

# Changes in Gasoline III – Year 2000 Supplemental Update



## Introduction

We have been receiving a lot of calls about when we plan on publishing a new “Changes in Gasoline” manual. The first version of the manual, printed in 1987, was updated and revised in 1988, 1990, and 1991. “Changes in Gasoline II,” printed in 1992, was a complete rewrite as was “Changes in Gasoline III” in January 1996. These frequent updates were necessitated by such issues as the 1990 Clean Air Act Amendments, changes in fuel specifications, a need for information about oxygenated fuels and reformulated gasoline, and developing information about fuel system deposits.

Since 1996 changes to gasoline have been less frequent and there has been no need to update the manual since its contents continue to be accurate. There have, however, been some developments and more are on the horizon. At the end of 1999 refiners will implement Phase II of the reformulated gasoline program. A number of geographic areas have achieved compliance with carbon monoxide (CO) standards and are no longer required to use oxygenated fuels. The Governor of California has called for a phaseout and ban on the use of methyl tertiary butyl ether (MTBE) over concerns about groundwater contamination. The U.S. Environmental Protection Agency (EPA) has proposed a new set of rules called Tier II that would place more stringent requirements on automobiles while at the same time requiring a significant reduction in gasoline sulfur levels. There have also been some minor changes in ASTM gasoline specifications.

While these developments may not warrant a full rewrite of the “Changes in Gasoline” manual, we believe they do require some type of update for our hundreds of thousands of readers. Consequently we have developed this supplemental up-

date to report on some of the aforementioned developments. This update is designed to be an insert to “Changes in Gasoline III.” The information covered in each chapter of this supplement is designed to coincide with the same numbered chapter in the manual.

We continue to follow our approach of separating fact from fiction and presenting information on topics from a perspective most useful to the auto service technician. It is our hope that you will find this supplement a useful addition to your “Changes in Gasoline III” manual.

We would also like to express our thanks to the Renewable Fuels Foundation for their past sponsorship of the manual series and this supplemental update. Finally we would like to express our thanks to the service technicians, service shops, colleges, technical/trade schools, and auto manufacturer training programs that use our manual. Collectively they have allowed the “Changes in Gasoline” manual series to achieve a circulation in excess of a half million copies making our manual the most widely circulated gasoline reference manual used by the auto service and repair community.



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# Chapter I Gasoline Quality – Standards, Specifications, & Additives – Update

## Specifications & Standards

The American Society for Testing and Materials (ASTM) continues to be the guiding force in fuel standards. ASTM D 4814 continues to serve as the industry’s voluntary consensus standard and is also adopted, in whole or in part, by several states as the legal guidelines for gasoline quality. Petroleum companies and pipeline operators continue to, in some cases, use specifications that are more stringent than the ASTM requirements. However, the ASTM guidelines are still the industry standard because they take into consideration the numerous requirements of both producers and users of fuel.

## Octane Quality

This section of the manual remains accurate. However auto manufacturers are beginning to alter their guidelines for vehicle octane requirements at higher altitudes. Absent electronic controls, the octane requirement of a spark ignition engine is less at higher altitudes. The ASTM guidelines allow for lower octane gasoline at higher altitudes. As a result, gasoline marketers in higher altitude areas such as Denver have traditionally sold 85 octane (R+M)/2 gasoline as their regular unleaded compared to 87 octane at lower altitudes. Midgrade and premium grades in these markets are also usually two octane numbers lower than their counterparts sold at lower altitudes.

Some automakers have started specifying a minimum of 87 octane even at higher altitudes. This is because vehicle controls now compensate for changes in barometric pressure by adjusting spark timing and air/fuel mixture. Consequently the octane requirement of these vehicles remains approximately the same at various altitudes. As an example, Ford’s 1999 model year owners manual states “We do not recommend gasoline labeled as ‘regular’ in high altitude areas that are sold with octane ratings of 86 or even less.” A

similar statement is used for vehicles requiring premium and specifies a minimum octane of 91.

## Volatility

The volatility of gasoline continues to be an important factor in vehicle performance. The trend today is towards lower and lower volatility fuels to reduce evaporative emissions. While fuels of low volatility do reduce evaporative fuel emissions, they also vaporize less readily and in some cases may contribute to poor cold start/warm up performance especially in sensitive vehicles. Because of this a Driveability Index (DI) has been added to the ASTM specifications to help improve cold start and warm up performance. The DI is calculated with a formula that utilizes the temperature at which ten percent, fifty percent, and ninety percent of the fuel is evaporated.

**Table S1-1 Driveability Index**

$$DI = (1.5 \times T_{10}) + (3.0 \times T_{50}) + T_{90}$$

Where  $T_{10}$  = distillation temperature at 10% evaporated

Where  $T_{50}$  = distillation temperature at 50% evaporated

Where  $T_{90}$  = distillation temperature at 90% evaporated

Table S1-2 provides an example of the calculated DI using a volatility class E winter grade gasoline.

**Table S1-2 DI Example**

Winter fuel

$T_{10} = 122$

$T_{50} = 190$

$T_{90} = 360$

$DI = (122 \times 1.5) + (190 \times 3) + 360$

$DI = 183 + 570 + 360$

$DI = 1113$

In Table S1-2 we use a fuel with a  $T_{10}$  of 122°F, a  $T_{50}$  of 190°F, and a  $T_{90}$  of 360°F. Applying the formula we see that the DI for this fuel is 1113.

The ASTM specifications specify a maximum DI for each volatility class. These are listed in Table S1-3.

**Table S1-3 Driveability Index Maximum Based on Fahrenheit Scale**

AA	=	1250
A	=	1250
B	=	1240
C	=	1230
D	=	1220
E	=	1200

The driveability index is a maximum. In other words, a number lower than that specified is acceptable but a higher number may cause poor cold start or poor warm up performance. This is why a lower maximum number is specified for winter grade gasolines.

The driveability index was developed a number of years ago. Consequently, a great deal of the development of the formula was on carbureted vehicles and utilized fuels which did not contain oxygenates. Recent testing has shown that the formula is also accurate for late model vehicles. However, it may become necessary to develop a small correction factor for oxygenated fuels. The DI formula continues to be assessed to determine if a more accurate formula can be developed.

It should be noted that while the automakers are concerned about fuels having the proper DI they have also expressed concerns about fuels that have  $T_{50}$  points that are too low. Where high DI fuels can contribute to poor cold start and warm up performance, if a fuel's  $T_{50}$  is excessively low it can vaporize too readily which can contribute to rich excursions making it difficult to maintain the air/fuel ratio at, or near, stoichiometry.

### **Gasoline Component Specifications**

As mentioned in the manual, there are usually no ASTM specifications for individual gasoline components. However ethanol, and in some cases MTBE, may be blended at the terminal level. This has resulted in ASTM specifications being set for ethanol and MTBE. In the case of ethanol this continues to be ASTM D 4806. The Renewable Fuels Association (RFA) member companies continue to adhere to specifications that are more stringent than ASTM. These more stringent standards are set forth in RFA Publication #960501 and RFA Recommended Practice #930601 (which superceded RFA Recommended Practice #911201 listed in the manual). RFA member companies represent in excess of ninety-five percent of all fuel grade ethanol produced in the U.S. The manual also mentions development of an ASTM standard for MTBE and that standard has been completed. It is ASTM D 5893 Standard Specification for Methyl Tertiary Butyl Ether (MTBE) for Downstream Blending for Use in Automotive Spark-Ignition Engine Fuel.

# Chapter 2 Changes in Gasoline Driven By Environmental Concerns – *Update*

## **Background**

The auto manufacturers continue to do their part in reducing vehicle emissions. With the introduction of so-called Tier I vehicles in 1999 hydrocarbon (HC) emissions have been reduced by 98% compared to pre-control era vehicles. Likewise automotive emissions of oxides of nitrogen (NO<sub>x</sub>) have been reduced 90% below pre-control levels. Despite these impressive gains, automobiles are still a significant source of air pollution because both the number of vehicles and the miles they are driven continue to increase. Consequently a number of strategies continue to be employed to try and achieve even greater reductions in the small amount of automotive emissions that remain. Future changes will include more stringent emissions standards on vehicles, further changes to gasoline and increasing numbers of alternative fuel vehicles.

Before moving on to some of the current and anticipated changes to gasoline, an update of topics covered in Chapter II of “Changes in Gasoline III” is in order. All key fuel related elements of the 1990 Clean Air Act Amendment have now been implemented with most now being in place for a number of years.

## **Oxygenated Gasoline Programs**

When the oxygenated gasoline programs were introduced there were 36 areas designated as CO non-attainment areas. The oxygenated gasoline program proved effective in its very first year dramatically reducing the number of exceedences of the CO standard. In fact, today there are only 18 remaining areas that are required to use oxygenated gasoline because of their CO non-attainment status (See update of Appendix B for a complete listing of remaining areas.)

## **Reformulated Gasoline**

While CO reduction is a success story, a number of metropolitan areas continue to exceed the standards for ozone. In fact, more areas, including Phoenix and St. Louis, have implemented reformulated gasoline programs since we last updated the manual in 1996. The Appendix B update includes a map of areas currently requiring reformulated gasoline.

There have also been a number of developments with the reformulated gasoline program, reformulated gasoline (RFG) itself, and the oxygenates it contains.

When Phase I of the RFG program was first implemented in 1995, refiners used EPA’s Simple Model to achieve compliance. However beginning in 1998 refiners were required to use the Complex Model. This provided refiners with more flexibility in meeting RFG program requirements. However, Complex Model RFG continues to be very similar to the gasoline stipulated in the Simple Model. Its benzene level is still restricted to 1.0 volume % maximum and it must contain 2.0 weight % oxygen on average. Some refiners have made minor adjustments, lowering volatility, aromatic levels, and olefin content, as well as reducing sulfur levels. Adjustment of one or a combination of these items allow the refiner to manufacture complying RFG in a manner most efficient and cost effective for their refinery configuration and slate of products produced.

Starting in the year 2000, and barring any changes to existing law, industry will be required to sell Phase II RFG. As discussed in the next chapter the emissions reduction requirements for Phase II RFG are more stringent than Phase I.

## California RFG

California implemented Phase II of their RFG program a number of years ago. There are some differences between the California RFG program (referred to as California Cleaner Burning Gasoline or CBG) and the federal program. We frequently receive questions on this topic since details on the differences were not covered in the manual.

The California CBG program is required state-wide. The State of California uses their own computer model for compliance. This model, called the "California Predictive Model," is similar to the federal complex model but does not incorporate evaporative emissions.

California's CBG program attempts to achieve greater emissions reductions than the federal program by placing more stringent requirements on certain gasoline parameters. The California specifications place maximums on aromatic content (22%), olefin content (4%), and sulfur content (30 ppm). In addition the maximum distillation temperature for T<sub>50</sub> and T<sub>90</sub> are lowered.

California does not require the use of oxygenates in all its CBG. The federal RFG areas in California must contain the required 2.0 wt% oxygen content. These areas include the greater Los Angeles area, Sacramento, and San Diego. California CBG in the remainder of the state is not required to contain oxygen if it can be shown to meet the standard without it.

Perhaps the most significant development in California has been the governor's decision to ban the use of MTBE by December 31, 2002. This is discussed in more detail in the next chapter.

Also California has just started to consider plans for Phase 3 of their Cleaner Burning Gasoline Program although few details are yet available.

It is also worthwhile to note that vehicles certified to meet California's more stringent emissions requirement need California CBG to do so. This is in large part due to California CBG's lower sulfur level. Some northeast states now require vehicles meeting California emissions standards but these areas do not have low sulfur gasoline.

Consequently California certified vehicles operating on higher sulfur fuels may illuminate the malfunction indicator light (MIL) or Check Engine Soon Light. The auto manufacturers have started including advisories on this in the fuel recommendation section of their vehicle owners manual. As examples, wording for the 1999 Chrysler and GM owners manuals are listed below.

### • Chrysler Corporation Sulfur in Gasoline

If you live in the northeast United States, your vehicle may have been designed to meet California low emission standards with clean burning, low sulfur, California gasoline. Gasoline sold outside California is permitted to have higher sulfur levels which may affect the performance of the vehicle's catalytic converter. This may cause the Check Engine or Service Engine Soon Light to illuminate.

Illumination of this light while operating on high sulfur gasoline does not necessarily mean your emission system control system is malfunctioning. Chrysler Corporation recommends that you try a different brand of unleaded gasoline having lower sulfur to determine if the problem is fuel related before returning your vehicle to an authorized dealer for service.

### • General Motors Corporation

If your vehicle is certified to meet California Emission Standards (indicated on the underhood tune-up label), it is designed to operate on fuels that meet California specifications. If such fuels are not available in states adopting California emissions standards, your vehicle will operate satisfactorily on fuels meeting federal specifications, but emission control system performance may be affected. The malfunction indicator lamp on your instrument panel may turn on and/or your vehicle may fail a smog-check test. If this occurs, return to your authorized (GM) dealer for diagnosis to determine the cause of failure. In the event it is determined that the cause of the condition is the type of fuels used, repairs may not be covered by your warranty.

## Other Information

Phase II of the Auto/Oil Air Quality Improvement Research Program (AQIRP) mentioned in the manual has been completed.

While the findings would be too voluminous to cover in accurate detail here, some of the findings were as follows:

- Lowering aromatics reduced HC, CO, and toxic exhaust emissions in current technology vehicles (Tier 0) and CO, NO<sub>x</sub>, and toxics in older technology vehicles.

- Adding oxygenates (from 2 to 2.7 wt%) reduced HC and CO in both current technology and older vehicles.
  - Reducing olefin content reduced NOx in both current technology and older vehicles but increased HC emissions in both.
  - Reducing vapor pressure by 1.0 psi (from 9 to 8) decreases HC, and CO exhaust emissions, and evaporative emissions in current technology vehicles.
  - Reducing sulfur content from 450 ppm to 50 ppm gave the most significant and consistent exhaust emissions reductions lowering HC, CO, NOx, and toxics in current technology vehicles and Federal Tier I technology vehicles.
- Other testing by various groups is always ongoing. This includes not only emissions research but driveability studies as well.

## Chapter 3 Reformulated Gasoline, Oxygenates and Oxygenated Fuels – *Update*

### Reformulated Gasoline-Phase II

The reformulated gasoline program has now been in place for five years confirming that there are no major performance related issues beyond the 2% to 3% fuel economy penalty.

Requirements for Phase II of the RFG program take effect on January 1, 2000 with refiners manufacturing compliant fuels well in advance of that date. Phase II of the program will require 25% reductions in volatile organic compounds (VOC), a 20% reduction in toxics, and a 5% reduction in oxides of nitrogen (NOx). These requirements are compared to Phase I requirements in Table S3-1.

<b>Table S3-1 Reformulated Gasoline Requirements</b>		
	<u>Phase I</u>	<u>Phase II</u>
VOC reduction	15%	25%
Toxics reduction	15%	20%
NOx reduction	n/a	5%

With Phase II RFG available, the annual smog forming emissions reductions from the RFG program will be equivalent to removing 16 million vehicles from the road. Early indications are that refiners will meet the more stringent emissions reduction requirements of Phase II primarily through further lowering the vapor pressure of gasoline in summer months and reducing its sulfur content. Other minor modifications will likely

include modest reductions in olefin and aromatic content and slight alteration of the distillation curve by removing some of the heaviest hydrocarbon components. Phase II gasoline will also be required to meet the same ASTM performance standards as Phase I so no major changes in performance are expected. In fact, EPA and industry recently completed a comprehensive test program utilizing Phase II RFG. The purpose of the test program was to identify any performance related issues with Phase II RFG before the fuel was introduced. EPA tested numerous vehicles in fleet operations over a period of several months. Climate conditions ranged from subfreezing temperatures in the north to record heat in the south. The combined test fleets drove over one million miles on Phase II RFG. Vehicles ranged in age from new to over 15 years old and included cars, trucks, vans, stepvans, and sport utility vehicles. The fleets involved and the number of vehicles operated on Phase II RFG are recapped in Table S3-2.

During the test program fuel system inspections were conducted. Driveability logs were also kept by vehicle operators to note any problems with starting, idling, etc. No problems with starting, running, idling, acceleration, or power were reported with any test fleet. One fleet manager described his fleet's use of Phase II RFG as "transparent." No increased or unscheduled repairs attributed to the fuel were reported.

In addition to the fleet tests, a separate study

**Table S3-2: Fleet Vehicles in EPA's Phase II RFG Test**

<u>Fleet</u>	<u>Cars</u>	<u>Trucks</u>
Boston Police Dept.	53	6
Elk Grove Village	37	12
Houston Lighting & Power	27	67

*(Total vehicles operating on Phase II RFG does not include control vehicles)*

was conducted on twelve vehicles of various makes, ages, and mileage. This study was to determine any differences in fuel economy between Phase I RFG and Phase II RFG. No significant differences in fuel economy between the two fuels was found.

It should also be noted that California has already implemented Phase II of its RFG program and extensive testing was also conducted prior to introduction of California Phase II CBG. These tests also included numerous automobile makes, models, and ages with varying odometer readings. Various non-automotive engines were also tested in the program. The final report did not indicate any areas of concern and, of course, this fuel has now been used in California for five years.

EPA also conducted tests on a variety of non-automotive engines. These tests included 177 pieces of lawn and garden power equipment, representing eleven use applications and utilizing both two stroke and four stroke engines ranging from 3 to 17 horsepower. Marine engines ranging from small two stroke 25 horsepower outboards to larger four stroke 500 horsepower inboards and stern drives were also tested. Finally, Harley Davidson conducted performance tests on six recent model motorcycles. This test also included system materials compatibility testing where various fuel system elastomers were soaked in Phase II RFG.

Based on the above EPA's final test report notes "...no difference in vehicle performance or fuel economy is expected when Phase II RFG replaces Phase I RFG. In addition, no difference in performance is expected with small engines, ma-

rine engines, or motorcycles." It is also worth noting that according to EPA survey data from last winter (1998/1999) "In virtually every RFG city, the fuel last winter met Phase II RFG Standards." This would indicate that few changes will occur as a result of the Phase II requirement.

**Volatility:** Since refiners now use the complex model there is not a set limit on gasoline vapor pressure. However in order to meet the emissions reduction requirements refiners still dramatically reduce the vapor pressure of summer grade gasolines. The summer grade of Phase II RFG will almost always have lower vapor pressure than the 7.2 to 8.1 psi required during the initial years of the program.

*NOTE: In an effort to reduce vehicle emissions some areas have required gasolines with lowered vapor pressure during summer months. Such gasolines are not reformulated gasolines but merely use one of the control parameters used in RFG. The vapor pressure of such gasolines is typically as low or lower than the vapor pressure of RFG and may or may not contain oxygenates.*

*While low vapor pressure gasolines reduce evaporative emissions during the summer, they have little effect on exhaust emissions and may, in some cases, make exhaust emissions of some components increase. Likewise, the toxic emissions of these fuels are usually not as low as those from RFG. Finally, if vapor pressure is lowered too much, it can have a negative impact on cold start performance and warm up driveability.*

*Areas currently utilizing low vapor pressure gasolines include Birmingham, Alabama, Atlanta, Georgia, and El Paso, Texas. The St. Louis area had also been using this approach but switched to a RFG program in 1999. The Portland Maine area has recently switched from RFG to a low vapor pressure gasoline program.*

**Future Changes:** With the RFG program fully implemented, the next change to gasoline looms on the horizon. EPA recently released a Notice of Proposed Rulemaking referred to as its "Tier II" rulemaking.

This program will require automobile manufacturers to further reduce vehicle emissions and would require a reduction in the sulfur content of all gasolines.

Currently gasoline contains an average of about 300 parts per million (ppm) sulfur. However the ASTM standards permit a sulfur content of up to 1000 ppm. Fuel quality surveys by the auto manufacturers have occasionally found gasolines with sulfur content near the upper limit or in a few cases, even above.

Sulfur poisons catalytic convertors reducing their effectiveness and shortening their life. In the past, sulfur contamination could be partially reversed through rich operation at high speed throttle positions. However, in order to meet current and future emissions standards, such operating modes are largely eliminated. Consequently gasoline with high sulfur levels can have a permanent negative impact on newer vehicles.

In order to assure that catalytic convertors remain effective, EPA has proposed limiting the sulfur content of gasoline to 30 ppm on average with no single gallon to exceed a maximum of 80 ppm. These requirements would be phased in beginning 2004 in order to provide refiners sufficient lead time to install the equipment necessary to reduce sulfur levels. The sulfur reduction requirements would apply to both reformulated and conventional gasolines. From a performance standpoint, sulfur reduction will be an improvement. Lower sulfur gasolines will lead to improved catalyst life and increased working efficiency.

Excessive sulfur levels in gasoline can also lead to acidic compounds in the crankcase oil which can contribute to premature engine wear. Potential problems of this nature would also be eliminated by the federal requirement for reduced sulfur levels.

As this supplemental update was being prepared, the Tier II rules had not yet been finalized but industry anticipates they will be adopted as proposed.

### **Oxygenates**

MTBE: Methyl Tertiary Butyl Ether (MTBE) has been the most widely used oxygenate in the RFG program. It has been used in 75% to 80% of all RFG produced in the first five years of the

program. The remaining RFG has contained ethanol. Initially there were complaints about the distinct odor of gasoline containing MTBE. Concerns were also expressed about the health effects resulting from exposure to MTBE. However research conducted thus far has failed to demonstrate that exposure to MTBE is of any greater concern than exposure to many other gasoline components or to gasoline itself. Some studies suggest that individuals with frequent exposure to MTBE vapors and/or exhaust emissions from gasoline/MTBE blends are more likely to have symptoms such as headaches, eye irritation, and nausea.

More recently, concerns have focused on the potential for MTBE to contaminate ground water and drinking water. In fact the Governor of California has acted to phase out and ban the use of MTBE in California gasoline. In California Executive Order D-5-99 the Governor stated that "On balance, there is significant risk to the environment from using MTBE in gasoline in California." The use of MTBE in California gasoline is to be phased down with a 100% removal to be achieved by December 31, 2002." While MTBE may be less harmful than other components in gasoline, it can contaminate ground water more quickly. When gasoline containing MTBE leaks from an underground tank (or is spilled) the MTBE tends to separate from the gasoline and moves farther and faster than other gasoline components. In some areas, MTBE has been detected in soil or water samples when no petroleum hydrocarbons were present. In fact, in its short history of increased usage, MTBE has become the second most widely detected contaminant in ground water samples. Other states have introduced legislation to ban the use of MTBE but to date only Iowa has done so. These developments make the future of MTBE's use in gasoline uncertain. While using MTBE in gasoline has provided satisfactory vehicle performance and helped clean up air pollution, the concern about ground water will likely lead to a reduction in the use of MTBE. Under current regulations if MTBE is banned refiners would need to use ethanol to meet the oxygen content requirement for RFG. Problems of this nature have not been experienced with ethanol.

## Chapter 4 Fuel System Deposits

### Fuel Quality Testing – *Update*

The information contained in Chapter 4 of the manual is still current. We have received a number of inquiries about how to obtain the Specific Gravity Hydrometer.

The Specific Gravity Hydrometer test kit can be obtained from:

Engine Control Learning Center  
892 Cambridge Drive  
Elk Grove Village, IL 60007  
Phone: 800-524-0944 or  
847-228-0484

## Chapter 5 Auto Manufacturer Fuel Recommendations – *Update*

The auto manufacturers fuel recommendations contained in “Changes in Gasoline III” were based on 1995 model year vehicle owners manuals. For the 1999 model year the recommendations regarding ethanol and MTBE remain largely the same. Four manufacturers, Ford, GM, Isuzu, and Rolls Royce have changed their recommendations regarding methanol indicating it is not approved for use. A few manufacturers have joined the ranks of those recommending RFG or detergent gasolines while a few have dropped their wording on detergent gasoline since all gasoline sold in the U.S. has been required to contain detergents for a number of years now. More manufacturers have also included language cautioning against the use of over-the-counter additives. In addition, Ford and GM have included a statement advising not to use premium gasoline in vehicles not specifically requiring it. Ford has also included wording advising against using gasoline below 87 octane at high altitudes (See chapter 1 Update - Octane Quality for additional discussion).

Eight manufacturers include wording advising against the use of methylcyclopentadienyl manganese tricarbonyl (MMT). MMT is a metallic additive

similar to lead. The auto manufacturers have expressed concerns that use of MMT will cause premature spark plug fouling, decrease catalytic converter efficiency and possibly cause the on-board diagnostic (OBD) system to malfunction.

Finally six manufacturers have included wording regarding sulfur content or related requirements. Vehicles designed for use in California (and certain Northeast states) have been designed to meet low emissions standards when operating on California RFG which is very low in sulfur. When these vehicles are operated on gasoline with higher sulfur levels, the emissions control system may not be able to function properly and the malfunction indicator light (MIL) (Service Engine Soon light) will illuminate.

This chapter includes a revised Table 5-1, now titled S5-1, to reflect these changes and additions. Information which is changed or new from Table 5-1 in the manual is indicated by bold type.

It should also be noted that ethanol flexible fuel vehicles (FFV) have now gone mainstream. Offerings include Fords FFV Taurus (by special order) and all 1999 and later model year Ford Rangers with the 3.0 L engine (as well as its Mazda twin). All 1998 and later model year Chrysler

**Table S5-1**

**Auto Manufacturers' Fuel Recommendation Recap (based on 1999 model year owners manual)**

	Approves of ethanol	Approved of MTBE	Approved methanol limits*	Precautionary language for oxygenates	Recommends or approves RFG	Recommends detergent gasoline	Precaution on use of after market additives	Advisory on sulfur content or California RFG	MMT Precaution	Octane advisory on altitude	Advisory on unnecessary premium use
<b>Manufacturer</b> .....											
Chrysler .....	yes	yes	no	x	yes	x	yes	yes	yes	yes	yes
Ford .....	yes	yes	<b>no</b> (1)	(1)	yes	x	(1)	yes	yes	yes	yes
GM .....	yes	yes	<b>no</b>	x	yes	x	(1)	yes	yes		
BMW .....	yes	yes	3%	x	x	yes	x				
Honda/Acura ...	yes	yes	5%	x	x	<b>yes</b>	x		<b>yes</b>		
Hyundai .....	yes	yes	no	(1)	x	yes	x				
Isuzu .....	yes	x	<b>no</b>	(2)	<b>yes</b>	x	(1)	<b>yes</b>	<b>yes</b>		
Jaguar .....	yes	yes	3%	(1)	x	<b>yes</b>	x				
<b>Kia</b> .....	<b>yes</b>	<b>x</b>	<b>no</b>	<b>(1)</b>							
Mazda .....	yes	x	no	(1)	x	x	yes				
Mercedes Benz	yes	yes	3%	x	x	yes	yes				
Mitsubishi .....	yes	yes	no	x	yes	yes	x	<b>yes</b>	<b>yes</b>		
Nissan/Infiniti .	yes	yes	5%	(1)	yes	x	yes				
Porsche .....	yes	yes	--	(1)	x	x	x				
Range Rover ...	yes	yes	<b>no</b>	x	yes	yes	<b>yes</b>		<b>yes</b>		
Rolls Royce ...	yes	yes	3%	x	x	x	<b>yes</b>		<b>yes</b>		
Saab .....	yes	yes	5%	x	yes	yes	x		<b>yes</b>		
Subaru .....	yes	yes	5%	x	yes	yes	x	<b>yes</b>			
Suzuki .....	yes	yes	5%	(1)	yes	x	x				
Toyota/Lexus ..	yes	yes	5%	(1)	x	yes	x				
Volkswagen/Audi...	yes	yes	3%	(1)	x	yes	yes				
Volvo .....	yes	yes	no	x	x	<b>yes</b>	x				

\* Requires equal amounts of cosolvents, plus corrosion inhibitors be used in the fuel.  
 (1) Mild precautionary wording (2) Strong precautionary wording  
 x No reference made in owners manual  
 Bold indicates change in information or additions of new information

product minivans (Chrysler/Dodge/Plymouth) with the 3.3L engine are also flexible fuel capable. Additionally GM has announced that for the 2000 model year certain configurations of its GMC Sonoma and Chevrolet S-10 pickup trucks will be flexible fuel capable. Consequently, there are hundreds of thousands of these vehicles on the road

with hundreds of thousands more added to the fleet each year.

All of these vehicles are capable of operating on fuels containing up to 85% denatured ethanol (commonly referred to as E-85) or 100% gasoline or any mixture of the two.

As an example of the fuel recommendations

for these vehicles we have included the fuel recommendation section from the 1999 Dodge Caravan FFV. Please note that Chrysler also recommends special engine oil while Ford does not.

### 1999 Dodge Caravan - E85 Recommendations

#### FLEXIBLE FUEL - (3.3L Federal Engines Only)

##### E-85 General Information

The information in this section is for Flexible Fuel vehicles only. These vehicles can be identified by the unique fuel filler door label that states Ethanol (E-85) or Unleaded Gasoline Only. This section only covers those subjects that are unique to these vehicles. Please refer to the other sections of this manual for information on features that are common between Flexible Fuel and gasoline only powered vehicles.

#### WARNING!

Only minivans with the E-85 fuel filler door label can operate on E-85.

#### Ethanol Fuel (E-85)

E-85 is a mixture of approximately 85% fuel ethanol and 15% unleaded gasoline.

#### WARNING!

Ethanol vapors are extremely flammable and could cause serious personal injury. Never have any smoking materials lit in or near the vehicle when removing the fuel filler tube cap (gas cap) or filling the tank. Do not use E-85 as a cleaning agent and never use it near an open flame.

#### Fuel Requirements

Your vehicle will operate on both unleaded gasoline with an octane rating of 87, or E-85 fuel, or any mixture of these two.

For best results, a refueling pattern that alternates between E-85 and unleaded gasoline should be avoided. When you do

switch fuels, it is recommended that

- you do not switch when the fuel gauge indicates less than 1/4 full
- You do not add less than 5 gallons when refueling
- you operate the vehicle immediately after refueling for a period of at least 5 minutes

Observing these precautions will avoid possible hard starting and/or significant deterioration in driveability during warm up.

NOTE: When the ambient temperature is above 90°F, you may experience hard starting and rough idle following start up even if the above recommendations are followed.

#### Selection of Engine Oil

For best performance and protection of your vehicle, use only crankcase engine oils that meet the following requirements:

- Engine Oil Selection for Operating on E-85 If you operate the vehicle on E-85 fuel either full or part-time, use only Mopar Flexible Fuel 5W-30 engine oil (P/N 4318086) or an equivalent that meets Chrysler Standard MS-9214. Equivalent commercial Flexible Fuel engine oils may be labeled as Flexible Fuel (FFV) or Alternate Fuel (AFV). These engine oils may be satisfactory if they meet the Chrysler Standard.

The 5W-30 engine oil installed at the factory meets the Chrysler requirements for Flexible Fuel engine oil.

SAE 5W-30 engine oil is preferred for use in Flexible Fuel engines.

Information on how to obtain a complete copy of the Auto Manufacturers Fuel Recommendations Data Base is included on page 27 of *Changes in Gasoline III*.

# Chapter 6 Oxygenated and Reformulated Gasolines in Power and Recreational Equipment – *Update*

Downstream Alternatives Inc. is currently updating its “Non-Automotive Gasoline Powered Equipment Fuel Recommendations” data base and has also recently discussed fuel quality related issues with several manufacturers. The primary fuel related concerns of the manufacturers relate to enleanment and fuel storage considerations.

**Enleanment:** Most manufacturers indicate that oxygenated fuels can be used without adjustments. In fact, several that initially indicated that adjustments to the air/fuel ratio were necessary have since indicated that it is not necessary to make adjustments.

The issues related to enleanment are primarily hesitation/rough idle and concerns about engine temperatures which are discussed in the manual. It should be noted that while it is possible to change the air/fuel ratio on older equipment, newer equipment is subject to certain emissions standards and it is illegal to alter the settings on this newer equipment.

**Storage Considerations:** The deterioration of gasoline which is stored for extended periods continues to be an industry concern. Gasoline stored for extended periods begins to oxidize and weather. This can result in loss of octane, loss of

volatile components that help with cold start, and most importantly can cause gum deposits in the carburetor. Most manufacturers continue to recommend that when equipment is stored for extended periods, the fuel should be treated with a stabilizer or the fuel system should be drained. The definition of extended storage varies among manufacturers. Additionally, some manufacturers offer slightly different guidelines for reformulated/oxygenated gasolines than those for conventional gasoline.

## **Phase II RFG**

As noted in Chapter 3, the RFG program requires implementation of Phase II RFG by January 1, 2000. Numerous and varied equipment has already been tested on Phase II RFG and no problems were found (see page 8 for additional details).

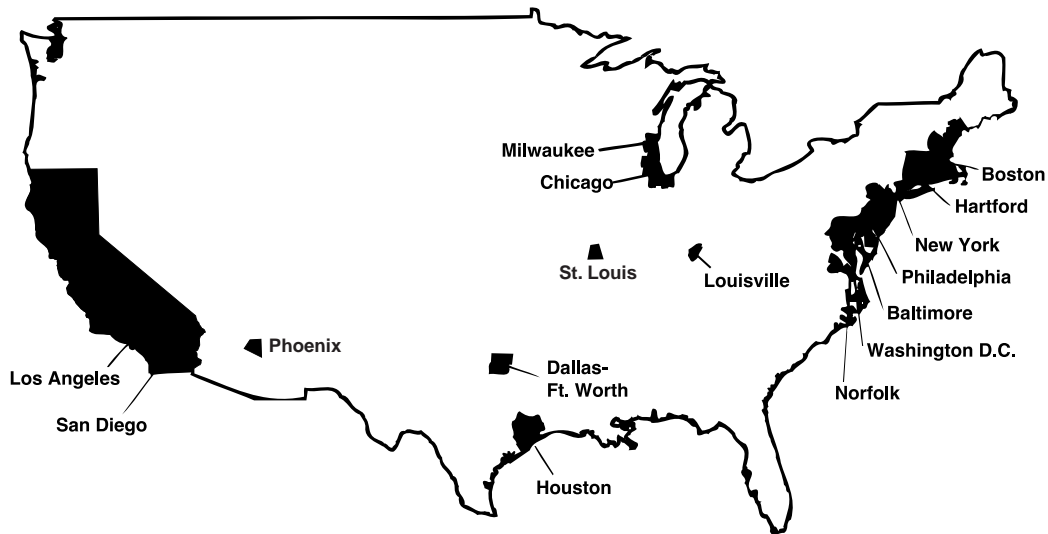
The fuel recommendations of equipment manufacturers have not changed significantly from the table in Chapter 6 of the manual. All major manufacturers continue to permit the use of ethanol and MTBE although some have switched to more positive wording in referencing them.

Information on how to obtain a current copy of our Non-automotive Gasoline Powered Equipment Data Base is included on page 32 of the manual.

# Appendix B Gasoline Program Areas – Update

**Figure SB-1 Reformulated Gasoline Program Areas**

The shaded portions of the map indicate areas that are required to use reformulated gasoline as of 1999



NOTE: California RFG Program differs slightly from the federal program

Source: US EPA

**Table SB-1 Oxygenated Fuel Program Areas**

The metropolitan areas listed below required wintertime oxygenated fuel programs as of 1999. Over twenty areas that originally required oxygenated fuel programs have been redesignated as CO attainment areas and no longer require oxygenated fuel. Such areas include Baltimore, Boston, Hartford, Philadelphia, Washington D.C., Greensboro, Syracuse, Cleveland, Duluth, Memphis, and several cities in California.

<u>City</u>	<u>State(s)</u>	<u>City</u>	<u>State(s)</u>
El Paso	TX	Reno	NV
Colorado Springs	CO	Grant's Pass	OR
Denver/Boulder	CO	Klamath Co.	OR
Ft. Collins	CO	Medford	OR
Missoula	MT	Las Vegas	NV
Provo/Orem	UT	Phoenix	AZ
Anchorage	AK	Los Angeles	CA
Portland/Vancouver	OR/WA	Spokane	WA
Minneapolis/St. Paul (1)	MN		

(1) The State of Minnesota has implemented a statewide oxygenated fuels program

Source: US EPA

**The “Changes in Gasoline” manual and supplement are no longer available in hard copy. Single copies are available via the internet at [www.ethanolrfa.org](http://www.ethanolrfa.org). This web site also contains information for multiple copy purchase.**