE (N-C17 H40)	12304	6	1896	229
54	9400	UNIDENTIFIED	2037	1	1902	38
55	9404	C15 H12 0,9 METHOXYANTHRACENE	38111	18	1914	711 *
56	9406	UNIDENTIFIED	3631	1	1920	65
57	9407	UNIDENTIFIED	1867	1	1922	35
58	9408	UNIDENTIFIED	1093	0	1925	20
59	9410	UNIDENTIFIED	2147	1	1931	72

Table
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60	9412	UNIDENTIFIED	2437	1	1937	67
61	9414	UNIDENTIFIED	1521	0	1943	49
62	9417	UNIDENTIFIED	2008	1	1952	62
63	9421	UNIDENTIFIED	1194	0	1964	38
64	9422	C17 H16 O (SEE 9409)	13049	6	1967	357
65	9425	UNIDENTIFIED	1952	0	1976	27
66	9428	UNIDENTIFIED	2671	0	1981	65
67	9429		8941	2	1988	183
68	9431	UNIDENTIFIED	1144	0	1994	37
69	9433	N C10 H12	1037	0	2000	37
70	9435	SILANATED	13637	4	2005	436
71	9437	(2,3-DIMETHYLPHENANTHRENE	5924	2	2011	189
72	9441	PART OF ABOVE PEAK	3370	1	2023	87
73	9444	UNIDENTIFIED	4119	1	2032	171
74	9445	UNIDENTIFIED	3629	1	2035	122
75	9449	UNIDENTIFIED	1791	0	2047	46
76	9450	UNIDENTIFIED	4403	2	2050	126
77	9452	C17 H14 (2-BENZYLNAPHTHALINE	4131	1	2056	113
78	9455	UNIDENTIFIED	2611	1	2065	62
79	9457	C16 H10 PYRENE OR FLUORANTHENE	4637	2	2071	118
80	9459		2600	1	2077	65
81	9460	UNIDENTIFIED	1583	0	2080	40
82	9473		15636	6	2089	410
83	9465	UNIDENTIFIED	1577	0	2094	37
84	9466	N C11 H14	2390	1	2097	61
85	9472	C17 H16 TRIMETHYLPHENANTHRENE	3727	1	2115	89
86	9477	C17 H16 TRIMETHYLPHENANTHRENE	7425	3	2130	246
87	9481	SILANATED	5857	2	2142	198
88	9483	UNIDENTIFIED	4613	1	2148	133
89	9486	SILANATED	7701	3	2157	266
90	9488	UNIDENTIFIED	2756	1	2163	91
91	9491	C18 H18 1-METHYL-7-ISOPROPYLPHENANTHRENE	11091	4	2172	368
92	9492		17426	6	2186	788

93	9498	ALKANE	2934	1	2192	83
94	9505	UNIDENTIFIED	6478	3	2214	184
95	9506	UNIDENTIFIED	1681	0	2218	56
96	9508	UNIDENTIFIED	2198	1	2224	71
97	9510	UNIDENTIFIED	1556	0	2231	92
98	9518	UNIDENTIFIED	4916	2	2257	140
99	9520	UNIDENTIFIED	3840	2	2263	130
100	9522	UNIDENTIFIED	1786	1	2270	60
101	9525	UNIDENTIFIED	2915	1	2280	94
102	9531	C20 H32 (N-BUTYL N-HEXYL TETRAHYDRONAPHTHALENE)	8834	4	2299	293 *
103	9533	SILANATED	5470	2	2306	184
104	9534	C20 H32 (N-BUTYL N-HEXYL TETRAHYDRONAPHTHALENE)	12660	7	2309	408 *
105	9538	UNIDENTIFIED	1614	0	2322	54
106	9539	UNIDENTIFIED	2910	1	2325	96
107	9541	UNIDENTIFIED	2106	1	2332	68
108	9545	UNIDENTIFIED	2775	2	2345	92
109	9552	UNIDENTIFIED	2808	2	2368	80
110	9553	UNIDENTIFIED	1786	1	2371	35
111	9559	UNIDENTIFIED	2861	2	2390	83
112	9560	UNIDENTIFIED	4476	3	2394	130
113	9561		3473	2	2397	110 *
114	9563	UNIDENTIFIED	1670	1	2404	48
115	9569	UNIDENTIFIED	1878	1	2424	60
116	9576	SILANATED	7815	7	2448	152
117	9579	UNIDENTIFIED	3081	3	2458	72
118	9582	UNIDENTIFIED	2063	2	2468	60
119	9596		2688	3	2516	52 *
120	9604	UNIDENTIFIED	2501	3	2545	98
121	9606		2050	2	2552	48 *
122	9611	UNIDENTIFIED	1078	1	2570	21
123	9617	SILANATED	4389	6	2592	103
124	9665	SILANATED	2740	7	2743	53

TABLE C-9. MS OF MIDDLE AROMATIC FRACTION, OIL NO. 3

Key

Peaks not included by CLEANUP program

9253 C₁₂H₁₂ Dimethylnaphthalene

9262 C₁₃H₁₂ (2)Methylbiphenyl

If the "identification" slot is empty, then no specific compound could be identified from the data.

MFO101 MAS

TABLE C-10. MS OF OIL NO. 1, HEAVY AROMATIC FRACTION

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	27282 C12 H12 DIMETHYLNAPHTHALENE		5532	15570	19	0	0
2	27303 C13 H12 METHYLBIPHENYL		2024	7056	9	0	0
3	27310 C15 H24 O 2,6-DI-T-BUTYL-4-METHYL PHENOL		11550	39837	34	0	0
4	27316 C13 H14 TRIMETHYLNAPHTHALENE		2197	7578	10	0	0
5	27326 C13 H14 TRIMETHYLNAPHTHALENE		5250	16939	19	0	0
6	27333 C13 H10 FLUORENE OR PHENALENE + C13 H14 TRIMETHYLNAPHTHALENE		6423	26106	23	0	0
7	27347 C14 H14 DIMETHYLBIPHENYL + ALKANE		1400	5932	6	0	0
8	27369 C14 H16 C4-ALKYLNAPHTHALENE		2854	8041	10	0	0
9	27370 C14 H12 O METHOXYFLUORENE OR C15 H16 ISOMER		1823	7677	6	0	0
10	27372 C14 H12 1-METHYLFLUORENE		15551	60290	41	0	0
11	27383 C14 H16 C4-ALKYLNAPHTHALENE + SILANATED		8348	41672	23	0	0
12	27386 C15 H16 ALKYL DIBENZENE		3252	17074	14	0	0
13	27398 C14 H10 ANTHRACENE OR PHENANTHRENE		2362	11539	12	0	0
14	27413 C15 H14 DIMETHYLFLUORENE		9843	48471	30	0	0
15	27423 C13 H10 S 3-METHYL DIBENZOTHIOPHENE		1687	7063	8	0	0
16	27434 C15 H18 C5-ALKYLNAPHTHALENE		1123	5368	5	0	0
17	27440 SILANATED		4979	14964	20	0	0
18	27444 C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE		6926	28084	25	0	0
19	27452 C15 H12 O METHOXYANTHRACENE OR C16 H16 ISOMER		5919	23754	23	0	0
20	27462 UNIDENTIFIED		2915	8923	10	0	0
21	27483 C16 H14 (3,6-)DIMETHYLPHENANTHRENE		9364	50841	31	0	0
22	27494 SILANATED		6372	16368	26	0	0
23	27510 UNIDENTIFIED		1200	5700	5	0	0
24	27521 C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE		4884	21406	19	0	0
25	27540 C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE		5316	19147	17	0	0
26	27544 SILANATED		6280	17368	24	0	0
27	27580 C19 H30 (SUCH AS 2-N-BUTYL-5-N-HEXYL INDAN)		1106	3746	5	0	0
28	27590 SILANATED		5077	18115	20	0	0

MFO18S.MAS

TABLE C-11. MS OF OIL FOR RUN NO. 2 (B-1), HEAVY AROMATIC FRACTION

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	30271	C13 H12 DIPHENYLMETHANE	1738.	5634.	23	0	0
2	30276	C12 H8 ACENAPHTHYLENE	8842.	29559.	74	0	0
3	30300	C15 H24 O 2,6-DI-T-BUTYL-4-METHYL PHENOL (IONOL)	75536.	161131.	95	0	0
4	30301	ALKYLBENZENE	3369.	7243.	12	0	0
5	30303	C14 H14 DIMETHYLBIPHENYL	7833.	31648.	41	0	0
6	30317	C13 H14 C3-ALKYLNAPHTHALENE	3654.	16688.	26	0	0
7	30322	C13 H10 FLUORENE OR PHENALENE	22416.	84873.	64	0	0
8	30330	C13 H10 METHYLACENAPHTHYLENE + UNIDENTIFIED	3242.	10996.	14	0	0
9	30331	C14 H14 DIMETHYLBIPHENYL	1467.	4765.	6	0	0
10	30333	ALKYLBENZENE	2549.	10462.	10	0	0
11	30335	C15 H16 (1,2-DIMETHYL-4-BENZYL BENZENE)	8116.	29942.	24	0	0
12	30336	UNIDENTIFIED	4401.	15883.	16	0	0
13	30340	C14 H14 ISOMER	2257.	10505.	8	0	0
14	30347	C15 H16 1,3-DIPHENYLPROPANE	8088.	26614.	40	0	0
15	30351	UNIDENTIFIED	1195.	5327.	10	0	0
16	30359	C15 H12 O METHOXYANTHRACENE	2652.	7687.	11	0	0
17	30363	C15 H16 ALKYL DIBENZENE	19671.	77020.	28	0	0
18	30366	C14 H12 1-METHYLFLUORENE + C16 H18 (TETRAMETHYLBIPHENYL)	55127.	226798.	60	0	0
19	30368	ALKYLBENZENE + C15 H14 ISOMER	4053.	18487.	8	0	0
20	30373	C15 H14 DIMETHYLFLUORENE	3447.	15785.	10	0	0
21	30377	C15 H16 ALKYL DIBENZENE + C14 H16 C4-ALKYLNAPHTHALENE	15215.	67561.	30	0	0
22	30381	C16 H18 ALKYL DIBENZENE	4250.	17260.	14	0	0
23	30387	C15 H16 ALKYL DIBENZENE	2865.	10481.	8	0	0
24	30389	C14 H10 ANTHRACENE OR PHENANTHRENE	28133.	99729.	51	0	0
25	30393	ALKYLBENZENE + UNIDENTIFIED (224,209)	4914.	17140.	14	0	0
26	30397	UNIDENTIFIED	5535.	15748.	13	0	0
27	30398	C14 H10 O ISOMER (TENT.)	5390.	19974.	13	0	0
28	30408	C15 H14 ALKENYL DIBENZENE	20163.	97016.	23	0	0

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29	30410	C15 H14 ALKENYL DIBENZENE	17007.	67484.	23	0	0
30	30413	C16 H16 OR C15 H12 O ISOMER	4741.	16802.	7	0	0
31	30417	UNIDENTIFIED	1060.	4174.	2	0	0
32	30419	C15 H14 ALKENYL DIBENZENE	13895	55279.	25	0	0
33	30421	ALKYLBENZENE + C15 H18 C5-ALKYLNAPHTHALENE	5245	24983	12	0	0
34	30427	C15 H18 OR C14 H14 O ISOMER + C16 H18 ALKYL DIBENZENE	6586	21880	13	0	0
35	30431	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	5014.	22085	8	0	0
36	30436	ALKYLBENZENE + UNIDENTIFIED (234,219)	1778	7255	2	0	0
37	30439	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	33762	142801.	41	0	0
38	30447	C16 H16 OR C15 H12 O ISOMER	17519.	80244.	22	0	0
39	30451	UNIDENTIFIED	2515	10159	4	0	0
40	30455	C16 H12 PHENYLNAPHTHALENE OR OTHER ISOMER	3906	15476.	7	0	0
41	30457	C14 H12 S * (TENT.)	2480	8625	4	0	0
42	30459	C17 H14 2-BENZYLNAPHTHALENE + UNIDENTIFIED	1885	6431	3	0	0
43	30461	C15 H12 O METHOXYANTHRACENE	4519	14170	7	0	0
44	30468	UNIDENTIFIED	2356.	9315	4	0	0
45	30478	C16 H14 (2,3-)DIMETHYLPHENANTHRENE	26076	124366.	26	0	0
46	30480	UNIDENTIFIED	2162.	9764.	2	0	0
47	30483	C16 H14 C2-ALKYLPHENANTHRENE OR ANTHRACENE	7213	28625	8	0	0
48	30485	SILANATED	1481.	5877.	2	0	0
49	30488	C15 H20 O2 ISOMER (TENT.)	2055	9518	3	0	0
50	30492	UNIDENTIFIED	1201.	6244.	1	0	0
51	30494	C17 H14 2-BENZYLNAPHTHALENE OR OTHER ISOMER	4969	19071.	7	0	0
52	30495	PART OF PEAK ABOVE	1360	7070	2	0	0
53	30498	C15 H24 O2 (SUCH AS 2,6-DI-T-BUTYL-4-METHOXY PHENOL)	4643	15265.	7	0	0
54	30500	C16 H10 PYRENE OR FLUORANTHENE	2251.	11138	3	0	0
55	30505	UNIDENTIFIED	2447.	11563	4	0	0
56	30512	C18 H14 TERPENE	6097.	22904.	8	0	0
57	30514	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	11941.	45872.	15	0	0
58	30519	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	7235	33857	9	0	0
59	30522	UNIDENTIFIED	2242	9163	3	0	0
60	30531	UNIDENTIFIED	1026.	5204.	1	0	0
61	30533	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE + SILANATED	5331.	20563.	6	0	0

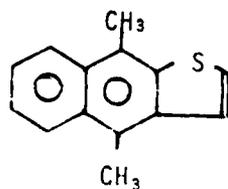
Table
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62	30537	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	9136.	20401.	7	0	0
63	30542	UNIDENTIFIED	3337.	13047.	5	0	0
64	30559	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	6447.	24886.	10	0	0
65	30564	UNIDENTIFIED	1303.	5509.	2	0	0
66	30572	C19 H30 (SUCH AS 2-N-BUTYL-3-N-HEXYL INDAN)	5784.	26969.	9	0	0
67	30577	SILANATED	2761.	8842.	4	0	0
68	30583	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	1773.	8261.	3	0	0
69	30598	UNIDENTIFIED	1423.	5975.	3	0	0
70	30600	UNIDENTIFIED	1776.	7742.	3	0	0
71	30619	SILANATED	1401.	4495.	3	0	0
72	30644	UNIDENTIFIED	1207.	5338.	3	0	0
73	30658	SILANATED	1462.	6528.	4	0	0
74	30705	UNIDENTIFIED	2732.	12997.	15	0	0

TABLE C-11. MS OF OIL FOG RUN NO. 2 (B-1), HEAVY AROMATIC FRACTION

Key

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2a **

30287

C₁₃H₁₂ methylbiphenyl

MFOTO1 MAS

TABLE C-12. MS OF OIL FOG RUN NO. 11 (8-1[HT]), HEAVY AROMATIC FRACTION

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	29300	C12 H8 ACENAPHTHYLENE	3789	16946	34	0	0
2	29320	C15 H24 O 2,6-DI-T-BUTYL-4-METHYL PHENOL	5217	11091	41	0	0
3	29322	C14 H14 1,2-DIPHENYLETHANE	2446	8699	20	0	0
4	29323	C14 H14 DIMETHYL BIPHENYL	2637	10830	27	0	0
5	29340	C13 H14 TRIMETHYLNAPHTHALENE	3238	15620	10	0	0
6	29341	C13 H10 FLUDRENE OR PHENALENE	16699	67516	72	0	0
7	29347	C13 H14 C3-ALKYLNAPHTHALENE + C14 H12 METHYLFLUDRENE	1200	4731	7	0	0
8	29353	ALKYLBENZENE	1493	5029	6	0	0
9	29354	C15 H16 ALKYL DIBENZENE	3327	10651	14	0	0
10	29355	C13 H10 FLUDRENE OR METHYL ACENAPHTHYLENE	6151	35473	28	0	0
11	29367	C15 H16 1,3-DIPHENYLPROPANE	1599	8252	15	0	0
12	29384	C14 H12 METHYLFLUDRENE OR 1,1-DIPHENYLETHENE	29910	133771	59	0	0
13	29392	C15 H14 DIMETHYLFLUDRENE	1949	7843	6	0	0
14	29396	C14 H12 METHYLFLUDRENE + C15 H16 ALKYL DIBENZENE	8733	35141	23	0	0
15	29400	C16 H18 ALKYL DIBENZENE	1188	4010	4	0	0
16	29406	C14 H12 METHYLFLUDRENE OR OTHER ISOMER	5250	17599	11	0	0
17	29408	C14 H10 ANTHRACENE OR PHENANTHRENE	69043	276945	79	0	0
18	29426	C15 H14 DIMETHYLFLUDRENE OR ALKENYL DIBENZENE	12676	57320	26	0	0
19	29432	C16 H16 OR C15 H12 O ISOMER	2608	10347	5	0	0
20	29439	C15 H14 DIMETHYLFLUDRENE OR ALKENYL DIBENZENE	9777	50394	21	0	0
21	29447	C15 H14 ISOMER + C16 H18 ISOMER	1913	9595	4	0	0
22	29450	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	7776	37277	13	0	0
23	29455	C15 H14 ISOMER + UNIDENTIFIED (219,234)	2471	9768	4	0	0
24	29456	PART OF PEAK BELOW	4358	21676	6	0	0
25	29458	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	38340	172630	49	0	0
26	29466	C15 H12 O METHOXYANTHRACENE	5524	23970	14	0	0
27	29471	C14 H22 O2 ISOMER (TENT.)	1454	6750	4	0	0
28	29475	C16 H12 PHENYLNAPHTHALENE	7402	30018	17	0	0

29	29480	UNIDENTIFIED	3984	19588	8	0	0
30	29481	UNIDENTIFIED	1217	6877	3	0	0
31	29488	UNIDENTIFIED	1709	7483	4	0	0
32	29498	C16 H14 DIMETHYLPHENANTHRENE OR DIMETHYLANTHRACENE	13669	74706	17	0	0
33	29501	UNIDENTIFIED	2360	9916	3	0	0
34	29503	C16 H14 ETHYL OR DIMETHYLPHENANTHRENE	24887	93437	30	0	0
35	29504	C16 H10 PYRENE OR FLUORANTHENE	6979	24412	11	0	0
36	29512	C16 H14 DIMETHYLPHENANTHRENE + C16 H10 PYRENE OR FLUORANTHENE	6510	29223	9	0	0
37	29515	UNIDENTIFIED	4186	22802	7	0	0
38	29518	UNIDENTIFIED	2074	8205	3	0	0
39	29519	C16 H10 PYRENE OR FLUORANTHENE	8996	41044	17	0	0
40	29525	C14 H22 O2 ISOMER	1116	5178	2	0	0
41	29533	C18 H14 TERPHENYL	2192	9156	4	0	0
42	29541	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	1716	7230	3	0	0
43	29550	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	2850	16088	4	0	0
44	29552	C17 H12 METHYLPYRENE OR BENZ[<i>a</i>]ANTHRACENE	5938	28079	9	0	0
45	29556	SILANATED	1658	8291	2	0	0
46	29558	C17 H12 METHYLPYRENE OR BENZ[<i>a</i>]ANTHRACENE	3958	22666	7	0	0
47	29560	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	1617	9230	3	0	0
48	29565	UNIDENTIFIED	1769	8425	3	0	0
49	29567	C17 H12 METHYLPYRENE OR BENZ[<i>a</i>]ANTHRACENE	2729	14122	5	0	0
50	29583	UNIDENTIFIED	1283	6294	2	0	0
51	29602	SILANATED	1944	6628	3	0	0
52	29624	UNIDENTIFIED	1838	10625	4	0	0
53	29644	SILANATED	1072	4322	3	0	0
54	29684	SILANATED	1075	3933	4	0	0

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TABLE C-13. MS OF OIL NO. 2, HEAVY AROMATIC FRACTION

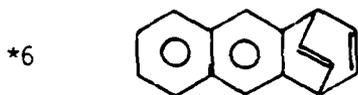
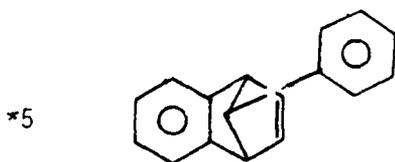
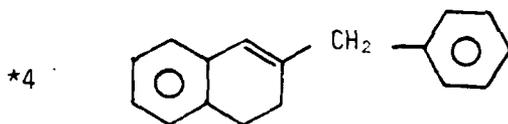
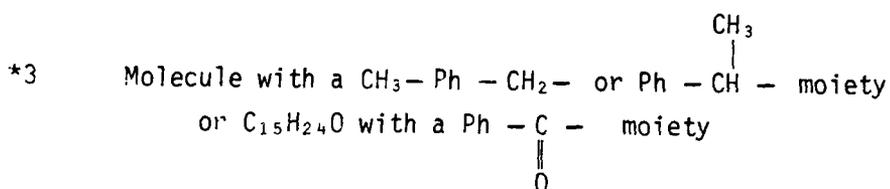
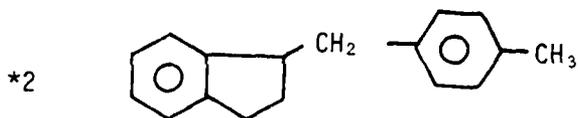
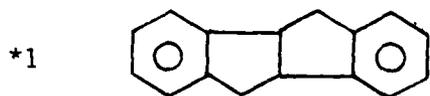
PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	25019	C H2 CL2 DICHLOROMETHANE	642295	3948723	97	0	0
2	25030	UNIDENTIFIED	87657	504584	13	0	0
3	25031	UNIDENTIFIED	398385	2393974	59	0	0
4	25033	UNIDENTIFIED	98536	608782	15	0	0
5	25041	UNIDENTIFIED	2171949	5498316	82	0	0
6	25042	UNIDENTIFIED	4419300	11187918	92	0	0
7	25044	UNIDENTIFIED	1255575	3818613	69	0	0
8	25056	UNIDENTIFIED	1337	3061	0	0	0
9	25332	C14 H30 N-TETRADECANE	7244	19333	34	0	0
10	25366	SILANATED	2899	14163	17	0	0
11	25388	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE OR C15 H24 O ISOMER	5773	16832	28	0	0
12	25398	C16 H14 4B,5,9B,10-TETRAHYDROINDENO[2,1-A]INDENE *1	21826	70161	58	0	0
13	25402	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE OR *2	4788	15764	21	0	0
14	25422	SILANATED + C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	12533	30998	39	0	0
15	25429	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE OR *2	2002	8429	8	0	0
16	25434	C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE OR *3	13431	60459	33	0	0
17	25439	C17 H16 3-BENZYL-1,2-DIHYDRONAPHTHALENE *4	4409	9060	13	0	0
18	25447	C16 H16 DIMETHYL-9,10-DIHYDROPHENANTHRENE OR C18 H12 O METHOXYANTHRACENE	3257	13549	13	0	0
19	25455	C17 H14 2-BENZYLNAPHTHALENE OR *5	3999	13926	14	0	0
20	25462	UNIDENTIFIED	1393	5860	4	0	0
21	25464	C16 H14 C2-ALKYLPHENANTHRENE OR ANTHRACENE OR OTHER ISOMER	2282	9883	7	0	0
22	25467	ALKYLBENZENE	1692	6323	4	0	0
23	25468	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	6038	23197	19	0	0
24	25471	UNIDENTIFIED	2386	11013	6	0	0
25	25475	SILANATED	10511	28139	23	0	0
26	25482	UNIDENTIFIED	1170	5922	3	0	0
27	25487	C16 H12 1-PHENYLNAPHTHALENE OR 1,4-DIHYDRO-1,4-ETHENOANTHRACENE *6	3722	16972	11	0	0
28	25492	C19 H20 O2 ISOMER (M232) (TENT.)	2140	9798	9	0	0

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29	29494	C19 H14 9-PHENYLFLORENE OR METHYLTRIPHENYLENE OR METHYLBENZANTHRACENE	1585	8098	4	0	0
30	29497	C14 H22 O2 (SUCH AS 2,6-DI-T-BUTYL-4-HYDROXY PHENOL)	4416	22818	11	0	0
31	29507	UNIDENTIFIED	1079	5102	2	0	0
32	29510	UNIDENTIFIED	1428	9420	3	0	0
33	29513	UNIDENTIFIED	1029	4240	2	0	0
34	29516	C17 H12 METHYLPYRENE OR 11H-BENZOCALFLORENE	7953	34044	19	0	0
35	29523	UNIDENTIFIED	3190	13080	6	0	0
36	29524	SILANATED	5966	16933	14	0	0
37	29533	C17 H12 METHYLPYRENE OR 11H-BENZOCALFLORENE	2428	13116	5	0	0
38	29548	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	9137	37723	19	0	0
39	29554	UNIDENTIFIED	4366	17145	8	0	0
40	29555	C18 H14 TERPHENYL OR STYRYLNAPHTHALENE	5921	23136	11	0	0
41	29561	C18 H14 TERPHENYL OR STYRYLNAPHTHALENE	13126	54438	21	0	0
42	29565	UNIDENTIFIED	1964	8333	3	0	0
43	29569	SILANATED	6194	18458	11	0	0
44	29573	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	5494	21280	11	0	0
45	29579	C20 H32 OR C19 H28 O ISOMER	2358	11941	5	0	0
46	29589	C18 H12 BENZ(A)ANTHRACENE, BENZO(C)PHENANTHRENE, CHRYSENE, OR TRIPHENYLENE	4132	17719	7	0	0
47	29599	UNIDENTIFIED	1462	6992	2	0	0
48	29611	SILANATED	6753	20679	12	0	0
49	29622	C19 H14 METHYLBENZ(A)ANTHRACENE	10058	45819	19	0	0
50	29650	SILANATED	3486	13283	8	0	0
51	29687	SILANATED	1378	6194	5	0	0

TABLE C-13. MS OF OIL NO. 2, HEAVY AROMATIC FRACTION

Key



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TABLE C-14. MS OF OIL FOG RUN NO. 4 (B-2). HEAVY AROMATIC FRACTION

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	26292	C12 H8 ACENAPHTHYLENE	1518.	6515	7	0	0
2	26333	C13 H10 FLUORENE OR PHENALENE	4700.	19178	23	0	0
3	26347	C13 H10 FLUORENE OR PHENALENE	1891.	9283	12	0	0
4	26375	C14 Q12 1-METHYLFLUORENE	9232.	46607	41	0	0
5	26385	SILANATED	3513.	10230	16	0	0
6	26387	C14 H12 METHYLFLUORENE	1055.	3070	9	0	0
7	26397	C14 H12 METHYLFLUORENE OR 1,1-DIPHENYLETHENE + C16 H18 ALKYLIDIBENZENE	1498.	6373	6	0	0
8	26399	C14 H10 PHENANTHRENE OR ANTHRACENE	7300.	30506	35	0	0
9	26409	C14 H22 O2 (2,6-DI-T-BUTYL-4-HYDROXY PHENOL)	3328.	16518	14	0	0
10	26418	C15 H14 DIMETHYLFLUORENE	7751.	34356	17	0	0
11	26419	C16 H14 *1	5524.	21132	15	0	0
12	26444	SILANATED	5719.	14149	14	0	0
13	26447	C15 H12 METHYLPHENANTHRENE OR METHYLANTHRACENE	16441.	74220	33	0	0
14	26457	C15 H12 O METHOXYANTHRACENE + C17 H16 TRIMETHYLPHENANTHRENE	9179.	39879	19	0	0
15	26464	C15 H12 O METHOXYANTHRACENE OR OTHER ISOMER	16049.	96600	34	0	0
16	26471	C15 H12 O METHOXYANTHRACENE OR OTHER ISOMER	4978.	19915	11	0	0
17	26478	UNIDENTIFIED (219, 248, 233)	1042.	3762	2	0	0
18	26486	C15 H12 O ISOMER	2318.	10766	3	0	0
19	26488	C16 H14 C2-ALKYLPHENANTHRENE OR ANTHRACENE + C14 H22 O2 ISOMER	15357.	71701	21	0	0
20	26492	UNIDENTIFIED	7836.	29991	12	0	0
21	26493	C16 H10 PYRENE OR FLUORANTHENE + UNIDENTIFIED	12764.	48852	19	0	0
22	26494	SILANATED	2136.	8415	4	0	0
23	26499	C14 H22 O2 ISOMER + SILANATED	8674.	44836	15	0	0
24	26507	UNIDENTIFIED	2220.	7085	4	0	0
25	26508	SILANATED	2958.	10449	6	0	0
26	26511	C16 H10 PYRENE OR FLUORANTHENE	4997.	20983	9	0	0
27	26512	C16 H12 PHENYLNAPHTHALENE OR *2	3486.	16336	6	0	0
28	26517	C14 H22 O2 ISOMER + C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	7544.	35538	12	0	0

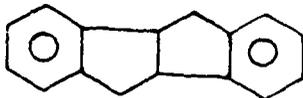
Table
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29	26526	C15 H12 N2 DIPHENYLPYRAZOLE	9019	36918	13	0	0
30	26532	C12 H10 O4 ISOMER (TENT) + C17 H16 C3-ALKYLPHENANTHRENE OR ANTHRACENE	12214	48930	18	0	0
31	26535	UNIDENTIFIED	1179	5231	1	0	0
32	26536	C17 H12 METHYLPYRENE OR 2,3-BENZOFUORENE	3861	18226	6	0	0
33	26542	C17 H12 METHYLPYRENE OR 2,3-BENZOFUORENE	6142	25355	10	0	0
34	26546	UNIDENTIFIED	1851	9271	3	0	0
35	26547	UNIDENTIFIED	1861	8819	2	0	0
36	26548	SILANATED	2492	7126	3	0	0
37	26549	C17 H14 2-BENZYLNAPHTHALENE OR *3 + C18 H18 C4-ALKYLPHENANTHRENE	8192	23317	14	0	0
38	26555	C17 H14 ISOMER	2589	11924	3	0	0
39	26557	C17 H12 METHYLPYRENE OR 2,3-BENZOFUORENE + UNIDENTIFIED (232,217)	10318	51710	14	0	0
40	26559	UNIDENTIFIED	2398	9688	4	0	0
41	26574	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	8682	31173	13	0	0
42	26576	SILANATED	3220	10829	5	0	0
43	26587	C18 H14 TERPHENYL OR STYRYLNAPHTHALENE	5835	23691	9	0	0
44	26594	SILANATED	2378	11554	3	0	0
45	26599	C18 H18 C4-ALKYLPHENANTHRENE OR ANTHRACENE	3954	17925	6	0	0
46	26602	C18 H14 TERPHENYL	2201	14442	3	0	0
47	26604	C20 H32 OR C19 H28 O ISOMER	1297	8507	2	0	0
48	26623	UNIDENTIFIED	1143	6283	2	0	0
49	26628	SILANATED	3247	13344	6	0	0
50	26636	SILANATED	2153	9579	4	0	0
51	26673	SILANATED	2493	12413	9	0	0
52	26714	SILANATED	2471	12592	15	0	0

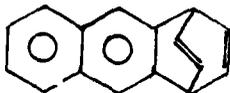
TABLE C-14. MS OF OIL FOG RUN NO. 4 (B-2), HEAVY AROMATIC FRACTION

Key

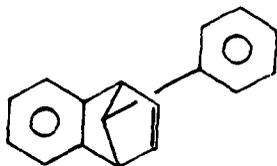
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TABLE C-15. MS OF OIL FOG RUN NO. 11 (B-1(HT)), HEAVIEST AROMATIC FRACTION

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	28219	C10 H8 NAPHTHALENE	5164	12749	34	0	0
2	28227	2-CHLOROPHTHOXY DERIVATIVE	3203	10240	26	0	0
3	28239	C11 H10 METHYLNAPHTHALENE	4988	15627	32	0	0
4	28242	C11 H10 METHYLNAPHTHALENE	3176	10154	20	0	0
5	28269	C12 H12 DIMETHYLNAPHTHALENE	7023	25647	41	0	0
6	28173	C14 H10 PHENANTHRENE OR ACETRACENE	1593	6253	16	0	0
7	28434	SILANATED	1911	9122	12	0	0
8	28487	SILANATED	5034	11593	21	0	0
9	28493	UNIDENTIFIED	1495	6797	7	0	0
10	28531	UNIDENTIFIED	1618	7461	5	0	0
11	28538	SILANATED	3791	11998	12	0	0
12	28548	UNIDENTIFIED	1538	9395	5	0	0
13	28584	SILANATED	4300	14177	13	0	0
14	28597	ALKYLBENZENE	2415	9223	6	0	0
15	28603	UNIDENTIFIED	1743	9202	5	0	0
16	28627	SILANATED	4893	16070	14	0	0
17	28668	SILANATED	4343	16033	14	0	0
18	28708	SILANATED	2222	10193	9	0	0

TABLE C-16. MS OF OIL NO. 2. NITROGEN BASES FRACTION

MF02NO.MAS

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCON	RETIND
1	9307	ALKANE	730.	2373.	17	0	0
2	9325	(SILANATED ?)	1993	5178.	25	0	0
3	9332	C13 H15 N TYPE A	653.	2130.	16	0	0
4	9339	UNIDENTIFIED	92755.	127548	108	0	0
5	9347	C14 H17 N TYPE B	981.	2529.	15	0	0
6	9351	ALKANE	587	2882.	7	0	0
7	9353	C12 H14 O4 DIETHYLPHTHALATE	856.	4202.	4	0	0
8	9355	C13 H15 N TYPE B	5941.	17591.	28	0	0
9	9356	C14 H17 N TYPE B	7238.	26295.	47	0	0
10	9358	C13 H17 N PENTAMETHYLINDOLE	1459.	3056.	13	0	0
11	9368	C14 H17 N TYPE B	7214.	21571.	41	0	0
12	9374	C14 H17 N TYPE A	6736.	20707.	42	0	0
13	9379	C14 H17 N TYPE B	4979.	14463.	29	0	0
14	9384	SILANATED	1407.	4214.	3	0	0
15	9386	C14 H17 N TYPE B	6329.	18385.	15	0	0
16	9387	ALKANE	4759.	13824.	10	0	0
17	9389	C14 H17 N TYPE A	55334.	136034.	72	0	0
18	9405	C15 H19 N TYPE A	47307.	132978.	82	0	0
19	9413	C15 H19 N TYPE B	33106.	76546.	67	0	0
20	9417	ALKANE	3408.	8337.	14	0	0
21	9419	C16 H21 N TYPE B	1213.	5213.	5	0	0
22	9422	UNIDENTIFIED	2150.	9240.	8	0	0
23	9429	C16 H21 N TYPE B	2793.	10132.	16	0	0
24	9430	UNIDENTIFIED	916.	4037.	5	0	0
25	9431	UNIDENTIFIED	2391.	7117.	13	0	0
26	9436	C15 H15 N (DIMETHYL 9,10-DIHYDROACRIDINE)	9621.	26576.	41	0	0

Table
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27	9438	SILANATED	2201	7096	14	0	0
28	9443	C14 H18 O4 DI-N-PROPYLPHTHALATE	544	2288	4	0	0
29	9450	ALKANE	3869	11927	25	0	0
30	9454	C15 H13 N METHYLPHENYLINDOLE OR DIMETHYLBENZODIQUINOLINE	4010	12668	20	0	0
31	9459	C15 H13 N METHYLPHENYLINDOLE OR DIMETHYLBENZODIQUINOLINE	9349	30781	23	0	0
32	9463	C16 H22 O4 DI-N-BUTYLPHTHALATE	17909	93570	43	0	0
33	9467	C15 H13 N METHYLPHENYLINDOLE OR DIMETHYLBENZODIQUINOLINE	3269	11802	9	0	0
34	9481	ALKANE	2007	5040	14	0	0
35	9487	UNIDENTIFIED	4629	11624	27	0	0
36	9488	SILANATED	2296	6057	17	0	0
37	9500	C16 H15 N OR C15 H11 N O	6985	23024	42	0	0
38	9512	ALKANE	1035	3411	9	0	0
39	9534	SILANATED & UNIDENTIFIED	7744	33116	50	0	0
40	9568	SILANATED	792	3084	11	0	0
41	9569	ALKANE OR BUTYRATE ESTER	601	2435	10	0	0
42	9577	SILANATED	843	3415	14	0	0
43	9589	UNIDENTIFIED	2688	9053	32	0	0
44	9631	PHTHALATE ESTER	541	2584	10	0	0
45	9689	SILANATED	560	2479	15	0	0

TABLE C-16. MS OF OIL NO. 2, NITROGEN BASES FRACTION

		Key
C ₁₃ H ₁₅ N	Type A	(184,185,157,156) -loss of H probably tetramethylquinoline
"	Type B	(185,170,186) -loss of CH ₃ probably C ₅ -alkylquinoline with at least one ethyl group
C ₁₄ H ₁₇ N	Type A	(198,199,171,200,172) -loss of H probably pentamethylquinoline
"	Type B	(184,199,200) -loss of CH ₃ probably C ₅ -alkylquinoline with at least one ethyl group
C ₁₅ H ₁₉ N	Type A	(212,213,185,198,214) -loss of H probably hexamethylquinoline
"	Type B	(198,185,213,212,199) -loss of CH ₃ probably C ₆ -alkylquinoline with at least one ethyl group
C ₁₆ H ₂₁ N	Type B	(212,227,226) -loss of CH ₃ probably C ₇ -alkylquinoline with at least one ethyl group
C ₁₅ H ₁₃ N		(207,208,206,165) Methylphenylindole or dimethylbenzoquinoline
C ₁₆ H ₁₅ N		(221,222,220,178,206) Dimethylphenylindole or trimethylbenzoquinoline or C ₁₅ H ₁₁ NO as diphenyloxazole or phenylquinoline oxide

TABLE C-17. MS OF OIL FOG RUN NO. 9(A-2), NITROGEN BASES FRACTION

MF02AN.MAS

PK#	SPEC	ID	TIC	AREA	TICRAT	RELCDN	RETIND
1	10181 C6 H8 O	CYCLOHEX-2-ENONE	13524	68725	54	0	0
2	10191 C6 H10 O	CYCLOHEX-2-ENOL	1057	4966	6	0	0
3	10200 C10 H18	4-T-BUTYLCYCLOHEXENE OR OTHER CYCLOHEXENE DERIVATIVE)	13607	49823	49	0	0
4	10246	UNIDENTIFIED	821	4131	6	0	0
5	10247 C10 H9 N	METHYLQUINOLINE	1461	7146	13	0	0
6	10264 C11 H11 N	DIMETHYLQUINOLINE	2105	6713	18	0	0
7	10289 C11 H11 N	DIMETHYLQUINOLINE	5566	24612	31	0	0
8	10288	UNIDENTIFIED	996	4960	6	0	0
9	10305	UNIDENTIFIED	474	2390	3	0	0
10	10309 C12 H13 N	TRIMETHYLQUINOLINE	6993	35151	31	0	0
11	10313 C12 H13 N	TRIMETHYLQUINOLINE	4123	20724	22	0	0
12	10314	UNIDENTIFIED	1726	8704	11	0	0
13	10317	ALKANE	433	2277	3	0	0
14	10324 C13 H15 N	TYPE A	1033	3631	8	0	0
15	10327	(SILANATED ?)	2674	9806	17	0	0
16	10329	UNIDENTIFIED	941	1817	6	0	0
17	10332 C11 H13 N	TRIMETHYLINDOLE	847	1839	4	0	0
18	10333 C13 H15 N	TYPE A	6675	12886	31	0	0
19	10338	UNIDENTIFIED	474	1007	2	0	0
20	10340 C13 H15 N	TYPE A	2326	4829	12	0	0
21	10344	UNIDENTIFIED	50872	105625	77	0	0
22	10352 C13 H15 N	TYPE B	2763	7223	16	0	0
23	10353 C14 H17 N	TYPE B	1777	6293	11	0	0
24	10357	ALKANE OR BUTYRATE ESTER	1189	4210	6	0	0
25	10359	UNIDENTIFIED	629	2227	3	0	0
26	10361	ALKANE (TENTATIVE)	789	2774	4	0	0

PART OF PEAK BELOW

27	10365	C13 H15 N	TYPE A	5817	21570	17	0	0
28	10366	C13 H15 N	TYPE A	7987	29517	24	0	0
29	10368	C14 H17 N	TYPE A	2474	10989	8	0	0
30	10369		UNIDENTIFIED	3000	13531	10	0	0
31	10377	C14 H17 N	TYPE A	3208	12947	18	0	0
32	10382	C13 H15 N	TYPE A	13495	37681	49	0	0
33	10384		ALKANE	756	3174	4	0	0
34	10391	C14 H17 N	TYPE A	7966	34139	31	0	0
35	10395		SILANATED	2639	12951	10	0	0
36	10397	C14 H17 N	TYPE B	5940	24853	23	0	0
37	10407	C14 H17 N	TYPE B & SILANATED	33534	129122	60	0	0
38	10411	C14 H17 N	TYPE A	60373	182797	65	0	0
39	10425	C15 H19 N	TYPE B	10481	37765	44	0	0
40	10433	C15 H19 N	TYPE A	48473	190006	66	0	0
41	10436		UNIDENTIFIED	463	1433	1	0	0
42	10445	C15 H19 N	TYPE B	31156	83830	58	0	0
43	10453		ALKANE & C16 H21 N TYPE B	7216	26127	22	0	0
44	10457		UNIDENTIFIED	6194	22426	22	0	0
45	10459		ALKANE	2996	10748	13	0	0
46	10467	C16 H21 N	TYPE B	2570	10633	11	0	0
47	10469		UNIDENTIFIED	3729	14786	19	0	0
48	10476	C15 H15 N	(DIMETHYL 9,10-DIHYDROACRIDINE)	10491	33712	34	0	0
49	10484		SILANATED	8031	32311	31	0	0
50	10490		UNIDENTIFIED	592	2690	3	0	0
51	10500		ALKANE	4261	14630	16	0	0
52	10503	C15 H13 N	METHYLPHENYLINDOLE OR DIMETHYLBENZOSUBINDOLINE	9033	34040	41	0	0
53	10509	C18 H13 N	METHYLPHENYLINDOLE OR DIMETHYLBENZOSUBINDOLINE	19060	90704	52	0	0
54	10518	C16 H22 O4	DI-N-BUTYLPHTHALATE	14975	94466	37	0	0
55	10544		UNIDENTIFIED	614	2059	4	0	0
56	10546		ALKANE	3066	6862	14	0	0
57	10556		SILANATED	6973	17395	37	0	0
58	10568	C16 H15 N	OR C15 H11 N O	6507	34379	31	0	0
59	10581		SILANATED	9090	34226	34	0	0

Table C-17	60	10590	ALKANE & UNIDENTIFIED	1531	9545	6	0	0
	61	10594	SILANATED	9342	39491	46	0	0
	62	10629	SILANATED	9253	14080	36	0	0
	63	10633	ALKANE	1463	3921	15	0	0
	64	10673	SILANATED	24574	120774	65	0	0
	65	10687	SILANATED	3379	10061	31	0	0
	66	10740	SILANATED	28348	91178	82	0	0
	67	10751	ALKANE	844	3341	16	0	0
	68	10765	PHTHALATE ESTER	664	2629	14	0	0
	69	10798	SILANATED	14793	34301	82	0	0
	70	10892	SILANATED	5014	20660	58	0	0
	71	10902	SILANATED	1172	5409	25	0	0

TABLE C-17. MS OF OIL FOG RUN NO. 9(A-2) NITROGEN BASES FRACTION

		Key
$C_{13}H_{15}N$	Type A	(184,185,157,156) -loss of H probably tetramethylquinoline
"	Type B	(185,170,186) -loss of CH_3 probably C_5 -alkylquinoline with at least one ethyl group
$C_{14}H_{17}N$	Type A	(198,199,171,200,172) -loss of H probably pentamethylquinoline
"	Type B	(184,199,200) -loss of CH_3 probably C_5 -alkylquinoline with at least one ethyl group
$C_{15}H_{19}N$	Type A	(212,213,185,198,214) -loss of H probably hexamethylquinoline
"	Type B	(198,185,213,212,199) -loss of CH_3 probably C_6 -alkylquinoline with at least one ethyl group
$C_{16}H_{21}N$	Type B	(212,227,226) -loss of CH_3 probably C_7 -alkylquinoline with at least one ethyl group
$C_{15}H_{13}N$		(207,208,206,165) Methylphenylindole or dimethylbenzoquinoline
$C_{16}H_{15}N$		(221,222,220,178,206) Dimethylphenylindole or trimethylbenzoquinoline or $C_{15}H_{11}NO$ as diphenyloxazole or Phenylquinoline oxide

APPENDIX D
AEROSOL DATA FROM EXPERIMENTS 3 THROUGH 12

AEROSOL EXPERIMENTAL DATA

The following Tables D-1 to D-10 give the complete experimental data on aerosol aging as measured with the P/Z impactor and the ASAS particle spectrometer, including data analysis and correlations for Experiment Nos. 3-12. Table 17 in the body of the report appears here as Table D-2.

Figures D-1 to D-10 are histograms of the particle size distribution in Experiments 3 to 12 as measured at the initiated time after t_0 . Note the change in distribution in Experiment No. 6, from 9 min in Figure D-4 to 16 min in Figure 8 in the body of the report.

TABLE D-1
EXPERIMENT NO. 3

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
30	616	.960	5	1.21	37222
			9	1.27	30886
40	536	1.35	15	1.25	27956
			20	1.25	29985
50	664	1.33	26	1.26	31380
			29	1.24	30318
60	854	1.343	43	1.37	25874
			56	1.28	26954
STATISTICAL ANALYSIS: FOR LINEAR REGRESSION 1) TSP vs t slope = 8.4 intercept = 289. correlation coef. = .805 2) \bar{d}_m vs t slope = .0113 intercept = .7377 correlation coef. = .764 <u>Equation:</u> $y = mt + c$ m = slope and c = intercept			STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$ $n_0 = 33860$ K = .005 correlation coef. = 0.747 <u>Equation:</u> $n = 33869 e^{-.005t}$ $\ln n = 10.43 - .005t$ 95% significance level		

TABLE D-2
EXPERIMENT NO. 4

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
2	144	.686	2	.776	45622
10	739	.842	4	.853	52368
18	667	.876	10	.813	46992
36	634	.824	15	.823	42884
44	566	.831	36	.846	33718
52	598	.878	44	.850	31352
50	506	1.00	52	.888	22506
			60	.893	13774

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION:</p> <p>1) TSP vs t slopes = - 3.9 intercept = 763 correlation coef. = -.944</p> <p>2) \bar{d}_m vs t slopes = .00313 intercept = .749 correlation coef. = .744</p> <p><u>Equation:</u> $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 55826$ $K = .0184$ correlation coef. = -0.93</p> <p><u>Equation:</u> $n = 55826 e^{-.0184t}$ $\ln n = 10.93 - .0184t$ 95% significance level</p>
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TABLE D-3
EXPERIMENT NO. 5

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
13	236.7	.821	2	.899	4907
17	184.2	.733	7	.880	4436
28	303	.734	14	.947	4622
37	372	.773	26	.926	5129
46	262.8	.790	36	.900	5432
56	283	.702	45	.906	5179
			54	.916	5527

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION</p> <p>1) TSP vs t slope = 1.786 intercept = 214.98 correlation coef. = 0.47</p> <p>2) \bar{d}_m vs t slope = -0.0011 intercept = 0.795 correlation coef. = -.425</p> <p><u>Equation:</u> $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 4582$ $K = 0.0034$ correlation coef. = .8294</p> <p><u>Equation:</u> $n = 4582 e^{-.0034t}$ $\ln n = 8.43 + .0034t$ 95% significance level</p>
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TABLE D-4
EXPERIMENT NO. 6

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
2	359	.6675	4	.888	32737
9	432	.6585	7	.870	24418
16	340	.7020	13	.872	33053
26	449	.7060	23	.873	26424
35	476	.724	32	.875	20506
44	489	.7712	41	.895	18356
51	440	.7607	58	.935	13532
60	450	.8270			
STATISTICAL ANALYSIS: FOR LINEAR REGRESSION 1) TSP vs t slope = 1.3 intercept = 394. correlation coef. = .5049 2) \bar{d}_m vs t slope = .00262 intercept = .6576 correlation coef. = .958 <u>Equation:</u> $y = mt + c$ m = slope and c = intercept			STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$ $n_0 = 34200$ K = .015 correlation coef. = -.9212 <u>Equation:</u> $n = 34200 e^{-.015t}$ $\ln n = 10.44 - .015t$ 99% significance level		

TABLE D-5
EXPERIMENT NO. 7

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
2	384	.796	2	1.158	6283
6	462	.767	6	1.113	6354
10	558	.7847	10	1.185	6810
16	605	.8235	16	1.168	6366
28	529	.834	24	1.185	5646
34	503	.8512	34	1.171	5480
44	567	.8167	44	1.071	5746
52	597	.8374	52	1.069	5480
60	514	.883	60	1.053	5328

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION</p> <p>1) TSP vs t slope = 0.5 intercept = 570 correlation coef. = -.2272</p> <p>2) \bar{d}_m vs t slope = .0014 intercept = .7821 correlation coef. = -.2272</p> <p>Equation: $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 6687$ $K = .004$ correlation coef. = -0.848</p> <p>Equation: $n = 6687 e^{-.004t}$ $\ln n = 8.808 - .0004t$ 99% significance level</p>
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TABLE D-6
EXPERIMENT NO. 8

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
12	748.2	.7726	2	.990	9046
20	778.9	.796	6	.987	9425
28	729.6	.792	12	.961	8116
38	714.6	.795	19	.900	6502
48	602.4	.792	27	.932	6677
58	604.2	.828	36	1.00	5668
			45	0.928	5640
			54	0.944	5423
STATISTICAL ANALYSIS: FOR LINEAR REGRESSION 1) TSP vs t slope = 3.947 intercept = 830.34 correlation coef. = -.913 2) \bar{d}_m vs t slope = .00083 intercept = .768 correlation coef. = -.913 <u>Equation:</u> $y = mt + c$ m = slope and c = intercept			STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$ $n_0 = 9118$ $K = .011$ correlation coef. = -0.941 <u>Equation:</u> $n = 9118 e^{-.011t}$ $\ln n = 9.118 - .011t$ 99% significance level		

TABLE D-7
EXPERIMENT NO. 9

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
9	586.8	.739			
17	791.4	.863			
27	849.3	.799	17	.919	37207
35	621.9	.834	26	.934	31712
44	698.4	.797	35	.920	28020
54	736.2	.810	44	.933	25129
			54	.917	19551
STATISTICAL ANALYSIS: FOR LINEAR REGRESSION 1) TSP vs t slope = .7894 intercept = 689.53 correlation coef. = .133 2) \bar{d}_m vs t slope = .00056 intercept = .790 correlation coef. = .226 <u>Equation:</u> $y = mt + c$ m = slope and c = intercept			STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$ $n_0 = 49662$ K = .0166 correlation coef. = .991 <u>Equation:</u> $n = 49662 e^{-.0166t}$ $\ln n = 10.813 - .0166t$ 99% significance level		

TABLE D-8
EXPERIMENT NO. 10

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
14	550.2	.7604	4	.928	12857
22	580.5	.761	8	.932	14037
32	543.9	.737	14	.921	11516
42	538.5	.742	22	.933	9058
51	542.7	.776	32	.936	8320
60	629.7	.798	42	.937	5957
			51	.933	5931
			60	.944	5770

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION</p> <p>1) TSP vs t slopes = .8216 intercept = 534.0 correlation coef. = .405</p> <p>2) \bar{d}_m vs t slopes = .00072 intercept = .736 correlation coef. = .561</p> <p><u>Equation:</u> $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 14186$ $k = .017$ correlation coef. = -0.9656</p> <p><u>Equation:</u> $n = 14186 e^{-.017t}$ $\ln n = 9.56 - .017t$ 99% significance level</p>
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TABLE D-9
EXPERIMENT NO. 11

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μ m)	Time (t) min	\bar{d}_m μ m	No. of Particles (n)
14	377.7	.535	5	.748	5950
22	299.1	.576	11	.754	5687
32	328.8	.563	18	.763	5627
41	345	.642	28	.767	5751
51	381	.629	37	.759	5713
60	327.6	.611	45	.797	5676
			54	.774	5638

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION</p> <p>1) TSP vs t slope = .0774 intercept = 340.4 correlation coef. = .0426</p> <p>2) \bar{d}_m vs t slope = .0019 intercept = .524 correlation coef. = .790</p> <p><u>Equation:</u> $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 5826$ $k = .0006$ correlation coef. = -0.643</p> <p><u>Equation:</u> $n = 5826 e^{-.0006t}$ $\ln n = 8.67 - .0006t$</p>
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TABLE-D-10
EXPERIMENT NO. 12

P/Z Impactor			ASAS		
Time (t) min	TSP mg/m ³	\bar{d}_m (μm)	Time (t) min	\bar{d}_m μm	No. of Particles (n)
12	805.2	.741	3	.8840	21870
20	867	.776	8	.8815	23754
30	888.3	.749	16	.8900	20126
40	811.5	.777	25	.8762	18160
50	673.8	.778	34	.912	14061
60	797.1	.795	44	.8823	14309
			55	.8920	10671

<p>STATISTICAL ANALYSIS: FOR LINEAR REGRESSION</p> <p>1) TSP vs t slopes = -2.11 intercept = .738 correlation coef. = -.512</p> <p>2) \bar{d}_m vs t slopes = .0009 intercept = .738 correlation coef. = .794</p> <p><u>Equation:</u> $y = mt + c$ m = slope and c = intercept</p>	<p>STATISTICAL ANALYSIS: FOR CURVE $n = n_0 e^{-kt}$</p> <p>$n_0 = 25084$ $K = .0146$ correlation coef. = -.966</p> <p><u>Equation:</u> $n = 25084 e^{-.0146t}$ $\ln n = 10.13 - .0146t$ 99% significance level</p>
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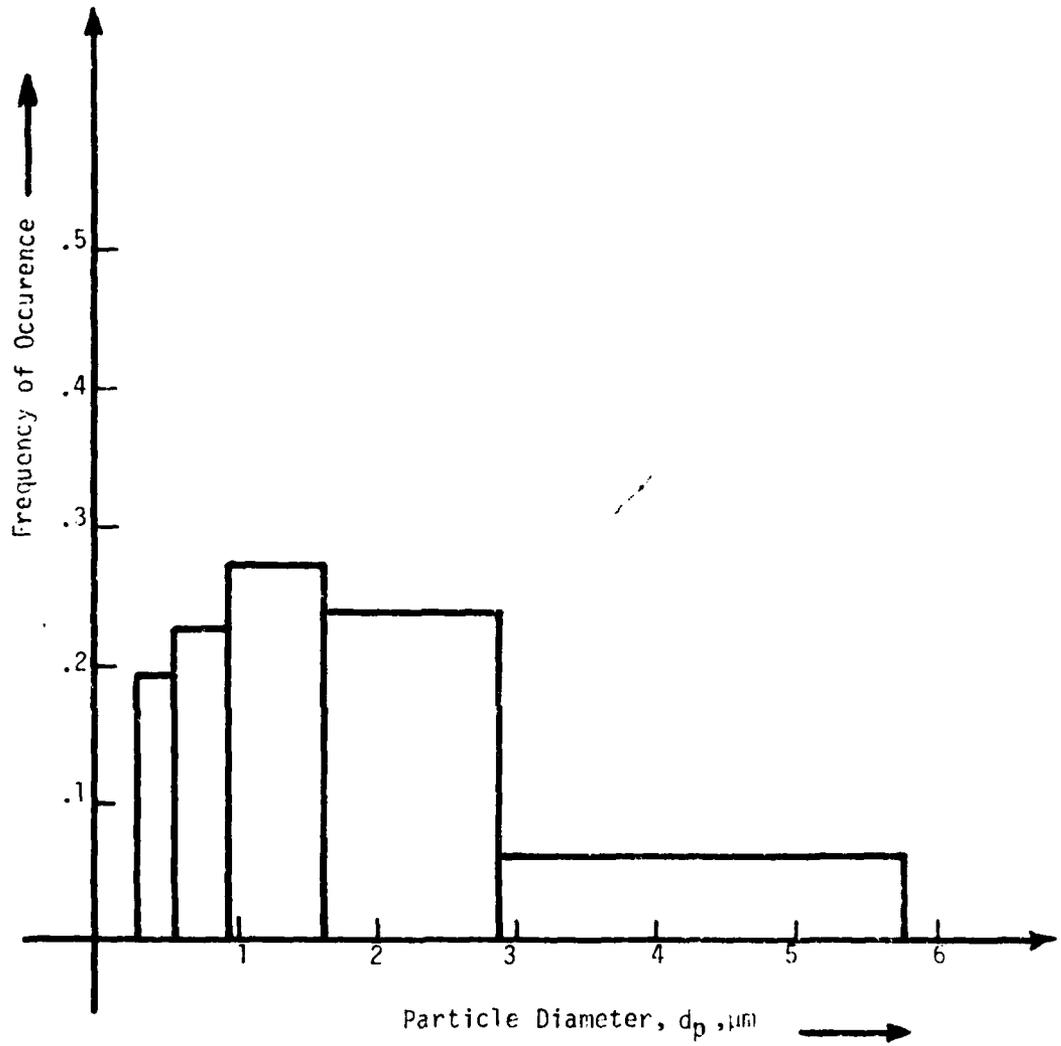


Figure D-1. Histogram of Mass Median Particle Size Distribution Experiment No. 3. 30 minutes after t_0 .

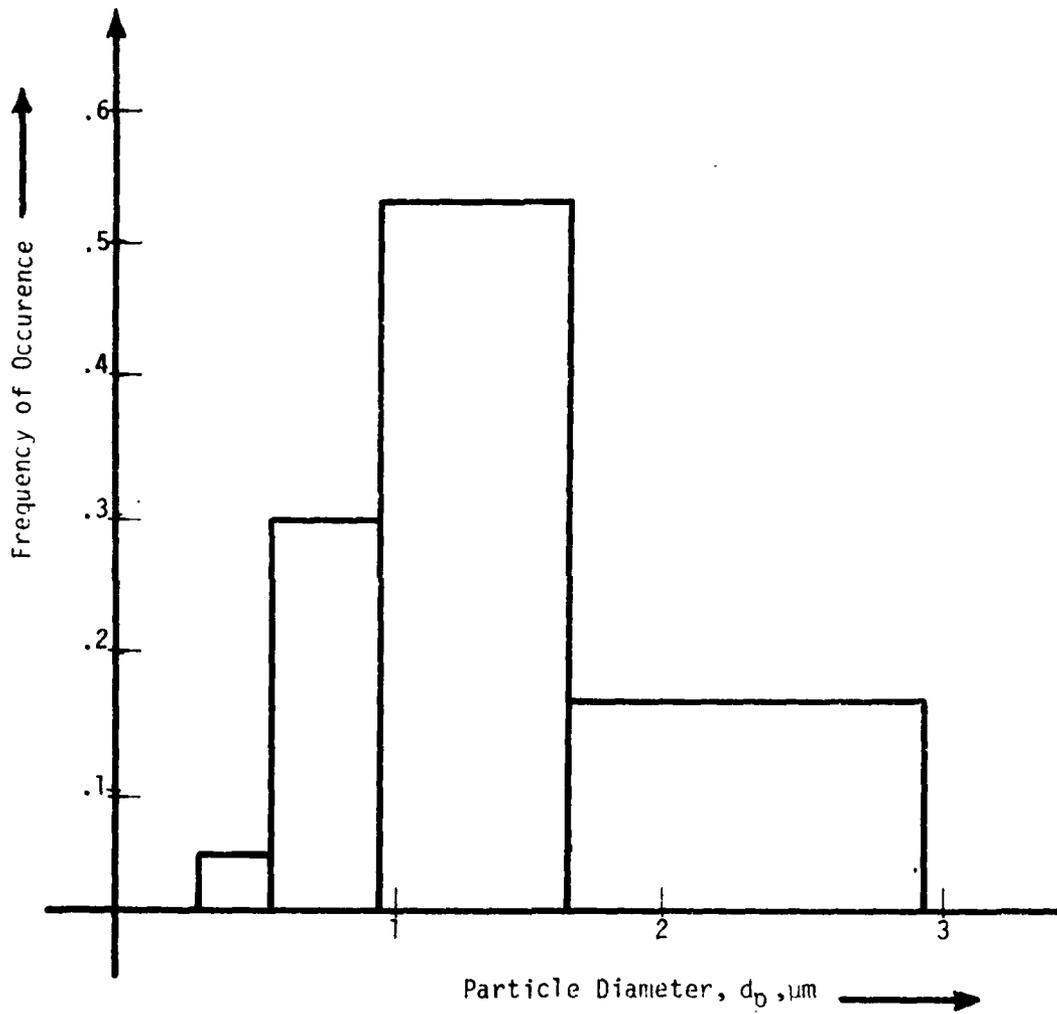


Figure D-2. Histogram of Mass Median Particle Size Distribution Experiment No. 4. 10 minutes after t_0 .

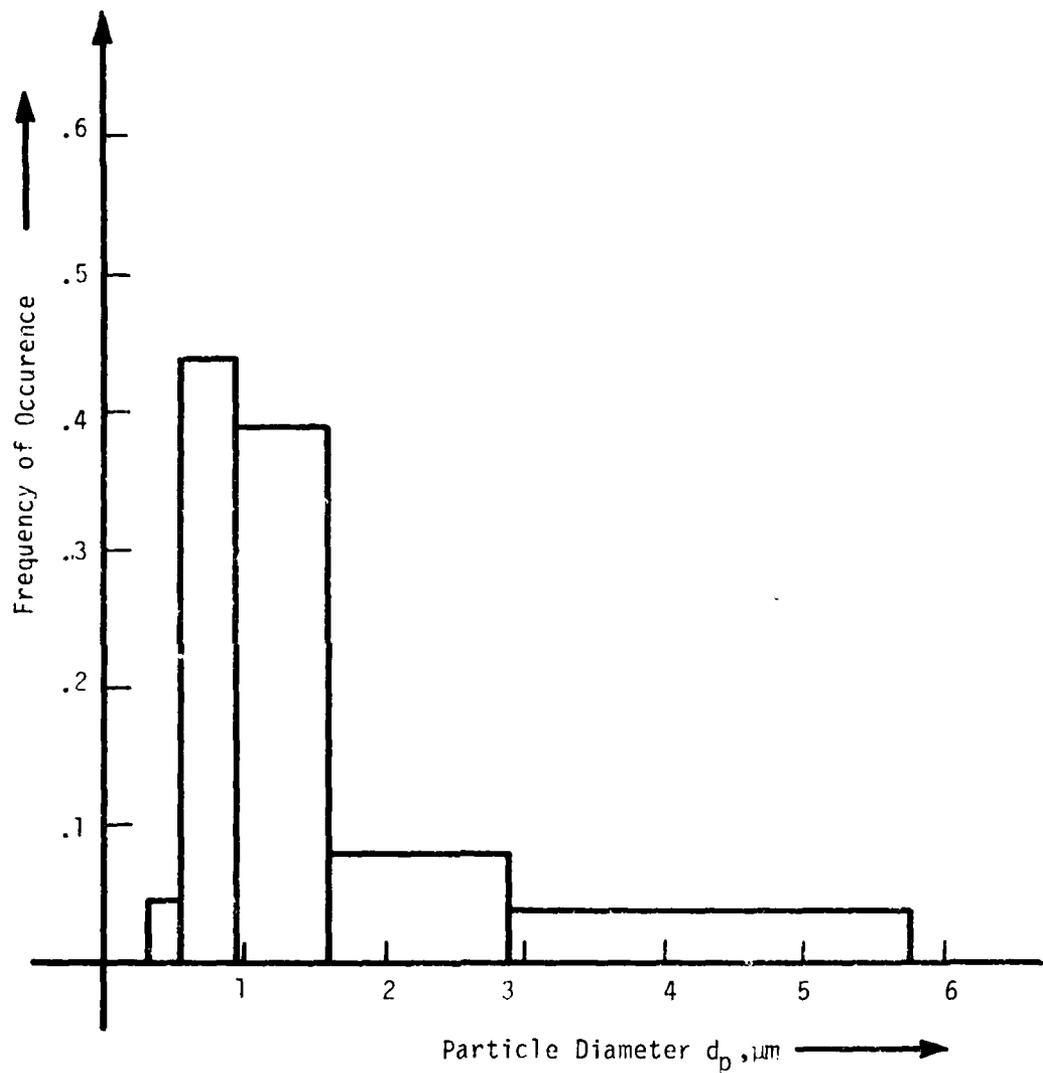


Figure D-3. Histogram of Mass Median Particle Size Distribution Experiment No. 5. 13 minutes after t_0 .

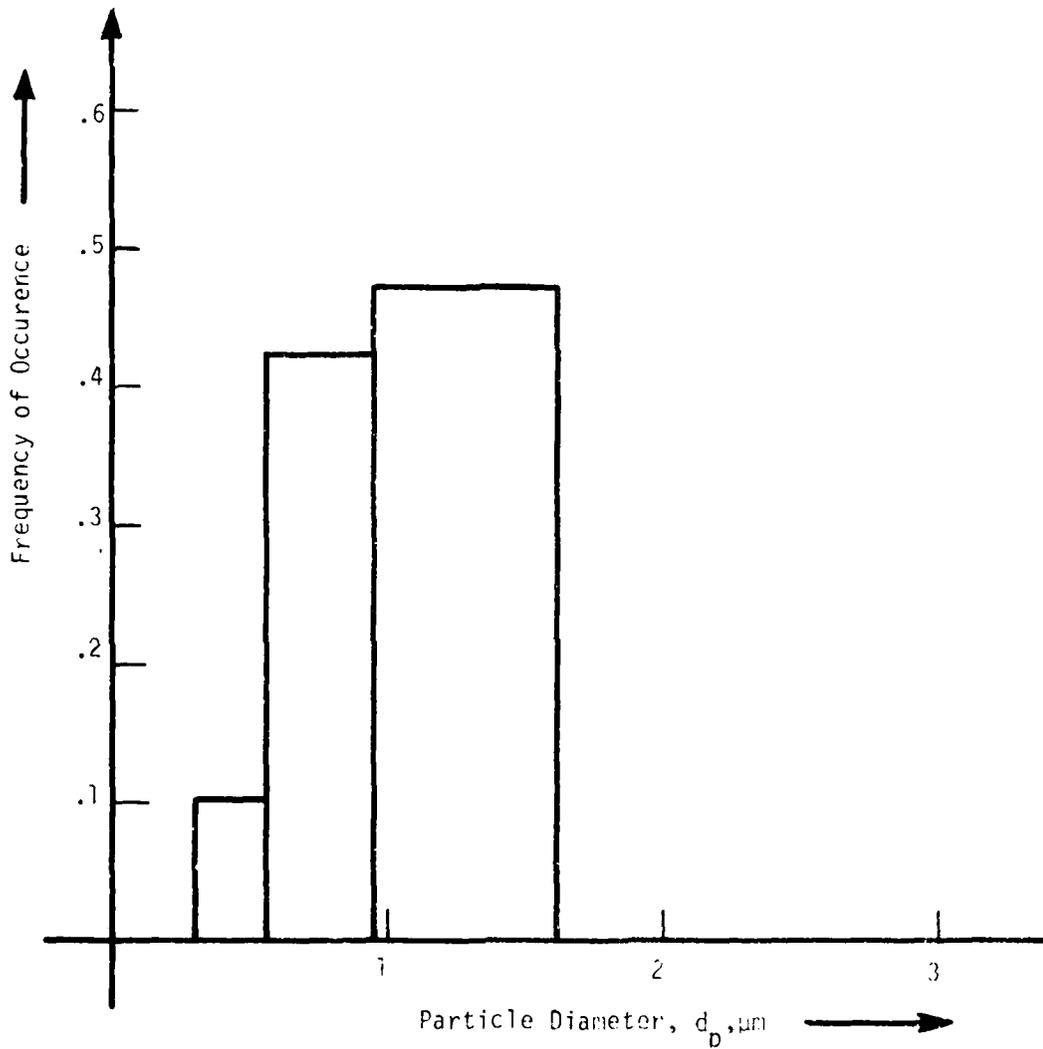


Figure D-4. Histogram of Mass Median Particle Size Distribution Experiment No. 6. 9 minutes after t_0 .

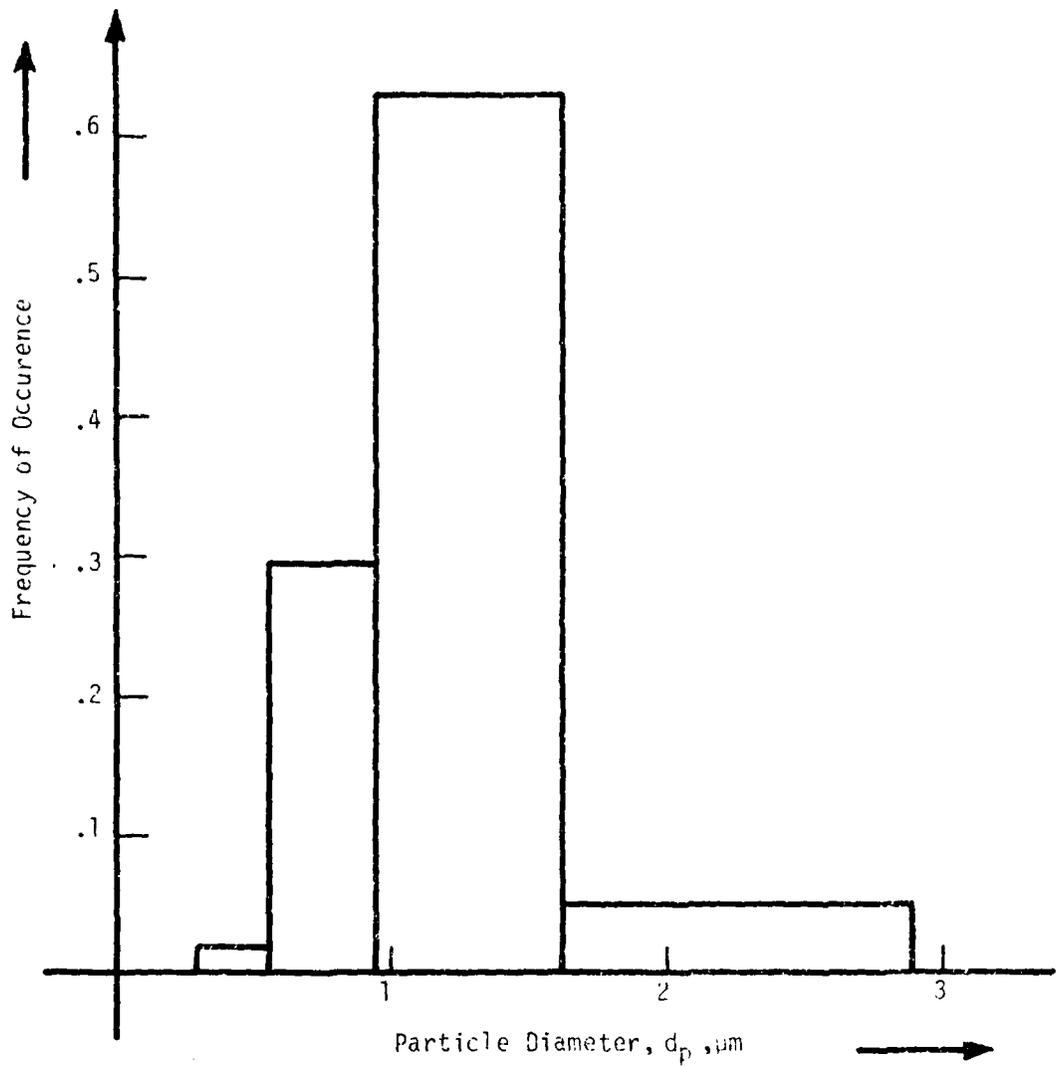


Figure D-5. Histogram of Mass Median Particle Size Distribution Experiment No. 7. 10 minutes after t_0 .

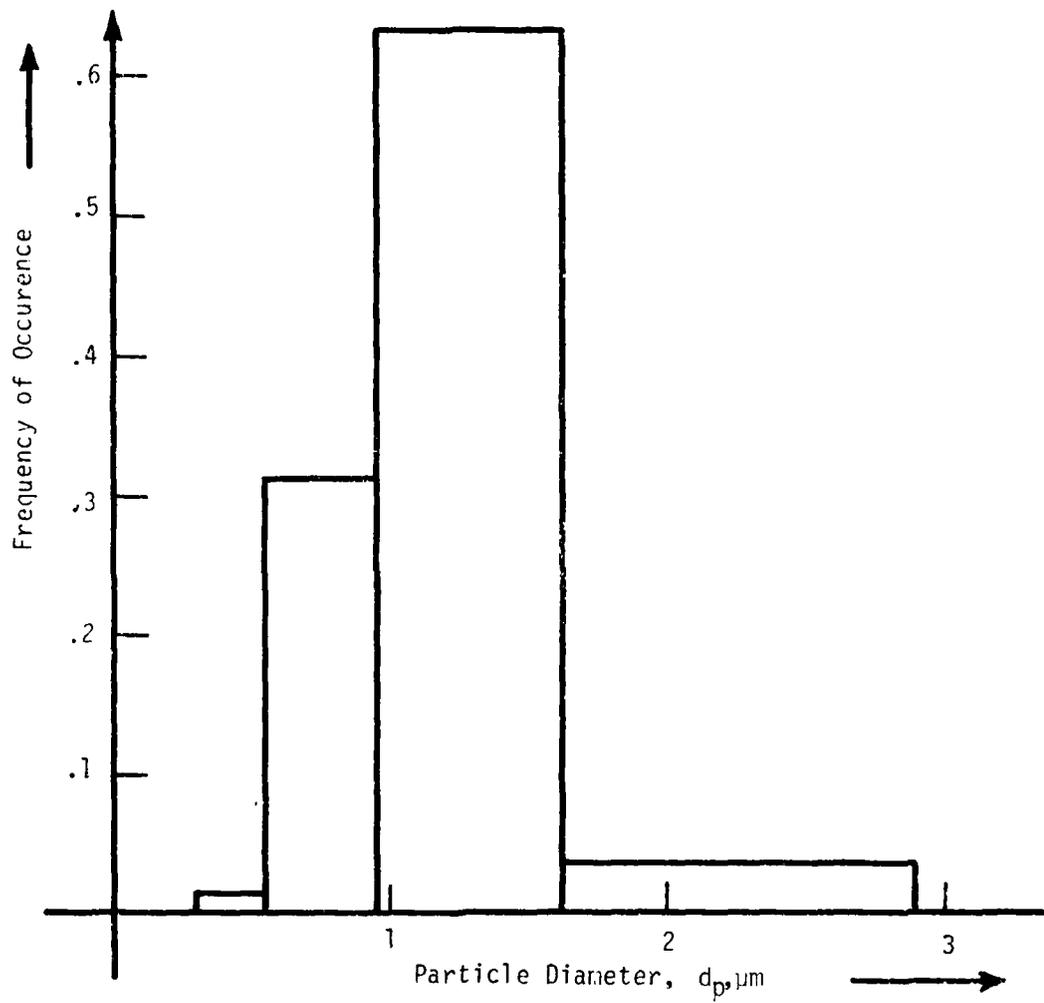


Figure D-6. Histogram of Mass Median Particle Size Distribution Experiment No. 8. 12 minutes after t_0 .

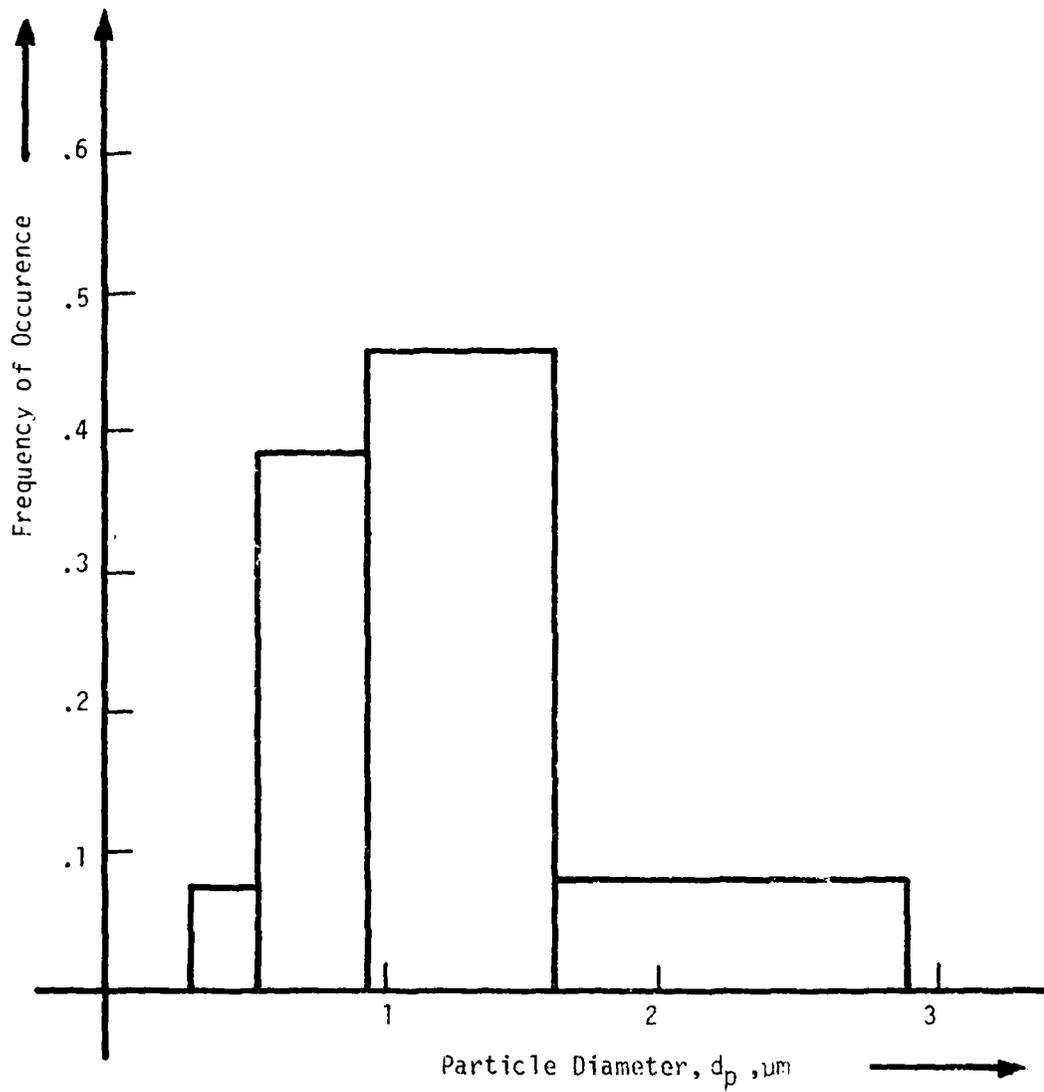


Figure D-7. Histogram of Mass Median Particle Size Distribution
Experiment No. 9. 9 minutes after t_0 .

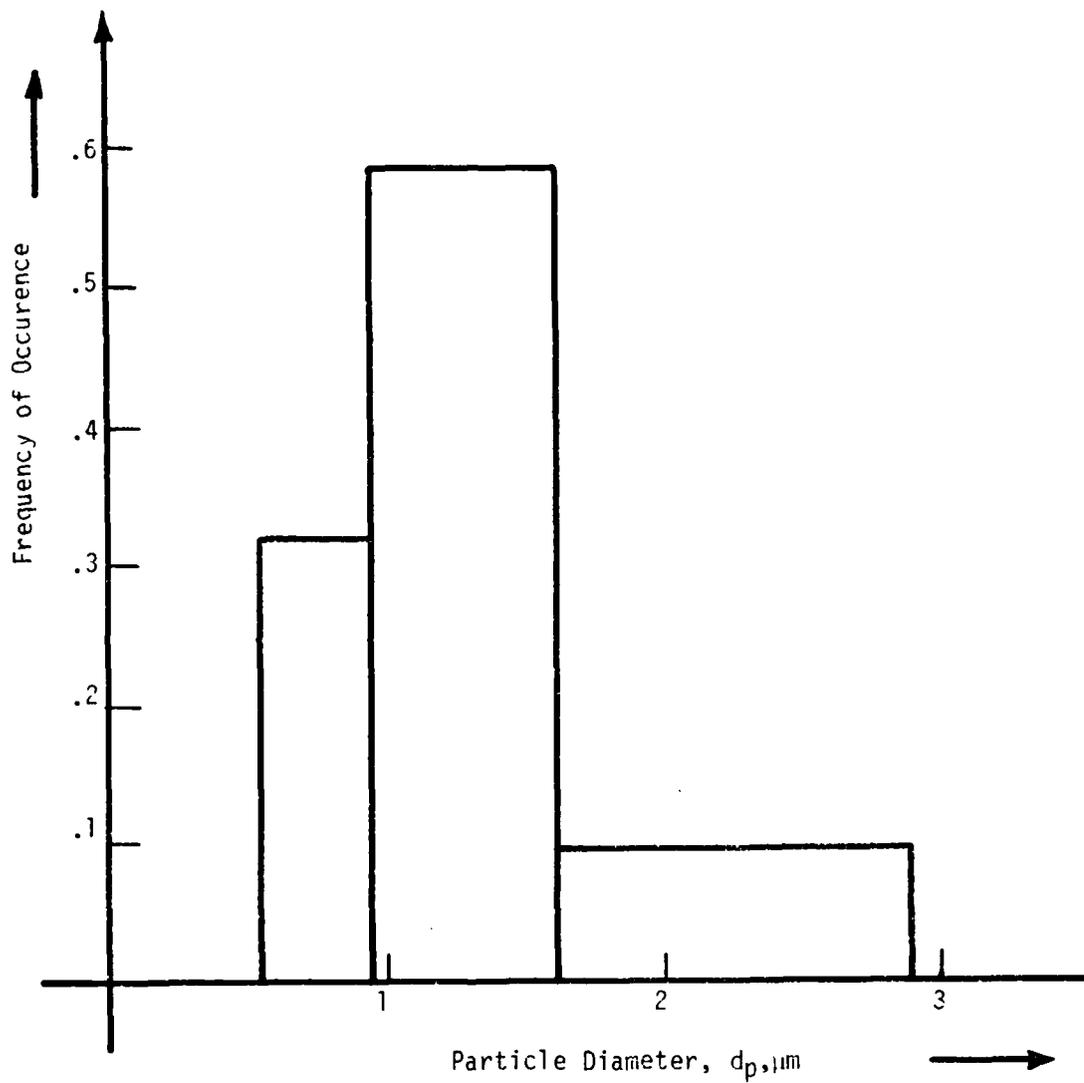


Figure D-8. Histogram of Mass Median Particle Size Distribution Experiment No. 10. 8 minutes after t_0 .

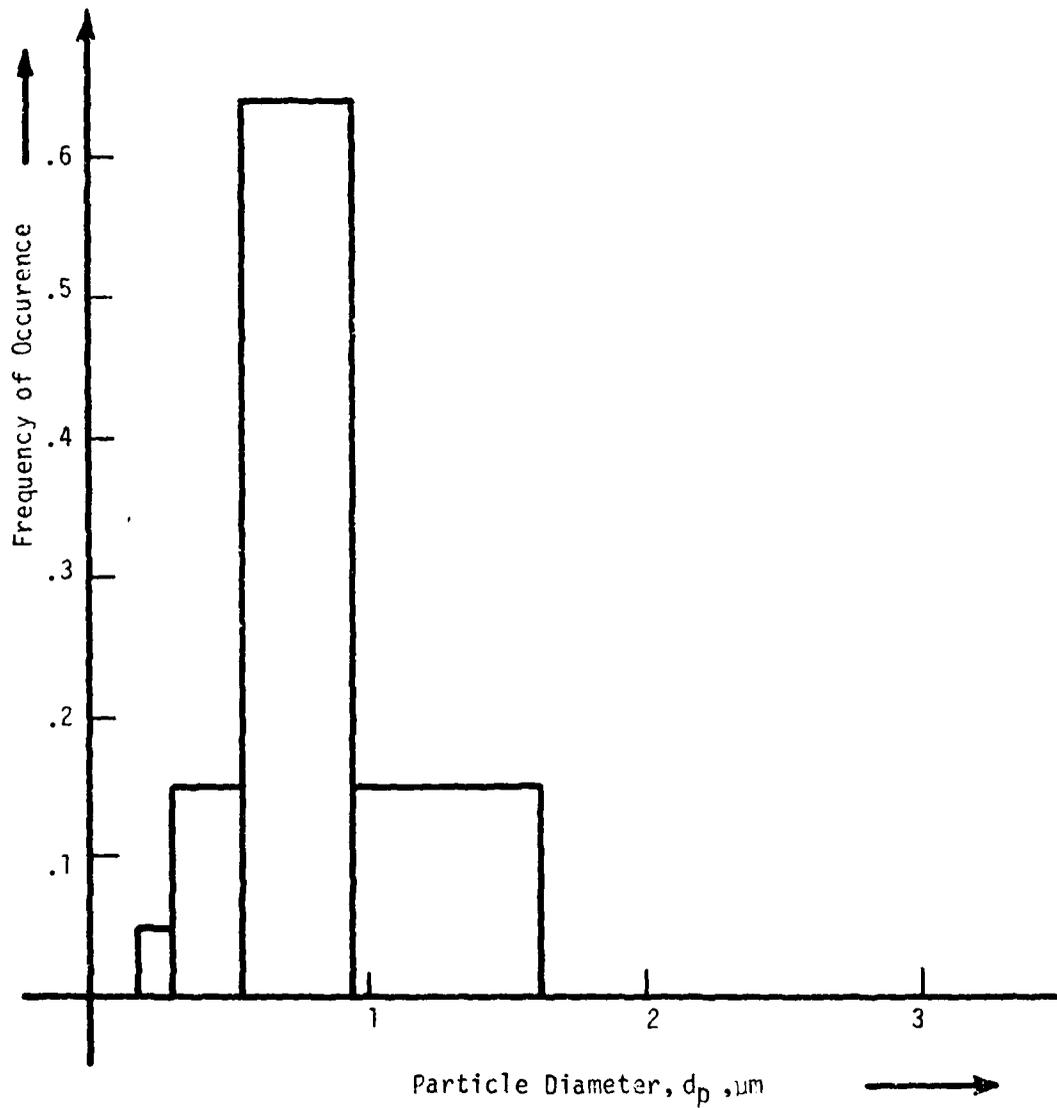


Figure D-9. Histogram of Mass Median Particle Size Distribution
Experiment No. 11. 8 minutes after t_0 .

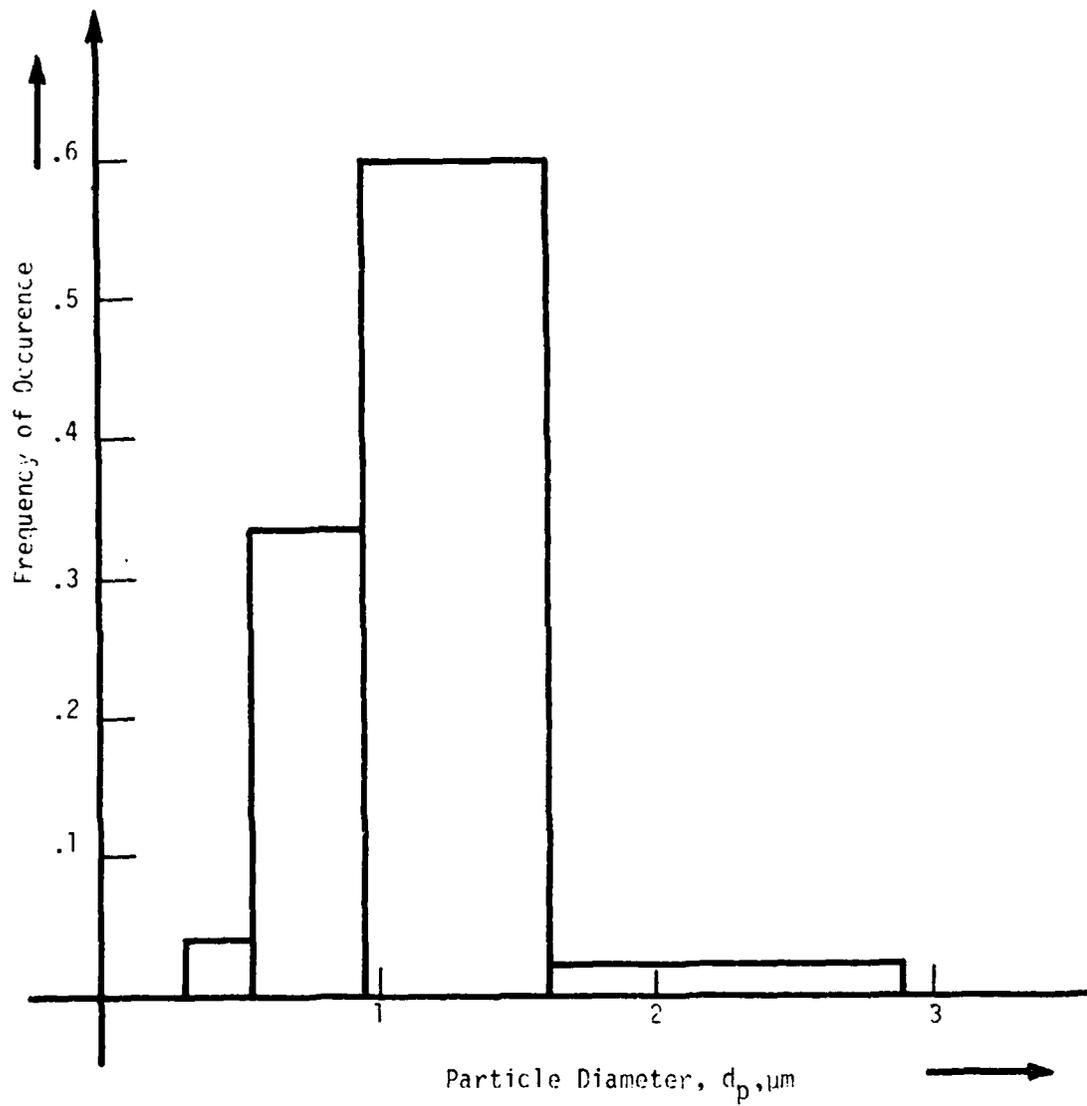


Figure D-10. Histogram of Mass Median Particle Size Distribution Experiment No. 12. 12 minutes after t_0 .

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