



Service Station Personnel Exposures to Oxygenated Fuel Components - 1994

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Service Station Personnel Exposures to Oxygenated Fuel Components - 1994

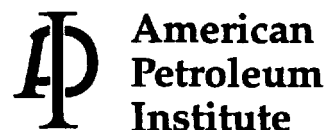
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EXECUTIVE SUMMARY

This study measures service station refueling attendant and mechanic exposures to fuel oxygenate species, selected aromatics and total fuel vapor hydrocarbons during normal activities at service stations dispensing oxyfuels during the winter season and conventional gasoline during the summer of 1994. Sixteen service stations in four geographical areas were selected for inclusion in the study (a seventeenth station [NY3] was monitored for one day during the winter season). Each station was located in a winter CO non-attainment area to assure the presence of oxygenated fuels. The locations included six stations in the northeast (New York City area-NY), three stations in the midwest (Minnesota-MN), four stations in the southwest (Arizona-AZ) and three stations in the northwest (Oregon-OR).

Additional station-specific data recorded during the exposure monitoring included volume of fuel dispensed, station traffic density, meteorology, presence of dispensing pump vapor emission controls, and miscellaneous "notable events" that might be reflected in the measurements. In order to determine the effects of weather conditions and the different seasonal amounts of oxygenate present, the study was conducted in two phases with sampling during the winter (February-April) oxyfuel season and in the summer (July-August) non-oxyfuel season. During each phase, monitoring was usually conducted on at least two people (one mechanic and one refueling attendant) per day per service station over three days. Long-term/shift (generally 8 hours) and short-term/task samples (approximately 15 minutes) were collected during the monitoring. Bulk liquid samples of each dispensed gasoline octane grade were collected at each station. Volatility (Reid Vapor Pressure-RVP), oxygenate speciation and aromatic content of each bulk liquid sample were analyzed.

During the winter, MTBE was detected in fuels at eight of the stations (7 NY and 1 AZ) in approximate amounts ranging from 10-17 wt%. TAME, ranging up to 3.7 wt%, was detected mixed with MTBE in fuels, at four NY stations. Ethanol was detected in the remaining stations' fuels (3 AZ, 3 MN, 3 OR) in amounts ranging from 4.6-10 wt%. During the summer sampling, MTBE was detected in gasoline at seven stations (6 NY, 1 OR) in amounts ranging from

ES-1

0.1-8.8 wt %. TAME (up to 2.2%) was found mixed with MTBE in three of the NY stations. Ethanol was detected in two MN stations in amounts ranging from 9.5-11 wt%. No oxygenates (> 0.1%) were detected in seven of the service stations (4 AZ, 1 MN, 2 OR) during the summer. Neither ETBE nor TBA were detected in liquid fuel samples during either the winter or summer phases of the study.

Four hundred and one personal service station worker exposure samples were collected during the study. This total includes 104 long-term and 120 short-term samples on refueling attendants, 86 long-term and 88 short-term samples on mechanics and 3 short-term samples on truck drivers during bulk fuel deliveries. Samples were evenly split between the winter (200) and summer (201) sampling phases and were analyzed for benzene, toluene, xylene, ethylbenzene, total hydrocarbons, ethanol, MTBE and TAME. Descriptive and distributional statistics were determined for long-/short-term samples of refueling attendant and mechanic exposures. Geometric mean exposures and ranges of exposure were computed by job category, season, fuel component, control technology and sample duration.

LONG-TERM AVERAGE SAMPLES

Long-term sample durations ranged from 93-570 minutes with most sampling durations longer than 6 hours. All individual refueling attendant long-term MTBE exposure concentrations were 0.5 ppm or less. The winter and summer geometric mean (GM) exposures were 0.2 ppm and 0.08 ppm, respectively.

Winter and summer mechanic GM exposures to MTBE were 0.12 ppm and 0.03 ppm, respectively, with only four individual MTBE samples exceeding 0.5 ppm. These four samples (0.63, 0.86, 1.3, 2.6 ppm) were taken during shifts where mechanic duties included fuel line servicing.

Excluding the three outlier samples discussed at pages 1-10 & 1-11, all individual attendant and mechanic long-term benzene values were below 1.2 ppm, with winter and summer GM exposures of 0.06 ppm or less. Only two long-term benzene samples exceeded 1 ppm (1.2, 1.1 ppm) and

only another five exceeded 0.3 ppm. Stage II vapor controls appeared to reduce the winter and summer long-term GM exposures for attendants.

SHORT-TERM AVERAGE SAMPLES

Short-term sample durations ranged between 8-35 minutes with all but 17 sample durations within the 15-20 minute range. Such samples were often taken during tasks thought potentially prone to higher peak exposures, for example, during storage tank gauging by attendants or during repair of automobile fuel systems by mechanics. Individual attendant MTBE samples remained below 2.1 ppm with winter and summer GM exposures of 0.6 ppm and 0.31 ppm, respectively. The GM of all short-term attendant samples was 0.41 ppm. Individual mechanic short-term MTBE exposures ranged up to 32 ppm with winter and summer GM exposures of 1.04 ppm and 0.42 ppm, respectively. The GM of all short-term mechanic MTBE samples was 0.74 ppm.

Individual attendant benzene short-term exposures remained below 0.91 ppm, with winter and summer GM exposures of 0.21 ppm. Although one short-term mechanic benzene sample reached 8.7 ppm, all other values remained below 5 ppm. Winter and summer GM mechanic benzene exposures were 0.29 ppm and 0.22 ppm, respectively. The GM of all short-term mechanic benzene values was 0.25 ppm.

Section 1

SCOPE OF STUDY AND RESULTS

INTRODUCTION

The Clean Air Act Amendments (CAAA) of 1990 mandated the addition of 2.7% oxygen from oxygenated organic species (oxygenates) to automotive fuels during the winter season in areas not attaining the National Ambient Air Quality Standards for carbon monoxide (CO). Oxygenates are added to gasoline to increase the octane rating and minimize incomplete combustion, reducing air pollutants including carbon monoxide and unburned hydrocarbons. Anecdotal reports of health complaints (e.g., headaches, irritation, nausea) allegedly associated with oxyfuel use led to a variety of research efforts in 1993 (EPA, 1995). These included measurements of customer fuel oxygenate additive exposure during commuting (Lioy et al., 1994) and refueling (IT, 1995a). A survey of oil company occupational exposure records (IT, 1995b) provided adequate numbers of exposure measurements for employees in most sectors of the petroleum refining and marketing industry. However, relatively few measurements were available to document the exposure of attendants refueling cars (Hartle, 1993) or auto mechanics repairing vehicles in service stations. This study measured service station refueling attendant and mechanic exposures to oxygenated species [methyl tertiary butyl ether (MTBE), tertiary amyl methyl ether (TAME), ethyl tertiary butyl ether (ETBE), tertiary butyl alcohol (TBA), ethanol (ETOH), selected aromatics (benzene-B, toluene-T, xylenes-X, ethylbenzene-EB) and total hydrocarbons (THC)] during normal activities at service stations dispensing oxyfuels during the winter season and non-oxyfuels during the summer of 1994. Characterizations of dispensed liquid fuel compositions and local meteorology during sampling were also undertaken.

SAMPLING AND ANALYSIS

Personal exposure results are grouped into four categories: refueling attendant long-term, refueling attendant short-term, mechanic long-term and mechanic short-term. Long-term samples were taken to approximate full-shift (8 hour) averaged exposures; sampling durations ranged between 93 and 570 minutes with most durations longer than 6 hours. Short-term samples were taken to approximate peak exposures and ranged between 8 and 35 minutes with most sample durations within the 15-20 minute range.

The long-term and short-term samples were often collected concurrently. Therefore, if a significant exposure occurred during a specific task or special event, such as during carburetor repair or a fuel spill, the exposure is also included within the full-shift sample for those individuals also undergoing full-shift sampling. Table 1-1 presents the numbers of samples collected during the Winter Phase from mid-February to mid-April and during the Summer Phase from mid-July to mid-August. The air samples were collected according to the method described in Appendix H. Following collection the samples were shipped to the analytical laboratory for analysis according to the methods described in Appendix I.

During both Winter and Summer sampling studies, there were a few cases when data from two employees were combined to represent an approximate 8-hour full-shift exposure. These cases resulted when the first employee completed a partial shift and was relieved by a second employee or, in a couple of cases, declined to participate during the second part of the day. In most cases, the sampling pump was transferred to a second station employee who completed the shift and a second sampling tube was attached to the second employee. Each set of these samples was combined in a time-weighted manner prior to use in statistical calculations to generate a full-shift equivalent exposure that was comparable with other data. In several other cases, a single sampling tube was used to measure the exposure of two employees. After completing the sampling on the first employee, the same sampling train was transferred to the second employee for the remainder of the shift.

During the Winter Phase, 95 long-term exposures and 105 short-term exposures were sampled. One of the long-term exposures, represented by samples AZ4-02A & AZ4-07A, was measured using consecutive samples collected on two employees. During the Summer Phase, 95 long-term exposures and 106 short-term exposures were sampled. Four of the long-term exposure measurements, represented by samples AZ1S-13A & -20A, AZ1S-15A & -19A, AZ3S-15A & -19A and AZ4S-01A & -07A were measured using consecutive samples collected on two employees. Although 16 stations were initially included in the study, a seventeenth station was sampled during the Winter Phase. After arriving at NY3, it was discovered that no mechanic was working there. A nearby station (NY9), owned by the proprietor, was identified and the second and third day of sampling were conducted there.

TABLE 1-1

NUMBER OF PERSONAL EXPOSURES MONITORED DURING WINTER PHASE						
Geographic Area	Total	Refueling Attendant		Mechanic		Drivers ^c
		Long-Term	Short-Term	Long-Term	Short-Term	Short-Term
Southwest ^a	73	13	24	12	24	0
Midwest ^b	23	9	3	9	2	0
Northeast ^c	55	18	11	17	7	2
Northwest ^d	49	11	21	6	11	0
TOTAL	200	51	59	44	44	2

NUMBER OF PERSONAL EXPOSURES MONITORED DURING SUMMER PHASE						
Geographic Area	Total	Refueling Attendant		Mechanic		Drivers ^c
		Long-Term	Short-Term	Long-Term	Short-Term	Short-Term
Southwest ^a	73	12	24	12	25	0
Midwest ^b	24	9	2	9	4	0
Northeast ^c	60	19	16	16	8	1
Northwest ^d	44	13	19	5	7	0
TOTAL	201	53	61	42	44	1

^a 4 Service Stations in Arizona

^b 3 Service Stations in Minnesota

^c In the winter, 7 Service Stations; 5 stations in Northern New Jersey and 2 in Connecticut. In the summer, 6 service stations; 4 stations in Northern New Jersey and 2 in Connecticut.

^d 3 Service Stations in Oregon

^e 3 truck drivers were monitored during bulk fuel deliveries. The results of these samples are not included in the statistical analysis.

OXYGENATE AND AROMATIC CONTENT OF BULK LIQUID FUELS

At each station, two samples of each octane grade of dispensed gasoline were collected. One bulk sample set was submitted to determine volatility by determining the Reid Vapor Pressure (RVP). The second set was initially analyzed by mass spectrophotometry (MS) to identify the species of oxygenate and the aromatic content and subsequently analyzed by gas chromatography (GC) to determine the percentage of each component. Table 1-2 summarizes the Winter and Summer data on oxygenate content. The bulk analysis data is presented in Appendix A.

The bulk sample analysis was used to determine which oxygenates were present and which should be subject to analysis in the air samples. Although the percent of the oxygenate was measured, the purpose of this analysis was only to determine which oxygenate was present. Since the oxygenates are more volatile than the remainder of the gasoline, this analysis should not be considered a definitive quantitative indicator of the amount of oxygenate which had been added to the fuel. In two cases during the Winter Phase, OR1 (88 octane) and MN2 (92 octane), the bulk sample submitted to the laboratory had leaked into the shipment case. However, a sufficient quantity of fuel remained to conduct the GC/MS analysis. The loss of part of the sample may have affected the character of the sample. Although 16 stations were initially included in the study, an additional station was added (as discussed on page 1-2) and a bulk sample was analyzed from this station during the Winter Phase.

TABLE 1-2

Service Stations	Bulk Liquid Samples - Oxygenate Content (%) Winter Phase ^a		
	Ethanol	MTBE	TAME
AZ-1	6.7 - 7.6	ND ^b	ND
AZ-2	ND	11 - 12	ND
AZ-3	7.2 - 8.0	ND	ND
AZ-4	8.4 - 8.7	ND	ND
MN-2	10	ND	ND
MN-3	6.6 - 7.1	ND	ND
MN-4	6.2 - 7.3	ND	ND
NY-1	ND	11 - 14	1.4 - 3.7
NY-2	ND	10 - 13	<0.12 - 3.4
NY-3	ND	14 - 16	ND
NY-4	ND	14 - 17	ND
NY-6	ND	13 - 15	<0.11 - 1.1
NY-7	ND	12 - 13	<0.11 - 0.52
NY-9	ND	13 - 14	ND
OR-1	6.4 - 7.4	ND	ND
OR-2	6.9 - 7.1	ND	ND
OR-3	4.6 - 8.2	ND	ND

Service Stations	Bulk Liquid Samples - Oxygenate Content (%) Summer Phase ^a		
	Ethanol	MTBE	TAME
AZ-1S	ND	ND ^b	ND
AZ-2S	ND	ND	ND
AZ-3S	ND	ND	ND
AZ-4S	ND	ND	ND
MN-2S	9.5 - 9.7	ND	ND
MN-3S	ND	ND	ND
MN-4S	10 - 11	ND	ND
NY-1S	ND	0.1 - 5.2	<0.1 - 0.30
NY-2S	ND	<0.1 - 8.8	<0.1 - 1.0
NY-4S	ND	<0.1 - 1.3	ND
NY-6S	ND	<0.1 - 0.97	ND
NY-7S	ND	<0.1 - 3.3	ND
NY-9S	ND	0.34 - 1.7	<0.1 - 2.2
OR-1S	ND	ND	ND
OR-2S	ND	<0.1 - 0.71	ND
OR-3S	ND	ND	ND

^a % denotes percent by weight^b ND denotes "not detected" at a limit of 0.1%

For the Winter Phase, the bulk fuel analysis identified fuels from nine service stations which contained ethanol and fuels from eight service stations which contained MTBE. In addition to ethanol and MTBE, the fuels of three service stations contained TAME in relatively low amounts ($<0.11 - 3.7\%$). Where TAME was detected, MTBE was the main oxygenate present.

The results of the bulk fuel analysis for the Summer Phase identified fuels from two service stations which contained ethanol and fuels from seven service stations which contained MTBE. Again, fuels from three service stations contained TAME in relatively low amounts ($<0.1 - 2.2\%$). Where TAME was detected, MTBE was the main oxygenate present.

As expected with the end of the winter CO oxyfuel program, generally lower oxygenate concentrations and fewer numbers of stations with oxygenated fuels were present in the summer months, although ethanol levels in gasohol fuels increased. Oxygenates are used during the summer season to increase fuel octane.

The results of the aromatic analyses are summarized by geographical area in Table 1-3. The complete bulk analysis data is provided as Appendix A. Oxygenates and aromatic components detected in the bulk liquid fuels were assayed in the air samples with the exception of p-xylene, which is included in the total xylene result.

TABLE 1-3

Geographic Area	Bulk Liquid Samples - Aromatic Content (%) Winter Phase ^a				
	B	T	EB	X	p-X
Southwest	0.95 - 2.7	5.4 - 11	1.5 - 2.6	6.6 - 12	1.8 - 3.0
Midwest	0.79 - 3.2	7.5 - 11	1.3 - 2.4	6.0 - 12	1.7 - 3.0
Northeast	0.57 - 2.4	3.2 - 13	0.93 - 2.6	5.8 - 13	1.4 - 3.9
Northwest	0.24 - 3.5	7.1 - 18	1.5 - 3.2	7.0 - 15	1.9 - 3.8

Geographic Area	Bulk Liquid Samples - Aromatic Content (%) Summer Phase ^a				
	B	T	EB	X	p-X
Southwest	1.3 - 2.7	7.0 - 14	1.8 - 3.5	9.8 - 16	2.6 - 4.5
Midwest	0.29 - 1.9	6.7 - 8.7	0.64 - 2.0	2.2 - 9.7	0.63- 2.7
Northeast	0.75 - 2.2	5.7 - 17	1.3 - 4.0	7.2 - 16	2.1 - 4.9
Northwest	1.8 - 3.0	5.2 - 11	1.4 - 2.6	8.1 - 12	2.2 - 3.5

^a % denotes percent by weight

METEOROLOGICAL CONDITIONS

Meteorological conditions including temperature, wind speed, wind direction, relative humidity and barometric pressure were recorded at each station on each day of the study. An electronic weather station was set up on the service station property. Temperature and relative humidity measurements were recorded both inside (T_i , H_i) near the mechanic and outside (T_o , H_o) near the refueling attendants. For the outside measurements, the temperature and relative humidity probes were placed out of direct sunlight (a radiant energy source). The

windspeed and direction were recorded, as was the average barometric pressure (inches of mercury). Barometric pressures during the winter phase were obtained from the National Weather Service for the date and location of sampling. During the summer sampling phase the barometric pressure was recorded on site. The meteorological data are summarized in Table 1-4. The daily averages are presented in Appendix B.

NATLSCO staff also noted the type and quantity of precipitation (rain and snow) during the study. Early in the study, NATLSCO was requested to discontinue air sampling if heavy

TABLE 1-4

SUMMARY OF METEOROLOGICAL DATA WINTER PHASE						
Geographic Area	Date	Temperature (°F)		% RH		Wind Speed (MPH)
		Inside	Outside	Inside	Outside	
Southwest	2/17-26	45-90	44-79	13-45	17-57	0-11
Midwest	2/15-24	30-88	10-51	20-56	28-78	0-18
Northeast	2/21-4/14	39-87	30-81	19-81	19-93	0-16
Northwest	2/14-24	38-73	37-62	28-85	37-84	0-10
SUMMARY OF METEOROLOGICAL DATA SUMMER PHASE						
Geographic Area	Date	Temperature (°F)		% RH		Wind Speed (MPH)
		Inside	Outside	Inside	Outside	
Southwest	7/11-23	84-110	80-112	21-61	16-75	0-6
Midwest	7/19-28	66-103	61-96	26-72	28-92	0-10
Northeast	7/20-8/18	67-92	63-97	38-83	28-100	0-6
Northwest	8/8-17	68-102	61-97	21-58	17-71	0-8

precipitation (rain or snow) occurred. The only instance where this affected the study was during sampling at location NY9 on February 23. A steady rain was reported in the late morning and air sampling was halted after 260 minutes. However, the results of this sample were considered to be representative of the entire day and were included in the statistical analysis.

STAGE II VAPOR RECOVERY SYSTEMS

To help control gasoline vapor emissions, many service station pump nozzles are equipped with Stage II vapor recovery systems. Stage II vapor recovery systems capture vapors displaced from the vehicle fuel tank during refueling (Stage I systems capture vapors displaced from service station storage tanks during tank truck fuel deliveries). The presence of "Stage II Vapor Recovery Systems" was recorded (Table 1-5) during the study. The presence of Stage II systems would be expected to lower potential exposure in refueling attendants since they often work in close proximity to the dispensing pump nozzle. The refueling attendants exposure data for Stage II stations are analyzed separately in Appendix E and discussed later in this section.

TABLE 1-5

Stage II Vapor Recovery Systems at Service Stations	
With	Without
AZ-1	MN-2
AZ-2	MN-3
AZ-3	MN-4
AZ-4	OR-1
NY-1	OR-2
NY-2	
NY-3	
NY-4	
NY-6	
NY-7	
NY-9	
OR-3	

EXPOSURE MONITORING

As described above, 198 service station personal exposures were sampled during the Winter Phase of the study and 200 personal exposures during the Summer Phase. Three additional samples were collected on truck drivers during fuel deliveries. A review of Appendix C for both the Winter & Summer data shows that in the majority of samples, non-detectable or low levels of oxygenates and aromatics were detected in the personal air samples. The total exposure database, combining Winter and Summer Phases, is summarized in Table 1-6. The data collected for attendants at stations with Stage II emission controls are also separately summarized in Table 1-6. Tables 1-7 & 1-8 summarize the Winter Phase exposure data and Tables 1-9 & 1-10 summarize the Summer Phase data for attendants and mechanics, respectively. Both long-term and short-term sample data summaries are presented.

Tables 1-6 to 1-10 summarize 394 of the 398 collected service station worker exposures. Four samples collected during the study are not included in the statistical analysis. Three samples, collected during the Winter Phase in the Northwest, provide exposure values an order of magnitude higher than the rest and do not appear to result from typical operations observed during the study. As footnoted in Tables 1-6 and 1-7, these samples (OR2-06A, OR2-07 and OR2-16) are not included in the statistical analysis. The results from these samples can be found in Appendix C. The three samples were collected on two attendants during normal refuelling activities. Samples OR2-06A (full-shift) and OR2-07 (15 minutes) were taken concurrently on the same individual. Exposure during the short-term sample is incorporated into the long-term sample. During the short-term sample, the subject refueled two vehicles. Activities observed by NATLSCO staff during the sampling indicated that the attendant may have affected the outcome of the sampling. Additional sampling on this individual provided more typical results on subsequent days. The third sample, OR2-16, was a short-term sample collected on a different attendant at the same station while refueling vehicles. In this case, the attendant was observed to turn the fuel dispensing nozzle up to his chest, near the sampling tube, following each refueling. This sample did not affect the full-

shift sampling statistics, since this attendant did not undergo full-shift sampling. No exposures approaching these apparent outliers occurred during the Summer Phase.

The fourth sample (AZ4S-15A), collected during the Summer Phase in the Southwest was observed to have fallen off the subject into a puddle of oil. Since the charcoal absorbent could have been contaminated with oil, it was not included in the statistical analysis. The attendant's exposure is represented by sample AZ4S-17A.

Refueling attendants were sometimes observed setting a trigger on the refueling nozzle handle so that fuel was automatically dispensed until the automobile fuel tank was filled.

This "latching" procedure sets a nozzle trigger in an open position that is released by the back pressure from the vehicle fuel tank when full. This practice allows the attendant to perform duties away from the gas tank inlet while dispensing gasoline. In busy stations, latching allows the attendant to service multiple vehicles simultaneously. In either case, the attendant spends less time near the nozzles while gasoline is being dispensed and thus reduces the potential gasoline vapor exposure.

TABLE 1-6

SUMMARY OF EXPOSURE DATA RANGES FOR ALL SEASONS AND LOCATIONS								
Exposure Period	Concentration							
	ppm							mg/M ³
	B	T	X	EB	ETOH	MTBE	TAME	THC
REFUELING ATTENDANTS								
Long-Term ^a	<0.01-1.2	<0.01-2.1	<0.01-1	<0.01-1	<0.15-2.8	<0.03-0.50	<0.02-0.08	<0.37-110
Short-Term ^b	0.09-0.91	0.1-3.4	<0.06-7.7	<0.07-2.1	<1-2.4	<0.19-2.1	<0.24-0.46	<1.9-170
MECHANICS								
Long-Term	<0.01-0.38	<0.01-4.3	<0.01-2.2	<0.01-1	<0.15-2.1	<0.02-2.6	<0.02-0.03	<0.22-60
Short-Term	<0.1-8.7	<0.09-20	<0.08-30	<0.08-8.7	<1.5-6.5	<0.22-32	<0.24-0.27	<1.6-490
REFUELING ATTENDANTS WITH STAGE II EMISSIONS CONTROLS								
Long-Term	<0.01-1.1	0.02-2.1	0.01-1	<0.01-1	<1	<0.03-0.5	<0.02-0.08	<0.37-91
Short-Term	0.09-0.42	0.1-1	<0.06-7.7	<0.07-2.1	<1-2.4	<0.24-2.1	<0.24-0.46	<1.9-60

^a These entries do not include two samples for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-06A and AZ4S-15A. The text at page 1-10 & 1-11 provides an explanation.

^b These entries do not include two samples for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-07 and #OR2-16 and text at page 1-10.

TABLE 1-7

SUMMARY OF REFUELING ATTENDANTS EXPOSURE DATA RANGES - WINTER PHASE									
Exposure Period	Concentration								mg/M ³
	ppm								
	B	T	X	EB	ETOH	MTBE	TAME	THC	
	SOUTHWEST								
Long-Term	<0.01-0.04	<1	<1	<1	<1	0.38-0.5 ^a	NA ^b	1.8 - 14	
Short-Term	<0.12-0.24	<1	<1	<1	<1.3-<2.4	<0.33-2.1	NA	<1.9 - 60	
MIDWEST									
Long-Term	0.02-0.15	<1	<1	<1	<1	NA	NA	7.5 - 46	
Short-Term	<0.21	<1	<1	<1	<2.2-<2.4	NA	NA	<3.1 - 5.6	
NORTHEAST									
Long-Term	<0.01-<0.07	<1	<1	<1	NA	<0.03-0.5	<0.02-<0.08	<0.37 - 15	
Short-Term	<0.20-<0.42	<1	<1	<1	NA	<0.32-1.9	<0.24-<0.46	<3 - 20	
NORTHWEST									
Long-Term ^c	0.02-0.49	<1	<1	<1	<1	NA	NA	<4.2 - 63	
Short-Term ^d	<0.13-0.61	<1-3.4	<1-1.3	<1	<1.0-<2.2	NA	NA	2.8 - 100	

^a One service station in the southwest had MTBE. The other three had EtOH.

^b NA denotes "not analyzed". This species was not detected in the analysis of the bulk fuel samples. Refer to Table 1-2 above.

^c These entries do not include one sample for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-06A and text at page 1-10.

^d These entries do not include two samples for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-07 and #OR2-16 and text at page 1-10.

TABLE 1-8

SUMMARY OF AUTOMOBILE MECHANICS EXPOSURE DATA RANGES- WINTER PHASE									
Exposure Period	Concentration								
	ppm								mg/M ³
	B	T	X	EB	ETOH	MTBE	TAME	THC	
SOUTHWEST									
Long-Term	<0.01-0.34	<1-4.3	<1	<1	<1	<0.02-1.3	NA*	1.6 - 58	
Short-Term	<0.15-1.3	<1-20	<1-1.7	<1	<1.6-<2.4	<0.26-5.3	NA	<2.2 - 280	
MIDWEST									
Long-Term	<0.02-0.19	<1-1.1	<1	<1	<1	NA	NA	<0.22 - 51	
Short-Term	<0.21-0.47	<1	<1	<1	<2.2-<2.4	NA	NA	6.6 - 32	
NORTHEAST									
Long-Term	<0.01-0.3	<1	<1-2.2	<1	NA	0.02-2.6	<0.02-<0.03	<0.42 - 60	
Short-Term	<0.21-3.3	<1-6.2	<1-6.3	<1-1.5	NA	<0.32-32	<0.24-0.27	<3.0 - 490	
NORTHWEST									
Long-Term	<0.01-0.38	<1-1	<1	<1	<1	NA	NA	1.0 - 43	
Short-Term	<0.16-8.7	<1-19	<1-6.4	<1-1.6	<1.5-6.5	NA	NA	<2.5 - 470	

* NA denotes "not analyzed".

TABLE 1-9

SUMMARY OF REFUELING ATTENDANTS EXPOSURE DATA RANGES - SUMMER PHASE

Exposure Period	Concentration							mg/M ³
	ppm							
	B	T	X	EB	ETOH	MTBE	TAME	THC
SOUTHWEST								
Long-Term ^a	<0.02-0.15	0.02-0.27	0.01-0.34	<0.01-0.10	NA ^b	NA	NA	1.7-23
Short-Term	0.09-0.35	0.1-0.96	<0.06-7.7	<0.07-2.1	NA	NA	NA	<1.9-49
MIDWEST								
Long-Term	<0.01-0.05	<0.01-0.12	<0.01-0.14	<0.01-0.03	<0.15-2.8	NA	NA	1.3-14
Short-Term	<0.21	<0.18	<0.16	<0.16	<0.24	NA	NA	<3.1
NORTHEAST								
Long-Term	0.02-1.1	0.03-2.1	0.01-0.83	<0.01-0.19	NA	0.03-0.21	<0.02-<0.04	3.3-91
Short-Term	<0.16-<0.21	<0.18-0.55	0.12-0.94	<0.12-0.25	NA	<0.24-<0.33	<0.24	<3-29
NORTHWEST								
Long-Term	0.04-1.2	0.07-1.7	0.02-0.60	<0.01-0.13	NA	0.07-0.42	NA	4.7-110
Short-Term	<0.12-0.91	<0.1-0.99	<0.11-0.25	<0.09-<0.16	NA	<0.19-<0.33	NA	<2.6-170

^a These entries do not include one sample for which the results are very high compared to the remaining samples, see Appendix C, AZ4S-15A. The text at page 1-11 provides an explanation.

^b NA denotes "not analyzed".

TABLE 1-10

SUMMARY OF AUTOMOBILE MECHANICS EXPOSURE DATA RANGES - SUMMER PHASE									
Exposure Period	Concentration								mg/M ³
	ppm								THC
	B	T	X	EB	ETOH	MTBE	TAME		
SOUTHWEST									
Long-Term	<0.01-0.18	<0.01-0.9	<0.01-0.31	<0.01-0.09	NA*	NA	NA		0.90-19
Short-Term	<0.1-0.26	<0.09-3.0	<0.08-4.2	<0.08-1.2	NA	NA	NA		<1.6-29
MIDWEST									
Long-Term	<0.01-0.07	0.02-0.09	0.02-0.38	<0.01-0.09	<0.15-2.1	NA	NA		1.6-7.6
Short-Term	0.31-0.49	0.28-2.1	<0.16-1.0	<0.16-0.19	5.7	NA	NA		29-59
NORTHEAST									
Long-Term	<0.01-0.1	<0.02-0.34	<0.01-1.6	<0.01-0.45	NA	<0.02-0.18	<0.02-0.02		0.41-22
Short-Term	<0.13-2.3	<0.18-9.8	<0.15-30	<0.1-8.7	NA	<0.22-4.2	<0.24		<3.0-350
NORTHWEST									
Long-Term	<0.02-0.26	<0.02-1.8	<0.02-0.38	<0.02-0.08	NA	NA	NA		0.71-30
Short-Term	<0.16-0.39	<0.13-0.89	<0.11-0.73	<0.12-<0.16	NA	NA	NA		<2.3-20

* NA denotes "not analyzed"

TABLE 1-11

STATIONS WITH STAGE II EMISSION CONTROLS SUMMARY OF REFUELING ATTENDANTS EXPOSURE DATA RANGES - WINTER PHASE									
Exposure Period	Concentration								mg/M ³ THC
	ppm								
	B	T	X	EB	ETOH	MTBE	TAME		
	SOUTHWEST								
Long-Term	<0.01-0.04	<1	<1	<1	<1	0.38-0.5	NA*	1.8-14	
Short-Term	<0.12-0.24	<1	<1	<1	<1.3-<2.4	<0.33-2.1	NA	<1.9-60	
NORTHEAST									
Long-Term	<0.01-0.07	<1	<1	<1	NA	<0.03-0.5	<0.02-<0.08	<0.37-15	
Short-Term	<0.20-<0.42	<1	<1	<1	NA	<0.32-1.9	<0.24-<0.46	<3-20	
NORTHWEST									
Long-Term	0.02-0.03	<1	<1	<1	<1	NA	NA	7.8-11	
Short-Term	<0.13-<0.21	<1	<1	<1	<1.0-<1.9	NA	NA	<3.0-16	

* NA denotes "not analyzed."

TABLE 1-12

STATIONS WITH STAGE II EMISSION CONTROLS SUMMARY OF REFUELING ATTENDANTS EXPOSURE DATA RANGES - SUMMER PHASE									
Exposure Period	Concentration								mg/M ³
	ppm								THC
	B	T	X	EB	ETOH	MTBE	TAME		
SOUTHWEST									
Long-Term ^a	<0.02-0.15	0.02-0.27	0.01-0.34	<0.01-0.10	NA ^b	NA	NA		1.7-23
Short-Term	0.09-0.35	0.1-0.96	<0.06-7.7	<0.07-2.1	NA	NA	NA		<1.9-49
NORTHEAST									
Long-Term	0.02-1.1	0.03-2.1	0.01-0.83	<0.01-0.19	NA	0.03-0.21	<0.02-0.04		3.3-91
Short-Term	<0.16-<0.21	<0.18-0.55	0.12-0.94	<0.12-0.25	NA	<0.24-<0.33	<0.24		<3-29
NORTHWEST									
Long-Term	0.04-0.1	0.07-0.09	0.02-0.04	<0.01	NA	NA	NA		4.7-13
Short-Term	<0.17-0.37	<0.15-0.47	0.12-<0.15	<0.13-<0.16	NA	NA	NA		2.8-31

^a These entries do not include one sample for which the results are very high compared to the remaining samples, see Appendix C, AZ4S-15A. The text at page 1-11 provides an explanation.

^b NA denotes "not analyzed."

Section 2

STATISTICAL ANALYSIS

Individual personal sample concentration data by date, location, job type/task description and gallons pumped (for attendants) are presented in Appendix C. The descriptive (total number of samples, number of samples below the limit of detection, minimum, maximum, median, geometric mean, geometric standard deviation, limits of detection) and distributional (number of samples within decade concentration intervals) statistics for personal data by analyte, sample duration, job type, and season are presented in Appendix D. Appendix E presents the descriptive and distributional statistics for the attendants at service stations equipped with Stage II vapor recovery systems. A comparison of the attendant data from Appendices D & E shows the relative effect on personal exposure values of Stage II Vapor Recovery Systems.

In Appendix C for the analytes benzene, MTBE, TAME and total hydrocarbons, sample concentration values below the measurement method limit of detection (LOD) were reported as "less than" values at the sample-specific limit of detection. Note that in the winter concentration data for toluene, xylene, ethyl benzene and ethanol, small detected concentrations were reported as "<1 ppm" in accord with a long-standing NATLSCO laboratory practice of so reporting values less than one part per million for these compounds. However, this practice was changed for the summer data and the "less than" values reported there for toluene, xylene, ethylbenzene and ethanol correspond to the sample-specific LODs for the analytical method.

In the statistical analysis reported in Appendix D, concentrations reported as "less than" values are valued at that limit. For example, in the Winter data, mean values for xylene, toluene, ethylbenzene and ethanol, were computed by equating <1 ppm values to 1 ppm. This conservative approach provides statistical geometric mean (GM) values that overestimate actual mean exposures. Since a majority of the reported organic vapor concentrations are either "<1 ppm" or less than an analytical method LOD, the computed geometric means are higher than the actual mean concentrations. For example, if exposure to a specific compound was not detected, e.g., all values were below a 0.24 ppm method LOD, then the GM estimate of exposure by this approach would be calculated as 0.24 ppm.

The descriptive mean exposure statistics are summarized in Tables 2-1 & 2-2 for the long-term and short-term samples, respectively. The descriptive statistics for attendant exposure data at service stations with

Stage II Vapor Recovery Systems are presented separately in Table 2-3. A summary of combined winter and summer data are provided in Table 2-4 for the four oxyfuel components (B, THC, MTBE, TAME) that were consistently quantified to the analytical method LOD for both seasons.

TABLE 2-1

SUMMARY OF DESCRIPTIVE STATISTICS - LONG-TERM SAMPLES								
Conc (ppm)	Winter				Summer			
	Attendant ^a		Mechanic		Attendant ^b		Mechanic	
	Range	GM ^c	Range	GM	Range	GM	Range	GM
Ben	0.01-0.49	0.04	0.01-0.38	0.03	0.01-1.2	0.06	0.01-0.26	0.02
Tol	1	1	1-4.3	1.04	0.01-2.1	0.09	0.01-1.8	0.06
Xyl	1	1	1-2.2	1.03	0.01-0.83	0.05	0.01-1.6	0.07
EB	1	1	1	1	0.01-0.19	0.02	0.01-0.45	0.03
THC ^d	0.37-63	8.9	0.22-60	8.6	1.3-110	9.2	0.41-30	3.7
ETOH	1	1	1	1	0.15-2.8	0.48	0.15-2.1	0.42
MTBE	0.03-0.5	0.2	0.02-2.6	0.12	0.03-0.42	0.08	0.02-0.18	0.03
TAME	0.02-0.08	0.02	0.02-0.03	0.02	0.02-0.04	0.02	0.02	0.02

^a These entries do not include one sample for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-06A and text at page 1-10.

^b These entries do not include one sample for which the results may have been influenced when the sampling tube was contaminated with oil. See Appendix C, sample #AZ4S-15A and text at page 1-11.

^c Geometric Mean

^d Concentrations of THC are reported in mg/M³.

TABLE 2-2

SUMMARY OF DESCRIPTIVE STATISTICS - SHORT-TERM SAMPLES								
Conc (ppm)	Winter				Summer			
	Attendant ^a		Mechanic		Attendant		Mechanic	
	Range	GM ^b	Range	GM	Range	GM	Range	GM
Ben	0.12-0.61	0.21	0.15-8.7	0.29	0.09-0.91	0.21	0.1-2.3	0.22
Tol	1-3.4	1.02	1-20	1.5	0.10-0.99	0.22	0.09-9.8	0.26
Xyl	1-1.3	1.02	1-6.4	1.2	0.06-7.7	0.18	0.08-30	0.27
EB	1	1	1-1.6	1.0	0.07-2.1	0.16	0.08-8.7	0.19
THC ^c	1.9-100	8.5	2.2-490	10.8	1.9-170	6.4	1.6-350	6.2
ETOH	1.0-2.4	1.9	1.5-6.5	2.0	2.4	2.4	5.7	5.7
MTBE	0.32-2.1	0.6	0.26-32	1.04	0.19-0.33	0.31	0.22-4.2	0.42
TAME	0.24-0.46	0.28	0.24-0.27	0.25	0.24	0.24	0.24	0.24

^a These entries do not include two samples for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-07 and #OR2-16 and text at page 1-10.

^b Geometric Mean

^c Concentrations of THC are reported in mg/M³.

TABLE 2-3

SUMMARY OF DESCRIPTIVE STATISTICS - ALL ATTENDANT EXPOSURE DATA FOR SERVICE STATIONS WITH STAGE II VAPOR RECOVERY SYSTEMS								
Conc (ppm)	Winter				Summer			
	Long-Term		Short-Term		Long-Term ^a		Short-Term	
	Range	GM ^b	Range	GM	Range	GM	Range	GM
Ben	0.01-0.07	0.02	0.12-0.42	0.21	0.02-1.1	0.05	0.09-0.37	0.21
Tol	1	1	1	1	0.02-2.1	0.09	0.1-0.96	0.23
Xyl	1	1	1	1	0.01-0.83	0.05	0.06-7.7	0.18
EB	1	1	1	1	0.01-0.19	0.02	0.07-2.1	0.16
THC ^c	0.37-15	5.54	1.9-60	6.42	1.7-91	8.72	1.9-49	6.2
ETOH	1	1	1.0-2.4	1.88	ETOH NOT DETECTED ^d			
MTBE	0.03-0.5	0.20	0.32-2.1	0.60	0.03-0.21	0.07	0.24-0.33	0.32
TAME	0.02-0.08	0.02	0.24-0.46	0.28	0.02-0.04	0.02	0.24	0.24

^a These entries do not include one sample for which the results are suspect. See Appendix C, sample #AZ45-15A and text at page 1-11.

^b Geometric Mean

^c Concentrations of THC are reported in mg/M³.

^d ETOH was not detected in the bulk fuel samples of any service stations equipped with Stage II Vapor Recovery Systems during the Summer Phase.

TABLE 2-4

SUMMARY OF DESCRIPTIVE STATISTICS - ALL SEASONS AND LOCATIONS								
Conc (ppm)	Long-Term Samples				Short-Term Samples			
	Attendant ^a		Mechanic		Attendant ^b		Mechanic	
	GM ^c	GSD ^c	GM	GSD	GM	GSD	GM	GSD
Ben	0.05	2.65	0.03	2.79	0.21	1.30	0.25	2.09
THC ^d	9.06	2.61	5.70	3.47	7.39	2.83	8.15	4.91
MTBE	0.12	2.33	0.06	3.99	0.41	1.75	0.74	4.54
TAME	0.02	1.38	0.02	1.09	0.25	1.21	0.24	1.04

- ^a These entries do not include two samples for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-06A and AZ4S-15A. The text at page 1-10 & 1-11 provides an explanation.
- ^b These entries do not include two samples for which the results are very high compared to the remaining samples, see Appendix C, sample #OR2-07 and #OR2-16 and text at page 1-10.
- ^c Geometric Mean and Geometric Standard Deviation.
- ^d Concentrations of THC are reported in mg/M³.

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APPENDIX A

NOMINAL OXYGENATE AND AROMATIC CONTENT OF BULK FUEL SAMPLES

**SERVICE STATION PERSONNEL EXPOSURE STUDY
AMERICAN PETROLEUM INSTITUTE**

WINTER & SUMMER 1994

APPENDIX A

APPROXIMATE OXYGENATE AND AROMATIC CONTENT (WT %) OF BULK FUEL SAMPLES

SERVICE STATION PERSONNEL EXPOSURE STUDY AMERICAN PETROLEUM INSTITUTE WINTER & SUMMER 1994

Location	Octane	°F ^a	RVP	B	T	X	EB	p-X	EtOH	MTBE	TAME
WINTER											
AZ-1	87	77.4	10.2	1.3	5.9	7.5	1.7	2.1	7.6	-	-
	88	76.0	10.1	2.2	10.0	10.0	2.5	2.7	6.8	-	-
	92	80.4	10.3	1.3	9.6	9.9	1.9	2.8	6.7	-	-
AZ-2	87	69.4	9.5	1.2	5.8	9.1	1.7	2.5	-	11	-
	88	77.4	9.1	1.9	8.9	9.0	2.3	2.4	-	11	-
	92	80.4	9.0	1.7	10.0	12.0	2.1	3.0	-	12	-
AZ-3	87	63.5	9.5	1.6	6.4	7.7	1.5	2.3	8.0	-	-
	88	62.3	10.2	2.7	11.0	11.0	2.6	2.9	7.2	-	-
	92	66.4	10.6	1.0	8.9	9.7	1.6	2.4	7.9	-	-
AZ-4	87	67.8	9.4	0.95	5.4	8.2	1.8	2.2	8.4	-	-
	88	68.0	10.3	1.6	7.2	6.6	2.0	1.8	8.7	-	-
	92	70.2	9.8	1.3	8.0	8.8	2.3	2.4	8.4	-	-
MN-2	89	51.2	14.2	2.4	10.0	8.7	1.6	2.2	10.0	-	-
	92	49.1	14.4	_b	_b	_b	_b	_b	_b	-	-
MN-3	87	24.4	14.5	2.7	9.8	11.0	2.0	2.9	7.1	-	-
	92	22.8	14.6	1.2	7.9	8.0	1.4	2.0	6.6	-	-

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APPENDIX A

APPROXIMATE OXYGENATE AND AROMATIC CONTENT (WT %) OF BULK FUEL SAMPLES

WINTER & SUMMER 1994

Location	Octane	°F	RVP	B	T	X	EB	P-X	EtOH	MTBE	TAME
WINTER (Continued)											
MN-4	87	42.6	14.8	3.2	11.0	12.0	2.4	3.0	7.3	-	-
	92	26.6	15.3	0.79	7.5	6.0	1.3	1.7	6.2	-	-
NY-1	87	43.7	12.69	1.1	3.8	5.9	1.0	1.6	-	14.0	1.4
	89	56.8	12.1	0.82	3.3	6.1	1.1	1.7	-	11.0	1.4
	93	45.7	10.72	1.1	7.2	13.0	2.6	3.7	-	13.0	3.7
NY-2	87	50.5	11.4	0.78	4.3	5.8	1.1	1.4	-	13.0	<0.12
	89	55.7	11.2	0.90	5.2	8.0	1.6	2.1	-	12.0	1.5
	93	56.1	10.7	1.0	6.8	12.0	2.5	3.4	-	10.0	3.4
NY-3	87	48.4	11.5	1.2	4.2	5.9	1.3	1.6	-	14.0	-
	89	49.1	11.9	0.57	4.0	6.9	1.6	2.0	-	16.0	-
	93	48.9	13.6	0.75	5.8	10.0	2.6	3.0	-	15.0	-
NY-4	87	69.1	11.14	0.88	4.6	6.0	1.2	1.6	-	14.0	-
	89	70.3	12.13	1.0	6.2	8.5	1.5	2.4	-	14.0	-
	93	68.4	12.08	0.83	5.3	7.0	1.1	2.2	-	17.0	-
NY-6	87	55.2	10.53	2.3	3.2	6.0	0.93	1.7	-	15.0	0.16
	89	55.4	11.79	1.4	13.0	11.0	2.3	3.2	-	14.0	1.1
	93	61.0	8.18	2.4	7.3	11.0	1.7	3.9	-	13.0	<0.11

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APPENDIX A

APPROXIMATE OXYGENATE AND AROMATIC CONTENT (WT %) OF BULK FUEL SAMPLES

WINTER & SUMMER 1994

Location	Octane	°F	RVP	B	T	X	EB	p-X	EtOH	MTBE	TAME
WINTER (Continued)											
NY-7	87	55.4	8.0	1.5	3.8	7.4	1.2	2.2	-	13.0	0.52
	89	55.8	8.0	0.99	5.9	8.0	1.2	2.3	-	12.0	<0.11
	93	55.6	9.6	1.4	13.0	12.0	2.4	3.5	-	12.0	0.19
NY-9	87	45.9	11.4	1.0	4.2	6.1	1.4	1.7	-	14.0	-
	89	44.9	11.9	0.74	4.7	7.9	1.4	2.2	-	13.0	-
	93	45.6	13.7	0.72	5.5	10.0	2.5	3.0	-	14.0	-
OR-1	87	56.5	14.1	3.4	11.0	10.0	1.8	2.7	7.4	-	-
	88	57.2	14.9	^a	^a	^a	^a	^a	^a	-	-
	92	56.8	14.0	0.24	14.0	14.0	2.6	3.7	6.4	-	-
OR-2	87	59.0	14.6	2.8	9.6	9.4	1.7	2.4	7.1	-	-
	88	58.0	14.3	3.1	11.0	9.8	1.7	2.5	7.1	-	-
	92	58.9	13.3	3.5	18.0	15.0	2.7	3.8	6.9	-	-
OR-3	87	39.4	14.6	2.3	7.4	7.7	1.7	2.1	8.2	-	-
	88	37.2	15.4	2.2	7.1	7.0	1.5	1.9	7.0	-	-
	92	36.7	15.0	2.3	11.0	14.0	3.2	3.8	4.6	-	-

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APPENDIX A

APPROXIMATE OXYGENATE AND AROMATIC CONTENT (WT %) OF BULK FUEL SAMPLES

WINTER & SUMMER 1994

Location	Octane	°F	RVP	B	T	X	EB	p-X	EtOH	MTBE	TAME
SUMMER											
AZ-1	87	93.5	7.31	1.7	7.0	10	1.8	2.7	-	-	-
	88	96.2	7.35	2.7	12	11	2.7	3.3	-	-	-
	92	92.4	7.46	2.3	12	15	2.7	4.3	-	-	-
AZ-2	87	88.6	6.74	1.3	7.5	10	2.0	2.6	-	-	-
	88	88.4	6.98	2.0	11	10	2.6	2.8	-	-	-
	92	88.9	7.14	1.4	12	14	2.5	3.5	-	-	-
AZ-3	87	105.6	7.28	2.1	8.6	11	1.9	2.9	-	-	-
	88	95.6	7.18	2.5	10	10	2.7	2.8	-	-	-
	92	89.3	7.60	2.7	13	16	2.9	4.5	-	-	-
AZ-4	87	82	7.37	2.6	10	11	2.4	2.9	-	-	-
	88	83.8	7.41	2.7	9.8	9.8	3.2	2.8	-	-	-
	92	86.7	7.35	2.5	14	13	3.5	3.5	-	-	-
MN-2	89	78.4	9.57	1.5	7.0	7.0	1.4	1.8	9.7	-	-
	92	78.4	9.65	0.79	7.2	4.6	1.0	1.2	9.5	-	-
MN-3	87	72.5	8.88	1.9	8.3	9.7	2.0	2.7	-	-	-
	92	70.7	8.83	0.29	8.7	2.2	0.64	0.63	-	-	-

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APPENDIX A

APPROXIMATE OXYGENATE AND AROMATIC CONTENT (WT %) OF BULK FUEL SAMPLES

WINTER & SUMMER 1994

Location	Octane	°F	RVP	B	T	X	EB	p-X	EtOH	MTBE	TAME
SUMMER (Continued)											
MN-4	87	80.5	9.75	1.7	6.7	8.6	1.6	2.2	11	-	-
	92	80.3	9.63	1.1	7.1	5.6	1.0	1.4	10	-	-
NY-1	87	79.5	7.98	2.0	8.1	9.0	1.7	2.7	-	0.10	<0.1
	89	79.7	7.98	2.2	12	9.8	2.1	2.9	-	2.6	0.12
	93	79.1	8.96	1.9	16	9.6	2.2	2.9	-	5.2	0.30
NY-2	87	76.1	7.35	1.7	7.6	8.7	1.7	2.6	-	<0.1	<0.1
	89	75.5	8.05	2.0	9.1	10	2.2	3.1	-	2.5	0.51
	93	76.1	9.20	2.1	10	12.0	2.7	3.5	-	8.8	1.0
NY-4	87	76.5	8.40	0.98	5.7	7.2	1.3	2.1	-	<0.1	-
	89	75.1	8.46	0.99	9.7	11	2.2	3.2	-	0.80	-
	93	76.6	8.77	0.75	12	14	3.1	4.0	-	1.3	-
NY-6	87	84.2	8.66	1.8	6.8	7.6	1.4	2.2	-	<0.1	-
	89	84.6	8.83	1.0	12	14	3.2	4.1	-	0.97	-
	93	83.8	8.85	1.8	17	16	4.0	4.9	-	0.46	-
NY-7	87	81.0	8.67	1.8	7.0	9.1	1.7	2.6	-	<0.1	-
	89	82.8	8.70	0.93	10	12	2.8	3.6	-	0.24	-
	93	82.2	8.75	2.2	15	14	3.1	4.1	-	3.3	-

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APPENDIX A

APPROXIMATE OXYGENATE AND AROMATIC CONTENT (WT %) OF BULK FUEL SAMPLES

WINTER & SUMMER 1994

Location	Octane	°F	RVP	B	T	X	EB	P-X	EtOH	MTBE	TAME
SUMMER (Continued)											
NY-9	87	75.4	8.79	2.0	8.6	8.2	1.9	2.3	-	0.34	<0.1
	89	74.1	8.92	1.5	7.8	9.6	2.0	2.7	-	1.3	0.58
	93	76.9	9.14	0.77	10	12	2.7	3.7	-	1.7	2.2
OR-1	87	88.5	7.66	1.8	8.6	11	2.2	2.9	-	-	-
	88	87.6	7.21	2.4	7.2	8.4	1.7	2.2	-	-	-
	92	89.1	7.46	1.9	11	12	2.4	3.3	-	-	-
OR-2	87	81.3	7.09	2.8	9.9	11	2.1	3.1	-	0.71	-
	88	75.6	7.06	2.1	5.2	8.1	1.4	2.4	-	<0.1	-
	92	78.3	6.96	2.9	9.6	12	2.1	3.4	-	<0.1	-
OR-3	87	81.6	7.06	3.0	8.3	10	2.1	2.6	-	-	-
	88	80.9	7.22	2.7	7.5	8.3	1.7	2.2	-	-	-
	92	79.9	6.99	2.0	7.8	12	2.6	3.5	-	-	-
°F	Degrees Fahrenheit		X		Xylene		MTBE				
RVP	Reid Vapor Pressure		EB		Ethyl Benzene		TAME		Methyl-Tert-Butyl Ether		
B	Benzene		P-X		p-Xylene				t-Amyl Methyl Ether		
T	Toluene		EtOH		Ethanol						

Temperature of fuel dispensed for bulk sample; see discussion Appendix H.

Bulk fuel samples MN2 - 92 octane and OR1 - 88 octane during the Winter Phase were partially lost during shipment. Due to the volatilization of the lower boiling compounds these results are considered nonrepresentative.

APPENDIX B

SUMMARY OF METEOROLOGICAL DATA

**SERVICE STATION PERSONNEL EXPOSURE STUDY
AMERICAN PETROLEUM INSTITUTE**

WINTER & SUMMER 1994

APPENDIX B

SUMMARY OF METEOROLOGICAL DATA

SERVICE STATION PERSONNEL EXPOSURE
AMERICAN PETROLEUM INSTITUTE

WINTER & SUMMER 1994

Location	Date	T _i (°F)	T _o (°F)	WS (mph)	WD	H _i (%RH)	H _o (%RH)	Bar ("Hg)	P _{in}
WINTER									
AZ1	2-17-94	64-85	60-79	0-3	ESE	26-45	33-52	29.87	None
	2-18-94	56-67	54-69	0-6	WSW	26-40	25-53	29.74	None
	2-19-94	56-62	56-65	0-5	SW	30-45	33-51	29.89	None
AZ2	2-14-94	58-88	52-76	0-3	NE	15-30	21-33	30.03	None
	2-15-94	53-90	48-67	0	N/SE	21-44	33-52	30.01	None
	2-16-94	56-79	51-69	0	N/E	27-41	30-57	30.11	None
AZ3	2-21-94	53-69	51-70	0-4	SW/SE	29-42	36-52	29.99	None
	2-22-94	46-72	44-74	0-11	NE	14-43	19-55	30.00	None
	2-23-94	47-60	44-59	0-1	NE	13-23	20-33	30.12	None

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APPENDIX B

SUMMARY OF METEOROLOGICAL DATASERVICE STATION PERSONNEL EXPOSURE
AMERICAN PETROLEUM INSTITUTE

WINTER & SUMMER 1994

Location	Date	T _i (°F)	T _o (°F)	WS (mph)	WD	H _i (%RH)	H _o (%RH)	Bar (^o Hg)	P _{in}
WINTER (Continued)									
AZ4	2-24-94	52-67	52-70	0	N/NW	14-28	17-34	30.01	None
	2-25-94	45-67	44-71	0	N/NE	20-36	23-49	29.95	None
	2-26-94	48-69	48-71	0	N/NE	21-31	24-42	30.02	None
MN2	2-15-94	54-80	25-38	0-5	NE/NW	21-38	43-64	29.90	None
	2-16-94	45-82	28-48	0-10	SE/NW	30-41	41-67	29.68	None
	2-17-94	49-66	25-51	0-2	NE/SE	40-55	43-76	29.70	None
MN3	2-22-94	30-41	10-25	0-4	SW	20-23	34-47	29.64	None
	2-23-94	31-45	12-21	2-12	S/SW	27-34	61-71	29.26	Trace (^{<} 0.25"-S)
	2-24-94	35-67	10-30	0-2	S/SW	23-31	28-70	29.12	None

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APPENDIX B

SUMMARY OF METEOROLOGICAL DATA

SERVICE STATION PERSONNEL EXPOSURE
AMERICAN PETROLEUM INSTITUTE

WINTER & SUMMER 1994

Location	Date	T _i (°F)	T _o (°F)	WS (mph)	WD	H _i (%RH)	H _o (%RH)	Bar (¹ / ₂ Hg)	P _{in}
WINTER (Continued)									
MN4	2-18-94	54-88	43-50	6-18	SE	33-49	55-74	29.22	None
	2-19-94	55-59	38-47	0-7	S/NW	43-56	68-78	29.00	None
	2-21-94	30-40	13-26	2-7	NW	21-26	28-48	29.86	None
NY1	3-22-94	58-63	41-53	0-10	S/SE	34-45	38-75	29.95	None
	3-23-94	61-65	43-68	0-4	SW	31-37	34-59	30.25	None
	3-24-94	56-63	44-56	0-1	E	37-45	60-72	30.28	None
NY2	3-29-94	47-59	39-41	0-2	N	46-55	78-82	30.40	0.30-R
	3-30-94	48-56	39-53	0-3	N	31-41	38-67	30.58	None
	3-31-94	56-59	39-70	1-4	SW	27-33	27-58	30.73	None

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Documents
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APPENDIX B

SUMMARY OF METEOROLOGICAL DATASERVICE STATION PERSONNEL EXPOSURE
AMERICAN PETROLEUM INSTITUTE

WINTER & SUMMER 1994

Location	Date	T _i (°F)	T _o (°F)	WS (mph)	WD	H _i (%RH)	H _o (%RH)	Bar (^o Hg)	P _{in}
WINTER (Continued)									
NY3	2-21-94	54-59	50-54	0	N/SE	61-75	80-87	30.50	0.24-R
NY9	2-22-94	50-53	51-58	0-6	NW	31-43	27-40	30.61	None
	2-23-94	39-53	30-33	2-13	NE	47-57	81-85	30.79	1.5-S
NY4	3-22-94	72-83	46-65	8-16	S	19-33	19-51	29.95	None
	3-23-94	67-85	51-74	1-8	E/SE	21-27	19-39	30.29	None
	3-24-94	68-87	53-74	0-2	E/SE	23-33	24-48	30.28	None
NY6	4-4-94	50-57	44-56	0	ESE	31-41	33-53	30.37	None
	4-5-94	50-63	44-63	0-4	ESE/SE	-	37-48	30.46	None
	4-6-94	60-62	54-60	0	SE/E	44-65	65-85	30.31	0.05-R

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APPENDIX B

SUMMARY OF METEOROLOGICAL DATA

SERVICE STATION PERSONNEL EXPOSURE
AMERICAN PETROLEUM INSTITUTE

WINTER & SUMMER 1994

Location	Date	T _i (°F)	T _o (°F)	WS (mph)	WD	H _i (%RH)	H _o (%RH)	Bar ("Hg)	P _{in}
WINTER (Continued)									
NY7	4-12-94	54-59	46-52	0-5	SSW	60-69	72-85	30.36	0.25-R
	4-13-94	53-60	47-53	0-2	SE	66-73	87-93	29.94	0.30-R
	4-14-94	60-73	69-81	0-3	W/WNW	40-81	29-69	29.89	None
OR1	2-14-94	46-66	42-62	0-3	N/NW	41-73	48-80	30.20	None
	2-15-94	43-70	41-59	0-4	N/NE	32-75	46-60	30.04	Trace
	2-16-94	38-60	53-59	0-1	NW/SE	40-79	38-54	29.71	None
OR2	2-17-94	47-58	45-53	0-6	NW	50-65	53-74	29.22	0.15-R
	2-18-94	44-73	40-57	0-4	S/SW	31-63	45-77	29.64	Trace
	2-19-94	42-73	37-62	0-2	W/NW	28-61	37-76	29.75	Trace

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APPENDIX B

SUMMARY OF METEOROLOGICAL DATASERVICE STATION PERSONNEL EXPOSURE
AMERICAN PETROLEUM INSTITUTE

WINTER & SUMMER 1994

Location	Date	T _i (°F)	T _o (°F)	WS (mph)	WD	H _i (%RH)	H _o (%RH)	Bar ("Hg)	P _{in}
WINTER (Continued)									
OR3	2-22-94	50-67	46-52	0-10	SSW	37-53	66-71	30.22	Trace
	2-23-94	51-60	49-53	0-7	WSW	58-68	78-84	29.99	0.25-R
	2-24-94	42-55	39-44	0-1	NE	48-85	70-83	29.93	1.0-R