ANALYTICAL CHARACTERIZATION OF JET PROPELLANT 8 (JP-8) USING GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS)

by

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(Under the Direction of Jeff Fisher)

ABSTRACT

Jet propellant 8 (JP-8) is a kerosene-based fuel containing several hundred hydrocarbons and used in a variety of military vehicles, including aircraft. Studies have shown that the fuel exerts toxic effects on the respiratory, immune, and nervous systems. However, the chemical complexity of the fuel makes it difficult to analyze and determine the primary components responsible for the adverse effects. The objective of this study was to develop an analytical method, with accuracy and precision of 20% or better, for JP-8 aerosol and vapor samples using gas chromatography/mass spectrometry (GC/MS) and to apply this method to aerosol and vapor samples collected from a nose-only (mouse) exposure chamber at the University of Arizona. The validation was carried out using both neat JP-8 in chloroform and a thirty-four component surrogate hydrocarbon mixture (SHM), which was conducted to identify and quantify major constituents of the fuel. Funded by AFOSR [grant no F49620-03-1-0157].

INDEX WORDS: JP-8, Gas Chromatography/Mass Spectrometry, Jet Fuel, Aerosols, Vapors

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DEDICATION

This is dedicated to all of my family and friends, whose love, support, and encouragement have given me the strength and determination to achieve my goals. I also dedicate this work to my Lord and Savior, Jesus Christ, who makes all things possible.

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

REVIEW OF THE ANALYSIS OF PETROLEUM FUELS

Background of JP-8

JP-8 is a kerosene-based jet fuel used in a variety of military vehicles, in addition to jet engine aircraft. It is a complex mixture containing over four hundred hydrocarbons. Its composition is approximately 18% aromatic hydrocarbons, while the remaining components are aliphatic alkanes and their isomers (9% C_8-C_9, 65% C_{10}-C_{14} and 7% C_{15}-C_{17}) having an average molecular weight of 180 Daltons (Committee on Toxicology 1996, Zeiger and Smith 1998). It is composed primarily of four classes of compounds: n-alkanes and isoalkanes, olefins, naphthenes, and aromatics (Committee on Toxicology 2003, Mattie et al. 1991, ATSDR 1998). JP-8 is very similar to commercial jet fuel, Jet-A, in its hydrocarbon make-up, but small amounts of diethylene glycol monomethyl ether (DiEGME), a deicing agent; Statis 450, an anti-static material; and DCI-4A, a corrosion inhibitor, have been added to create JP-8 (Committee on Toxicology 1996, Zeiger and Smith 1998). JP-8 replaces an earlier jet fuel called JP-4, which contained a larger percentage of smaller hydrocarbon molecules and was therefore more volatile (Mattie et al. 1991). The wholesale change to JP-8 by the military in NATO countries was triggered by safety, survivability, and logistical concerns. The physical and chemical properties of JP-8 enhanced aircraft survivability and safety and promoted standardization of fuel for the military and commercial sectors in NATO countries.

Brief Toxicology of JP-8

The National Occupational Exposure Survey by NIOSH estimated that over 1 million employees were exposed to kerosene, the primary component of JP-8. JP-8 has been found at 22 EPA National Priority sites (ATSDR 1998). Exposure of laboratory animals to JP-8 has been associated with toxic responses in the lung and respiratory tract, nervous system, and immune system (Harris et al. 2000, 1997a, 1997b, 1997c; Drake at al. 2003; Robledo et al. 2000; Pfaff et al. 1996, 1995; Ritchie et al. 2001; Rossi et al. 2001). Inhalation studies conducted with rodents revealed that JP-8 caused increased pulmonary resistance, increased lung permeability, edema, endothelial damage, thickening of alveolar septa and macrophages, and damage to bronchiolar epithelium, induction of markers of apoptotic cell death, and alterations in protein expression (Hays et al. 1995; Robledo et al. 2000; Pfaff et al. 1995; Robledo and Witten 1998; Stoica et al. 2001; Witzmann et al. 1999; Drake et al. 2003). In humans, neurological studies have found that exposure to jet fuel is associated with headache, dizziness, nausea, vomiting, incoordination, fatigue, attention and memory problems, and irritability (Knave et al. 1978, Struwe et al. 1983; Smith et al. 1997). In rats, JP-8 exposure causes a decreased response to a variety of lever-pressing tests and alters concentrations of various neurotransmitters and their metabolites in the brain (Ritchie et al. 2001 and Rossi et al. 2001). Exposure to JP-8 also affects the immune system causing decreased spleen weight, decreased cellularity of the thymus, decreased numbers of splenic T cells, B cells, and macrophages, decreased function of natural killer cells, decreased numbers of precursor cytotoxic T lymphocyte and proliferating T lymphocyte cells, and suppressed production of lymphokine activated killer cells in mice (Harris et al. 2000, 1997a, 1997b, and 1997c). The administration of substance P prevented the loss of spleen and thymus cellularity (Harris et al. 1997c). Dermal application of JP-8 increases the production of the pro-

inflammatory cytokines, tumor necrosis factor α, interleukin-8, interleukin-10, and interleukin-1α (Ullrich and Lyons 2000 and Allen et al. 2000).

Analytical Studies

Numerous analytical studies have been conducted with JP-8, gasoline, and major components of each (Bernabei et al. 2000, 2003; Link et al. 2003; Cheng et al. 2001; Johnson and Synovec 2002; Liu and Pleil 2001; Kostecka et al. 1995; Kokosa and Przyjazny 2003; Zwank et al. 2002; Xie and Barcelona 2003; Rodgers et al. 2000; Ritchie et al. 2001; Rossi et al. 2001; Mattie et al. 1991; Egeghy et al. 2003; McDougal and Robinson 2002; McDougal et al. 2000; Rogers et al. 2004; Zahlsen et al. 1990, 1992; Serdar et al. 2003; Smith et al. 1997; Knave et al. 1978; Egeghy et al. 2000, 2002, 2003; Pleil and Lindstrom 1995; Pleil et al. 2000; Holm et al. 1987; Tu et al. 2004; Risby and Sehnert 1999; Whitman and Hinz 2001). Gas chromatography/mass spectrometry is the most common analytical technique used in the analysis of volatile hydrocarbon mixtures and their primary components. Gas chromatography is an analytical technique that was first pioneered in the 1950s by Archer John Porter Martin. Martin, an English biochemist, specialized in the development of chromatography and other analytical methods. In 1952, he was awarded the Nobel Prize in Chemistry along with Richard L. M. Synge for the development of paper partition chromatography (thin layer chromatography), a method for separating and identifying chemical substances in a mixture. Along with collaborator A. T. James, Martin developed a method for gas-liquid chromatography (Noble Prize website, encyclopedia website).

The system developed by James and Martin included a packed column that contained a stationary liquid phase distributed over the surface of an inert solid. The column is maintained at the appropriate temperature by a vapor jacket. The substances of interests are applied to the top

of the packing and blown through the column using an inert gas, which in the 1950s was nitrogen (N_2). Substances separate based on their volatility and interaction with the solid phase of the column at a given temperature. Substances are then detected and identified using appropriate methods. Archer's schematic of the system showed the sample in a boiler indicating that heating of the sample was required for separation (James and Martin 1952, 1954). Today, columns are kept in an oven to ensure thorough heating of the sample, and oven temperature programs are developed to enhance separation. Presently, we also enjoy the luxuries of autosamplers and a larger variety of detection methods.

Gas chromatography/mass spectrometry is the combination of two valuable analytical techniques. Gas chromatography separates different components of a mixture in time and then sends these components to the mass spectrometer (Kitson et al. 1996). The mass spectrometer then bombards the sample with a beam of electrons, ionizing and fragmenting the sample. Our GC/MS instrument uses a quadrupole mass filter. These filters are made up of four rods that ions must pass between to reach the detector. Ions are drawn out of the ion source using a low voltage potential and enter the quadrupole along the *z*-axis. The ions entering the quadrupole are sorted using a combination of applied radio frequencies and direct current voltages. Altering the voltages in a fixed manner allows for ions of a very narrow mass range to reach the detector, while other ions are deflected by the rods (Kitson et al. 1996).

Researchers have used a variety of analytical techniques to examine neat JP-8 as well as determine the presence and concentration of JP-8 in air, breath, urine, blood, and skin samples. One study conducted with aviation fuels to determine the total and polycyclic aromatic hydrocarbon composition using GC/MS operated in selected ion monitoring mode revealed that a variety of substituted benzenes, naphthalenes, substituted naphthalenes, and xylenes were present

in various fuels (Bernabei et al. 2000). Another study was performed to determine the concentration of phenolic antioxidants utilized HPLC-ED as the instrument of choice for analysis (Bernabei et al. 2003). JP-8 fuel has been analyzed using GC-AED and GC-MS following chemical oxidation and separation by HPLC to characterize the sulfur content of the fuel (Link et al. 2003). Researchers found that JP-8 sulfur content is comprised mainly of thiols, sulfides, disulfides, and benzothiophenes. A study conducted involving the chemical composition of aerosols emitted from kerosene heaters burning various jet fuels revealed that out of three jet fuels—1-K kerosene, commercial air jet fuel Jet A, and JP-8—JP-8 had the lowest sulfur content (Cheng et al. 2001). A study conducted with JP-8, JP-5, and JP-TS utilized GC x GC analysis and ANOVA statistical analysis to develop a pattern of recognition for fuels. Researchers found this method to be a useful tool for increasing the classification power of two-dimensional comprehensive gas chromatography (Johnson and Synovec 2002). Further studies have been undertaken to determine trace amounts of volatile organic compounds from jet fuel present in human blood using GC/MS in full scan mode (Liu and Pleil 2001). Studies have been conducted with gasoline to determine its aromatic composition using GC/MS operated in full scan mode (Kostecka et al. 1995). Another study utilized headspace microdrop analysis, GC/FID, and GC/MS to determine the concentration of benzene, toluene, ethylbenzene, and the xylenes present in dilute samples of gasoline (Kokosa and Przyjazny 2003). Direct acqueous injection GC/MS has also been employed to analyze water samples for the presence of trace gasoline components such as methyl *tert*-butyl ether (MTBE), benzene, toluene, ethylbenzene, and the xylenes (Zwank et al. 2002). Studies have also been conducted to examine JP-4 and JP-8 in the environment. A study conducted in 2003 examined the degradation of JP-4 in the environment with and without the presence of chemical oxidizers (Xie and Barcelona 2003), while a 2000

study examined the effects of weathering on JP-8 (Rodgers et al. 2000). Further work has been carried out with neat JP-8 using GC and GC/FID to verify the purity, composition, and chemical constituency of the fuel (Ritchie et al. 2001, Rossi et al. 2001, Mattie et al. 1991). Samples of neat fuel collected from aircraft during removal of fuel prior to maintenance (aged fuel) or from fuel trucks prior to aircraft fuelling have also been analyzed using GC/MS operated in selected ion monitoring mode to determine concentrations of benzene and naphthalene (Egeghy et al. 2003).

For dermal studies, GC/MS was utilized to determine concentrations in exposure solutions as well as skin samples (McDougal and Robinson 2002, McDougal et al. 2000, Rogers et al. 2004, Zahlsen et al. 1990 and 1992, Serdar et al. 2003). GC/MS was used to identify and quantify components of interest found in receptor solution and in skin biopsy punches (McDougal and Robinson 2002, McDougal et al. 2000). Some compounds of interest in these experiments include nonane, decane, undecane, dodecane, tridecane, tetradecane, diethylene glycol monomethyl ether, methyl naphthalenes, trimethyl benzene, naphthalene, dimethyl benzene (xylene), dimethyl naphthalenes, and methyl benzene (toluene). Headspace GC/MS was used to determine concentrations of m-xylene and 1-methylnaphthalene in keratinocytes (Rogers et al. 2004). Kinetic studies performed by Zahlsen et al. (1990, 1992) used GC to determine the concentration of hydrocarbons in biological materials. Concentrations of benzene and naphthalene were measured in urine samples using headspace solid phase microextraction GC/MS (Serdar et al. 2003), a technique that involved concentrating the analyte onto a polydimethylsiloxane fiber. The fiber was then placed in a port on the GC where it was desorbed and the analyte passed into the GC for analysis.

An extensive effort to quantify concentrations of JP-8 components in air and breath samples has been undertaken. Investigators utilized a variety of sampling equipment, adsorbents, and analytical equipment to better understand exposure concentrations. One study used industrial hygiene monitoring in an effort to determine exposure concentrations (Smith et al. 1997). Air samples were collected on charcoal tubes according to NIOSH guidelines, and analysis was carried out using GC/FID. Epidemiological studies were undertaken to determine exposure concentrations of Swedish military workers. Workers were outfitted with air samplers, with the sampling port positioned in front of their nose. The sampler contained a Teflon sampling tube with an internal diameter of 4 mm and a length of 7 m. The air flow of the tube during sampling was 2 L/min. The concentrations of the fuel vapors were measured using a flame ionization detector, and concentrations were expressed as a time weighted average (Knave et al. 1978). Other human studies were conducted to measure exposure concentrations of benzene and naphthalene (Egeghy et al. 2003, Serdar et al. 2003). In these studies, personal exposure was monitored using passive monitors made up of aluminum tubes (90 mm x 63 mm od x 50 mm id). Each tube contains 0.1 g of the adsorbent 20/35 mesh Tenax TA held in place by stainless steel screens used to create an open diffusion channel of 1.5 cm x 50 mm id. An additional screen is placed 1 mm from the surface to serve as a turbulence barrier to maintain the concentration gradient necessary for constant diffusion uptake. One of the end caps is removed from the monitor in order to collect a sample (Egeghy et al. 2000 and 2002). Breath samples were also obtained from workers using 75 mL glass bulbs (Serdar et al. 2003, Egeghy et al. 2003). The bulb has two caps on each end. To collect a sample, the subject removes both end caps, blows into the jar, and caps the free end while the bulb is still in the mouth. The remaining cap is quickly replaced upon removal of the device from the mouth. The volume of the bulb is

small compared to the volume of exhaled breath, so only end-exhaled air is collected (Egeghy et al 2000 and 2002). The sorbent tubes are thermally desorbed and analyzed using a GC equipped with a photoionization detector (Egeghy et al. 2003) while other samples are analyzed using GC/MS (Serdar et al. 2003). Another laboratory group has examined exposure concentrations of Air Force personnel (Pleil and Lindstrom 1995, Pleil et al. 2000). Personal samples were collected using portable, battery-operated whole-air sampler units that use mass flow control to collect a constant flow of air into an evacuated sampling container (Pleil et al. 2000), while breath samples were collected in evacuated stainless steel canisters with volumes of either 1 L or 1.8 L (Pleil and Lindstrom 1995, Pleil et al. 2000). The breath sampling apparatus consists of an evacuated 1 L canister fitted with a small Teflon tube used as a mouthpiece. As the subject exhales, the canister valve is opened and the breath is collected in the evacuated space. The sample is then pressurized with neutral gas prior to analysis, and analysis is carried out using an ion-trap GC/MS system operated in full scan mode with cryogenic pre-concentration (Pleil and Lindstrom 1995, Pleil et al. 2000). Another study examined the effect of exposure to MC-77 (Swedish military version of JP-4, the predecessor to JP-8) vapors under different work conditions. Exposure samples were collected using personal monitors containing activated charcoal as the adsorbent. Monitors sample the air at a rate of 20 mL/min for half-day (4 hour) samples and 200 mL/min for short-time (15 minute) samples. Tubes were kept at -20^{o}C until the day of analysis. Extraction was done using 4 mL of carbon disulfide, and analysis was performed using a GC/FID (Holm et al. 1987). Another study examined human exposure of military personnel using yet another adsorbent (Tu et al. 2004, Risby and Sehnert 1999). Samples of mixed expired breath were collected on carbonaceous adsorbents using a glass thermal desorption tube packed with equal amounts of a graphitized carbon (Carbopack X) and a

carbon molecular sieve (Carboxen-1018) separated by glass wool. Breath is sampled through the bed of graphitized carbon into the bed of carbon molecular sieve (Risby and Sehnert 1999). The breath molecules trapped on the adsorbents were quantified by two-stage thermal desorption-capillary gas chromatography with flame ionization and flame photometric detection (Tu et al. 2004). A study very similar to the one conducted by our laboratory was performed jointly by the United States Air Force and Exxon Mobil (Whitman and Hinz 2001). In this study, mice were exposed to aerosolized and vaporized JP-8. During one exposure, vapor samples were collected on charcoal tubes and aerosol samples were collected on glass fiber filters and cascade impactor plates. The tubes, filters, and plates were extracted using carbon disulfide, and the resulting sample was analyzed using a GC/FID equipped with a 30 meter CP-Sil 5 CB column to determine the concentrations of a standard set of hydrocarbons. The study conducted by our laboratory utilized similar methods. Aerosol samples were collected from a nose-only exposure chamber in Tucson, and vapor samples were collected using charcoal tubes. Samples were extracted using chloroform and then analyzed using a GC/MS system equipped with a 150 m Supelco DH 150 column operated in full scan mode.

JP-8 is comprised of a variety of hydrocarbons with varying molecular weights. As mentioned previously, exposure to JP-8 has been found to exert a wide range of toxic effects on the immune system, respiratory tract, skin, and nervous system. These effects are directly linked to components present in the fuel. Thus, more research needs to be done to better understand the chemical nature of the fuel and determine which components are present in exposure situations as well as their concentrations. For this reason, our laboratory has developed a GC/MS method to analyze aerosol and vapor samples of JP-8 collected from a nose-only exposure chamber at the University of Arizona in Tucson, Arizona.

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CHAPTER 2

VALIDATION OF A GC/MS METHOD FOR THE QUANTIFICATION OF JET PROPELLANT 8 (JP-8) USING A THIRTY-FOUR COMPONENT SURROGATE MIXTURE[1]

[1] Dietzel, K. D., Campbell, J. L., Bartlett, M. G., Witten, M. L., Fisher, J. W. Submitted to *Environmental Science and Technology*.

Abstract

JP-8 is a kerosene-based jet fuel containing several hundred hydrocarbons and is used in a variety of military vehicles, including aircraft. The chemical complexity of JP-8 makes analysis of individual components difficult. The objective of this study was to develop an analytical method, with an accuracy and precision of 20% or better, for JP-8 aerosol and vapor samples using gas chromatography/mass spectrometry (GC/MS). Preliminary analysis of the hydrocarbon composition of aerosol and vapor samples of JP-8 collected from a nose-only mouse exposure chamber at the University of Arizona was undertaken. Thirty-four of the primary components detected in the atmosphere were used to create a surrogate hydrocarbon mixture (SHM) for GC/MS analysis. Our SHM contained n-alkanes ranging from n-octane to n-heptadecane, toluene, n-ethylbenzene, xylenes, n-substituted cyclohexanes, 3-ethyltoluene, 2-methylnonane, trimethylbenzenes, indene, methyldecanes, 1,2,3,4-tetrahydronaphthalene, naphthalene, methylnaphthalenes, and dimethylnaphthalenes. Three separate runs containing a standard curve, ranging from 1.25 μg/mL to 250 μg/mL, and five replicates each of the surrogate at concentrations of 1.25 μg/mL, 4.0 μg/mL, 75 μg/mL, and 200 μg/mL were analyzed. The average precision obtained for the thirty-four components was 8% or better, while the average accuracy was 13.5% or better. Based on these results, we attained our desired precision and accuracy and have thus developed a suitable method for analyzing JP-8. This method was then used to determine the concentration of major components in JP-8 samples acquired from the nose-only exposure chamber at the University of Arizona. From the data collected, we saw an overlapping region between the aerosol and vapor phases from undecane (C_{11}) to pentadecane (C_{15}). We also observed a concentration dependency for the individual components such that the

concentration of the individual components was highly dependent on the overall sample concentration.

Introduction

JP-8 is a kerosene-based jet fuel used in a variety of military vehicles, in addition to jet engine aircraft. JP-8 is the battlefield fuel for all NATO ground and air forces. It is a complex hydrocarbon mixture containing over four hundred hydrocarbons. Its composition is approximately 18% aromatic hydrocarbons, while the remaining components are aliphatic alkanes and their isomers (9% C_8-C_9, 65% C_{10}-C_{14} and 7% C_{15}-C_{17}) having an average molecular weight of 180 Daltons (Committee on Toxicology 1996). It is composed primarily of four classes of compounds: n-alkanes and isoalkanes, olefins, naphthenes, and aromatics (Committee on Toxicology 2003). JP-8 is very similar to commercial jet fuel, Jet-A, in its hydrocarbon make-up, but small amounts of diethylene glycol monomethyl ether (DiEGME), a deicing agent; Statis 450, an anti-static material; and DCI-4A, a corrosion inhibitor, have been added to create JP-8 (Committee on Toxicology 1996). JP-8 replaces an earlier jet fuel called JP-4, which contained a larger percentage of smaller hydrocarbon molecules and was therefore more volatile (Mattie et al. 1991). The wholesale change to JP-8 by the military in NATO countries was triggered by safety, survivability, and logistical concerns. The physical and chemical properties of JP-8 enhanced aircraft survivability and safety and promoted standardization of fuel for the military and commercial sectors in NATO countries.

The National Occupational Exposure Survey by the National Institute for Occupational Safety and Health estimated that over 1 million employees were exposed to kerosene, the primary component of JP-8. JP-8 has been found at 22 EPA National Priority sites (Agency for Toxic Substances and Disease Registry 1998). Exposure of personnel to JP-8 aerosol and vapor

mixtures has become a concern in recent years (Committee on Toxicology 2003). In cold climates, the higher flash point and lower volatility of JP-8 cause aircraft engine "cold starts" which results in the spraying of non-combusted aerosolized fuel onto personnel in the vicinity of the jet (Committee on Toxicology 2003). The potential health effects from this exposure to JP-8 are unknown and exposures poorly characterized. However, one study reported that workers occupationally exposed to JP-8 vapors had subtle changes in their ability to maintain balance (Smith et al. 1997). Jet fuel exposure, not specifically JP-8, has been reported to cause clinical symptoms in Scandinavian aircraft workers. There workers reported fatigue, headache, dizziness, nausea, anxiety, vegetative hyperreactivity, and attention span deficient (Knave et al. 1978, Struwe et al. 1983). Clinical evaluations of these workers suggested deleterious changes in their nervous system (Knave et al. 1976).

In laboratory animals exposure to JP-8 has been associated with toxic responses in the lung and respiratory tract, nervous system, and immune system (Harris et al. 2000, 1997a, 1997b, 1997c; Drake at al. 2003; Robledo et al. 1999; Pfaff et al. 1996, 1995; Ritchie et al. 2001; Rossi et al. 2001). All of the nose-only inhalation studies were conducted at the University of Arizona using an exposure generation system that created an aerosolized JP-8 (Harris et al. 2000, 1997a, 1997b, 1997c; Drake at al. 2003; Robledo et al. 1999; Pfaff et al. 1996, 1995) which contained both aerosol droplets and vapor. Other JP-8 inhalation studies were conducted at Wright-Patterson Air Force Base using vapor generation systems (Ritchie et al. 2001; Rossi et al. 2001). Recently Exxon-Mobil examined the sensory irritation of JP-8 aerosol and vapor in mice (Whitman and Hinz 2001). For each of these studies, the hydrocarbon composition of JP-8 vapor and aerosol in the inhalation chamber atmospheres was never evaluated with the exception of the Exxon-Mobil study (Harris et al. 2000, 1997a, 1997b, 1997c; Drake at al. 2003; Robledo

et al. 1999; Pfaff et al. 1996, 1995; Mattie et al. 1991; Ritchie et al. 2001; Rossi et al. 2001; Whitman and Hinz 2001). For this reason, our laboratory developed a sensitive gas chromatography/mass spectrometry (GC/MS) method to simultaneously quantify thirty-four hydrocarbons found in an inhalation chamber (University of Arizona) containing aerosolized JP-8. Gas chromatography/mass spectrometry (GC/MS) methods have been reported for the quantification of a limited number of hydrocarbons in jet fuel (Bernabei et al. 2003, 2000; Link et al. 2003; Cheng et al. 2001; Johnson and Synovec 2002; Liu and Pleil 2001; Kostecka et al. 1995; Kokosa and Przyjazny 2003; Zwank et al. 2002; McDougal et al. 2000). In addition, our colleagues have conducted experiments in order to identify major components present in the aerosol and vapor phases as well as compare their compositions when collected on different media (Gregg et al. 2005).

Experimental Section

The method validation procedures described by Shah et al. (2000) were used in this experiment.

Materials. The chemicals used for the method validation, their purity, CAS number, supplier, and retention time are listed in Table 1. The retention times for all samples were determined using authentic standards. The thirty-four components were chosen based on the percentages of their peak areas in neat JP-8 (shown in Table 1).

Surrogate Hydrocarbon Mixture (SHM). Thirty milligrams of each of the components listed in Table 1 was placed in a 40 mL volatile organic analysis vial (VWR Scientific, West Chester, PA). Chloroform (Acros Organics, New Jersey, USA) was added to make the final volume 40 mL.

Validation Solutions. The stock SHM was diluted to create a 500 μg/mL solution. Serial dilutions were then performed using the 500 μg/mL solution to construct a calibration curve with

concentrations of 350 μg/mL, 250 μg/mL, 100 μg/mL, 50 μg/mL, 10 μg/mL, 5 μg/mL, 2.5 μg/mL, and 1.25 μg/mL. It was discovered that the two highest concentrations, 350 μg/mL and 500 μg/mL, did not follow a linear trend and were thus dropped from the standard curve. Five replicates at concentrations of 1.25 μg/mL, 4.0 μg/mL, 75 μg/mL, and 200 μg/mL were analyzed as well. Chloroform blanks separated each concentration and were placed before and after the calibration curve samples to ensure that no carryover existed in the system.

JP-8 Validation. A validation of this method was also carried out using neat JP-8 to allow determination of the total amount of fuel. Following the same procedure as described for the SHM, a standard curve of JP-8 was constructed and five replicates at concentrations of 25 μg/mL, 75 μg/mL, 500 μg/mL, and 1000 μg/mL were analyzed.

Tucson Sample Collection. A trip was made to the University of Arizona in September 2004. An atmosphere of JP-8 aerosol and vapor was created using a DeVilbiss Ultra-Neb nebulizer (Model 099HD, Somerset, Pennsylvania) (Pfaff et al. 1996). Aerosol samples were collected on glass fiber filters (47 mm, SKC, Inc., Eighty Four, PA) housed in a stainless steel filter holder (SKC, Inc.) followed by a coconut charcoal tube (50/100 mg, SKC, Inc.) used to collect vapor samples (Whitman and Hinz 2001). Samples were collected using a handheld pump (AirChek2000 Model 210-2002, SKC, Inc.) with an approximate flow rate of 100 mL/min from a mouse nose-only port on the exposure chamber (Figure 1). Aerosol samples were extracted using 5 mL of chloroform, while the vapor samples were extracted using 1 mL of chloroform (Smith et al. 2005). Samples remained in chloroform for approximately 1 hour and were then transferred into 2 mL GC vials and sealed for shipping to The University of Georgia. Samples were shipped on ice packs via FedEx. A 1 μL/mL solution of JP-8 was also shipped and compared against a

freshly made solution to determine any loss due to shipping. The analysis revealed that no loss occurred during shipping.

Recovery. Experiments were also conducted to determine the percentage of sample recovered from the charcoal tubes and glass fiber filters. The main chamber of the charcoal tube was emptied into a 2 mL vial, and either 1 μL, 3 μL, or 9 μL of JP-8 was added to the charcoal. The vial was sealed, and one hour later, 1 mL of chloroform was added to the vial. The vial was sealed again, and one hour after the addition of chloroform, 200 μL of sample was removed from the vial and placed in a 300 μL vial insert placed in a 2 mL GC vial. The sample was analyzed using GC/MS and the resulting peak areas were compared to a sample of neat JP-8 at the same concentration (1 μL/mL, 3 μL/mL, or 9 μL/mL). Five replicates at each concentration were analyzed. The same method was used for the glass fiber filters, with a few exceptions. Filters were placed in 1 ounce jars (Qorpak, Fisher Scientific, Pittsburgh, PA) and extraction was carried out using 5 mL of chloroform.

Stability. The stability of JP-8 was evaluated over a 9 day period. This was carried out by creating a 2 mL stock JP-8 solution with a concentration of 1574 μg/mL (2 μL/mL) and placing 200 μL aliquots into nine different 300 μL vial inserts placed in 2 mL GC vials. The vials were numbered one through nine, and one sample was analyzed each day over a nine day period.

JP-8 Concentration Determination. In order to determine the overall concentration of the aerosol and vapor samples taken from the nose-only exposure chamber at the University of Arizona, standard curves of JP-8 (Jet A plus additives, AFRL/PRTG, Wright-Patterson Air Force Base, OH) were created and weighted using $1/X^2$ weighting in JMP-IN 5.1 (SAS Institute Inc., Cary, NC). The area of the chloroform peaks was subtracted from the total area and the remaining area was plotted against the concentration. From the curve obtained, a linear equation appears to best

describe the relationship between the peak area of JP-8 and the concentration of JP-8. In order to determine the concentration of the aerosol and vapor samples, samples were analyzed using GC/MS. The total peak area was calculated and the solvent peaks were subtracted from this total. The resulting area was then used to determine the sample concentration using the equation generated from the standard curve of JP-8.

Chromatography—Tucson Samples. Samples were analyzed with an Agilent 6890 gas chromatograph (GC) equipped with a 5973N mass spectrometer (MS) operated in full scan mode. Charcoal tube samples were analyzed at full strength and at one-tenth of the original concentration. 150 µL of each chilled sample was placed into a 300 µL vial insert and placed into a 2 dram auto sampler vial (National Scientific, San Rafael, CA) for injection on the GC. A Petrocol DH 150 (Supelco) column, with dimensions 150 m x 0.25 mm x 1 µm, was used for the analyses. The injection volume was 3 µL and the split ratio was 3:1. The inlet temperature was 250^{o}C, column flow was 1 mL/min (constant flow mode), initial oven temperature was 90^{o}C, ion source temperature was 230^{o}C, and quadrupole temperature was 150^{o}C. The oven temperature was increased to 120^{o}C, 140^{o}C, 160^{o}C, 180^{o}C, 200^{o}C, and 210^{o}C using 5^{o}C per minute increments, and samples were held at each temperature for 40 minutes.

Chromatography—Method Validation Samples. Samples and standards were analyzed with an Agilent 6890 gas chromatograph (GC) equipped with a 5973N mass spectrometer (MS) operated in scan mode. 200 µL of each sample was placed into a 300 µL vial insert and placed into a 2 dram auto sampler vial (National Scientific, Fisher Scientific) for injection on the GC. Chromatographic conditions are the same as those used for the analysis of the Tucson samples.

Data Analysis. Standard curves for the individual components were weighted using $1/X^2$ weighting in JMP-IN 5.1 (SAS Institute Inc., Cary, NC). These curves were then used to

determine the concentration of each component in the solution using Microsoft Excel 2002 (Redmond, WA). Accuracy and precision were then calculated using Excel using the following equations:

Accuracy = (|experimental value-theoretical value|/theoretical value)*100

Precision = (100 * Std Dev)/Average

Results and Discussion

Method Validation—Surrogate Hydrocarbon Mix. We were able to obtain average precision and accuracy values for all thirty-four components of 8.01 % or better and 13.43% or better, respectively. The average precision and accuracy of each of the thirty-four components at the four different concentrations is shown in Tables 2 and 3, respectively. Based on these results, we can determine the concentration of any of the thirty-four components in JP-8 to within 13.5%. The average slopes and intercepts of each of the thirty-four components are shown in Table 4. Using a 3:1 signal-to-noise ratio, the limit of detection of our method was determined to be 1.0 μg/mL, while the limit of quantification was set at 1.25 μg/mL.

Method Validation –JP-8. We were able to obtain accuracy and precision values of 16.3% or better and 7.0 % or better, respectively. The resulting interday precision values (n=15) for samples at 25 μg/mL, 75 μg/mL, 500 μg/mL, and 1000 μg/mL were 6.7%, 4.4%, 5.1%, and 7.0 %, respectively. The resulting interday accuracy values (n=15) for samples at 25 μg/mL, 75 μg/mL, 500 μg/mL, and 1000 μg/mL were 16.3 %, 10.7%, 12.0%, and 15.5 %, respectively. The resulting slope and intercept for the three JP-8 standard curves constructed during the method validation process were 5940846.7 ± 378283.9 and 128350000 ± 5943366.1, respectively.

Recovery. The resulting percentage of mass recovered from the charcoal tubes and glass fiber filters was 87.6 % (± 17.4%) and 100.0% (± 16.4%), respectively (n=5). Based on these results, adjustments were made in the calculations of mass collected from the charcoal tube samples collected at the University of Arizona.

Stability. JP-8 samples were found to be stable at ambient temperature within the accuracy and precision ranges for this method for up to nine days (n=9).

Analysis of Tucson Samples. Table 5 summarizes the overall concentration of the glass fiber filter and charcoal tube samples, as well as the percent aerosol of each run. From the data, we found that the percent aerosol ranged from 2.75% to 15.35%. However, introduction of water droplets into the chamber may account for some of the higher percentages seen. Overall the average percent aerosol was determined to be 8.51%. Comparison between the aerosol and vapor chromatographs revealed an overlapping region from undecane to pentadecane (Figure 2). A visual comparison between the chromatographs of the aerosol phase, the vapor phase, and the SHM showed that the SHM encompassed many of the compounds present in both phases (Figure 2). Comparison between neat JP-8 and the SHM illustrated that the SHM is representative of the neat fuel (Figure 2).

Samples were also analyzed to determine the concentration of the individual components. The analysis revealed that the concentration of the individual components was dependent upon the overall sample concentration. Tables 6 and 7 show a comparison between samples of high concentration and low concentration for the charcoal tubes and the glass fiber filters, respectively. For both the aerosol and vapor samples, a concentration dependency is seen. Samples with higher concentrations consistently show higher concentrations of individual components, while samples of lower concentration show a significant decrease in individual

component concentration when compared to higher concentration samples. For the vapor samples (Table 6), the individual component concentrations can be decreased by as much as 64.0% and as little as 15.2%. For the aerosol samples (Table 7) the variability is much more dramatic. The concentrations of the individual components can be decreased by 77.5% to 64.7%. The higher decreases in concentration of the individual components in the aerosol samples can be attributed to their already low concentrations compared to the vapor samples. The aerosol samples contain fewer components than the vapor samples and in some cases, as shown in Table 7, the concentrations of the individual components drop below the limit of quantification. The components can still be identified, but they are present in concentrations either at or slightly above the LOD. Some of the components identified in the neat fuel are not seen in either the vapor or aerosol samples due to their low concentrations. These compounds include indene, naphthalene, 1,3-dimethylnaphthalene, 1,6-dimethylnaphthalene, 2,6-dimethylnaphthalene, 2,7-dimethylnaphthalene, 1,2,3,4-tetrahydronaphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. Toluene was found to coelute with another compound, 2-methylheptane, so it could not be quantified in the samples.

For each sample type collected, the percent mass of the individual components was also determined and these values are shown for the selected samples in Tables 6 and 7. The average percent mass values for the charcoal tube samples and glass fiber filter samples collected were 69.41% and 42.81%, respectively. The comparison data (Tables 6 and 7) show that for the charcoal tube samples, we are able to account for approximately the same percentage of the total mass of the sample. However, there is a slight decrease in percent mass for the aerosol comparison data. This is due to the fact that, as mentioned previously, the concentrations of some of the components present in the aerosol samples were below the limit of quantification.

Thus, their percent masses were not applicable, and so higher percent mass values were observed for samples with higher overall concentration.

Other studies have been conducted to examine the exposures of Air Force personnel to various fuels. In comparison with these studies, the levels of individual components generated in the nose-only mouse exposure chamber at the University of Arizona were significantly higher than levels of the same components present in ambient air and breath samples taken from personnel and work environments (Holm et al. 1987, Pleil et al. 2000). There exists a several hundred-fold increase in the concentrations of most of the individual components. The personnel exposure levels that correlate with the data obtained from the chamber were from ambient air taken from inside fuel tanks. However, these values were still significantly lower than the values obtained from the Tucson exposure chamber.

The atmosphere generated for animal studies conducted jointly by the Air Force and Exxon Mobil involved the quantification of a specific set of hydrocarbons present in the generated JP-8 atmosphere (Whitman and Hinz 2001). This study was conducted using a different exposure system than the one in Arizona, yet the results obtained are somewhat similar. The percent aerosol values obtained were 3.4%, 15.6%, 25.0%, and 34.5%, while our values were 2.75%, 6.41, 9.52%, and 15.35%. Air Force and Exxon Mobil researchers noted that increasing their total concentrations produced an increase in their percent aerosol values. However, this trend was not seen in our study. This is due to the different concentrations generated by our laboratory and the United States Air Force and Exxon Mobil. The Air Force and Exxon Mobil report overall concentrations of 3565 mg/m^3, 1837 mg/m^3, 1090 mg/m^3, and 681 mg/m^3, with aerosol concentrations of 1230 mg/m^3, 459 mg/m^3, 170 mg/m^3, and 23 mg/m^3, respectively. Thus, an increase in aerosol concentration occurred with an increase in overall

concentration. In our study, we generated overall concentrations of 2013.70 mg/m^3, 1605.20 mg/m^3, 1543.16 mg/m^3, and 821.09 mg/m^3, with aerosol concentrations of 191.70 mg/m^3, 44.16 mg/m^3, 236.95 mg/m^3, and 52.59 mg/m^3, respectively. These results indicate that aerosol production is better controlled by the system used by the Air Force and Exxon Mobil than the system in Arizona. It is worthy to note that in both studies, an increase in aerosol concentration produced an increase in the percent aerosol value.

The list of hydrocarbons examined by Exxon Mobil and the Air Force included some of the compounds used for our method validation including n-octane, ethylbenzene, m-xylene, p-xylene, o-xylene, n-nonane, 3-ethyltoluene, mesitylene, pseudocumene, n-decane, n-undecane, n-dodecane, n-tetradecane, and n-hexadecane. For this study, aerosol samples were collected on glass fiber filters and cascade impactor plates and vapor samples were collected on charcoal tubes. Extraction was done using carbon disulfide, and the resulting samples were analyzed using GC/FID equipped with a 30 meter column (Whitman and Hinz 2001). The individual component data revealed that lower molecular weight compounds persist in the vapor phase and are not present in the aerosol phase at measurable levels, while the higher molecular weight compounds are more abundant in the aerosol phase (Whitman and Hinz 2001). This same trend was seen with our data as well.

Comparison of the method developed by our laboratory to previous methods shows quite a bit of variation. Other analytical studies conducted on fuels did not utilize a column as long as 150 meters, instead columns ranging from 10-30 meters in length were used. Thus, other methods have much shorter run times, yet their ability to identify certain components becomes limited since a higher number of coeluents exist. With our method, we achieve reasonable and reproducible resolution for the major components of JP-8.

The toxicological impact of exposure to JP-8 is of great concern to researchers. However, in order to study the toxic effects of JP-8, the major components of the fuel must be separated, identified, and quantified. Using the method developed by our laboratory, we can determine the concentration of individual components of JP-8 in aerosol, vapor, and neat fuel. This method can be used further to quantify individual components present in biological matrices for toxicological assessment and pharmacokinetic model development.

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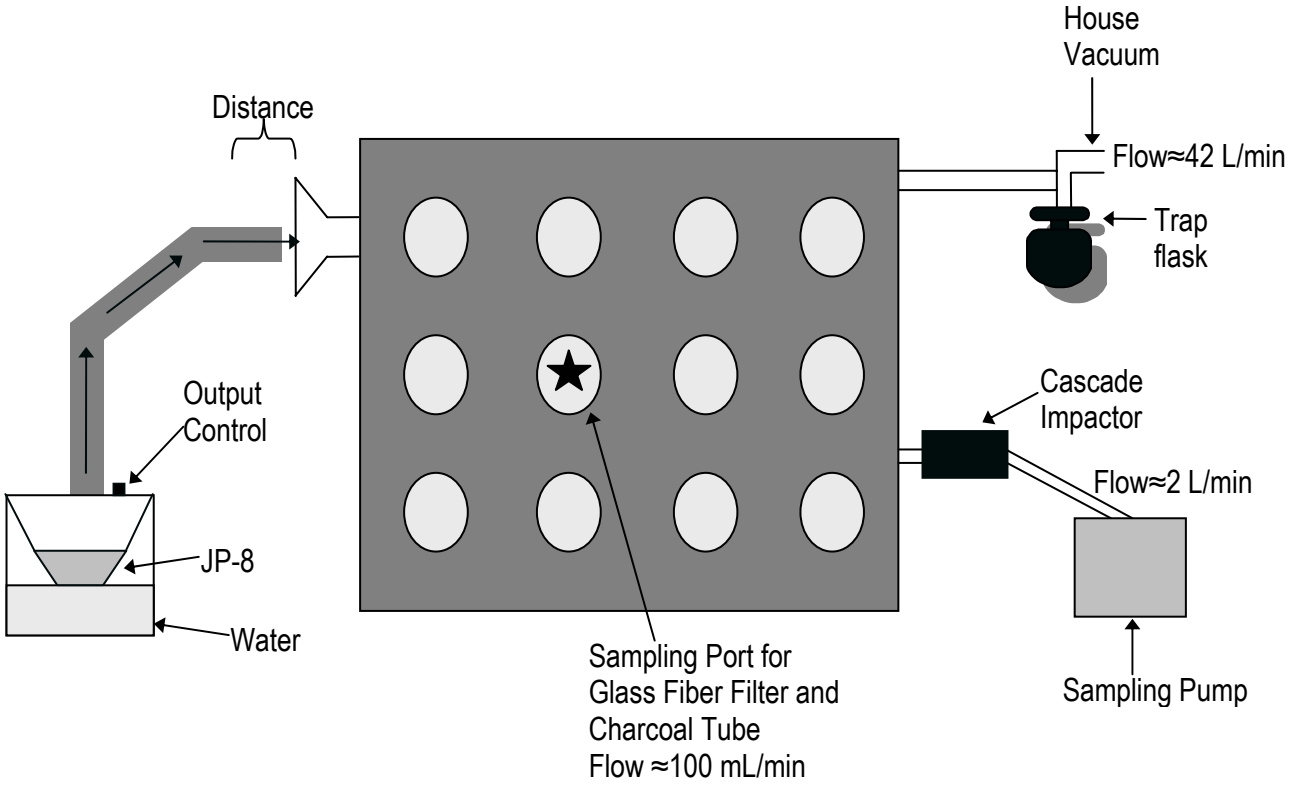

Figure 1: Schematic of the nose-only exposure chamber in the Witten laboratory at the University of Arizona.

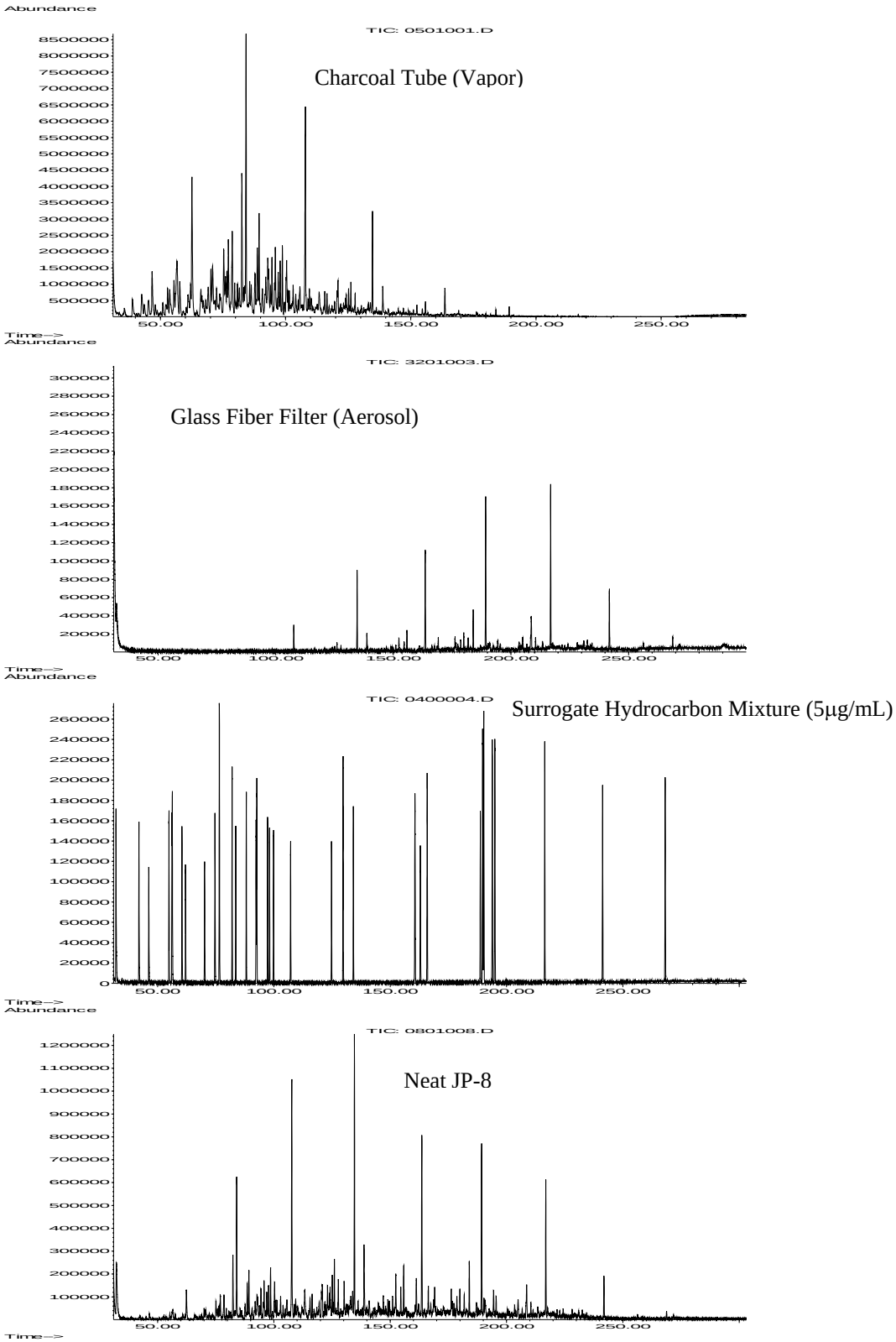

Figure 2: Chromatographic output for visual comparison of the vapor phase, aerosol phase, surrogate, and neat JP-8.

Table 1. List of the components used to create the surrogate solution for the method validation.

Compound	Purity	CAS#	Supplier	Retention Time (min)	Percent Mass in Neat JP-8 (%)
Toluene	99.8%	108-88-3	Aldrich	42.22	0.15
n-Octane	99+%	111-65-9	Sigma	46.50	0.55
n-Ethylbenzene	99.8%	100-41-4	Acros	55.21	0.32
m-Xylene	99+%	108-38-3	Aldrich	56.51	0.26
p-Xylene	99+%	106-42-3	Aldrich	56.70	
o-Xylene	99.5%	95-47-6	Fluka	60.84	0.44
n-Nonane	99%	111-84-2	Sigma	62.39	2.05
n-Propylcyclohexane	99%	1678-92-8	Aldrich	70.63	0.78
3-Ethyltoluene	99%	620-14-4	Aldrich	75.12	0.69
2-Methylnonane	99%	871-83-0	Avocado*	76.95	0.59
Mesitylene	99%	108-67-8	Acros	76.97	
Pseudocumene	NK	95-63-6	Sigma	82.41	2.05
n-Decane	99+%	124-18-5	Sigma	84.00	5.58
1,2,3-Trimethylbenzene	98%	526-73-8	Chem Service	88.51	1.55
n-Butylcyclohexane	99+%	1678-93-9	Acros	92.77	1.17
Indene	NK	95-13-6	Chem Service	93.06	0.27
4-Methyldecane	98.7%	2847-72-5	Chem Service	97.73	1.24
2-Methyldecane	99.5%	6975-98-0	Chem Service	98.57	1.88
3-Methyldecane	98.9%	13151-34-3	Chem Service	100.32	1.92
n-Undecane	99%	1120-21-4	Sigma	107.70	8.63
1,2,3,4-Tetrahydronaphthalene	98%	119-64-2	Chem Service	125.20	0.67
Naphthalene	NK	91-20-3	Supelco	130.22	0.97
n-Dodecane	99%	112-40-3	Sigma	134.64	6.73
2-Methylnaphthalene	97%	91-57-6	Aldrich	161.32	1.11
n-Tridecane	99%	629-50-5	Sigma	163.61	4.92
1-Methylnaphthalene	97%	90-12-0	Acros	166.47	0.77
n-Tetradecane	99%	629-59-4	Avocado*	189.31	3.88
2,6-Dimethylnaphthalene	99%	581-42-0	Acros	190.30	0.50
2,7-Dimethylnaphthalene	99%	582-16-1	Acros	190.82	0.28
1,3-Dimethylnaphthalene	96%	575-41-7	Acros	194.47	0.62
1,6-Dimethylnaphthalene	95%	575-43-9	Ultra Scientific	195.54	0.48
n-Pentadecane	99%	629-62-9	Avocado*	216.91	2.35
n-Hexadecane	99%	544-76-3	Acros	241.90	0.83
n-Heptadecane	99%	629-78-7	Alfa Aesar #	268.81	0.19

* Avocado Research Chemicals

Johnson Matthey

NK=Not Known

Table 2. Interday precision for thirty-four components of JP-8 (n=15).

Component	**1.25 µg/mL**	**4.0 µg/mL**	**75.0 µg/mL**	**200.0 µg/mL**
Toluene	5.67	6.66	7.55	4.94
n-Octane	5.48	6.46	7.16	4.95
n-Ethylbenzene	5.51	7.13	6.92	4.23
m-Xylene/p-Xylene	5.61	7.15	6.60	4.01
o-Xylene	5.48	7.34	6.44	4.04
n-Nonane	5.70	7.22	6.55	4.29
n-Propylcyclohexane	5.54	7.32	6.52	4.24
3-Ethyltoluene	5.87	7.48	6.02	3.55
2-Methylnonane/Mesitylene	5.47	7.45	5.80	3.30
Pseudocumene	5.66	7.49	5.60	3.03
n-Decane	5.48	7.53	5.77	3.19
1,2,3-Trimethylbenzene	5.58	7.53	5.54	2.68
Butylcyclohexane	5.25	7.48	5.65	2.79
Indene	5.63	7.50	5.40	2.53
4-Methyldecane	5.84	7.72	5.31	2.53
2-Methyldecane	5.73	7.65	5.08	2.39
3-Methyldecane	5.84	7.65	5.05	2.31
n-Undecane	5.84	7.76	4.95	2.26
1,2,3,4-Tetrahydronaphthalene	5.74	7.53	4.57	1.85
Naphthalene	5.73	7.61	4.71	1.76
n-Dodecane	6.30	7.72	4.64	1.88
2-Methylnaphthalene	6.30	7.78	4.32	1.57
n-Tridecane	6.27	7.89	4.32	1.67
1-Methylnaphthalene	6.09	7.71	3.95	1.36
n-Tetradecane	6.15	8.01	3.85	1.39
2,6-Dimethylnaphthalene	6.05	7.82	3.50	1.21
2,7-Dimethylnaphthalene	5.88	7.62	3.29	1.17
1,3-Dimethylnaphthalene	5.99	7.80	3.09	1.19
1,6-Dimethylnaphthalene	5.93	7.76	2.91	1.15
n-Pentadecane	6.17	7.96	2.77	1.22
n-Hexadecane	5.88	8.00	2.75	1.21
n-Heptadecane	5.86	7.91	2.72	1.24

Table 3. Interday accuracy for thirty-four components of JP-8 (n=15).

Component	**1.25 μg/mL**	**4.0 μg/mL**	**75 μg/mL**	**200 μg/mL**
Toluene	10.60	13.43	6.78	10.51
n-Octane	13.45	13.43	6.47	10.46
n-Ethylbenzene	9.16	11.48	6.88	10.55
m-Xylene/p-Xylene	9.31	10.30	6.82	9.52
o-Xylene	9.15	11.01	6.79	10.79
n-Nonane	11.51	10.24	6.86	10.60
n-Propylcyclohexane	9.96	11.40	6.66	11.38
3-Ethyltoluene	8.27	10.35	6.96	11.60
2-Methylnonane/Mesitylene	9.78	7.29	7.32	8.94
Pseudocumene	8.19	10.24	6.42	10.33
n-Decane	9.76	7.42	7.43	10.80
1,2,3-Trimethylbenzene	8.11	9.62	6.89	11.19
Butylcyclohexane	8.36	9.04	6.89	13.64
Indene	8.65	8.05	7.21	9.43
4-Methyldecane	8.96	7.26	7.16	11.43
2-Methyldecane	9.30	6.97	7.20	11.26
3-Methyldecane	9.05	7.15	7.39	11.49
n-Undecane	9.18	7.47	7.57	12.30
1,2,3,4-Tetrahydronaphthalene	8.18	8.59	6.15	11.36
Naphthalene	8.15	9.10	6.48	10.99
n-Dodecane	8.25	7.23	7.23	11.57
2-Methylnaphthalene	7.92	10.79	6.27	11.35
n-Tridecane	8.61	7.88	6.81	12.50
1-Methylnaphthalene	8.12	9.41	5.98	10.65
n-Tetradecane	8.29	8.21	6.98	11.71
2,6-Dimethylnaphthalene	7.85	10.24	5.70	9.90
2,7-Dimethylnaphthalene	7.99	8.52	5.71	9.55
1,3-Dimethylnaphthalene	7.87	9.35	5.76	9.93
1,6-Dimethylnaphthalene	7.95	8.37	5.58	9.69
n-Pentadecane	10.77	7.57	7.19	10.84
n-Hexadecane	7.98	8.77	6.97	10.80
n-Heptadecane	7.78	9.27	6.24	10.58

Table 4. Average slope and intercept values determined for each of the thirty-four components from the standard curves generated during the method validation process (n=4).

Component	Average Slope ± SD	Average Intercept ± SD
Toluene	3817831 ± 320247	204056 ± 666217
n-Octane	2808202 ± 217041	501090 ± 471426
n-Ethylbenzene	4281650 ± 354920	-56658 ± 699287
m-Xylene/p-Xylene	8338082 ± 677881	164862 ± 1380118
o-Xylene	4056173 ± 330276	-145367 ± 675390
n-Nonane	2940896 ± 215060	77103 ± 507979
n-Propylcyclohexane	3552188 ± 277063	-88795 ± 583862
3-Ethyltoluene	4937234 ± 416993	-464857 ± 817429
2-Methylnonane/Mesitylene	7848555 ± 623830	261497 ± 1354420
Pseudocumene	4890311 ± 455088	-498917 ± 773264
n-Decane	3261218 ± 235695	-31577 ± 537939
1,2,3-Trimethylbenzene	4685031 ± 388619	-491651 ± 748284
Butylcyclohexane	4071905 ± 312911	-382944 ± 620774
Indene	5357752 ± 436255	-464050 ± 900926
4-Methyldecane	3968452 ± 291211	-243515 ± 623103
2-Methyldecane	3718356 ± 265204	-156819 ± 605862
3-Methyldecane	3791670 ± 274616	-262660 ± 623651
n-Undecane	3721846 ± 266379	-417098 ± 592842
1,2,3,4-Tetrahydronaphthalene	3529566 ± 293470	-586596 ± 529997
Naphthalene	6288533 ± 530679	-908186 ± 966717
n-Dodecane	4242518 ± 304934	-617765 ± 610193
2-Methylnaphthalene	7070928 ± 623974	-1978968 ± 1062463
n-Tridecane	4588279 ± 325728	-1089510 ± 660684
1-Methylnaphthalene	6809512 ± 588606	-1593031 ± 1048879
n-Tetradecane	4977485 ± 357307	-1377993 ± 665308
2,6-Dimethylnaphthalene	8419722 ± 735644.9	-2347875 ± 1261538.87
2,7-Dimethylnaphthalene	8992264 ± 767945.8	-1888118.15 ± 1316844.84
1,3-Dimethylnaphthalene	8498289 ± 735644	-2371250 ± 1204981.88
1,6-Dimethylnaphthalene	8604238 ± 735317.9	-2147053.65 ± 1231137.95
n-Pentadecane	6114404 ± 434850.1	-1314838.13 ± 1033601.93
n-Hexadecane	6388266 ± 465903.8	-2109906 ± 670335.553
n-Heptadecane	7065268 ± 530919.8	-2410600 ± 654191.068

Table 5. Calculated JP-8 concentrations from a nose-only exposure chamber at the University of Arizona using GC/MS analysis of glass fiber filters and charcoal tubes.

Sample Collection Time (min)	48	40	42.5	20
	Calculated Concentration of JP-8 in Chamber (mg/m^3)			
Glass Fiber Filter – GC/MS	44.16	52.59	191.70	236.95
Charcoal Tube – GC/MS	1561.04	768.50	182.00	1306.21
Glass Fiber Filter + Charcoal Tube	1605.20	821.09	2013.70	1543.16
Percent Aerosol [a] (%)	2.75	6.41	9.52	15.35

[a] Glass fiber filter concentration divided by the sum of charcoal tube and glass fiber filter concentrations

Table 6. Comparison of the individual component concentrations present on charcoal tube samples.

Total Sample Concentration: 1822.00 mg/m^3			Total Sample Concentration: 768.50 mg/m^3	
Component Concentration (mg/m^3)	Percent Mass of Sample (%)	Component	Percent Mass of Sample (%)	Component Concentration (mg/m^3)
148.67	8.16	n-Octane	7.84	60.26
58.08	3.19	n-Ethylbenzene	2.90	22.32
30.47	1.67	m-Xylene/p-Xylene	1.43	10.97
41.57	2.28	o-Xylene	1.98	15.25
245.56	13.48	n-Nonane	12.02	92.39
83.15	4.56	n-Propylcyclohexane	4.06	31.22
44.53	2.44	3-Ethyltoluene	2.35	18.08
33.56	1.84	2-Methylnonane/Mesitylene	1.72	13.22
35.47	1.95	Pseudocumene	1.87	14.39
214.31	11.76	n-Decane	11.53	88.59
45.72	2.51	1,2,3-Trimethylbenzene	2.44	18.78
44.15	2.42	Butylcyclohexane	2.37	18.23
33.67	1.85	4-Methyldecane	1.83	14.07
35.58	1.95	2-Methyldecane	1.91	14.66
30.73	1.69	3-Methyldecane	1.69	12.99
116.94	6.42	n-Undecane	6.32	48.56
35.99	1.98	n-Dodecane	1.99	15.27
12.89	0.71	n-Tridecane	0.99	7.60
5.9	0.32	n-Tetradecane	0.51	3.95
1.78	0.10	n-Pentadecane	0.20	1.51
Total Percent Mass Accounted For (%)	71.28		67.97	Total Percent Mass Accounted For (%)

Table 7. Summary of the concentration of individual components present on glass fiber filter samples.

Total Sample Concentration: 191.70 mg/m^3			Total Sample Concentration: 52.59 mg/m^3	
Component Concentration (mg/m^3)	Percent Mass of Sample (%)	Component	Percent Mass of Sample (%)	Component Concentration (mg/m^3)
7.79	4.07	n-Undecane	ND	Below LOQ
8.83	4.61	n-Dodecane	3.79	1.99
13.15	6.86	n-Tridecane	6.61	3.47
21.89	11.42	n-Tetradecane	11.76	6.18
20.58	10.74	n-Pentadecane	12.00	6.31
9.25	4.82	n-Hexadecane	6.21	3.27
2.41	1.26	n-Heptadecane	ND	Below LOQ
Total Percent Mass Accounted For (%)	43.77		40.37	Total Percent Mass Accounted For (%)

ND = Not Determined

CHAPTER 3

SUMMARY

The toxicological impact of exposure to JP-8 is of great concern to researchers. Exposure to JP-8 exerts a wide variety of toxic effects as previously described. The toxic nature of the fuel makes it important to understand the chemical make-up of the fuel and determine which components of the fuel are responsible for inducing toxic responses. In order to do this, methods must exist that allow the components of the fuel to be separated, identified, and quantified.

For this reason, our laboratory developed a gas chromatography/mass spectrometry (GC/MS) method to analyze JP-8. With this method, we have been able to identify primary components of the fuel and determine their concentrations in aerosol, vapor, and neat JP-8. In comparison with other studies, shorter columns, ranging from 10-30 meters, were used allowing much shorter run times. However, their ability to identify certain components becomes limited due to an increased number of coeluents. Our method, which utilizes a 150 meter column, allows reasonable and reproducible resolution for the major components of JP-8.

With the identification and quantification of major components of JP-8, further work can be done in order to determine the concentrations of major JP-8 components in biological and environmental samples. Animal studies can be conducted in an effort to understand the dose-response relationship of JP-8 and this information can then aid in the development of a physiologically-based pharmacokinetic model as well as increase the toxicological assessment of the fuel.

APPENDIX A

PRELIMINARY DATA ACQUIRED FROM TUCSON AUGUST 2003

A trip was made to the University of Arizona in late July 2003 and samples were analyzed in August 2003. During this trip, aerosol samples were collected on glass fiber filters and seven stage cascade impactor plates and vapor samples were collected on charcoal tubes. A personal sampling pump used by the University of Arizona researchers pulled a flow of 2 L/min through the cascade impactor, while a personal sampling pump used by the University of Georgia researchers pulled a flow of 100 mL/min through the glass fiber filter and charcoal tubes. Each stage of the impactor was weighed prior to generating the JP-8 atmosphere. At the end of each chamber run, the plates were again weighed and each stage was placed in a Qorpak vial containing 5 mL of chloroform for extraction. Glass fiber filters and charcoal tubes were treated as described previously. Glass fiber filter and charcoal tube samples were collected at 60 and 15 minutes, while impactor plates were collected at 60 minutes. After extracting with chloroform for one hour, samples were aliquoted into 2 mL GC vials and shipped by to UGA for GC/MS analysis. The following tables summarize the results of the study. For all tables, a * denotes an extrapolated value (a value that lies outside the limits of the standard curve).

Table 1. Calculated JP-8 concentrations of glass fiber filter and charcoal tube samples collected for 60 minutes.

Run Number	1	3	5	7	8
	Calculated Concentration of JP-8 in Chamber (mg/m^3)				
Impactor Plates – Weight	75.83	35.83	42.50	1.67	46.67
Impactor Plates – GC/MS	82.47	40.39	30.42	ND	34.56
Glass Fiber Filter – GC/MS	168.73	63.02*	109.25	ND	90.34
Charcoal Tube – GC/MS	1687.53	1744.54	2030.39	598.55	1619.55
Glass Fiber Filter + Charcoal Tube	1856.26	1807.57	2139.64	598.55	1709.89
Percent Aerosol [a] (%)	9.09	3.49	5.11	0	5.28

[a] Glass fiber filter concentration divided by the sum of charcoal tube and glass fiber filter concentrations
ND = non-detect

Table 2. Calculated JP-8 concentrations of glass fiber filter and charcoal tube samples collected for 15 minutes.

Run Number	2	4	6
	Calculated Concentration of JP-8 in Chamber (mg/m^3)		
Glass Fiber Filter – GC/MS	288.67	303.17	221.67*
Charcoal Tube – GC/MS	2283.58	2749.90	1576.57
Glass Fiber Filter + Charcoal Tube	2572.25	3053.07	1798.24
Percent Aerosol [a] (%)	11.22	9.93	12.33

[a] Glass fiber filter concentration divided by the sum of charcoal tube and glass fiber filter concentrations

Table 3. Compositional analysis of each individual stage of the cascade impactor from Run #1.

Stage 1

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	2142562	2.10*	0.010	1.31	1.72
Undecane	7144490	5.45	0.027	3.41	4.46
Dodecane	10999895	7.28	0.036	4.55	5.95
Tridecane	14462609	9.40	0.047	5.87	7.68
Tetradecane	16581011	9.72	0.049	6.07	7.95
1,6-dimethylnaphthalene	1059006	0.03*	0.000	0.02	0.02
1,2-dimethylnaphthalene	2081170	2.95*	0.015	1.85	2.42
Pentadecane	12567410	6.09	0.030	3.81	4.98
Hexadecane	4056314	2.98*	0.015	1.86	2.44
Total:				**28.75**	

Stage 2

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	3144666	2.66*	0.013	3.33	2.18
Dodecane	5941313	4.18	0.021	5.22	3.42
Tridecane	8305794	5.89	0.029	7.36	4.82
Tetradecane	9673944	6.17	0.031	7.72	5.05
Pentadecane	7654493	3.93	0.020	4.91	3.21
Hexadecane	2288709	2.23*	0.011	2.79	1.82
Total:				**31.33**	

Stage 3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	5244764	4.51	0.023	1.41	3.69
1,2,3-trimethylbenzene	1102860	12.86	0.064	4.02	10.52
Undecane	17368046	12.58	0.063	3.93	10.29
Naphthalene	2189167	0.14*	0.001	0.05	0.12
Dodecane	25599679	16.23	0.081	5.07	13.27
Tridecane	36842582	22.14	0.111	6.92	18.10
Tetradecane	49050291	26.39	0.132	8.25	21.58
2,6-dimethylnaphthalene	4555998	1.23*	0.006	0.38	1.00
1,3-dimethylnaphthalene	5517126	1.39*	0.007	0.43	1.14
1,6-dimethylnaphthalene	3170310	2.08*	0.010	0.65	1.70
1,2-dimethylnaphthalene	7308296	7.97	0.040	2.49	6.52
Pentadecane	39392303	17.88	0.089	5.59	14.62
Hexadecane	14468272	7.39	0.037	2.31	6.04
Heptadecane	2507622	1.28*	0.006	0.40	1.04
Total:				**41.89**	

Stage 4					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Nonane	1269484	1.61*	0.008	0.20	1.32
Mesitylene/2-methylnonane	2139880	0.17*	0.001	0.02	0.14
Pseudocumene	5130053	1.62*	0.008	0.20	1.32
Decane	16361238	13.16	0.066	1.60	10.76
1,2,3-trimethylbenzene	5450858	49.01	0.245	5.98	40.08
Butylcyclohexane	4006440	1.39*	0.007	0.17	1.14
Undecane	52864570	37.32	0.187	4.55	30.52
Naphthalene	7119348	2.08*	0.010	0.25	1.70
Dodecane	78947398	48.94	0.245	5.97	40.03
Tridecane	107172180	62.17	0.311	7.58	50.84
Tetradecane	142201509	74.21	0.371	9.05	60.69
2,6-dimethylnaphthalene	13815615	4.60*	0.023	0.56	3.76
2,7-dimethylnaphthalene	8831143	2.32*	0.012	0.28	1.90
1,3-dimethylnaphthalene	20575517	9.16	0.046	1.12	7.49
1,6-dimethylnaphthalene	12261740	10.90	0.054	1.33	8.91
1,5-dimethylnaphthalene	3267891	0.59*	0.003	0.07	0.48
1,2-dimethylnaphthalene	22883660	22.93	0.115	2.80	18.75
Pentadecane	129767625	57.60	0.288	7.02	47.11
Hexadecane	54425123	24.30	0.122	2.96	19.88
Heptadecane	10899303	4.31	0.022	0.53	3.52
Octadecane	1155204	1.67*	0.008	0.20	1.37
Total:				**52.45**	

Stage 5

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	4314540	3.79	0.019	1.11	3.10
Undecane	16025828	11.64	0.058	3.42	9.52
Naphthalene	1913323	0.04*	0.000	0.01	0.03
Dodecane	24142215	15.34	0.077	4.51	12.54
Tridecane	31656808	19.18	0.096	5.64	15.69
Tetradecane	40435429	21.97	0.110	6.46	17.96
2,6-dimethylnaphthalene	3566413	0.87*	0.004	0.26	0.71
2,7-dimethylnaphthalene	5409519	0.81*	0.004	0.24	0.66
1,3-dimethylnaphthalene	4359166	0.79*	0.004	0.23	0.65
1,6-dimethylnaphthalene	2518821	1.44*	0.007	0.42	1.18
1,2-dimethylnaphthalene	5485426	6.22*	0.031	1.83	5.09
Pentadecane	37494666	17.04	0.085	5.01	13.94
Hexadecane	16452645	8.23	0.041	2.42	6.73
Heptadecane	3242794	1.54*	0.008	0.45	1.26
Total:				**32.03**	

Stage 6

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	1490091	1.59*	0.008	1.99	1.30
Undecane	6336676	4.89	0.024	6.11	4.00
Dodecane	9830951	6.56	0.033	8.20	5.37
Tridecane	12893476	8.50	0.043	10.63	6.95
Tetradecane	15913746	9.38	0.047	11.72	7.67
1,2-dimethylnaphthalene	1943405	2.82*	0.014	3.53	2.31
Pentadecane	16651341	7.88	0.039	9.85	6.45
Hexadecane	10004031	5.50	0.027	6.87	4.49
Heptadecane	3373428	1.59*	0.008	1.99	1.30
Total:				**60.89**	

Stage 7

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Dodecane	1208423	1.28*	0.006	6.38	1.04
Tridecane	1726498	2.15*	0.011	10.73	1.75
Tetradecane	2483790	2.48*	0.012	12.41	2.03
Pentadecane	2678159	1.74*	0.009	8.71	1.42
Hexadecane	902313	1.64*	0.008	8.21	1.34
Total:				**46.44**	

Table 4. Compositional analysis of each individual stage of the cascade impactor from Run #3.

Stage 1					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Dodecane	1447970	1.42*	0.01	7.11	1.16
Tridecane	2304968	2.47*	0.01	12.37	2.02
Tetradecane	4858547	3.70	0.02	18.51	3.03
Pentadecane	5242092	2.87*	0.01	14.34	2.35
Hexadecane	1732862	1.99*	0.01	9.97	1.63
Total:				**62.31**	
Stage 2					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	910079	1.11*	0.01	2.77	0.91
Dodecane	1596133	1.51*	0.01	3.78	1.24
Tridecane	2952843	2.84*	0.01	7.11	2.33
Tetradecane	5891576	4.23	0.02	10.58	3.46
Pentadecane	6059276	3.23	0.02	8.07	2.64
Hexadecane	1968964	2.09*	0.01	5.24	1.71
Total:				**37.54**	
Stage 3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	2439532	2.17*	0.01	2.72	1.78
Dodecane	3864761	2.90*	0.01	3.63	2.38
Tridecane	6333638	4.77	0.02	5.96	3.90
Tetradecane	13195335	7.98	0.04	9.98	6.53
Pentadecane	14665705	7.01	0.04	8.76	5.73
Hexadecane	5580891	3.62	0.02	4.53	2.96
Total:				**35.58**	

Stage 4					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	4646151	4.05	0.02	1.01	3.31
Undecane	14570455	10.63	0.05	2.66	8.69
Naphthalene	2031518	0.08*	0.00	0.02	0.07
Dodecane	21453066	13.69	0.07	3.42	11.20
Tridecane	35638373	21.45	0.11	5.36	17.54
Tetradecane	66517112	35.36	0.18	8.84	28.91
2,6-dimethylnaphthalene	5344910	1.51*	0.01	0.38	1.24
2,7-dimethylnaphthalene	8470194	2.16*	0.01	0.54	1.77
1,3-dimethylnaphthalene	6746782	2.03*	0.01	0.51	1.66
1,6-dimethylnaphthalene	3599515	2.49*	0.01	0.62	2.04
Pentadecane	73293158	32.78	0.16	8.19	26.81
Hexadecane	30763307	14.29	0.07	3.57	11.68
Heptadecane	6392075	2.68*	0.01	0.67	2.19
Total:				**35.80**	

Stage 5					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	3638767	3.26	0.02	1.16	2.67
Undecane	11401798	8.42	0.04	3.01	6.89
Dodecane	16133695	10.43	0.05	3.72	8.53
Tridecane	25908283	15.91	0.08	5.68	13.01
Tetradecane	46507176	25.08	0.13	8.96	20.51
2,6-dimethylnaphthalene	3554126	0.86*	0.00	0.31	0.71
2,7-dimethylnaphthalene	5780818	0.98*	0.00	0.35	0.80
1,3-dimethylnaphthalene	4576556	0.90*	0.00	0.32	0.74
1,6-dimethylnaphthalene	2434942	1.36*	0.01	0.49	1.11
1,2-dimethylnaphthalene	7013259	7.69	0.04	2.75	6.29
Pentadecane	56177573	25.26	0.13	9.02	20.65
Hexadecane	28836195	13.47	0.07	4.81	11.02
Heptadecane	6756551	2.81*	0.01	1.00	2.30
Total:				**41.58**	

Stage 6					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	1196633	1.31*	0.01	3.27	1.07
Dodecane	2020946	1.77*	0.01	4.43	1.45
Tridecane	3373072	3.08	0.02	7.71	2.52
Tetradecane	6525918	4.56	0.02	11.39	3.73
Pentadecane	8313714	4.22	0.02	10.55	3.45
Hexadecane	5367132	3.53	0.02	8.83	2.89
Heptadecane	1871715	1.05*	0.01	2.61	0.86
Total:				**48.79**	
Stage 7--Non-detectable					

Table 5. Compositional analysis of each individual stage of the cascade impactor from Run #5.

Stage 1					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	3362074	2.82*	0.01	3.52	2.30
Dodecane	7355907	5.05	0.03	6.31	4.13
Tridecane	11232794	7.56	0.04	9.45	6.18
Tetradecane	14605578	8.71	0.04	10.88	7.12
1,2-dimethylnaphthalene	1745497	2.63*	0.01	3.29	2.15
Pentadecane	12579480	6.09	0.03	7.62	4.98
Hexadecane	4197799	3.04*	0.02	3.80	2.48
Total:				**44.86**	
Stage 2					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	2956267	2.53*	0.01	2.11	2.07
Dodecane	6352051	4.43	0.02	3.69	3.62
Tridecane	9492262	6.57	0.03	5.47	5.37
Tetradecane	12289198	7.52	0.04	6.26	6.15
1,2-dimethylnaphthalene	1368847	2.27*	0.01	1.89	1.86
Pentadecane	10367812	5.12	0.03	4.27	4.19
Hexadecane	3215388	2.62*	0.01	2.19	2.14
Total:				**25.88**	

Stage 3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	3593387	2.98*	0.01	1.65	2.43
Dodecane	9170348	6.16	0.03	3.42	5.04
Tridecane	13680251	8.95	0.04	4.97	7.32
Tetradecane	18956370	10.94	0.05	6.08	8.95
1,6-dimethylnaphthalene	947673	0.84*	0.00	0.46	0.68
1,2-dimethylnaphthalene	2377018	3.24*	0.02	1.80	2.65
Pentadecane	17959496	8.46	0.04	4.70	6.92
Hexadecane	6608679	4.06	0.02	2.25	3.32
Heptadecane	1023746	0.74*	0.00	0.41	0.60
Total:				**25.75**	

Stage 4

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	2691871	2.35*	0.01	0.84	1.92
Dodecane	6618983	4.59	0.02	1.64	3.76
Tridecane	10518119	7.15	0.04	2.55	5.85
Tetradecane	15978515	9.41	0.05	3.36	7.70
1,2-dimethylnaphthalene	1898721	2.78*	0.01	0.99	2.27
Pentadecane	16095621	7.64	0.04	2.73	6.25
Hexadecane	6049124	3.82	0.02	1.36	3.13
Total:				**13.48**	

Stage 5

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	817418	1.07*	0.01	0.36	0.87
Undecane	5812571	4.52	0.02	1.51	3.70
Dodecane	13812219	9.00	0.05	3.00	7.36
Tridecane	21085064	13.17	0.07	4.39	10.77
Tetradecane	32779095	18.04	0.09	6.01	14.75
2,6-dimethylnaphthalene	2636135	0.53*	0.00	0.18	0.43
2,7-dimethylnaphthalene	4042724	0.21*	0.00	0.07	0.17
1,3-dimethylnaphthalene	3185881	0.19*	0.00	0.06	0.15
1,6-dimethylnaphthalene	1723984	0.67*	0.00	0.22	0.55
1,2-dimethylnaphthalene	4490886	5.27*	0.03	1.76	4.31
Pentadecane	36548335	16.63	0.08	5.54	13.60
Hexadecane	17082309	8.49	0.04	2.83	6.95
Heptadecane	3659900	1.69*	0.01	0.56	1.38
Total:				**26.49**	

Stage 6					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Dodecane	2534141	2.09*	0.01	3.48	1.71
Tridecane	5320561	4.19	0.02	6.99	3.43
Tetradecane	9360208	6.01	0.03	10.02	4.92
Pentadecane	11990507	5.83	0.03	9.72	4.77
Hexadecane	6537191	4.03	0.02	6.71	3.29
Heptadecane	1693898	0.98*	0.00	1.64	0.80
Total:				**38.56**	
Stage 7--Non-detectable					

Table 6. Compositional analysis of each individual stage of the cascade impactor from Run #8.

Stage 1					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	4024623	3.28*	0.02	2.05	2.68
Dodecane	9039350	6.08	0.03	3.80	4.97
Tridecane	12931890	8.52	0.04	5.33	6.97
Tetradecane	15288802	9.06	0.05	5.66	7.41
1,2-dimethylnaphthalene	1627212	2.52*	0.01	1.57	2.06
Pentadecane	12205709	5.93	0.03	3.71	4.85
Hexadecane	3808116	2.87*	0.01	1.80	2.35
Total:				**23.91**	
Stage 2					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	3899268	3.19*	0.02	1.99	2.61
Dodecane	8325462	5.64	0.03	3.52	4.61
Tridecane	11874468	7.92	0.04	4.95	6.48
Tetradecane	14687103	8.75	0.04	5.47	7.15
1,2-dimethylnaphthalene	1511403	2.41*	0.01	1.50	1.97
Pentadecane	12337971	5.99	0.03	3.74	4.90
Hexadecane	4063845	2.98*	0.01	1.86	2.44
Total:				**23.05**	

Stage 3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	6501631	5.00	0.03	2.27	4.09
Dodecane	14259774	9.28	0.05	4.22	7.59
Tridecane	19772934	12.42	0.06	5.64	10.16
Tetradecane	26053291	14.58	0.07	6.63	11.93
2,6-dimethylnaphthalene	1836122	0.24*	0.00	0.11	0.19
1,6-dimethylnaphthalene	1344576	0.30*	0.00	0.14	0.25
1,2-dimethylnaphthalene	3306332	4.13*	0.02	1.88	3.38
Pentadecane	23304210	10.81	0.05	4.91	8.84
Hexadecane	8550128	4.88	0.02	2.22	3.99
Heptadecane	1329200	0.85*	0.00	0.39	0.69
Total:				**28.41**	

Stage 4					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	6565049	5.05	0.03	2.29	4.13
Dodecane	13967733	9.10	0.05	4.14	7.44
Tridecane	19693699	12.37	0.06	5.62	10.12
Tetradecane	25456076	14.28	0.07	6.49	11.67
2,6-dimethylnaphthalene	1543944	0.13*	0.00	0.06	0.11
1,6-dimethylnaphthalene	1351860	0.31*	0.00	0.14	0.26
1,2-dimethylnaphthalene	3272484	4.10*	0.02	1.86	3.35
Pentadecane	24483168	11.33	0.06	5.15	9.26
Hexadecane	9480807	5.27	0.03	2.40	4.31
Heptadecane	1493443	0.91*	0.00	0.41	0.74
Total:				**28.57**	

Stage 5					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	1953308	1.95*	0.01	0.65	1.60
Undecane	11975388	8.82	0.04	2.94	7.21
Dodecane	1417566	1.40*	0.01	0.47	1.15
Tridecane	2410890	2.54*	0.01	0.85	2.07
Tetradecane	37622282	20.52	0.10	6.84	16.78
2,6-dimethylnaphthalene	3272297	0.76*	0.00	0.25	0.62
2,7-dimethylnaphthalene	4937889	0.60*	0.00	0.20	0.49
1,3-dimethylnaphthalene	3792429	0.50*	0.00	0.17	0.41
1,6-dimethylnaphthalene	1962415	0.90*	0.00	0.30	0.74
1,2-dimethylnaphthalene	5060880	5.81*	0.03	1.94	4.76
Pentadecane	41344468	18.74	0.09	6.25	15.32
Hexadecane	20902756	10.11	0.05	3.37	8.27
Heptadecane	4592644	2.03*	0.01	0.68	1.66
Total:				**24.90**	
Stage 6					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Dodecane	2228618	1.90*	0.01	4.75	1.55
Tridecane	2862476	2.79*	0.01	6.98	2.28
Tetradecane	3654181	3.08*	0.02	7.71	2.52
Pentadecane	4957772	2.74*	0.01	6.86	2.24
Hexadecane	3373682	2.69*	0.01	6.72	2.20
Heptadecane	936889	0.71*	0.00	1.77	0.58
Total:				**34.79**	
Stage 7--Non-detectable					

Table 7. Individual component data for impactor plates (all areas from each stage summed together).

Run #1					
Total Concentration in Air: 75.83 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Nonane	1269484	1.61*	0.01	0.09	0.07
Decane	29823198	23.63	0.12	1.30	0.98
Undecane	102884276	72.18	0.36	3.97	3.01
Naphthalene	11221838	3.69*	0.02	0.20	0.15
Dodecane	156669874	96.60	0.48	5.31	4.03
Tridecane	213059947	122.45	0.61	6.73	5.10
Tetradecane	276339720	143.08	0.72	7.86	5.96
2,6-dimethylnaphthalene	23002982	7.94	0.04	0.44	0.33
2,7-dimethylnaphthalene	21143295	7.74	0.04	0.43	0.32
1,3-dimethylnaphthalene	33375204	15.77	0.08	0.87	0.66
1,6-dimethylnaphthalene	19009877	18.36	0.09	1.01	0.77
1,2-dimethylnaphthalene	39701957	39.07	0.20	2.15	1.63
Pentadecane	246205997	108.78	0.54	5.98	4.53
Hexadecane	102597407	44.70	0.22	2.46	1.86
Heptadecane	20023147	7.60	0.04	0.42	0.32
Octadecane	1155204	1.67*	0.01	0.09	0.07
Total:				**39.28**	
Run #3					
Total Concentration in Air: 35.83 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	8284918	6.88	0.03	0.80	0.29
Undecane	30518497	21.74	0.11	2.53	0.91
Naphthalene	2031518	0.08*	0.00	0.01	0.00
Dodecane	46516571	29.06	0.15	3.38	1.21
Tridecane	76511174	44.72	0.22	5.20	1.86
Tetradecane	143495664	74.88	0.37	8.71	3.12
2,7-dimethylnaphthalene	14251012	4.70*	0.02	0.55	0.20
1,3-dimethylnaphthalene	11323338	4.39*	0.02	0.51	0.18
1,6-dimethylnaphthalene	6034457	5.77*	0.03	0.67	0.24
1,2-dimethylnaphthalene	19840621	20.01	0.10	2.33	0.83
Pentadecane	163751518	72.54	0.36	8.43	3.02
Hexadecane	74249351	32.70	0.16	3.80	1.36
Heptadecane	15020341	5.80	0.03	0.67	0.24
Total:				**37.59**	

Run #5

Total Concentration in Air: 42.50 mg/m3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	817418	1.07*	0.01	0.10	0.04
Undecane	21811954	15.68	0.08	1.54	0.65
Dodecane	45843649	28.65	0.14	2.81	1.19
Tridecane	60208584	35.44	0.18	3.47	1.48
Tetradecane	103968964	54.58	0.27	5.35	2.27
2,7-dimethylnaphthalene	4042724	0.21*	0.00	0.02	0.01
1,3-dimethylnaphthalene	6140663	1.71*	0.01	0.17	0.07
1,6-dimethylnaphthalene	2671657	2.51*	0.01	0.25	0.10
1,2-dimethylnaphthalene	11880969	12.36	0.06	1.21	0.52
Pentadecane	105541251	46.95	0.23	4.60	1.96
Hexadecane	43690490	19.76	0.10	1.94	0.82
Heptadecane	6377544	2.67*	0.01	0.26	0.11
Total:				**21.72**	

Run #7

Total Concentration in Air: 0 mg/m^3

Sample Non-detectable

Run #8

Total Concentration in Air: 46.67 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	1953308	1.95*	0.01	0.17	0.08
Undecane	32965959	23.45	0.12	2.09	0.98
Dodecane	69309188	43.03	0.22	3.84	1.79
Tridecane	94885053	55.18	0.28	4.93	2.30
Tetradecane	122761735	64.23	0.32	5.73	2.68
2,7-dimethylnaphthalene	10474991	3.04*	0.02	0.27	0.13
1,3-dimethylnaphthalene	10053765	3.73*	0.02	0.33	0.16
1,6-dimethylnaphthalene	4658851	4.44*	0.02	0.40	0.18
1,2-dimethylnaphthalene	14778311	15.14	0.08	1.35	0.63
Pentadecane	118633298	52.71	0.26	4.71	2.20
Hexadecane	50179334	22.51	0.11	2.01	0.94
Heptadecane	8352176	3.39	0.02	0.30	0.14
Total:				**26.14**	

Avg % Mass: 24.95

Table 8. Individual component data for glass fiber filter samples collected for one hour.

Run #1					
Total Concentration in Air: 168.73 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	1664853	1.73*	0.01	0.84	1.41
Undecane	8734348	6.56	0.03	3.18	5.36
Dodecane	15319605	9.93	0.05	4.82	8.11
Tridecane	21824437	13.59	0.07	6.60	11.10
Tetradecane	31316480	17.28	0.09	8.39	14.12
2,7-dimethylnaphthalene	4164583	0.26*	0.00	0.13	0.22
1,6-dimethylnaphthalene	1774582	1.64*	0.01	0.80	1.34
1,2-dimethylnaphthalene	4388299	5.17*	0.03	2.51	4.22
Pentadecane	30175200	13.83	0.07	6.71	11.30
Hexadecane	13060715	6.79	0.03	3.30	5.55
Total:				**37.27**	
Run #3					
Total Concentration in Air: 63.02 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Dodecane	970622	1.13*	0.01	1.45	0.92
Tridecane	1832297	2.21*	0.01	2.83	1.80
Tetradecane	4469212	3.50	0.02	4.49	2.86
Pentadecane	6772953	3.54	0.02	4.54	2.89
Hexadecane	3245674	2.63*	0.01	3.38	2.15
Total:				**16.68**	
Run #5					
Total Concentration in Air: 109.25 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	3789131	3.11*	0.02	2.32	2.54
Dodecane	10073177	6.71	0.03	5.01	5.48
Tridecane	15837418	10.18	0.05	7.60	8.32
Tetradecane	20750356	11.86	0.06	8.85	9.69
1,6-dimethylnaphthalene	1024847	0.91*	0.00	0.68	0.74
1,2-dimethylnaphthalene	2756696	3.60*	0.02	2.69	2.94
Pentadecane	20808949	9.71	0.05	7.25	7.93
Hexadecane	8810267	4.99	0.02	3.72	4.08
Total:				**38.12**	

Run #7					
Estimated Concentration in Air: 0 mg/m^3					
Sample Non-detectable					
Run #8					
Total Concentration in Air: 90.34 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	1500112	1.52*	0.01	1.38	1.24
Dodecane	6488685	4.51	0.02	4.10	3.69
Tridecane	11599608	7.77	0.04	7.06	6.34
Tetradecane	16022670	9.43	0.05	8.58	7.71
Pentadecane	15984173	7.59	0.04	6.90	6.20
Hexadecane	6707229	4.10	0.02	3.73	3.35
Total:				**31.75**	
Avg % Mass: 24.76					

Table 9. Individual component data for charcoal tube samples collected for one hour.

Run #1						
Total Concentration in Air: 1687.53 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	76350084	90.50	0.09	0.10	1.00	14.79
2-methylheptane/toluene	245961193	207.52	0.21	0.24	2.30	33.91
Octane	394289595	391.61	0.39	0.45	4.33	63.99
Ethylbenzene	277437960	211.22	0.21	0.24	2.34	34.51
m-xylene/p-xylene	704995397	191.16	0.19	0.22	2.11	31.23
Nonane	1089270483	942.45	0.94	1.08	10.42	153.99
Proylcyclohexane	483466209	334.98	0.33	0.38	3.71	54.74
Propylbenzene	138736364	123.15	0.12	0.14	1.36	20.12
3-ethyltoluene	537371466	326.19	0.33	0.37	3.61	53.30
2-methylnonane/mesitylene	545685667	414.33	0.41	0.47	4.58	67.70
2-ethyltoluene	218659250	124.98	0.12	0.14	1.38	20.42
Pseudocumene	826419739	409.42	0.41	0.47	4.53	66.90
Decane	1528609868	1189.42*	1.19	1.36	13.16	194.35
Butylcyclohexane	378366986	233.93	0.23	0.27	2.59	38.22
Undecane	1254831132	875.09	0.88	1.00	9.68	142.99
Naphthalene	60404943	22.99	0.02	0.03	0.25	3.76
Dodecane	460255518	282.76	0.28	0.32	3.13	46.20
Tridecane	142192792	82.11	0.08	0.09	0.91	13.42
Tetradecane	45505458	24.57	0.02	0.03	0.27	4.01
2,7-dimethylnaphthalene	6541351	1.31*	0.00	0.00	0.01	0.21
1,6-dimethylnaphthalene	2872696	2.70*	0.00	0.00	0.03	0.44
1,2-dimethylnaphthalene	5269488	6.02*	0.01	0.01	0.07	0.98
Pentadecane	8732822	4.40	0.00	0.01	0.05	0.72
Total:					**71.82**	

Run #3						
Total Concentration in Air: 1744.54 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	68317723	81.12	0.08	0.09	0.87	13.25
2-methylheptane/toluene	235364967	198.53	0.20	0.23	2.12	32.44
Octane	296727578	294.83	0.29	0.34	3.15	48.18
Ethylbenzene	280163641	213.30	0.21	0.24	2.28	34.85
m-xylene/p-xylene	693149989	187.93	0.19	0.21	2.01	30.71
Nonane	1098413248	950.35	0.95	1.08	10.17	155.29
Propylcyclohexane	479461646	332.20	0.33	0.38	3.55	54.28
Propylbenzene	144319899	128.20	0.13	0.15	1.37	20.95
3-ethyltoluene	548797679	333.17	0.33	0.38	3.56	54.44
2-methylnonane/mesitylene	506676988	384.61	0.38	0.44	4.11	62.84
2-ethyltoluene	220244406	125.91	0.13	0.14	1.35	20.57
Pseudocumene	829080054	410.74	0.41	0.47	4.39	67.11
Decane	1569792257	1221.46*	1.22	1.39	13.07	199.58
Butylcyclohexane	386296331	238.86	0.24	0.27	2.56	39.03
Undecane	1266877625	883.48	0.88	1.01	9.45	144.36
Naphthalene	56602136	21.50	0.02	0.02	0.23	3.51
Dodecane	457781832	281.24	0.28	0.32	3.01	45.95
Tridecane	155351315	89.60	0.09	0.10	0.96	14.64
Tetradecane	55590578	29.75	0.03	0.03	0.32	4.86
2,7-dimethylnaphthalene	10685755	3.13*	0.00	0.00	0.03	0.51
1,3-dimethylnaphthalene	4479587	0.85*	0.00	0.00	0.01	0.14
1,6-dimethylnaphthalene	1879367	1.74*	0.00	0.00	0.02	0.28
1,2-dimethylnaphthalene	5672697	6.40	0.01	0.01	0.07	1.05
Pentadecane	11374241	5.56	0.01	0.01	0.06	0.91
Total:					**68.73**	

Run #5						
Total Concentration in Air: 2030.39 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	70382111	83.53	0.08	0.10	0.77	13.65
2-methylheptane/toluene	256965713	216.86	0.22	0.25	1.99	35.43
Octane	426783267	423.85	0.42	0.48	3.90	69.26
Ethylbenzene	347415899	264.83	0.26	0.30	2.44	43.27
m-xylene/p-xylene	790046537	214.28	0.21	0.24	1.97	35.01
Nonane	1234102066	1067.69*	1.07	1.22	9.82	174.46
Propylcyclohexane	551297885	382.15	0.38	0.44	3.52	62.44
Propylbenzene	171318255	152.66	0.15	0.17	1.40	24.94
3-ethyltoluene	648385349	394.06	0.39	0.45	3.62	64.39
2-methylnonane/mesitylene	604506185	459.15	0.46	0.52	4.22	75.02
2-ethyltoluene	268948307	154.36	0.15	0.18	1.42	25.22
Pseudocumene	1014666424	502.89	0.50	0.57	4.63	82.17
Decane	1819327590	1415.55*	1.42	1.62	13.02	231.30
Butylcyclohexane	468732697	290.06	0.29	0.33	2.67	47.40
Undecane	1577372010	1099.90*	1.10	1.26	10.12	179.72
Naphthalene	80590124	30.91	0.03	0.04	0.28	5.05
Dodecane	597717717	367.05	0.37	0.42	3.38	59.98
Tridecane	195955301	112.71	0.11	0.13	1.04	18.42
Tetradecane	68018106	36.13	0.04	0.04	0.33	5.90
2,6-dimethylnaphthalene	12766819	4.22*	0.00	0.00	0.04	0.69
2,7-dimethylnaphthalene	13042136	4.17*	0.00	0.00	0.04	0.68
1,3-dimethylnaphthalene	14601922	6.08*	0.01	0.01	0.06	0.99
1,6-dimethylnaphthalene	3902796	3.70*	0.00	0.00	0.03	0.61
1,2-dimethylnaphthalene	9296287	9.88	0.01	0.01	0.09	1.61
Pentadecane	12813528	6.20	0.01	0.01	0.06	1.01
Total:					**70.86**	

Run #7						
Total Concentration in Air: 598.55 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	2558596	4.27	0.00	0.00	0.13	0.70
2-methylheptane/toluene	7933057	5.50	0.01	0.01	0.17	0.90
Octane	22502162	22.81	0.02	0.03	0.71	3.73
Ethylbenzene	23710383	16.83	0.02	0.02	0.53	2.75
m-xylene/p-xylene	71345695	18.87	0.02	0.02	0.59	3.08
Nonane	210182540	182.27	0.18	0.21	5.68	29.78
Propylcyclohexane	104894839	71.74	0.07	0.08	2.24	11.72
Propylbenzene	25105267	20.22	0.02	0.02	0.63	3.30
3-ethyltoluene	125002815	74.08	0.07	0.08	2.31	12.10
2-methylnonane/mesitylene	127926241	96.02	0.10	0.11	2.99	15.69
2-ethyltoluene	33681502	16.94	0.02	0.02	0.53	2.77
Pseudocumene	180876509	88.88	0.09	0.10	2.77	14.52
Decane	503059423	391.72	0.39	0.45	12.22	64.01
Butylcyclohexane	127990777	78.41	0.08	0.09	2.45	12.81
Undecane	412092040	287.70	0.29	0.33	8.97	47.01
Naphthalene	16161488	5.63	0.01	0.01	0.18	0.92
Dodecane	118122744	72.97	0.07	0.08	2.28	11.92
Tridecane	27820673	17.00	0.02	0.02	0.53	2.78
Tetradecane	8487311	5.56	0.01	0.01	0.17	0.91
Pentadecane	1827471	1.37*	0.00	0.00	0.04	0.22
Total:					**46.12**	

Run #8						
Total Concentration in Air: 1619.55 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	3232084	5.06	0.01	0.01	0.06	0.83
2-Methylheptane/Toluene	13776280	10.46	0.01	0.01	0.12	1.71
Octane	43720010	43.85	0.04	0.05	0.51	7.17
Ethylbenzene	55714514	41.35	0.04	0.05	0.48	6.76
m-xylene/p-xylene	182908977	49.21	0.05	0.06	0.57	8.04
Nonane	550671184	476.70	0.48	0.54	5.50	77.89
Propylcyclohexane	275621523	190.46	0.19	0.22	2.20	31.12
Propylbenzene	78516068	68.60	0.07	0.08	0.79	11.21
3-ethyltoluene	368495431	222.94	0.22	0.25	2.57	36.43
2-methylnonane/mesitylene	425457633	322.72	0.32	0.37	3.72	52.73
2-ethyltoluene	152672429	86.44	0.09	0.10	1.00	14.12
Pseudocumene	644849922	319.27	0.32	0.36	3.68	52.17
Decane	1525764525	1187.21*	1.19	1.36	13.69	193.99
Butylcyclohexane	397133544	245.59	0.25	0.28	2.83	40.13
Undecane	1548349032	1079.67*	1.08	1.23	12.45	176.42
Naphthalene	73810427	28.25	0.03	0.03	0.33	4.62
Dodecane	592328528	363.74	0.36	0.42	4.19	59.44
Tridecane	182210905	104.89	0.10	0.12	1.21	17.14
Tetradecane	62251454	33.17	0.03	0.04	0.38	5.42
2,7-dimethylnaphthalene	9696848	2.70*	0.00	0.00	0.03	0.44
1,3-dimethylnaphthalene	7898312	2.62*	0.00	0.00	0.03	0.43
1,6-dimethylnaphthalene	2104193	1.96*	0.00	0.00	0.02	0.32
1,2-dimethylnaphthalene	8185494	8.81	0.01	0.01	0.10	1.44
Pentadecane	16297792	7.73	0.01	0.01	0.09	1.26
Total:					**56.54**	
Avg % Mass: 62.81						

Table 10. Individual component data for glass fiber filter samples collected for 15 minutes.

Run #2					
Total Concentration in Air: 288.67 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Dodecane	3827673	2.88*	0.01	3.27	9.42
Tridecane	6827596	5.05	0.03	5.74	16.50
Tetradecane	9656783	6.16	0.03	7.01	20.15
Pentadecane	9016635	4.53	0.02	5.14	14.80
Hexadecane	3249760	2.64*	0.01	3.00	8.62
Total:				**24.16**	
Run #4					
Total Concentration in Air: 303.17 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	879898	1.09*	0.01	1.18	3.55
Dodecane	4283978	3.16*	0.02	3.44	10.33
Tridecane	7781333	5.59	0.03	6.08	18.28
Tetradecane	11095231	6.90	0.03	7.50	22.56
Pentadecane	10948723	5.38	0.03	5.84	17.57
Hexadecane	4163190	3.02*	0.02	3.29	9.88
Total:				**27.33**	
Run #6					
Total Concentration in Air: 221.67 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Tetradecane	896606	1.67*	0.01	2.45	5.45
Pentadecane	1496116	1.22*	0.01	1.80	3.99
Total:				**4.25**	
Avg % Mass: 18.58					

Table 11. Individual component data for charcoal tube samples collected for 15 minutes.

Run #2						
Total Concentration in Air: 2283.58 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	11442251	14.65	0.01	0.02	0.48	9.58
2-methylheptane/toluene	57341383	47.44	0.05	0.05	1.55	31.00
Octane	104040000	103.69	0.10	0.12	3.39	67.77
Ethylbenzene	69880516	52.21	0.05	0.06	1.71	34.12
m-xylene/p-xylene	92038755	24.50	0.02	0.03	0.80	16.01
Nonane	289876707	251.18	0.25	0.29	8.22	164.17
Propycyclohexane	124464219	85.35	0.09	0.10	2.79	55.78
Propylbenzene	33196628	27.55	0.03	0.03	0.90	18.00
3-ethyltoluene	133884755	79.51	0.08	0.09	2.60	51.97
2-Methylnonane/Mesitylene	123373817	92.55	0.09	0.11	3.03	60.49
2-ethyltoluene	40681703	21.02	0.02	0.02	0.69	13.74
Pseudocumene	182436435	89.66	0.09	0.10	2.93	58.60
Decane	424588473	330.69	0.33	0.38	10.82	216.14
n-Butylcyclohexane	99297917	60.58	0.06	0.07	1.98	39.60
Undecane	333671195	233.04	0.23	0.27	7.62	152.31
Naphthalene	12770957	4.30*	0.00	0.00	0.14	2.81
Dodecane	118899102	73.44	0.07	0.08	2.40	48.00
Tridecane	35703277	21.49	0.02	0.02	0.70	14.04
Tetradecane	973360	1.71*	0.00	0.00	0.06	1.12
Pentadecane	1358548	1.16*	0.00	0.00	0.04	0.76
Total:					**52.85**	

Run #4						
Total Concentration in Air: 2749.9 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	12878346	16.33	0.02	0.02	0.44	10.67
2-methylheptane/toluene	72223778	60.07	0.06	0.07	1.63	39.26
Octane	125532629	125.01	0.13	0.14	3.40	81.71
Ethylbenzene	84611727	63.49	0.06	0.07	1.73	41.50
m-xylene/p-xylene	127775603	34.22	0.03	0.04	0.93	22.36
Nonane	344978486	298.83	0.30	0.34	8.12	195.31
Propylcyclohexane	147410418	101.30	0.10	0.12	2.75	66.21
Propylbenzene	40634905	34.28	0.03	0.04	0.93	22.41
3-ethyltoluene	161587254	96.45	0.10	0.11	2.62	63.04
2-Methylnonane/Mesitylene	150932178	113.55	0.11	0.13	3.09	74.21
2-ethyltoluene	63833606	34.55	0.03	0.04	0.94	22.58
Pseudocumene	239765515	118.12	0.12	0.13	3.21	77.21
Decane	498080184	387.85	0.39	0.44	10.54	253.50
n-Butylcyclohexane	116537122	71.29	0.07	0.08	1.94	46.60
Undecane	386561372	269.91	0.27	0.31	7.34	176.41
Naphthalene	17300910	6.08*	0.01	0.01	0.17	3.97
Dodecane	132048190	81.51	0.08	0.09	2.22	53.27
Tridecane	35268125	21.24	0.02	0.02	0.58	13.88
Tetradecane	10220132	6.45	0.01	0.01	0.18	4.22
Pentadecane	1839428	1.37*	0.00	0.00	0.04	0.90
Total:					**52.78**	

Run #6						
Total Concentration in Air: 1576.57 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Heptane	7009456	9.47	0.01	0.01	0.45	6.19
2-methylheptane/toluene	30950480	25.04	0.03	0.03	1.19	16.36
Octane	59475179	59.48	0.06	0.07	2.82	38.88
Ethylbenzene	36717588	26.80	0.03	0.03	1.27	17.52
m-xylene/p-xylene	85745497	22.79	0.02	0.03	1.08	14.90
Nonane	165037559	143.23	0.14	0.16	6.78	93.61
Propylcyclohexane	71879057	48.78	0.05	0.06	2.31	31.88
Propylbenzene	17672056	13.48	0.01	0.02	0.64	8.81
3-ethyltoluene	74313869	43.09	0.04	0.05	2.04	28.16
2-Methylnonane/Mesitylene	70509407	52.27	0.05	0.06	2.48	34.16
2-ethyltoluene	20101300	9.00	0.01	0.01	0.43	5.88
Pseudocumene	96456454	46.97	0.05	0.05	2.22	30.70
Decane	261535101	203.86	0.20	0.23	9.66	133.24
n-Butylcyclohexane	61836773	37.32	0.04	0.04	1.77	24.39
Undecane	220614543	154.24	0.15	0.18	7.31	100.81
Naphthalene	8901198	2.78*	0.00	0.00	0.13	1.82
Dodecane	85013709	52.66	0.05	0.06	2.49	34.42
Tridecane	23721535	14.67	0.01	0.02	0.69	9.59
Tetradecane	5379232	3.97	0.00	0.00	0.19	2.59
Total:					**45.94**	
Avg % Mass: 50.52						

APPENDIX B

PRELIMINARY DATA ACQUIRED FROM TUCSON NOVEMBER 2003

A trip was made to the University of Arizona in November 2003 to collect aerosol and vapor samples from the exposure chamber. During this trip, aerosol samples were collected on glass fiber filters and seven stage cascade impactor plates and vapor samples were collected on charcoal tubes. Sample collection and extraction was carried out as previously described (see Appendix A). However, extraction was carried out on all seven stages of the cascade impactor simultaneously instead of by each individual stage as was previously done. All samples were collected at 60 minutes. After extracting with chloroform for one hour, samples were aliquoted into 2 mL GC vials and shipped by to UGA for GC/MS analysis. The following tables summarize the results of the study. For all tables, a * denotes an extrapolated value (a value that lies outside the limits of the standard curve).

Run Number	1	2	3	4
	Calculated Concentration of JP-8 in Chamber (mg/m^3)			
Impactor Plates – Weight	19.17	49.17	47.50	19.17
Impactor Plates – GC/MS	22.42	47.19	37.06	20.99
Glass Fiber Filter – GC/MS	246.98	1086.13	1610.04	657.05
Charcoal Tube – GC/MS	295.95	902.88	1145.01	518.28
Glass Fiber Filter + Charcoal Tube	542.93	1989.02	2755.05	1175.33
Percent Aerosol [a] (%)	45.49	54.61	58.44	55.90

[a] Glass fiber filter concentration divided by the sum of charcoal tube and glass fiber filter concentrations

Table 2. Individual component data for cascade impactor samples.

Run #1					
Estimated Concentration in Air: 19.17 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	784479	1.04*	0.01	0.23	0.04
Undecane	8085605	6.11	0.03	1.33	0.25
Dodecane	19332535	12.39	0.06	2.69	0.52
Tridecane	37115111	22.29	0.11	4.85	0.93
Tetradecane	57826367	30.89	0.15	6.72	1.29
2,7-dimethylnaphthalene	8424188	2.14*	0.01	0.46	0.09
1,3-dimethylnaphthalene	6467789	1.88*	0.01	0.41	0.08
1,6-dimethylnaphthalene	4242750	4.03*	0.02	0.88	0.17
1,2-dimethylnaphthalene	9873125	10.44	0.05	2.27	0.43
Pentadecane	64021454	28.70	0.14	6.24	1.20
Hexadecane	33863139	15.60	0.08	3.39	0.65
Heptadecane	8736022	3.53	0.02	0.77	0.15
Total:				**30.23**	
Run #2					
Estimated Concentration in Air: 49.17 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	3754950	3.35	0.02	0.28	0.14
Undecane	30859608	21.98	0.11	1.86	0.92
Naphthalene	4603705	1.09*	0.01	0.09	0.05
Dodecane	53314125	33.23	0.17	2.82	1.38
Tridecane	89531512	52.13	0.26	4.42	2.17
Tetradecane	129439522	67.66	0.34	5.73	2.82
2,6-dimethylnaphthalene	15742989	5.30*	0.03	0.45	0.22
2,7-dimethylnaphthalene	10558876	3.08*	0.02	0.26	0.13
1,3-dimethylnaphthalene	23547253	10.70	0.05	0.91	0.45
1,6-dimethylnaphthalene	14409156	13.90	0.07	1.18	0.58
1,2-dimethylnaphthalene	25780678	25.71	0.13	2.18	1.07
Pentadecane	127441061	56.58	0.28	4.79	2.36
Hexadecane	57547246	25.63	0.13	2.17	1.07
Heptadecane	13523217	5.25	0.03	0.45	0.22
Octadecane	1911878	1.98*	0.01	0.17	0.08
Total:				**27.76**	

Run #3

Estimated Concentration in Air: 47.50 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	2123901	2.08*	0.01	0.18	0.09
Undecane	22267532	15.99	0.08	1.40	0.67
Naphthalene	2909627	0.43*	0.00	0.04	0.02
Dodecane	48053799	30.00	0.15	2.63	1.25
Tridecane	69154545	40.53	0.20	3.56	1.69
Tetradecane	99784267	52.44	0.26	4.60	2.18
2,7-dimethylnaphthalene	15563723	5.28*	0.03	0.46	0.22
1,3-dimethylnaphthalene	15386906	6.49	0.03	0.57	0.27
1,6-dimethylnaphthalene	9100234	8.75	0.04	0.77	0.36
1,2-dimethylnaphthalene	18920410	19.12	0.10	1.68	0.80
Pentadecane	110995940	49.35	0.25	4.33	2.06
Hexadecane	54245334	24.23	0.12	2.13	1.01
Heptadecane	13044833	5.08	0.03	0.45	0.21
Octadecane	1875825	1.97*	0.01	0.17	0.08
Total:				**22.96**	

Run #4

Estimated Concentration in Air: 19.17 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	9965474	7.42	0.04	1.61	0.31
Dodecane	23233160	14.78	0.07	3.21	0.62
Tridecane	36715331	22.06	0.11	4.80	0.92
Tetradecane	51410822	27.60	0.14	6.00	1.15
2,7-dimethylnaphthalene	7809554	1.87*	0.01	0.41	0.08
1,3-dimethylnaphthalene	6025980	1.65*	0.01	0.36	0.07
1,6-dimethylnaphthalene	3487453	3.30*	0.02	0.72	0.14
1,2-dimethylnaphthalene	8513914	9.13	0.05	1.98	0.38
Pentadecane	53853825	24.24	0.12	5.27	1.01
Hexadecane	24525040	11.64	0.06	2.53	0.49
Heptadecane	5311807	2.29*	0.01	0.50	0.10
Total:				**27.39**	

Avg % Mass: 27.08

Table 3. Individual component data for glass fiber filter samples.

Run #1					
Estimated Concentration in Air: 246.98 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	1138762	1.32*	0.01	0.41	1.02
Undecane	9089667	6.81	0.03	2.10	5.29
Dodecane	18055490	11.61	0.06	3.58	9.03
Tridecane	25229394	15.52	0.08	4.79	12.07
Tetradecane	30911079	17.08	0.09	5.27	13.28
1,3-dimethylnaphthalene	4047180	0.63*	0.00	0.19	0.49
1,6-dimethylnaphthalene	2348603	2.19*	0.01	0.68	1.71
1,2-dimethylnaphthalene	4779856	5.54*	0.03	1.71	4.31
Pentadecane	28997298	13.31	0.07	4.11	10.35
Hexadecane	12103654	6.39	0.03	1.97	4.97
Heptadecane	2307471	1.20*	0.01	0.37	0.94
Total:				**25.19**	
Run #2					
Estimated Concentration in Air: 1086.13 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	9591586	7.89	0.04	0.55	6.14
n-Butylcyclohexane	2243499	0.30*	0.00	0.02	0.23
Undecane	55405346	39.09	0.20	2.74	30.40
Naphthalene	7859197	2.37*	0.01	0.17	1.84
Dodecane	106327128	65.73	0.33	4.60	51.12
Tridecane	138415041	79.96	0.40	5.60	62.18
Tetradecane	159889873	83.29	0.42	5.83	64.78
2,6-dimethylnaphthalene	20926072	7.18	0.04	0.50	5.59
2,7-dimethylnaphthalene	15118199	5.09*	0.03	0.36	3.95
1,3-dimethylnaphthalene	30941026	14.51	0.07	1.02	11.29
1,6-dimethylnaphthalene	19201033	18.55	0.09	1.30	14.43
1,2-dimethylnaphthalene	29158673	28.95	0.14	2.03	22.52
Pentadecane	132191350	58.67	0.29	4.11	45.63
Hexadecane	54656398	24.40	0.12	1.71	18.98
Heptadecane	12522434	4.89	0.02	0.34	3.81
Octadecane	1512795	1.82*	0.01	0.13	1.41
Total:				**31.00**	

Run #3

Estimated Concentration in Air: 1610.04 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Pseudocumene	2184368	0.16*	0.00	0.01	0.12
Decane	13692280	11.08	0.06	0.52	8.62
n-Butylcyclohexane	3661050	1.18*	0.01	0.06	0.92
Undecane	92405598	64.88	0.32	3.06	50.46
Naphthalene	14949729	5.15	0.03	0.24	4.01
Dodecane	175671329	108.25	0.54	5.11	84.19
Tridecane	224808406	129.14	0.65	6.10	100.43
Tetradecane	256315640	132.80	0.66	6.27	103.28
2,6-dimethylnaphthalene	40415453	14.28	0.07	0.67	11.10
2,7-dimethylnaphthalene	30852438	12.01	0.06	0.57	9.34
1,3-dimethylnaphthalene	61822101	30.46	0.15	1.44	23.69
1,6-dimethylnaphthalene	37811416	36.61	0.18	1.73	28.47
1,2-dimethylnaphthalene	58308026	56.94	0.28	2.69	44.28
Pentadecane	212885294	94.14	0.47	4.44	73.21
Hexadecane	90640215	39.64	0.20	1.87	30.83
Heptadecane	17986094	6.87	0.03	0.32	5.34
Octadecane	2519343	2.24*	0.01	0.11	1.74
Total:				**35.21**	

Run #4

Estimated Concentration in Air: 657.05 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Decane	1906251	1.91*	0.01	0.24	1.49
Undecane	21770607	15.65	0.08	1.99	12.17
Naphthalene	2690955	0.34*	0.00	0.04	0.27
Dodecane	47613101	29.73	0.15	3.78	23.12
Tridecane	66943598	39.27	0.20	5.00	30.54
Tetradecane	81795079	43.20	0.22	5.50	33.60
2,7-dimethylnaphthalene	7214097	1.61*	0.01	0.20	1.25
1,3-dimethylnaphthalene	14482479	6.02*	0.03	0.77	4.68
1,6-dimethylnaphthalene	8891917	8.54	0.04	1.09	6.65
1,2-dimethylnaphthalene	13996815	14.39	0.07	1.83	11.19
Pentadecane	68214151	30.55	0.15	3.89	23.76
Hexadecane	27176801	12.77	0.06	1.62	9.93
Heptadecane	5548354	2.37*	0.01	0.30	1.85
Total:				**26.25**	

Avg % Mass: 29.41

Table 4. Individual component data for charcoal tube samples.

Run #1						
Estimated Concentration in Air: 295.95 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Nonane	15625330	14.03	0.01	0.02	0.82	2.18
2-Methylnonane/Mesitylene	18190068	12.40	0.01	0.01	0.73	1.93
Pseudocumene	29004831	13.47	0.01	0.02	0.79	2.10
Decane	122678230	95.85	0.10	0.11	5.61	14.91
n-Butylcyclohexane	33445837	19.68	0.02	0.02	1.15	3.06
Undecane	224880034	157.21	0.16	0.18	9.20	24.45
Naphthalene	12997776	4.39	0.00	0.01	0.26	0.68
Dodecane	151634645	93.52	0.09	0.11	5.47	14.55
Tridecane	77998387	45.56	0.05	0.05	2.67	7.09
Tetradecane	34312928	18.82	0.02	0.02	1.10	2.93
2,7-dimethylnaphthalene	7030386	1.53*	0.00	0.00	0.09	0.24
1,2-dimethylnaphthalene	4864406	5.63*	0.01	0.01	0.33	0.88
Pentadecane	7805342	4.00	0.00	0.00	0.23	0.62
Total:					**28.46**	

Run #2						
Estimated Concentration in Air: 902.88 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Nonane	60889604	53.17	0.05	0.06	1.02	8.27
n-Propylcyclohexane	36971575	24.51	0.02	0.03	0.47	3.81
Propylbenzene	10034962	6.57	0.01	0.01	0.13	1.02
3-ethyltoluene	62691775	35.99	0.04	0.04	0.69	5.60
2-Methylnonane/Mesitylene	83238569	61.97	0.06	0.07	1.19	9.64
2-ethyltoluene	19329132	8.55	0.01	0.01	0.16	1.33
Pseudocumene	134153000	65.68	0.07	0.07	1.26	10.22
Decane	452151779	352.13	0.35	0.40	6.77	54.77
n-Butylcyclohexane	127585628	78.16	0.08	0.09	1.50	12.16
Undecane	795982667	555.27	0.56	0.63	10.67	86.37
Naphthalene	52829963	20.02	0.02	0.02	0.38	3.11
Dodecane	462739336	284.28	0.28	0.32	5.46	44.22
Tridecane	175058573	100.82	0.10	0.12	1.94	15.68
Tetradecane	52614113	28.22	0.03	0.03	0.54	4.39
2,7-dimethylnaphthalene	10487036	3.05*	0.00	0.00	0.06	0.47
1,3-dimethylnaphthalene	11811648	4.64*	0.00	0.01	0.09	0.72
1,6-dimethylnaphthalene	3235498	3.06*	0.00	0.00	0.06	0.48
1,2-dimethylnaphthalene	5761554	6.49	0.01	0.01	0.12	1.01
Pentadecane	8636809	4.36	0.00	0.00	0.08	0.68
Total:					**32.61**	

Run #3						
Estimated Concentration in Air: 1145.01 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Nonane	63576236	55.49	0.06	0.06	0.84	8.63
Propylcyclohexane	39110893	26.00	0.03	0.03	0.39	4.04
Propylbenzene	11437521	7.84	0.01	0.01	0.12	1.22
3-ethyltoluene	71527407	41.39	0.04	0.05	0.63	6.44
2-Methylnonane/Mesitylene	97850907	73.10	0.07	0.08	1.11	11.37
2-ethyltoluene	23579836	11.04	0.01	0.01	0.17	1.72
Pseudocumene	166828208	81.91	0.08	0.09	1.24	12.74
Decane	534122433	415.89	0.42	0.47	6.30	64.69
n-Butylcyclohexane	158507707	97.36	0.10	0.11	1.48	15.14
Undecane	1007974715	703.03	0.70	0.80	10.66	109.35
Naphthalene	70029061	26.77	0.03	0.03	0.41	4.16
Dodecane	568509515	349.14	0.35	0.40	5.29	54.31
Tridecane	196608684	113.08	0.11	0.13	1.71	17.59
Tetradecane	53358629	28.60	0.03	0.03	0.43	4.45
2,7-dimethylnaphthalene	8235053	2.06*	0.00	0.00	0.03	0.32
1,6-dimethylnaphthalene	2403353	2.25*	0.00	0.00	0.03	0.35
1,2-dimethylnaphthalene	6810995	7.50	0.01	0.01	0.11	1.17
Pentadecane	9144859	4.58	0.00	0.01	0.07	0.71
Total:					**31.03**	

Run #4						
Estimated Concentration in Air: 518.28 mg/m^3						
Component	Area	Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Nonane	9968733	9.14	0.01	0.01	0.34	1.42
Propylcyclohexane	6837530	3.55*	0.00	0.00	0.13	0.55
3-ethyltoluene	14609197	6.59	0.01	0.01	0.24	1.03
2-Methylnonane/Mesitylene	25330549	17.84	0.02	0.02	0.66	2.78
Pseudocumene	34276806	16.09	0.02	0.02	0.59	2.50
Decane	191806897	149.62	0.15	0.17	5.51	23.27
Butylcyclohexane	55885608	33.62	0.03	0.04	1.24	5.23
Undecane	442535585	308.92	0.31	0.35	11.38	48.05
Naphthalene	26430727	9.66	0.01	0.01	0.36	1.50
Dodecane	264864736	162.95	0.16	0.19	6.00	25.35
Tridecane	100123850	58.16	0.06	0.07	2.14	9.05
Tetradecane	36978318	20.19	0.02	0.02	0.74	3.14
2,6-dimethylnaphthalene	6859878	2.07*	0.00	0.00	0.08	0.32
2,7-dimethylnaphthalene	6736991	1.40*	0.00	0.00	0.05	0.22
1,2-dimethylnaphthalene	6127763	6.84	0.01	0.01	0.25	1.06
Pentadecane	6791783	3.55	0.00	0.00	0.13	0.55
Total:					**29.83**	
Avg % Mass: 30.48						

APPENDIX C

DATA ACQUIRED FROM TUCSON SEPTEMBER 2004

Samples were collected and extracted as previously described. A standard curve was generated for total JP-8 to determine the overall concentration of the samples. Individual component concentrations and percent mass values were also determined. The following tables summarize the data. Charcoal tubes were analyzed at full strength as well as at $1/10^{th}$ of full strength. The data reported for the charcoal tubes is from the diluted samples due to the fact that the full strength samples exceeded the limits of the JP-8 standard curve.

Table 1. Calculated JP-8 concentrations of glass fiber filters and charcoal tubes.

Sample Collection Time (min)	48	40	42.5	20
	Calculated Concentration of JP-8 in Chamber (mg/m^3)			
Glass Fiber Filter – GC/MS	44.16	52.59	191.70	236.95
Charcoal Tube – GC/MS	1561.04	768.50	1822.00	1306.21
Glass Fiber Filter + Charcoal Tube	1605.20	821.09	2013.70	1543.16
Percent Aerosol [a] (%)	2.75	6.41	9.52	15.35

[a] Glass fiber filter concentration divided by the sum of charcoal tube and glass fiber filter concentrations

Table 2. Individual component data for glass fiber filter samples.

Run #1 (48 minutes)					
Total Concentration in Air: 44.16 mg/m^3					
Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	2068821	0.80	0.00	1.85	0.82
Dodecane	3158279	1.01	0.01	2.35	1.04
Tridecane	8198829	2.11	0.01	4.89	2.16
Tetradecane	23746996	5.06	0.03	11.73	5.18
Pentadecane	35979319	6.14	0.03	14.23	6.28
Hexadecane	20325223	3.55	0.02	8.23	3.64
Heptadecane	6441637	1.32	0.01	3.05	1.35
Total:				**42.13**	

Run #2 (20 minutes)

Total Concentration in Air: 236.95 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	6639170	1.99	0.01	2.06	4.89
Dodecane	13626765	3.41	0.02	3.54	8.38
Tridecane	32697778	7.31	0.04	7.58	17.97
Tetradecane	61605751	12.49	0.06	12.96	30.70
Pentadecane	68656845	11.39	0.06	11.81	27.99
Hexadecane	31168881	5.22	0.03	5.42	12.83
Heptadecane	7972254	1.53	0.01	1.59	3.76
Total:				**44.96**	

Run #4 (42.5 minutes)

Total Concentration in Air: 191.70 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	28431638	7.68	0.04	4.07	7.79
Dodecane	36690589	8.70	0.04	4.61	8.83
Tridecane	59268184	12.96	0.06	6.86	13.15
Tetradecane	107816687	21.57	0.11	11.42	21.89
Pentadecane	123906699	20.28	0.10	10.74	20.58
Hexadecane	56385370	9.11	0.05	4.82	9.25
Heptadecane	14036335	2.38	0.01	1.26	2.41
Total:				**43.77**	

Run #5 (40 minutes)

Total Concentration in Air: 52.59 mg/m^3

Component	Area	Conc. (μg/mL)	Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Undecane	3582170	1.19	0.01	2.45	1.29
Dodecane	6810306	1.85	0.01	3.79	1.99
Tridecane	13437270	3.22	0.02	6.61	3.47
Tetradecane	27182221	5.73	0.03	11.76	6.18
Pentadecane	34205501	5.85	0.03	12.00	6.31
Hexadecane	16943516	3.03	0.02	6.21	3.27
Heptadecane	5093103	1.13	0.01	2.31	1.22
Total:				**40.37**	

Avg % Mass: 42.81

Table 3. Individual component data for diluted charcoal tube samples.

Run #1							
Estimated Concentration in Air: 1561.04 mg/m^3							
Component	Area	Conc. (μg/mL)	Full Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Octane	173189222	59.22	592.20	0.59	0.68	8.87	138.42
Ethylbenzene	107233053	24.27	242.67	0.24	0.28	3.63	56.72
m & p-xylene	110561618	12.94	129.36	0.13	0.15	1.94	30.24
o-xylene	69918905	16.83	168.30	0.17	0.19	2.52	39.34
Nonane	310756479	102.55	1025.46	1.03	1.17	15.35	239.68
Proylcyclohexane	126251046	34.41	344.12	0.34	0.39	5.15	80.43
3-ethyltoluene	91891120	18.14	181.39	0.18	0.21	2.72	42.40
2-methylnonane/mesitylene	109523758	13.59	135.90	0.14	0.16	2.03	31.76
Pseudocumene	64078037	12.93	129.32	0.13	0.15	1.94	30.23
Decane	280495015	83.69	836.89	0.84	0.96	12.53	195.61
1,2,3-trimethylbenzene	83311905	17.38	173.75	0.17	0.20	2.60	40.61
Butylcyclohexane	53122606	12.86	128.56	0.13	0.15	1.92	30.05
4-methyldecane	47937772	11.92	119.21	0.12	0.14	1.78	27.86
2-methyldecane	42905636	11.41	114.11	0.11	0.13	1.71	26.67
3-methyldecane	37577192	9.84	98.40	0.10	0.11	1.47	23.00
Undecane	111281923	29.30	292.98	0.29	0.33	4.39	68.48
Dodecane	16414175	4.05	40.50	0.04	0.05	0.61	9.47
Tridecane	4092672	1.24	12.36	0.01	0.01	0.19	2.89
Tetradecane	3967396	1.18	11.75	0.01	0.01	0.18	2.75
Pentadecane	2596647	0.77	7.69	0.01	0.01	0.12	1.80
Total:						**71.64**	

Run#2							
Estimated Concentration in Air: 1306.21 mg/m^3							
Component	Area	Conc. (μg/mL)	Full Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Octane	56696502	19.37	193.72	0.19	0.22	8.32	108.67
Ethylbenzene	29935255	6.92	69.16	0.07	0.08	2.97	38.80
m & p-xylene	22533509	2.77	27.67	0.03	0.03	1.19	15.52
o-xylene	17835840	4.45	44.54	0.04	0.05	1.91	24.98
Nonane	99503648	32.93	329.33	0.33	0.38	14.14	184.74
Propylcyclohexane	39997235	11.03	110.32	0.11	0.13	4.74	61.89
3-ethyltoluene	19650070	4.10	40.98	0.04	0.05	1.76	22.99
2-methylnonane/mesitylene	32402254	4.13	41.27	0.04	0.05	1.77	23.15
Pseudocumene	13307797	2.90	29.04	0.03	0.03	1.25	16.29
Decane	88703903	26.58	265.80	0.27	0.30	11.41	149.10
1,2,3-Trimethylbenzene	14797416	3.31	33.14	0.03	0.04	1.42	18.59
Butylcyclohexane	21795597	5.42	54.16	0.05	0.06	2.33	30.38
4-methyldecane	15928449	4.10	41.03	0.04	0.05	1.76	23.01
2-methyldecane	13994001	3.85	38.53	0.04	0.04	1.65	21.62
3-methyldecane	21417792	5.71	57.06	0.06	0.07	2.45	32.01
Undecane	42704694	11.40	114.02	0.11	0.13	4.90	63.96
Dodecane	14328554	3.57	35.72	0.04	0.04	1.53	20.04
Tridecane	6895521	1.83	18.31	0.02	0.02	0.79	10.27
Tetradecane	3089490	1.00	10.03	0.01	0.01	0.43	5.63
Total:						**66.73**	

Run #4							
Estimated Concentration in Air: 1822.00 mg/m^3							
Component	Area	Conc. (μg/mL)	Full Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc. in Air (mg/m^3)
Octane	187612801	64.15	641.53	0.64	0.73	8.16	148.67
Ethylbenzene	110773462	25.06	250.62	0.25	0.29	3.19	58.08
m & p-xylene	112401741	13.15	131.49	0.13	0.15	1.67	30.47
o-xylene	74587471	17.94	179.39	0.18	0.20	2.28	41.57
Nonane	321127789	105.96	1059.63	1.06	1.21	13.48	245.56
Propylcyclohexane	131670335	35.88	358.81	0.36	0.41	4.56	83.15
3-ethyltoluene	97418205	19.21	192.14	0.19	0.22	2.44	44.53
2-methylnonane/mesitylene	116783765	14.48	144.81	0.14	0.17	1.84	33.56
Pseudocumene	76092831	15.31	153.06	0.15	0.17	1.95	35.47
Decane	310019767	92.48	924.80	0.92	1.06	11.76	214.31
1,2,3-Trimethylbenzene	94786883	19.73	197.30	0.20	0.23	2.51	45.72
Butylcyclohexane	79212701	19.05	190.52	0.19	0.22	2.42	44.15
4-methyldecane	58609258	14.53	145.28	0.15	0.17	1.85	33.67
2-methyldecane	57990265	15.35	153.54	0.15	0.18	1.95	35.58
3-methyldecane	50946419	13.26	132.60	0.13	0.15	1.69	30.73
Undecane	192386486	50.46	504.64	0.50	0.58	6.42	116.94
Dodecane	66499271	15.53	155.30	0.16	0.18	1.98	35.99
Tridecane	24452948	5.56	55.62	0.06	0.06	0.71	12.89
Tetradecane	10947288	2.55	25.46	0.03	0.03	0.32	5.90
Pentadecane	2599420	0.77	7.69	0.01	0.01	0.10	1.78
Total:						**71.28**	

Run #5							
Estimated Concentration in Air: 768.50 mg/m^3							
Component	Area	Conc. (μg/mL)	Full Conc. (μg/mL)	Mass (mg)	Corrected Mass (mg)	Percent Mass (%)	Conc in Air (mg/m^3)
Octane	71612232	24.47	244.74	0.24	0.28	7.84	60.26
Ethylbenzene	39513492	9.07	90.66	0.09	0.10	2.90	22.32
m & p-xylene	37149300	4.46	44.55	0.04	0.05	1.43	10.97
o-xylene	25159484	6.19	61.94	0.06	0.07	1.98	15.25
Nonane	113427622	37.52	375.21	0.38	0.43	12.02	92.39
Propylcyclohexane	46077764	12.68	126.80	0.13	0.14	4.06	31.22
3-ethyltoluene	36341235	7.34	73.42	0.07	0.08	2.35	18.08
2-methylnonane/mesitylene	42535214	5.37	53.70	0.05	0.06	1.72	13.22
Pseudocumene	28200625	5.85	58.46	0.06	0.07	1.87	14.39
Decane	120266117	35.98	359.78	0.36	0.41	11.53	88.59
1,2,3-Trimethylbenzene	35810666	7.63	76.27	0.08	0.09	2.44	18.78
Butylcyclohexane	30164021	7.40	74.04	0.07	0.08	2.37	18.23
4-methyldecane	22531916	5.72	57.16	0.06	0.07	1.83	14.07
2-methyldecane	22025479	5.95	59.53	0.06	0.07	1.91	14.66
3-methyldecane	19737504	5.28	52.76	0.05	0.06	1.69	12.99
Undecane	74580820	19.72	197.21	0.20	0.23	6.32	48.56
Dodecane	25805818	6.20	62.03	0.06	0.07	1.99	15.27
Tridecane	12806812	3.09	30.87	0.03	0.04	0.99	7.60
Tetradecane	6153288	1.60	16.05	0.02	0.02	0.51	3.95
Pentadecane	1640565	0.62	6.15	0.01	0.01	0.20	1.51
Total:						**67.97**	
Avg % Mass: 69.41							