STATUS OF UNLEADED AND LOW-LEAD GASOLINE COMPOSITION

INTERIM REPORT
FLRL NO. 16

by

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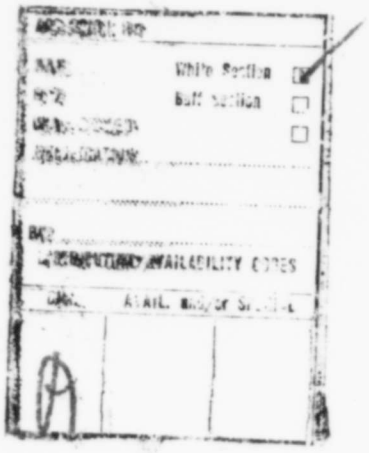

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13. ABSTRACT

Numerous technical and statistical publications have been made on the chemical, physical, and performance properties of unleaded and low-lead gasolines. However, very little information is available on the aromatic and olefinic distribution of these fuels since the standard FIA method (ASTM D 1319) used to determine hydrocarbon composition gives only an approximation of total aromatics, olefins, and saturates. Because of the necessity to have definitive analysis of these hydrocarbon species for ~~obvious~~ reasons relating not only to fuel performance/emissions but also to potential fuel-handling/distribution problems, a program was conducted to provide a representative sampling of current marketplace unleaded/low-lead gasolines for subsequent analysis of their aromatic and olefinic hydrocarbon distributions.

As a result of this investigation, the following conclusions were reached:

(1) The average aromatic content of the new gasoline is 27 percent for the unleaded and 29 percent for the low-lead products, which is higher than the conventionally leaded gasolines.

(2) Toluene is the major aromatic component of these fuels.

(3) The olefin content is generally lower in these new fuels than in conventionally leaded gasolines.

(4) The sulfur level is generally low and appears to be lower than in conventionally leaded fuels.

(5) The unleaded gasolines show an average lead content of 0.03 g/gal while the low-lead gasolines have an average of 0.47 g/gal lead.

(6) The products of six out of nine companies marketing *unleaded* gasolines contain phosphorus.

(7) Virtually all these gasolines contain a multifunctional additive or upper-cylinder lubricant, as indicated by high values for the unwashed existent gum determination.

(8) The octane quality of the unleaded and low-lead gasolines which range from 91 RON (87 antiknock quality) to over 100 RON (95 antiknock quality), in one instance, indicates that the marketing practices for these fuels have not stabilized as a result of individual company preferences and/or pending lead-reduction legislation.

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I. INTRODUCTION

Federal regulations to control exhaust emissions of automobiles have caused significant changes in the composition of gasolines during the past five years. Gasoline surveys reported semiannually by the Bureau of Mines, road octane surveys published periodically by duPont, and samplings conducted by the Coating and Chemical Laboratory (C&CL) and the Army Fuels and Lubricants Research Laboratory (AFLRL), specifically on low and unleaded gasolines, indicate that in addition to the lead content reduction, changes in the basic hydrocarbon composition are taking place. Although the Bureau of Mines and duPont surveys indicated these trends through changes in Reid vapor pressure, gravity, distillation, etc., the samplings obtained and analyzed by AFLRL were designed to determine more specifically the hydrocarbon makeup of the unleaded and low-lead gasolines.

Based on Bureau of Mines surveys for winter and summer gasolines since 1968 (summarized in Table I), the average research octane numbers for both the premium and regular

TABLE I. BUREAU OF MINES GASOLINE SURVEY DATA

	No. of Samples	Gravity, °API	Lead, g/gal	Sulfur, weight %	RON	RVP, lb
Regular Grade						
Winter 1968-1969	2178	62.9	2.13	0.043	93.8	12.1
Summer 1969	2397	61.1	2.48	0.042	93.8	9.1
Winter 1969-1970	2470	63.0	2.26	0.043	93.8	12.1
Summer 1970	2495	61.1	2.43	0.042	93.8	9.1
Winter 1970-1971	1999	63.1	2.02	0.039	93.9	12.1
Summer 1971	1981	60.9	2.22	0.043	94.0	9.0
Premium Grade						
Winter 1968-1969	2185	63.1	2.69	0.031	99.8	12.2
Summer 1969	2390	60.9	2.89	0.022	99.9	9.2
Winter 1969-1970	2475	62.9	2.71	0.020	99.8	12.1
Summer 1970	2483	60.8	2.81	0.021	99.8	9.2
Winter 1970-1971	2026	62.6	2.60	0.023	99.8	12.1
Summer 1971	2048	60.7	2.67	0.022	99.8	9.2
Southern California, District 17, Regular Grade						
Winter 1968-1969	51	59.8	1.78	0.110	93.7	11.4
Summer 1969	49	58.7	2.03	0.041	93.6	9.1
Winter 1969-1970	75	60.1	2.19	0.100	92.9	11.2
Summer 1970	83	58.7	1.83	0.074	93.1	9.1
Winter 1970-1971	84	59.9	1.53	0.055	93.5	11.5
Summer 1971	76	58.0	1.66	0.118	93.4	8.6

grades have remained consistent over the past four years.[1-6]* The higher vapor pressure of winter gasolines indirectly provides lower lead content since the more volatile components (i.e., butanes and pentanes) needed for winter fuels have high-octane ratings.

Southern California was the first area to institute emission controls on vehicles and compositional controls on gasolines. Examination of the Bureau of Mines data for

*Superscript numbers in parenthesis refer to the list of References.

District 17, Southern California, since the winter of 1968-1969, shows a significant lower average lead content and an overall lower API gravity compared to the country-wide survey data, which is indicative of higher aromatic concentration.

Data for unleaded and low-lead gasolines, generally classified in the Bureau of Mines reports as third-grade gasolines, were first reported in the summer of 1970 survey where 89 items were listed. The winter of 1970-1971 report had 416 items representing unleaded/low-lead gasolines, and the summer of 1971 report had 573. The average API gravity for the unleaded/low-lead gasolines of the summer of 1971 report was 58.8 deg compared to 60.9 deg average for the regular grades in the same report. Unleaded (0.07 g/gal or less lead content), 91 Research Octane Number (RON) gasolines had an average 57.9 deg API for 98

TABLE II. DUPONT SURVEY DATA

Regular Grade Summer 1969 Averages

	RON	Lead, g/gal	Aromatics, %	Olefins, %	RVP, lb	Gravity, ° API
Northeastern						
Boston	94.7	2.24	21	14	10.2	60.9
Cleveland-Detroit	95.0	2.57	22	11	10.2	60.8
New York	94.4	2.41	23	10	10.4	61.2
Philadelphia-Baltimore	95.0	2.08	23	14	9.8	60.6
Average	94.8	2.33	22	12	10.2	60.9
North Central						
Chicago	94.9	2.58	22	11	10.0	61.4
Kansas City-Wichita	92.2	2.47	15	12	9.3	63.3
Minneapolis-St. Paul	93.2	2.01	22	12	9.8	61.1
St. Louis	94.7	2.80	21	10	9.8	61.6
Average	93.8	2.47	20	11	9.7	61.8
Southeastern						
Atlanta	94.6	2.24	22	8	9.7	62.2
Florida	94.4	2.55	21	10	9.7	61.4
Louisville	94.7	2.53	22	10	10.4	61.6
New Orleans	94.1	2.63	19	8	9.7	60.2
Richmond	95.0	2.38	22	12	9.7	62.0
Average	94.6	2.47	21	10	9.8	61.5
Southwestern						
Denver	91.2	2.15	18	13	8.6	60.7
El Paso	92.4	2.44	21	13	8.0	59.8
Houston	94.0	2.38	18	10	9.6	61.3
Tulsa-Oklahoma City	92.5	2.44	15	12	9.4	63.0
Average	92.5	2.40	18	12	8.9	61.2
Western						
Bakersfield	92.0	2.76	10	12	11.0	62.8
Los Angeles	94.0	2.10	23	10	9.5	59.2
Salt Lake	92.3	2.03	17	15	8.1	60.7
San Francisco	94.8	2.40	16	14	8.9	60.3
Seattle	93.3	2.88	13	16	9.3	63.4
Average	93.3	2.43	16	13	9.4	61.3
Grand Average	93.8	2.42	19	12	9.6	61.3

items and low-lead (0.5 g/gal maximum lead content), 93 to 98 RON gasolines had an average 58.8 deg API for 69 items.

A survey reported by duPont, conducted in 22 marketing areas in the summer of 1969 (Table II), shows that the regular grade gasolines averaged throughout the country had a RON of 93.8, 2.42 g/gal lead content, 19 volume percent aromatics, 12 volume percent olefins, 9.6 lb vapor pressure, and 61.3 deg API.[7-11] These averages correspond to those reported by the Bureau of Mines for the same period. DuPont also reported surveys conducted in August 1970[12], winter of 1970-1971[13], and summer of 1971.[14] In these reports, the gasoline samples were classified for the first time into the following categories:

Regular–lead content over 1.0 g/gal,
Regular, low-lead–0.2 to 1.0 g/gal lead,
Low regular, unleaded–below 0.2 g/gal lead, and
Low regular, low-lead–0.2 to 1.0 g/gal lead.

The average data for these three surveys are shown in Table III. Although the number of samples, indicated in parenthesis, for each category was small, a significant increase in aromatics and decrease in olefin content compared to the 1969 values is shown for all categories.

TABLE III. DUPONT SURVEY DATA

	RON	Lead, g/gal	Aromatics, %	Olefins, %	RVP, lb	Gravity, °API
August of 1970						
Regular (24*)	95.0	2.33	24	8	9.0	59.5
Regular Low-Lead (3)	94.8	0.2 to 1.0	28	6	10.0	58.3
Low Regular - Unleaded (8)	91.7	Below 0.2	25	6	9.6	59.9
Low Regular - Low Lead (1)	91.1	0.2 to 1.0	30	7	9.5	56.7
Winter 1970-1971						
Regular (38)	94.7	Over 1.0	21	10	11.9	62.3
Regular - Low-Lead (10)	94.6	0.2 to 1.0	25	8	11.4	59.8
Low Regular - Unleaded (16)	91.7	Below 0.2	27	8	9.8	58.6
Low Regular - Low Lead (3)	91.2	0.2 to 1.0	23	5	11.9	60.8
Summer 1971						
Regular (50)	94.9	Over 1.0	23	9	10.0	60.7
Regular - Low-Lead (17)	94.9	0.2 to 1.0	29	7	9.4	59.1
Low Regular - Unleaded (20)	91.6	Below 0.2	26	8	9.7	59.5
Low Regular - Low-Lead (4)	91.7	0.2 to 1.0	26	8	9.7	60.7

*Numbers in parenthesis represent samples analyzed.

II. AFLRL FUEL ANALYSES PROGRAM

A. Refinery Sampling (1970)

With the initial introduction of unleaded and low-lead gasolines on the market early in 1970, the Army was given the responsibility of preparing a gasoline specification for use by the Defense Fuel Supply Center (DFSC) in compliance with Federal Property Management Regulation E-12. Because of the absence of any technical data describing these new gasolines, a need existed to have these gasolines analyzed as the developed data would provide the basis for the gasoline-procurement document. Published literature on composition and control of automotive exhaust emissions indicated that the composition of gasolines, and especially the aromatic components, would have a significant effect on exhaust emissions composition.[15-17] Therefore, the Coating and Chemical Laboratory, Aberdeen Proving Ground, obtained and forwarded to AFLRL samples of unleaded and low-lead gasolines from refineries which represented all products (including some proto-type blends) being marketed by 15 companies at that time. A summary of the data obtained on those samples is shown in Table IV. When all of the low-lead samples were grouped together, their research octane numbers varied from 91.1 to 96.6, while unleaded gasolines all had approximately a 91 RON. The average aromatic and olefinic content of these samples compare closely to those reported in the duPont surveys for the summer of 1970 and the *aromatics are higher in concentration than those for the conventionally leaded regular grade gasoline.*

TABLE IV. C & CL-AFLRL 1970 SAMPLING DATA

	Unleaded Gasolines 10 Samples		Low-Lead Gasolines 9 Samples	
	Range	Avg	Range	Avg
Gravity, ° API	55.7 to 63.9	59.9	54.8 to 63.5	58.9
Research Octane No.	90.4 to 91.6	91.0	91.1 to 96.6	93.5
Motor Octane No.	82.0 to 84.6	83.5	84.0 to 88.5	85.6
Lead, g/gal	<0.1	<0.1	0.24 to 0.55	0.44
Aromatics, %	16 to 33	25	14 to 36	28
Olefins, %	0 to 11	6	1 to 8	6

B. Service Station and Refinery Sampling (1971-1972)

In 1971 the availability of these new gasolines became more widespread, and the effect that these fuels might have on performance of military and government vehicles designed for operation on normally leaded gasolines was of prime concern, especially since these vehicles are expected to remain in service much longer than civilian vehicles.

Since other published gasoline surveys do not present detailed hydrocarbon analyses, although the duPont reports did give hydrocarbon-type analyses by FIA, this program was undertaken to study, insofar as available analytical techniques permitted, the more detailed aromatic composition of these fuels. A gas chromatographic procedure for aromatic distribution in gasolines developed at AFLRL and the subject of a paper presented at the April 1972 National Meeting of the American Chemical Society, held in Boston, Massachusetts[18] was utilized to determine quantitatively the aromatic compounds through xylenes present in gasolines. The C_9 and greater aromatics are determined as a group. This report summarizes these analyses as well as other physical and chemical characteristics of refin

and service station unleaded and low-lead gasoline samples obtained throughout the continental United States.

During the early fall of 1971, AFLRL obtained 124 samples from service stations located in various cities in Texas, Arizona, California, Nevada, Utah, Wyoming, Colorado, and New Mexico and refinery samples from a number of different petroleum companies, all of which represented unleaded and low-lead products. Early in 1972, 64 service station samples were obtained in Texas, Arkansas, Tennessee, Alabama, Georgia, Florida, Mississippi, and Louisiana. During the late winter of 1972, samples were obtained for AFLRL from the states of New York, Michigan, Minnesota, Montana, and Washington. A total of 15 companies were represented in the overall sampling and reflect virtually all of those companies marketing these fuels at present, with the possible exception of some small companies. All but 3 of these companies were included in the 1970 sampling; therefore, comparison of the 1971-1972 refining samples reflects the many changes in refining and blending technology.

The **National Petroleum News Factbook**, May 1971[19], page 41, listed 21 companies marketing unleaded and low-lead gasolines. Of those listed, 4 market the same brand and are presumed to be affiliated. Another company began marketing a low-lead product probably after this list was published. The products of 4 of the companies listed were not obtained during this sampling.

The service station and refinery samples obtained in the fall of 1971 were analyzed completely for physical and chemical characteristics. The refinery samples and selected service station samples were also subjected to gas chromatograph aromatic distribution and boiling point distribution analyses. The winter samples obtained in southern, eastern, midwestern, northern, and northeastern states were analyzed more selectively with respect to samples as well as analytical procedures. The data obtained for all these samples are tabulated in the Appendix, Tables 1 through 14; gas chromatographic data are shown in Tables 15 and 16 of the Appendix.

C. Summary of Results

The analyses of 198 samples of unleaded and low-lead gasolines, obtained from refineries and service stations throughout the United States, show a large variation in octane quality level, in hydrocarbon composition, and in other properties. These fuels can be classified into:

Unleaded–100 RON–95 antiknock quality
Unleaded–91 RON–87 antiknock quality
Low-lead–91 RON–87 antiknock quality
Low-lead–94 to 97 RON–89 to 92 antiknock quality.

The antiknock quality is defined as the averaged research and motor octane numbers. The average aromatic content of these fuels generally increases with the higher antiknock quality gasolines, and is higher than the reported average aromatic content of conventionally

leaded regular grade gasolines. Toluene is the principal aromatic component of these fuels. *The average olefin content of the unleaded and low-lead gasolines is generally lower than that for the conventionally leaded regular gasoline.* These observations are illustrated by the bar graph in Figure 1. Though averages are used to describe general composition trends, it is important to note from the detailed analysis data that hydrocarbon composition varies widely from refinery to refinery and that large variations exist in fuels marketed under a single brand name when the marketing area is large. Therefore, each product must be considered as an individual sample to obtain a true picture of available gasoline composition.

Sulfur levels of these fuels are generally low and appear to be lower than those for regular grade leaded fuels. *Most companies marketing unleaded 91 RON gasoline add an organic phosphorus compound to their product.* The unleaded 91 RON fuels had an average lead content of 0.03 g/gal and relatively few service station samples exceeded 0.07 g/gal. The low-lead, 91 RON fuels averaged 0.50 g/gal and the low-lead, 94 to 97 RON fuels averaged 0.46 g/gal lead. *The majority of the unleaded and low-lead gasolines contain either a detergent-dispersant additive or an upper-cylinder lubricant.*

D. Conclusions

As a result of this study, the following conclusions have been reached:

- The unleaded and low-lead gasolines being marketed have higher average aromatic content than the regular normally leaded gasolines. Toluene is the major aromatic component of these new fuels.

- The olefin content of these fuels was slightly less than in conventionally leaded gasolines.

- The sulfur content of the new gasolines appeared to be lower than that of the conventionally leaded products.

- The unleaded gasolines averaged 0.03 g/gal lead content while the low-lead gasolines averaged 0.47 g/gal lead.

- The products of six companies marketing *unleaded* gasolines contained an organo-phosphorus additive which averaged 0.063 g/gal phosphorus content.

- Virtually all of these products contained a multifunctional additive or upper-cylinder lubricant.

- Although many petroleum companies are currently marketing unleaded and low-lead gasolines to meet the requirements of the new low-compression ratio automotive engines (and to comply with the Environmental Protection Agency's regulations to reduce and eventually remove lead alkyl compounds from gasoline), *it is very apparent that the marketing practice for these products is not uniform in terms of octane quality level and lead concentration, but rather seems to conform to individual company preferences.*

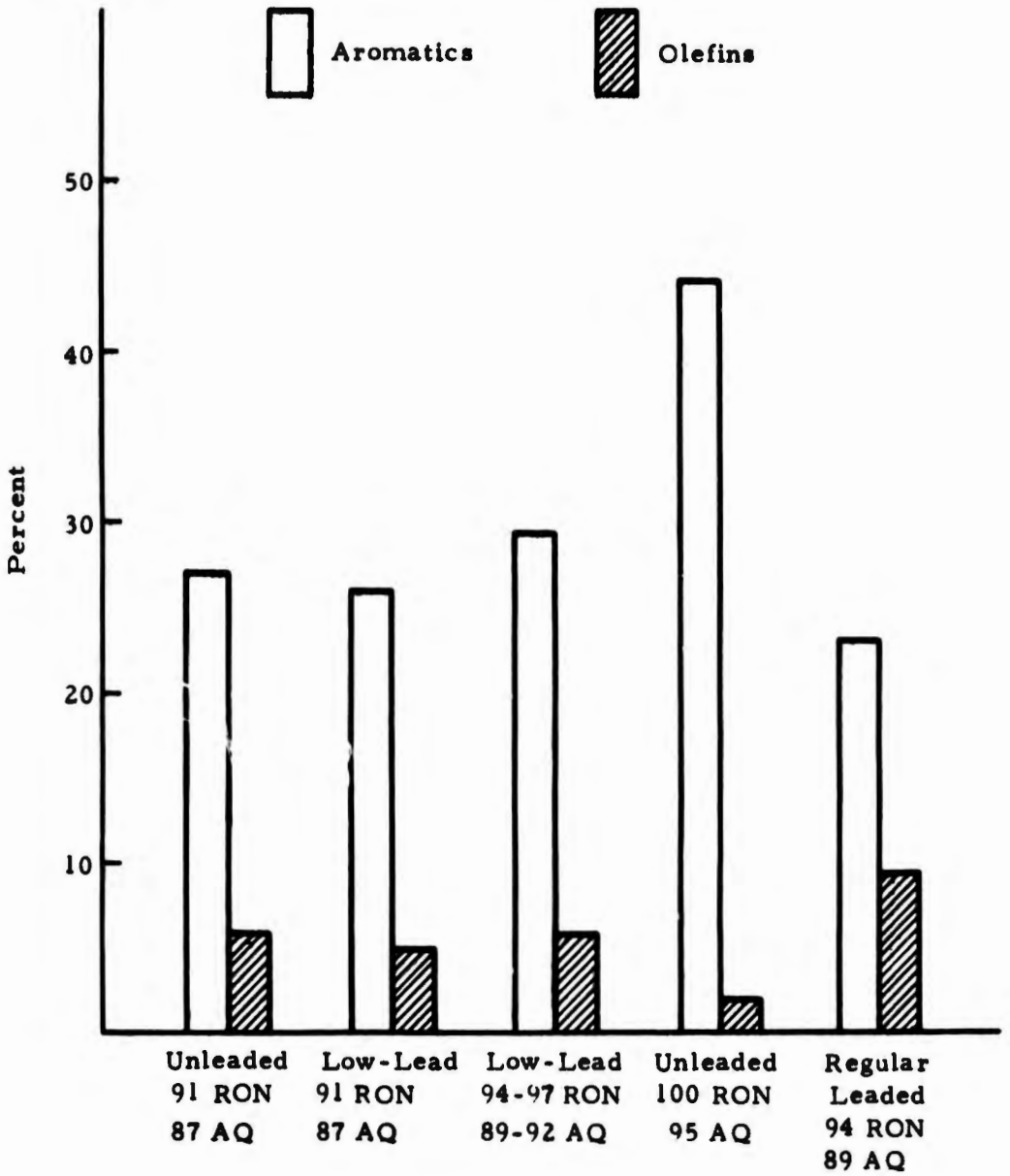

FIGURE 1. AVERAGE AROMATIC AND OLEFIN CONCENTRATIONS VERSUS OCTANE LEVELS

- As a result of the trends noted in this analysis, the increase in utilization of aromatic components should continue to be monitored.

E. Discussion of Data

Table V summarizes the gravity, aromatic, olefin, sulfur, and lead-content data obtained for service station samples from 34 cities subdividing the fuels into:

Unleaded–antiknock quality 87 minimum (91 RON)
Low-lead–antiknock quality 87 minimum (91 RON)
Low-lead–antiknock quality 89 minimum (94 RON)

These samples were further divided into geographical areas, and the averages for several properties are shown in Tables VI, VII, and VIII. Although the octane numbers were not determined on all samples, this division is based on what each company is normally marketing. Octane numbers were measured on all of the refinery samples as indicated in Tables I through 14 of the Appendix. It should be noted that three of the unleaded samples, considered to be classified in State Group No. 1, as described in Federal Specification VV-G-001690, and one sample in State Group No. 4 failed to meet the 87 and 86.5 minimum antiknock quality levels for the special-grade gasoline as stated in that specification.[20] All of the low-lead (antiknock quality 89 minimum) and the unleaded (antiknock quality 95 minimum) gasolines were within the requirements of Federal Specification VV-G-001690 for regular and premium grades, respectively. A few samples obtained as unleaded or low-lead gasoline were found to contain lead in amounts equivalent to conventionally leaded gasolines. Therefore, they were not included in the averages although they appear in the Appendix tabulations.

As was indicated earlier, the samples obtained first in the southwestern and western states were fall samples, and the remaining ones were winter samples. This difference in seasons is reflected partially in the higher average API gravity for winter samples. The unleaded and low-lead samples obtained in the western part of the country show higher average aromatic content than those obtained in the eastern half. The difference in season

TABLE V. SUMMARY OF DATA FOR SERVICE STATION GASOLINES
1971 to 1972 AFLRL Sampling

	Unleaded 91 RON 87 AQ* 88 Service Station Samples		Low-Lead 91 RON 87 AQ* 23 Service Station Samples		Low-Lead 94‡ RON 89‡ AQ* 68 Service Station Samples	
	Range	Avg	Range	Avg	Range	Avg
Gravity, °API	52.7 to 69.0	59.4	57.2 to 63.4	61.2	53.6 to 66.5	58.7
Aromatics, volume %	10 to 39	27	15 to 33	26	16 to 42	29
Olefins, volume %	0 to 35	6	1 to 28	5	1 to 13	6
Sulfur, weight %	0.002 to 0.083	0.018	0.010 to 0.068	0.041	0.004 to 0.048	0.022
Lead, g/gal	0 to 0.17	0.03	0.32 to 1.00	0.50	0.34 to 0.68	0.46

Note: Samples from 34 cities.
*Antiknock quality.

TABLE VI. UNLEADED GASOLINES (91 RON)
87 Antiknock Quality
Average Values

Area	No. of Samples	Gravity, ° API	Aromatics, volume %	Olefins, volume %	Sulfur, weight %	Lead, g/gal
Fall Samples						
California, Nevada	25	57.0	31	3	0.021	0.03
Utah, Wyoming, Colorado	8	58.3	27	8	0.023	0.05
Arizona, New Mexico, West Texas	11	59.1	26	4	0.019	0.03
Winter Samples						
East Texas, Arkansas, Florida, Tennessee, Georgia, Alabama, Mississippi, Louisiana	26	61.4	23	8	0.013	0.03
Iowa, Nebraska, Missouri, Oklahoma, Kansas	5	–	26	8	–	–
Michigan, New York	5	61.5	26	7	–	0.04
Minnesota	2	65.8	18	18	–	0.01
Washington	3	57.9	29	6	–	0.03
Avg		59.4	27	6	0.018	0.03

TABLE VII. LOW-LEAD GASOLINES (91 RON)
87 Antiknock Quality
Average Values

Area	No. of Samples	Gravity, ° API	Aromatics, volume %	Olefins, volume %	Sulfur, weight %	Lead, g/gal
Fall Samples						
California, Nevada	5	58.6	29	3	0.063	0.47
Winter Samples						
East Texas, Arkansas, Tennessee, Georgia, Florida, Alabama, Mississippi, Louisiana	12	62.0	20	4	0.034	0.49
Nebraska, Missouri	2	–	28	5	–	–
Michigan, New York	3*	62.2	26	6	–	–
Montana	1*	63.5	15	28	–	–
Avg		61.2	26	5	0.041	0.50

*One sample each from Detroit, Michigan; Buffalo, New York; and Billings, Montana, represent individual companies marketing gasoline in this classification. All other samples are from a fourth company which markets nationwide.

also has an effect on aromatic content since the addition of high vapor pressure, high octane number components to winter gasoline, reduces the need for high aromatic content in order to maintain octane number levels.

The low-lead, 91 to 93 RON (87 antiknock quality), samples shown in Table VII represent the product of essentially one company which markets nationwide. Three other

TABLE VIII. LOW-LEAD GASOLINES (94-97 RON)
89 to 92 Antiknock Quality
Average Values

Area	No. of Samples	Gravity, °API	Aromatics, volume %	Olefins, volume %	Sulfur, weight %	Lead, g/gal
Fall Samples						
California, Nevada	28	57.7	31	4	0.029	0.45
Utah, Wyoming, Colorado	2	57.8	30	6	0.015	0.46
Arizona, New Mexico, West Texas	6	60.6	22	5	0.024	0.45
Winter Samples						
East Texas, Arkansas, Florida, Tennessee, Georgia, Alabama, Mississippi	27	59.1	30	7	0.016	0.47
Iowa, Nebraska, Missouri, Oklahoma, Kansas	3	–	21	2	–	–
Michigan, New York	1	62.1	28	2	–	0.49
Washington	1	66.5	18	5	–	0.52
Avg		58.7	29	6	0.022	0.46

companies are represented by one sample each in these averages. Most petroleum companies marketing low-lead gasolines are blending their products to a 94 or greater octane number, (89 antiknock quality minimum) and these products are shown in Table VIII. In general, the averages show an increasing trend in aromatic content as the antiknock quality increases. The unleaded 87 antiknock quality fuels averaged 27 percent aromatics; the low-lead 87 antiknock quality fuels, 26 percent; and the low-lead 89 and greater antiknock quality fuels, 29 percent. The 95 antiknock quality unleaded gasolines averaged 44 percent aromatics.

The average olefin content for all the unleaded and low-lead gasolines is about 6 percent with little difference being observed between the low-lead and unleaded gasolines. Two unusual samples with high olefin concentration were obtained from marketing outlets of the same company. One, an unleaded gasoline, had 10 percent aromatics and 35 percent olefins; the second one, a low-lead gasoline, had 15 percent aromatics and 28 percent olefins.

To permit a visual observation of the service station sample distribution, with respect to aromatic and olefin composition, histograms are shown in Figures 2 and 3 for all the samples analyzed. The range of aromatics or olefin percentages are shown on the x-axis of the histograms, and the percent of samples tested are shown along the y-axis. The numbers above each bar indicate the number of samples represented by the bar. Figures 4, 5, 6, and 7 are histograms for the same samples divided into geographical areas. Histograms for the eastern, northern, mid-western, and northeastern areas were not prepared because the samples analyzed were few. Since the low-lead, 87 antiknock quality samples were few in number, their histograms by geographical area are not shown.

The gas chromatographic analyses, presented in Tables 15 and 16 of the Appendix showing aromatic distribution of many of these samples, indicate that the principal aromatic

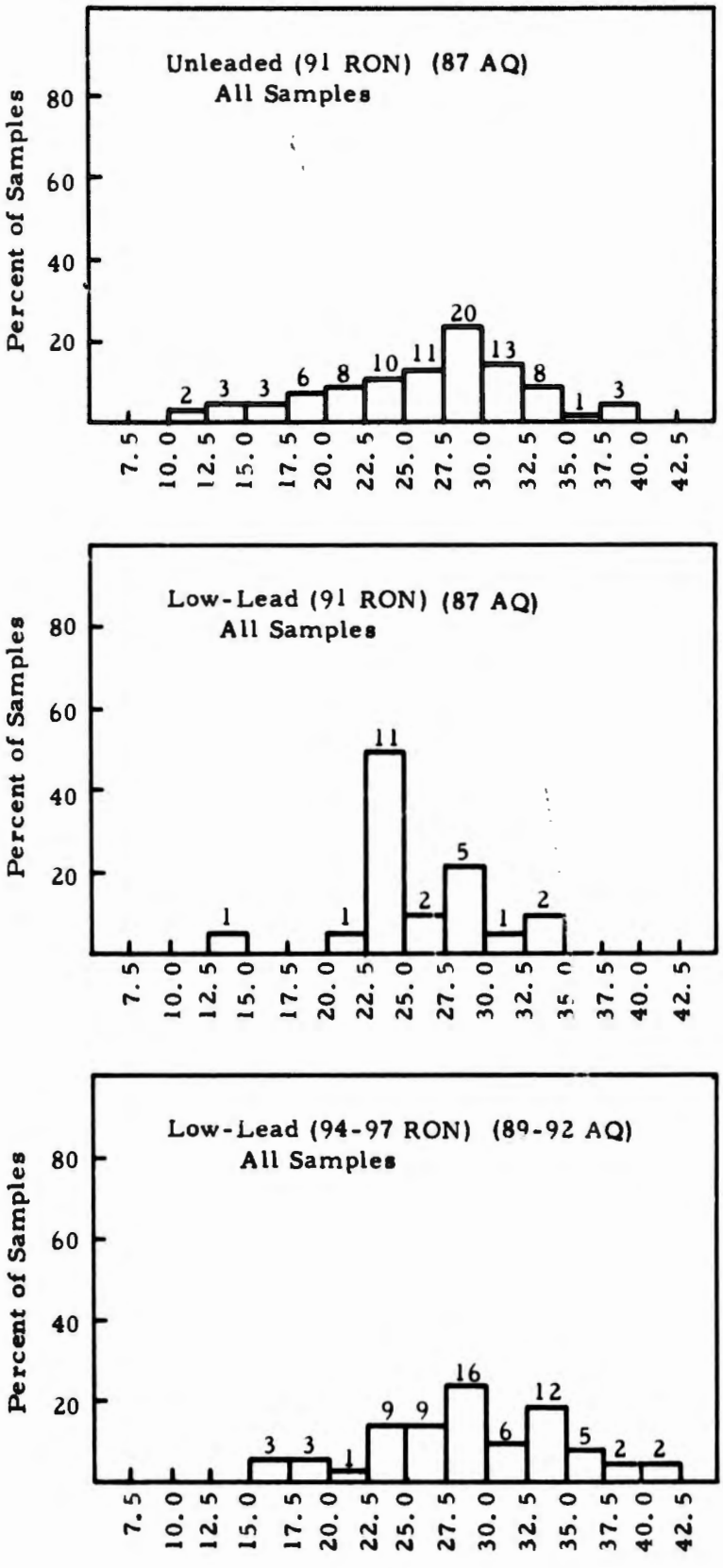

FIGURE 2 AROMATICS

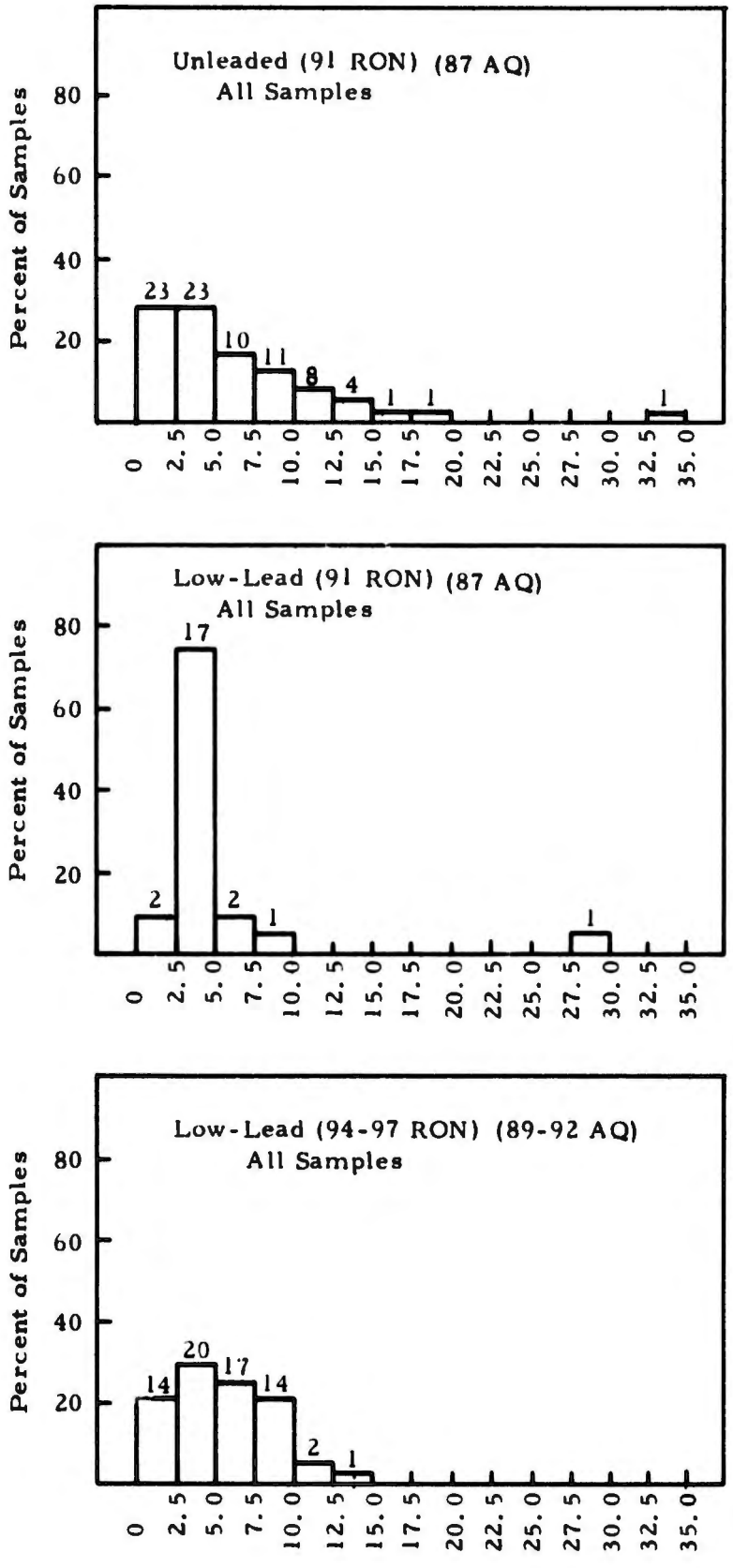

FIGURE 3 OLEFINS

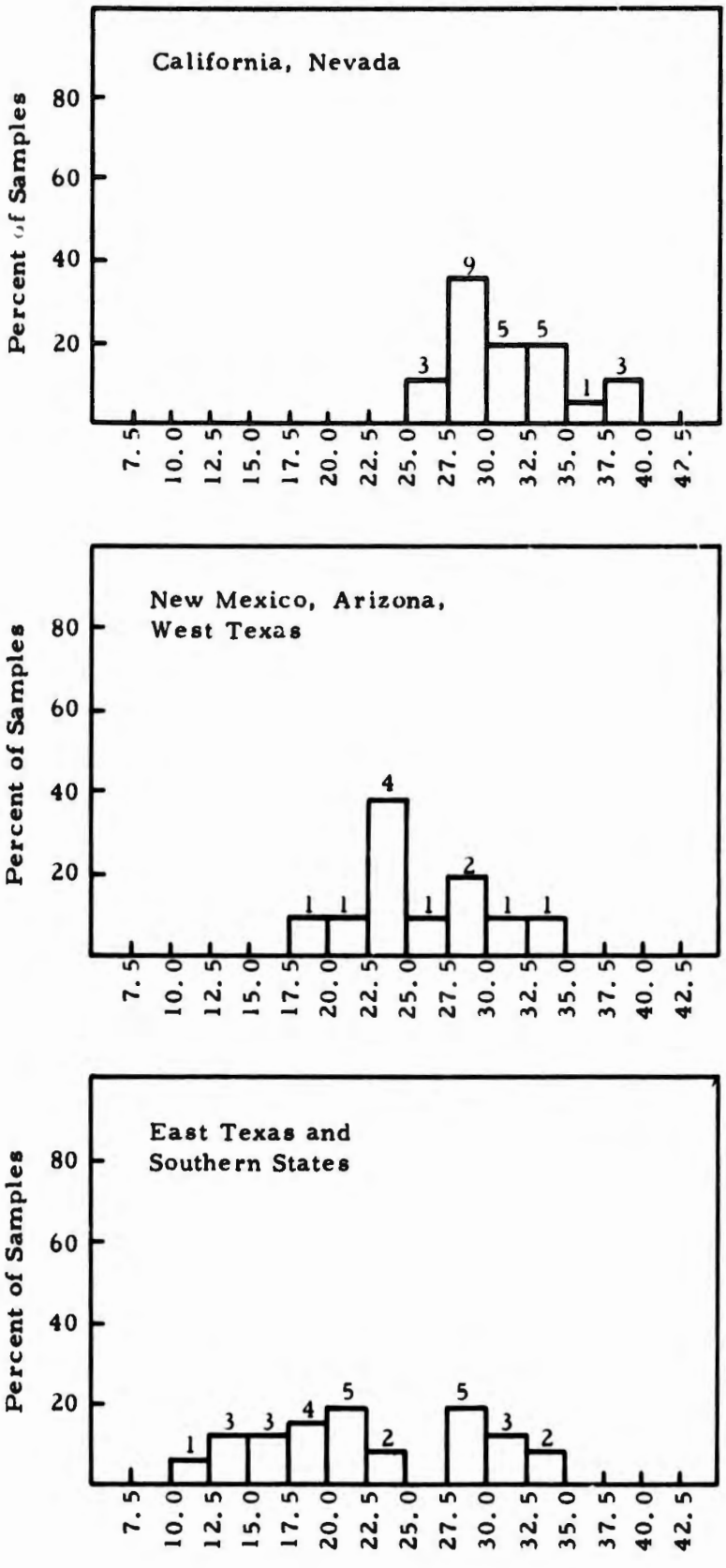

FIGURE 4 AROMATICS–UNLEADED GASOLINES (91 RON) (87 AQ)

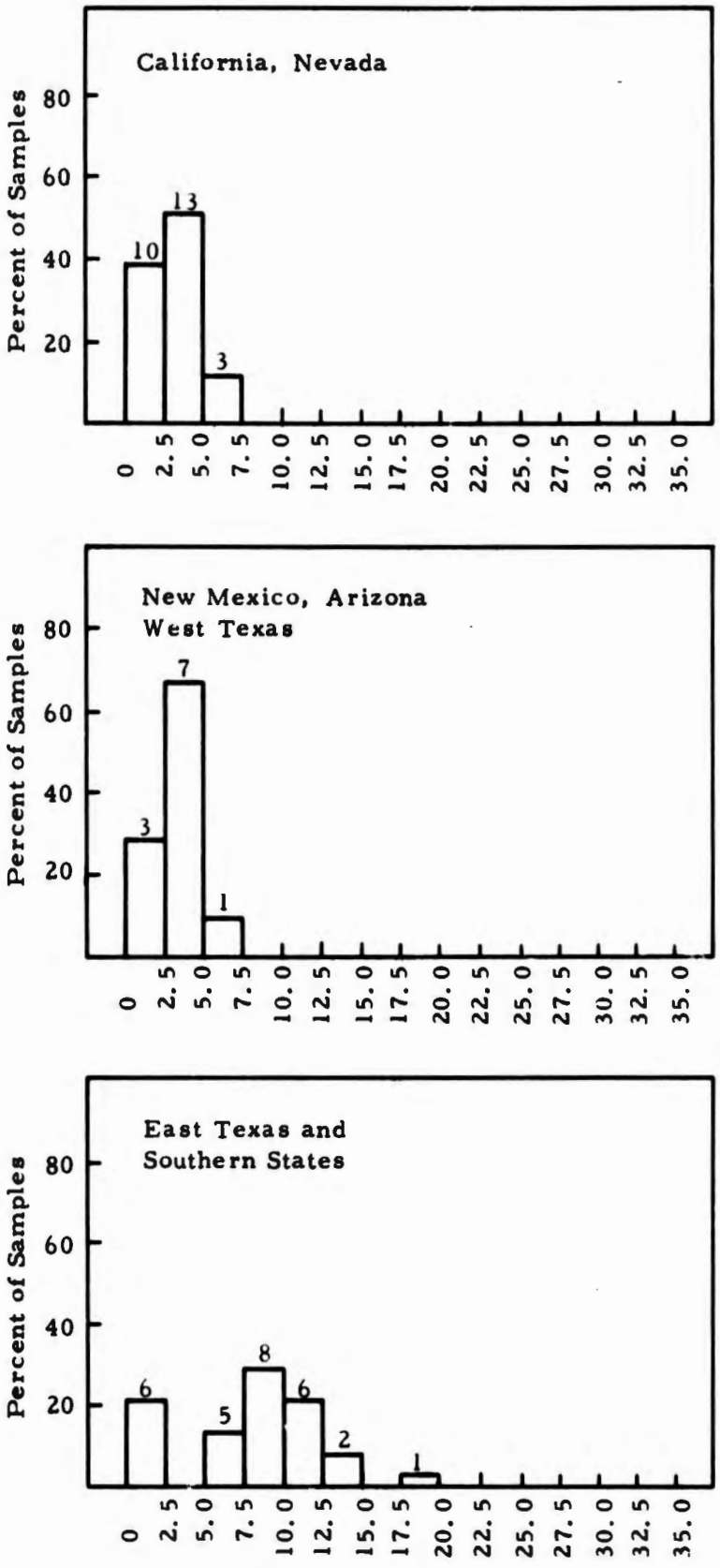

FIGURE 5 OLEFINS–UNLEADED (91 RON) (87 AQ)

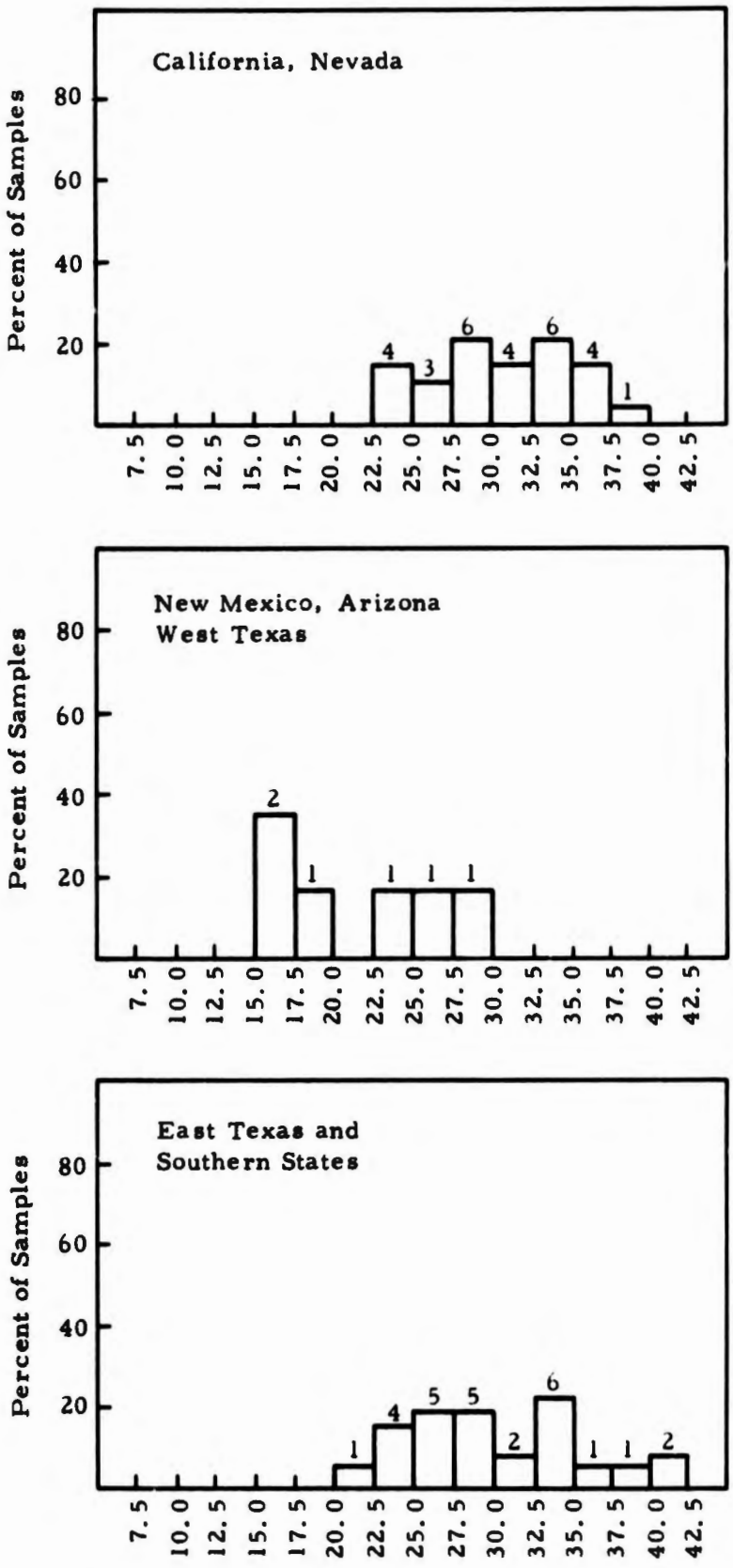

FIGURE 6 AROMATICS–LOW-LEAD (94 to 97 RON) (89 to 92 AQ)

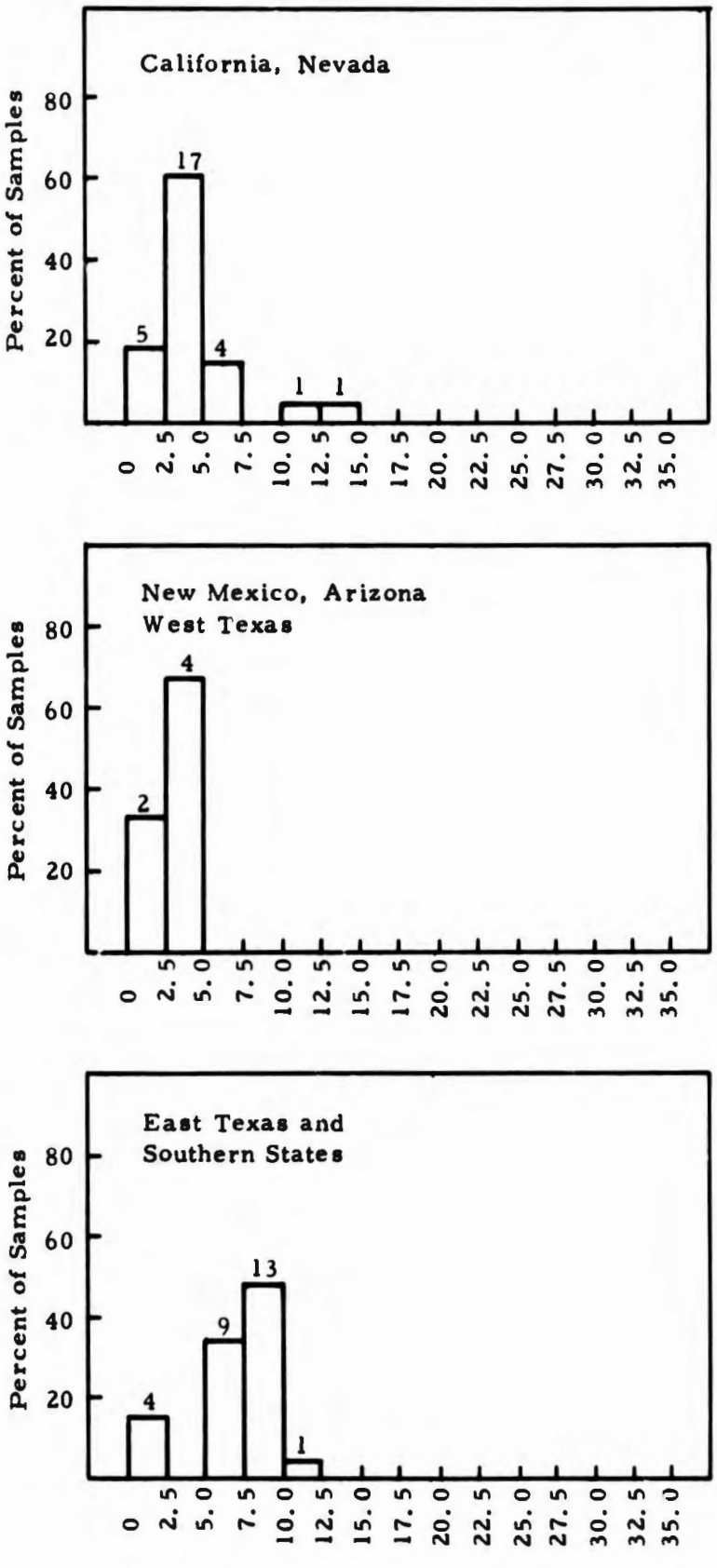

FIGURE 7 OLEFINS–LOW-LEAD (94 to 97 RON) (89 to 92 AQ)

component found in gasoline is toluene and the xylenes are also relatively high in concentration. As much as 25 percent toluene was found in some premium 95 antiknock quality unleaded samples, and the C_9 + aromatics concentrations show wide variances from sample to sample. Table IX contains a sumary of these data.

TABLE IX. SUMMARY OF AROMATIC DISTRIBUTION BY GAS CHROMATOGRAPHY

Aromatics, volume %	Premium 100 RON 95 AQ* (4 Samples)			Unleaded 91 RON 87 AQ* (33 Samples)			Low-Lead 91 to 97 RON 87 to 92 AQ* (33 Samples)		
	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg
Benzene	0.8	0.3	0.5	1.7	0.3	0.9	2.0	0.6	1.0
Toluene	24.4	15.5	19.0	15.9	2.0	6.8	25.0	2.1	6.3
Ethylbenzene	2.9	1.6	2.0	2.7	0.4	1.5	3.2	0.8	1.6
m + p-Xylene	10.8	5.9	7.6	10.5	1.8	5.2	10.3	2.7	5.6
o-Xylene	3.6	2.8	3.2	7.9	0.6	2.2	3.8	1.0	2.1
C_6 through C_8 Total	35.9	28.0	32.2	25.0	6.7	15.8	31.6	7.3	16.6
C_9+ Aromatics	16.9	12.4	15.0	18.6	1.7	13.2	20.1	7.2	13.9
Total Aromatics	50.2	44.4	47.2	39.3	8.4	28.9	46.5	17.1	30.4

*Antiknock Quality

The boiling point distribution GC analyses (Appendix, Tables 15 and 16) show a large variation in butane, n-pentane, and iso-pentane composition in these gasolines. The high vapor-pressure winter gasolines, as expected, contained much higher concentrations of these low-boiling hydrocarbons than the lower vapor pressure fall gasolines and, in some samples, up to 1 percent isobutane was detected. Based on chromatographs, the C_4 and C_5 olefin concentration appears to be generally proportional to the total olefin content; however, quantitative data on low molecular weight olefins were not obtained. The composition of the higher boiling components in gasoline varies considerably as indicated by the boiling point distribution data at 90 percent off and above, much more so than indicated by D86 distillations of the same gasolines.

The concentration of sulfur determined in these fuels was generally low. The unleaded samples collected in California and Nevada had an average of 0.023 weight percent sulfur, and the highest value found was 0.083 weight percent. The overall average for the samples analyzed was 0.018. The low-lead, 91 to 93 RON samples were found to average 0.040 weight percent sulfur, and the low-lead, 94 and greater RON samples averaged 0.022 weight percent sulfur.

The analysis for phosphorus of these samples indicates that six out of nine companies marketing unleaded gasolines add an organo-phosphorus compound to their product.

The unwashed gum values for most of these samples were relatively high, in many instances well above 100 mg/100 ml. These data indicate that all but three of the companies marketing these gasolines include a nonvolatile dispersant-detergent or upper cylinder lubricant in their fuels.

A product analysis by company shows that the fifteen companies sampled in this program market unleaded and low-lead products as follows:

(1) One company markets an unleaded 95 antiknock quality (100 RON) and an unleaded 87 antiknock quality (91 RON) gasoline,

(2) Two companies market an unleaded 87 antiknock quality (91 RON) and a low-lead 89 antiknock quality (94 RON) gasoline,

(3) One company markets an unleaded 87 antiknock quality (91 RON) and a low-lead 89 antiknock quality (94 RON) gasoline,

(4) Five companies market an unleaded 87 antiknock quality (91 RON) gasoline,

(5) Two companies market a low-lead 87 antiknock quality (91 RON) gasoline,

(6) Three companies market a low-lead 89 antiknock quality (94 RON) gasoline, and

(7) One company markets a low-lead 92 antiknock quality (96 RON) gasoline.

These variations in marketing practices indicate that the octane quality level for unleaded and low-lead gasolines being manufactured to meet the requirements of the new low-compression ratio engines have not yet been stabilized.

APPENDIX

TABULATION OF DATA

TABLE 1. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY A

Grade Designation Premium - Unleaded

Source of Sample	Tx Cty Ref	Houston	Houston	Little Rock	Memphis	Birmingham	Atlanta	Tallahassee	Mobile	Gulf Port
AFLRL Code No.	3894	4003	4004	4168	4172	4184	4186	4197	4205	4211
Property										
Gravity, °API	53.4	53.1	54.7	59.7	55.7	55.3	54.1	53.2	52.8	52.7
Reid Vapor Pressure, lbs.	10.2	10.2	11.0	12.5	12.5	13.5	13.3	11.4	11.8	11.8
Distillation, °F										
IBP	91	84	83	84	80	85	85	85	85	87
10% evap.	120	120	115	110	110	103	108	112	114	114
20% evap.	152	154	146	145	144	123	132	139	140	142
50% evap.	233	234	233	235	233	232	230	233	232	232
90% evap.	313	325	324	316	320	321	316	326	322	320
EP	368	372	370	385	370	380	381	377	374	368
% Recovered	97.4	97.5	97.0	97.5	97.0	97.5	97.5	97.5	97.5	97.5
% Residue	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
% Loss	1.4	1.2	2.0	1.5	1.2	1.5	1.5	1.5	1.5	1.5
Temp. at V/L = 20, °F	136	137	137	125	125	120	121	130	129	129
Gum, mg/100 ml										
Unwashed	0.7	5.0	6.0	3.8	3.8	4.5	2.6	7.3	4.3	4.2
Washed	0.1	1.1	0.5	0.9	0.1	0.4	0.4	2.9	0.4	0.1
Aromatics, % (FIA)	46	44	41	29	39	51	51	45	46	47
Olefins, % (FIA)	2	1	1	1	1	4	2	1	4	5
Lead, g/gal	<0.01	0	0	0	0.01	0.03	0.01	0.01	0	0
Phosphorus, g/gal	0.002	0	0.001	0	0	0	0	0	0	0
Sulfur, wt %	0.006	0.002	0.005	0.002	0.004	0.003	0.005	0.003	0.003	0.005
Research Octane No.	102.7	101.5	100.9							
Motor Octane No.	91.0	91.5	91.0							
Antiknock Quality, (R+M)/2	96.8	96.5	96.0							

TABLE 1. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY A (Cont'd)

Grade Designation Premium - Unleaded

Source of Sample	New Orleans	Beaumont								
AFLRL Code No.	4218	4222	___	___	___	___	___	___	___	___
Property										
Gravity, °API	56.0	52.9								
Reid Vapor Pressure, lbs.	12.9	11.7								
Distillation, °F										
IBP	80	86								
10% evap.	106	116								
20% evap.	128	143								
50% evap.	227	234								
90% evap.	318	232								
EP	376	372								
% Recovered	97.5	97.5								
% Residue	1.0	1.0								
% Loss	1.5	1.5								
Temp. at V/L = 20, °F	122	130								
Gum, mg/100 ml										
Unwashed	3.7	4.0								
Washed	0.1	0.2								
Aromatics, % (FIA)	41	47								
Olefins, % (FIA)	2	3								
Lead, g/gal	0.02	0.01								
Phosphorus, g/gal	0.001	0								
Sulfur, wt %	0.003	0.004								
Research Octane No.										
Motor Octane No.										

TABLE 2. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY A

Grade Designation Lead-Free

Source of Sample	Tx Cty Ref	Whiting Ref	Salt Lake City	Salt Lake City	Cheyenne	Cheyenne	Denver	Denver	Memphis	Birmingham
AFLRL Code No.	3895	4012	4089	4090	4091	4092	4093	4097	4173	4155
Property										
Gravity, °API	59.6	60.7	58.9	59.9	57.6	56.4	57.0	59.1	59.7	57.9
Reid Vapor Pressure, lbs.	9.8	11.6	9.5	9.5	8.8	8.1	8.5	9.9	10.5	10.5
Distillation, °F										
IBP	92	83	93	91	95	93	93	91	90	92
10% evap.	118	113	129	122	124	128	129	123	119	114
20% evap.	136	135	161	149	149	154	154	146	143	137
50% evap.	202	213	215	223	235	240	239	229	220	215
90% evap.	332	330	339	344	348	349	350	351	336	336
EP	377	403	401	407	423	424	416	420	407	402
% Recovered	97.9	97.5	97.8	98.0	98.0	97.8	98.0	98.0	98.0	98.0
% Residue	1.1	1.0	1.2	1.0	1.0	1.2	1.0	1.0	1.0	1.0
% Loss	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temp. at V/L = 20, °F	132	126	138	140	143	148	146	137	133	131
Gum, mg/100 ml										
Unwashed	0.9	11.0	57.0	43.0	70.0	71.0	101	12.2	8.5	2.7
Washed	0.4	1.4	2.8	1.7	0.8	0.5	0	0.2	2.2	0.3
Aromatics, % (FIA)	33	28	26	27	30	30	30	27	29	32
Olefins, % (FIA)	8	7	10	16	6	6	5	6	2	14
Lead, g/gal	< 0.01	0	0.01	0	0.01	0	0	0	0.02	0.03
Phosphorus, g/gal	0.087	0.066	0.070	0.061	0.063	0.064	0.064	0.060	0.040	0.080
Sulfur, wt %	0.011	0.048	0.016	0.019	0.015	0.031	0.030	0.043	0.024	0.017
Research Octane No.	92.0	90.8								
Motor Octane No.	82.6	82.4								
Antiknock Quality, (R+M)/2	87.3	86.6								

TABLE 2. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY A (Cont'd)

Grade Designation Lead-Free

Source of Sample	Atlanta	Talla-hassee	Mobile	Gulf Port	New Orleans	Des Moines	St. Louis	Kansas City	Detroit	Minnea-polis
AFLRL Code No.	4187	4198	4206	4212	4219	4262	4272	4286	4314	4312
Property										
Gravity, °API	59.0	64.6	58.7	59.8	58.3				63.8	69.0
Reid Vapor Pressure, lbs.	11.5	11.2	10.4	11.0	11.0				12.8	13.2
Distillation, °F										
IBP	87	90	91	89	86					
10% evap.	112	116	119	116	118					
20% evap.	134	136	139	135	139					
50% evap.	210	186	214	203	216					
90% evap.	337	326	328	325	329					
EP	407	386	382	382	391					
% Recovered	97.8	97.5	98.0	98.0	98.0					
% Residue	1.2	1.0	1.0	1.0	1.0					
% Loss	1.0	1.5	1.0	1.0	1.0					
Temp. at V/L = 20, °F	126	123	131	127	130					
Gum, mg/100 ml										
Unwashed	4.5	5.4	5.0	4.7	4.2				2.6	5.6
Washed	0.2	3.6	2.9	2.6	2.5				0.4	0.7
Aromatics, % (FIA)	33	20	30	29	30	29	18	29	22	10
Olefins, % (FIA)	9	8	19	11	12	16	13	12	10	35
Lead, g/gal	0.10	2.62	0.01	0.46	0.02	0.02	0.04	0.02	0.01	0.01
Phosphorus, g/gal	0.083	0.001	0.083	0.075	0.099				0.068	0.076
Sulfur, wt %	0.018	0.029	0.020	0.018	0.015					
Research Octane No.										
Motor Octane No.										

TABLE 2. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY A (Cont'd)

Grade Designation Lead-Free

Source of Sample	Billings									
AFLRL Code No.	4334	—	—	—	—	—	—	—	—	—
Property										
Gravity, °API	63.4									
Reid Vapor Pressure, lbs.	9.0									
Distillation, °F										
IBP										
10% evap.										
20% evap.										
50% evap.										
90% evap.										
EP										
% Recovered										
% Residue										
% Loss										
Temp. at V/L = 20, °F										
Gum, mg/100 ml										
Unwashed	3.6									
Washed	2.0									
Aromatics, % (FIA)	15									
Olefins, % (FIA)	28									
Lead, g/gal	1.00									
Phosphorus, g/gal	0.044									
Sulfur, wt %										
Research Octane No.										
Motor Octane No.										

TABLE 3. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY B

Grade Designation Lead-Free

Source of Sample	Houston	Houston	San Diego	San Diego	Los Angeles	Los Angeles	San Francisco	San Francisco	Phila. Refinery	Watson, Cal. Refinery
AFLRL Code No.	3996	3998	4037	4041	4054	4061	4079	4080	4146	4148
Property										
Gravity, °API	56.8	56.3	59.9	58.0	60.5	59.7	55.0	56.1	57.6	56.9
Reid Vapor Pressure, lbs.	9.8	9.8	7.8	8.0	7.9	9.2	8.6	9.1	11.2	10.8
Distillation, °F										
IBP	91	92	97	97	91	93	95	89	85	87
10% evap.	120	121	128	131	124	120	127	123	112	115
20% evap.	140	144	148	152	142	138	156	153	134	136
50% evap.	225	232	217	221	215	215	238	235	220	233
90% evap.	335	336	329	324	314	324	343	338	332	332
EP	402	398	408	396	396	395	407	404	402	406
% Recovered	97.5	97.0	97.8	98.0	98.0	98.0	97.8	98.0	97.8	98.0
% Residue	1.3	1.3	1.2	1.0	1.2	1.2	1.2	1.0	1.2	1.0
% Loss	1.2	1.7	1.0	1.0	0.8	0.8	1.0	1.0	1.0	1.0
Temp. at V/L = 20, °F	137	138	145	145	144	137	145	142	129	133
Gum, mg/100 ml										
Unwashed	81	111	106	28.1	96.7	98.3	109	48.2	138	91
Washed	0.3	0	0.3	0.1	0.1	0.3	0.6	1.5	0.5	0.6
Aromatics, % (FIA)	33	35	28	30	29	28	33	34	34	35
Olefins, % (FIA)	2	1	3	2	5	5	6	7	1	2
Lead, g/gal	< 0.01	< 0.01	0	0.02	0.01	0.01	0.01	0.17	0	0.02
Phosphorus, g/gal	0.025	0.038	0.034	0.003	0.038	0.037	0.038	0.014	0.023	0.012
Sulfur, wt %	0.006	0.006	0.019	0.018	0.020	0.031	0.052	0.061	0.007	0.011
Research Octane No.	90.4	90.8							91.9	92.2
Motor Octane No.	84.1	84.3							84.0	83.4
Antiknock Quality, (R+M)/2	87.2	87.6							88.0	87.8

TABLE 3. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY B (Cont'd)

Grade Designation Lead-Free

Source of Sample	E. Chicago Refinery	Detroit	Seattle							
AFLRL Code No.	4155	4310	4316	———	———	———	———	———	———	———
Property										
Gravity, °API	61.4	63.7	56.3							
Reid Vapor Pressure, lbs.	12.1	14.7	8.6							
Distillation, °F										
IBP	87									
10% evap.	108									
20% evap.	128									
50% evap.	201									
90% evap.	346									
EP	425									
% Recovered	97.3									
% Residue	1.2									
% Loss	1.5									
Temp. at V/L = 20, °F	121									
Gum, mg/100 ml										
Unwashed	106	1.9	31.5							
Washed	0.3	0.3	4.6							
Aromatics, % (FIA)	26	20	32							
Olefins, % (FIA)	13	7	7							
Lead, g/gal	< 0.01	2.50	0.05							
Phosphorus, g/gal	0.034	0.002	0.013							
Sulfur, wt %	0.046									
Research Octane No.	90.6									
Motor Octane No.	80.9									
AntiknockQuality, (R+M)/2	85.8									

TABLE 4. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY C

Grade Designation Lead-Free

Source of Sample	New Braunfels	Houston	Houston	El Paso	El Paso	Phoenix	Phoenix	San Diego	San Diego	Los Angeles
AFLRL Code No.	3978	3997	4001	4017	4021	4024	4025	4040	4043	4050
Property										
Gravity, °API	56.4	57.7	57.4	60.9	60.5	60.4	60.5	56.2	56.0	55.7
Reid Vapor Pressure, lbs.	8.7	8.9	8.9	7.9	7.9	7.7	7.9	8.4	8.5	8.0
Distillation, °F										
IBP	92	91	91	95	91	95	95	94	92	93
10% evap.	119	124	121	133	131	132	134	129	126	127
20% evap.	138	146	143	154	153	155	155	150	148	149
50% evap.	235	235	237	219	218	220	219	223	222	225
90% evap.	320	330	327	316	315	318	316	342	340	342
EP	386	395	390	394	392	394	388	412	410	414
% Recovered	98.0	98.0	97.8	98.0	98.0	98.0	98.0	97.9	97.8	97.8
% Residue	1.2	1.1	1.2	1.1	1.2	1.2	1.1	1.1	1.1	1.1
% Loss	0.8	0.9	1.0	0.9	0.8	0.8	0.9	1.0	1.1	1.1
Temp. at V/L = 20, °F	143	145	143	146	145	148	146	144	143	145
Gum, mg/100 ml										
Unwashed	2.8	24.0	24.0	6.7	23.5	70.0	68.5	22.0	26.2	30.1
Washed	0.4	0	0	0.5	1.0	1.6	0.6	0.5	1.0	1.2
Aromatics, % (FIA)	32	30	32	25	26	25	24	34	34	36
Olefins, % (FIA)	2	1	1	4	3	5	5	2	2	3
Lead, g/gal	0.01	< 0.01	0.01	0.02	0.02	0.04	0.05	0.08	0.03	0.01
Phosphorus, g/gal	0.057	0.071	0.067	0.016	0.082	0.179	0.177	0.078	0.087	0.090
Sulfur, wt %	0.003	0.002	0.005	0.011	0.016	0.034	0.021	0.007	0.014	0.015
Research Octane No.	92.1	91.8	91.6							
Motor Octane No.	83.8	84.4	84.2							
Antiknock Quality, (R+M)/2	88.0	88.1	87.9							

TABLE 4. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY C (Cont'd)

Grade Designation Lead-Free

Source of Sample	Los Angeles	San Francisco	San Francisco	Reno	Reno	Albu-querque	Albu-querque	Amarillo	Dallas	Little Rock
AFLRL Code No.	4053	4063	4066	4083	4085	4099	4100	4105	4164	4169
Property										
Gravity, °API	55.7	55.9	55.8	56.8	57.0	61.5	61.9	61.0	63.8	64.2
Reid Vapor Pressure, lbs.	8.0	8.0	8.1	8.5	8.6	8.0	8.6	7.9	10.8	10.4
Distillation, °F										
IBP	93	94	93	95	97	97	91	97	91	89
10% evap.	127	135	138	128	130	135	129	133	114	115
20% evap.	150	164	164	154	154	163	155	154	128	134
50% evap.	227	228	230	220	220	222	218	219	202	207
90% evap.	342	343	340	334	335	316	320	314	317	306
EP	414	414	413	415	413	398	398	390	388	383
% Recovered	98.0	98.1	98.0	98.0	97.8	98.0	97.8	98.0	98.0	98.0
% Residue	1.2	1.2	1.1	1.0	1.2	1.0	1.2	1.0	1.0	1.0
% Loss	0.8	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temp. at V/L = 20, °F	146	148	148	142	142	146	142	146	127	130
Gum, mg/100 ml										
Unwashed	19.7	22.8	30.6	23.6	26.4	44.4	35.8	19.1	28.6	14.8
Washed	2.7	1.7	1.4	2.4	1.9	0.3	0.6	0.7	0.7	0.4
Aromatics, % (FIA)	33	32	31	30	29	22	20	24	22	17
Olefins, % (FIA)	2	5	4	2	2	5	5	3	1	7
Lead, g/gal	0	0.01	0.01	0.03	0.03	0	0	0.02	0.02	0.08
Phosphorus, g/gal	0.083	0.086	0.089	0.082	0.084	0.129	0.128	0.073	0.075	0.059
Sulfur, wt %	0.014	0.011	0.009	0.007	0.009	0.013	0.012	0.013	0.003	0.006
Research Octane No.										
Motor Octane No.										

TABLE 4. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY C (Cont'd)

Grade Designation Lead-Free

Source of Sample	Memphis	Birmingham	Atlanta	Tallahassee	Mobile	New Orleans	Des Moines	St. Louis	Detroit	Minneapolis
AFLRL Code No.	4174	4181	4191	4196	4201	4215	4262	4263	4305	4313
Property										
Gravity, °API	65.1	63.8	62.0	58.8	59.8	65.3			62.7	62.6
Reid Vapor Pressure, lbs.	11.1	10.8	11.4	9.1	10.6	12.1			11.8	12.8
Distillation, °F										
IBP	85	91	85	95	87	86				
10% evap.	115	119	115	130	118	114				
20% evap.	136	144	141	161	150	136				
50% evap.	209	218	225	238	233	214				
90% evap.	335	345	341	354	353	336				
EP	411	422	419	438	434	422				
% Recovered	97.7	98.0	96.7	98.0	97.8	98.0				
% Residue	1.3	1.0	1.2	1.0	1.2	1.0				
% Loss	1.0	1.0	2.1	1.0	1.0	1.0				
Temp. at V/L = 20, °F	128	131	129	144	134	124				
Gum, mg/100 ml										
Unwashed	109	24.6	33.6	19.4	21.7	23.1			41.1	21.1
Washed	1.3	1.8	0.1	3.3	1.7	0.5			0.9	0.4
Aromatics, % (FIA)	14	15	21	23	24	16	32	25	25	26
Olefins, % (FIA)	10	10	6	7	7	11	1	1	2	2
Lead, g/gal	0.04	0.03	0.03	0.04	0.04	0.02	0.02	0.02	0.12	0.01
Phosphorus, g/gal	0.068	0.039	0.036	0.067	0.053	0.034			0.061	0.074
Sulfur, wt %	0.013	0.001	0.010	0.013	0.014	0.013				
Research Octane No.										
Motor Octane No.										

TABLE 4. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY C (Cont'd)

Grade Designation Lead-Free

Source of Sample	Seattle									
AFLRL Code No.	4319	—	—	—	—	—	—	—	—	—
Property										
Gravity, °API	59.6									
Reid Vapor Pressure, lbs.	9.7									
Distillation, °F										
IBP										
10% evap.										
20% evap.										
50% evap.										
90% evap.										
EP										
% Recovered										
% Residue										
% Loss										
Temp. at V/L = 20, °F										
Gum, mg/100 ml										
Unwashed	21.1									
Washed	0.4									
Aromatics, % (FIA)	26									
Olefins, % (FIA)	2									
Lead, g/gal	0.01									
Phosphorus, g/gal	0.074									
Sulfur, wt %										
Research Octane No.										
Motor Octane No.										

TABLE 5. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY D

Grade Designation Lead-Free

Source of Sample	El Segundo Refinery	Oakland Refinery	El Paso	El Paso	Phoenix	Phoenix	San Diego	San Diego	Los Angeles	Los Angeles
AFLRL Code No.	3993	4014	4019	4022	4027	4028	4029	4034	4048	4052
Property										
Gravity, °API	58.6	57.5	56.3	55.4	55.4	56.4	58.1	58.4	57.6	56.5
Reid Vapor Pressure, lbs.	7.3	8.4	8.1	7.8	7.1	7.6	7.3	7.3	6.6	7.3
Distillation, °F										
IBP	101	98	95	93	97	93	101	99	96	96
10% evap.	137	133	134	140	147	145	138	135	132	133
20% evap.	153	150	158	168	177	174	156	152	151	153
50% evap.	220	205	235	238	245	238	217	212	219	226
90% evap.	326	335	356	355	365	344	316	310	325	334
EP	393	445	426	443	442	438	380	389	396	414
% Recovered	98.0	98.0	98.8	98.0	98.0	98.5	98.0	98.0	98.0	97.8
% Residue	1.3	1.2	0.9	1.2	1.3	1.2	1.1	1.0	1.0	1.3
% Loss	0.7	0.8	0.3	0.8	0.7	0.3	0.9	1.0	1.0	0.9
Temp. at V/L = 20, °F	149	141	148	151	160	152	149	147	151	150
Gum, mg/100 ml										
Unwashed	117	116	3.4	322	153	155	129	134	156	135
Washed	0.1	1.9	2.1	2.2	0.7	10.9	0.5	0.2	0.1	0.1
Aromatics, % (FIA)	27	30	31	33	29	29	30	29	32	31
Oletins, % (FIA)	7	9	7	2	2	3	5	5	5	6
Lead, g/gal	0.01	0	0.01	0.02	0.07	0.04	0.08	0.09	0.07	0.49
Phosphorus, g/gal	0.002	0	0.001	0.001	0.001	0	0	0	0.002	0.011
Sulfur, wt %	0.087	0.010	0.024	0.024	0.027	0.017	0.062	0.058	0.083	0.060
Research Octane No.	91.9	90.8								
Motor Octane No.	82.9	81.6								
Antiknock Quality, (R+M)/2	87.4	86.2								

TABLE 5. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY D (Cont'd)

Grade Designation Lead-Free

Source of Sample	San Francisco	San Francisco	Reno	Reno	Denver	Denver	Memphis	Birmingham	Atlanta	Tallahassee
AFLRL Code No.	4070	4074	4082	4087	4094	4098	4178	4179	4188	4194
Property										
Gravity, °API	59.3	59.8	58.8	58.7	58.6	58.7	62.0	61.9	61.7	62.8
Reid Vapor Pressure, lbs.	8.0	7.9	7.5	7.7	6.8	6.5	8.8	9.1	9.1	9.1
Distillation, °F										
IBP	98	101	101	100	97	107	97	97	99	99
10% evap.	131	131	128	129	141	145	128	125	128	129
20% evap.	145	145	146	148	166	167	148	146	147	149
50% evap.	200	199	199	199	228	228	198	199	200	203
90% evap.	333	327	334	338	333	320	320	326	318	305
EP	420	413	426	421	401	394	422	428	425	422
% Recovered	98.0	98.1	98.0	98.0	98.0	97.8	98.0	98.0	98.0	98.0
% Residue	1.3	1.4	1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.0
% Loss	0.7	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Temp. at V/L = 20, °F	142	142	143	141	145	155	137	136	136	137
Gum, mg/100 ml										
Unwashed	116	120	142	126	109	126	95.7	115	107	88.1
Washed	0.3	1.9	0.2	1.0	0.2	0.2	2.0	2.9	0.2	2.7
Aromatics, % (FIA)	27	27	28	27	24	24	21	22	22	20
Olefins, % (FIA)	3	4	4	4	8	6	8	8	7	12
Lead, g/gal	0.01	0.03	0	0.01	0.01	0.01	0.04	0.08	0.10	0.05
Phosphorus, g/gal	0.001	0	0	0	0	0	0	0	0	0
Sulfur, wt %	0.007	0.008	0.007	0.006	0.017	0.015	0.018	0.019	0.018	0.016
Research Octane No.										
Motor Octane No.										

TABLE 5. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY D (Cont'd)

Grade Designation Lead-Free

Source of Sample	Mobile	Biloxi	New Orleans	Seattle						
AFLRL Code No.	4200	4207	4216	4315	___	___	___	___	___	___
Property										
Gravity, °API	63.0	63.0	62.9	58.1						
Reid Vapor Pressure, lbs.	9.2	10.4	10.0	7.8						
Distillation, °F										
IBP	93	93	96							
10% evap.	126	128	129							
20% evap.	145	148	149							
50% evap.	198	198	198							
90% evap.	315	317	320							
EP	418	422	426							
% Recovered	97.6	97.7	97.5							
% Residue	1.4	1.3	1.5							
% Loss	1.0	1.0	1.0							
Temp. at V/L = 20, °F	135	131	133							
Gum, mg/100 ml										
Unwashed	116	121	312	123						
Washed	0.2	0.3	1.7	0.4						
Aromatics, % (FIA)	18	17	19	29						
Olefins, % (FIA)	9	11	9	5						
Lead, g/gal	0.01	0.01	0.01	0.03						
Phosphorus, g/gal	0	0	0							
Sulfur, wt %	0.020	0.019	0.017							
Research Octane No.										
Motor Octane No.										

TABLE 6. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY E

Grade Designation Lead-Free

Source of Sample	San Diego	San Diego	Los Angeles	Los Angeles	Los Angeles Refinery					
AFLRL Code No.	4039	4044	4046	4056	4137	—	—	—	—	—
Property										
Gravity, °API	56.4	53.2	53.4	52.4	55.0					
Reid Vapor Pressure, lbs.	9.0	8.7	9.2	8.2	10.4					
Distillation, °F										
IBP	91	88	87	94	93					
10% evap.	128	131	128	137	123					
20% evap.	155	162	160	167	150					
50% evap.	221	237	237	239	233					
90% evap.	318	329	327	331	317					
EP	396	403	400	398	389					
% Recovered	97.6	97.8	97.6	97.9	98.0					
% Residue	1.0	1.0	1.1	1.2	1.0					
% Loss	1.4	1.2	1.3	0.9	1.0					
Temp. at V/L = 20, °F	141	145	143	149	136					
Gum, mg/100 ml										
Unwashed	87.6	91.3	94.2	81.3	75.8					
Washed	0.1	0.6	0.4	<0.1	0.3					
Aromatics, % (FIA)	31	38	38	39	34					
Olefins, % (FIA)	1	1	1	0.1	1					
Lead, g/gal	0.04	0.02	0.01	0.03	0.01					
Phosphorus, g/gal	0	0	0.002	0	0.001					
Sulfur, wt %	0.003	0.004	0.003	0.003	0.002					
Research Octane No.					91.7					
Motor Octane No.					82.8					
Antiknock Quality, (R+M)/2					87.2					

TABLE 7. PROPERTIES OF GASOLINE SAMPLES FROM:

	Company J Lead-Free			Company K Lead-Free			Company L Lead-Free		Company M Lead-Free	
Source of Sample	Mobile	New Orleans		Cleveland Refinery	Detroit		Detroit		Toledo Refinery	
AFLRL Code No.	4204	4217		4151	4306		4311		4123	
Property										
Gravity, °API	65.5	67.7		57.4	58.2		61.5		61.5	
Reid Vapor Pressure, lbs.	10.8	11.5		8.8	9.9		12.3		13.2	
Distillation, °F										
IBP	89	85		93					77	
10% evap.	118	114		128					104	
20% evap.	138	134		148					130	
50% evap.	200	196		217					218	
90% evap.	326	320		328					338	
EP	414	406		393					408	
% Recovered	98.0	97.8		98.0					96.0	
% Residue	1.0	1.2		1.0					1.2	
% Loss	1.0	1.0		1.0					2.8	
Temp. at V/L = 20, °F	128	127		141					118	
Gum, mg/100 ml										
Unwashed	26.0	26.1		98.5	93.8		1.8		2.8	
Washed	1.0	0.6		0.4	0.6		0.2		1.1	
Aromatics, % (FIA)	13	11		30	32		24		26	
Olefins, % (FIA)	13	12		10	5		12		8	
Lead, g/gal	0.04	0.03		0.04	0.01		0.02		0.02	
Phosphorus, g/gal	0.005	0.005		0.072	0.068		0.041		0.068	
Sulfur, wt %	0.013	0.015		0.017					0.010	
Research Octane No.				91.9					91.6	
Motor Octane No.				81.8					83.6	
Antiknock Quality, (R+M)/2				86.8					87.6	

TABLE 8. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY F

Grade Designation Low-Lead

Source of Sample	Houston	Houston	San Diego	San Diego	Los Angeles	Los Angeles	Dallas	Little Rock	Memphis	Birmingham
AFLRL Code No.	4000	4008	4035	4042	4060	4062	4166	4171	4177	4182
Property										
Gravity, °API	61.4	61.4	58.7	58.2	58.0	57.2	62.1	63.2	61.5	62.8
Reid Vapor Pressure, lbs.	9.4	9.2	9.4	9.4	8.8	9.2	10.0	11.5	13.0	11.9
Distillation, °F										
IBP	94	91	91	96	91	91	93	89	81	83
10% evap.	121	123	121	124	124	121	120	114	104	109
20% evap.	141	142	138	142	143	142	138	133	123	129
50% evap.	211	215	206	208	215	217	207	204	208	203
90% evap.	331	334	347	347	344	355	332	332	328	328
EP	404	408	430	422	420	421	404	403	406	406
% Recovered	97.7	98.0	97.5	97.9	98.0	97.9	98.0	97.8	97.5	98.0
% Residue	1.2	1.2	1.1	1.1	1.0	1.4	1.0	1.2	1.0	1.0
% Loss	1.1	0.8	1.4	1.0	1.0	0.7	1.0	1.0	1.5	1.0
Temp. at V/L = 20, °F	136	138	135	136	144	138	133	125	118	124
Gum, mg/100 ml										
Unwashed	7.3	8.4	6.0	5.1	8.7	6.2	3.7	4.0	4.6	5.0
Washed	2.2	3.5	0.3	0.2	0.1	1.1	1.1	0	1.9	1.5
Aromatics, % (FIA)	25	25	30	30	31	33	23	25	27	22
Olefins, % (FIA)	4	5	3	3	4	4	4	3	1	5
Lead, g/gal	0.45	0.44	0.56	0.54	0.46	0.32	0.65	0.57	0.43	0.43
Phosphorus, g/gal	0.003	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.003	0.002
Sulfur, wt %	0.046	0.047	0.060	0.064	0.061	0.068	0.042	0.041	0.019	0.040
Research Octane No.	90.7	90.7								
Motor Octane No.	84.8	84.4								
Antiknock Quality, (R+M)/2	87.8	87.6								

TABLE 8. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY F (Cont'd)

Grade Designation Low-Lead

Source of Sample	Atlanta	Talla-hassee	Mobile	Biloxi	New Orleans	Beau-mont	St. Louis	Seattle	Detroit	
AFLRL Code No.	4189	4195	4199	4208	4213	4224	4288	4317	4309	
Property										
Gravity, °API	62.1	62.5	61.2	61.8	61.0	62.6		64.6	62.4	
Reid Vapor Pressure, lbs.	10.7	10.8	12.1	11.8	11.2	10.8		12.3	13.2	
Distillation, °F										
IBP	90	91	89	91	87	89				
10% evap.	115	115	112	114	112	116				
20% evap.	136	135	130	133	132	134				
50% evap.	208	207	209	205	209	207				
90% evap.	332	327	326	328	324	338				
EP	405	402	402	402	404	410				
% Recovered	98.0	98.0	97.8	98.0	98.0	98.0				
% Residue	1.0	1.0	1.2	1.0	1.0	1.0				
% Loss	1.0	1.0	1.0	1.0	1.0	1.0				
Temp. at V/L = 20, °F	129	128	123	124	127	129				
Gum, mg/100 ml										
Unwashed	3.4	5.7	5.0	5.0	3.9	3.4		1.8	4.3	
Washed	0.2	2.6	1.3	0.2	0.9	0.4		0.4	0.7	
Aromatics, % (FIA)	23	23	30	25	28	24	23	11	24	
Olefins, % (FIA)	4	5	3	5	3	5	4	trace	6	
Lead, g/gal	0.54	0.46	0.50	0.43	0.43	0.56	0.47	3.50	0.43	
Phosphorus, g/gal	0.002	0.002	0.003	0.006	-	-				
Sulfur, wt %	0.042	0.039	0.010	0.036	0.021	0.042				
Research Octane No.										
Motor Octane No.										

TABLE 9. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY G

Grade Designation Low-Lead

Source of Sample	San Antonio	Houston	Houston	San Francisco	San Francisco	Baytown Refinery	Dallas	Little Rock	Memphis	Birmingham
AFLRL Code No.	3743	4002	4006	4072	4075	4114	4163	4170	4175	4183
Property										
Gravity, °API	55.5	57.7	57.3	58.5	57.9	62.0	62.9	64.2	60.8	60.5
Reid Vapor Pressure, lbs.	9.7	9.8	9.4	9.3	9.0	11.6	12.2	12.6	13.6	13.4
Distillation, °F										
IBP	91	88	91	92	93	80	85	85	83	83
10% evap.	118	117	121	126	126	111	102	104	103	102
20% evap.	139	137	142	148	147	136	116	119	119	118
50% evap.	221	220	225	218	218	216	190	196	191	195
90% evap.	315	325	327	331	327	326	325	327	308	328
EP	371	380	380	390	386	389	390	382	382	387
% Recovered	96.2	98.0	98.0	98.2	97.3	97.0	98.0	97.8	97.5	97.3
% Residue	1.2	1.0	1.2	1.2	1.3	1.0	1.0	1.2	1.0	1.2
% Loss	2.6	1.0	0.8	0.6	1.4	2.0	1.0	1.0	1.5	1.5
Temp. at V/L = 20, °F	136	135	138	138	140	126	117	117	112	117
Gum, mg/100 ml										
Unwashed	5.1	4.9	5.8	4.8	5.4	2.0	3.6	4.0	6.6	6.3
Washed	0	0.1	0.8	0.6	0.2	0.2	0.5	0.2	1.5	0.3
Aromatics, % (FIA)	39	33	34	29	30	23	26	30	30	36
Olefins, % (FIA)	9	8	7	11	13	10	7	7	8	8
Lead, g/gal	0.37	0.47	0.49	0.45	0.51	0.47	0.65	0.57	0.43	0.42
Phosphorus, g/gal	0.009	0	0	0.014	0.026	0	0	0	0	0
Sulfur, wt %	-	0.016	0.013	0.030	0.035	0.024	0.019	0.017	0.015	0.013
Research Octane No.	97.1	96.9	97.1			96.3				
Motor Octane No.	86.6	87.6	86.4			86.6				
Antiknock Quality, (R+M)/2	91.8	92.2	91.8			91.4				

TABLE 9. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY G (Cont'd)

Grade Designation Low-Lead

Source of Sample	Atlanta	Mobile	Gulf Port	New Orleans	Beaumont					
AFLRL Code No.	4190	4203	4210	4214	4221	___	___	___	___	___
Property										
Gravity, °API	59.5	57.0	57.9	58.7	61.7					
Reid Vapor Pressure, lbs.	13.5	11.7	12.8	13.2	12.2					
Distillation, °F										
IBP	81	85	85	85	85					
10% evap.	104	113	108	105	105					
20% evap.	124	136	130	125	124					
50% evap.	200	220	214	204	199					
90% evap.	313	320	318	316	320					
EP	386	398	387	390	382					
% Recovered	98.0	98.0	97.5	97.2	98.0					
% Residue	1.0	1.0	1.0	1.3	1.0					
% Loss	1.0	1.0	1.5	1.5	1.0					
Temp. at V/L = 20, °F	114	127	120	116	119					
Gum, mg/100 ml										
Unwashed	1.0	4.8	3.8	5.6	3.2					
Washed	0	1.2	1.0	1.8	0.1					
Aromatics, % (FIA)	39	26	34	34	26					
Olefins, % (FIA)	6	10	12	10	10					
Lead, g/gal	0.48	0.44	0.42	0.42	0.50					
Phosphorus, g/gal	0	0	-	-	-					
Sulfur, wt %	0.016	0.016	0.021	0.015	0.019					
Research Octane No.										
Motor Octane No.										

TABLE 10. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY H

Grade Designation Low-Lead

Source of Sample	San Antonio	Houston	Houston	Los Angeles	Los Angeles	San Francisco	San Francisco	Dallas	Beaumont	St. Louis
AFLRL Code No.	3977	3999	4005	4049	4058	4068	4076	4165	4225	4282
Property										
Gravity, °API	52.3	53.6	53.7	58.0	55.3	59.7	59.7	58.3	60.6	
Reid Vapor Pressure, lbs.	9.6	9.5	9.2	7.9	6.6	8.2	8.1	10.3	11.5	
Distillation, °F										
IBP	87	88	89	93	99	98	99	91	89	
10% evap.	125	123	125	133	140	128	128	119	116	
20% evap.	152	150	150	154	160	143	143	139	139	
50% evap.	229	240	239	222	228	200	200	220	223	
90% evap.	333	330	332	360	351	324	323	323	332	
EP	411	414	413	421	421	412	406	402	417	
% Recovered	98.0	97.2	97.8	98.0	98.5	98.5	98.1	97.8	97.8	
% Residue	1.2	1.2	1.2	1.1	1.0	1.2	1.3	1.2	1.2	
% Loss	0.8	1.6	1.0	0.9	0.5	0.3	0.6	1.0	1.0	
Temp. at V/L = 20, °F	139	141	143	146	155	140	141	133	129	
Gum, mg/100 ml										
Unwashed	2.5	7.0	10.0	5.0	7.2	7.5	8.6	5.8	5.3	
Washed	1.0	0	1.3	0.5	0.9	0.4	0.2	0.7	0.1	
Aromatics, % (FIA)	45	42	42	27	33	27	26	31	26	28
Olefins, % (FIA)	2	2	1	6	7	1	2	1	2	1
Lead, g/gal	0.24	0.34	0.37	0.43	0.46	0.51	0.49	0.41	0.40	0.53
Phosphorus, g/gal	0.001	0	0	0.003	0.002	0.002	0.002	0		
Sulfur, wt %	0.006	0.014	0.016	0.037	0.036	0.007	0.006	0.011	0.004	
Research Octane No.	98.0	95.1	95.4							
Motor Octane No.	88.2	86.6	88.0							
Antiknock Quality, (R+M)/2	93.1	90.8	91.7							

TABLE 10. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY H (Cont'd)

Grade Designation Low-Lead

Source of Sample	Kansas City	Detroit	Seattle							
AFLRL Code No.	4283	4304	4318	———	———	———	———	———	———	———
Property										
Gravity, °API		62.1	66.5							
Reid Vapor Pressure, lbs.		11.2	11.9							
Distillation, °F										
IBP										
10% evap.										
20% evap.										
50% evap.										
90% evap.										
EP										
% Recovered										
% Residue										
% Loss										
Temp. at V/L = 20, °F										
Gum, mg/100 ml										
Unwashed		8.3	14.8							
Washed		0.7	0							
Aromatics, % (FIA)	16	28	18							
Olefins, % (FIA)	2	2	5							
Lead, g/gal	0.49	0.49	0.52							
Phosphorus, g/gal		-	-							
Sulfur, wt %										
Research Octane No.										
Motor Octane No.										

TABLE 11. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY D

Grade Designation Low-Lead

Source of Sample	El Segundo Refinery	Oakland Refinery	San Diego	San Diego	Los Angeles	Los Angeles	San Francisco	San Francisco	Reno	Reno
AFLRL Code No.	3992	4013	4030	4033	4047	4051	4065	4069	4081	4086
Property										
Gravity, °API	59.5	61.4	58.8	57.4	58.7	59.0	62.6	62.5	62.2	62.0
Reid Vapor Pressure, lbs.	9.0	9.3	9.0	9.1	8.7	8.4	9.1	9.2	9.2	9.0
Distillation, °F										
IBP	94	93	93	93	93	89	91	90	97	92
10% evap.	121	124	122	122	124	121	124	120	124	124
20% evap.	135	139	137	140	140	139	140	136	140	142
50% evap.	194	196	194	205	203	200	197	193	196	198
90% evap.	325	315	318	324	320	323	313	310	318	322
EP	393	417	399	414	400	402	402	397	400	406
% Recovered	98.0	97.8	98.7	98.0	97.8	97.7	98.0	98.3	97.8	97.8
% Residue	1.2	1.2	1.1	1.1	1.0	1.1	1.2	1.1	1.2	1.2
% Loss	0.8	1.0	0.2	0.9	1.2	1.2	0.8	0.5	1.0	1.0
Temp. at V/L = 20, °F	135	134	135	136	138	138	135	133	135	136
Gum, mg/100 ml										
Unwashed	104	126	133	116	132	139	108	94.5	195	202
Washed	0.5	2.2	0.2	0.3	0.2	0.1	0.7	0.6	0.2	0.2
Aromatics, % (FIA)	32	26	32	32	33	34	25	24	24	24
Olefins, % (FIA)	5	3	5	4	3	4	2	3	4	4
Lead, g/gal	0.44	0.44	0.43	0.42	0.41	0.41	0.40	0.37	0.45	0.43
Phosphorus, g/gal	0	0	0	0	0	0.001	0	0	0	0
Sulfur, wt %	0.042	0.003	0.046	0.036	0.038	0.046	0.006	0.007	0.007	0.006
Research Octane No.	95.5	94.7								
Motor Octane No.	86.0	87.1								
Antiknock Quality, (R+M)/2	90.8	90.9								

TABLE 12. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY E

Grade Designation Low-Lead

Source of Sample	Houston	Houston	El Paso	El Paso	Phoenix	Phoenix	San Diego	San Diego	Los Angeles	Los Angeles
AFLRL Code No.	3995	4007	4018	4020	4023	4026	4032	4038	4045	4055
Property										
Gravity, °API	57.4	57.4	61.0	61.1	62.3	62.2	54.8	55.2	54.8	54.7
Reid Vapor Pressure, lbs.	8.9	8.9	7.5	7.6	6.7	6.7	9.0	9.0	8.9	8.8
Distillation, °F										
IBP	93	93	97	97	102	100	89	89	89	88
10% evap.	126	126	138	137	141	140	126	125	127	126
20% evap.	148	146	160	158	160	160	152	150	156	155
50% evap.	225	225	223	222	217	218	235	232	243	242
90% evap.	336	335	349	340	335	343	344	341	342	342
EP	408	410	422	422	416	428	415	420	401	402
% Recovered	97.7	97.8	98.5	97.9	98.0	98.5	97.9	97.9	97.9	97.8
% Residue	1.2	1.1	1.3	1.2	1.4	1.0	1.1	1.2	1.1	1.0
% Loss	1.1	1.1	0.2	0.9	0.6	0.5	1.0	0.9	1.0	1.2
Temp. at V/L = 20, °F	141	141	149	148	152	152	143	144	145	145
Gum, mg/100 ml										
Unwashed	77	80	87	89	98	119	90	102	71.7	73.4
Washed	0.8	0.7	0.8	1.0	0.8	0.5	0.4	0.3	0.5	0.1
Aromatics, % (FIA)	34	34	23	20	18	16	36	37	37	35
Olefins, % (FIA)	10	8	6	7	7	7	3	3	5	6
Lead, g/gal	0.43	0.41	0.47	0.47	0.42	0.47	0.51	0.47	0.40	0.43
Phosphorus, g/gal	0	0	0.002	0	0.001	0.001	0	0	0	0
Sulfur, wt %	0.023	0.022	0.039	0.023	0.035	0.036	0.034	0.034	0.048	0.048
Research Octane No.	94.6	94.9								
Motor Octane No.	86.0	84.5								
Antiknock Quality, (R+M)/2	90.3	89.7								

TABLE 12. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY E (Cont'd)

Grade Designation Low-Lead

Source of Sample	San Francisco	Beaumont Ref.	San Francisco	Denver	Denver	Amarillo	Amarillo	L. A. Refinery	Dallas	Little Rock
AFLRL Code No.	4064	4107	4067	4095	4096	4103	4104	4138	4162	4167
Property										
Gravity, °API	59.5	59.8	53.8	57.8	57.7	57.7	59.1	54.9	61.0	58.1
Reid Vapor Pressure, lbs.	8.6	9.1	7.7	8.5	8.2	9.3	8.8	10.3	11.3	10.2
Distillation, °F										
IBP	94	84	95	97	97	93	91	89	87	87
10% evap.	123	114	131	128	127	137	135	118	118	119
20% evap.	142	135	159	148	149	176	173	147	146	147
50% evap.	208	206	245	219	219	240	239	242	223	233
90% evap.	332	310	348	348	346	335	324	349	323	337
EP	384	392	406	422	418	412	412	401	391	402
% Recovered	97.8	97.8	98.0	97.8	97.8	97.8	98.0	97.8	97.3	97.8
% Residue	1.2	1.1	1.0	1.2	1.2	1.2	1.0	1.2	1.2	1.2
% Loss	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.0
Temp. at V/L = 20, °F	139	135	151	142	143	144	146	137	130	136
Gum, mg/100 ml										
Unwashed	34.7	121	80.7	76.6	89.3	66.2	58.6	79.4	63.5	88.1
Washed	0.4	0.5	0.7	0.2	0.2	0.5	0.2	0.2	1.1	0
Aromatics, % (FIA)	30	31	40	27	30	29	26	37	25	32
Olefins, % (FIA)	6	7	4	8	5	1	1	4	7	8
Lead, g/gal	0.47	0.42	0.49	0.46	0.46	0.44	0.45	0.35	0.46	0.68
Phosphorus, g/gal	0	0.006	0.001	0	0	0	0	0	0.001	0
Sulfur, wt %	0.046	0.019	0.039	0.011	0.019	0.007	0.006	0.033	0.015	0.011
Research Octane No.		94.3						95.5		
Motor Octane No.		85.6						85.3		
Antiknock Quality, (R+M)/2		90.0						90.4		

TABLE 12. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY E (Cont'd)

Grade Designation Low-Lead

Source of Sample	Memphis	Birmingham	Atlanta	Tallahassee	Mobile	Biloxi	New Orleans	Beaumont	Tulsa	
AFLRL Code No.	4176	4180	4192	4193	4202	4209	4220	4223	4259	
Property										
Gravity, °API	60.3	59.8	61.1	59.5	58.6	58.9	58.9	61.1		
Reid Vapor Pressure, lbs.	9.9	10.9	11.4	9.9	9.8	9.8	9.2	9.4		
Distillation, °F										
IBP	93	91	86	91	91	91	91	96		
10% evap.	123	118	118	123	122	122	125	126		
20% evap.	152	144	145	148	144	145	148	154		
50% evap.	221	228	229	219	216	218	218	220		
90% evap.	323	333	327	318	326	327	319	318		
EP	386	407	402	404	404	406	404	402		
% Recovered	98.0	97.8	97.8	97.8	97.8	98.0	98.0	98.0		
% Residue	1.0	1.2	1.2	1.2	1.2	1.0	1.0	1.0		
% Loss	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
Temp. at V/L = 20, °F	136	132	131	136	135	136	139	138		
Gum, mg/100 ml										
Unwashed	74.6	64.7	64.4	71.0	74.7	68.8	58.1	70.9		
Washed	1.6	2.8	2.5	2.2	0.5	0.5	0.5	0.8		
Aromatics, % (FIA)	22	26	24	25	29	28	29	25	18	
Olefins, % (FIA)	6	8	7	7	8	9	10	7	3	
Lead, g/gal	0.43	0.55	0.57	0.39	0.43	0.61	0.47	0.41	0.43	
Phosphorus, g/gal	0	0	0	0	0	0	-	-		
Sulfur, wt %	0.024	0.012	0.011	0.015	0.017	0.017	0.016	0.011		
Research Octane No.										
Motor Octane No.										

TABLE 13. PROPERTIES OF GASOLINE SAMPLES FROM COMPANY I

Grade Designation Low-Lead

Source of Sample	S.F. Refinery	L.A. Refinery	San Diego	San Diego	Los Angeles	Los Angeles	San Francisco	San Francisco	Reno	Reno
AFLRL Code No.	4109	4110	4031	4036	4057	4059	4071	4077	4084	4088
Property										
Gravity, °API	54.3	58.2	54.4	55.3	56.9	57.2	59.0	56.2	54.8	56.1
Reid Vapor Pressure, lbs.	9.0	8.8	8.4	8.6	9.2	8.5	8.6	8.6	8.9	8.6
Distillation, °F										
IBP	91	92	93	91	86	90	92	95	93	95
10% evap.	126	128	135	133	126	131	125	125	128	127
20% evap.	149	152	164	162	154	158	144	146	152	149
50% evap.	228	217	230	228	221	220	207	216	224	219
90% evap.	342	350	340	336	336	333	336	326	338	334
EP	436	427	407	404	414	416	421	416	430	423
% Recovered	98.0	98.0	97.8	97.7	97.5	97.5	97.0	97.8	97.8	98.0
% Residue	1.2	1.0	1.1	1.0	1.1	1.1	1.1	1.2	1.2	1.0
% Loss	0.8	1.0	1.1	1.3	1.4	1.4	1.9	1.0	1.0	1.0
Temp. at V/L = 20, °F	142	141	146	144	139	143	139	144	142	142
Gum, mg/100 ml										
Unwashed	39.6	17.8	17.8	10.7	13.1	15.9	4.8	34.4	31.6	37.0
Washed	0	0	0.3	0.2	0.1	0.2	0.7	0.7	0.5	1.4
Aromatics, % (FIA)	39	25	31	31	28	28	29	33	37	34
Olefins, % (FIA)	4	6	2	1	3	4	4	5	5	5
Lead, g/gal	0.44	0.44	0.46	0.47	0.48	0.46	0.41	0.44	0.43	0.44
Phosphorus, g/gal	0.006	0.008	0	0.001	0	0.002	0	0	0	0
Sulfur, wt %	0.042	0.035	0.025	0.017	0.021	0.025	0.024	0.041	0.042	0.035
Research Octane No.	95.0	94.6								
Motor Octane No.	85.5	84.8								
Antiknock Quality, (R+M)/2	90.2	89.7								

TABLE 14. PROPERTIES OF GASOLINE SAMPLES FROM:

Source of Sample		Company M Low-Lead Richmond Refinery	Company M Low-Lead Ashland Refinery	Company M Low-Lead Buffalo		Company N Low-Lead Tulsa Refinery		Company O Low-Lead Detroit		
AFLRL Code No.	____	4139	4143	4307	____	4153	____	4308	____	____
Property										
Gravity, °API		59.4	59.7	61.2		59.6		63.0		
Reid Vapor Pressure, lbs.		12.4	10.7	13.6		13.2		12.4		
Distillation, °F										
IBP		89	91			81				
10% evap.		108	113			102				
20% evap.		126	133			123				
50% evap.		217	205			217				
90% evap.		366	354			338				
EP		427	426			413				
% Recovered		97.5	98.0			97.3				
% Residue		1.0	1.0			1.2				
% Loss		1.5	1.0			1.5				
Temp. at V/L = 20, °F		122	128			118				
Gum, mg/100 ml										
Unwashed		6.5	12.5	4.8		2.6		15.0		
Washed		1.9	0.4	0.6		0.8		0.4		
Aromatics, % (FIA)		29	28	27		31		26		
Olefins, % (FIA)		6	11	8		8		5		
Lead, g/gal		0.50	0.46	0.50		0.50		0.34		
Phosphorus, g/gal		0.009	0.008	0.007		0.002				
Sulfur, wt %		0.041	0.033			0.023				
Research Octane No.		91.4	91.7			94.4				
Motor Octane No.		83.8	83.0			85.0				
Antiknock Quality, (R+M)/2		87.6	87.4			89.7				

TABLE 15. GAS CHROMATOGRAPHIC ANALYSES

Unleaded Gasolines

Company	A	A	A	A	A	A	A
Grade	Premium	Premium	Premium	Premium	Lead-Free	Lead-Free	Lead-Free
Source	Tx Cty-Ref.	Houston	Houston	Atlanta	Tx Cty-Ref.	Whtg-Ref.	Atlanta
AFLRL Code No.	3894	4003	4004	4186	3895	4012	4187
Aromatics, v%							
Benzene	0.8	0.7	0.4	0.3	0.4	1.2	0.5
Toluene	15.9	20.0	15.5	24.4	2.7	5.0	4.4
Ethyl Benzene	2.9	1.6	1.9	1.7	1.9	1.6	1.5
M & P-Xylene	10.8	5.9	7.0	6.5	7.8	4.8	6.3
O-Xylene	3.6	2.8	3.2	3.0	2.9	1.9	2.7
C_6 through C_8 Arom.	34.0	31.0	28.0	35.9	15.7	14.5	19.9
C_9+ Aromatics	12.4	16.9	16.4	14.3	17.4	12.0	13.0
Total Aromatics	46.4	47.9	44.4	50.2	33.1	26.5	32.9
Aromatics by FIA, v%	46	44	41	51	33	28	33
Boiling-Point Distribution							
Below 100°F, wt %	16	16	17	22	17	19	18
20 wt % off, °F	145	152	127	82	127	102	126
30 wt % off, °F	201	197	192	190	145	154	148
50 wt % off, °F	247	237	237	241	214	234	236
70 wt % off, °F	295	283	283	285	295	284	289
90 wt % off, °F	341	336	336	341	348	347	350
98 wt % off, °F	392	397	387	395	399	413	399
99 wt % off, °F	407	411	406	414	415	437	413
100 wt % off, °F	482	595	591	483	465	547	483
Light ends Composition							
Isobutane, wt %	0	0.5	0.5	2	0	0	1
N-butane, wt %	5.0	4.5	5.5	2	3	6	4
Isopentane, wt %	9.0	9.0	9.0	16	5	6	5
N-pentane, wt %	1.0	1.0	1.0	1.5	7	4	5

TABLE 15. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Unleaded Gasolines

Company	A	A	A	B	B	B	B
Grade	Lead-Free	Lead-Free	Lead-Free*	Clear	Clear	Clear	Lead-Free
Source	Detroit	Minneapolis	Billings	Houston	Houston	San Diego	Phil. Ref.
AFLRL Code No.	4314	4312	4334	3996	3998	4037	4146
Aromatics, v%							
Benzene	1.1	0.8	0.7	0.6	0.9	0.7	1.3
Toluene	4.4	2.6	2.8	13.7	15.9	4.3	6.7
Ethyl Benzene	1.5	0.6	0.7	1.1	1.0	1.3	1.9
M & P-Xylene	4.3	2.0	2.6	2.8	2.2	5.4	8.5
O-Xylene	1.7	0.7	0.9	1.3	1.1	1.9	2.9
C_6 through C_8 Arom.	13.0	6.7	7.7	19.5	21.1	13.6	21.3
C_9+ Aromatics	8.8	1.7	6.6	18.6	18.2	13.1	16.5
Total Aromatics	21.8	8.4	14.3	38.1	39.3	26.7	37.8
Aromatics by FIA, v%	22	10	15	32	34	28	34
Boiling-Point Distribution							
Below 100°F, wt %	21	23	14	23	21	17	20
20 wt % off, °F	90	89	139	92	86	130	99
30 wt % off, °F	151	132	167	158	188	154	150
50 wt % off, °F	218	195	227	237	238	233	237
70 wt % off, °F	281	243	285	278	284	285	287
90 wt % off, °F	338	313	354	345	351	345	350
98 wt % off, °F	394	373	424	401	398	407	429
99 wt % off, °F	416	403	450	431	417	427	467
100 wt % off, °F	481	460	515	550	546	511	573
Light ends Composition							
Isobutane, wt %	trace	0.5	0	0.5	0.5	trace	1
N-butane, wt %	8	7.5	3	2.5	2.5	1	3
Isopentane, wt %	6	8	5	8.0	9.0	12	13
N-pentane, wt %	5	3	4	8.0	9.0	3	3

*Contains 1.0 g/gal lead

TABLE 15. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Unleaded Gasolines

Company	B	B	B	D	D	D	D
Grade	Lead-Free	Lead-Free	Lead-Free	Unleaded	Unleaded	Unleaded	Lead-Free
Source	Calif. Ref.	Ind. Ref.	Seattle	ElSgndo-Ref	Oklnd-Ref	Phoenix	Tallahassee
AFLRL Code No.	4148	4155	4316	3993	4014	4027	4194
Aromatics, v%							
Benzene	1.0	0.5	0.7	0.7	1.4	1.0	0.6
Toluene	6.3	3.6	5.3	4.8	6.5	4.8	7.3
Ethyl Benzene	2.0	1.0	1.5	1.1	2.5	1.6	0.8
M & P-Xylene	7.7	4.0	6.1	5.5	3.8	5.3	2.9
O-Xylene	2.7	1.6	2.3	2.4	1.5	1.9	1.0
C_6 through C_8 Arom.	19.7	10.7	15.9	14.5	15.7	14.6	12.6
C_9+ Aromatics	16.1	13.7	16.3	13.6	15.5	17.5	6.2
Total Aromatics	35.8	24.2	32.3	28.1	31.2	32.1	18.8
Aromatics by FIA, v%	35	26	32	26	30	29	20
Boiling-Point Distribution							
Below 100°F, wt %	20	21	14	15	16	10	16
20 wt % off, °F	96	90	139	130	133	170	129
30 wt % off, °F	170	150	192	161	157	195	163
50 wt % off, °F	240	219	240	239	222	243	207
70 wt % off, °F	289	287	297	285	282	300	239
90 wt % off, °F	357	373	366	339	349	384	330
98 wt % off, °F	445	457	418	399	435	458	425
99 wt % off, °F	497	485	440	414	460	492	449
100 wt % off, °F	587	566	470	548	549	566	476
Light ends Composition							
Isobutane, wt %	0.5	0.5	trace	0	0.5	<0.5	0.5
N-butane, wt %	3.5	6.0	3	1	1	2	1.5
Isopentane, wt %	13.0	6.5	7	8	7	5	8.5
N-pentane, wt %	3.0	5.0	4	6	6	2	2

TABLE 15. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Unleaded Gasolines

Company	D	C	C	C	C	C	C
Grade	Lead-Free	Unleaded	Unleaded	Unleaded	Unleaded	Lead-Free	Lead-Free
Source	Seattle	NewBrnfls	Houston	Houston	Phoenix	Tallahassee	Detroit
AFLRL Code No.	4315	3978	3997	4001	4025	4196	4305
Aromatics, v%							
Benzene	1.2	0.7	0.7	0.7	1.7	0.6	0.9
Toluene	7.6	6.6	7.3	7.1	8.0	3.2	7.4
Ethyl Benzene	1.6	2.7	2.4	2.6	1.4	1.1	1.8
M & P-Xylene	3.2	7.0	6.0	6.7	4.4	4.2	4.8
O-Xylene	1.4	2.9	2.6	2.8	1.7	1.5	7.9
C_6 through C_8 Arom.	15.0	19.9	19.0	19.9	17.2	10.6	16.8
C_9 Aromatics	14.3	14.9	15.1	15.3	9.2	14.4	10.0
Total Aromatics	29.3	34.8	34.1	35.2	26.4	25.0	26.8
Aromatics by FIA, v%	29	32	30	32	24	23	25
Boiling-Point Distribution							
Below 100°F, wt %	15	19	19	19	17	13	21
20 wt % off, °F	134	126	125	127	130	152	84
30 wt % off, °F	167	180	180	175	182	198	139
50 wt % off, °F	221	241	240	242	232	239	217
70 wt % off, °F	275	287	286	287	270	296	267
90 wt % off, °F	349	340	344	345	335	375	336
98 wt % off, °F	414	401	400	401	402	444	405
99 wt % off, °F	444	415	415	426	426	453	431
100 wt % off, °F	474	545	539	595	510	495	470
Light ends Composition							
Isobutane, wt%	trace	0	0	0	trace	0.5	trace
N-butane, wt %	1	2	2	3	2	3.5	6
Isopentane, wt %	9	12	12	11	9	6	12
N-pentane, wt %	4	5	4	5	5	3	3

TABLE 15. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Unleaded Gasolines

Company	C	C	E	E	K	K	L
Grade	Lead-Free	Lead-Free	Unleaded	Unleaded	Lead-Free	Lead-Free	Lead-Free
Source	Minneapolis	Seattle	San Diego	L.A.-Ref.	Detroit	Clev. Ref.	Detroit
AFLRL Code No.	4313	4319	4039	4137	4306	4151	4311
Aromatics, v%							
Benzene	0.8	1.1	1.6	1.0	0.8	0.7	0.3
Toluene	8.0	4.8	8.4	7.8	5.2	5.3	2.0
Ethyl Benzene	1.8	1.3	1.9	2.2	1.6	1.6	1.1
M & P-Xylene	5.0	5.6	8.5	10.5	6.8	6.9	4.2
O-Xylene	2.0	2.0	2.9	3.5	2.5	2.5	1.6
C_6 through C_8 Arom.	17.6	14.8	23.3	25.0	16.9	17.0	9.2
C_9+ Aromatics	10.5	13.0	12.6	13.3	16.2	15.5	14.8
Total Aromatics	28.1	27.8	35.9	38.3	33.1	32.5	24.0
Aromatics by FIA, v%	26	26	31	34	32	30	24
Boiling-Point Distribution							
Below 100°F, wt %	21	13	15	16	16	16	21
20 wt % off, °F	85	137	138	134	131	136	98
30 wt % off, °F	151	185	184	191	164	159	151
50 wt % off, °F	236	234	234	241	238	236	236
70 wt % off, °F	280	283	281	288	286	286	293
90 wt % off, °F	410	347	337	338	347	335	384
98 wt % off, °F	440	425	399	391	398	385	449
99 wt % off, °F	453	447	428	405	411	394	453
100 wt % off, °F	497	477	512	514	468	446	479
Light ends Composition							
Isobutane, wt %	0.5	0.5	-	<0.5	1	0.5	0.5
N-butane, wt %	7.5	3.5	4	5	2	1.5	6.5
Isopentane, wt %	11	5	8	10	10	9	6
N-pentane, wt %	2	4	3	1	2	4	3

TABLE 15. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Unleaded Gasolines

Company	J	M
Grade	Lead-Free	Lead-Free
Source	Mobile	Toledo-Ref
AFLRL Code No.	4204	4123
Aromatics, v%		
Benzene	0.5	1.2
Toluene	4.5	5.8
Ethyl Benzene	0.4	1.2
M & P-Xylene	1.8	5.0
O-Xylene	0.6	1.7
C_6 through C_8 Arom.	7.8	14.9
C_9+ Aromatics	7.0	11.6
Total Aromatics	14.8	26.5
Aromatics by FIA, v%	13	26
Boiling-Point Distribution		
Below 100°F, wt %	18	20
20 wt % off, °F	129	94
30 wt % off, °F	162	157
50 wt % off, °F	202	234
70 wt % off, °F	238	284
90 wt % off, °F	347	346
98 wt % off, °F	429	406
99 wt % off, °F	453	425
100 wt % off, °F	481	487
Light ends Composition		
Isobutane, wt %	trace	1
N-butane, wt %	5	7
Isopentane, wt %	8	8
N-pentane, wt %	1	4

TABLE 16. GAS CHROMATOGRAPHIC ANALYSES

Low-Lead Gasolines

Company	D	D	D	G	G	G	G
Grade	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead
Source	ElSgndo-Ref	Oklnd-Ref	San Diego	Houston	Houston	Baytown-Ref	Atlanta
AFLRL Code No.	3992	4013	4030	4002	4006	4114	4190
Aromatics, v%							
Benzene	0.7	1.2	0.7	0.7	0.7	0.6	1.4
Toluene	6.0	5.5	6.0	9.7	8.3	2.2	12.3
Ethyl Benzene	1.4	2.8	1.4	2.6	2.6	1.2	1.5
M & P-Xylene	6.8	4.0	6.8	5.5	5.8	3.5	5.9
O-Xylene	2.4	1.6	2.4	2.1	2.2	1.7	2.5
C_6 through C_8 Arom.	17.3	15.0	17.3	20.6	19.6	9.2	23.6
C_9+ Aromatics	14.9	12.0	15.1	12.8	14.8	11.9	9.9
Total Aromatics	23.2	27.0	32.4	33.4	34.4	21.1	33.5
Aromatics by FIA, v%	32	26	32	33	34	23	39
Boiling-Point Distribution							
Below 100°F, wt %	21	20	20	19	19	18	22
20 wt % off, °F	89	101	99	103	114	122	96
30 wt % off, °F	137	141	138	155	153	152	147
50 wt % off, °F	211	204	210	239	237	226	244
70 wt % off, °F	285	247	281	285	288	283	289
90 wt % off, °F	339	337	337	339	337	343	347
98 wt % off, °F	404	412	394	399	392	400	412
99 wt % off, °F	434	452	408	414	407	415	431
100 wt % off, °F	548	546	492	548	546	509	497
Light ends Composition							
Isobutane, wt %	0	0.5	< 0.5	0	0	0.5	0.5
N-butane, wt %	2	1.5	2	4	4	6.5	7.0
Isopentane, wt %	10	13.0	9	9	9	6	7.5
N-pentane, wt %	7	4.0	7	6	6	5	6.0

TABLE 16. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Low-Lead Gasolines

Company	E	E	E	E	E	E	I
Grade	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Reg-L/L
Source	L.A.-Ref	Bemnt-Ref	Houston	Houston	Phoenix	Atlanta	San Diego
AFLRL Code No.	4138	4107	3995	4007	4026	4192	4031
Aromatics, v%							
Benzene	0.7	0.7	0.9	0.8	0.7	0.6	0.9
Toluene	4.7	7.9	7.2	7.4	2.1	4.2	5.1
Ethyl Benzene	1.5	1.7	1.7	1.7	0.8	1.4	1.5
M & P-Xylene	7.0	6.3	6.2	6.2	2.7	5.8	6.4
O-Xylene	2.4	2.2	2.2	2.2	1.0	2.0	2.3
C_6 through C_8 Arom.	16.3	18.8	18.2	18.3	7.3	14.0	16.2
C_9+ Aromatics	20.1	11.3	13.1	13.4	9.8	11.1	16.5
Total Aromatics	36.4	30.1	31.3	31.7	17.1	25.1	32.7
Aromatics by FIA, v%	37	31	34	34	16	24	31
Boiling-Point Distribution							
Below 100°F, wt %	16	19	17	17	14	16	12
20 wt % off, °F	129	103	126	127	137	132	150
30 wt % off, °F	181	148	169	164	177	175	189
50 wt % off, °F	246	232	236	237	218	237	234
70 wt % off, °F	316	284	287	287	275	285	286
90 wt % off, °F	363	335	349	350	359	337	360
98 wt % off, °F	406	411	410	411	417	404	428
99 wt % off, °F	425	451	440	436	442	423	453
100 wt % off, °F	510	510	545	545	516	483	512
Light ends Composition							
Isobutane, wt %	<0.5	0.5	0	0	0	1	<0.5
N-butane, wt %	5	5	3.0	3.0	1	5	4
Isopentane, wt %	7	8	7.5	8.5	8	6.5	5
N-pentane, wt %	3	4	5.0	4.0	4	3	2

TABLE 16. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Low-Lead Gasolines

Company	I	I	F	F	F	F	F
Grade	Reg-L/L	Reg-L/L	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead
Source	L.A.-Ref	S.F.-Ref	Houston	Houston	San Diego	Mobile	Detroit
AFLRL Code No.	4110	4109	4000	4008	4035	4199	4309
Aromatics, v%							
Benzene	0.8	0.9	0.7	0.7	0.9	2.0	0.7
Toluene	3.5	6.9	4.9	4.9	3.9	8.3	3.9
Ethyl Benzene	1.1	1.9	1.3	1.2	1.0	1.5	1.0
M & P-Xylene	4.2	8.2	4.8	4.7	4.9	6.5	4.5
O-Xylene	1.6	3.0	1.6	1.6	1.8	2.3	1.6
C_6 through C_8 Arom.	11.2	20.9	13.3	13.1	12.5	20.6	11.7
C_9+ Aromatics	15.0	19.7	11.9	11.6	17.8	13.6	12.8
Total Aromatics	26.2	40.6	25.2	24.7	30.3	34.2	24.5
Aromatics by FIA, v%	25	39	25	24	30	30	24
Boiling-Point Distribution							
Below 100°F, wt %	13	16	19	19	19	21	30
20 wt % off, °F	140	130	125	111	127	89	97
30 wt % off, °F	173	171	151	156	151	149	151
50 wt % off, °F	222	237	226	225	226	237	221
70 wt % off, °F	285	289	286	285	292	285	284
90 wt % off, °F	369	358	353	353	366	341	362
98 wt % off, °F	454	441	420	414	449	404	431
99 wt % off, °F	471	456	449	439	469	432	457
100 wt % off, °F	562	510	594	548	542	474	479
Light ends Composition							
Isobutane, wt %	trace	0.5	0	0	0.5	trace	0.5
N-butane, wt %	4	2.5	3	3	2.5	7	8.5
Isopentane, wt %	6	6	11	11	8	9	6
N-pentane, wt %	1	6	4	4	6	4	4

TABLE 16. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Low-Lead Gasolines

Company	H	H	H	H	H	H	H
Grade	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead
Source	SanAntonio	Houston	Houston	LosAngeles	Beaumont	Detroit	Seattle
AFLRL Code No.	3977	3999	4005	4049	4225	4304	4318
Aromatics, v%							
Benzene	1.2	1.9	1.9	0.7	1.3	1.8	1.0
Toluene	25.0	9.6	9.3	3.9	5.2	6.7	4.4
Ethyl Benzene	1.0	3.2	3.1	0.9	2.6	1.6	0.8
M & P-Xylene	3.0	10.3	10.1	4.3	8.0	5.6	3.7
O-Xylene	1.4	3.8	3.7	1.5	2.8	2.0	1.3
C_6 through C_8 Arom.	31.6	28.8	28.1	11.3	19.9	17.7	11.2
C_9+ Aromatics	14.9	16.1	15.7	15.7	11.8	10.0	7.2
Total Aromatics	46.5	44.9	43.8	27.0	31.7	27.7	18.4
Aromatics by FIA, v%	45	42	42	27	26	28	18
Boiling-Point Distribution							
Below 100°F, wt %	16	16	16	14	20	19	20
20 wt % off, °F	133	133	132	134	94	127	95
30 wt % off, °F	202	181	185	175	164	155	143
50 wt % off, °F	242	242	240	236	231	221	202
70 wt % off, °F	278	287	286	288	284	279	240
90 wt % off, °F	350	345	344	381	331	335	332
98 wt % off, °F	411	411	415	440	399	396	396
99 wt % off, °F	446	446	449	450	422	417	418
100 wt % off, °F	545	550	594	499	487	491	479
Light ends Composition							
Isobutane, wt %	1	0.5	0.5	trace	1	0.5	trace
N-butane, wt %	3	2.5	2.5	3	4	5.5	6
Isopentane, wt %	7	9.0	8.0	6	10	8	9
N-pentane, wt %	5	4.0	4.5	4	4	4	3

TABLE 16. GAS CHROMATOGRAPHIC ANALYSES (Cont'd)

Low-Lead Gasolines

Company	M	M	M	N	O
Grade	Low-Lead	Low-Lead	Low-Lead	Low-Lead	Low-Lead
Source	Richmond-Ref	Ashland-Ref	Buffalo	Tulsa-Ref	Detroit
AFLRL Code No.	4139	4143	4307	4153	4308
Aromatics, v%					
Benzene	0.7	0.8	1.0	1.0	0.8
Toluene	2.8	2.5	3.8	5.5	4.6
Ethyl Benzene	1.0	0.8	1.1	1.5	1.2
M & P-Xylene	4.5	3.9	4.9	5.9	5.3
O-Xylene	1.6	1.5	1.8	2.2	1.9
C_6 through C_8 Arom.	10.6	9.5	12.6	16.1	13.8
C_9 Aromatics	18.8	16.5	14.6	15.3	12.7
Total Aromatics	29.4	26.0	27.2	31.4	26.5
Aromatics by FIA, v%	29	28	27	31	26
Boiling-Point Distribution					
Below 100°F, wt %	23	21	23	19	19
20 wt % off, °F	90	93	84	101	105
30 wt % off, °F	142	139	134	157	151
50 wt % off, °F	237	215	217	239	222
70 wt % off, °F	312	291	287	288	285
90 wt % off, °F	387	366	362	365	349
98 wt % off, °F	446	443	435	444	410
99 wt % off, °F	456	458	448	463	440
100 wt % off, °F	510	513	479	552	479
Light ends Composition					
Isobutane, wt %	< 0.5	0.5	1	trace	1
N-butane, wt %	7	3.5	6	9	7
Isopentane, wt %	7	10	9	8	7
N-pentane, wt %	8	5	5	3	3

REFERENCES

1. Motor Gasolines, Winter 1968-1969, U.S. Department of Interior, Bureau of Mines.

2. Motor Gasolines, Summer 1969, Ibid.

3. Motor Gasolines, Winter 1969-1970, Ibid.

4. Motor Gasolines, Summer 1970, Ibid.

5. Motor Gasolines, Winter 1970-1971, Ibid.

6. Motor Gasolines, Summer 1971, Ibid.

7. Road Octane Survey, Northeastern U.S. Gasolines, Summer 1969, E.I. duPont de Nemours & Co. (Inc.).

8. Road Octane Survey, North Central U.S. Gasolines, Summer 1969, Ibid.

9. Road Octane Survey, Southeastern U.S. Gasolines, Summer 1969, Ibid.

10. Road Octane Survey, Southwestern U.S. Gasolines, Summer 1969, Ibid.

11. Road Octane Survey, Western U.S. Gasolines, Sumer 1969, Ibid.

12. Road Octane Survey, Interim Survey of Unleaded and Low-Lead Gasolines, August 1970, Ibid.

13. Road Octane Survey, Winter 1970-1971, Ibid.

14. Road Octane Survey, Summer 1971, Ibid.

15. Ebersole, G.D., "Hydrocarbon Reactivities of Motor Fuel Evaporation Losses," SAE Paper 69089 Presented at SAE International Automotive Congress, Detroit, Michigan, January 13-17, 1969.

16. Jackson, M.W., and Everett, R.L., "Effect of Fuel Composition on Amount and Reactivity of Evaporative Emissions," SAE Paper 69008B, Ibid.

17. Dishart, K.T., and Harris, W.C., "The Effects of Gasoline Hydrocarbon Composition on Automotive Exhaust Emissions," Proc. Am. Petr. Inst., Div. Refin., *48*, pp. 612-642 (1968).

18. Stavinoha, L.L., and Newman, F.M., "The Isolation and Determination of Aromatics in Gasoline by Gas Chromatography," Presented at ACS National Meeting, Boston, Mass., April 1972 and published as Technical Report No. AD-739-540.

19. Who's Marketing Low-Lead and No-Lead Gasolines?, **National Petroleum News Factbook**, May 1971.

20. Federal Specification VV-G-001690 (Army-MR), Gasoline, Automotive Low-Leaded or Unleaded, July 9, 1971.