

# Analysis of Fuel Additives and Impurities in Gasoline

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## INTRODUCTION

Gasoline is simply a mixture of aliphatic (carbon and hydrogen only) carbon chains. There are usually seven to 11 carbon atoms in each chain. The most common chain is octane, which are eight carbons long. Octane can handle compression very well, which is a necessary component for fuel.

The octane rating for gasoline is simply the percent or percent equivalent of the chemical octane in the gasoline. The octane rating is determined by using a variable compression engine. The octane rating is determined when the gasoline ignites by compression, instead of by ignition via the spark plug (Brain, 2). When gasoline ignites by compression, it also causes the engine to knock.

## ABSTRACT

**Federal laws and regulations regulate gasoline composition in order to prevent pollution and health hazards. The chemical composition and select physical characteristics of different gasoline samples were analyzed in this work. 87 and 91 octanes were collected from three different gasoline stations in Bemidji, Minnesota. The PetroSpec GS-1000 gasoline analyzer was used to determine various characteristics of the samples. The Precision Scientific RVP 100 determines the Reid Vapor Pressure of the gasoline, and was used with the PetroSpec to determine the quality of the samples from the various gas stations. The results were compared to the Federal laws and regulations to see if the gasoline is within the specified mandates, and to determine its overall quality.**

Three separate hypothesis tests were carried out. The first test involves the 87 octane gasoline. The average octane ratings should equal each other, as well as equal or

exceed the octane rating posted on the pump. The number on the pump is supposed to be the minimum octane rating. The average of the sample vapor pressures should equal the average vapor pressures of the other two 87 octane samples. The distillation graphs should show similar flow rates and graphs because of the similar characteristics of the samples.

Similar to the 87 octane gasoline, the average 91 octane readings should equal each other as well as the pump value. The vapor pressure and distillation graphs should correlate between the different samples.

The 87 and 91 octanes should comply with the federal standards for oxygen content, benzene content, and aromatic content as stated in the Clean Air Act of 1990 (Appendix). The numbers in the clean air act are a minimum of two percent by weight oxygen content, a maximum of one percent by volume for benzene, and a maximum of 25 percent by volume for aromatics.

## **Experimental Section**

**Sample Collection.** The samples were collected from three different gasoline stations in Bemidji, Minnesota. Each one of the gasoline stations was a different brand of gasoline. Six one-gallon gasoline cans were marked with the gasoline station and octane number. This allowed the gasoline to be collected into the same containers for the duration of the experiment, thus reducing the risk of contamination via other sample impurities.

When at the gasoline station, one-half gallon of gasoline was dispensed into the appropriate container. The container was then sealed, and the other octane was filled in

the same manner. This procedure was done until all six samples were collected. It usually took about one-half hour to collect all of the samples.

After collection, the samples were taken back to the fuel testing lab where they were put into a refrigerator. Refrigeration slows the decomposition of gasoline, keeping the samples stable for a longer period of time. The refrigeration was also done to equilibrate all six samples after they were collected.

**Reid Vapor Pressure Test.** Figure 1 represents a diagram of the Precision Scientific RVP 100 instrument, which was used to determine the Reid Vapor Pressure of the samples. This test was done first because the gasoline needs to be fresh, and below 40°F for this test. The gasoline is poured into the stainless steel container until the container is filled. The gasoline should arc above the top of the container. The air chamber is screwed onto the container containing the liquid. The apparatus is put into the 100°F water bath of the vapor testing machine. The hose on the air chamber is connected to one of the four ports on the machine, and pressing the start button starts the test. The whole procedure is time dependant, and should be done within a few minutes. If not, the vapor pressure of the gasoline will change due to it warming up. Figure 2 represents the data obtained from the tests.

**Distillation Test.** Figure 3 represents a diagram of the Herzog MP 626 gasoline distillator that was used for this experiment. The test is started by pipetting 100 mL of the sample into a volumetric flask equipped with a sidearm. The flask is placed in the heating area of the machine, and the top is placed onto the flask. The safety clip is attached to the top of the flask. The correct information is entered into the computer, and the test is started. The computer controls the heating, measures the distillation rate, and

the percent recovered. The computer analyzes the data and generates a print out at the end of the experiment. Figure 4 represents a sample printout of a gasoline distillation test.

**Composition Test.** Figure 5 is a diagram of the PetroSpec GS-1000 gasoline analyzer that was used to determine the chemicals in the gasoline sample. A 15 mL portion of gasoline was pipetted into a clean, dry glass vial. The vial is screwed onto the instrument arm, and different values regarding the sample are entered into the machine. The machine draws up 5 mL of the sample, and analyzes the sample. The results are sent to a printer and printed. Figure 6 represents a summary of the results for each sample from the composition test

## **RESULTS AND DISCUSSION**

**Percent Oxygen.** The percent oxygen values were fairly consistent with a mean value of 2.847, and a standard deviation of 1.229 (see figure 7). Figure 8 represents a boxplot of the percent oxygen values. The interesting information is the three outliers, which are samples C1, C2, and C3. These samples are significantly different from all of the other samples, and are below the 2 percent by weight oxygen requirement in the Clean Air Act Laws. Minnesota has an oxygen mandate of a minimum of 2.7 percent by volume (Brown, 5). The explanation for this is that this sample did not contain any ethanol. Ethanol,  $\text{CH}_3\text{CH}_2\text{OH}$ , is an oxygenate which increases the percent oxygen in the gasoline. Some gasoline, if properly designated, can be ethanol free. This ethanol free gasoline is used in antique cars, small engines, boat motors, and some motorcycles for better performance. There is supposed to be a sticker on the pump stating the gasoline

should only be used for antique cars, small engines, boat motors, and some motorcycles. This pump did not have any sticker stating that it was a special gasoline on it.

**Percent Benzene.** The percent benzene values were spread distributed over a fairly wide range with a mean value of 0.9778, and a standard deviation of 0.3232. Figure 9 represents a boxplot of the percent benzene values. Many of the gasoline samples (B1, B3, D1, D2, D3, and F3) did not comply with the Clean Air Act maximum value of one percent by volume. The percent benzene is monitored because benzene is a proven carcinogen. Lower levels of benzene in gasoline reduce the risk and exposure of benzene to the person dispensing the gasoline.

**Percent Ethanol.** Figure 10 represents a boxplot of the percent ethanol distribution. The percent ethanol is analogous with the percent oxygen with C1, C2, and C3 being outliers from the rest of the data. Minnesota has a year-round 7.7 percent minimum ethanol mandate (Brown, 5). All of the samples, except for C1, C2, and C3, comply with the Minnesota mandate of 7.7 percent.

**Percent Olefins.** The percent olefins had a large distribution ranging from 8.0 to 23.3. Figure 11 represents a boxplot of the distribution. The mean value is 13.433, and the standard deviation is 4.143

**Percent Aromatics.** The percent aromatics ranged from 12.4 to 25.1. Figure 12 represents a boxplot of the aromatic distribution. Only one of the samples, D3, was above the maximum of 25 percent. D3 was only .1 above the maximum. The other two D samples were below and in compliance with the law. This suggests that the high value is not a constant happening, but more likely a random distribution in the gasoline.

**Percent Saturates.** Saturates are the rest of the gasoline that is not a specific chemical. The saturates are the aliphatic carbon chains, which are the main part of the gasoline. Figure 13 is a boxplot showing the variance among the percent of saturates in the samples. This figure shows the high amount of variance that each company has in their specific brand of gasoline compared to other brands.

**Percent Methyl Tertiary-Butyl Ether (MTBE).** MTBE is an oxygenate that was commonly used in lieu of ethanol. MTBE is currently being phased out of gasoline because it is a suspected carcinogen, and is water-soluble. It is appearing in ground water in new locations due to its use in gasoline. Figure 14 is a boxplot of the MTBE levels found in the samples. The MTBE levels are low, which is in accordance with the general trend of eliminating it from gasoline.

**Experimental Octane.** The experimental octane values in figure 6 represent an extrapolated octane number calculated by the PetroSpec instrument. This number is not as accurate as the actual octane number because the actual octane number is tested on an engine to obtain the correct reading. All of the samples that were slightly below the octane number posted on the pump may in fact, be in compliance. The results obtained cannot be conclusive because of the manner in which the octane number is calculated.

**Reid Vapor Pressure (RVP).** The data from figure 2 was used in the RVP 87 and RVP boxplots. Figure 15 represents the RVP from the 87 octane samples, and figure 16 represents the RVP from the 91 octane samples. The Reid Vapor pressure for non-oxygenated gasoline is supposed to be 9psi, and 10psi for oxygenated gasoline. These values represent vapor pressures determined in the summer. In the winter, the vapor

pressures are increased to account for the colder weather. The increased vapor pressure allows the gasoline to combust at a normal temperature.

**Distillation.** The distillation graphs for all of the samples containing ethanol were similar in flow rate and appearance. Figure 17 represents a sample distillation graph of a sample containing ethanol. All of the graphs containing ethanol had an inflection point between 70°F and 80°F. The distillation rate also decreased at this time, but then increased after a short period. A plausible explanation for this is the distillation of ethanol. The ethanol slows down the distillation rate because it is reaching its boiling point of 79°F. Figure 18 represents a distillation graph from a sample containing no ethanol. The C samples were the only samples to contain little or no ethanol. The graph is smooth, and steadily increases in the middle portion. There is no inflection point. The distillation rate steadily increases to a high point when half of the sample has distilled, and then slowly decreases, as the remaining part of the sample is distilled.

## **CONCLUSIONS AND PERSPECTIVES**

The results have shown that different gasoline brands are composed of different percentages of chemicals. Sometimes, specific chemicals are in too high or too low of a concentration as mandated by state or federal laws. These chemicals pose a health threat to the consumer handling the gasoline. This establishes the need for ongoing testing and monitoring of the dangerous chemicals associated with gasoline.

The 87 octane samples were similar in composition, but had enough unique differences to make them distinguishable. The 91 octane samples showed a higher degree in variance.



Based on the testing, some gasoline samples are not complying with the Federal Clean Air Act mandates regarding percentage composition. Further testing is recommended to see if this is a periodic or consistent event. If this is a consistent event, government testing should be done, and appropriate action taken based on their results.

## Works Cited

Brain, Marshall. "How Gasoline Works." <[www.howstuffworks.com/gasoline.htm](http://www.howstuffworks.com/gasoline.htm)>

Brown, Ralph J. <<http://www.usd.edu/~rbrown/ETHANOL%SB1%SD.PAPER2.PDF>>.

"Federal Clean Air Act of 1990." <<http://www.epa.gov/oar/caa/caa211.txt>>.

Figure 1

# Precision RVP-100 Reid Vapor Pressure Apparatus

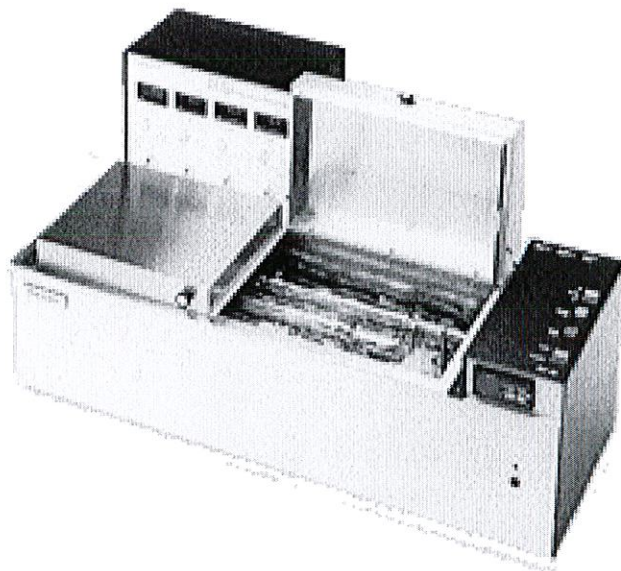


Figure 2

Vapor Pressure Results			
	A1	A2	A3
Vapor Pressure (psig)	15.03	14.89	13.84
	B1	B2	B3
Vapor Pressure (psig)	13.89	13.43	13.25
	C1	C2	C3
Vapor Pressure (psig)	11.80	10.10	9.03
	D1	D2	D3
Vapor Pressure (psig)	12.65	12.21	10.96
	E1	E2	E3
Vapor Pressure (psig)	12.43	13.69	12.76
	F1	F2	F3
Vapor Pressure (psig)	13.35	13.10	11.70

# Herzog MP-626 Gasoline Distillator

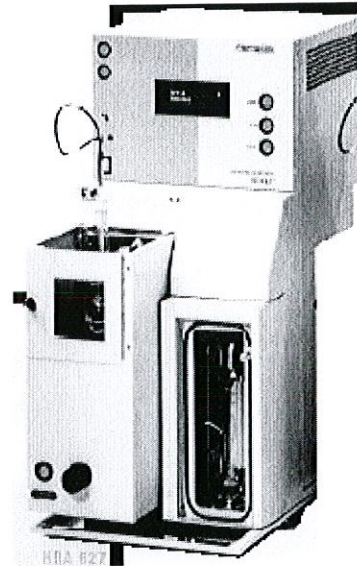


Figure 4

HERZOG MP 626

Version : 4.02

Unit no. : 1

01:41:AM 01.01.1988

Sample number : 38

Sample description : A1

Program number : DEANymcm.ex

Distill. Standard : D 86-123 - 1

Distill. Group : 1 Distill. Thermometer : 7C

Condenser Temperat. : 1 xC Initial Heat Temp.1: 240 xC

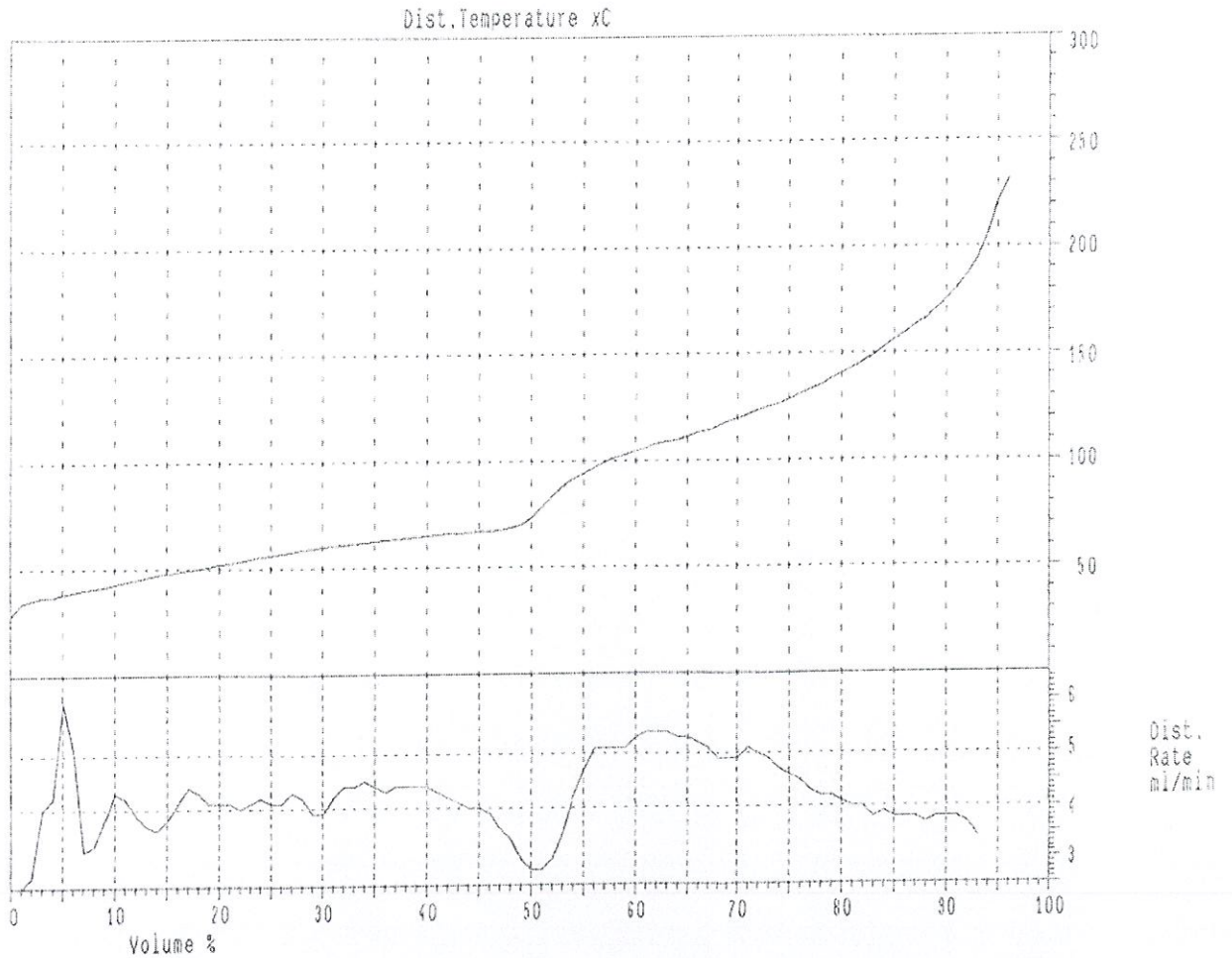
Receiver Temperat. : 16 xC Initial Heat Temp.2: 424 xC

Distillation Rate : 4.5 ml/min After Initial Heat : 3 min

FBP detect : 2 xC Final heat adjustment pt.: 93 %

Distillation Termin.: FBP Final heat adjustment by : 20 %

Follow the heat curve : OFF



Time to IBP : 271.9 sec

Figure 5

# PetroSpec GS-1000 Gasoline Analyzer



Figure 6

Petrospec Data Analysis									
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Experimental	Percent
Sample	Oxygen	Benzene	Ethanol	Olefins	Aromatics	Saturates	Octane	MTBE	
A1	3.71	0.96	9.9	14.5	18.9	56.3	90.2	0.3	
A2	3.62	0.94	9.6	15.8	19.1	55.1	90.2	0.4	
A3	3.62	0.97	9.7	15.4	19.0	55.7	90.0	0.2	
B1	3.58	1.04	9.7	10.3	22.9	57.0	88.0	0.0	
B2	3.70	0.94	9.8	12.0	22.0	55.7	87.5	0.3	
B3	3.67	1.38	9.8	10.0	23.9	56.0	87.9	0.3	
C1	0.69	0.52	1.7	23.3	14.3	60.4	90.8	0.3	
C2	0.08	0.44	0.0	19.0	12.6	67.9	91.8	0.0	
C3	0.07	0.45	0.0	18.8	12.4	68.4	91.5	0.0	
D1	3.58	1.11	9.7	10.3	22.6	57.4	86.7	0.0	
D2	3.63	1.28	9.7	9.4	24.0	56.6	87.5	0.3	
D3	3.58	1.63	9.7	8.0	25.1	57.3	87.0	0.0	
E1	2.92	0.86	7.9	14.9	19.0	58.1	90.5	0.0	
E2	3.00	0.84	7.9	15.6	19.0	57.0	90.6	0.2	
E3	2.96	0.84	7.9	14.2	18.4	59.3	90.6	0.2	
F1	2.85	0.95	7.7	10.6	23.2	58.5	87.5	0.0	
F2	2.96	0.98	7.9	11.2	22.8	57.9	87.6	0.2	
F3	3.03	1.47	8.1	8.5	25.0	58.1	87.2	0.2	



Figure 7

## Descriptive Statistics

Variable	N	Mean	Median	TrMean	STDev	SE Mean
RVP 87	9	12.727	13.100	12.727	0.942	0.314
RVP 91	9	12.619	12.760	12.619	2.048	0.683
Percent Oxygen	18	2.847	3.305	2.967	1.229	0.290
Percent Benzene	18	0.9778	0.9550	0.9706	0.3232	0.0762
Percent Ethanol	18	7.594	8.850	7.925	3.360	0.792
Percent Olefins	18	13.433	13.100	13.156	4.143	0.977
Percent Aromatics	18	20.233	20.550	20.419	3.993	0.941
Percent Saturates	18	58.483	57.350	58.075	3.760	0.886
Percent MTBE	18	0.1611	0.2000	0.1563	0.1420	0.0335
Variable	Minimum	Maximum	Q1	Q3		
RVP 87	10.960	13.890	11.955	13.390		
RVP 91	9.030	15.030	10.950	14.365		
Percent Oxygen	0.070	3.710	2.903	3.623		
Percent Benzene	0.4400	1.6300	0.8400	1.1525		
Percent Ethanol	0.000	9.900	7.850	9.700		
Percent Olefins	8.000	23.300	10.225	15.650		
Percent Aromatics	12.400	25.100	18.775	23.375		
Percent Saturates	55.100	68.400	56.225	58.700		
Percent MTBE	0.0000	0.4000	0.0000	0.3000		

Figure 8

# Percent Oxygen Number Summary

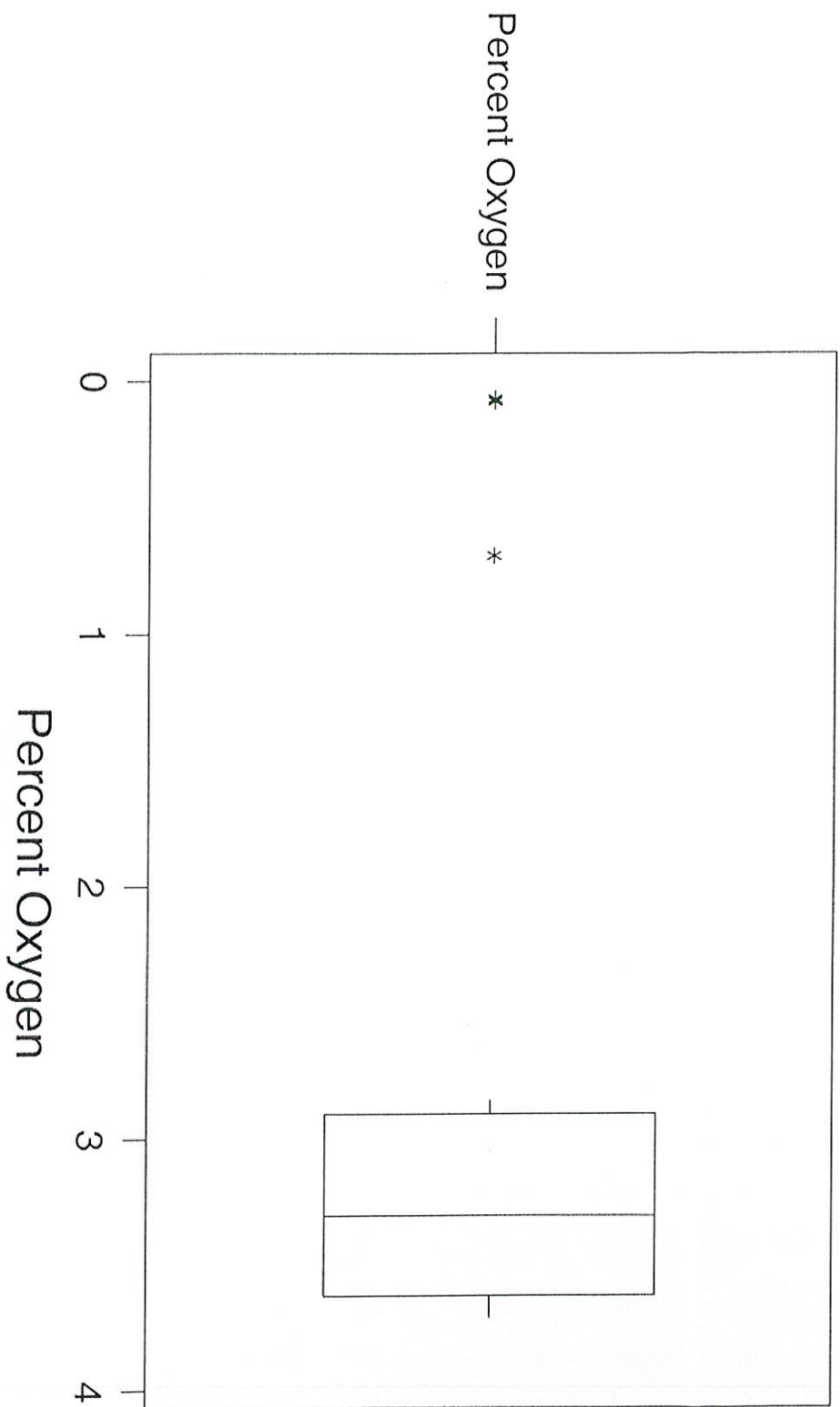


Figure 9

# Percent Benzene Number Summary

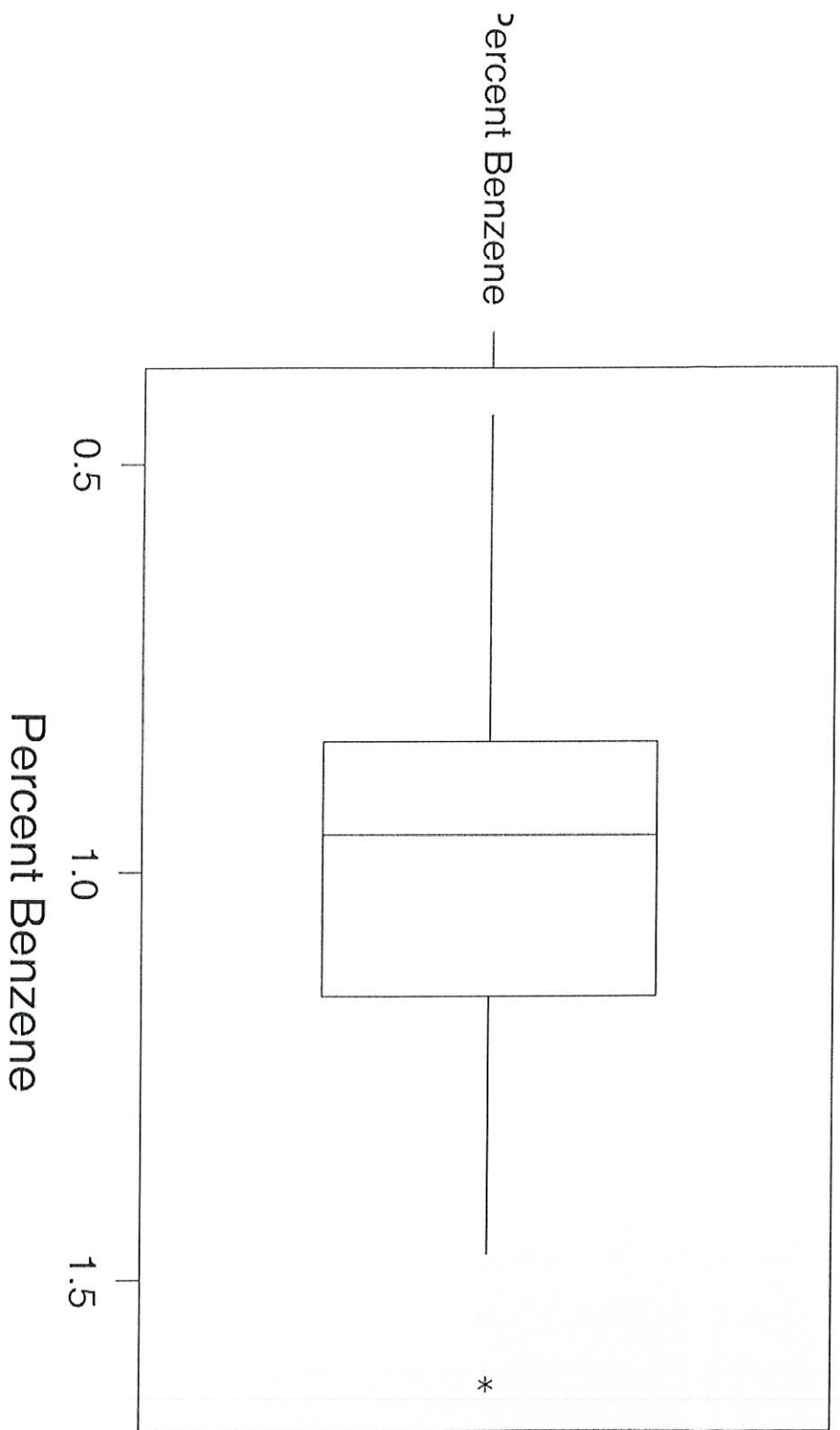


Figure 10

# Percent Ethanol Number Summary

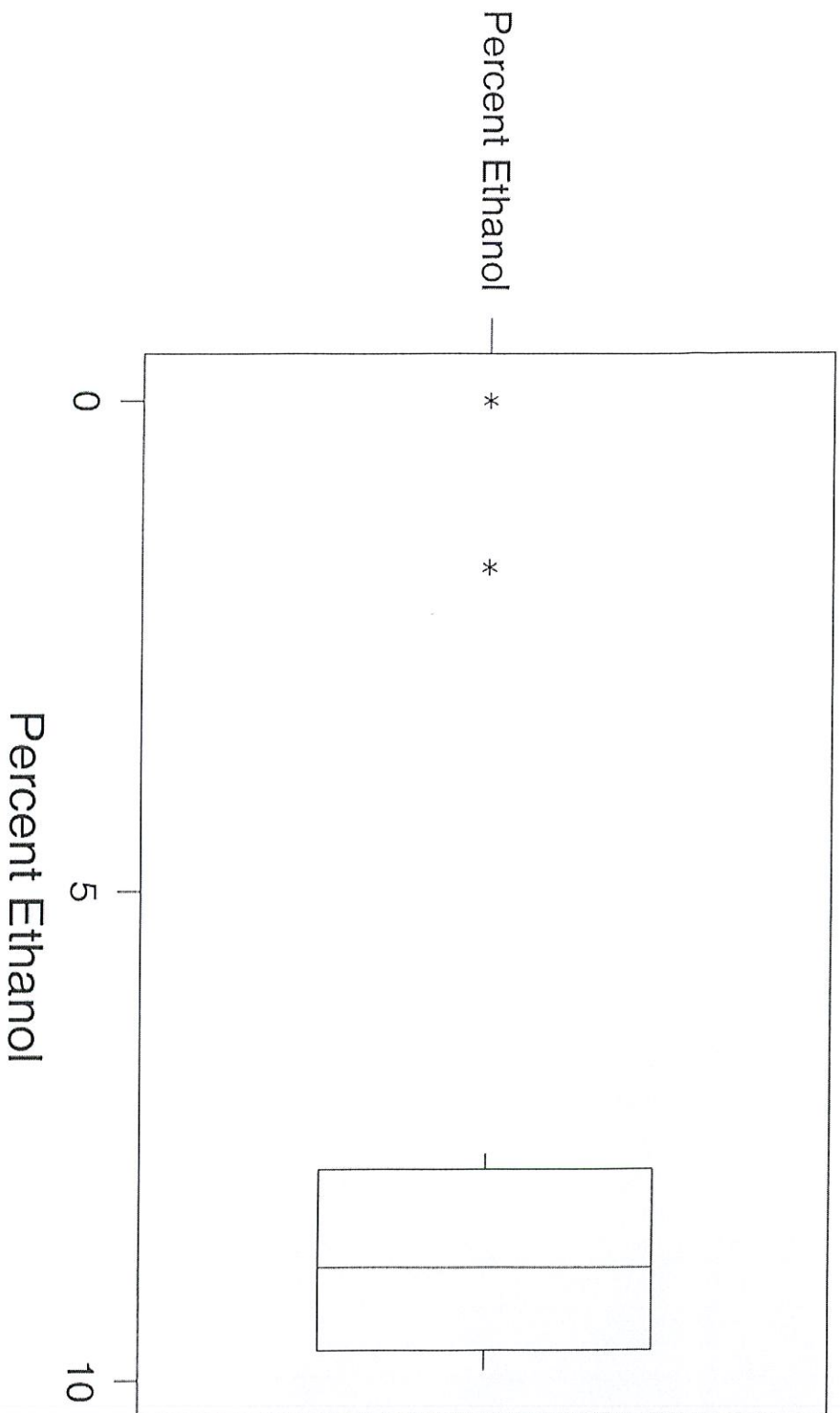


Figure 11

# Percent Olefins Number Summary

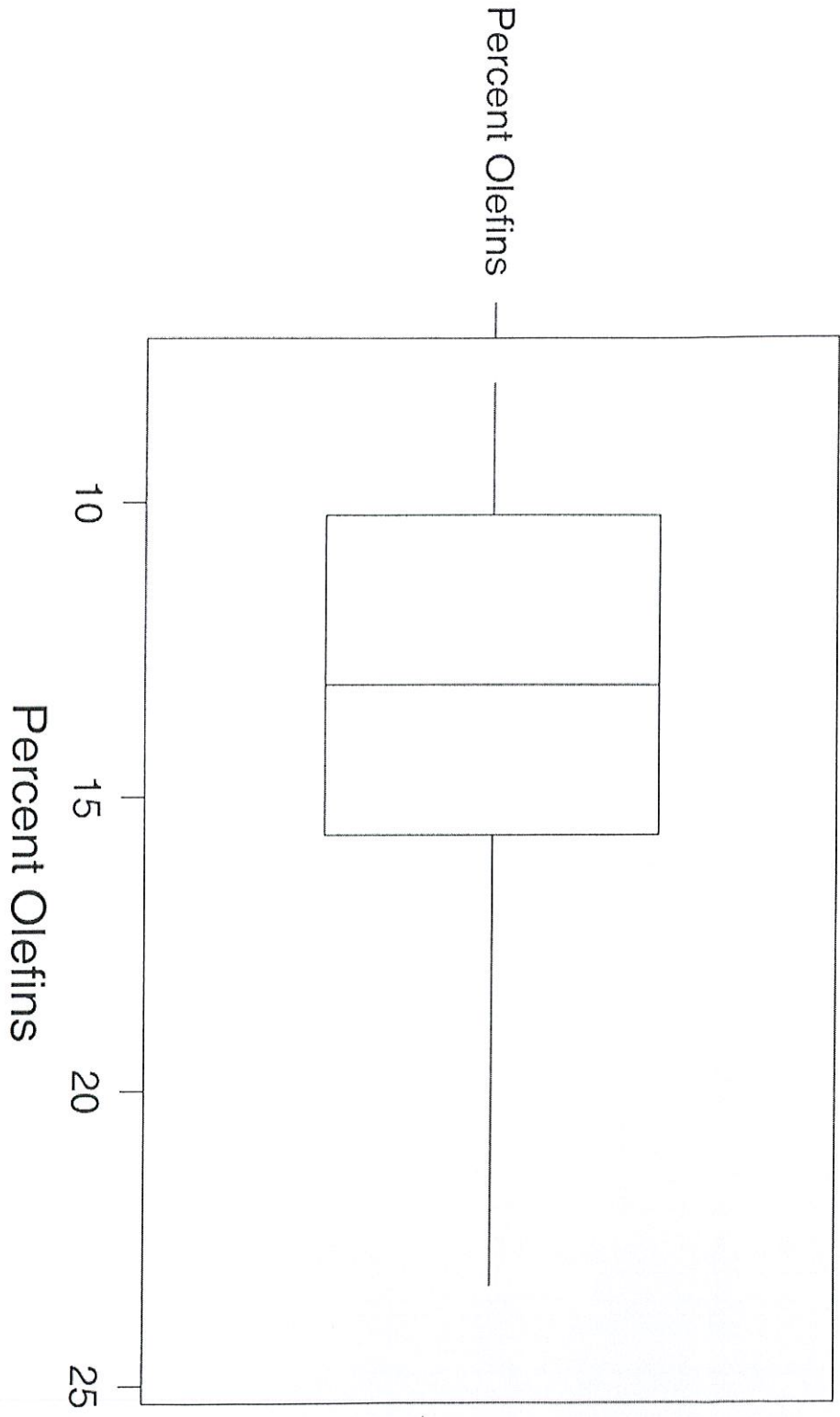


Figure 12

# Percent Aromatics Number Summary

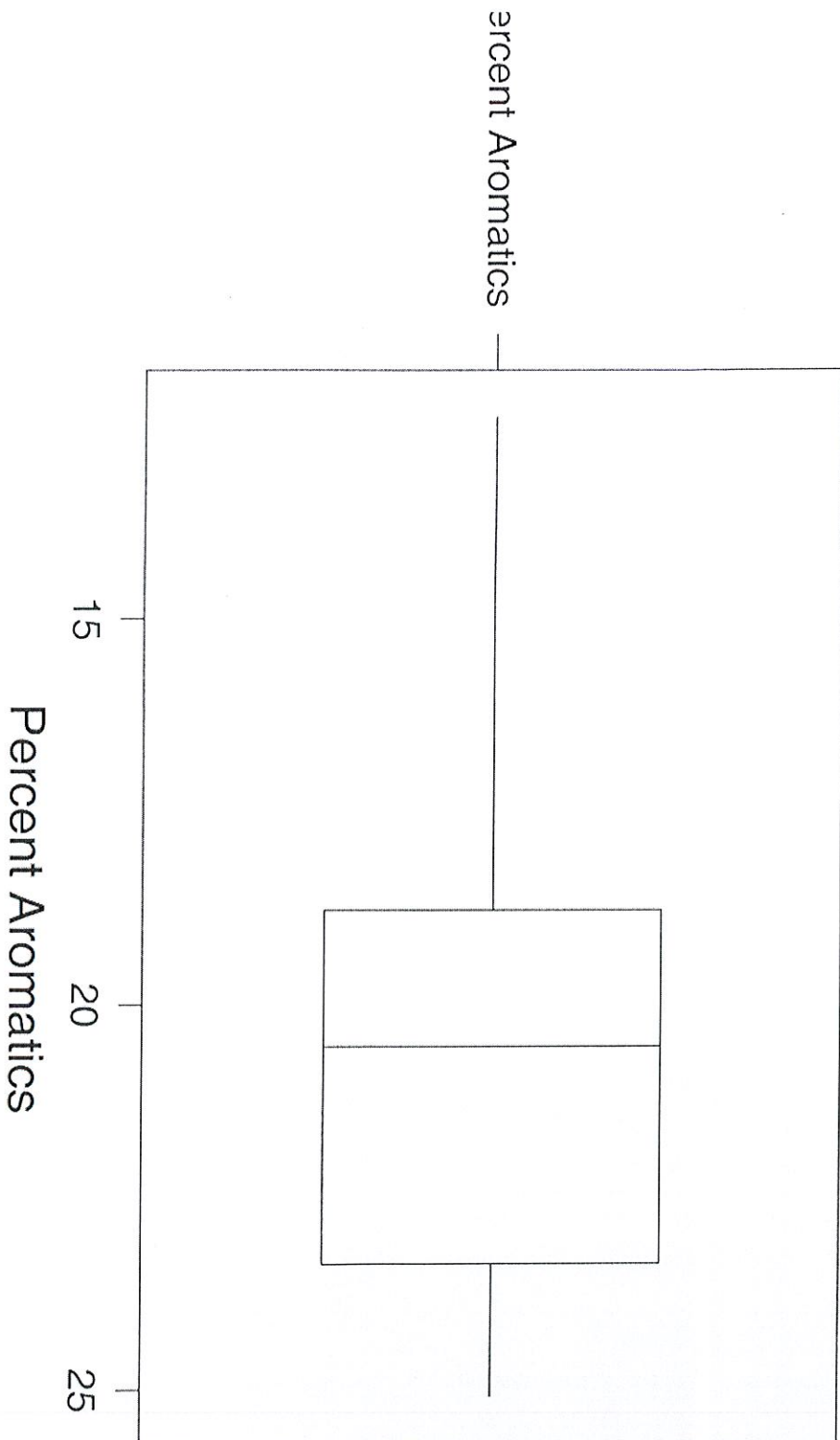


Figure 13

# Percent Saturates Number Summary

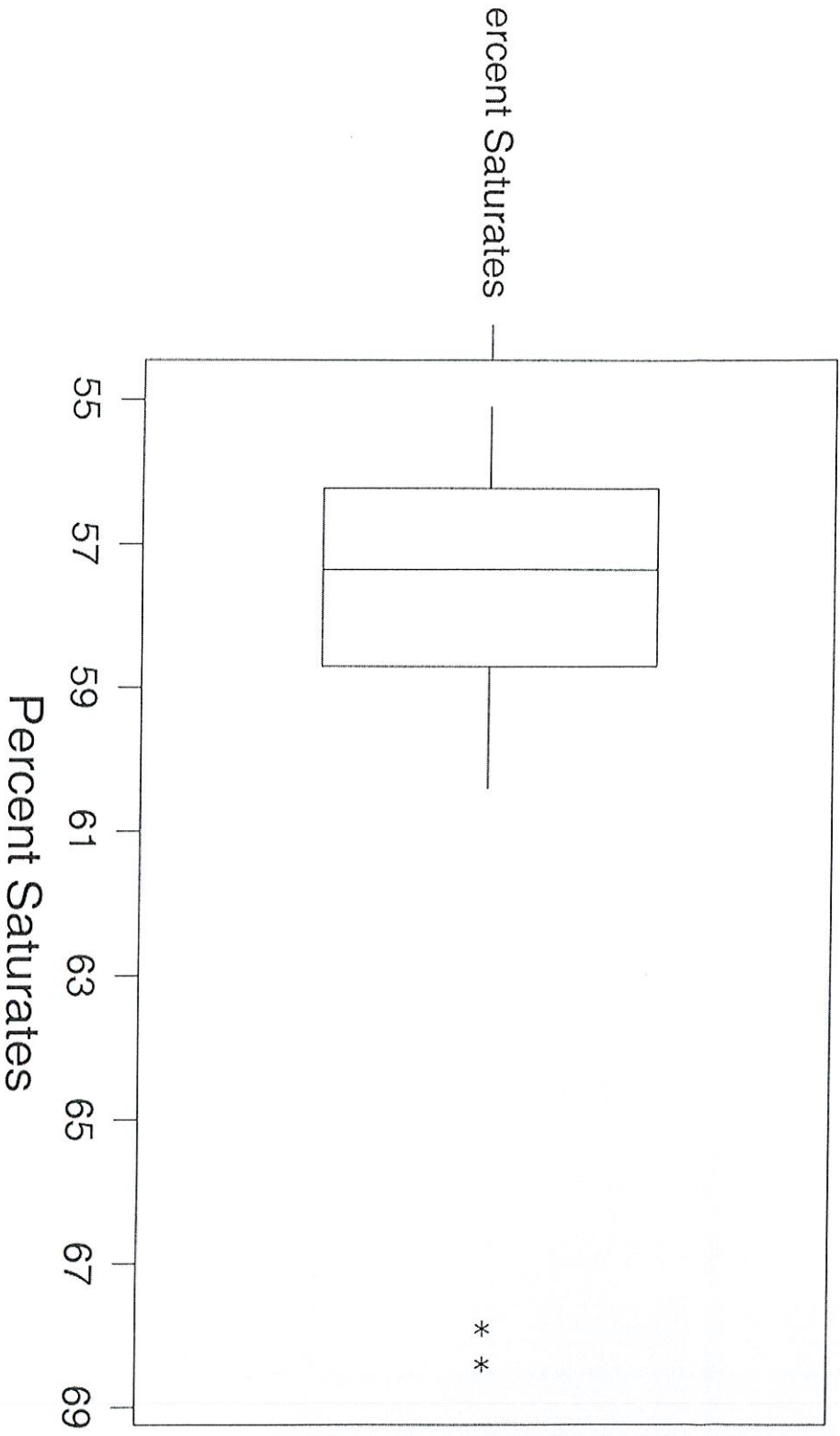


Figure 14

# Percent MTBE Number Summary

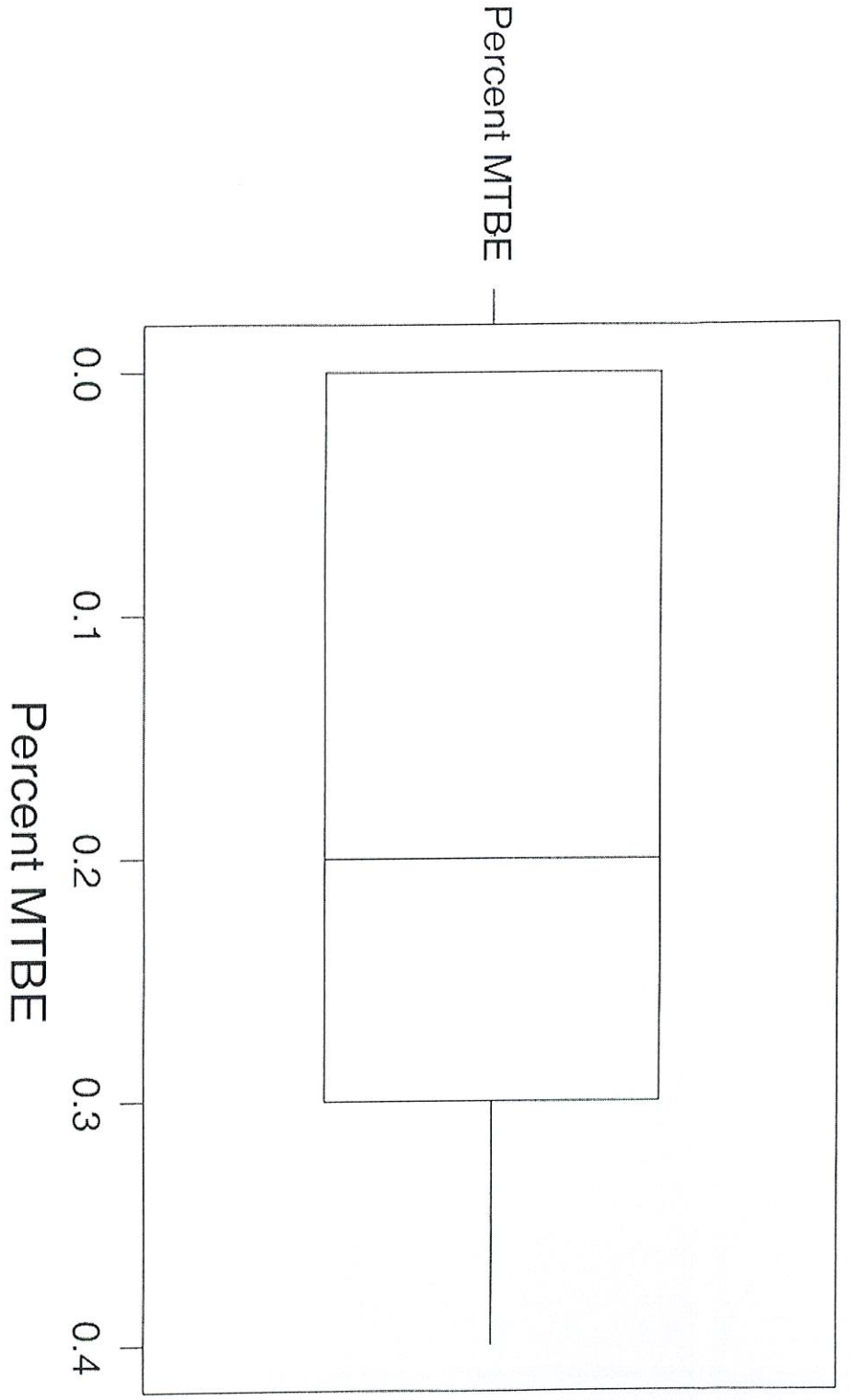




Figure 15

# RVP 87 Number Summary

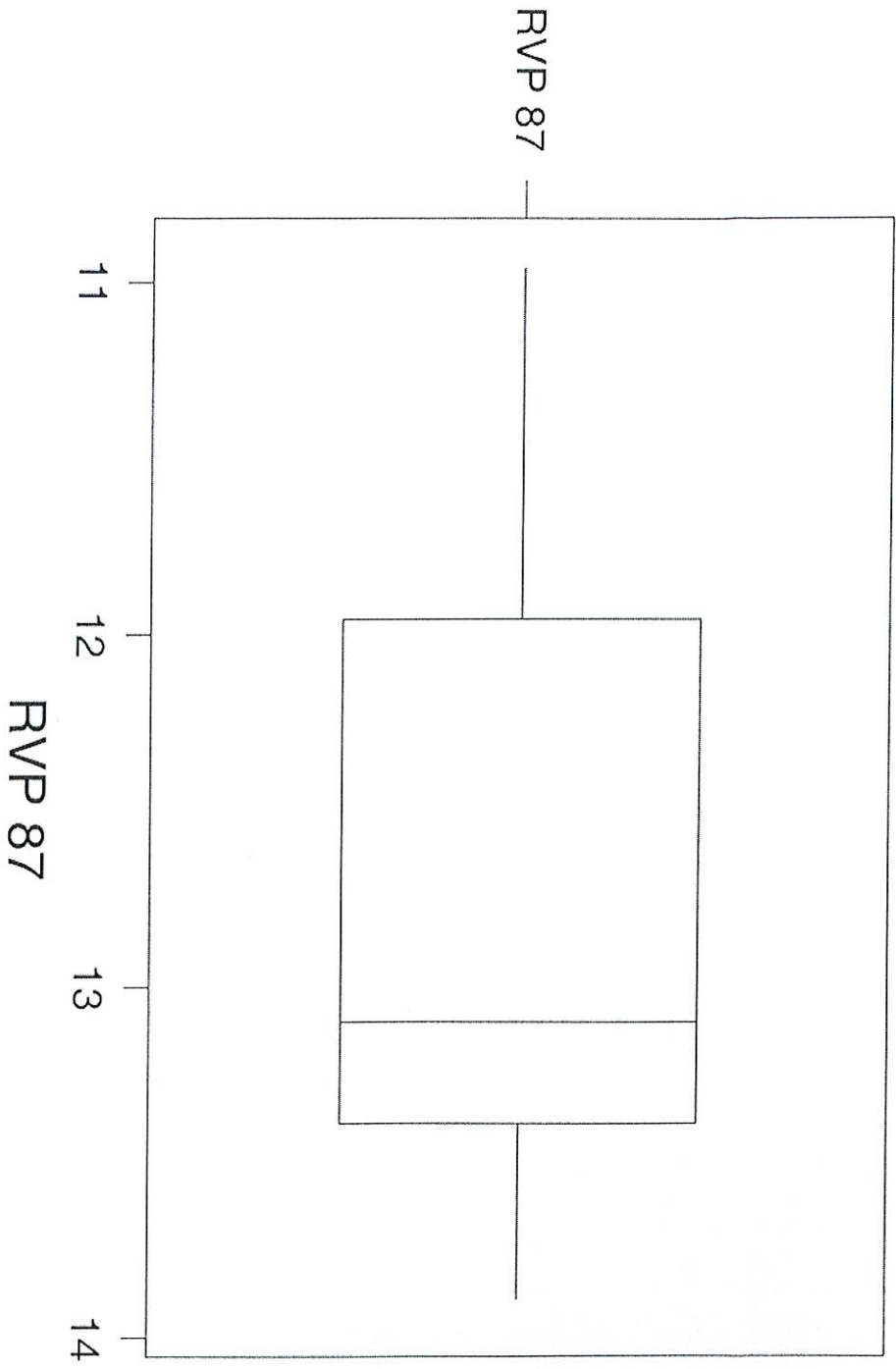


Figure 16

# RVP 91 Number Summary

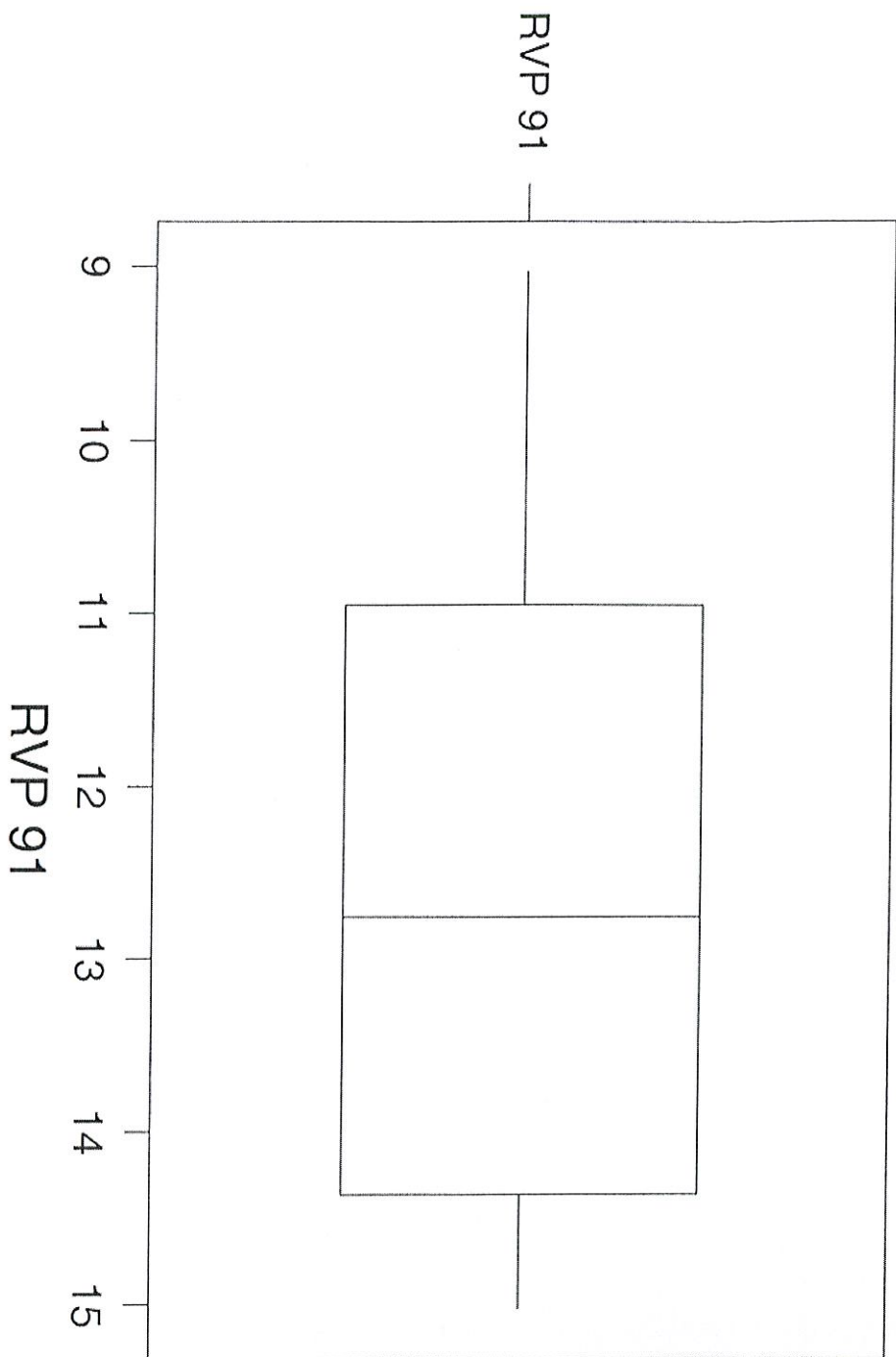


Figure 17

PRINTING MP 626

version : 4.02

Unit no. : 1

11:26:PM 01.10.1988

Sample number : 46

Sample description : B2

Program number : DEANrmon.exrmon.exe

Distill. Standard : D 86-123 - 1

Distill. Group : 1 Distill. Thermometer : 7C

Condenser Temperat. : 1 xC Initial Heat Temp.1: 240 xC

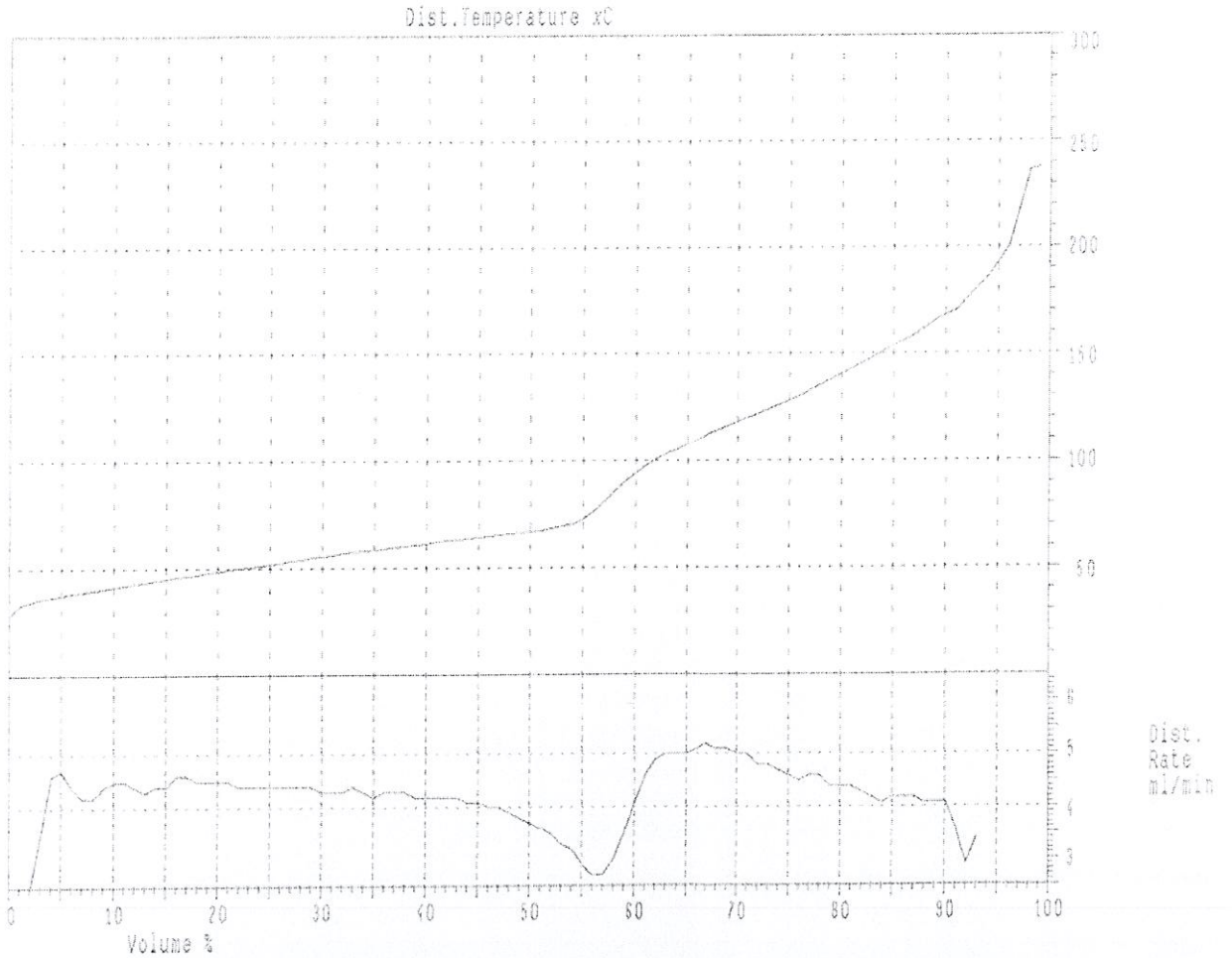
Receiver Temperat. : 16 xC Initial Heat Temp.2: 424 xC

Distillation Rate : 4.5 ml/min After Initia. Heat : 3 min

FBP detect : 2 xC Final heat adjustment pt.: 93 %

Distillation Termin.: FBP Final heat adjustment by : 20 %

Follow the heat curve : OFF



Time to IBP : 266.3 sec

Figure 18

DATE TIME: 01.17.1988

VERSION: 4.02

Unit no. : 1 00:54:AM 01.17.1988

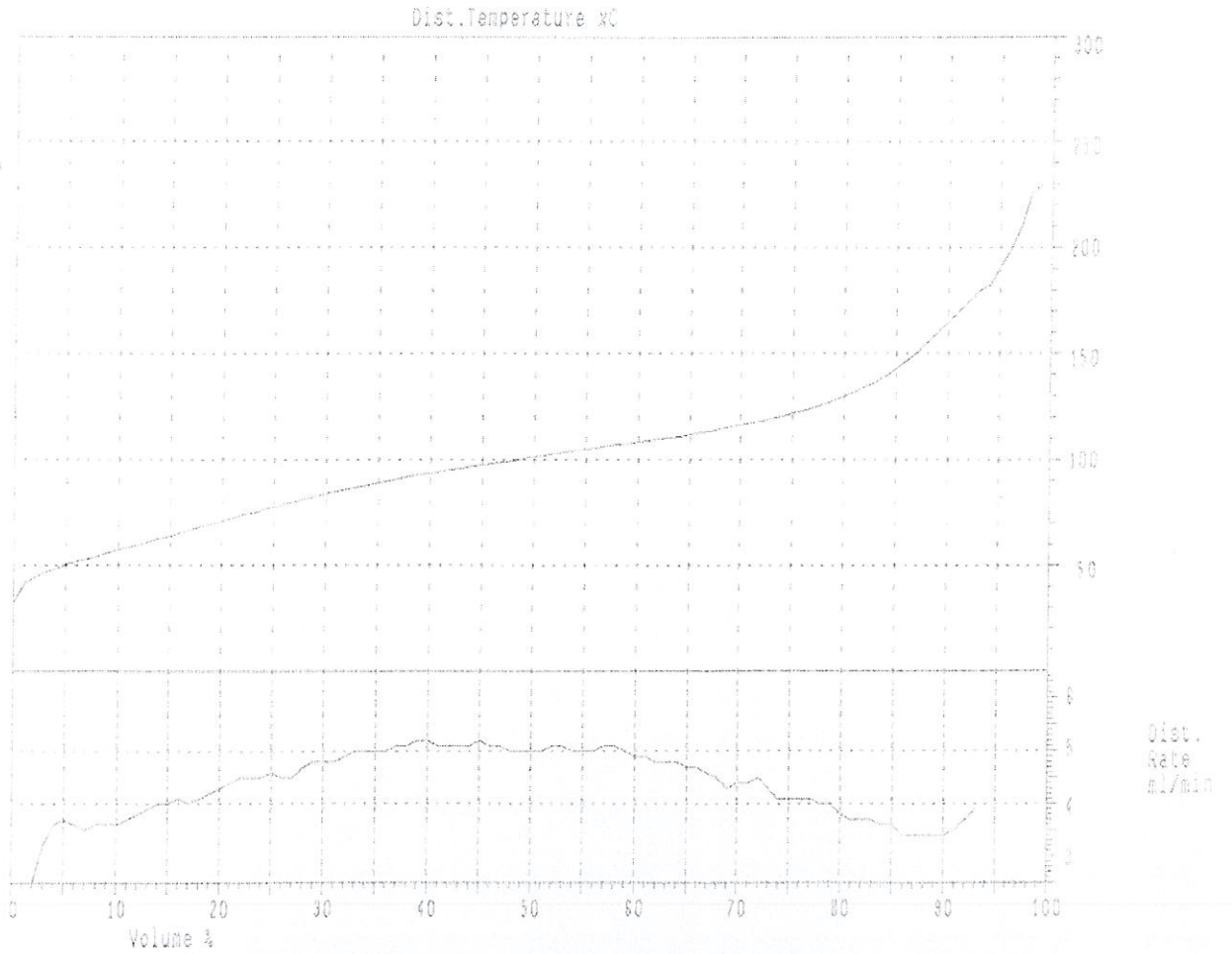
Sample number : 81  
 Sample description : C3

Program number : DEANracm.exracm.exe

Distill. Standard : D 86-123 - 1  
 Distill. Group : 1 Distill. Thermometer : 7C

Condenser Temperat. : 1 xC Initial Heat Temp.1: 240 xC  
 Receiver Temperat. : 16 xC Initial Heat Temp.2: 424 xC  
 Distillation Rate : 4.5 ml/min After Initial Heat : 3 min

FBP detect : 2 xC Final heat adjustment pt.: 93 %  
 Distillation Termin.: FBP Final heat adjustment by : 20 %  
 Follow the heat curve : OFF



Time to IBP : 348.4 sec

# Appendix

alternative aromatic level as prescribed by the Administrator under subsection (i)(2).

(h) Reid Vapor Pressure Requirements.-

(1) Prohibition.-Not later than 6 months after the date of the enactment of the Clean Air Act Amendments of 1990, the Administrator shall promulgate regulations making it unlawful for any person during the high ozone season (as defined by the Administrator) to sell, offer for sale, dispense, supply, offer for supply, transport, or introduce into commerce gasoline with a Reid Vapor Pressure in excess of 9.0 pounds per square inch (psi). Such regulations shall also establish more stringent Reid Vapor Pressure standards in a nonattainment area as the Administrator finds necessary to generally achieve comparable evaporative emissions (on a per-vehicle basis) in nonattainment areas, taking into consideration the enforceability of such standards, the need of an area for emission control, and economic factors.

(2) Attainment areas.-The regulations under this subsection shall not make it unlawful for any person to sell, offer for supply, transport, or introduce into commerce gasoline with a Reid Vapor Pressure of 9.0 pounds per square inch (psi) or lower in any area designated under section 107 as an attainment area. Notwithstanding the preceding sentence, the Administrator may impose a Reid vapor pressure requirement lower than 9.0 pounds per square inch (psi) in any area, formerly an ozone nonattainment area, which has been redesignated as an attainment area.

(3) Effective date; enforcement.-The regulations under this subsection shall provide that the requirements of this subsection shall take effect not later than the high ozone season for 1992, and shall include such provisions as the Administrator determines are necessary to implement and enforce the requirements of this subsection.

(4) Ethanol waiver.- For fuel blends containing gasoline and 10 percent denatured anhydrous ethanol, the Reid vapor pressure limitation under this subsection shall be one pound per square inch (psi) greater than the applicable Reid vapor pressure limitations established under paragraph (1); Provided, however, That a distributor, blender, marketer, reseller, carrier, retailer, or wholesale purchaser-consumer shall be deemed to be in full compliance with the provisions of this subsection and the regulations promulgated thereunder if it can demonstrate (by showing receipt of a certification or other evidence acceptable to the Administrator) that-

(A) the gasoline portion of the blend complies with the Reid vapor pressure limitations promulgated pursuant to this subsection;

(B) the ethanol portion of the blend does not exceed its waiver condition under subsection (f)(4); and

(C) no additional alcohol or other additive has been added to increase the Reid Vapor Pressure of the ethanol portion of the blend.

(5) Areas covered.-The provisions of this subsection shall apply only to the 48 contiguous States and the District of Columbia.

(i) Sulfur Content Requirements for Diesel Fuel.- (1) Effective October 1, 1993, no person shall manufacture, sell, supply, offer for sale or supply, dispense, transport, or introduce into commerce motor vehicle diesel fuel which contains a concentration of sulfur in excess of 0.05 percent (by weight) or which fails to meet a cetane index minimum of 40.

(2) Not later than 12 months after the date of the enactment of the Clean Air Act Amendments of 1990, the Administrator shall promulgate regulations to implement and enforce the requirements

of paragraph (1). The Administrator may require manufacturers and importers of diesel fuel not intended for use in motor vehicles to dye such fuel in a particular manner in order to segregate it from motor vehicle diesel fuel. The Administrator may establish an equivalent alternative aromatic level to the cetane index specification in paragraph (1).

(3) The sulfur content of fuel required to be used in the certification of 1991 through 1993 model year heavy-duty diesel vehicles and engines shall be 0.10 percent (by weight). The sulfur content and cetane index minimum of fuel required to be used in the certification of 1994 and later model year heavy-duty diesel vehicles and engines shall comply with the regulations promulgated under paragraph (2).

(4) The States of Alaska and Hawaii may be exempted from the requirements of this subsection in the same manner as provided in section 324. The Administrator shall take final action on any petition filed under section 324 or this paragraph for an exemption from the requirements of this subsection, within 12 months from the date of the petition.

(j) Lead Substitute Gasoline Additives.-(1) After the date of the enactment of the Clean Air Act Amendments of 1990, any person proposing to register any gasoline additive under subsection

(a) or to use any previously registered additive as a lead substitute may also elect to register the additive as a lead substitute gasoline additive for reducing valve seat wear by providing the Administrator with such relevant information regarding product identity and composition as the Administrator deems necessary for carrying out the responsibilities of paragraph (2) of this subsection (in addition to other information which may be required under subsection (b)).

(2) In addition to the other testing which may be required under subsection (b), in the case of the lead substitute gasoline additives referred to in paragraph (1), the Administrator shall develop and publish a test procedure to determine the additives' effectiveness in reducing valve seat wear and the additives' tendencies to produce engine deposits and other adverse side effects. The test procedures shall be developed in cooperation with the Secretary of Agriculture and with the input of additive manufacturers, engine and engine components manufacturers, and other interested persons. The Administrator shall enter into arrangements with an independent laboratory to conduct tests of each additive using the test procedures developed and published pursuant to this paragraph. The Administrator shall publish the results of the tests by company and additive name in the Federal Register along with, for comparison purposes, the results of applying the same test procedures to gasoline containing 0.1 gram of lead per gallon in lieu of the lead substitute gasoline additive. The Administrator shall not rank or otherwise rate the lead substitute additives. Test procedures shall be established within 1 year after the date of the enactment of the Clean Air Act Amendments of 1990. Additives shall be tested within 18 months of the date of the enactment of the Clean Air Act Amendments of 1990 or 6 months after the lead substitute additives are identified to the Administrator, whichever is later.

(3) The Administrator may impose a user fee to recover the costs of testing of any fuel additive referred to in this subsection. The fee shall be paid by the person proposing to register the fuel additive concerned. Such fee shall not exceed \$20,000 for a single fuel additive.

(4) There are authorized to be appropriated to the Administrator not more than \$1,000,000 for the second full fiscal year after the date of the enactment of the Clean Air Act Amendments of 1990 to establish test procedures and conduct engine tests as provided in this subsection. Not more than

\$500,000 per year is authorized to be appropriated for each of the 5 subsequent fiscal years.

(5) Any fees collected under this subsection shall be deposited in a special fund in the United States Treasury for licensing and other services which thereafter shall be available for appropriation, to remain available until expended, to carry out the Agency's activities for which the fees were collected.

(k) Reformulated Gasoline for Conventional Vehicles.-

(1) EPA regulations.-Within 1 year after the enactment of the Clean Air Act Amendments of 1990, the Administrator shall promulgate regulations under this section establishing requirements for reformulated gasoline to be used in gasoline-fueled vehicles in specified nonattainment areas. Such regulations shall require the greatest reduction in emissions

of ozone forming volatile organic compounds (during the high ozone season) and emissions of toxic air pollutants (during the entire year) achievable through the reformulation of conventional gasoline, taking into consideration the cost of achieving such emission reductions, any nonair-quality and other air-quality related health and environmental impacts and energy requirements.

2) General requirements.- The regulations referred to in paragraph (1) shall require that reformulated gasoline comply with paragraph (3) and with each of the following requirements (subject to paragraph (7)):

(A) NOx emissions.- The emissions of oxides of nitrogen (NOx) from baseline vehicles when using the reformulated gasoline shall be no greater than the level of such emissions from such vehicles when using baseline gasoline. If the Administrator determines that compliance with the limitation on emissions of oxides of nitrogen under the preceding sentence is technically infeasible, considering the other requirements applicable under this subsection to such gasoline, the Administrator may, as appropriate to ensure compliance with this subparagraph, adjust (or waive entirely), any other requirements of this paragraph (including the oxygen content requirement contained in subparagraph (B)) or any requirements applicable under paragraph (3)(A).

(B) Oxygen content.- The oxygen content of the gasoline shall equal or exceed 2.0 percent by weight (subject to a testing tolerance established by the Administrator) except as otherwise required by this Act. The Administrator may waive, in whole or in part, the application of this subparagraph for any ozone nonattainment area upon a determination by the Administrator that compliance with such requirement would prevent or interfere with the attainment by the area of a national primary ambient air quality standard.

(C) Benzene content.- The benzene content of the gasoline shall not exceed 1.0 percent by volume.

(D) Heavy metals.- The gasoline shall have no heavy metals, including lead or manganese. The Administrator may waive the prohibition contained in this subparagraph for a heavy metal (other than lead) if the Administrator determines that addition of the heavy metal to the gasoline will not increase, on an aggregate mass or cancer-risk basis, toxic air pollutant emissions from motor vehicles.

(3) More stringent of formula or performance standards.- The regulations referred to in paragraph (1) shall require compliance with the more stringent of either the requirements set forth in subparagraph (A) or the



requirements of subparagraph (B) of this paragraph. For purposes of determining the more stringent provision, clause (i) and clause (ii) of subparagraph (B) shall be considered independently.

(A) Formula.-

(i) Benzene.- The benzene content of the reformulated gasoline shall not exceed 1.0 percent by volume.

(ii) Aromatics.- The aromatic hydrocarbon content of the reformulated gasoline shall not exceed 25 percent by volume.

(iii) Lead.- The reformulated gasoline shall have no lead content.

(iv) Detergents.- The reformulated gasoline shall contain additives to prevent the accumulation of deposits in engines or vehicle fuel supply systems.

(v) Oxygen content.- The oxygen content of the reformulated gasoline shall equal or exceed 2.0 percent by weight (subject to a testing tolerance established by the Administrator) except as otherwise required by this Act.

(B) Performance standard.-

(i) VOC emissions.- During the high ozone season (as defined by the Administrator), the aggregate emissions of ozone forming volatile organic compounds from baseline vehicles when using the reformulated gasoline shall be 15 percent below the aggregate emissions of ozone forming volatile organic compounds from such vehicles when using baseline gasoline. Effective in calendar year 2000 and thereafter, 25 percent shall be substituted for 15 percent in applying this clause, except that the Administrator may adjust such 25 percent requirement to provide for a lesser or greater reduction based on technological feasibility, considering the cost of achieving such reductions in VOC emissions. No such adjustment shall provide for less than a 20 percent reduction below the aggregate emissions of such air pollutants from such vehicles when using baseline gasoline. The reductions required under this clause shall be on a mass basis.

(ii) Toxics.- During the entire year, the aggregate emissions of toxic air pollutants from baseline vehicles when using the reformulated gasoline shall be 15 percent below the aggregate emissions of toxic air pollutants from such vehicles when using baseline gasoline. Effective in calendar year 2000 and thereafter, 25 percent shall be substituted for 15 percent in applying this clause, except that the Administrator may adjust such 25 percent requirement to provide for a lesser or greater reduction based on technological feasibility, considering the cost of achieving such reductions in toxic air pollutants. No such adjustment shall provide for less than a 20 percent reduction below the aggregate emissions of such air pollutants from such vehicles when using baseline gasoline. The reductions required under this clause shall be on a mass basis.

Any reduction greater than a specific percentage reduction required under this subparagraph shall be treated as satisfying such percentage reduction requirement.

(4) Certification procedures.-

(A) Regulations.- The regulations under this subsection shall include procedures under which the Adminis-

trator shall certify reformulated gasoline as complying with the requirements established pursuant to this subsection. Under such regulations, the Administrator shall establish procedures for any person to petition the Administrator to certify a fuel formulation, or slate of fuel formulations. Such procedures shall further require that the Administrator shall approve or deny such petition within 180 days of receipt. If the Administrator fails to act within such 180-day period, the fuel shall be deemed certified until the Administrator completes action on the petition.

(B) Certification; equivalency.- The Administrator shall certify a fuel formulation or slate of fuel formulations as complying with this subsection if such fuel or fuels-

(i) comply with the requirements of paragraph (2), and

(ii) achieve equivalent or greater reductions in emissions of ozone forming volatile organic compounds and emissions of toxic air pollutants than are achieved by a reformulated gasoline meeting the applicable requirements of paragraph (3).

(C) EPA determination of emissions level.- Within 1 year after the enactment of the Clean Air Act Amendments of 1990, the Administrator shall determine the level of emissions of ozone forming volatile organic compounds and emissions of toxic air pollutants emitted by baseline vehicles when operating on baseline gasoline. For purposes of this subsection, within 1 year after the enactment of the Clean Air Act Amendments of 1990, the Administrator shall, by rule, determine appropriate measures of, and methodology for, ascertaining the emissions of air pollutants (including calculations, equipment, and testing tolerances).

(5) Prohibition.- Effective beginning January 1, 1995, each of the following shall be a violation of this subsection:

(A) The sale or dispensing by any person of conventional gasoline to ultimate consumers in any covered area.

(B) The sale or dispensing by any refiner, blender, importer, or marketer of conventional gasoline for resale in any covered area, without (i) segregating such gasoline from reformulated gasoline, and (ii) clearly marking such conventional gasoline as "conventional gasoline, not for sale to ultimate consumer in a covered area".

Any refiner, blender, importer or marketer who purchases property segregated and marked conventional gasoline, and thereafter labels, represents, or wholesales such gasoline as reformulated gasoline shall also be in violation of this subsection. The Administrator may impose sampling, testing, and recordkeeping requirements upon any refiner, blender, importer, or marketer to prevent violations of this section.

(6) Opt-in areas.- (A) Upon the application of the Governor of a State, the Administrator shall apply the prohibition set forth in paragraph (5) in any area in the State classified under subpart 2 of part D of title I as a Marginal, Moderate, Serious, or Severe Area (without regard to whether or not the 1980 population of the area exceeds 250,000). In any such case, the Administrator shall establish an effective date for such prohibition as he deems appropriate, not later than January 1, 1995, or 1 year after such application is received, whichever is later. The

Administrator shall publish such application in the Federal Register upon receipt.

(B) If the Administrator determines, on the Administrator's own motion or on petition of any person, after consultation with the Secretary of Energy, that there is insufficient domestic capacity to produce gasoline certified under this subsection, the Administrator shall, by rule, extend the effective date of such prohibition in Marginal, Moderate, Serious, or Severe Areas referred to in subparagraph (A) for one additional year, and may, by rule, renew such extension for 2 additional one-year periods. The Administrator shall act on any petition submitted under this paragraph within 6 months after receipt of the petition. The Administrator shall issue such extensions for areas with a lower ozone classification before issuing any such extension for areas with a higher classification.

(7) Credits.- (A) The regulations promulgated under this subsection shall provide for the granting of an appropriate amount of credits to a person who refines, blends, or imports and certifies a gasoline or slate of gasoline that-

(i) has an oxygen content (by weight) that exceeds the minimum oxygen content specified in paragraph (2);

(ii) has an aromatic hydrocarbon content (by volume) that is less than the maximum aromatic hydrocarbon content required to comply with paragraph (3); or

(iii) has a benzene content (by volume) that is less than the maximum benzene content specified in paragraph (2).

(B) The regulations described in subparagraph (A) shall also provide that a person who is granted credits may use such credits, or transfer all or a portion of such credits to another person for use within the same nonattainment area, for the purpose of complying with this subsection.

(C) The regulations promulgated under subparagraphs (A) and (B) shall ensure the enforcement of the requirements for the issuance, application, and transfer of the credits. Such regulations shall prohibit the granting or transfer of such credits for use with respect to any gasoline in a nonattainment area, to the extent the use of such credits would result in any of the following:

(i) An average gasoline aromatic hydrocarbon content (by volume) for the nonattainment (taking into account all gasoline sold for use in conventional gasoline-fueled vehicles in the nonattainment area) higher than the average fuel aromatic hydrocarbon content (by volume) that would occur in the absence of using any such credits.

(ii) An average gasoline oxygen content (by weight) for the nonattainment area (taking into account all gasoline sold for use in conventional gasoline-fueled vehicles in the nonattainment area) lower than the average gasoline oxygen content (by weight) that would occur in the absence of using any such credits.

(iii) An average benzene content (by volume) for the nonattainment area (taking into account all gasoline sold for use in conventional gasoline-fueled vehicles in the nonattainment area) higher than the average benzene content (by volume) that would occur in the absence of using any such credits.

(8) Anti-dumping rules.-

(A) In general.- Within 1 year after the enactment of the Clean Air Act Amendments of 1990, the Administrator shall promulgate regulations applicable to each refiner, blender, or importer of gasoline ensuring that gasoline sold or introduced into commerce by such

refiner, blender, or importer (other than reformulated gasoline subject to the requirements of paragraph (1)) does not result in average per gallon emissions (measured on a mass basis) of (i) volatile organic compounds, (ii) oxides of nitrogen, (iii) carbon monoxide, and (iv) toxic air pollutants in excess of such emissions of such pollutants attributable to gasoline sold or introduced into commerce in calendar year 1990 by that refiner, blender, or importer. Such regulations shall take effect beginning January 1, 1995.

(B) Adjustments.- In evaluating compliance with the requirements of subparagraph (A), the Administrator shall make appropriate adjustments to insure that no credit is provided for improvement in motor vehicle emissions control in motor vehicles sold after the calendar year 1990.

(C) Compliance determined for each pollutant independently.- In determining whether there is an increase in emissions in violation of the prohibition contained in subparagraph (A) the Administrator shall consider an increase in each air pollutant referred to in clauses (i) through (iv) as a separate violation of such prohibition, except that the Administrator shall promulgate regulations to provide that any increase in emissions of oxides of nitrogen resulting from adding oxygenates to gasoline may be offset by an equivalent or greater reduction (on a mass basis) in emissions of volatile organic compounds, carbon monoxide, or toxic air pollutants, or any combination of the foregoing.

(D) Compliance period.- The Administrator shall promulgate an appropriate compliance period or appropriate compliance periods to be used for assessing compliance with the prohibition contained in subparagraph (A).

(E) Baseline for determining compliance.- If the Administrator determines that no adequate and reliable data exists regarding the composition of gasoline sold or introduced into commerce by a refiner, blender, or importer in calendar year 1990, for such refiner, blender, or importer, baseline gasoline shall be substituted for such 1990 gasoline in determining compliance with subparagraph (A).

(9) Emissions from entire vehicle.- In applying the requirements of this subsection, the Administrator shall take into account emissions from the entire motor vehicle, including evaporative, running, refueling, and exhaust emissions.

(10) Definitions.- For purposes of this subsection-

(A) Baseline vehicles.- The term "baseline vehicles" mean representative model year 1990 vehicles.

(B) Baseline gasoline.-

(i) Summertime.- The term "baseline gasoline" means in the case of gasoline sold during the high ozone period (as defined by the Administrator) a gasoline which meets the following specifications:

BASELINE GASOLINE FUEL PROPERTIES

API Gravity . . . . .	57.4
Sulfur, ppm . . . . .	339
Benzene, % . . . . .	1.53
RVP, psi . . . . .	8.7
Octane, R+M/2 . . . . .	87.3
IBP, F . . . . .	91
10%, F . . . . .	128
50%, F . . . . .	218

90%, F . . . . .	330
End Point, F . . . . .	415
Aromatics, % . . . . .	32.0
Olefins, % . . . . .	9.2
Saturates, % . . . . .	58.8

(ii) Wintertime.- The Administrator shall establish the specifications of "baseline gasoline" for gasoline sold at times other than the high ozone period (as defined by the Administrator). Such specifications shall be the specifications of 1990 industry average gasoline sold during such period.

(C) Toxic air pollutants.- The term "toxic air pollutants" means the aggregate emissions of the following:

- Benzene
- 1,3 Butadiene
- Polycyclic organic matter (POM)
- Acetaldehyde
- Formaldehyde.

(D) Covered area.- The 9 ozone nonattainment areas having a 1980 population in excess of 250,000 and having the highest ozone design value during the period 1987 through 1989 shall be "covered areas" for purposes of this subsection. Effective one year after the reclassification of any ozone nonattainment area as a Severe ozone nonattainment area under section 181(b), such Severe area shall also be a "covered area" for purposes of this subsection.

(E) Reformulated gasoline.- The term "reformulated gasoline" means any gasoline which is certified by the Administrator under this section as complying with this subsection.

(F) Conventional gasoline.- The term "conventional gasoline" means any gasoline which does not meet specifications set by a certification under this subsection.

(1) Detergents.- Effective beginning January 1, 1995, no person may sell or dispense to an ultimate consumer in the United States, and no refiner or marketer may directly or indirectly sell or dispense to persons who sell or dispense to ultimate consumers in the United States any gasoline which does not contain additives to prevent the accumulation of deposits in engines or fuel supply systems. Not later than 2 years after the date of the enactment of the Clean Air Act Amendments of 1990, the Administrator shall promulgate a rule establishing specifications for such additives.

(m) Oxygenated Fuels.-

(1) Plan revisions for co nonattainment areas.- (A) Each State in which there is located all or part of an area which is designated under title I as a nonattainment area for carbon monoxide and which has a carbon monoxide design value of 9.5 parts per million (ppm) or above based on data for the 2-year period of 1988 and 1989 and calculated according to the most recent interpretation methodology issued by the Administrator prior to the enactment of the Clean Air Act Amendments of 1990 shall submit to the Administrator a State implementation plan revision under section 110 and part D of title I for such area which shall contain the provisions specified under this subsection regarding oxygenated gasoline.

(B) A plan revision which contains such provisions shall also be submitted by each State in which there is located any area which, for any 2-year period after 1989 has a carbon monoxide design value of 9.5 ppm or above. The revision shall be submitted within 18 months after such 2-year period.

