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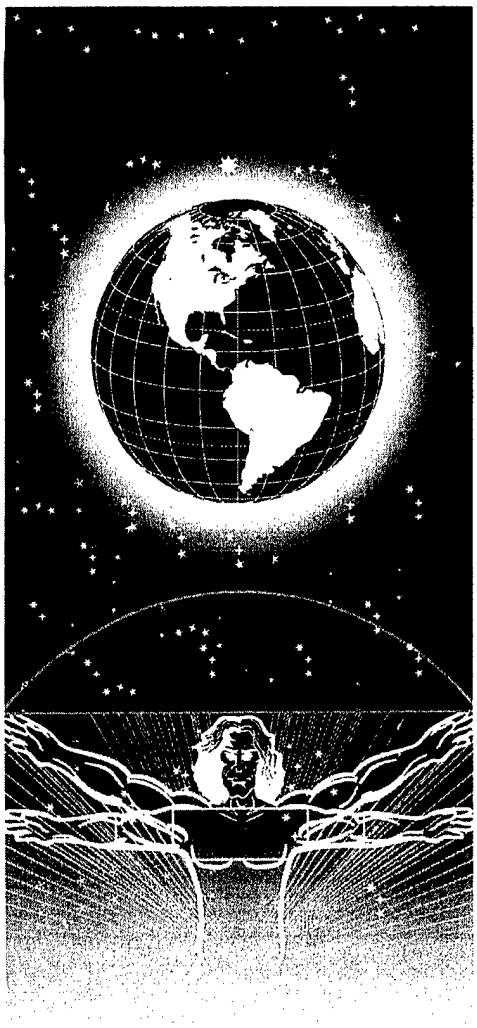

# UNITED STATES AIR FORCE
# IERA

# Sensory Irritation Study in Mice: JP-4, JP-8, JP-8+100

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August 2001



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Chief Toxicologist, RSRE

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**13. ABSTRACT** *(Maximum 200 words)*

AFIERA, in concert with Army and Navy colleagues, designed a study based on ASTM's "Standard Method E 981-84" to characterize and compare the relative potency of three jet fuels to cause respiratory tract sensory irritation. These fuels were JP-4, JP-8 and JP-8+100. These fuels were administered for 30 minute periods by means of a head-only exposure system to groups of four male Swiss-Webster mice. Test atmospheres laden with these fuels were presented as vapor-only (JP-4) or as a vapor/aerosol mixtures (JP-8, JP-8+100). Analytical sampling data revealed differences in the distribution and relative proportions of the hydrocarbon species contained in the vapor and aerosol phases. Generally, compounds with carbon numbers in the range of C11-C12 represented the principle constituents in the aerosol phase. Each fuel was tested over a range of air concentrations (685 - 11,430 mg/m3 for JP-4, 681 - 3,565 mg/m3 for JP-8, and 777 - 2,356 mg/m3 for JP-8 +100 ) that resulted in minimal to severe decreases in respiratory rate. All three fuels evoked breathing patterns that were characteristic of upper airway sensory irritation at all exposure levels. Within the context of this study, there was no apparent evidence of pulmonary (deep lung) irritation or narcosis at any exposure level. The concentration that reduced the respiratory rate by 50% (RD50) was calculated for each fuel: JP-4 = 4842 mg/m3; JP-8 = 2876 mg/m3; JP-8 +100 = 1629 mg/m3. The relative irritancy of these fuels may be ranked as follows: JP-8 + 100 >JP-8 > JP-4. Based on Alarie's 3% "rule of thumb" and without the introduction of additional information, the data suggest the following prospective PELs for these fuels: JP-4 at ~145 mg/m3; JP-8 at ~86 mg/m3; JP-8 +100 at ~49 mg/m3.

**14. SUBJECT TERMS**
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ExxonMobil BIOMEDICAL SCIENCES, INC.

FINAL REPORT

PROJECT NUMBER: 162951

TEST SUBSTANCES:

JP-4 (MRD-00-629)
JP-8 (MRD-00-630)
JP-8+100 (MRD-00-631)

SENSORY IRRITATION STUDY IN MICE

PERFORMED FOR:

Department of the Air Force
311th Human Systems Wing
Environmental Science Branch
Brooks Air Force Base
Texas, 78235-5123

PERFORMED AT:

EXXONMOBIL BIOMEDICAL SCIENCES, INC.
LABORATORY OPERATIONS
1545 ROUTE 22 EAST, P.O. BOX 971
ANNANDALE, NJ 08801-0971

COMPLETION DATE: August 29, 2001
01TP 92

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## APPROVAL SIGNATURES

29 Aug 01

J. J. Freeman, Ph.D., D.A.B.T.
Director: Laboratory Operations

Date

I hereby accept responsibility for the validity of these data and declare that to the best of my knowledge, the study contained herein was performed under my supervision in compliance with OECD Principles of Good Laboratory Practice except as follows:

The EMBSI Industrial Hygiene Analytical Service Laboratory (IHASL) is not a fully GLP compliant laboratory, although it is accredited by the American Industrial Hygiene Association.

Frederick T. Whitman

29 AUG 01

Frederick T. Whitman, M.P.H.
Study Director
ExxonMobil Biomedical Sciences, Inc.
1545 Route 22 East, P.O. Box 971
Annandale, New Jersey 08801-0971

Date

## QUALITY ASSURANCE STATEMENT

STUDY NUMBER: 162951

TEST SUBSTANCE: MRD-00-629, MRD-00-630, MRD-00-631

STUDY SPONSOR: Department of the Air Force

Listed below are the inspections performed by the Quality Assurance Unit of ExxonMobil Biomedical Sciences, Inc., the date(s) of inspection, and the date(s) findings were reported to the Study Director and Management.

| Study Phase Inspected | Date(s) of Inspection | Reported to Study Director | Reported to Management |
|---|---|---|---|
| Protocol | 06 Oct 00 | 06 Oct 00 | 13 Oct 00 |
| Dosing (Day 0) | 01 Dec 00 | 01 Dec 00 | 12,13 Dec 00 |
| Final Report | 05 May 01 to 28 Jun 01 | 28 Jun 01 | 28 Jun 01 & 16 Jul 01 |
| Second Review of Final Report | 10-13 Jul 01 | 13 Jul 01 | 13 Jul 01 & 14 Aug 01 |
| Third Review of Final Report | 13 Aug 01 | 13 Aug 01 | 13,16 Aug 01 |

The final report accurately reflects the methods, procedures and observations documented in the raw data.

W. James Bover, Ph.D.
Quality Assurance Section Head

29 Aug 01
Date

## PERSONNEL

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|---|---|
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| Sponsor: | Department of the Air Force<br>311th Human Systems Wing<br>Environmental Science Branch<br>Brooks Air Force Base<br>Texas, 78235-5123 |
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| Quality Assurance/Archives Section Head: | W. J. Bover, Ph.D. |
| Veterinarian: | R. L. Harris, D.V.M. |

## SUMMARY

This study was conducted to evaluate the sensory irritation potential of JP-4 (MRD-00-629), JP-8 (MRD-00-630), and JP-8 100 (MRD-00-631) in mice during inhalation exposure.

The test substances were administered head only for 30 minutes to groups of four male Swiss-Webster mice as either vapor-only (JP-4) or combined vapor/aerosol atmospheres (JP-8+100 and JP-8). Group mean exposure concentrations ranged from 685 - 11430 $mg/m^3$ (JP-4), 681 - 3613 $mg/m^3$ (JP-8), and 777 - 2356 $mg/m^3$ (JP-8+100). Analytical sampling data demonstrated clear differences in the distribution and relative proportions of individual hydrocarbon species contained in the aerosol and vapor phases, with the lighter molecular weight hydrocarbons more abundant in the vapor samples. The on-line vapor and aerosol monitors demonstrated that the test atmospheres for all groups were stable throughout the exposure periods.

The three test substances evoked breathing patterns characteristic of upper airway sensory irritation at all exposure levels. Within the context and limits of this study, examination of the breathing patterns revealed no apparent pulmonary (deep lung) irritation or narcosis at any level for all three substances.

Each substance was tested over a range of air concentrations that resulted in minimal to extreme respiratory rate decreases (>50% decrease). This allowed calculation of an $RD_{50}$ value for each test substance. The $RD_{50}$ values were:

| | | |
|---|---|---|
| JP-4 | - | 4842 $mg/m^3$, with 95% confidence limits of 2375 to 9873. |
| JP-8 | - | 2876 $mg/m^3$, with 95% confidence limits of 2107 to 3925. |
| JP-8+100 | - | 1629 $mg/m^3$, with 95% confidence limits of 1418 to 1871 |

Based on these results, the relative irritancy ranking of the three test substances could be described as: JP-8+100 > JP-8 > JP-4.

# INTRODUCTION

This study was conducted in order to evaluate the sensory irritation potential in the mouse of JP-4 (MRD-00-629), JP-8 (MRD-00-630) and JP-8+100 (MRD-00-631).

Alarie (1966) proposed that a correlation exists between chemicals causing a decrease in respiratory rate in male Swiss-Webster-mice and sensory irritant properties in humans. Measurement of the reflex decrease in respiratory rate that occurs with stimulation of trigeminal nerve endings in the nasal mucosa of mice therefore may be used as screening tool to predict acceptable exposure concentrations or to help establish threshold limit values, short-term exposure limits, etc. The RD50, defined as the concentration associated with a 50% decrease in respiratory rate, is often used as a benchmark to evaluate airborne chemicals or mixtures of chemicals for sensory irritant effects.

The study was conducted by ExxonMobil Biomedical Sciences, Inc. (EMBSI), Laboratory Operations, Mammalian Toxicology Laboratory, 1545 Route 22 East, P.O. Box 971, Annandale, New Jersey 08801-0971 which is accredited by the Association for the Assessment and Accreditation of Laboratory Animal Care (AAALAC International). The analytical portion of the study was conducted by the EMBSI Industrial Hygiene Analytical Service Laboratory (IHASL), which is accredited by the American Industrial Hygiene Association.

***Study Initiation (Protocol Signature Date)***

November 9, 2000

***Experimental Starting and Completion Date***

November 29, 2000 and May 8, 2001

***Justification for Selection of Test System***

Swiss-Webster mice are the strain and species of choice for sensory irritation studies (ASTM E981-84, 1996).

***Justification of Dosing Route***

Potential human exposure may be by the inhalation route.

## *Compliance*

This study was conducted in compliance with the following standards:

OECD, Organization for Economic Cooperation and Development, Principles of Good Laboratory Practice, C(97) 186/Final, 1997.

Unites States Environmental Protection Agency, 40 CFR Part 792, Toxic Substances Control Act (TSCA), Good Laboratory Practice Standards (GLP's), Final Rule 1989.

This study was conducted in general agreement with the following guidelines and standards:

Standard Test Method for Estimating Sensory Irritation of Airborne Chemicals. American Society for Testing and Materials. Designation: E981-84 (Reapproved 1996).

Animal Welfare Act of 1966 (P.L. 89-544), as amended in 1970, 1976, and 1985. Code of Federal Regulations, Title 9 [Animals and Animal Products], Subchapter A - Animal Welfare Parts 1, 2, and 3.

Guide for the Care and Use of Laboratory Animals, Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council, National Academy Press, Washington, D.C., 1996.

# MATERIALS AND METHODS

## TEST SUBSTANCE

### *Substance Identification*

| EMBSI Identification: | Sponsor Identification: |
|---|---|
| MRD-00-629 | JP-4 |
| MRD-00-630 | JP-8 |
| MRD-00-631 | JP-8+100 |
| Supplier: | Mantech Environmental Tech Inc.<br>WPAB Area B Bldg. 79 Rm. 154<br>Dayton, OH 45433 |
| Date Received: | July 19, 2000 |
| Expiration Date: | July 2005 |
| Description: | Pale yellow liquids |
| Storage Condition: | Room temperature |

Each test substance, as received, was considered the "pure" substance.

### *Characterization of Test Substance*

Samples of the test atmosphere at each exposure level were analyzed by gas chromatography. The concentrations of selected individual components were reported. Samples of each neat (liquid) test substance also were analyzed by gas chromatography for reference and comparison to the air samples.

### *Analysis of Mixtures*

Not applicable to this study.

### *Solubility*

Not applicable to this study.

### *Sample Retention*

Archival samples of the test substances were not retained for this study.

### *Carrier*

Air

# MATERIALS AND METHODS

## TEST SYSTEM

### *Test Animal*

| | |
|---|---|
| Species: | Mouse |
| Strain/stock: | Swiss-Webster |
| Supplier: | Charles River Laboratories, Inc.<br>Portage, MI |

### *Animal Receipt Information*

| Receipt Date: | Order Number: |
|---|---|
| 7 November 2000 | 20070958 |
| 5 December 2000 | 20076820 |
| 2 January 2001 | 20100021 |
| 7 March 2001 | 20114956 |
| 24 April 2001 | 20126876 |

### *Quarantine and Acclimation Period*

At least 7 days; animals were examined for viability at least once daily.

### *Number and Sex/Group*

4 males

### *Age at Initiation of Dosing*

5 - 10 weeks

### *Weight at Initiation of Dosing*

24 - 30 grams

### *Animal Identification*

Tail tattoo and corresponding cage identification.

*Selection*

More animals than required for the conduct of the study were purchased and acclimated. Animals determined to be unsuitable for inclusion in the study because of poor health, outlying body weight, or other abnormalities were excluded from selection by the attending veterinarian, Study Director and/or the technical staff. Animals were allocated to study groups immediately prior to exposure on the basis of general health and body weight requirements.

*Housing*

| | |
|---|---|
| Room: | PE112 |
| Housing: | Single housed during the study period. |
| Caging: | Suspended stainless steel and wire mesh with absorbent paper below cages. |

*Feed*

PMI Certified Rodent Diet Checkers 5002

| | |
|---|---|
| Manufacturer: | PMI Feeds, Richmond, Indiana |
| Analysis: | Performed by PMI Feeds. Copies of the feed analyses are maintained at the EMBSI Laboratory. |
| Contaminants: | There were no known contaminants in the feed believed to have been present at levels that may have interfered with this study. |

The availability of feed was checked at least once daily for all animals.

*Water*

Automatic Watering System, ad libitum

| | |
|---|---|
| Supplier: | ExxonMobil Research and Engineering, Potable Water System. |
| Analysis: | Periodic analysis is the responsibility of EMBSI. A copy of the results is maintained at EMBSI. |
| Contaminants: | There were no known contaminants in the water believed to have been present at levels that may have interfered with this study. |

The availability of water was checked at least once daily for all animals.

### *Environmental Conditions*

| | |
|---|---|
| Temperature: | 64 to 72 degrees Fahrenheit |
| Humidity: | 30 to 70 percent relative humidity |
| Lighting: | Approximately 12 hours light (0600 to 1800) and 12 hours dark (1800 to 0600) by automatic timer. |

Monitored at least once daily. Additionally, a non-validated computerized system monitored the temperature, humidity, and lighting continuously for alarm purposes.

## EXPERIMENTAL DESIGN

### *Preparation of Test Substance*

The test substance was administered as received.

### *Experimental Groups*

| Test Substance | Mean Analytical Concentration ($mg/m^3$) | Number of Animals |
|---|---|---|
| JP - 4 (MRD-00-629) | 11430 ± 66 | 4 |
| JP - 4 (MRD-00-629) | 1888 ± 55 | 4 |
| JP - 4 (MRD-00-629) | 956 ± 59 | 4 |
| JP - 4 (MRD-00-629) | 685 ± 56 | 4 |
| JP - 8 (MRD-00-630) | 3565 ± 129 | 4 |
| JP - 8 (MRD-00-630) | 1837 ± 68 | 4 |
| JP - 8 (MRD-00-630) | 1090 ± 22 | 4 |
| JP - 8 (MRD-00-630) | 681 ± 40 | 4 |
| JP - 8 (MRD-00-630) | 708 ± 33 | 4 |
| JP - 8 + 100 (MRD-00-631) | 2356 ± 10 | 4 |
| JP - 8 + 100 (MRD-00-631) | 1519 ± 39 | 4 |
| JP - 8 + 100 (MRD-00-631) | 777 ± 26 | 4 |

**Note:** Two additional groups were exposed but not presented in the main study data due to missing or inconsistent analytical samples. The results of these additional exposures are presented in Appendix B.

*Administration of Test Substance*

Figures 1-2 present schematic drawings of the test atmosphere generation and exposure systems.

Each test substance was administered as either an aerosol, vapor or mixed atmosphere in air.

Vapor test atmospheres were generated by using a syringe pump to deliver the test substance to the inside surface of a heated glass "counter current" generator. The vapor generator was a cylindrical glass tube impressed with a spiral indentation that served as a channel for the liquid test substance. The spiral indentation was heated with heating tape to a constant temperature (dependent on the target concentration), and continuously monitored by a thermocouple probe and digital thermometer. The test substance volatilized as it flowed down the heated generator. The resulting vapors were drawn into the exposure chamber with the supply air moving countercurrent to the liquid flow.

Alternatively, test atmospheres were generated as a liquid droplet aerosol using a Collison nebulizer. The nebulizer's reservoir was filled with the test substance to a level just below the top of the liquid feed tube. Compressed air was supplied to the nebulizer, metered by a rotameter at a rate sufficient to aerosolize the test substance. The resultant liquid aerosol atmosphere mixed with additional room air that was drawn through the reservoir and expelled into the chamber.

*Concentration Determinations*

Exposure concentrations were determined on both a nominal and analytical basis. The nominal concentration was calculated by dividing the net weight of the test substance used during the exposure by the total volume of air passing through the chamber.

Analytical chamber concentrations were determined three times during each exposure by drawing a known volume of chamber air, metered by a critical orifice, through a sampling train consisting of a 25 mm glass fiber filter for analysis of non-volatile aerosol followed by a charcoal sorbent tube for total volatile hydrocarbons (vapor). After sampling, the sorbent tubes were capped and the filter samples were placed in sealed glass vials containing approximately 10 ml carbon disulfide. The sorbent tubes and filters were then submitted to the Industrial Hygiene Analytical Service Laboratory (IHASL) for subsequent analysis.

Both sample types (aerosol and vapor) were analyzed by gas chromatography/FID and each reported as total hydrocarbon concentration (THC). Additionally, one sample set (filter and sorbent tube) from each exposure was analyzed for a standard

list of representative hydrocarbons in order to evaluate and compare the distribution of individual components within the aerosol and vapor phases.

The analytical exposure concentrations (THC) were calculated both separately and as the sum of the aerosol and vapor phase concentrations. One sample of each neat test substance also was analyzed for reference and comparison to the chamber samples.

An on-line infrared vapor monitor (MIRAN 1A) was used during each exposure (when practical due to the amount of aerosol present) to monitor the relative levels and stability of the vapor phase of the chamber atmosphere.

An on-line photometric particle monitor (Sibata Model P5) also was used during each exposure to monitor the relative levels and stability of the aerosol present in the chamber atmospheres.

*Particle Size Analysis*

A particle size determination of the aerosol portion of the test atmosphere was conducted once for each test substance, during a representative animal exposure, using a Sierra Instruments Model 210 Cascade Impactor. Preweighed glass fiber filters were used to collect the aerosol on each stage. A bulk estimation technique was employed to characterize the particle size distribution of the test atmosphere. The change in weight of the filter for each stage was measured and the cumulative percent of the sample collected on each stage was calculated. This information plus the stage constants (size cutoff diameters in microns) for the impactor were used, with the aid of a computer, to calculate the 15.9%, 50.0%, and 84.1% particle sizes (equivalent aerodynamic diameter), the geometric standard deviation, and the estimated percent of the aerosol less than or equal to 1, 10, and 15 microns in size.

Additionally, the filters from the three stages closest to the 15.9%, 50.0%, and 84.1% particle sizes (equivalent aerodynamic diameter) were analyzed by gas chromotography/FID for individual hydrocarbon concentrations.

### *Animal Exposure Procedures*

The chamber used for the exposures was all glass and had a total volume of approximately 4.0 liters. It operated under slight negative pressure to the room at approximately 30.0 liters per minute airflow, regulated by a calibrated flow-limiting orifice. The theoretical equilibration time ($T_{99}$) was calculated as 36 seconds, which is approximately 2% of the exposure duration.

The test animals were loaded into body-only plethysmographs which isolated the animal's head from its body via a latex dam. The plethysmographs were then mounted onto the glass exposure chamber such that the animals received head-only exposures to the test atmosphere.

Each animal was monitored by a differential air pressure transducer that converted the tidal pressure changes produced by the animal's breathing within the plethysmograph into an electrical signal. The signals produced by the tidal pressure changes (animal breathing patterns) were recorded on an eight-channel analog oscillograph (Gould, Model RS 3800).

Each exposure group was monitored in the following sequence:

| | |
|---|---|
| Pre-test: | At least 10 minutes of room air to establish baseline rates. |
| Exposure: | 30 minutes of test substance exposure. |
| Recovery: | At least 10 minutes of room air to monitor return to pre-test levels. |

### *Animal Observations*

Individual animal observations were performed before, during and after each exposure.

### *Termination*

All test animals were euthanized via asphyxiation with carbon dioxide after completion of the exposure and discarded without further evaluation.

### *Animal Response Evaluation*

Animal respiratory rates and breathing patterns were determined from the oscillographic record. The average pretest rate and the lowest representative rate during exposure were determined for each animal in a group. The low rate was divided by the pretest rate to obtain a "Percent of Pretest" value. The Percent of Pretest value was subtracted from 100% to yield the animal response (Percent Change in Rate). Individual animals in each group were evaluated first, then averaged to determine the mean group response. The post-exposure (recovery) rates were similarly evaluated to determine the recovery response - the percent return to pretest rates.

### *Statistical Analysis*

Statistical analyses included means and standard deviations for relevant study data. (Snedecor and Cochran, 1989).

The mean group responses and exposure concentrations were entered into a computerized least-squares analysis to determine the concentration of test material required to reduce respiratory rate by 50% ($RD_{50}$), the 95% confidence limits, the slope function of the plotted data, and the fit of the data from the experiment (Snedecor and Cochran, 1989: Litchfield and Wilcoxon, 1949).

### *Records*

The protocol, all raw data, the final report, computer generated listings of raw data, and supporting documentation are maintained on file in the EMBSI archives. Raw data for the analytical samples will be maintained in the Industrial Hygiene Laboratory files.

# RESULTS

## EXPOSURE CONCENTRATIONS:

Tables 1-13 present summaries of the analytical data. Appendix A presents the analytical methods and summaries of the individual hydrocarbon analyses for selected samples.

### *JP-4 (MRD-00-629)*

Four groups of male mice were exposed for 30 minutes to total analytical concentrations of 11430, 1888, 956, or 685 mg/m$^3$. The exposure atmospheres for this test substance (generated as a vapor) essentially contained no aerosol except at the highest concentration (11430 mg/m$^3$). A small amount of aerosol was found at this level (82 mg/m$^3$) although it represented less than 1% of the total concentration.

A particle size sample was taken during the exposure at the highest level (11430 mg/m3) however there was insufficient aerosol present to accurately calculate a particle size distribution.

### *JP-8 (MRD-00-630)*

Four groups of male mice were exposed for 30 minutes to total analytical concentrations of 3565, 1837, 1090, or 681 mg/m$^3$. The exposures for this test substance (generated as an aerosol) were predominantly vapor although they included significant amounts of aerosol. The proportion of aerosol ranged from 3% at 681 mg/m$^3$ to 35% at 3613 mg/m$^3$. There was a clear difference in the distribution and relative proportions of individual hydrocarbon species contained in the aerosol and vapor phases, with the lighter molecular weight hydrocarbons more abundant in the vapor samples (see Appendix A for individual hydrocarbon analyses and chromatograms).

A fifth group of mice was exposed to a vapor-generated atmosphere (708 mg/m3) at a level similar to the lowest aerosol-generated group (681 mg/m$^3$) in order to compare the animal responses to these potentially different exposures. This group contained no detectable aerosol.

A particle size sample was taken during the exposure at the 1090 mg/m$^3$ level. The results of this analysis showed a median aerodynamic particle size of 0.25 microns, with 99.7% of the particles less than or equal to 10 microns and 84.7% less than or equal to 1.0 micron. This demonstrates that the aerosol was highly respirable.

### *JP-8+100 (MRD-00-631)*

Three groups of male mice were exposed for 30 minutes to total analytical concentrations of 2356, 1519, or 777 mg/m$^3$. The exposures for this test substance also were predominantly

vapor phase with the proportion of aerosol ranging from 26% at 2356 mg/m$^3$ to 4% at 777 mg/m$^3$. The difference in the relative proportions of individual hydrocarbon species between the aerosol and vapor phases was similar to JP-8, except there appeared to be an even higher amount of lighter molecular weight hydrocarbons in the vapor samples (see Appendix A for individual hydrocarbon analyses and chromatograms).

A particle size sample was taken during the exposure at the 2356 mg/m$^3$ level. The results of this analysis showed a median aerodynamic particle size of 1.27 microns, with 99.9% of the particles less than or equal to 10 microns and 36.5% less than or equal to 1.0 micron. This demonstrates that the aerosol phase of JP-8+100 also was highly respirable.

## ANIMAL RESPONSE DATA:

Tables 2-4 present summaries of the animal response data. Figures 3-9 present graphs of the individual and group mean respiratory rates.

### *JP-4 (MRD-00-629)*

Group mean respiratory rates were decreased from baseline values 58%, 51%, 28%, and 11% at mean exposure concentrations of 11430, 1888, 956, and 685 mg/m$^3$, respectively. Breathing patterns characteristic of sensory irritation were observed in all mice in the three highest exposure concentrations; only 2 of the 4 mice in the lowest exposure group exhibited slight irritation (2 were normal). There was no evidence of narcosis or pulmonary irritation at any level.

The mice in the two highest exposure groups (11430 and 1888 mg/m$^3$) exhibited a decreased recovery following exposure (61% and 82% of baseline values) compared to the two lower exposure groups which returned to pre-exposure levels (103% at 956 mg/m$^3$; 96% at 685 mg/m$^3$).

All mice in all four groups appeared normal at clinical observations performed prior to, during, and immediately after the exposures.

### *JP-8 (MRD-00-630)*

Group mean respiratory rates were decreased from baseline values 50%, 46%, 38%, and 22% at mean exposure concentrations of 3565, 1837, 1090, or 681 mg/m$^3$, respectively. Breathing patterns characteristic of sensory irritation were observed in all mice in all groups. There was no evidence of narcosis or pulmonary irritation at any level.

An additional group was exposed to JP-8 as a vapor-only atmosphere at 708 mg/m$^3$ and produced a similar response (28% decrease) compared to the aerosol-generated 681 mg/m$^3$ group (22% decrease).

The post-exposure recovery responses were depressed in all five groups, with the amount of depression proportional to the exposure concentration (75%, 77%, 86%, 93%, and 86% of baseline values at 3565, 1837, 1090, 681, and 708 mg/m$^3$, respectively).

All mice in all five groups appeared normal at clinical observations performed prior to, during, and immediately after the exposures.

*JP-8+100 (MRD-00-631)*

Group mean respiratory rates were decreased from baseline values 63%, 53%, or 18% at mean exposure concentrations of 2356, 1519, or 777 mg/m$^3$, respectively. Breathing patterns characteristic of sensory irritation were observed in all mice in all groups. There was no evidence of narcosis or pulmonary irritation at any level.

The mice in the two highest exposure groups (2356 and 1519 mg/m$^3$) exhibited a decreased recovery following exposure (59% and 68% of baseline values) compared to the lowest exposure group (777 mg/m$^3$) which returned to pre-exposure levels (103%).

All mice in all three groups appeared normal at clinical observations performed prior to, during, and immediately after the exposures.

## $RD_{50}$ CALCULATIONS:

Figure 10 presents a graph of the exposure concentrations vs. respiratory rate decreases.

The exposure concentration of each test substance that would produce a 50% decrease in respiratory rate ($RD_{50}$) was calculated to be:

| | | |
|---|---|---|
| JP-4 | - | 4842 mg/m$^3$, with 95% confidence limits of 2375 to 9873. |
| JP-8 | - | 2876 mg/m$^3$, with 95% confidence limits of 2107 to 3925. |
| JP-8+100 | - | 1629 mg/m$^3$, with 95% confidence limits of 1418 to 1871 |

## CONCLUSIONS

Exposures to test atmospheres of each of the three test substances, JP-4 (MRD-00-629), JP-8 (MRD-00-630) and JP-8+100 (MRD-00-631) produced breathing patterns characteristic of upper airway sensory irritation in mice. Within the context and limits of this study, examination of the breathing patterns revealed no apparent pulmonary (deep lung) irritation or narcosis at any level for all three substances.

The exposures were generated as vapor-only (JP-4) or mixed vapor/aerosol atmospheres (JP-8 and JP-8+100). Each substance was tested over a range of air concentrations that resulted in minimal to extreme respiratory rate decreases (>50% decrease). The calculated $RD_{50}$ values showed a relative irritancy ranking of JP-8+100 > JP-8 > JP-4.

Analytical sampling data demonstrated clear differences in the distribution and relative proportions of individual hydrocarbon species contained in the aerosol and vapor phases. As expected, there were differences among the three test substances with JP-4 exhibiting a range of lower molecular weight hydrocarbons compared to JP-8 or JP-8+100. Within the mixed vapor/aerosol atmospheres of JP-8 and JP-8+100, the vapor phase samples showed a greater abundance of lighter hydrocarbons compared to the aerosol phase samples. The on-line vapor and aerosol monitors demonstrated that the test atmospheres for all groups were stable throughout the exposure periods.

## PROTOCOL EXCEPTIONS

On six occasions the animal room temperature or humidity was outside of the ranges specified in the protocol. These slight and transient deviations should not have affected the quality or integrity of the data.

## REFERENCES

Additional references for the Alarie sensory irritation assay:

Alarie, Y. (1966) Arch. Environ. Health 13:433

Alarie, Y. (1981) Fd. Cosmet. Toxicol. 19:623

Barrow, C., Alarie, Y., Warrick, J. and Stock, M. (1977) Arch. Environ. Health 32:68

Nielsen, G.D., and Alarie, Y. (1982) Tox. Appl. Pharm. 65:459

Weyel, D.A., Rodney, B.S., and Alarie, Y. (1982) Tox. Appl. Pharm. 64:423

FIGURE 1 - SCHEMATIC OF GENERATION AND EXPOSURE SYSTEM
(COUNTER-CURRENT VAPOR GENERATOR)

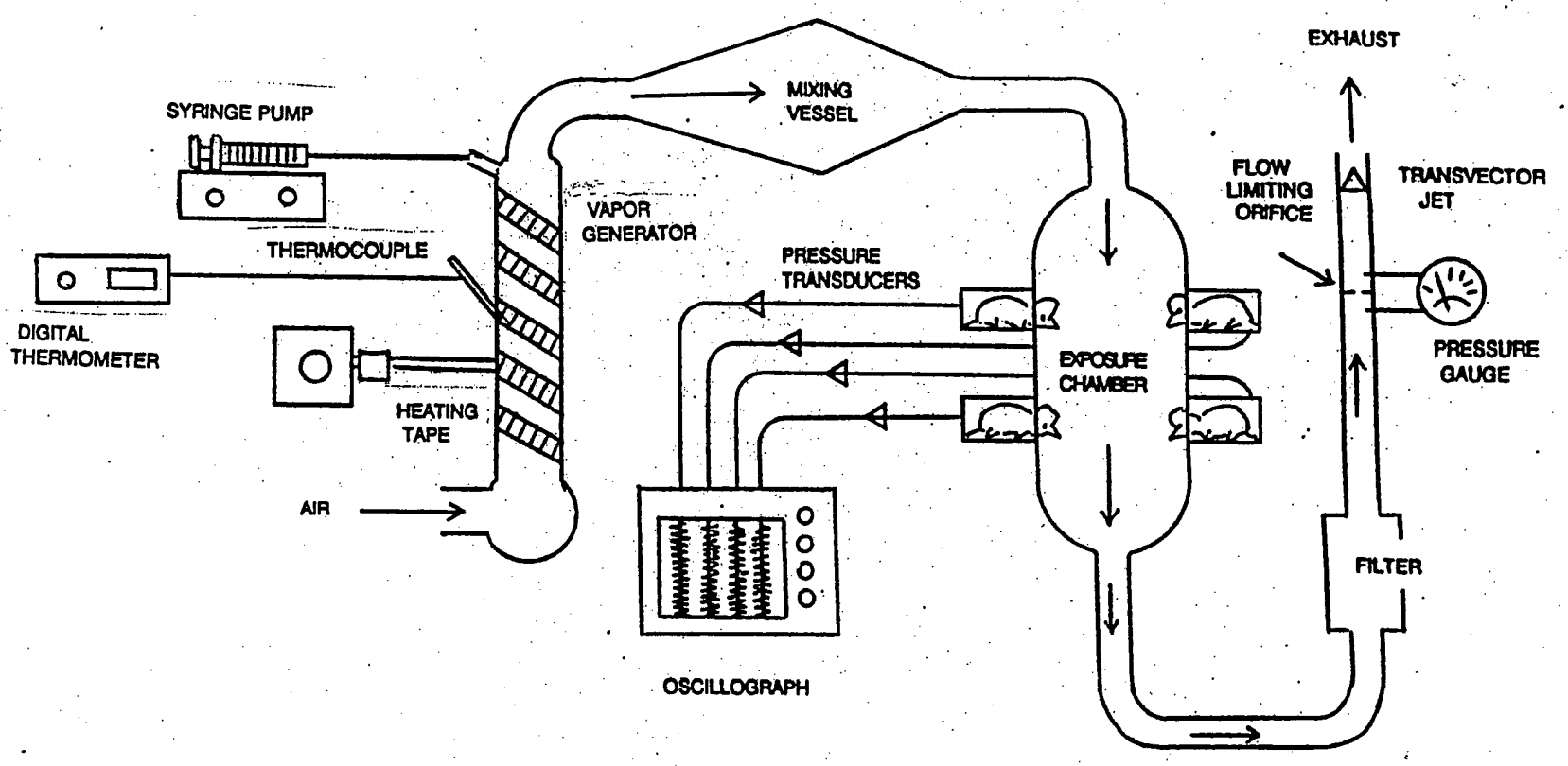
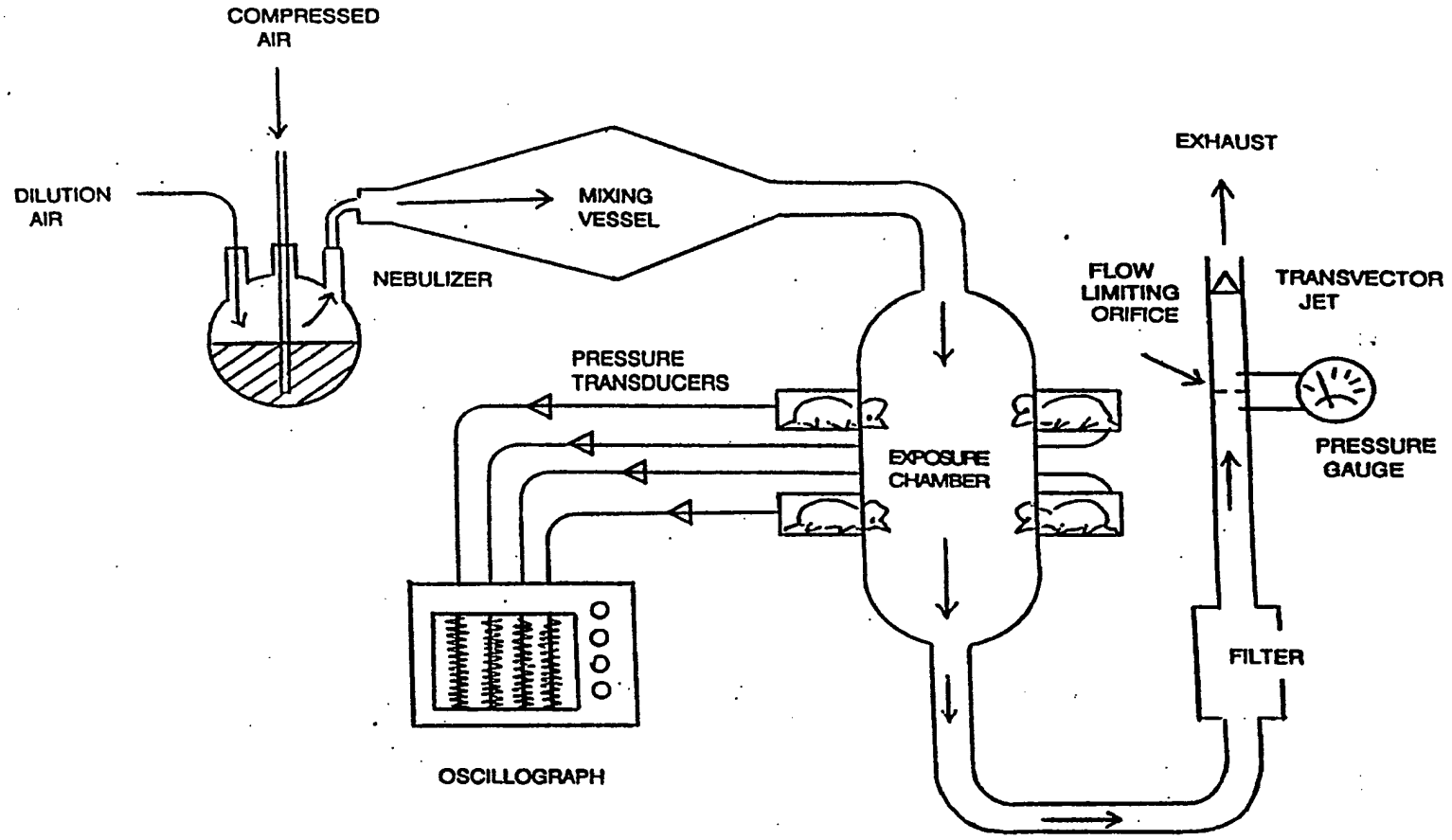


FIGURE 2 - SCHEMATIC OF GENERATION AND EXPOSURE SYSTEM
(NEBULIZER)



## TABLE 1 - SUMMARY OF MEAN STUDY DATA

| Test Substance | JP - 4 | | | | JP - 8 | | | | | JP - 8 + 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Exposure Concentration | | | | | | | | | | | | |
| Mean Concentration (mg/m$^3$) | 11430 | 1888 | 956 | 685 | 3565 | 1837 | 1090 | 681 | 708 | 2356 | 1519 | 777 |
| Standard Deviation | 66 | 55 | 59 | 56 | 129 | 68 | 22 | 40 | 33 | 10 | 39 | 26 |
| Coefficient of Variation (%) | 0.6 | 2.9 | 6.2 | 8.2 | 3.6 | 3.7 | 2.0 | 5.9 | 4.7 | 0.4 | 2.5 | 3.3 |
| Vapor/Aerosol Concentration | | | | | | | | | | | | |
| Vapor Concentration (mg/m$^3$) | 11349 | 1888 | 956 | 685 | 2335 | 1379 | 920 | 658 | 708 | 1754 | 1220 | 748 |
| Aerosol Concentration (mg/m$^3$) | 81 | 0 | 0 | 0 | 1230 | 459 | 170 | 23 | 0 | 603 | 300 | 29 |
| % Aerosol | 0.7 | 0 | 0 | 0 | 34.5 | 25.0 | 15.6 | 3.4 | 0 | 25.6 | 19.7 | 3.7 |
| Particle Size Analysis | | | | | | | | | | | | |
| Median particle size (um) | 5.35 | | | | | | 0.25 | | | 1.27 | | |
| Geometric Standard Deviation | 2.21 | | | | | | 3.89 | | | 2.00 | | |
| Percent Less Than 10 microns | 78.4 | | | | | | 99.7 | | | 99.9 | | |
| Percent Less Than 1 micron | 1.7 | | | | | | 84.7 | | | 36.5 | | |
| Animal Response Data | | | | | | | | | | | | |
| Percent Respiratory Rate Decrease | -58 | -51 | -28 | -11 | -50 | -46 | -38 | -22 | -28 | -63 | -53 | -18 |
| Percent Recovery to Baseline | 61 | 82 | 103 | 96 | 75 | 77 | 86 | 93 | 86 | 59 | 68 | 103 |
| $RD_{50}$ (mg/m$^3$) | 4842 | | | | 2876 | | | | | 1629 | | |
| 95 % Confidence Interval | 2375 - 9873 | | | | 2107 - 3925 | | | | | 1418 - 1871 | | |

* - Atmosphere generated as vapor only

# TABLE 2 - SUMMARY OF ANIMAL RESPONSE DATA
## JP-4 (MRD-00-629)

| CONCENTRATION | ANIMAL NUMBER | BODY WEIGHT (g) | EXPOSURE RESPONSE (%) | RECOVERY RESPONSE (%) | IRRITATION TYPE/ SEVERITY* | GROSS OBSERVATIONS (pretest) | (inchamber) | (postdose) |
|---|---|---|---|---|---|---|---|---|
| 11,430 mg/m$^3$ | IAY933 | 28 | -61 | 71 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY934 | 28 | -56 | 57 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY945 | 29 | -53 | 53 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY950 | 29 | -61 | 62 | SENSORY/EXTREME | NOA | NOA | NOA |
| | **MEAN** | **29** | **-58** | **61** | | | | |
| | **S.D.** | **0.6** | **3.9** | **7.8** | | | | |
| 1,888 mg/m$^3$ | IAY939 | 30 | -45 | 85 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY941 | 30 | -56 | 79 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY943 | 30 | -56 | 76 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY944 | 30 | -47 | 87 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **30** | **-51** | **82** | | | | |
| | **S.D.** | **0.0** | **5.8** | **5.1** | | | | |
| 956 mg/m$^3$ | IAY952 | 28 | -29 | 94 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY953 | 27 | -33 | 98 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY963 | 29 | -30 | 115 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY972 | 28 | -18 | 105 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | **MEAN** | **28** | **-28** | **103** | | | | |
| | **S.D.** | **0.8** | **6.6** | **9.2** | | | | |
| 685 mg/m$^3$ | IAZ386 | 27 | -12 | 97 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | IAZ394 | 28 | -9 | 96 | SENSORY/NONE | NOA | NOA | NOA |
| | IAZ402 | 27 | -16 | 91 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | IAZ405 | 27 | -7 | 100 | SENSORY/NONE | NOA | NOA | NOA |
| | **MEAN** | **27** | **-11** | **96** | | | | |
| | **S.D.** | **0.5** | **3.9** | **3.7** | | | | |

**NOA - NO OBSERVABLE ABNORMALITIES**

*** Severity categorized as: slight = 12-19%; moderate = 20-49%; extreme = ≥ 50%.**

# TABLE 3 - SUMMARY OF ANIMAL RESPONSE DATA
## JP-8 (MRD-00-630)

| CONCENTRATION | ANIMAL NUMBER | BODY WEIGHT (g) | EXPOSURE RESPONSE (%) | RECOVERY RESPONSE (%) | IRRITATION TYPE/ SEVERITY* | GROSS OBSERVATIONS (pretest) | (inchamber) | (postdose) |
|---|---|---|---|---|---|---|---|---|
| 3613 mg/m$^3$ | IAZ385 | 29 | -54 | 76 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ391 | 29 | -54 | 72 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ397 | 30 | -51 | 74 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAZ399 | 29 | -42 | 76 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **29** | **-50** | **75** | | | | |
| | **S.D.** | **0.5** | **5.7** | **1.9** | | | | |
| 1837 mg/m$^3$ | IAY981 | 24 | -42 | 80 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY984 | 24 | -52 | 64 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY986 | 24 | -54 | 70 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAY989 | 24 | -34 | 95 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **24** | **-46** | **77** | | | | |
| | **S.D.** | **0.0** | **9.3** | **13.5** | | | | |
| 1090 mg/m$^3$ | IAY974 | 27 | -41 | 77 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY976 | 27 | -33 | 90 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY977 | 30 | -37 | 90 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY994 | 27 | -41 | 85 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **28** | **-38** | **86** | | | | |
| | **S.D.** | **1.5** | **3.8** | **6.1** | | | | |
| 681 mg/m$^3$ | IAZ393 | 28 | -24 | 91 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAZ400 | 28 | -25 | 86 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAZ401 | 28 | -15 | 100 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | IAZ403 | 28 | -23 | 95 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **28** | **-22** | **93** | | | | |
| | **S.D.** | **0.0** | **4.6** | **5.9** | | | | |
| 708 mg/m$^3$ | IAY978 | 28 | -25 | 86 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY979 | 27 | -36 | 73 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY980 | 28 | -30 | 90 | SENSORY/MODERATE | NOA | NOA | NOA |
| | IAY982 | 27 | -22 | 96 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **28** | **-28** | **86** | | | | |
| | **S.D.** | **0.6** | **6.1** | **9.7** | | | | |

**NOA - NO OBSERVABLE ABNORMALITIES**

*** Severity categorized as: slight = 12-19%; moderate = 20-49%; extreme = ≥ 50%.**

## TABLE 4 - SUMMARY OF ANIMAL RESPONSE DATA (CONT'D)
### JP-8 + 100 (MRD-00-631)

| CONCENTRATION | ANIMAL NUMBER | BODY WEIGHT (g) | EXPOSURE RESPONSE (%) | RECOVERY RESPONSE (%) | IRRITATION TYPE/ SEVERITY* | GROSS OBSERVATIONS (pretest) | (inchamber) | (postdose) |
|---|---|---|---|---|---|---|---|---|
| 2356 mg/m$^3$ | IAZ390 | 28 | -64 | 56 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ392 | 28 | -70 | 46 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ395 | 29 | -52 | 77 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ404 | 27 | -67 | 58 | SENSORY/EXTREME | NOA | NOA | NOA |
| | **MEAN** | **28** | **-63** | **59** | | | | |
| | **S.D.** | **0.8** | **7.9** | **12.9** | | | | |
| 1519 mg/m$^3$ | IAZ459 | 25 | -54 | 48 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ460 | 26 | -50 | 75 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ467 | 26 | -52 | 65 | SENSORY/EXTREME | NOA | NOA | NOA |
| | IAZ469 | 26 | -55 | 82 | SENSORY/EXTREME | NOA | NOA | NOA |
| | **MEAN** | **26** | **-53** | **68** | | | | |
| | **S.D.** | **0.5** | **2.2** | **14.8** | | | | |
| 777 mg/m$^3$ | IAZ466 | 27 | -17 | 98 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | IAZ468 | 27 | -16 | 116 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | IAZ470 | 26 | -15 | 103 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | IAZ471 | 26 | -22 | 94 | SENSORY/MODERATE | NOA | NOA | NOA |
| | **MEAN** | **27** | **-18** | **103** | | | | |
| | **S.D.** | **0.6** | **3.1** | **9.6** | | | | |

**NOA - NO OBSERVABLE ABNORMALITIES**

*** Severity categorized as: slight = 12-19%; moderate = 20-49%; extreme = ≥ 50%.**

FIGURE 3 - GROUP MEAN RESPIRATORY RATES: JP-4 (MRD-00-629)

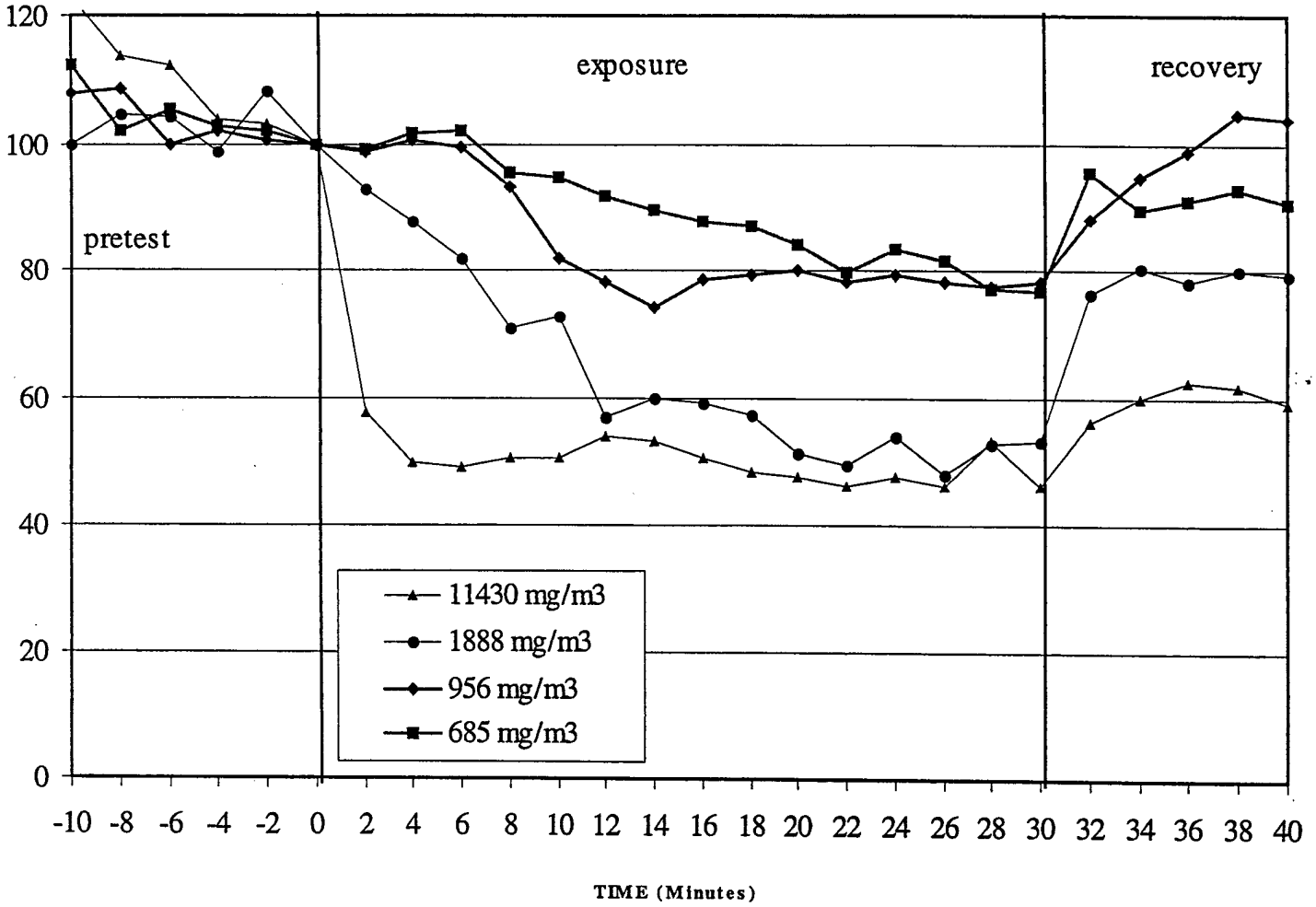


FIGURE 4 - GROUP MEAN RESPIRATORY RATES: JP-8 (MRD-00-630)

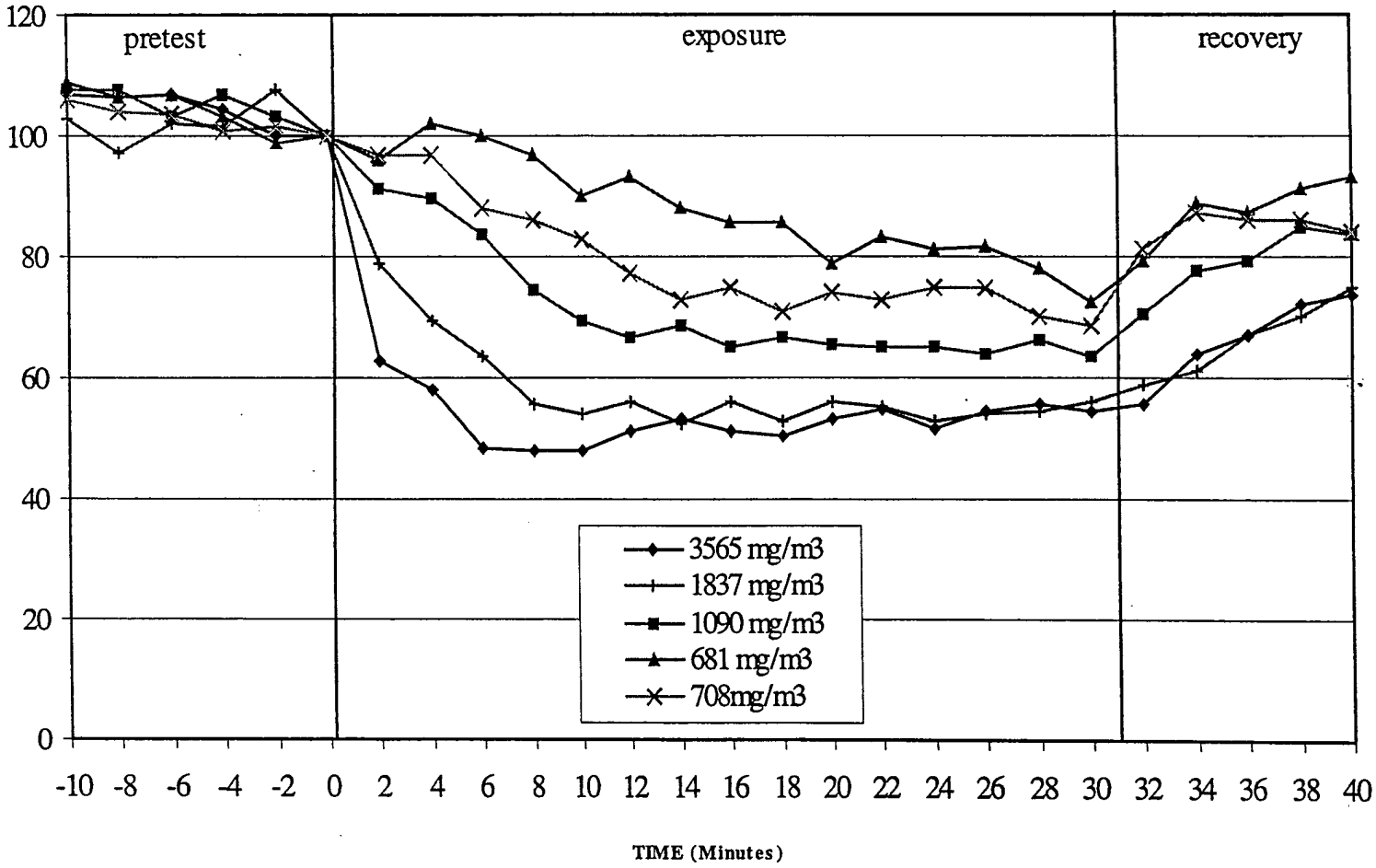
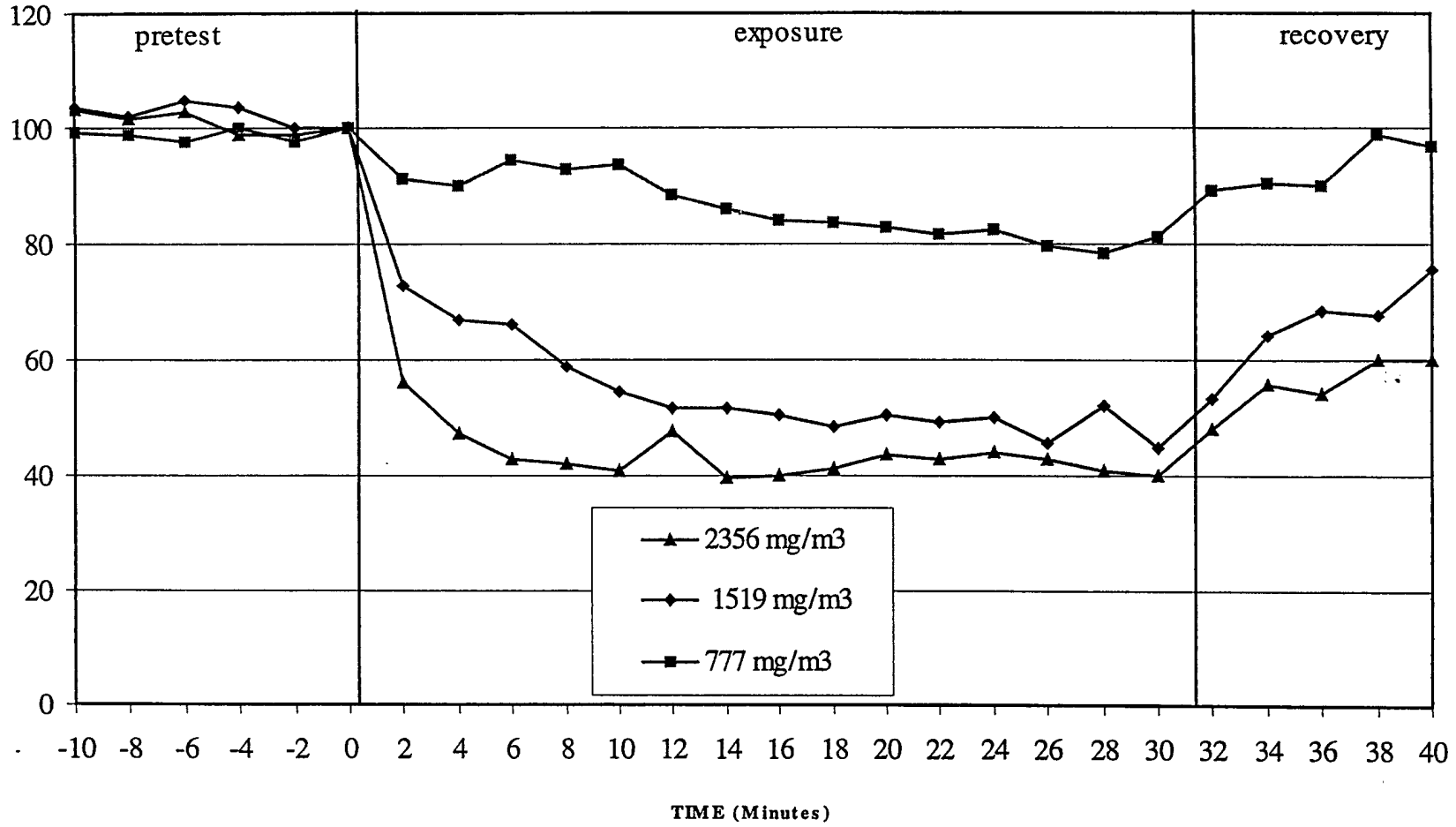
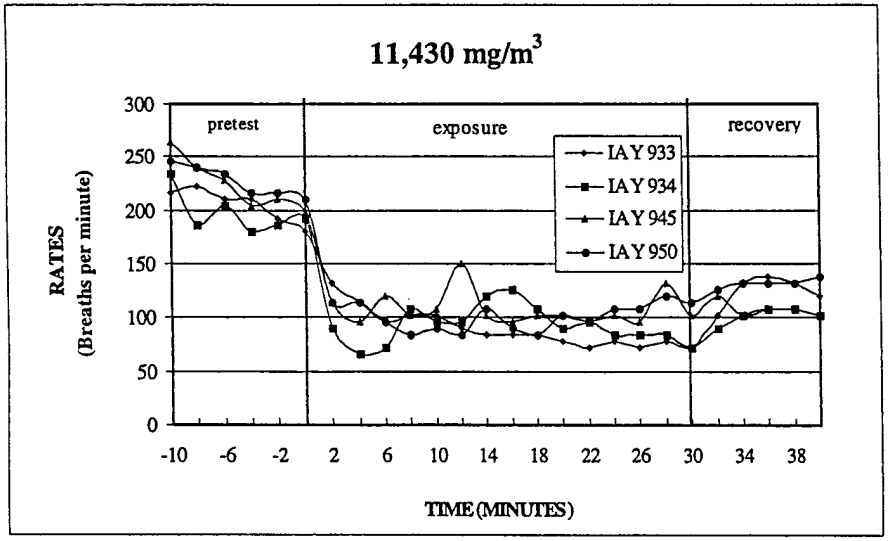
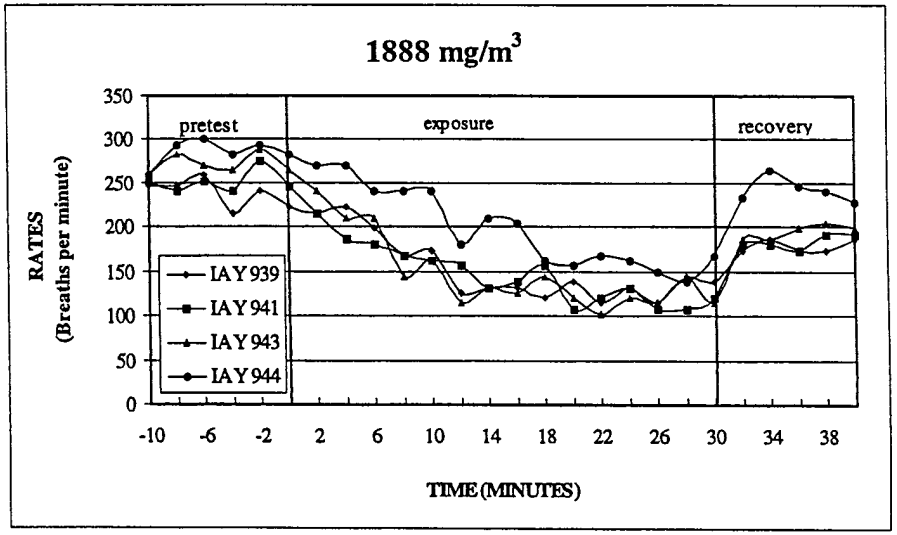


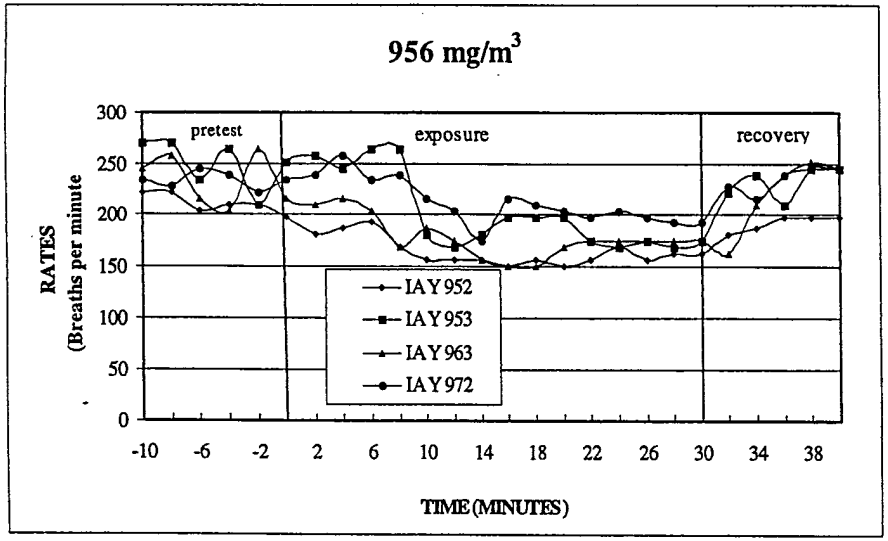
FIGURE 5 - GROUP MEAN RESPIRATORY RATES: JP-8+100 (MRD-00-631)

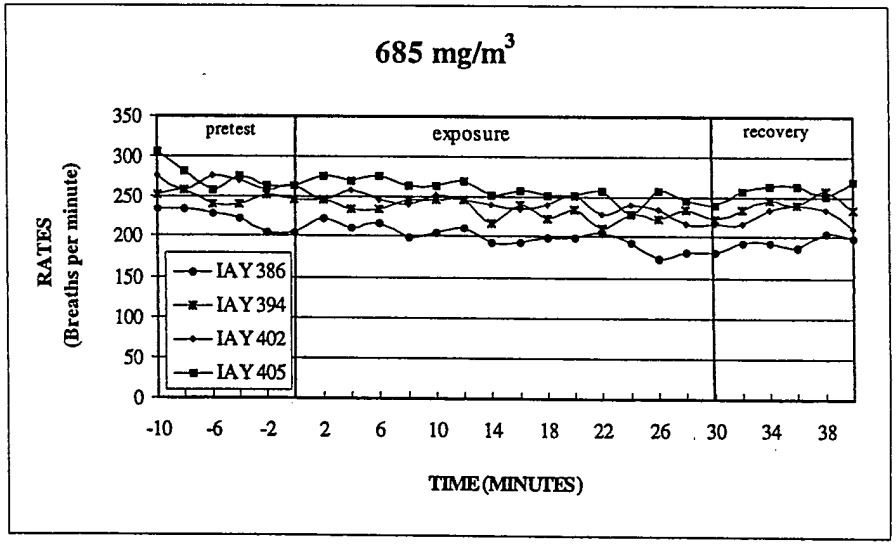


## FIGURE 6 - INDIVIDUAL RESPIRATORY RATES: JP-4 (MRD-00-629)

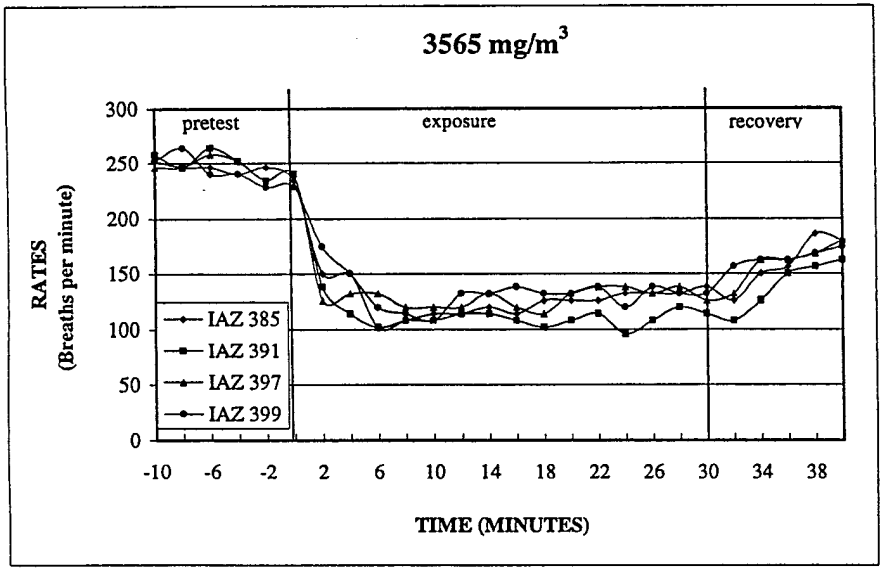


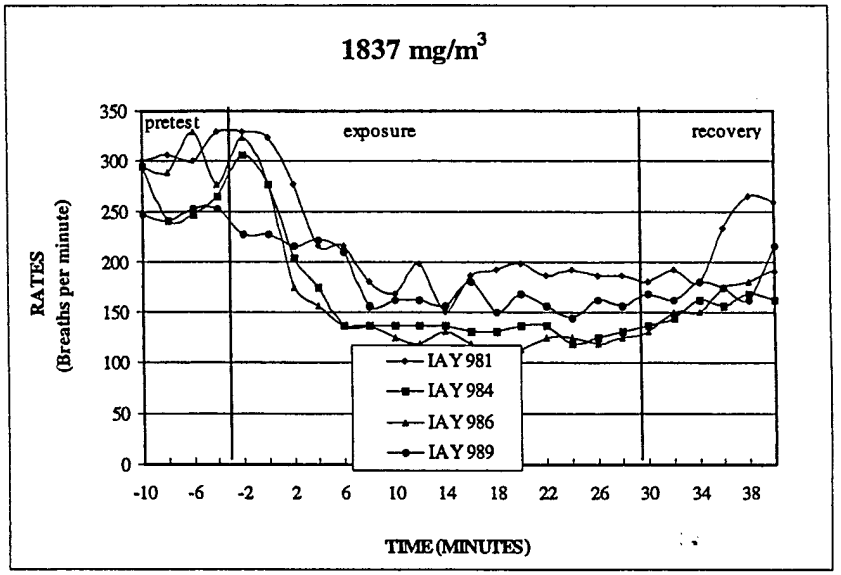



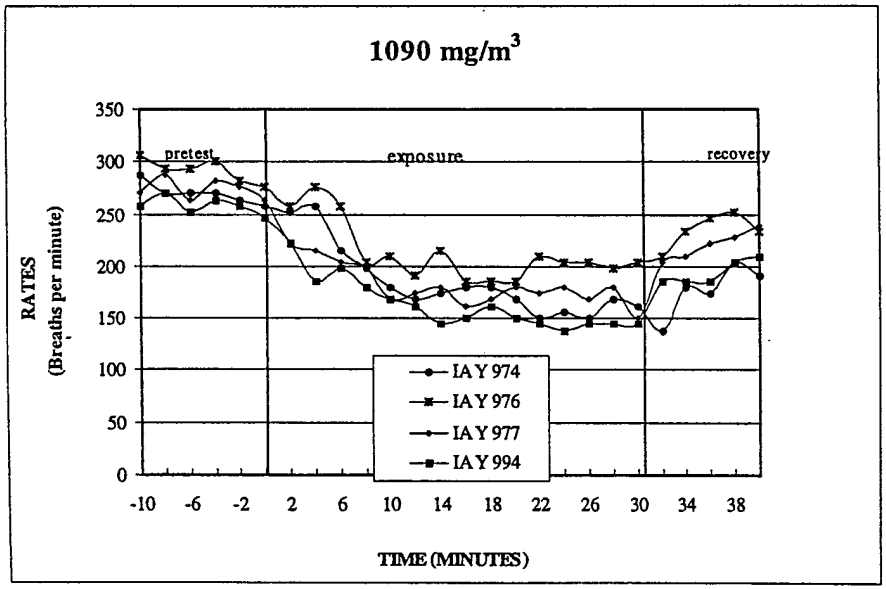



## FIGURE 7 - INDIVIDUAL RESPIRATORY RATES: JP-8 (MRD-00-630)



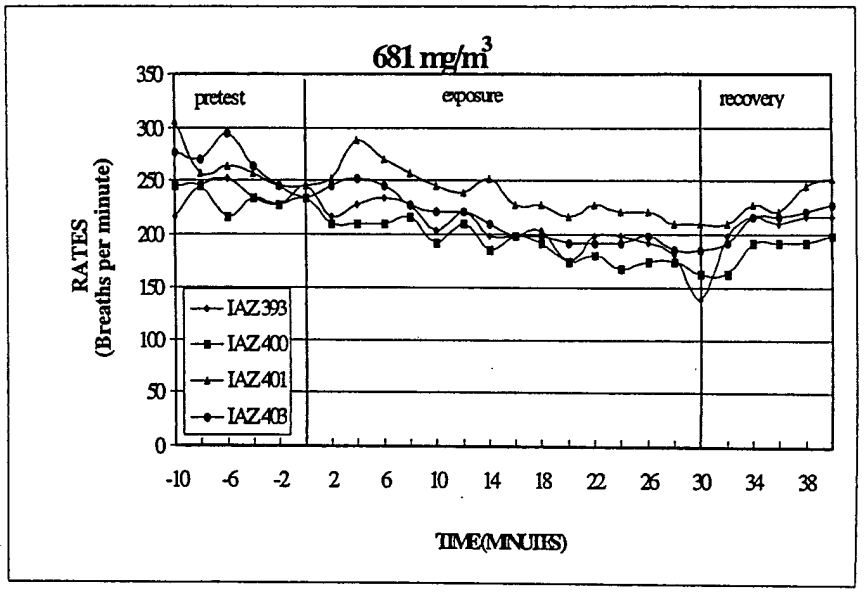
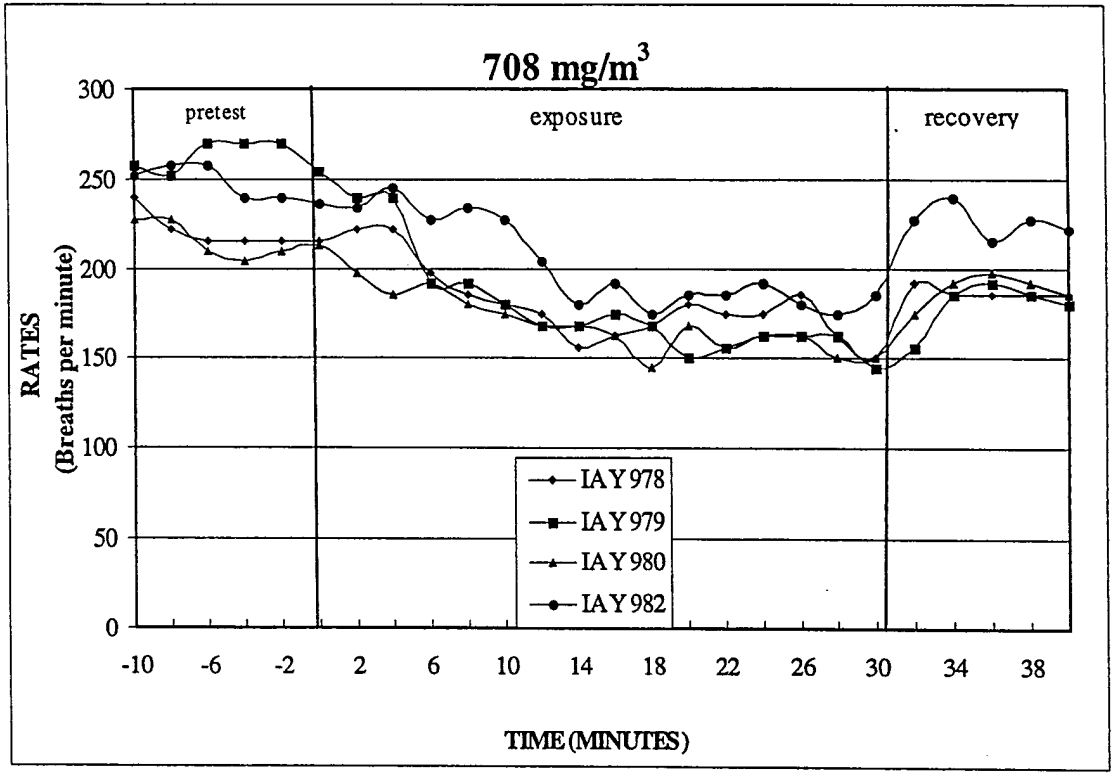
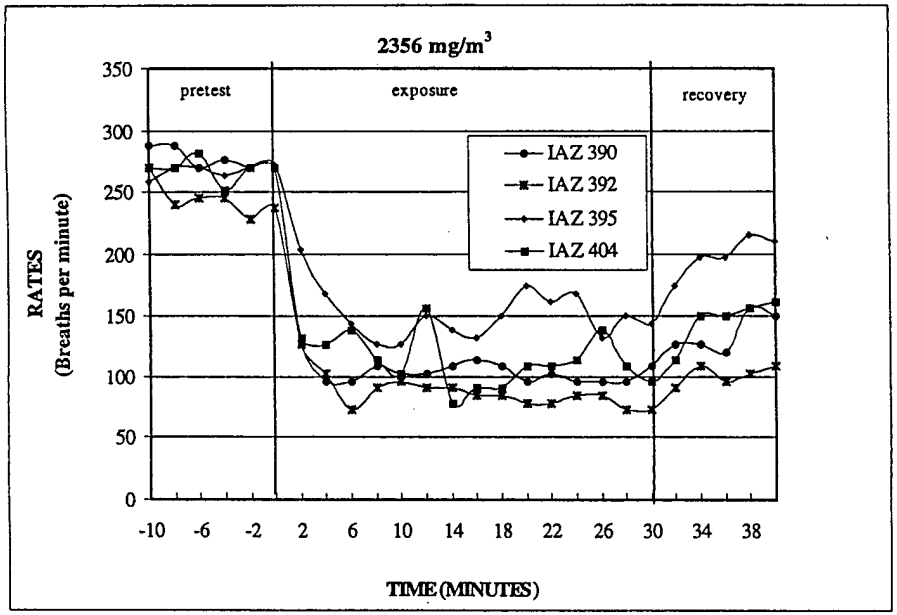
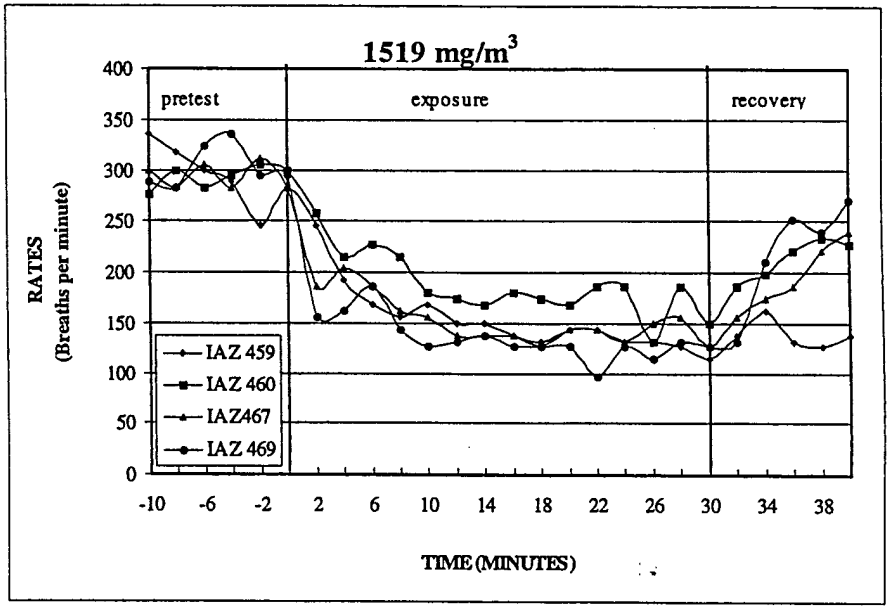



FIGURE 8 - INDIVIDUAL RESPIRATORY RATES: JP-8 (MRD-00-630)
Vapor Only Exposure



## FIGURE 9 - INDIVIDUAL RESPIRATORY RATES: JP-8+100



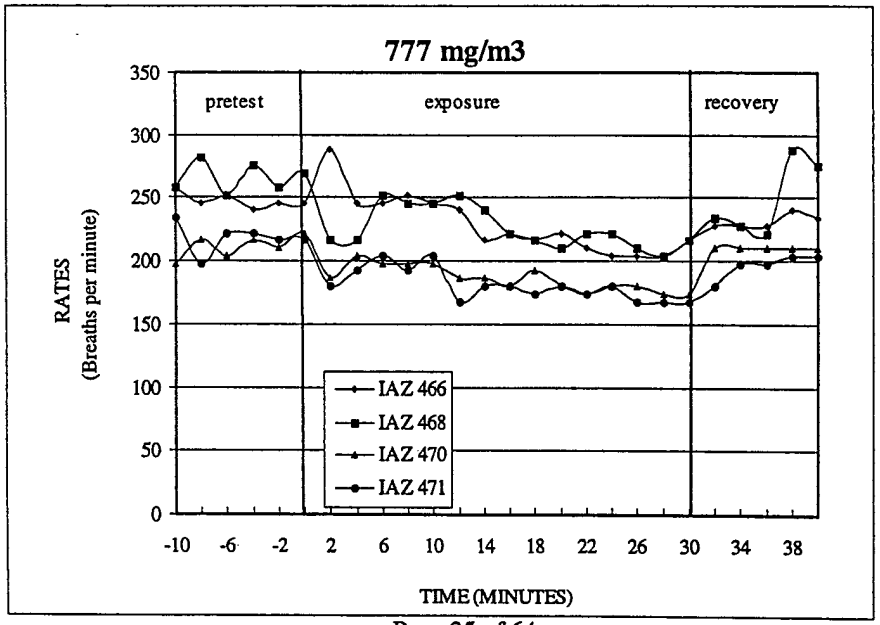
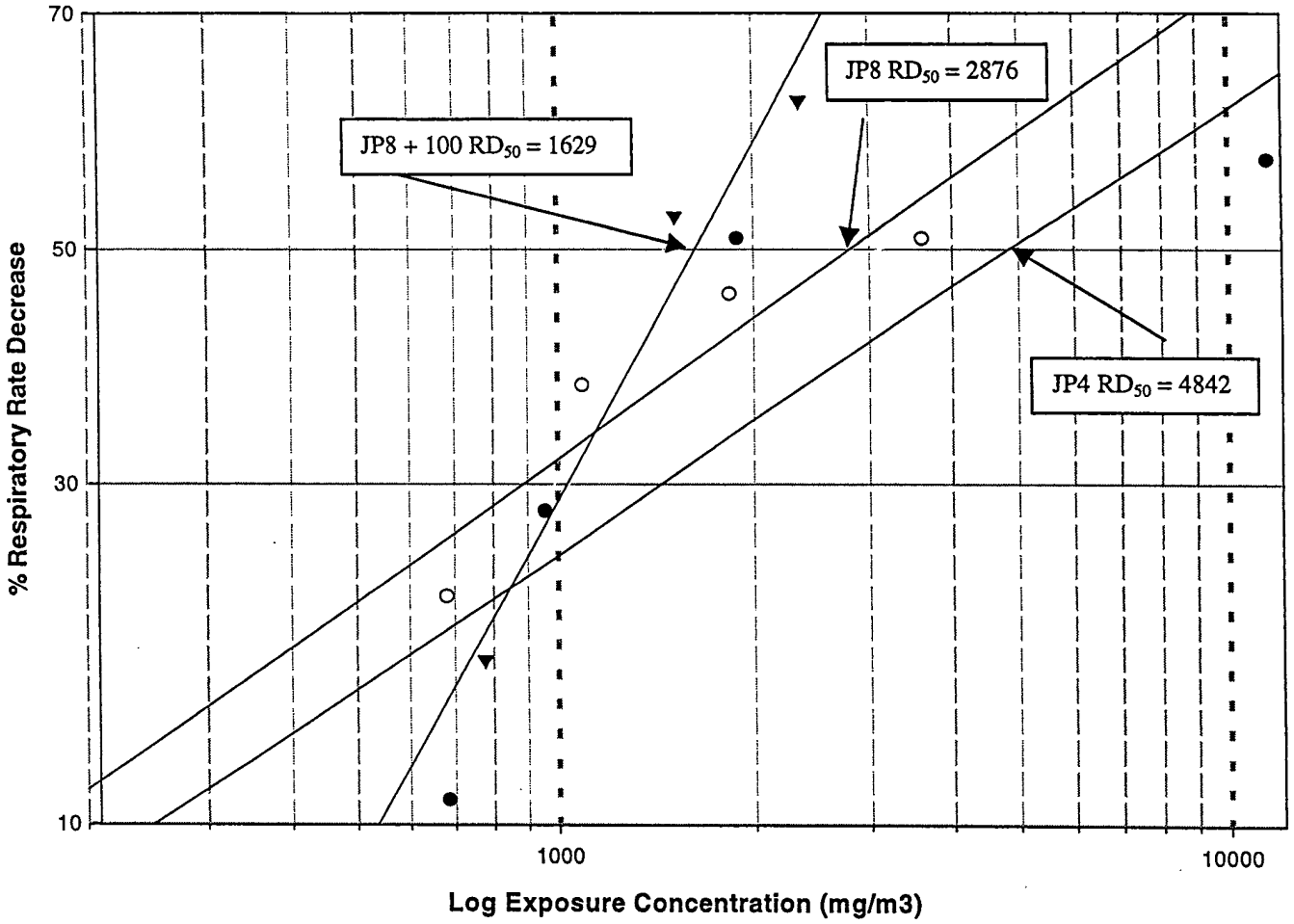



FIGURE 10 - RD $_{50}$ CALCULATION: JP-4, JP-8, JP-8+100



## TABLE 5 - SUMMARY OF ANALYTICAL DATA: JP-4 (MRD-00-629)

| Sample #: | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-Volatile Aerosol (filter), $mg/m^3$ | 118 | 82 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Volatile Hydrocarbons (sorbent tube), $mg/m^3$ | 11337 | 11273 | 11436 | 1943 | 1886 | 1834 | 948 | 1018 | 901 | 621 | 713 | 722 |
| Total Analytical Concentration, $mg/m^3$ | 11455 | 11355 | 11479 | 1943 | 1886 | 1834 | 948 | 1018 | 901 | 621 | 713 | 722 |
| **Mean Analytical Concentration, $mg/m^3$** | 11430 ± 66 | | | 1888 ± 55 | | | 956 ± 59 | | | 685 ± 56 | | |
| **Nominal Concentration, $mg/m^3$** | 33889 | | | 4000 | | | 1333 | | | 1111 | | |
| Median Particle Size (um)* | 5.35** | | | | | | | | | | | |
| Geometric Standard Deviation (um) | 2.21 | | | | | | | | | | | |
| % less than or equal to 15 um | 90.3 | | | | | | | | | | | |
| % less than or equal to 10 um | 78.4 | | | | | | | | | | | |
| % less than or equal to 1 um | 1.7 | | | | | | | | | | | |

* Mass Median equivalent aerodynamic size (50% size).

** insufficient aerosol in sample for valid particle size analysis

## TABLE 6 - SUMMARY OF ANALYTICAL DATA: JP-8 (MRD-00-630)

| Sample #: | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-Volatile Aerosol (Filter), $mg/m^3$ | 1152 | 1244 | 1294 | 442 | 465 | 469 | 160 | 166 | 183 | 21 | 25 | 22 | 0 | 0 | 0 |
| Volatile Hydrocarbons (sorbent tube), $mg/m^3$ | 2265 | 2386 | 2356 | 1350 | 1451 | 1335 | 908 | 945 | 908 | 622 | 698 | 654 | 700 | 744 | 680 |
| Total Analytical Concentration, $mg/m^3$ | 3559 | 3630 | 3650 | 1792 | 1916 | 1804 | 1068 | 1111 | 1091 | 643 | 723 | 676 | 700 | 744 | 680 |
| **Mean Analytical Concentration, $mg/m^3$** | $3613 \pm 48$ | | | $1837 \pm 68$ | | | $1090 \pm 22$ | | | $681 \pm 40$ | | | $708 \pm 33$ | | |
| **Nominal Concentration, $mg/m^3$** | 5333 | | | 3333 | | | 2000 | | | 1111 | | | 1222 | | |
| Median Particle Size (um)* | | | | | | | 0.25 | | | | | | | | |
| Geometric Standard Deviation (um) | | | | | | | 3.89 | | | | | | | | |
| % less than or equal to 15 um | * Mass Median equivalent aerodynamic size (50% size). | | | | | | 99.9 | | | | | | | | |
| % less than or equal to 10 um | | | | | | | 99.7 | | | | | | | | |
| % less than or equal to 1 um | | | | | | | 84.7 | | | | | | | | |

## TABLE 7 - SUMMARY OF ANALYTICAL DATA : JP-8 + 100 (MRD-00-631)

| Sample #: | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| Non-Volatile Aerosol (Filter), $mg/m^3$ | 606 | 615 | 587 | 291 | 297 | 311 | 25 | 31 | 31 |
| Volatile Hydrocarbons (sorbent tube), $mg/m^3$ | 1759 | 1731 | 1771 | 1191 | 1220 | 1248 | 781 | 725 | 738 |
| Total Analytical Concentration, $mg/m^3$ | 2365 | 2346 | 2358 | 1482 | 1517 | 1559 | 806 | 756 | 769 |
| **Mean Analytical Concentration, $mg/m^3$** | $2356 \pm 35$ | | | $1519 \pm 39$ | | | $777 \pm 26$ | | |
| **Nominal Concentration, $mg/m^3$** | 4111 | | | 2667 | | | 1333 | | |
| Median Particle Size (um)* | | | | | | | 1.27 | | |
| Geometric Standard Deviation (um) | | | | | | | 2.00 | | |
| % less than or equal to 15 um | * Mass Median equivalent aerodynamic size (50% size). | | | | | | 99.98 | | |
| % less than or equal to 10 um | | | | | | | 99.86 | | |
| % less than or equal to 1 um | | | | | | | 36.47 | | |

## APPENDIX A : TABLE 1A- ANALYTICAL PROCEDURES AND DETAILED HYDROCARBON ANALYSES

| | |
|---|---|
| **METHOD:** | Hydrocarbons in Air |
| SUBSTANCE(S) | (See Chem/Phys Properties) |
| DETECTION LIMIT: | 1ug |
| MIN.DET.CONC.: | 0.1 ppm |
| IHMC CLASS: | A/B |
| **SAMPLING CONDITIONS:** | |
| SAMPLING DEVICE(S): | Charcoal Tubes (100/50mg, 400/200mg) |
| MANUFACTURER: | SKC, Inc. |
| CATALOG NUMBER: | 226-01, 226-09 |
| SAMPLE STABILITY (days): | >28 |
| SHIPMENT/STORAGE: | Dry Ice/Freezer |
| **ANALYTICAL CONDITIONS:** | |
| DESORPTION SOLVENT: | Carbon Disulfide (CS2) |
| VOLUME (mLs) | 1 (small tube)<br>2 (large tube) |
| DESORPTION CONDITIONS: | TIME (min): 30 min |
| TEMP: | Ambient |
| SPECIAL INSTRUCTIONS: | None |
| INSTRUMENT: | HP5890 (or equivalent) |
| COLUMN: | 30M x 0.53 mm id CP-Sil 5 CB |
| TEMPERATURE PROGRAM: | 35C (4 min) --> 200 C @ 5C/min |
| INJECTOR TEMP (C): | 200 |
| SAMPLE SIZE (uL) | 1.00 |
| DETECTOR | Flame Ionization (FID) |
| **FLOWS:** | FUEL - Hydrogen (H2) 30 (cc/min)<br>OXIDANT - Air 375 (cc/min)<br>CARRIER - Helium (He) or Nitrogen (N2) 5-10 (cc/min) |

## TABLE 1A- ANALYTICAL PROCEDURES AND DETAILED HYDROCARBON ANALYSES (CONT'D)

### CHEMICAL/PHYSICAL PROPERTIES:

| SUBSTANCE (& synonym) | DENSITY (gms/mL) | MOL. WT. | RETENTION TIME (min) |
|---|---|---|---|
| Isopentane | 0.620 | 72.15 | 2.8 |
| n-Pentane | 0.626 | 72.15 | 3.3 |
| 2-Methylpentane | 0.653 | 86.17 | 5.4 |
| 3-Methylpentane | 0.664 | 86.17 | 5.9 |
| n-Hexane | 0.660 | 86.17 | 6.5 |
| Methylcyclopentane | 0.749 | 84.16 | 7.6 |
| Benzene | 0.880 | 78.11 | 8.6 |
| Cyclohexane | 0.778 | 84.16 | 8.9 |
| 3-Methylhexane | 0.687 | 100.21 | 9.6 |
| Iso-Octane | 0.692 | 114.22 | 10.2 |
| Heptane | 0.684 | 100.20 | 10.6 |
| Toluene | 0.868 | 92.14 | 12.9 |
| 3-Methylheptane | 0.706 | 114.22 | 13.7 |
| n-Octane | 0.703 | 114.22 | 14.7 |
| Ethylbenzene | 0.866 | 106.20 | 16.7 |
| p&m-Xylene | 0.863 | 106.20 | 17.0 |
| o-Xylene | 0.880 | 106.20 | 17.9 |
| Nonane | 0.722 | 106.20 | 18.5 |
| Cumene | 0.862 | 120.19 | 19.1 |
| Propylbenzene | 0.862 | 120.19 | 20.1 |
| p&m-Ethyltoluene | 0.863 | 120.19 | 20.5 |
| 1,3,5-Trimethylbenzene | 0.876 | 120.19 | 20.7 |
| o-Ethyltoluene | 0.881 | 120.19 | 21.0 |
| 1,2,4-Trimethylbenzene | 0.865 | 120.19 | 21.6 |
| Decane | 0.730 | 142.30 | 22.1 |
| n-Undecane | 0.740 | 156.31 | 25.3 |
| Dodecane | 0.749 | 170.34 | 28.4 |
| Tetradecane | 0.763 | 198.40 | 33.8 |
| Hexadecane | 0.773 | 226.45 | 38.7 |
| Total Hydrocarbons as n-Hexane Equivalents (sum of all peaks minus the solvent peak) | | | 1-40 |

STOCK STANDARD: 40µL each component / 100mLs CS2

WORKING STANDARDS: 10/25 mL Serial Dilutions of Stock to cover concentration range of interest.

**TABLE 2A - INDIVIDUAL HYDROCARBON DATA: JP-4 (MRD-00-629)**

(all values are mg/m$^3$)

| Group Designation | I | | II | | III | | IV | |
|---|---|---|---|---|---|---|---|---|
| Sample Media | Sorbent Tube | Filter | Sorbent Tube | Filter | Sorbent Tube | Filter | Sorbent Tube | Filter |
| Sample Concentration | 11273 | 82 | 1886 | 0 | 945 | 0 | 713 | 0 |
| Total Concentration | 3630 | | 1886 | | 1018 | | 713 | |
| Individual Hydrocarbons: | Vapor | Aerosol | Vapor | Aerosol | Vapor | Aerosol | Vapor | Aerosol |
| Isopentane | 36 | * | 5 | * | 2 | * | 2 | * |
| n-Pentane | 81 | * | 11 | * | 5 | * | 4 | * |
| 2-Methylpentane | 167 | * | 23 | * | 11 | * | 8 | * |
| 3-Methylpentane | 92 | * | 13 | * | 6 | * | 4 | * |
| n-Hexane | 347 | * | 48 | * | 23 | * | 15 | * |
| Methylcyclopentane | 307 | * | 42 | * | 20 | * | 14 | * |
| Benzene | 76 | * | 10 | * | 5 | * | 3 | * |
| Cyclohexane | 389 | * | 54 | * | 27 | * | 17 | * |
| 3-Methylhexane | 321 | * | 45 | * | 22 | * | 15 | * |
| Isooctane | 415 | * | 55 | * | 37 | * | 25 | * |
| n-Heptane | 720 | * | 100 | * | 50 | * | 33 | * |
| Toluene | 373 | * | 50 | * | 35 | * | 18 | * |
| 3-Methylheptane | 198 | * | 27 | * | 14 | * | 10 | * |
| n-Octane | 761 | * | 109 | * | 55 | * | 37 | * |
| Ethylbenzene | 112 | * | 16 | * | 9 | * | 6 | * |
| p-m-Xylene | NA | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| o-Xylene | NA | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Xylenes | 455 | * | 64 | * | 35 | * | 25 | * |
| n-Nonane | 263 | * | 41 | * | 21 | * | 15 | * |
| Cumene | 23 | * | 4 | * | 2 | * | 2 | * |
| Propylbenzene | 31 | * | 5 | * | 3 | * | 2 | * |
| p-m Ethyltoluene | 74 | * | 12 | * | 6 | * | 5 | * |
| 1,3,5-Trimethylbenzene | 112 | * | 19 | * | 10 | * | 7 | * |
| o-Ethyltoluene | 37 | * | 7 | * | 3 | * | 3 | * |
| 1,2,4-Trimethylbenzene | 112 | * | 19 | * | 10 | * | 7 | * |
| n-Decane | 169 | 1 | 33 | * | 17 | * | 11 | * |
| n-Undecane | 143 | 4 | 43 | * | 23 | * | 16 | * |
| n-Dodecane | 61 | 9 | 38 | * | 22 | * | 15 | * |
| n-Tetradecane | 2 | 7 | 7 | * | 11 | * | 7 | * |
| n-Hexadecane | * | 1 | * | * | * | * | <1 | * |

* below the analytical limit of detection (0.1-0.2 mg/m3 based on sample volume) n/a - Not applicable (Not all samples analyzed for individual xylenes)

## TABLE 3A - INDIVIDUAL HYDROCARBON DATA: JP-8 (MRD-00-630)
(all values are mg/m³)

| Group Designation: | I | | II | | III | | IV | | V | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Media | Sorbent Tube | Filter | Sorbent Tube | Filter | Sorbent Tube | Filter | Sorbent Tube | Filter | Sorbent Tube | Filter |
| Sample Concentration | 2386 | 1244 | 1451 | 465 | 1018 | 166 | 698 | 25 | 713 | * |
| Total Concentration | 3613 | | 1916 | | 1111 | | 723 | | 713 | |
| Individual Hydrocarbons: | Vapor | Aerosol | Vapor | Aerosol | Vapor | Aerosol | Vapor | Aerosol | Vapor | Aerosol |
| Isopentane | * | * | * | * | 2 | * | * | * | * | * |
| n-Pentane | * | * | * | * | 5 | * | * | * | * | * |
| 2-Methylpentane | 1 | * | * | * | 11 | * | 1 | * | * | * |
| 3-Methylpentane | 1 | * | * | * | 6 | * | * | * | * | * |
| n-Hexane | 1 | * | * | * | 23 | * | 1 | * | * | * |
| Methylcyclopentane | 2 | * | * | * | 20 | * | 1 | * | * | * |
| Benzene | 1 | * | * | * | 5 | * | * | * | * | * |
| Cyclohexane | 2 | * | * | * | 27 | * | 1 | * | * | * |
| 3-Methylhexane | 4 | * | * | * | 22 | * | 1 | * | * | * |
| Isooctane | 6 | * | 1 | * | 37 | * | 2 | * | * | * |
| n-Heptane | 9 | * | 2 | * | 50 | * | 3 | * | 1 | * |
| Toluene | 12 | * | 4 | * | 25 | * | 3 | * | 1 | * |
| 3-Methylheptane | 10 | * | 4 | * | 14 | * | 2 | * | 1 | * |
| n-Octane | 35 | * | 18 | * | 55 | * | 9 | * | 3 | * |
| Ethylbenzene | 16 | * | 9 | * | 9 | * | 4 | * | 2 | * |
| p-m-Xylene | n/a | n/a | 16 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| o-Xylene | n/a | n/a | 7 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Xylenes | 52 | * | 23 | * | 35 | * | 11 | * | 4 | * |
| n-Nonane | 71 | 2 | 39 | * | 21 | * | 17 | * | 10 | * |
| Cumene | 14 | * | 8 | * | 2 | * | 3 | * | 2 | * |
| Propylbenzene | 20 | 1 | 11 | * | 3 | * | 5 | * | 3 | * |
| p-m Ethyltoluene | 45 | 2 | 25 | * | 6 | * | 11 | * | 7 | * |
| 1,3,5-Trimethylbenzene | 80 | 4 | 45 | 1 | 10 | * | 19 | * | 15 | * |
| o-Ethyltoluene | 37 | 2 | 21 | * | 3 | * | 9 | * | 7 | * |
| 1,2;4-Trimethylbenzene | 71 | 4 | 39 | 1 | 10 | * | 17 | * | 14 | * |
| n-Decane | 135 | 13 | 77 | 3 | 17 | 0 | 32 | * | 31 | * |
| n-Undecane | 171 | 47 | 107 | 11 | 23 | 2 | 43 | * | 59 | * |
| n-Dodecane | 93 | 82 | 69 | 24 | 22 | 6 | 32 | 1 | 51 | * |
| n-Tetradecane | 9 | 87 | 11 | 5 | 11 | 17 | 12 | 3 | 15 | 0 |
| n-Hexadecane | * | 23 | * | 11 | * | 6 | 2 | 2 | 2 | 0 |

* below the analytical limit of detection (0.1-0.2 mg/m3 based on sample volume) n/a - Not applicable (Not all samples analyzed for individual xylenes)

## TABLE 4A - INDIVIDUAL HYDROCARBON DATA: JP-8+100 (MRD-00-631)
(all values are mg/m$^3$)

| Group Designation: | I | | II | | III | |
|---|---|---|---|---|---|---|
| Sample Media | Sorbent Tube | Filter | Sorbent Tube | Filter | Sorbent Tube | Filter |
| Sample Concentration | 1771 | 615 | 1220 | 297 | 725 | 31 |
| Total Concentration | 2386 | | 1517 | | 777 | |
| Individual Hydrocarbons: | Vapor | Aerosol | Vapor | Aerosol | Vapor | Aerosol |
| Isopentane | * | 1 | * | * | 2 | * |
| n-Pentane | * | * | * | * | 2 | * |
| 2-Methylpentane | 2 | * | 1 | * | 3 | * |
| 3-Methylpentane | 1 | * | * | * | 2 | * |
| n-Hexane | 3 | * | 1 | * | 3 | * |
| Methylcyclopentane | 3 | * | 1 | * | 3 | * |
| Benzene | 1 | * | 1 | * | 1 | * |
| Cyclohexane | 3 | * | 1 | * | 3 | * |
| 3-Methylhexane | 6 | * | 2 | * | 4 | * |
| Isooctane | 9 | * | 4 | * | 6 | * |
| n-Heptane | 14 | * | 6 | * | 9 | * |
| Toluene | 17 | * | 8 | * | 9 | * |
| 3-Methylheptane | 11 | * | 7 | * | 6 | * |
| n-Octane | 38 | * | 23 | * | 18 | * |
| Ethylbenzene | 16 | * | 10 | * | 7 | * |
| p-m-Xylene | 44 | * | n/a | n/a | n/a | n/a |
| o-Xylene | 12 | * | n/a | n/a | n/a | n/a |
| Xylenes | 56 | * | 37 | 23 | 24 | * |
| n-Nonane | 57 | * | 39 | * | 23 | * |
| Cumene | 11 | * | 7 | * | 4 | * |
| Propylbenzene | 15 | * | 10 | * | 5 | * |
| p-m Ethyltoluene | 33 | * | 23 | * | 13 | * |
| 1,3,5-Trimethylbenzene | 46 | * | 30 | 0 | 16 | * |
| o-Ethyltoluene | 37 | * | 25 | 0 | 14 | * |
| 1,2,4-Trimethylbenzene | 47 | 1 | 31 | 62 | 16 | * |
| n-Decane | 100 | 4 | 67 | 1 | 34 | * |
| n-Undecane | 129 | 19 | 89 | 4 | 42 | * |
| n-Dodecane | 77 | 40 | 61 | 10 | 30 | 1 |
| n-Tetradecane | 10 | 57 | 14 | 25 | 11 | 4 |
| n-Hexadecane | * | 18 | 6 | 9 | 1 | 2 |

* below the analytical limit of detection (0.1-0.2 mg/m3 based on sample volume) n/a - Not applicable (Not all samples analyzed for individual xylenes)

## TABLE 5A - INDIVIDUAL HYDROCARBON DATA: PARTICLE SIZE SAMPLES
### JP-4 (MRD-00-629)

| Test Substance | JP-4 | | | JP-8 | | | JP-8+100 | | |
|---|---|---|---|---|---|---|---|---|---|
| Total Exposure Concentration | 11430 mg/m$^3$ | | | 1090 mg/m$^3$ | | | 777 mg/m$^3$ | | |
| Aerosol Concentration | 82 mg/m$^3$ | | | 920 mg/m$^3$ | | | 29 mg/m$^3$ | | |
| Stage Constant (cutoff diameter) | 2.60 um | 4.10 um | 6.80 um | 0.30 um | 0.84 um | 1.50 um | 0.54 um | 1.50 um | 2.60 um |
| % aerosol less than | 1 | 32 | 81 | 0 | 78 | 92 | 0 | 63 | 88 |
| **Individual Hydrocarbons:** | | | | | | | | | |
| Isopentane | * | * | * | * | * | * | * | 0 | * |
| n-Pentane | * | * | * | * | * | * | * | 0 | * |
| 2-Methylpentane | * | * | * | * | * | * | * | 0 | * |
| 3-Methylpentane | * | * | * | * | * | * | * | 0 | * |
| n-Hexane | * | * | * | * | * | * | * | 0 | * |
| Methylcyclopentane | * | * | * | * | * | * | * | 0 | * |
| Benzene | * | * | * | * | * | * | * | 0 | * |
| Cyclohexane | * | * | * | * | * | * | * | 0 | * |
| 3-Methylhexane | * | * | * | * | * | * | * | 0 | * |
| Isooctane | * | * | * | * | * | * | * | 0 | * |
| n-Heptane | * | * | * | * | * | * | * | 0 | * |
| Toluene | * | * | * | * | * | * | * | 0 | * |
| 3-Methylheptane | * | * | * | * | * | * | * | 0 | * |
| n-Octane | * | * | * | * | * | * | * | 0 | * |
| Ethylbenzene | * | * | * | * | * | * | * | 0 | * |
| P-M Xylene | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| O-Xylene | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Xylenes | * | * | * | * | * | * | * | 0 | * |
| n-Nonane | * | * | * | * | * | * | * | 0 | * |
| Cumene | * | * | * | * | * | * | * | 0 | * |
| Propylbenzene | * | * | * | * | * | * | * | 0 | * |
| p-m Ethyltoluene | * | * | * | * | * | * | * | 0 | * |
| 1,3,5-Trimethylbenzene | * | * | * | * | * | * | * | 0 | * |
| o-Ethyltoluene | * | * | * | * | * | * | * | 0 | * |
| 1,2,4-Trimethylbenzene | * | * | * | * | * | * | * | 0 | * |
| n-Decane | * | * | * | * | 0.087 | * | * | 0.16 | * |
| n-Undecane | * | * | * | 0.067 | 0.393 | 0.247 | * | 0 | * |
| n-Dodecane | * | * | * | 0.147 | 0.860 | 0.560 | * | 0.14 | * |
| n-Tetradecane | * | * | * | 0.793 | 3.20 | 2.427 | * | 0.37 | * |
| n-Hexadecane | * | * | * | 0.420 | 1.54 | 0.827 | * | 0.28 | * |

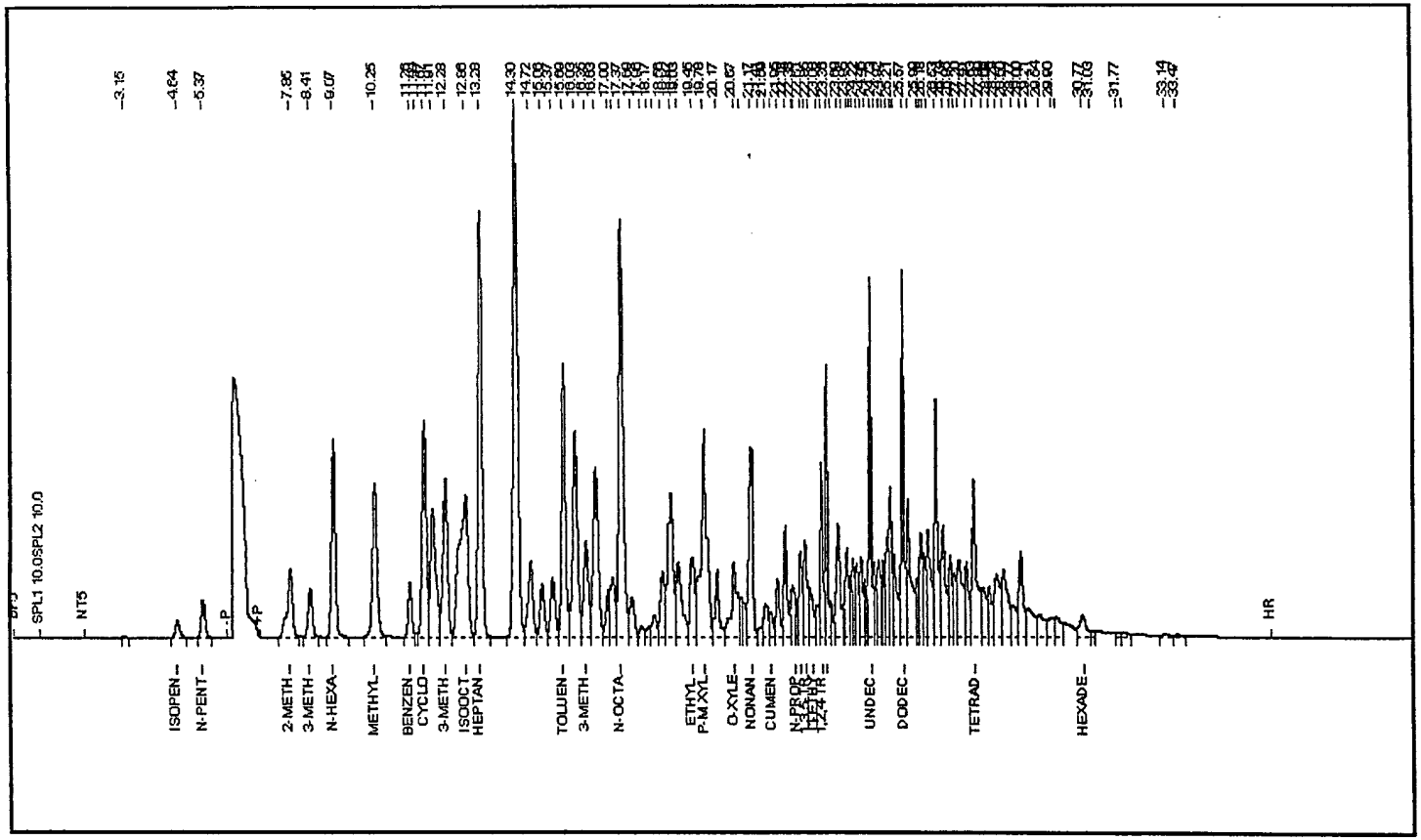
* below the analytical limit of detection (0.1-0.2 mg/m3 based on sample volume) n/a - Not applicable (Not all samples analyzed for individual xylenes)

## TABLE 6A - INDIVIDUAL HYDROCARBON DATA - NEAT TEST SUBSTANCES

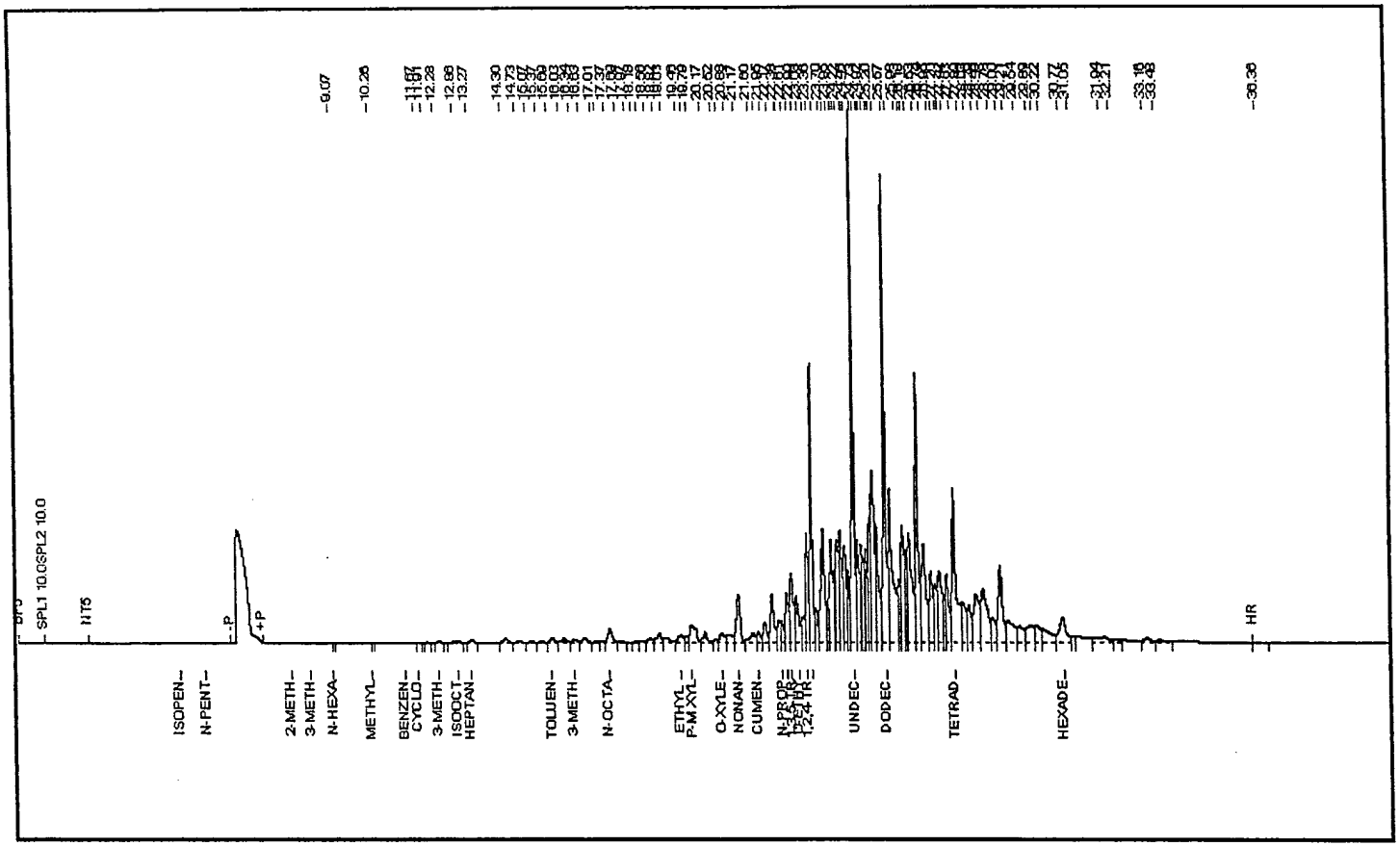
| Individual Hydrocarbons | JP 4 | JP 8 | JP 8 + 100 |
|---|---|---|---|
| | MRD-00-629 | MRD-00-630 | MRD-00-631 |
| | Percent By Volume* | | |
| Isopentane | 0.1437 | ND | ND |
| n-Pentane | 0.3237 | ND | ND |
| 2-Methylpentane | 0.7302 | ND | ND |
| 3-Methylpentane | 0.4139 | ND | ND |
| n-Hexane | 1.5403 | 0.0011 | 0.0023 |
| Methylcyclopentane | 1.3913 | 0.0006 | 0.0014 |
| Benzene | 0.3551 | ND | ND |
| Cyclohexane | 1.7803 | 0.0033 | 0.0030 |
| 3-Methylhexane | 1.5065 | 0.0119 | 0.0078 |
| Isooctane | 2.4941 | 0.0256 | 0.0112 |
| n-Heptane | 3.3458 | 0.0481 | 0.0357 |
| Toluene | 2.0009 | 0.0721 | 0.0664 |
| 3-Methylheptane | 0.9567 | 0.0604 | 0.0524 |
| n-Octane | 3.8056 | 0.2609 | 0.2506 |
| Ethylbenzene | 0.6458 | 0.1414 | 0.1322 |
| P-M Xylene | 3.3541 | 0.6610 | 0.6319 |
| n-Nonane | 1.5714 | 0.9103 | 0.8886 |
| Cumene | 0.1870 | 0.1756 | 0.1672 |
| Propylbenzene | 0.1830 | 0.2846 | 0.2698 |
| p-m Ethyltoluene | 0.5318 | 0.6921 | 0.6801 |
| 1,3,5-Trimethylbenzene | 0.5948 | 1.0785 | 1.0677 |
| o-Ethyltoluene | 0.4586 | 0.8522 | 0.8416 |
| 1,2,4-Trimethylbenzene | 0.8171 | 1.2355 | 1.2192 |
| n-Decane | 1.2687 | 2.8907 | 2.8641 |
| n-Undecane | 1.7350 | 5.5171 | 5.5065 |
| n-Dodecane | 1.8808 | 5.3191 | 5.3032 |
| n-Tetradecane | 1.4537 | 3.0523 | 3.0658 |
| n-Hexadecane | 0.3169 | 0.7690 | 0.7602 |
| Total Analytes* | 35.7868 | 24.0634 | 23.8289 |

* percent of total test substance analyzed. Total analytes = sum of the 28 individual hydrocarbons; remainder is other unidentifed hydrocarbons.
ND - None Detected

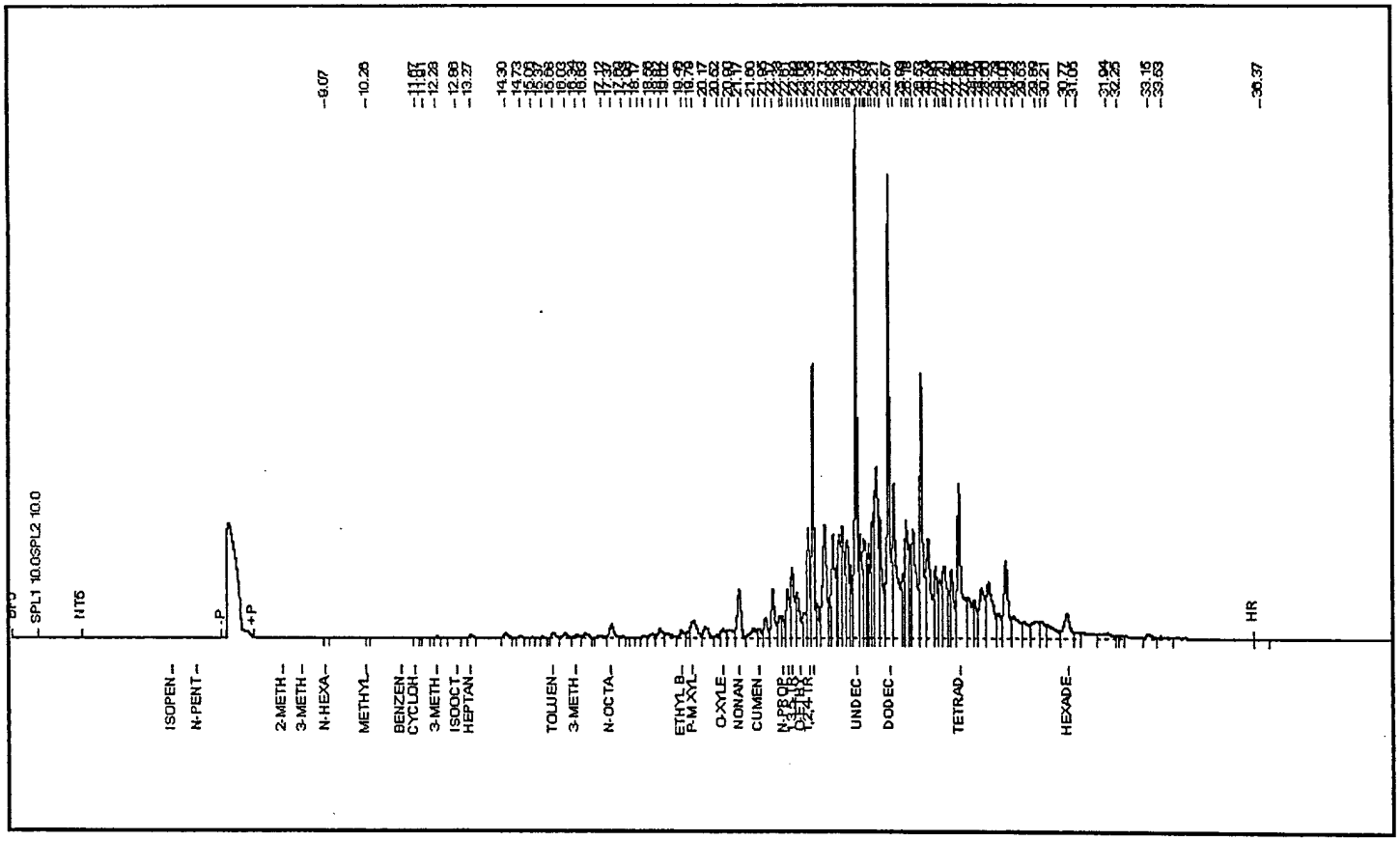
## FIGURE 1A - CHROMATOGRAM FOR NEAT SUBSTANCE
## JP - 4



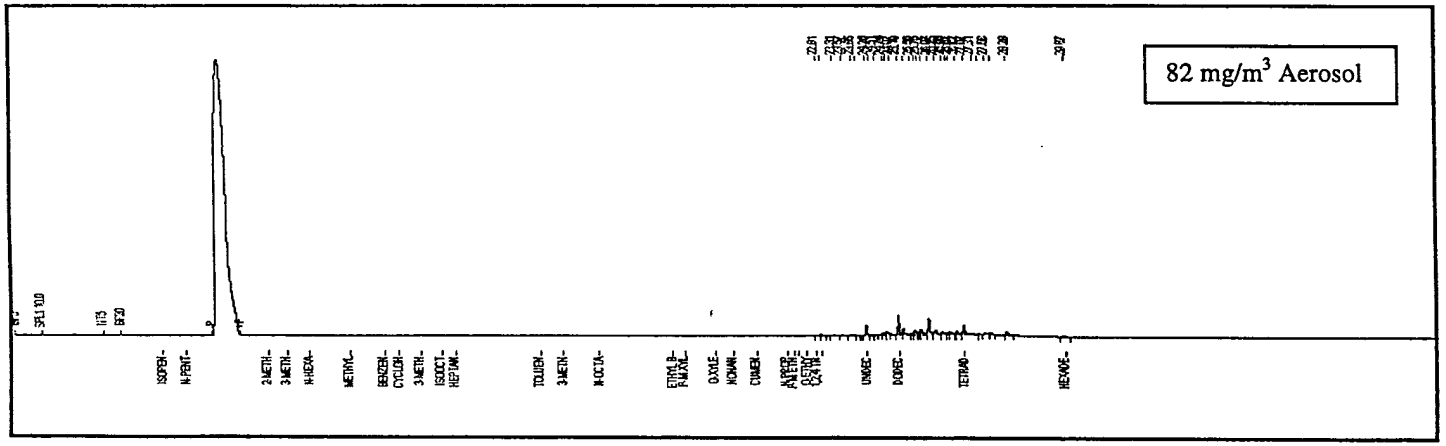
## FIGURE 2A CHROMATOGRAM FOR NEAT SUBSTANCE
## JP - 8

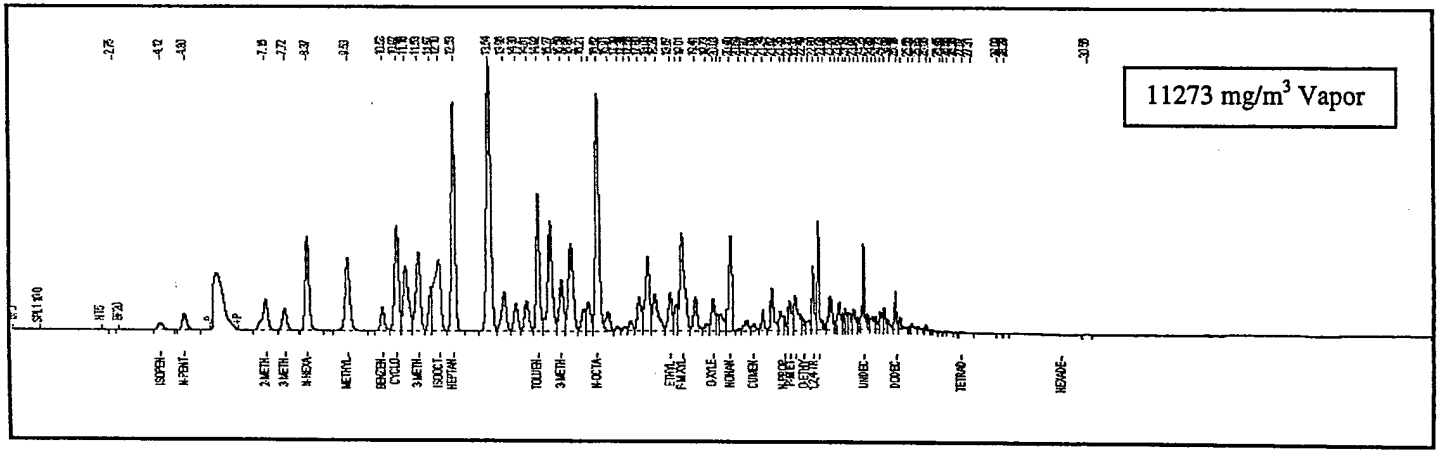


## FIGURE 3A - CHROMATOGRAM FOR NEAT SUBSTANCE
## JP - 8 + 100

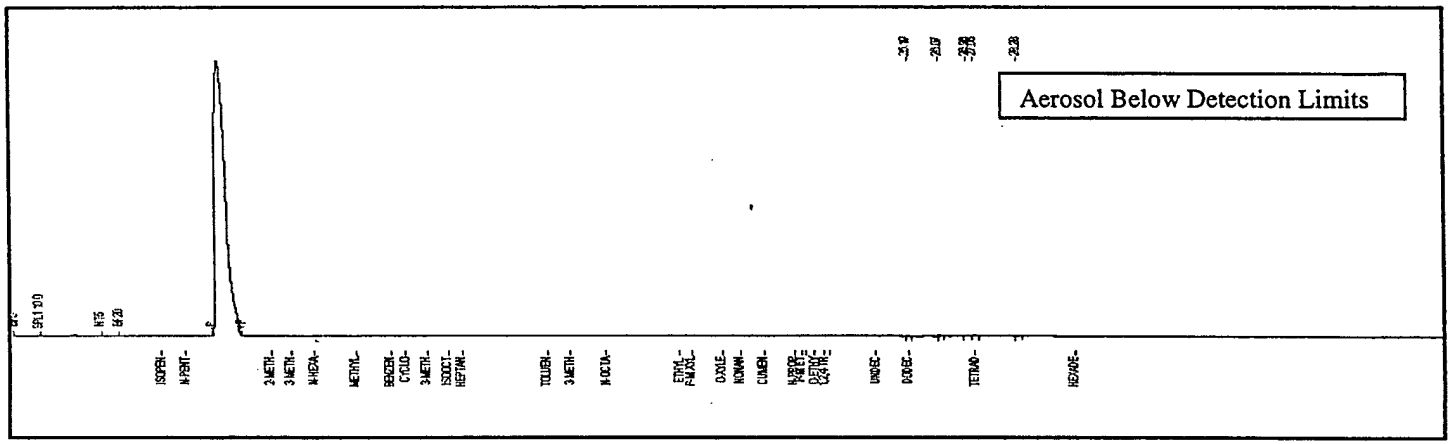


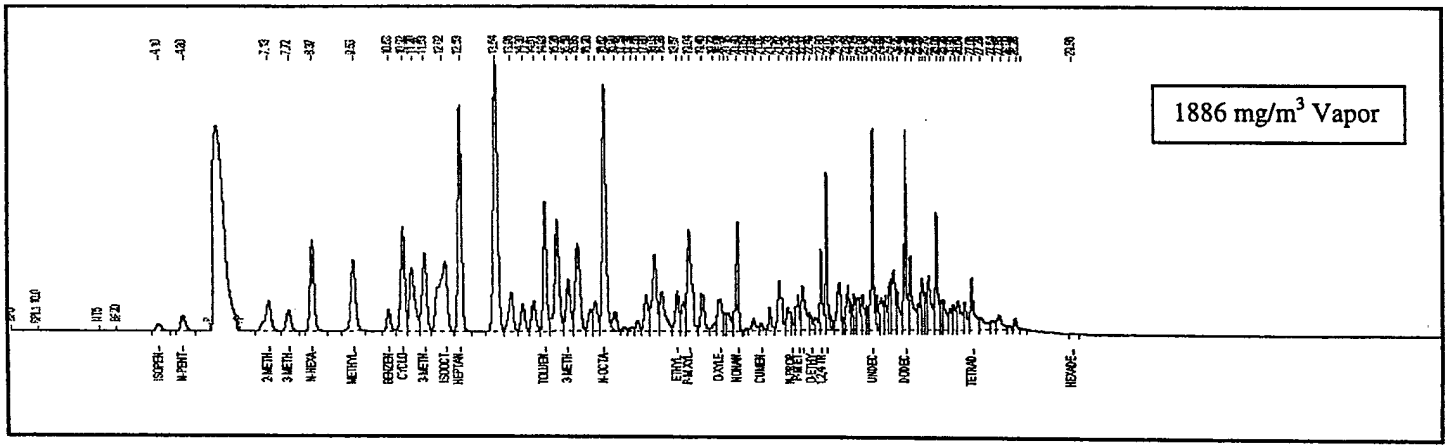
## FIGURE 4A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
**JP - 4 (Mean Concentration 11430 mg/m$^3$)**



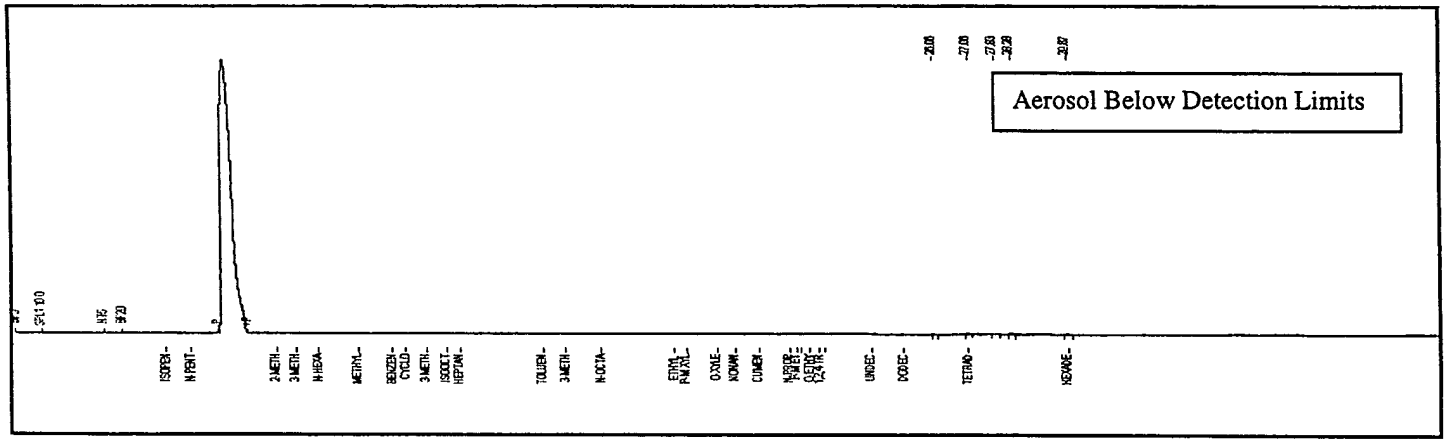



## FIGURE 5A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
## JP - 4 (Mean Concentration 1888 mg/m$^3$)



## FIGURE 6A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
## JP - 4 (Mean Concentration 956 mg/m$^3$)



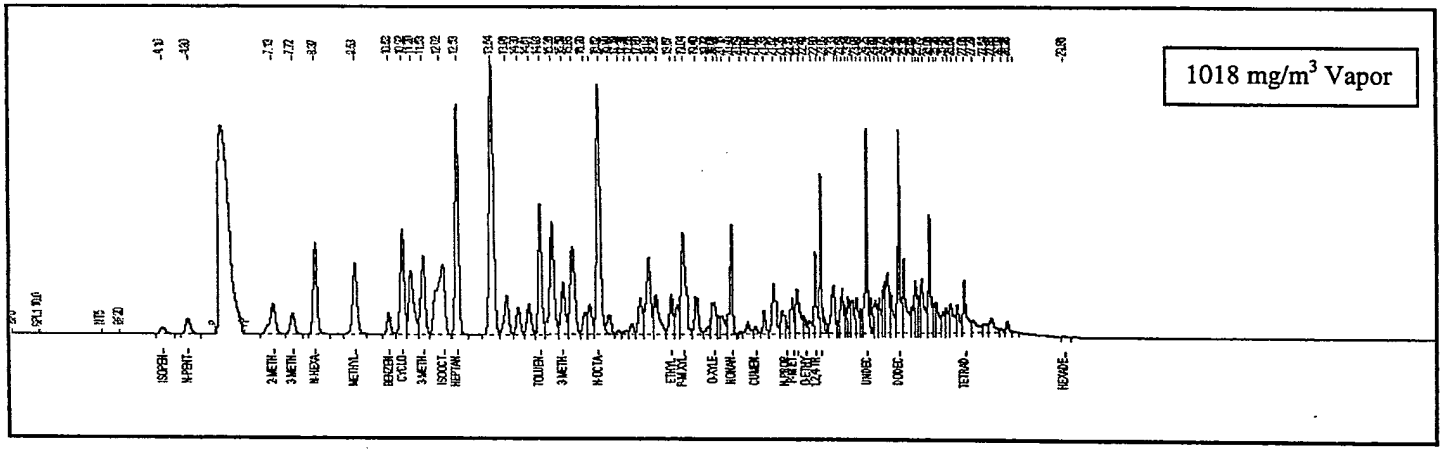
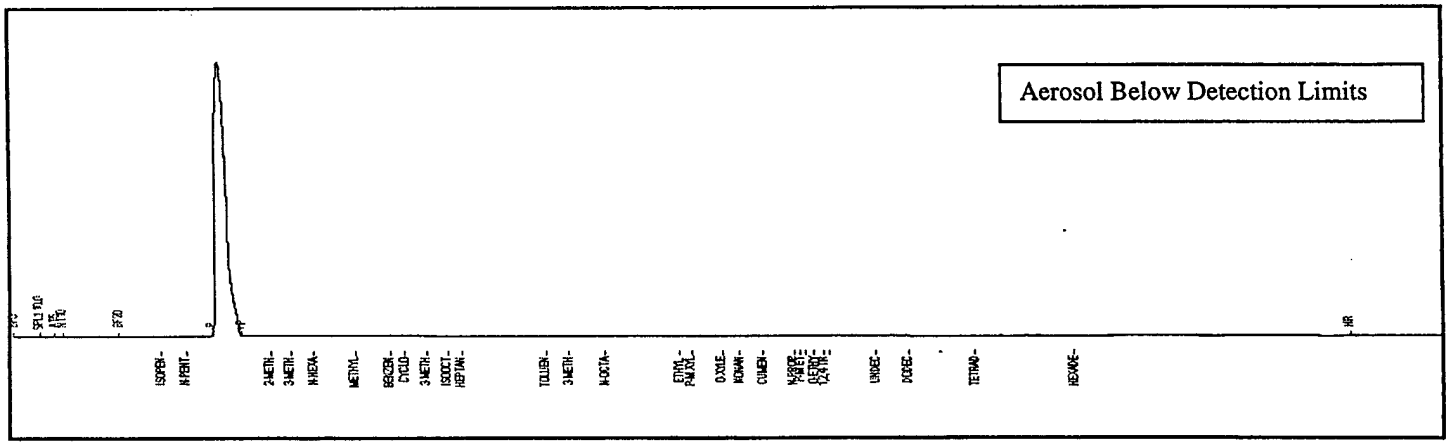
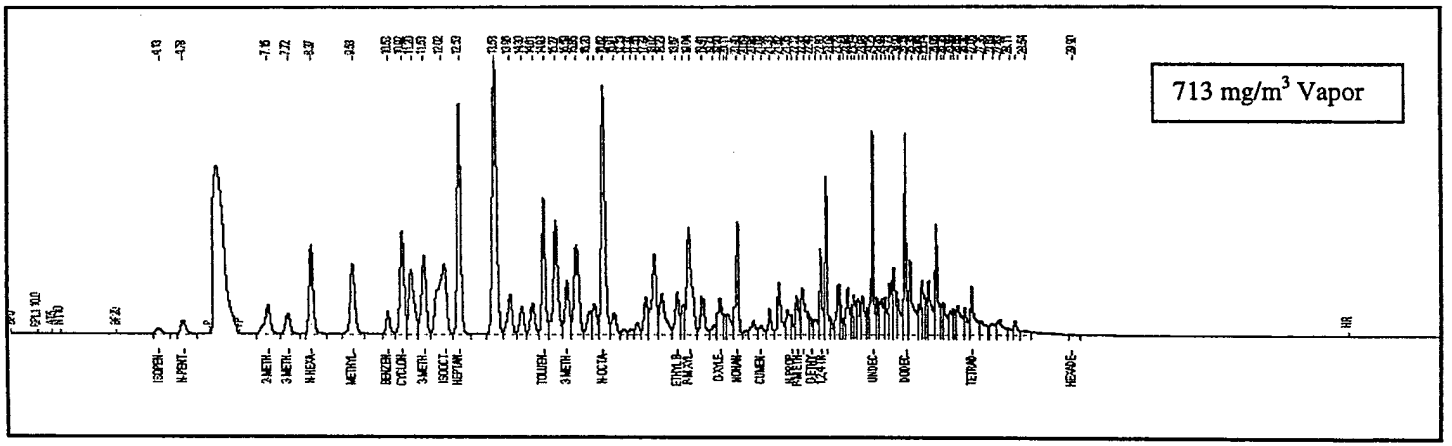
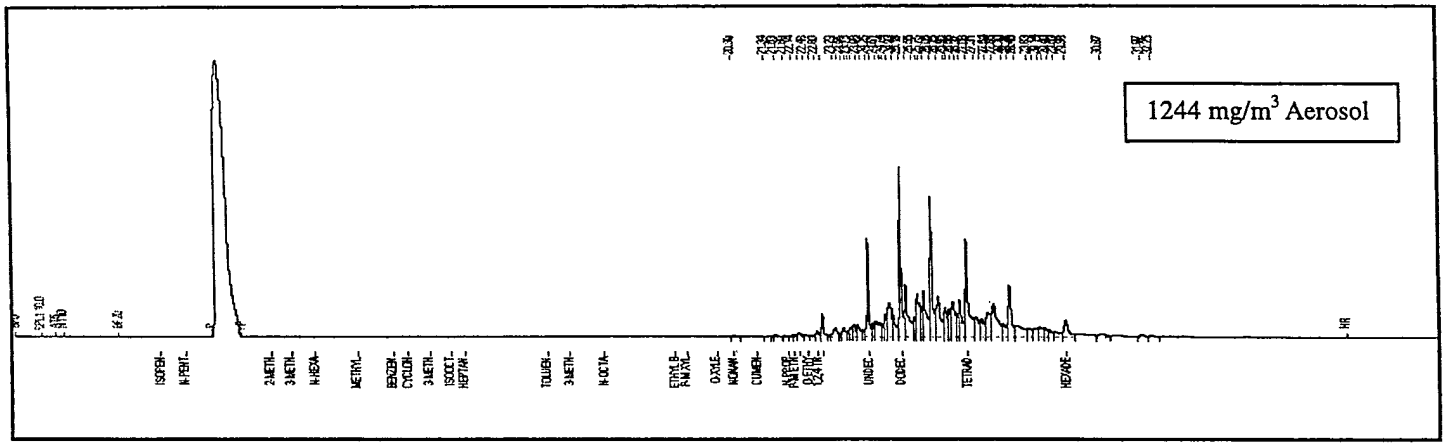



**FIGURE 7A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES**
**JP - 4 (Mean Concentration 685 mg/m$^3$)**



## FIGURE 8A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
### JP - 8 (Mean Concentration 3565 mg/m$^3$)



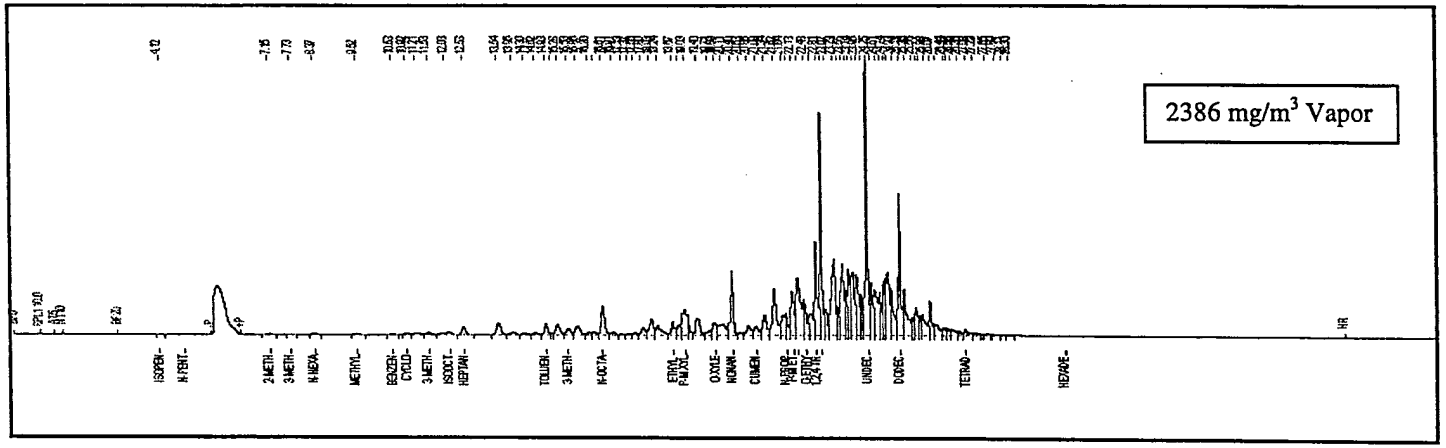
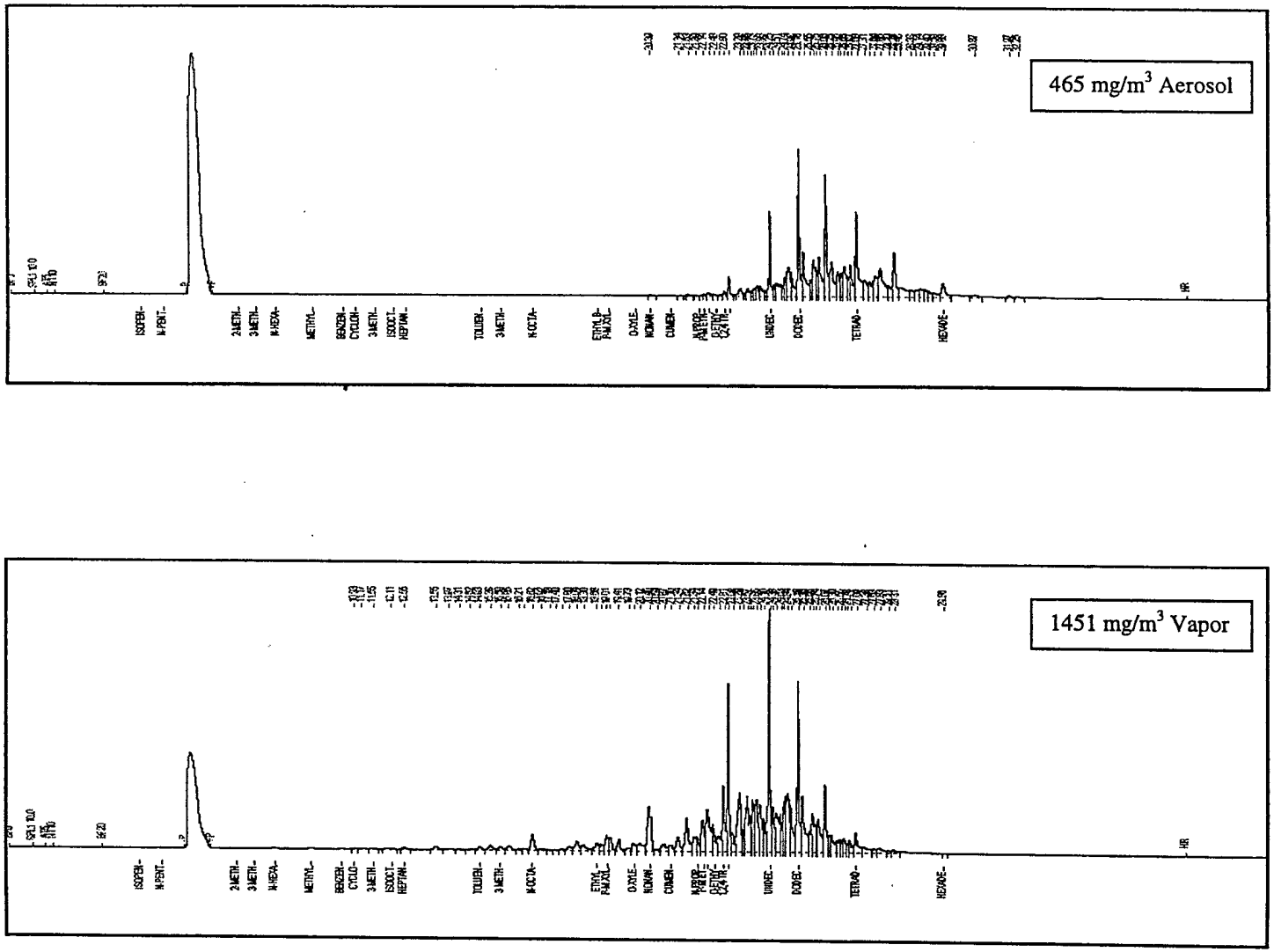
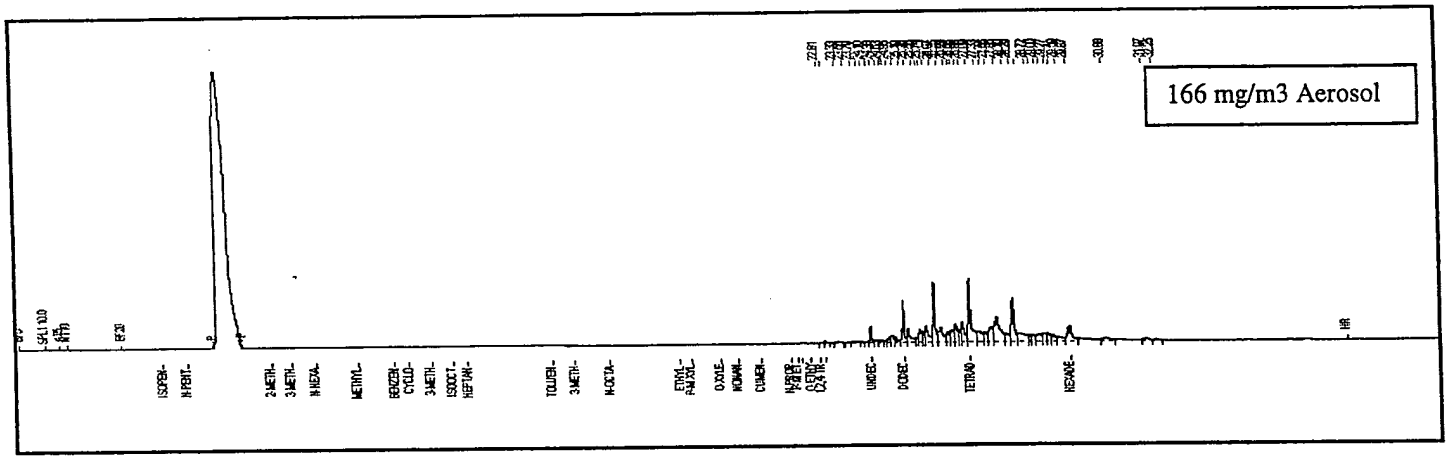
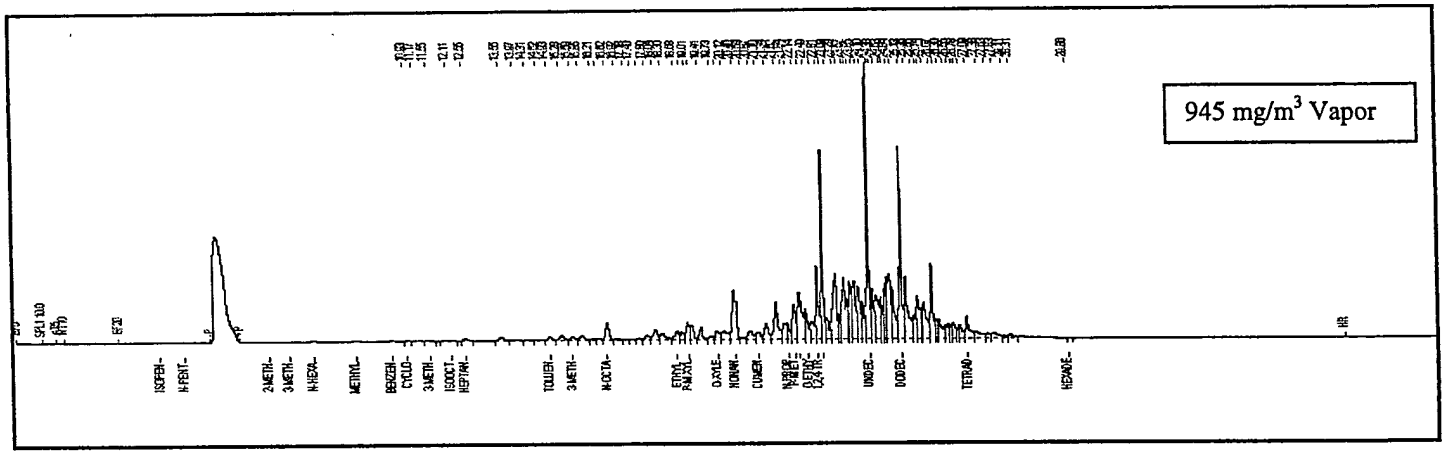



**FIGURE 9A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES**
**JP - 8 (Mean Concentration 1837 mg/m$^3$)**

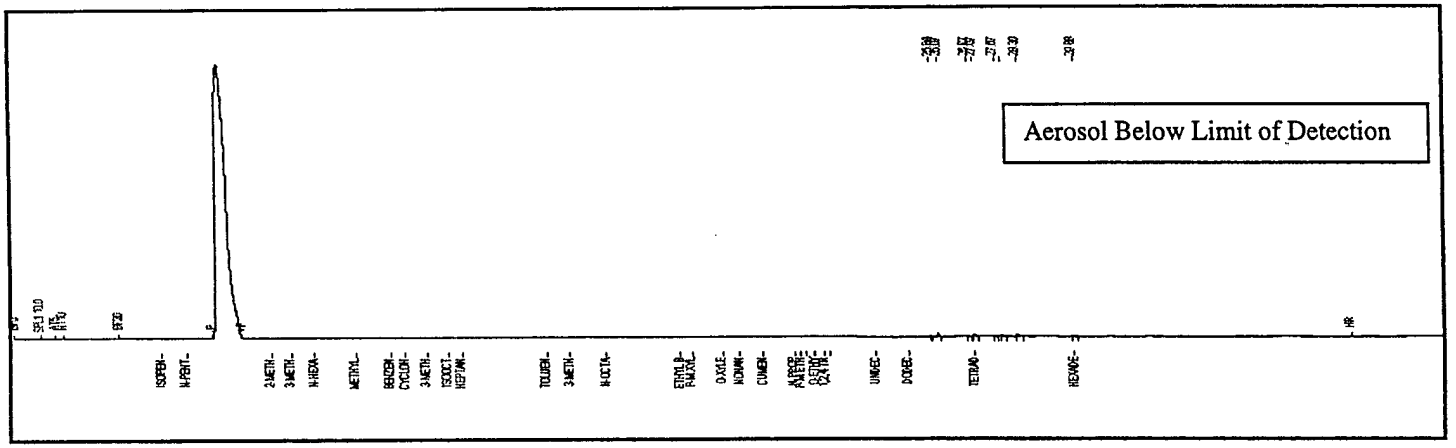


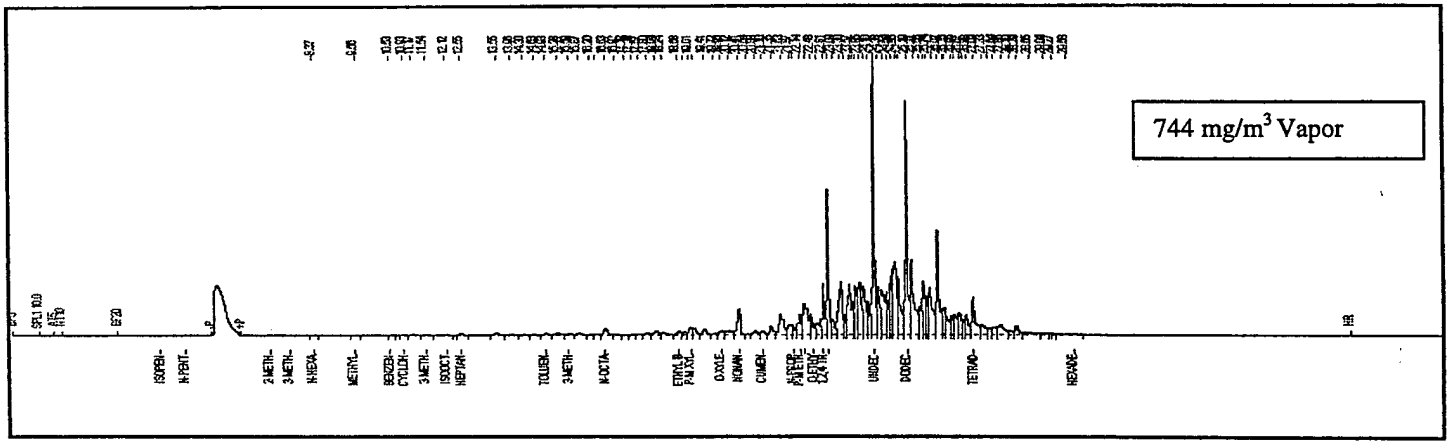
## FIGURE 10A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
### JP - 8 (Mean Concentration 1090 mg/m$^3$)



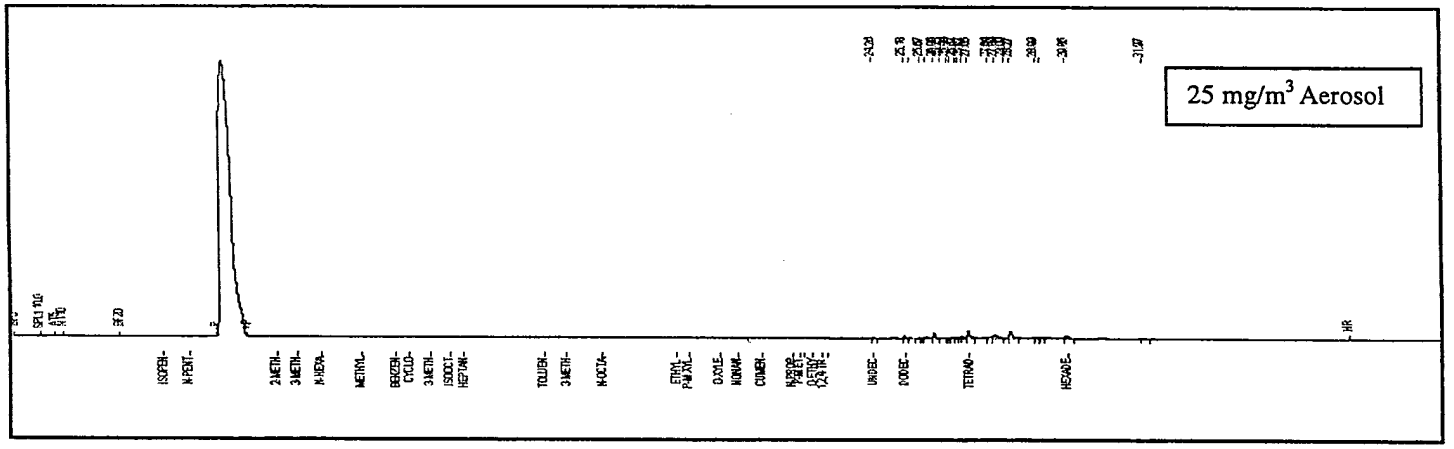



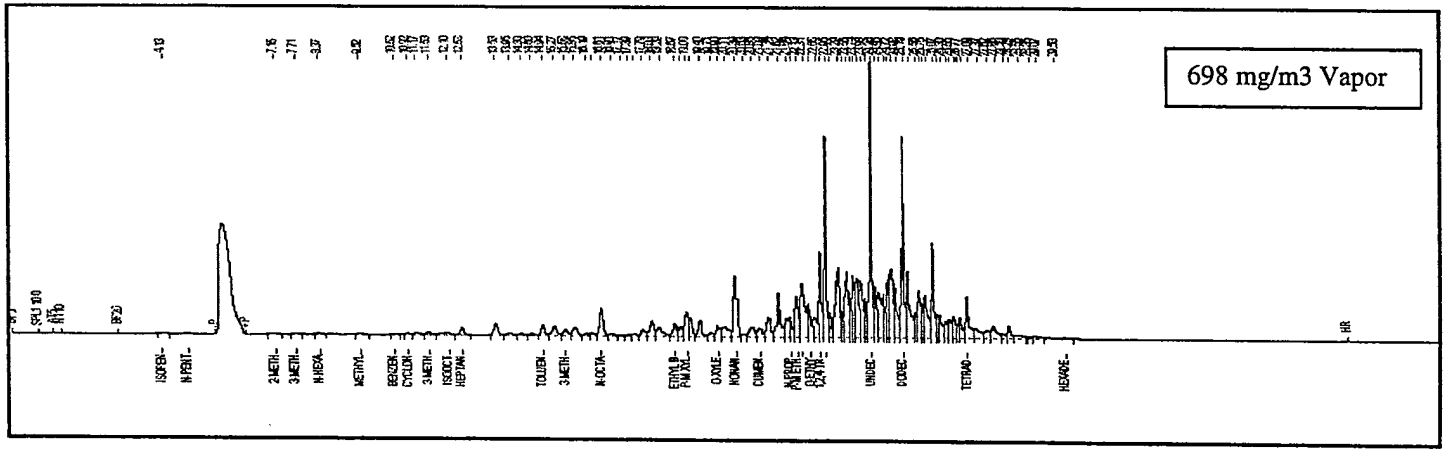
## FIGURE 11A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
## JP - 8 (Mean Concentration 681 mg/m$^3$)



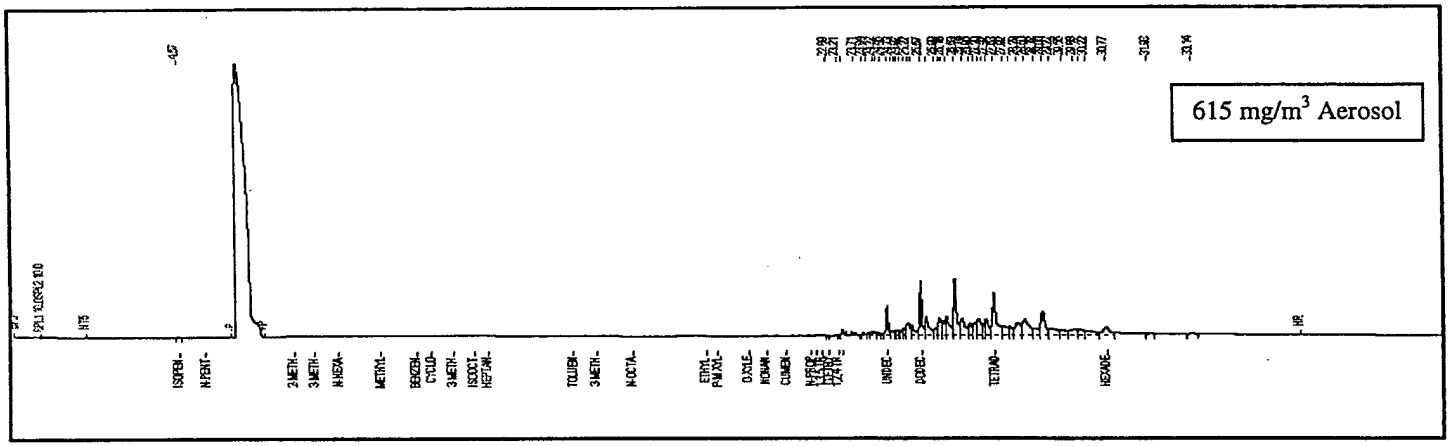



## FIGURE 12A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
### JP - 8 (Mean Concentration 681 mg/m$^3$)



## FIGURE 13A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
**JP - 8 + 100 (Mean Concentration 2356 mg/m$^3$)**



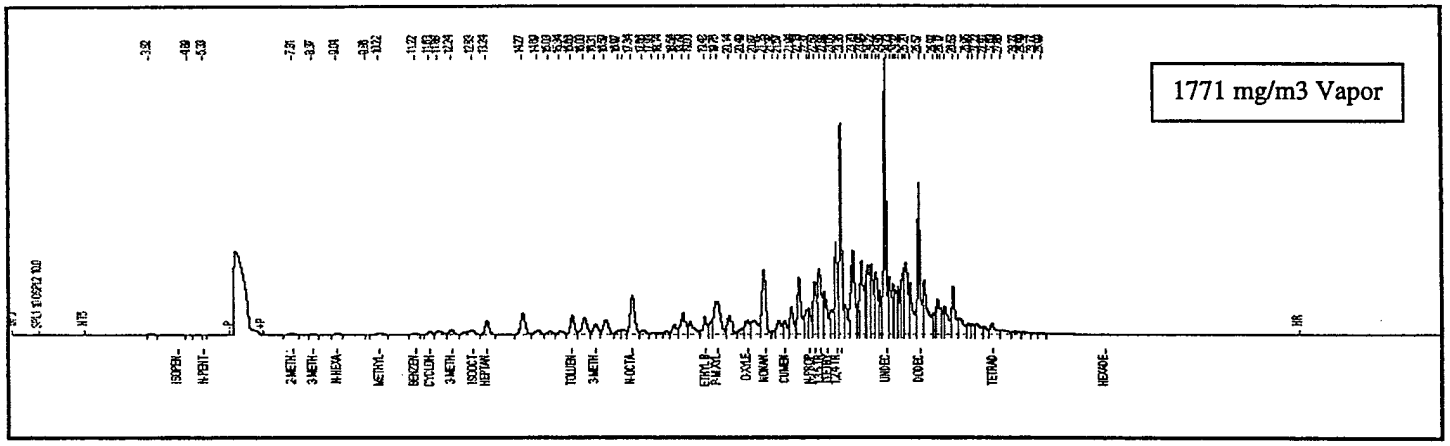
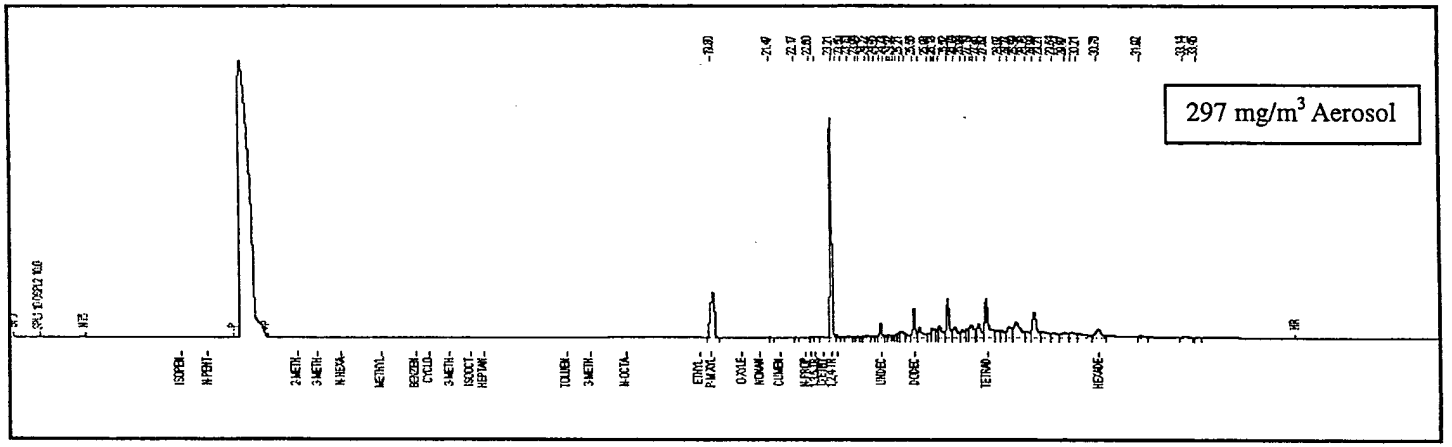
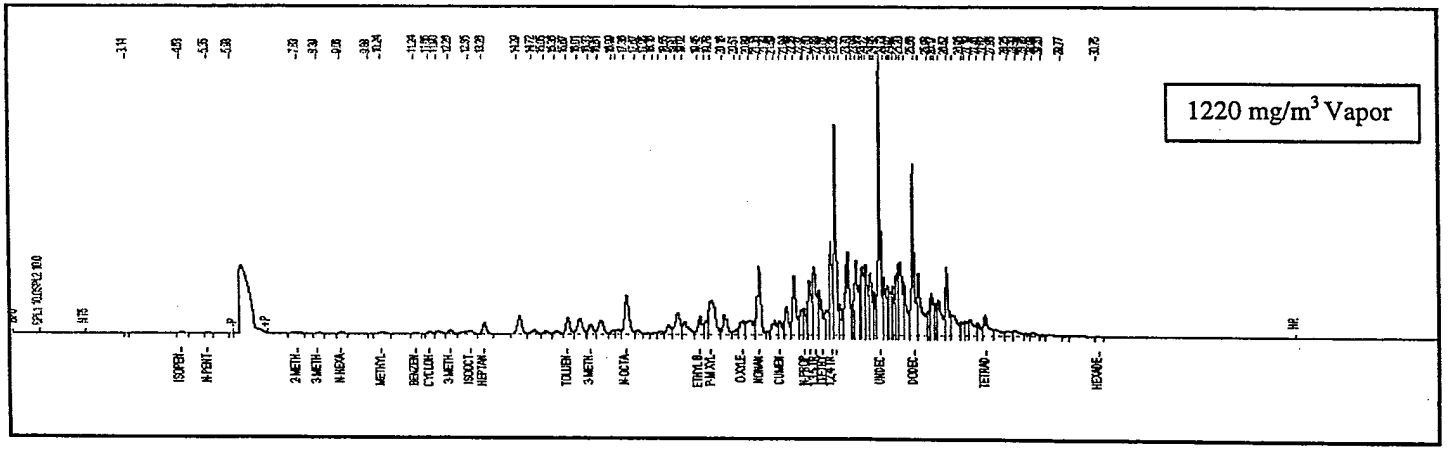
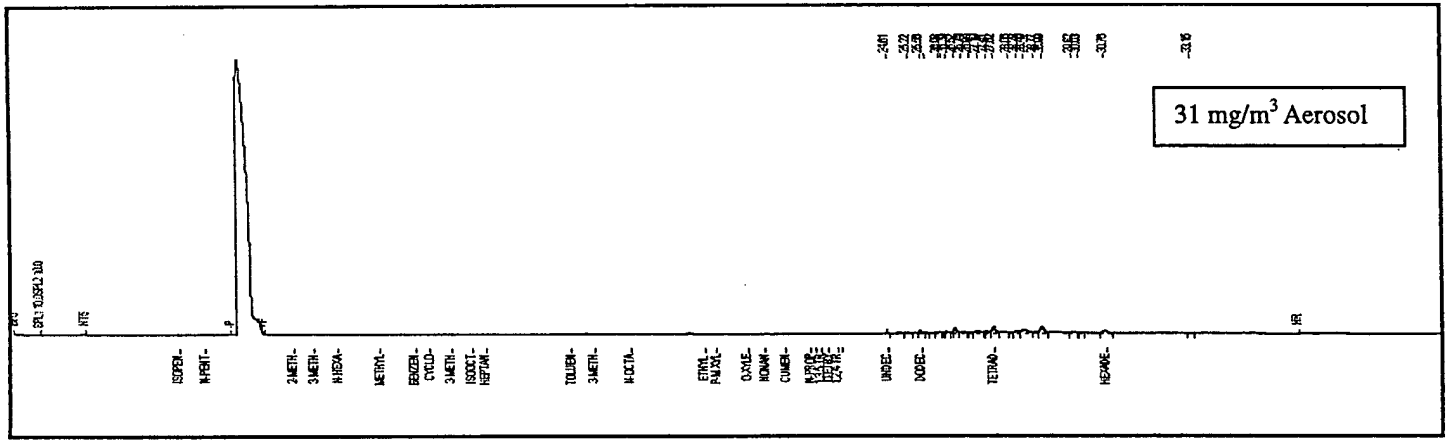



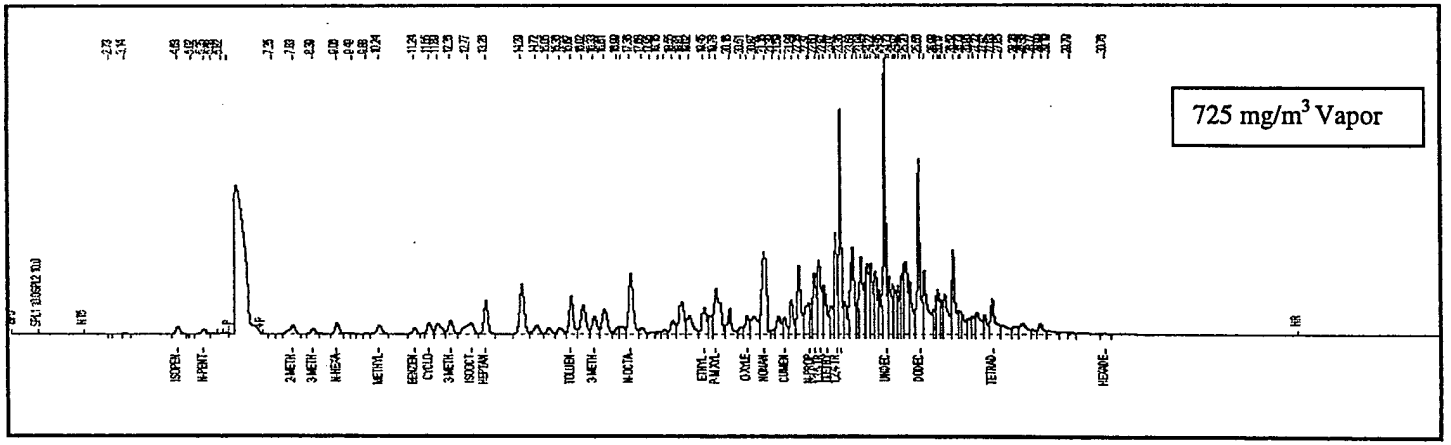
**FIGURE 14A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES**
**JP - 8 + 100 (Mean Concentration 1519 mg/m$^3$)**



## FIGURE 15A - COMPARISON OF CHROMATOGRAMS FOR SELECTED INDIVIDUAL AEROSOL AND VAPOR SAMPLES
## JP - 8 + 100 (Mean Concentration 777 mg/m$^3$)



## APPENDIX B: TABLE 1B - SUMMARY OF ANALYTICAL DATA (ADDITIONAL EXPOSURES REPEATED DUE TO MISSING OR INCONSISTENT DATA)

| Test Substance | JP 4 (MRD-00-629) | | | JP 8 (MRD-00-630) | | |
|---|---|---|---|---|---|---|
| Sample #: | 1 | 2 | 3 | 1 | 2 | 3 |
| Non-Volatile Aerosol (Filter), $mg/m^3$ | 0 | 0 | 0 | 1711 | 1611 | 1286 |
| Volatile Hydrocarbons (Sorbent tube), $mg/m^3$ | 257 | 0 | 949 | [1] | [1] | 2331 |
| Total Analytical Concentration, $mg/m^3$ | 257 | 0 | 949 | 1711 | 1611 | 3617 |
| **Mean Analytical Concentration, $mg/m^3$** | $402 \pm 491$ | | | $2313 \pm 1130$ | | |
| **Nominal Concentration, $mg/m^3$** | 1111 | | | 7222 | | |

[1] - No Sample Taken

## TABLE 2B - SUMMARY OF ANIMAL RESPONSE DATA
## (ADDITIONAL EXPOSURES REPEATED DUE TO MISSING OR INCONSISTENT DATA)

| EXPOSURE CONCENTRATION | | ANIMAL NUMBER | BODY WEIGHT (g) | EXPOSURE RESPONSE (%) | RECOVERY RESPONSE (%) | IRRITATION TYPE/ SEVERITY* | GROSS OBSERVATIONS (pretest) | (inchamber) | (postdose) |
|---|---|---|---|---|---|---|---|---|---|
| 402 mg/m$^3$ | JP - 4 | IAY956 | 28 | -19 | 99 | SENSORY/SLIGHT | NOA | NOA | NOA |
| | | IAY957 | 29 | -21 | 102 | SENSORY/MODERATE | NOA | NOA | NOA |
| | | IAY962 | 29 | -24 | 88 | SENSORY/MODERATE | NOA | NOA | NOA |
| | | IAY965 | 29 | -28 | 86 | SENSORY/MODERATE | NOA | NOA | NOA |
| | | **MEAN** | **29** | **-23** | **94** | | | | |
| | | **S.D.** | **0.5** | **3.9** | **7.9** | | | | |
| 2313 mg/m$^3$ | JP - 8 | IAY991 | 30 | -76 | 33 | SENSORY/EXTREME | NOA | NOA | NOA |
| | | IAY988 | 28 | -51 | 71 | SENSORY/EXTREME | NOA | NOA | NOA |
| | | IAY992 | 30 | -64 | 80 | SENSORY/EXTREME | NOA | NOA | NOA |
| | | IAY993 | 28 | -57 | 70 | SENSORY/EXTREME | NOA | NOA | NOA |
| | | **MEAN** | **29** | **-62** | **64** | | | | |
| | | **S.D.** | **1.2** | **10.7** | **20.8** | | | | |

**NOA - NO OBSERVABLE ABNORMALITIES**

*** Severity categorized as: slight = 12-19%; moderate = 20-49%; extreme = ≥ 50%.**

## FIGURE 1B - INDIVIDUAL RESPIRATORY RATES
## (ADDITIONAL EXPOSURES REPEATED DUE TO MISSING OR INCONSISTENT DATA)