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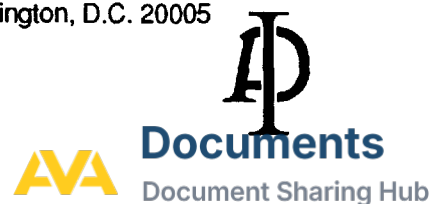
On page 10, paragraph 3, line 1, the text reads as follows:

"Fenceline samples were collected at a rate of approximately 50 milliliters per minute and represented one 24-hour period."

The text should read:

"Fenceline samples were collected at a rate of approximately 350 milliliters per minute and represented one 24-hour period."

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005



Gasoline Vapor Exposure Assessment at Service Stations

HEALTH AND ENVIRONMENTAL SCIENCES
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Gasoline Vapor Exposure Assessment at Service Stations

Health and Environmental Sciences Department

API PUBLICATION NUMBER 4553

PREPARED UNDER CONTRACT BY:

CLAYTON ENVIRONMENTAL CONSULTANTS
CYPRESS, CALIFORNIA

JULY 1991

**American
Petroleum
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1.0 INTRODUCTION

The American Petroleum Institute (API) retained Clayton Environmental Consultants, Inc. to perform a gasoline vapor exposure assessment at six service stations (representing six different companies) selected by the API. The purpose of the study was to characterize the exposure of consumers to airborne gasoline components during self-serve fill-up operations. In addition to personal exposure assessment, air samples were collected at the station fenceline. Clayton also measured local meteorological data, recorded numerous operational parameters, and collected bulk samples of the various grades of gasoline at each station.

Of the six service stations monitored, two are located in the Cincinnati, Ohio area, two are in Phoenix, Arizona, and the other two are in the Los Angeles, California area. Sampling at the stations was performed in the months of October and November, 1990. The National Institute for Occupational Safety and Health (NIOSH) personnel concurrently conducted a study of gasoline vapor exposures of full service attendants.

The following-Clayton staff participated in the study:

- Dr. Jaswant Singh, CIH, Program Director
- Cindy J. Mueller, CIH, Project Manager
- Robert Lieckfield, CIH, Laboratory Director
- David R. Dorenzo, Air Quality Meteorologist
- Alice Farrar, CIH, Quality Assurance Advisor
- Steven R. O'Donnell, Field Industrial Hygienist
- Ron Poore, Field Industrial Hygienist
- Alvin Samala, Field Industrial Hygienist

This report includes sampling results, a discussion of the assessment strategy, and analytical methods employed.

2.0 SUMMARY OF RESULTS

2.1 SAMPLING AND ANALYSIS

A total of 120 "integrated" exposure samples representing 1013 customers and 72 fenceline samples were collected. The majority of the samples collected were analyzed for the following six gasoline constituents (referred to as the Option A constituents):

- n-Hexane
- Benzene
- Xylene
- Toluene
- Methyl tertiary butyl ether (MTBE)
- Total hydrocarbons (THC)

Total hydrocarbon results reported throughout the study encompass all organic compounds including n-hexane, benzene, xylene, and toluene. Results are reported as milligrams of hydrocarbon compounds per cubic meter of air (mg/m^3) and parts of vapor per million parts of air (ppm). The conversion from mg/m^3 to ppm requires the molecular weight of a component. Because the THC concentrations are quantitated as n-hexane (using n-hexane as a reference standard) a molecular weight of n-hexane (86.17) was used for converting mg/m^3 results to ppm.

Eighteen of the samples (12 customer exposure and 6 fenceline samples) were analyzed for the 58 components (Option B) shown in Appendix D. Samples of bulk gasoline were collected at each station. One sample of each available grade (excluding diesel) was collected and analyzed. Analytical results, service station operational parameters and meteorological data are included in the following appendices:

- Appendix A - Geometric Mean Concentrations of Customer Exposure by Grades of Gasoline
- Appendix B - Analytical Results - Customer Exposure Concentrations, Option "A" Constituents
- Appendix C - Service Station Operating Data
- Appendix D - Analytical Results - Customer Exposure and Fenceline Concentrations, Option "B" Constituents
- Appendix E - Site (Service Station) Diagrams

Appendix F - Analytical Results - "Fenceline" Samples (Option "A" Constituents)

Appendix G - Analytical Limits of Quantitation

Appendix H - Meteorological Data

Service stations have been assigned the following codes throughout the report (including tables) as follows:

C-01, C-02 = Cincinnati, Ohio stations

P-01, P-02 = Phoenix, Arizona stations

L-01, L-02 = Los Angeles, California stations

2.2 CUSTOMER EXPOSURE DATA

Table 2.1 includes a summary of the customer exposure data for Option A constituents including n-hexane, benzene, xylene, toluene, MTBE and THC. The table shows the number of samples collected for each grade of gasoline at each station, the average fill time and the geometric mean concentrations of airborne components. Table 2.2 shows the range of concentrations for each of the six constituents by grade of gasoline at each station.

2.3 SUMMARY OF FENCELINE DATA

Table 2.3 summarizes the fenceline concentrations for Option A constituents. The table includes the geometric means for perimeter sample concentrations, as well as, the upwind and downwind sample results.

2.4 BULK SAMPLE ANALYSIS

Eighteen samples of bulk gasoline were collected from the six service stations. One bulk sample was collected for each grade of gasoline. Table 2.4 summarizes the results of the bulk sample analyses for Option A constituents.

3.0 ASSESSMENT STRATEGY/METHODOLOGY

To characterize consumer exposure to gasoline vapor (during self-serve fill-up) and determine the fenceline air concentrations Clayton performed the following:

- Measurement of consumer exposures to gasoline vapors during self-serve fill-up
- Measurement of ambient air concentrations at the "fenceline"
- Collection of bulk gasoline samples
- Collection of service station operating data (i.e. station throughput, tank topping off, etc.)
- Gathering of meteorological data
- Analyses of air and bulk samples
- Reduction and organization of data

TABLE 2.1
SUMMARY OF CUSTOMER EXPOSURE DATA
GEOMETRIC MEAN CONCENTRATIONS PER AVERAGE FILL TIME ¹

STATION CODE GAS GRADE	# OF SAMPLES ²	AVG. FILL TIME min:sec	N-HEX (ppm)	BNZ (ppm)	XYL (ppm)	TOL (ppm)	MTBE (ppm)	THC ⁴ (ppm)	THC (mg/m ³)
C-01 - RU	14	1:39	0.57	0.25	0.11	0.37	0.40 ³	50	170
C-01 - MU	3	1:27	0.28	0.14	0.13	0.29	0.23 ³	39	140
C-01 - SU	3	1:21	0.29	0.09	0.12	0.23	0.18 ³	27	95
C-02 - RU	13	1:20	0.46	0.21	0.10	0.20	0.26 ³	48	170
C-02 - MU	4	1:18	0.57	0.09	0.16	0.21	0.50 ³	59	210
C-02 - SU	3	1:23	0.45	0.13	0.14	0.15	0.43 ³	37	130
P-01 - RU	15	1:10	0.88	0.63	0.15	0.48	5.4	43	150
P-01 - RL	2	1:01	1.7	1.2	0.3	1.1	25	110	400
P-01 - SU	3	1:11	0.61	0.58	0.22	0.74	9.1	49	180
P-02 - RU	14	1:32	0.40	0.25	0.08	0.22	3.3	21	72
P-02 - RL	4	1:57	0.52	0.35	0.14	0.32	4.9	29	100
P-02 - SU	2	2:13	0.29	0.23	0.14	0.23	3.1	17	61
L-01 - RU	12	1:54	0.45	0.3	0.13	0.33	0.13	27	94
L-01 - MU	5	2:24	0.12	0.15	0.11	0.18	0.09	9	31
L-01 - SU	3	2:03	0.11	0.13	0.13	0.18	0.12	9.1	32
L-02 - RU	14	1:49	0.50	0.33	0.12	0.33	0.13	24	85
L-02 - SU	6	1:46	0.50	0.49	0.13	0.47	2.9	26	90

Note: The summary table above is the geometric mean of all integrated samples for each grade of gasoline. Results are reports as part of vapor per million parts of air (ppm) and milligrams of chemical compound per cubic meter of air mg/m³.

N-Hex	=	N-Hexane	RU	=	Regular Unleaded
Bnz	=	Benzene	MU	=	Mid-Grade Unleaded
Xyl	=	Xylene	SU	=	Super (Premium) Unleaded
Tol	=	Toluene	RL	=	Regular Leaded

- ¹ Does not represent an 8-hour time weighted average exposure
- ² Each sample contained an average of 8-10 fill-up operations
- ³ Sample results are reported as maximum values (see analytical section)
- ⁴ THC based on molecular weight of n-hexane (86.17)

TABLE 2.2
SUMMARY OF CUSTOMER EXPOSURE DATA
RANGE OF AIRBORNE CONCENTRATIONS ^{1,2}

STATION CODE/ GAS GRADE	N-HEXANE (ppm)	BENZENE (ppm)	XYLENE (ppm)	TOLUENE (ppm)	MTBE (ppm)	THC ⁴ (ppm)	THC (mg/m ³)
C-01 - RU	0.26 - 1.8	0.10 - 0.79	0.06 - 0.39	0.14 - 1.2	0.17 - 1.5 ³	22 - 170	78 - 590
C-01 - MU	0.08 - 0.57	0.04 - 0.35	0.06 - 0.20	0.07 - 0.68	0.08 - 0.42 ³	18 - 61	63 - 220
C-01 - SU	0.24 - 0.41	0.08 - 0.12	0.08 - 0.11	0.2 - 0.32	0.1 - 0.26 ³	21 - 43	73 - 150
C-02 - RU	0.03 - 1.0	0.06 - 0.49	0.07 - 0.20	0.05 - 0.43	0.05 - 0.62 ³	11 - 97	40 - 340
C-02 - MU	0.40 - 0.66	0.05 - 0.20	0.09 - 0.20	0.10 - 0.29	0.33 - 0.62 ³	40 - 74	140 - 260
C-02 - SU	0.35 - 0.55	0.08 - 0.20	0.10 - 0.20	0.10 - 0.22	0.32 - 0.61 ³	30 - 46	110 - 160
P-01 - RU	0.09 - 3.9	0.1 - 2.6	0.08 - 0.48	0.10 - 1.7	0.09 - 38	4.1 - 190	14 - 660
P-01 - RL	1.3 - 2.1	1.1 - 1.4	0.30 - 0.31	1.1 - 1.2	20 - 31	93 - 130	330 - 480
P-01 - SU	0.20 - 1.4	0.20 - 1.2	0.08 - 0.44	0.24 - 1.4	2.8 - 18	14 - 95	51 - 340
P-02 - RU	0.05 - 1.1	0.03 - 0.79	0.02 - 0.2	0.03 - 0.65	0.42 - 9.2	2.6 - 58	9.2 - 200
P-02 - RL	0.28 - 1.1	0.18 - 0.79	0.10 - 0.19	0.17 - 0.67	2.8 - 9.6	16 - 64	56 - 230
P-02 - SU	0.18 - 0.47	0.14 - 0.38	0.10 - 0.20	0.12 - 0.43	1.8 - 5.4	9.8 - 31	34 - 110
L-01 - RU	0.22 - 1.4	0.16 - 0.85	0.10 - 0.25	0.17 - 0.84	0.04 - 1.4	11 - 83	39 - 290
L-01 - MU	0.09 - 0.43	0.08 - 0.33	0.10 - 0.13	0.11 - 0.39	0.07 - 0.1	4.8 - 30	17 - 100
L-01 - SU	0.09 - 0.15	0.1 - 0.17	0.1 - 0.2	0.15 - 0.23	0.08 - 0.17	6.7 - 12	24 - 43
L-02 - RU	0.07 - 1.4	0.06 - 1.1	0.03 - 0.27	0.07 - 0.95	0.06 - 0.33	3.3 - 81	11 - 280
L-02 - SU	0.23 - 1.1	0.15 - 1.2	0.05 - 0.22	0.16 - 1.0	1.1 - 6.5	8.3 - 68	29 - 240

Note: The summary table represents the range of concentrations for all integrated samples for each grade of gasoline. Results are reported in parts of vapor per million parts of air (ppm) and milligrams of chemical compound per cubic meter of air (mg/m³) for THC.

RU = Regular Unleaded
MU = Mid-Grade Unleaded

SU = Super Unleaded
RL = Regular Leaded

- ¹ Does not represent an 8-hour time weighted average exposure
- ² Each sample contained an average of 8-10 fill-up operations
- ³ Sample results are reported as maximum values (see analytical section)
- ⁴ THC based on molecular weight of n-hexane (86.17)

TABLE 2.3
SUMMARY OF FENCELINE SAMPLE CONCENTRATIONS

STATION CODE	N-HEX (ppm)	BENZENE (ppm)	XYLENE (ppm)	TOLUENE (ppm)	MTBE (ppm)	THC ² (ppm)	THC (mg/m ³)
C-01							
Perimeter Samples	0.003	0.003	0.004	0.007	0.002 ¹	0.11	0.39
Upwind Sample	0.004	0.002	0.004	0.007	0.001 ¹	0.07	0.25
Downwind Sample	0.003	0.004	0.004	0.006	0.003 ¹	0.14	0.50
C-02							
Perimeter Samples	0.002	0.003	0.004	0.002	0.002 ¹	0.08	0.28
Upwind Sample	0.001	0.002	0.003	0.002	0.002 ¹	0.03	0.11
Downwind Sample	0.003	0.004	0.005	0.006	0.003 ¹	0.15	0.53
P-01 ³							
Perimeter Samples	0.007	0.008	0.010	0.016	0.03	0.29	1.1
Upwind Sample	0.005	0.007	0.008	0.015	0.02	0.19	0.68
Downwind Sample	0.008	0.008	0.009	0.02	0.03	0.42	1.5
P-02 ³							
Perimeter Samples	0.003	0.004	0.004	0.006	0.014	0.12	0.43
Upwind Sample	0.003	0.004	0.004	0.006	0.015	0.12	0.43
Downwind Sample	0.003	0.005	0.004	0.005	0.015	0.09	0.32
L-01 ³							
Perimeter Samples	0.004	0.005	0.008	0.006	0.004	0.09	0.33
Upwind Sample	0.005	0.007	0.01	0.006	0.006	0.02	0.07
Downwind Sample	0.004	0.006	0.006	0.007	0.005	0.18	0.62
L-02							
Perimeter Samples	0.004	0.005	0.007	0.007	0.005	0.13	0.46
Upwind Sample	0.004	0.005	0.009	0.007	0.005	0.10	0.33
Downwind Sample	0.004	0.005	0.006	0.005	0.004	0.12	0.41

Note: Results are reported in ppm and mg/m³. Perimeter sample results are given as the geometric mean concentrations of the total fence line samples collected at the station.

¹ Sample results are reported as maximum values (see analytical section)

² THC based on molecular weight of n-hexane (86.17)

³ Variable wind speed on day sampling was conducted

TABLE 2.4
SUMMARY OF BULK SAMPLE ANALYSIS
PERCENT BY VOLUME

STATION CODE/ GAS GRADE	N-HEXANE	BENZENE	XYLENE	TOLUENE	MTBE	THC
C-01 - RU	1.5	0.86	6.0	4.9	0.10	64
C-01 - MU	1.3	0.79	6.7	10	<0.003	68
C-01 - SU	1.5	0.43	14	7.1	<0.003	71
C-02 - RU	1.8	0.98	5.4	4.4	0.12	64
C-02 - MU	1.5	0.60	11	3.8	<0.003	68
C-02 - SU	2.1	0.35	13	3.6	<0.003	72
P-01 - RU	1.8	2.1	4.2	3.7	12	68
P-01 - RL	1.0	1.4	5.2	3.6	12	65
P-01 - SU	0.59	1.1	6.0	5.2	12	63
P-02 - RU	1.1	1.5	4.5	3.3	12	68
P-02 - RL	1.1	1.3	4.8	3.6	12	62
P-02 - SU	0.89	1.3	8.1	6.1	12	66
L-01 - RU	1.9	2.1	7.5	6.1	0.23	75
L-01 - MU	1.7	2.6	9.6	8.5	0.27	84
L-01 - SU	0.86	1.9	10	10	0.27	74
L-02 - RU	1.5	2.6	7.8	6.7	0.19	72
L-02 - RL	2.3	2.7	11	8.7	0.43	84
L-02 - SU	1.9	4.1	10	12	13	84

Note: Results are expressed as percentages on a volume to volume basis. The concentrations for the five components can not be added to obtain concentrations for the total hydrocarbons. The total hydrocarbon concentrations also include compounds other than the five individual components. Moreover, total hydrocarbon concentrations are calculated on n-hexane (using n-hexane standard for quantification). The molecular weight on n-hexane is 86.17

3.1 MEASUREMENTS OF CONSUMER EXPOSURE TO GASOLINE VAPOR

The average time to dispense gasoline during a self fill-up was found to be 1:43 minutes. The average gasoline dispensing time may vary from station to station depending upon the gasoline flow rates among other factors. The average dispensing time for each station during Clayton's study is shown in the table below:

AVERAGE FILL TIME

STATION DESIGNATION	FILL TIME min:sec
C-01	1:35
C-02	1:20
P-01	1:09
P-02	1:41
L-01	2:03
L-02	1:48

Clayton estimated that to achieve the detection limits desired, a minimum sample volume of 10 liters would be necessary. This required approximately ten minutes of sampling time at a sampling flow rate of one liter per minute (Lpm). Clayton, therefore, selected 8-10 vehicle fuelings to collect one approximate 10 liter sample. Clayton calibrated the sampling pumps prior to and after collecting each sample (8-10 customers) using a primary calibration standard. The average flow rate was used to calculate the volume of air drawn.

To collect the consumer samples, the Clayton industrial hygienists held the activated charcoal tube as close to the customer's breathing zone as practical. Sampling was begun when the gas cap was removed and stopped when the pump nozzle was replaced. After sufficient sampling volume (about 10 liters) was obtained from a minimum of 8-10 vehicle fuelings, each activated charcoal tube was capped, labeled, and shipped in a refrigerated cooler by overnight courier to Clayton's American Industrial Hygiene Association (AIHA)-accredited laboratory in Novi, Michigan where it was refrigerated until analysis.

Using this technique, 20 discrete customer exposure samples were collected over a 2-day period at each service station. A total of 120 samples, therefore, were collected for self-serve fill-up customers. Sampling was performed using standard battery-powered pumps equipped with 600 milligram activated charcoal tubes. Samples were collected at a flowrate of approximately one liter per minute.

3.2 MEASUREMENTS OF AMBIENT CONCENTRATIONS AT THE "FENCELINE"

Concurrently with the consumer exposure sampling, Clayton performed fenceline sampling to measure airborne concentrations of select gasoline vapor constituents to estimate potential community exposures. To accomplish this, six fixed locations were established at each service station. On a four-sided lot, one sampling station was located near the mid point of each boundary line. One sample was also located upwind and one downwind of the gasoline pump islands, at the perimeter of the stations. Upwind and downwind sampling stations were selected on the basis of predicted wind direction. The sampling stations remain stationary although wind direction at three of the stations (P-O1, P-O2, L-O1) was variable. Sampling was performed using standard battery-powered pumps equipped with 600 milligram activated charcoal tubes.

Fenceline samples were collected at a rate of approximately 50 milliliters per minute and represented one 24-hour period. Two discrete sample sets were collected, one for each 12-hour period at each station. Due to inclement weather at the C-O2 station, the second half of perimeter samples was discontinued and a new 24-hour sampling round was conducted on the second day. A total of 72 samples were collected at the six service stations. Diagrams showing fenceline sample locations are included in Appendix E.

3.3 COLLECTION OF BULK GASOLINE SAMPLES

Bulk samples representing the various grades of gasoline being dispensed were collected at each service station. The following grades of gasoline were sampled:

- Regular leaded
- Regular unleaded

- Mid-grade unleaded
- Super premium unleaded

A total of 18 bulk samples were collected each comprising approximately 50 milliliters of gasoline. Bulk gasoline samples, excluding diesel, were collected from each grade available at each station. At station L-02 the regular leaded gasoline was not pumped during the sampling period. Therefore, customer samples could not be collected. One sample of each grade of gasoline was collected.

3.4 COLLECTION OF OPERATING DATA

Appropriate operating parameters were noted to allow correlations with measured exposures. These included:

- Station designation
- Station type (full or self-service)
- Location
- Date
- Sample number
- Number of fill-ups per sample
- Type of fuel pumped
- Amount of gasoline pumped
- Tank "Topping off" data*
- Wind direction

* *"Topping off" is defined as attempts to fill the tank as near to its capacity as possible by overriding the automatic fuel shut-off valve.*

In addition, the Clayton industrial hygienists noted accidental spills or overflows, if any, and any other problems encountered that may affect airborne concentrations. The following table illustrates the frequency of spills and overflows.

PERCENT DISTRIBUTION OF SPILLS DURING REFUELING

AMOUNT OF RELEASE	LOCATION OF STATION		
	CINCINNATI	PHOENIX	LOS ANGELES
None	32	27	52
Drips (≤ 1 ml)	52	50	40
Drips and/or spills (> 1 ml)	14	22	7

ml = milliliter

Note: Percentages do not equal 100% due to rounding errors. Cincinnati and Phoenix stations were equipped with conventional dispensing systems with limited use of safety latches. Los Angeles stations were equipped with vapor recovery systems (Stage II) and with wide use of safety latches.

Clayton's industrial hygienists also noted the location of the storage tank vents, general condition of the service station equipment, and the location of the fill tube on the vehicle relative to the filler's position. In addition to the information provided in the tables, descriptions are provided below for each station.

Station C-01

Station C-01 is located 20 miles north of Cincinnati, in Springdale, Ohio at a busy intersection approximately one half of a mile from Interstate 275. The corners opposite the station include a shopping mall, a shopping plaza and a gasoline station. The lot south of the property contained a large auto dealership. A small food-mart and car wash were also on the service station property.

During the sampling period two tanker trucks delivered a total of 17,606 gallons of fuel to the station.

One of the gasoline pumps had a leaky handle which was replaced at 2:15 p.m. on October 16, 1990 potentially affecting samples APIS-04RU, APIS-01SU, and APIS-02SR. There were no safety latches present, although approximately 5% of the customers would lock the nozzle in place with a gas cap and walk away from the

vicinity of the fill tube.

Station C-02

Station C-02 is located approximately 20 miles northeast of Cincinnati, in Kenwood, Ohio, in a mixed residential and commercial area. The areas surrounding the station included a large shopping mall, several restaurants, and small stores. The station is approximately one mile from Interstate 71.

The station also houses a busy auto repair facility onsite. The station pumps were in good condition with a limited number of safety latches in use. One tank truck of fuel was delivered to the station during the sampling period, bringing 9,099 gallons of fuel.

During the first day of sampling winds were blowing at 8 - 15 miles per hour with gusts to 25 miles per hour and it was raining most of the day.

Station P-01

Station P-01 is located approximately 10 miles west of downtown Phoenix, Arizona at a moderately busy intersection which includes two supermarkets, a service station, a vacant lot, and a convenience store. Interstate 10 is approximately one-half mile south of the service station.

The station has a service garage and a small snack shop onsite. The station pump equipment was in good condition with no safety latches in use at the self-serve islands. 8,850 gallons of fuel were delivered (representing one tank truck) during the sampling period.

Two unusual fill-ups were observed at this location. A customer filled a 17-gallon portable tank in a pick-up truck positioning the filler nozzle at the customer's breathing zone height (sample #APIE-01R). The second incident involved a very short customer filling a large truck. This resulted in placing the filler nozzle at the customer's breathing zone level (sample #APIE-01X).

Station P-02

Station P-02 is located approximately 20 miles north of downtown Phoenix, Arizona at a very busy intersection with a service station, shopping plaza, and restaurant located on the opposite corner. The adjacent properties included an equipment rental facility and a vacant lot. The station contained a propane tank for consumer sales, a service garage, and a snack shop. One tank truck delivery was made during the sampling period, representing 8,350 gallons of fuel (excluding diesel).

The station equipment was in good condition. Safety latches were in limited use. Two unusual occurrences were noted at this location. A customer apparently dumped a five gallon container of a liquid which appeared to be solvent on the corner of the station lot near perimeter sample #APIT-02AF. The second incident involved the spillage of approximately one gallon of gas during one customer fill (sample #APIT-02R).

Station L-01

Station L-01 is located in downtown Los Angeles, California in a mixed residential and commercial area. The station is in front of a large office building with a parking garage and across the street from an apartment complex.

The streets adjacent to the station have a low volume of traffic and one contained a bus stop. Interstate 110 is approximately one-half mile from the station.

This station appeared well-kept with attendants cleaning up spills almost immediately. Each of the pumps was equipped with a vapor recovery system (Stage II) and a safety latch, which was extensively used. Stage II vapor recovery systems are the systems used for retail as opposed to Stage I systems used for truck loading and unloading. The station also housed a repair facility underneath the station in a parking garage. One spill of approximately one-half gallon was observed (sample # APIU-9U).

Station L-02

Station L-02 is located in Orange, California, a suburb approximately 30 miles southeast of Los Angeles. This station is situated on a busy street with a freeway on-ramp on its south side and the freeway on its west side. The north side of the lot contains a small restaurant. Across the street to the east was a 200-foot steep grade with residential area beyond.

The station contained a repair facility. Station pumps islands were equipped with vapor recovery systems (Stage II) and safety latches, which were extensively used.

3.5 COLLECTION OF METEOROLOGICAL DATA

Clayton was responsible for collecting meteorological data from station C-02, P-02, and L-02 stations. NIOSH collected and supplied Clayton with the meteorological data from the remaining three stations (C-01, P-01, and C-02). To collect local meteorological data at the three stations assigned to Clayton, a portable meteorological station was installed at each station to measure wind speed, wind direction, ambient temperature and relative humidity.

The meteorological sensors were positioned at the top of an 11 foot mast supported by a tripod. The meteorological measurement equipment was placed on the roof of the C-02 and P-02 service stations and at approximate roof level at the L-02 station. This placement allowed for the measurement of wind flow patterns representative of the general area. Measurements near buildings and other obstacles are affected by air flow wakes produced by these structures. The rooftop placement minimized these influences and provided additional equipment security.

The wind speed sensor was capable of measuring air flows up to 100 miles per hour (mph) with a threshold of approximately 1.0 mph. The wind direction sensor had a full 360 degree range (the recorded direction is that from which the wind blows). The relative humidity (RH) sensor was capable of measurements from 0 to 100 percent (%) with an accuracy of approximately $\pm 2\%$. The temperature sensor was capable of measurements from -10 to 50 degrees Celsius (C) with an accuracy of approximately $\pm 0.5^\circ$ C. A radiation shield was used with the RH and temperature

sensor.

Prior to the initiation of the sampling program, all equipment was checked for proper operation. A four-pen strip chart recorder was used to record the measurements. Alignment of the proper time setting on the chart paper was conducted at the start of each measurement period, and time checks and equipment operation noted at least once per day thereafter. The strip chart data were reduced and compiled into 15 minute average values, and are presented in Appendix H.

3.6 ANALYTICAL METHOD SUMMARY

Air and bulk samples were analyzed for specific organic components specified by API. The majority of the samples were analyzed for n-hexane, benzene, xylene, toluene, MTBE, and THC (Option A constituents). Eighteen of the 192 samples were analyzed for 58 organic constituents (Option B) listed in Appendix D. The Option B analyses were performed on 10% of the total number of samples and represent 12 customer exposure samples and six fenceline samples. The Option B analyses were performed on samples that had the greatest sample volume or the greatest likelihood of detection because of accidental releases (i.e., spills) during sampling period.

Laboratory analyses were performed at Clayton's Novi, Michigan laboratory using gas chromatographic procedures. The detailed analytical procedures are described in Section 4.0.

3.6.1 Quality Control

All samples were subjected to routine quality assurance and quality control procedures in place at the Clayton laboratories. These include chain-of-custody, sample logging, sample assignments, review of raw data, and review of the final laboratory report. Specifically, the following quality control procedures were used for the API project:

- Laboratory blanks were run for each batch of samples. An extra blank was run for each day when the batch analysis took more than one day. The blank samples were selected from the same batch of charcoal tubes as used for the field sampling.

- Duplicate analyses were run for 10% of the samples.
- Analyses of spiked samples submitted by NIOSH was carried out as part of the quality assurance program. NIOSH staff compared these data and indicated that Clayton's data were within the quality assurance parameters established by NIOSH.

3.6.2 Total Hydrocarbon Results

Total hydrocarbon concentrations are expressed as n-hexane and were calculated using n-hexane as a reference standard for quantification. These concentrations, therefore, encompass every organic compound that responds to flame ionization detector. Because relative response factors for individual organic compounds vary, the total hydrocarbon concentrations, quantitated with a n-hexane standard, do not correspond to a sum of concentrations of individual organic compounds. Total hydrocarbon results are expressed as mg/m³ as well as ppm. The conversion from mg/m³ to ppm was performed using the molecular weight of n-hexane (86.17).

3.6.3 Bulk Sample Results

Bulk samples were analyzed using 1.0 microliter of bulk gasoline dissolved in 1.0 milliliter of n-hexane. Analysis was performed using gas chromatography. Analytical results are reported in micrograms per milliliter of sample and expressed as percentages on a volume to volume basis.

It should be noted that the total hydrocarbon concentrations are not an additive of the five individual compounds reported. The THC concentrations include a variety of other organic compounds (not individually quantitated), that respond to the flame ionization detector. Moreover, the individual response factors for the flame ionization detector vary from one organic compound to another resulting in a THC concentration in gasoline of less than 100%.

3.6.4 Methyl Tertiary Butyl Ether Results

Section 4.0 provides details of the analytical method employed for the analysis of MTBE. The error range for quantitative MTBE is 8-12%. Analyses were performed by gas chromatography and identification of the MTBE peak was based on the retention time as compared with a known MTBE standard.

The first batch of samples collected from the Cincinnati stations were analyzed (for Option A components) using the RTI analytical methods. Using the RTI method, difficulties were encountered in resolving MTBE from an interference peak. Generally, the interfering peaks can be resolved by using a different column. The Clayton laboratory was unable to resolve the MTBE peak using different columns (while using the RTI method). For the Arizona and California samples, the newly released NIOSH Method 1615 was adopted, thereby successfully resolving the MTBE peak from the interferences. All samples resulting from the Arizona and California stations were, therefore, analyzed using the NIOSH 1615 method. In addition, all Option B samples (including those from Ohio) were analyzed using the NIOSH 1615 method. It should be emphasized that NIOSH 1615 is essentially the same as the RTI method, except the use of subambient temperatures (for NIOSH 1615).

Based on the above, the MTBE values reported from the two Ohio stations are likely to be higher than the actual MTBE concentrations (because of the possible presence of interfering peak) and are, therefore, treated as the maximum values.

3.6.5 Xylene Results

The results reported for xylene include the ortho, meta, and para isomers. Because of the difficulty in separately resolving the ortho and para isomers, the analysis results in a combined ortho/para value. Although the instrument response factor for both ortho and the para isomers is equivalent, there is a slight difference in desorption efficiency. The ortho isomer has a desorption efficiency of 92% and the para isomer 96%. The combined concentration was calculated based on the lower desorption efficiency of 92%, resulting in a slight over correction of the combined ortho/para xylene value.

3.7 DATA REDUCTION

Geometric means and geometric standard deviations were calculated for all sampling data. Geometric statistics were chosen to summarize the data by its probable logarithmic distribution. "Less than" values are shown as "equal to" values in summarizing statistics.

4.0 LABORATORY ANALYSES

Air and bulk samples were analyzed at Clayton's American Industrial Hygiene Association (AIHA)-accredited laboratory in Novi, Michigan. The majority of the air samples and all of the bulk samples were analyzed for the six components comprising option "A", i.e., n-hexane, benzene, toluene, xylene, MTBE, and THC's. Selected air samples were analyzed for the 58 components (option "B" analytes) specified by API as "constituents of gasoline."

The analytical limits of quantitation (LOQ) are reported in Appendix G. The Clayton laboratory uses the convention of LOQ as the lowest value for reliable quantitation. The LOQ is verified by analysis of a standard during each sample batch. The analytical LOQs for Option A components are as follows:

COMPONENT	LOQ (Micrograms per sample)
n-hexane	3 ug
benzene	4 ug
xylene*	9 ug
toluene	4 ug
MTBE	4 ug

ug = micrograms

**xylene includes ortho, meta, and para isomers*

Analyses for the samples collected at the first two service stations in Cincinnati, Ohio were performed by gas chromatography using flame ionization detection (GC/FID) referencing the Research Triangle Institute (RTI) method. MTBE could not be fully resolved by this technique due to interferences from cyclopentane (a likely component of gasoline). Clayton attempted to resolve the MTBE peak through the use of different chromatographic columns, but was unsuccessful in resolving MTBE from the interferences. The MTBE results for the Cincinnati stations are, therefore, reported as "maximum values", and may represent more than one component.

Analyses for the Phoenix and Los Angeles air samples and Option B constituents (including those from the Cincinnati stations) were performed by NIOSH Method 1615, (August 15, 1990) referenced in the NIOSH Manual of Analytical Methods, Third Edition. The NIOSH method 1615 is a reference method for determining organic compounds in a mixture and is essentially equivalent to the RTI method. The "new" NIOSH method, however, incorporates subambient temperature programming resulted in successful resolution of the MTBE from interferences. For analyses, the 600 milligram charcoal tube samples were desorbed in 1 milliliter (mL) of cold carbon disulfide for a minimum of 30 minutes prior to analysis. Front and back tube sections were desorbed and analyzed separately.

The analytical conditions were as follows:

Instrument:	Hewlett-Packard Model 5880 Gas Chromatograph
Detector:	Flame ionization
Column:	Supelco DB 1 capillary, 0.32 mL ID, 1 micrometer film thickness, 60 meter length
Temperature Program:	Initial Stage: 0° C for 7 minutes Ramp 1: 5° C per minute Second Stage: 25° C for 1 minute Ramp 2: 10° C per minute Third Stage: 250° C for 5 minutes
Run Time:	60 minutes
Injection Volume:	1 microliter (uL), automated injection (Hewlett-Packard Model 7671A)
Injection Temperature:	200° C
Detector Temperature:	250° C

Calibration standards were prepared from serial dilution of a stock standard prepared by volumetric addition (5 uL) of each component to a 10 mL volume of carbon disulfide. Quantitative analyses were based on a four-point calibration curve. Instrument response of calibration standards and air samples was determined by electronic integration. Integration response was verified by manual review of individual chromatograms.

The analytical run sequence for a sample set consisted of the following:

- Generation of a four-point calibration curve
- Analysis of the solvent blank

Analyses of 25 samples

Generation of four-point calibration curve

The total sequence lasted 36 hours.

Additional quality control procedures incorporated into the analytical run sequence included three levels of desorption efficiencies, prepared in duplicate, at the beginning of the project followed by one pair of desorption efficiencies weekly for the duration of the project.

APPENDIX A
GEOMETRIC MEAN CONCENTRATIONS
OF CUSTOMER EXPOSURE BY GRADES
OF GASOLINE

Table A-1
 SUMMARY ANALYTICAL RESULTS FOR REGULAR UNLEADED GASOLINE
 GEOMETRIC MEAN CONCENTRATIONS OF CUSTOMER EXPOSURE RESULTS
 OCTOBER-NOVEMBER, 1990

Service Station Designation	Number of Samples/Customers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)
C-01	14/115	2 0.57	170	0.82 0.25	0.51 0.11	1.4 0.37	1.5 0.4
C-02	13/113	1.6 0.46	170	0.71 0.21	0.45 0.1	0.75 0.2	0.78 0.26
P-01 +	15/142	3.1 0.88	150	2.1 0.63	0.66 0.15	1.8 0.48	20 5.4
P-02 +	14/116	1.4 0.4	72	0.82 0.25	0.39 0.08	0.82 0.22	12 3.3
L-01 ++	12/97	1.6 0.45	94	0.97 0.3	0.64 0.13	1.2 0.33	0.41 0.13
L-02 ++	14/112	1.6 0.5	85	1.0 0.33	0.46 0.12	1.2 0.33	0.4 0.13

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether

+ Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.

++ Los Angeles stations were equipped with Stage II vapor recovery systems.



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Table A-2

API
SUMMARY ANALYTICAL RESULTS FOR LEADED GASOLINE
GEOMETRIC MEAN CONCENTRATIONS OF CUSTOMER EXPOSURE RESULTS
OCTOBER-NOVEMBER, 1990

Service Station Designation	Number of Samples/Customers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)
C-01	0	***	***	***	***	***	***
C-02	0	***	***	***	***	***	***
P-01 +	2/19	5.8	400	3.9	1.3	4.3	88
P-02 +	4/33	1.8	100	1.1	0.57	1.2	18
L-01 ++	0	***	***	***	***	***	***
L-02 ++	0	***	***	***	***	***	***

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether

*** Station did not have leaded gasoline or no samples were collected.

+ Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.

++ Los Angeles stations were equipped with Stage II vapor recovery systems.



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Table A-3
 API
 SUMMARY ANALYTICAL RESULTS FOR MID-GRADE UNLEADED GASOLINE
 GEOMETRIC MEAN CONCENTRATIONS OF CUSTOMER EXPOSURE RESULTS
 OCTOBER-NOVEMBER, 1990

Service Station Designation	Number of Samples/Customer	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)
C-01	3/27	0.98	140	0.48	0.13	1.1	0.23
C-02	4/35	2	210	0.29	0.09	0.85	1.8
P-01 +	0	***	***	***	***	***	***
P-02 +	0	***	***	***	***	***	***
L-01 ++	5/40	0.58	31	0.46	0.15	0.67	0.26
L-02 ++	0	***	***	***	***	***	***

* Total Hydrocarbons as n-Hexane
 ** Methyl Tertiary Butyl Ether
 *** Station does not have mid-grade unleaded gasoline
 + Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.
 ++ Los Angeles stations were equipped with Stage II vapor recovery systems.



Table A-4
API
 SUMMARY ANALYTICAL RESULTS FOR PREMIUM UNLEADED GASOLINE
 GEOMETRIC MEAN CONCENTRATIONS OF CUSTOMER EXPOSURE RESULTS
 OCTOBER-NOVEMBER, 1990

Service Station Designation	Number of Samples/ Customers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
C-01	3/25	1	0.29	95	27	0.29	0.09	0.5	0.12	0.78	0.23	0.68	0.18
C-02	3/25	1.6	0.45	130	37	0.38	0.13	0.63	0.14	0.63	0.15	1.5	0.43
P-01 +	3/26	2	0.61	180	49	1.8	0.58	1.1	0.22	2.8	0.74	33	9.1
P-02 +	2/16	1	0.29	61	17	0.69	0.23	0.57	0.14	0.84	0.23	11	3.1
L-01 ++	3/24	0.4	0.11	32	9.1	0.42	0.13	0.56	0.13	0.69	0.18	0.4	0.12
L-02 ++	6/48	1.8	0.5	90	26	1.6	0.49	0.6	0.13	1.8	0.47	11	2.9

* Total Hydrocarbons as n-Hexane

** Methyl tertiary Butyl Ether

+ Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.

++ Los Angeles stations were equipped with Stage II vapor recovery systems.



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APPENDIX B
ANALYTICAL RESULTS
CUSTOMER EXPOSURE CONCENTRATIONS,
OPTION A CONSTITUENTS



Documents

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Table B-1

API
ANALYTICAL RESULTS - SERVICE STATION C-01
CUSTOMER EXPOSURE CONCENTRATIONS
OCTOBER 16-17, 1990

Sample Number	Air Volume (liters)	Number of Consumers per sample	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)					
Regular Unleaded Gasoline-													
APIS-01RU***	11	8	4.8	120	2.2	0.7	1.2	0.27	0.62	0.17			
APIS-02RU	13	8	1.8	47	0.71	0.2	0.39	0.09	1.3	0.33	1.6	0.44	
APIS-03RU	13	8	1.4	38	0.55	0.2	0.39	0.09	1.1	0.29	1.3	0.35	
APIS-04RU	12	7	1.9	47	0.75	0.2	0.41	0.1	1.4	0.37	1.7	0.46	
APIS-05RU	14	8	2.4	62	1	0.32	0.65	0.2	1.8	0.51	2.1	0.58	
APIS-06RU	10	10	1.8	44	0.72	0.2	0.51	0.1	1.2	0.33	1.3	0.37	
APIS-07RU	13	8	1.6	39	0.7	0.2	0.62	0.1	1.2	0.33	1.3	0.36	
APIS-08RU	12	8	1.9	42	0.66	0.2	0.5	0.1	1.4	0.37	1.5	0.41	
APIS-09RU	12	10	6.3	170	2.5	0.79	1.5	0.39	4.6	1.2	5.3	1.5	
APIS-10RU	12	8	3.2	270	1.2	0.37	0.68	0.2	2.1	0.54	2.6	0.73	
APIS-11RU	16	8	1.5	95	0.51	0.2	0.25	0.06	0.76	0.2	0.89	0.25	
APIS-12RU	17	8	1	95	0.41	0.1	0.3	0.07	0.77	0.2	0.89	0.25	
APIS-13RU	13	8	2.5	63	1.2	0.36	0.54	0.1	1.5	0.41	2	0.55	
APIS-14RU	17	8	0.9	78	0.36	0.1	0.24	0.06	0.54	0.14	0.72	0.2	
Geometric Mean													
Geometric Standard Deviation													
1.7 1.7 1.7 1.7 1.7 1.8 1.6 1.7 1.7 1.7 1.7 1.7 1.7													

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether, sample results are reported as maximum values (see analytical section)

*** Sample analyzed for 58 components



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Table B-1 (cont.)

API
ANALYTICAL RESULTS - SERVICE STATION C-01
CUSTOMER EXPOSURE CONCENTRATIONS
OCTOBER 16-17, 1990

Sample Number	Air Volume (liters)	Number of Consumers per sample	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Mid-Grade Unleaded Gasoline-														
APIS-01SR	15	8	0.27	0.08	63	18	0.14	0.04	0.27	0.07	0.27	0.08		
APIS-02SR	10	9	1.7	0.49	180	52	0.71	0.2	0.71	0.2	1.8	0.49	1.3	0.37
APIS-03SR	15	10	2	0.57	220	61	1.1	0.35	0.71	0.17	2.5	0.68	1.5	0.42
Geometric Mean														
Geometric Standard Deviation														
Premium Unleaded Gasoline-														
APIS-01SU***	10	8	1.5	0.41	150	43	0.4	0.12	0.89	0.21	1.2	0.32	0.4	0.09
APIS-02SU	12	9	0.84	0.24	79	22	0.25	0.08	0.42	0.1	0.67	0.2	0.92	0.26
APIS-03SU	12	8	0.85	0.24	73	21	0.25	0.08	0.34	0.08	0.59	0.2	0.85	0.23
Geometric Mean														
Geometric Standard Deviation														
* Total Hydrocarbons as n-Hexane														
*** Methyl Tertiary Butyl Ether, sample results are reported as maximum values(see analytic section)														
**** Sample analyzed for 58 components														

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether, sample results are reported as maximum values(see analytic section)

*** Sample analyzed for 58 components



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Table B-2

API
ANALYTICAL RESULTS - SERVICE STATION C-02
CUSTOMER EXPOSURE CONCENTRATIONS
OCTOBER 18-19, 1990

Sample Number	Air Volume (liters)	Number of Consumers per sample	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Regular Unleaded Gasoline-														
APIB-01R	12	10	2.2	0.62	200	57	0.76	0.2	0.42	0.1	0.92	0.25	1.6	0.44
APIB-02R	10	8	0.59	0.2	48	14	0.2	0.06	0.39	0.09	0.19	0.05	0.39	0.1
APIB-03R	10	9	2.3	0.66	220	63	0.87	0.3	0.38	0.09	0.96	0.26	1.5	0.43
APIB-04R	11	9	3.7	1	340	97	1.4	0.45	0.81	0.2	1.6	0.43	2.5	0.7
APIB-05R	11	10	2.5	0.72	250	72	0.96	0.3	0.44	0.1	1.1	0.28	1.7	0.46
APIB-06R***	14	8	3.3	0.94	320	90	1.6	0.49	0.8	0.2	1.5	0.39	0.53	0.15
APIB-07R	11	8	0.94	0.27	86	24	0.38	0.1	0.38	0.09	0.38	0.1	0.57	0.2
APIB-08R	13	9	3.6	1	340	97	1.4	0.44	0.54	0.1	1.4	0.37	2.2	0.62
APIB-09R	11	8	0.09	0.03	40	11	0.18	0.06	0.37	0.08	0.18	0.05	0.18	0.05
APIB-10R	11	8	2.6	0.75	250	72	1	0.32	0.38	0.09	1	0.28	1.7	0.47
APIB-11R	10	10	1.9	0.52	170	50	0.72	0.2	0.41	0.09	0.82	0.2	1.1	0.31
APIB-12R	13	8	1.8	0.5	180	52	0.72	0.2	0.32	0.07	0.79	0.21	0.12	0.33
APIB-13R	11	8	1.7	0.48	160	46	0.81	0.25	0.41	0.1	0.87	0.23	0.4	0.1
Geometric Mean			1.6	0.46	170	48	0.71	0.21	0.45	0.1	0.75	0.2	0.78	0.26
Geometric Standard Deviation			2.6	2.5	2	2	2	2	1.2	1.3	2	2	2.6	2.2
Total Hydrocarbons as n-Hexane														
*** Methyl Tertiary Butyl Ether, sample results are reported as maximum values(see analytical section)														
*** Sample analyzed for 58 components														

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether, sample results are reported as maximum values(see analytical section)

*** Sample analyzed for 58 components

Table B-2 (cont.)

API
ANALYTICAL RESULTS - SERVICE STATION C-02
CUSTOMER EXPOSURE CONCENTRATIONS
OCTOBER 18-19, 1990

Sample Number	Air Volume (liters) per sample	Number of Consumers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Mid-Grade Unleaded Gasoline-														
APIB-01P	12	9	2.2	0.63	230	65	0.17	0.05	0.85	0.2	1.11	0.29	1.9	0.55
APIB-02P	10	8	2.3	0.66	260	74	0.19	0.06	0.87	0.2	0.97	0.26	2.2	0.62
APIB-03P	12	10	2.3	0.64	230	64	0.57	0.2	0.73	0.2	0.89	0.24	2	0.56
APIB-04P	13	8	1.4	0.4	140	40	0.39	0.1	0.39	0.09	0.55	0.1	1.2	0.33
Geometric Mean			2	0.57	210	59	0.29	0.09	0.68	0.16	0.85	0.21	1.8	0.5
Geometric Standard Deviation			1.2	1.2	1.3	1.3	1.7	1.7	1.4	1.4	1.3	1.5	1.3	1.3
Premium Unleaded Gasoline-														
APIB-01S	11	8	1.3	0.35	110	30	0.27	0.08	0.54	0.1	0.54	0.1	1.5	0.42
APIB-02S**	12	8	1.6	0.46	130	38	0.4	0.14	0.8	0.3	0.57	0.15	1.1	0.32
APIB-03S	12	9	1.9	0.55	160	46	0.49	0.2	0.57	0.1	0.81	0.22	2.2	0.61
Geometric Mean			1.6	0.45	130	37	0.38	0.13	0.63	0.14	0.63	0.15	1.5	0.43
Geometric Standard Deviation			1.2	1.2	1.2	1.2	1.3	1.5	1.2	1.4	1.2	1.3	1.3	1.3

* Total Hydrocarbons as n-Hexane
** Methyl Tertiary Butyl Ether, sample results are reported as maximum values (see analytical section)
*** Sample analyzed for 58 components



Table B-3

API
ANALYTICAL RESULTS - SERVICE STATION P-01+
CUSTOMER EXPOSURE CONCENTRATIONS
OCTOBER 30-31, 1990

Sample Number	Air Volume (liters)	Number of Consumers per sample	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Regular Unleaded Gasoline-														
APIE-01U	11	11	9	2.6	430	120	5.5	1.7	1.1	0.25	4.2	1.1	99	28
APIE-02U	11	11	4.8	1.4	280	79	3.2	1	0.9	0.21	3.4	0.91	46	13
APIE-03U	11	10	14	3.9	660	190	8.4	2.6	2.2	0.48	6.3	1.7	140	38
APIE-04U	11	10	3.6	1	160	46	2.4	0.75	0.7	0.2	2.2	0.58	19	5.3
APIE-05U	10	10	3.7	1.1	180	50	2.2	0.68	0.5	0.1	2.1	0.55	36	10
APIE-06U	12	10	3.5	0.98	170	49	2.3	0.7	0.7	0.2	1.9	0.51	29	7.9
APIE-07U	10	10	2.9	0.81	140	41	2.1	0.64	0.7	0.2	2.3	0.6	29	8
APIE-08U	12	8	1.8	0.51	90	25	1.1	0.33	0.3	0.08	0.9	0.24	16	4.5
APIE-09U	11	9	3.7	1	170	50	2.3	0.72	0.4	0.08	1.6	0.41	34	9.4
APIE-10U***	14	8	4.4	1.2	250	71	2.7	0.85	1.2	0.29	2.8	0.73	0.4	0.09
APIE-11U	9	9	0.3	0.09	14	4.1	0.4	0.1	0.6	0.1	0.4	0.1	2.7	0.74
APIE-12U	13	8	5.6	1.6	270	77	3.6	1.1	0.7	0.2	2.5	0.66	62	17
APIE-13U	11	10	1.6	0.45	76	22	1	0.32	0.5	0.1	0.93	0.25	7.3	2
APIE-14U	12	10	1.1	0.31	53	15	0.7	0.2	0.4	0.1	0.6	0.2	8.5	2.4
APIE-15U'	11	8	3.4	0.96	170	48	2.2	0.68	0.4	0.09	1.4	0.37	34	9.4
Geometric Mean			3.1	0.88	150	43	2.1	0.63	0.66	0.15	1.8	0.48	20	5.4
Geometric Standard Deviation			2.4	2.4	2.4	2.4	2.1	2.2	1.6	1.7	2	2	4.2	4.3

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether

*** Sample analyzed for 58 components.

+ Phenix has a minimum regulatory requirement for oxygenates in automotive fuels.

Table B-3 (cont.)

API
ANALYTICAL RESULTS - SERVICE STATION P-01+
CUSTOMER EXPOSURE CONCENTRATIONS
OCTOBER 30-31, 1990

Sample Number	Air Volume (liters) per sample	Number of Consumers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Regular Leaded Gasoline-														
APIE-01R	12	9	7.3	2.1	480	130	4.4	1.4	1.3	0.3	4.6	1.2	110	31
APIE-02R	8.3	10	4.6	1.3	330	93	3.4	1.1	1.3	0.31	4	1.1	71	20
Geometric Mean														
Geometric Standard Deviation			5.8	1.7	400	110	3.9	1.2	1.3	0.3	4.3	1.1	88	25
Premium Unleaded Gasoline-														
APIE-01X	11	8	2.9	0.83	310	88	2.6	0.8	1.8	0.39	4.5	1.2	66	18
APIE-02X	11	9	0.6	0.2	51	14	0.6	0.2	0.4	0.08	0.92	0.24	10	2.8
APIE-03X***	12	9	4.8	1.4	340	95	3.8	1.2	1.9	0.44	5.4	1.4	55	15
Geometric Mean														
Geometric Standard Deviation			2	0.61	180	49	1.8	0.58	1.1	0.22	2.8	0.74	33	9.1
Geometric Standard Deviation														
			2.4	2.3	2.9	2.4	2.2	2.2	2.1	2	2.2	2.2	2.3	2.3

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether

*** Sample analyzed for 58 components.

+ Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.



Table B-4
API
ANALYTICAL RESULTS - SERVICE STATION P-02 +
CUSTOMER EXPOSURE CONCENTRATIONS
NOVEMBER 1-2, 1990

Sample Number	Air Volume (liters)	Number of Consumers per sample	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)
Regular Unleaded Gasoline-								
APIT-01U	17	8	3 0.85	170 48	1.8 0.58	0.56 0.13	1.6 0.43	31 8.6
APIT-02U	14	8	1.2 0.33	66 19	0.79 0.25	0.31 0.07	0.78 0.21	13 3.6
APIT-03U	17	8	1.6 0.45	100 29	1.1 0.35	0.41 0.09	1 0.27	17 4.7
APIT-04U	11	8	3.3 0.93	140 40	1.8 0.56	0.59 0.14	1.9 0.51	26 7.1
APIT-05U	17	8	3.3 1.1	61 17	0.68 0.21	0.33 0.06	0.72 0.19	10 2.8
APIT-06U	11	10	1.4 0.39	76 22	0.92 0.29	0.27 0.06	0.9 0.24	12 3.2
APIT-07U	15	8	3.6 1	200 58	2.5 0.79	0.88 0.16	2.4 0.65	29 8.1
APIT-08U	15	8	0.45 0.13	24 6.7	0.28 0.09	0.1 0.02	0.3 0.08	2.7 0.75
APIT-09U	13	8	0.63 0.18	37 11	0.45 0.14	0.13 0.03	0.42 0.11	6.2 1.7
APIT-10U	11	9	0.49 0.14	27 7.7	0.32 0.1	0.12 0.03	0.38 0.1	3.8 1.1
APIT-11U	14	8	0.16 0.05	9.2 2.6	0.1 0.03	0.7 0.1	0.13 0.03	1.5 0.42
APIT-12U	14	8	2.2 0.63	120 35	1.2 0.39	0.7 0.1	1.1 0.28	20 5.5
APIT-13U	12	9	3 0.85	190 53	1.9 0.58	0.8 0.2	1.6 0.42	33 9.2
APIT-14U	12	8	2.4 0.69	140 39	1.6 0.49	0.8 0.2	1.5 0.4	27 7.5
Geometric Mean			1.4 0.4	72 21	0.82 0.25	0.39 0.08	0.82 0.22	12 3.3
Geometric Standard Deviation			2.4 2.5	2 3	2.4 2.4	2.1 2.8	1.6 2.3	4 2.3

* Total Hydrocarbons as n-Hexane
** Methyl Tertiary Butyl Ether

Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.

Table B-4 (cont.)

API
ANALYTICAL RESULTS - SERVICE STATION P-02 +
CUSTOMER EXPOSURE CONCENTRATIONS
NOVEMBER 1-2, 1990

Sample Number	Air Volume (liters) per sample	Number of Consumers	n-Hexane (mg/m ³) (ppm)	THC* (mg/m ³) (ppm)	Benzene (mg/m ³) (ppm)	Xylene (mg/m ³) (ppm)	Toluene (mg/m ³) (ppm)	MTBE** (mg/m ³) (ppm)
Regular Leaded Gasoline--								
APIT-01R***	23	8	0.97	56	0.58	0.18	0.63	10
APIT-02R	14	8	1.4	62	0.78	0.24	1	13
APIT-03R	18	8	2.1	130	1.5	0.46	1.3	22
APIT-04R	18	9	3.9	230	2.5	0.79	2.5	34
Geometric Mean			1.8	100	1.1	0.35	1.2	18
Geometric Standard Deviation			1.7	1.8	1.6	1.8	1.6	1.6
Premium Unleaded Gasoline--								
APIT-01S***	20	8	0.63	34	0.4	0.14	0.44	6.5
APIT-02S	17	8	1.7	110	1.2	0.38	1.6	19
Geometric Mean			1	61	0.69	0.23	0.84	11
Geometric Standard Deviation			1.6	1.8	1.7	1.6	1.9	1.7

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether

*** Sample analyzed for 58 components.

+ Phoenix has a minimum regulatory requirement for oxygenates in automotive fuels.



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Table B-5

API
ANALYTICAL RESULTS - SERVICE STATION L-01+
CUSTOMER EXPOSURE CONCENTRATIONS
NOVEMBER 6-7, 1990

Sample Number	Air Volume (liters) per sample	Number of Consumers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Regular Unleaded Gasoline-														
APIU-01U***	23	8	3.2	0.9	190	54	1.9	0.58	0.92	0.22	2	0.54	0.54	0.15
APIU-02U	16	8	2	0.57	120	34	1.1	0.34	0.6	0.13	1.4	0.37	0.28	0.08
APIU-03U	14	8	4.8	1.4	290	83	2.7	0.85	1.1	0.25	3.2	0.84	1.9	0.54
APIU-04U	18	8	0.81	0.23	39	11	0.55	0.17	0.5	0.1	0.63	0.17	0.12	0.04
APIU-05U	17	8	0.83	0.24	55	16	0.53	0.17	0.5	0.1	0.74	0.2	0.2	0.06
APIU-06U	15	8	0.95	0.27	64	18	0.61	0.19	0.6	0.1	0.78	0.21	0.72	0.2
APIU-07U	17	8	0.85	0.24	55	16	0.5	0.16	0.5	0.1	0.66	0.17	0.2	0.07
APIU-08U	12	9	2.7	0.76	180	50	1.7	0.52	0.8	0.17	2	0.53	0.47	0.13
APIU-09U	12	8	1.3	0.36	79	23	0.74	0.23	0.7	0.2	0.94	0.25	0.2	0.09
APIU-10U	14	8	0.76	0.22	45	13	0.53	0.17	0.6	0.1	0.86	0.23	0.2	0.08
APIU-11U	16	8	2.9	0.83	170	49	1.9	0.6	0.5	0.19	2.3	0.62	4.9	1.4
APIU-12U	13	8	1.6	0.47	93	26	1.1	0.34	0.6	0.14	1.6	0.42	0.25	0.07
Geometric Mean			1.6	0.45	94	27	0.97	0.3	0.64	0.13	1.2	0.33	0.41	0.13
Geometric Standard Deviation			1.8	1.8	1.9	1.9	1.8	1.8	1.3	1.4	1.7	1.7	2.8	2.6

Total Hydrocarbons as n-Hexane

1.3 Methyl Tertiary Butyl Ether

*** Sample analyzed for 58 components.

Los Angeles stations were equipped with Stage II vapor recovery systems.



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Table B-5 (cont.)

API
ANALYTICAL RESULTS - SERVICE STATION L-01+
CUSTOMER EXPOSURE CONCENTRATIONS
NOVEMBER 6-7, 1990

Sample Number	Air Volume (liters) per sample	Number of Consumers	n-Hexane (mg/m3) (ppm)	THC* (mg/m3) (ppm)	Benzene (mg/m3) (ppm)	Xylene (mg/m3) (ppm)	Toluene (mg/m3) (ppm)	MTBE** (mg/m3) (ppm)						
Mid-Grade Unleaded Gasoline-														
APIU-01P	21	8	1.5	0.43	100	30	1	0.33	0.55	0.13	1.5	0.39	0.28	0.08
APIU-02P***	25	8	0.31	0.09	22	6.3	0.4	0.14	0.8	0.2	0.4	0.11	0.4	0.09
APIU-03P	19	8	0.94	0.27	17	4.8	0.61	0.19	0.48	0.11	1.1	0.28	0.3	0.08
APIU-04P	19	8	0.36	0.1	25	7.2	0.26	0.08	0.5	0.1	0.43	0.11	0.37	0.1
APIU-05P	16	8	0.42	0.12	32	9	0.33	0.1	0.6	0.1	0.47	0.13	0.1	0.07
Geometric Mean			0.58	0.12	31	9	0.46	0.15	0.58	0.11	0.67	0.18	0.26	0.09
Geometric Standard Deviation			1.8	1.8 *	1.9	2.4	1.6	1.6	1.1	1.1	1.7	1.7	1.6	2.3
Premium Unleaded Gasoline-														
APIU-01H	19	8	0.39	0.11	33	9.5	0.45	0.14	0.5	0.1	0.69	0.18	0.61	0.17
APIU-02H	16	8	0.53	0.15	43	12	0.55	0.17	0.5	0.1	0.87	0.23	0.52	0.14
APIU-03H	13	8	0.3	0.09	24	6.7	0.31	0.1	0.7	0.2	0.55	0.15	0.2	0.08
Geometric Mean			0.4	0.11	32	9.1	0.42	0.13	0.56	0.13	0.69	0.18	0.4	0.12
Geometric Standard Deviation			1.3	1.2	1.3	1.3	1.3	1.2	1.2	1.4	1.2	1.2	1.6	1.4

* Total Hydrocarbons as n-Hexane

** Methyl Tertiary Butyl Ether

*** Sample analyzed for 58 components.

Los Angeles stations were equipped with Stage II vapor recovery systems.



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