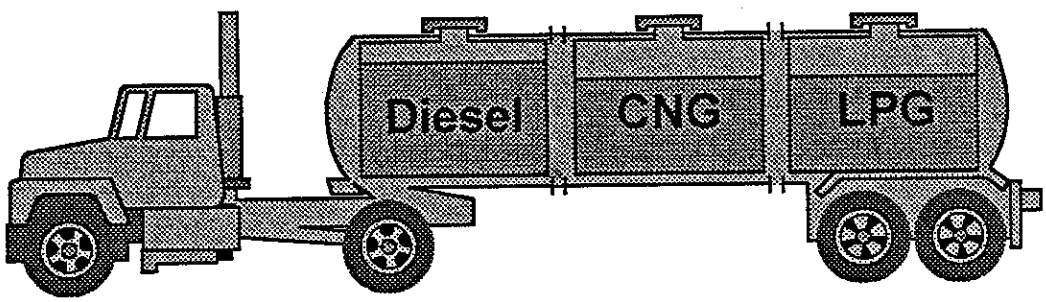
California Environmental Protection Agency

Air Resources Board

STAFF REPORT

Proposed New Specifications for Diesel Engine Certification Fuel, Proposed Amendments to the Oxygen Specification for Natural Gas Certification Fuel, and Proposed Amendments to the Commercial Motor Vehicle Liquefied Petroleum Gas Regulations



Release Date: August 5, 1994

State of California
California Environmental Protection Agency
AIR RESOURCES BOARD

STAFF REPORT: Initial Statement of Reasons

PUBLIC HEARING TO CONSIDER PROPOSED NEW SPECIFICATIONS FOR DIESEL ENGINE CERTIFICATION FUEL, PROPOSED AMENDMENTS TO THE OXYGEN SPECIFICATION FOR NATURAL GAS CERTIFICATION FUEL, AND PROPOSED AMENDMENTS TO THE COMMERCIAL MOTOR VEHICLE LIQUEFIED PETROLEUM GAS REGULATIONS

Date of Release: August 5, 1994
Scheduled for Consideration: September 22, 1994

Location:
2020 L Street
Sacramento, CA 95814

This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGEMENTS

This report was prepared with the assistance of staff of the Mobile Source Division. Specifically, we would like to thank Veronika Pesinova, Annette Guerrero, and Tom Chang. Additionally, we would like to acknowledge the cooperation of the members of the Engine Manufacturers Association, Mr. Warren Slodowske of Navistar International, and the cooperation of the members of the Western Propane Gas Association.

Prepared by:

Industrial Section
Criteria Pollutants Branch
Stationary Source Division

Principal Authors:

Jose Gomez
Erik White
Kim Nguyen

Technical Editor

Elizabeth Parkhurst

Office of Legal Affairs

Tom Jennings

Reviewed and Approved by:

Peter D. Venturini, Chief, Stationary Source Division
Ronald A. Friesen, Assistant Chief, Stationary Source Division
Dean C. Simeroth, Chief, Criteria Pollutants Branch
Gary M. Yee, Manager, Industrial Section

TABLE OF CONTENTS

Page

I. REPORT SUMMARY AND RECOMMENDATIONS 1

A. Introduction 1
B. Summary 2
C. Recommendations 4

II. PROPOSED SPECIFICATIONS FOR DIESEL ENGINE CERTIFICATION FUEL . 5

A. Background of Current Commercial Motor Vehicle Diesel Regulations 5
B. Current Specifications for Diesel Engine Certification Fuel 6
C. Analysis of Commercially Available Motor Vehicle Diesel Fuel 9
D. Proposed Specifications 10
E. Reaction of Affected Parties 13

III. PROPOSED AMENDMENTS TO THE OXYGEN SPECIFICATION FOR NATURAL GAS CERTIFICATION FUEL 15

A. Background of Current Oxygen Specification for Commercial Compressed Natural Gas Fuel 15
B. Current Specifications for Compressed Natural Gas Certification Fuel 15
C. Analysis of Oxygen Content in Current Compressed Natural Gas Certification Fuel 16
D. Proposed Modifications 17
E. Reaction of Affected Parties 18

IV. PROPOSED AMENDMENTS TO THE COMMERCIAL MOTOR VEHICLE LIQUEFIED PETROLEUM GAS REGULATIONS 19

A. Current Liquefied Petroleum Gas Regulations 19
B. Analysis of Current Liquefied Petroleum Gas Production 19
C. Issues Associated with a 5.0 Volume Percent Propene Content Limit 20
D. Proposed Modifications 21
E. Reaction of Affected Parties 22

TABLE OF CONTENTS

(Continued)

Page

V. ENVIRONMENTAL AND ECONOMIC IMPACTS 23

A. Environmental Impacts 23
B. Cost Impacts 24
C. Small Business Impacts 24
D. Global Warming and Ozone Depletion 25

REFERENCES 27

APPENDICES

Appendix A: Proposed Amendments to sections 1956.8(b), 1956.8(d), and 1960.1(k), and 2292.6 of Title 13, California Code of Regulations.

Appendix B: Proposed Amendments to "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engine and Vehicles" adopted April 8, 1985, as last amended March 24, 1994.

Appendix C: Proposed Amendments to "California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles," adopted April 25, 1986, as last amended May 28, 1993.

Appendix D: Proposed Amendments to "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," adopted May 20, 1987, as last amended September 22, 1993.

I.

REPORT SUMMARY AND RECOMMENDATIONS

A. INTRODUCTION

In this staff report, we are proposing that the Air Resources Board (ARB or Board) consider adopting new specifications for diesel engine certification fuel used in certifying some categories of diesel engines and vehicles. Certification fuel, as opposed to commercial fuel, is a special type of fuel that is used for the testing of motor vehicles to determine if the vehicles comply with motor vehicle emission standards established by the ARB. In order to ensure repeatable and reliable engine test results, it is necessary to specify certification fuels with consistent fuel properties and narrow tolerances. The current low-aromatics diesel engine certification fuel lacks these consistent properties and narrow tolerances. The proposed specifications are to add these elements to the specifications for low-aromatics diesel engine certification fuel.

In addition, we are proposing amendments to the oxygen specification for compressed natural gas (CNG) certification fuel and amendments to the commercial motor vehicle liquefied petroleum gas (LPG) regulations, which were adopted as part of the ARB's Alternative Fuels Regulations. Since the Board's adoption of the Alternative Fuels Regulations on March 12, 1992, industry representatives have raised concerns that the current 0.5 mole percent oxygen content specification for CNG certification fuel poses a potential safety hazard during the blending process. Concerns were also raised regarding the availability of 5.0 volume percent propene motor vehicle LPG fuel. Based on our recent analyses, we believe that amendments to the oxygen specification for CNG certification fuel and amendments to the commercial motor vehicle LPG regulations are appropriate.

The staff report also discusses the feasibility and costs associated with producing the diesel engine certification fuel and the CNG certification fuel. We examine the environmental impacts of the proposed regulatory action. We also evaluate the feasibility of implementing the existing regulatory requirement limiting the propene content of LPG commercial motor vehicle fuel to 5.0 volume percent starting January 1, 1995. Finally, we discuss the impact, if any, this regulatory action would have on small business and the impact on global warming and ozone depletion.

In developing the proposed regulatory action, we held a public workshop on April 10, 1994 and had several meetings and discussions with interested parties. We also considered the information presented by the Engine Manufacturers Association (EMA), Navistar International, the Western Propane Gas Association (WPGA), and other interested parties.

B. SUMMARY

1. Diesel Engine Certification Fuel

In November 1988, the Board adopted regulations pertaining to the composition of commercial motor vehicle diesel fuel (Reformulated Diesel Fuel Regulations). The ARB's motor vehicle emissions test procedures allow the use of diesel fuel meeting the reference fuel requirements of the Reformulated Diesel Fuel Regulations to certify 1995 and subsequent model-year medium-duty diesel vehicles and engines, 1995 and subsequent model-year diesel-fueled passenger cars and light-duty trucks, 1996 and 1997 urban bus engines, as well as 1995 and later diesel-fueled utility and lawn and garden equipment engines. This fuel can have widely varying properties because the specifications do not have a lower limit on the aromatic hydrocarbon or sulfur contents. Additionally, no upper limit on cetane is specified. Thus, engine manufacturers requested the ARB to develop more narrow specifications than those currently allowed under the motor vehicle test procedures.

We are proposing new specifications for diesel engine certification fuel which are based on the characteristics of diesel fuel currently produced in California meeting the basic 10 volume percent aromatic hydrocarbon content limit that is the key element in the Reformulated Diesel Fuel Regulations. This fuel offers the most consistent characteristics on which to base a certification fuel. Diesel fuel meeting the new certification specifications could be used, in addition to fuels meeting the federally established diesel certification fuel specifications, to certify 1995 and subsequent model-year medium-duty diesel motor vehicles and engines, 1995 and subsequent model-year diesel-fueled passenger cars and light-duty-trucks, 1996 and 1997 urban bus engines, as well as 1995 and later diesel-fueled utility and lawn and garden equipment engines. The new diesel engine certification fuel would also be used for in-use compliance testing of vehicles and engines certified with the fuel.

2. Compressed Natural Gas Certification Fuel

On March 12, 1992, the ARB adopted specifications for alternative fuels for motor vehicles, known as the Alternative Fuels Regulations. The ARB's action included amending the specifications for CNG fuel used during the certification of 1994 and subsequent model motor vehicles and engines to determine compliance with exhaust emissions standards. Included in the CNG certification fuel specifications is a 0.5 mole percent oxygen requirement. Since the adoption of the Alternative Fuels Regulations, industry representatives have raised concerns regarding the potential risk of explosion during the blending of oxygen into the certification fuel to obtain a 0.5 mole percent oxygen content. In order to reduce this risk, we are proposing to modify the oxygen requirement for CNG certification fuel to a 0.5 mole percent maximum.

3. Specifications for Commercial Liquefied Petroleum Gas Fuel

The adopted Alternative Fuels Regulations also included specifications for commercial motor vehicle LPG fuel. These specifications limit the propylene (propene) content to 5.0 volume percent, starting January 1, 1995. The Board adopted the 5.0 volume percent propene limit due to the high ozone forming potential of propene (propene is 19 times more reactive than propane, the main component of motor vehicle LPG). At that time, the ARB granted an interim 10.0 volume percent propene limit, effective from January 1, 1993 through December 31, 1994. The ARB provided the two-year delay in the implementation of the lower propene content requirement to address the uncertainty regarding the availability of low propene LPG fuel.

The WPGA has requested that the ARB reevaluate the feasibility of implementing the 5.0 volume percent propene specification which will become effective January 1, 1995. WPGA contends that its members are presently unable to secure guaranteed and continuous supplies of LPG fuel that meet the 5.0 volume percent propene specification. They claim that this could lead to regional supply shortages. Additionally, because there is no specification for propene content in commercial grade LPG for non-vehicle use, the specification of a propene content in motor vehicle LPG fuel could require a separate storage and distribution system for motor vehicle LPG. Postponing the implementation of the lower propene content requirement until January 1, 1997, would allow time to address the concerns raised by the WPGA. Also, when production of Phase 2 reformulated gasoline (RFG) begins on March 1, 1996, the amount of propene in LPG may change. Propene may become a valuable component for production of Phase 2 RFG. If it does, propene will be used as a component in the production of gasoline and the propene content of LPG will be reduced significantly.

C. RECOMMENDATIONS

We recommend that the Board amend the following sections of Title 13, California Code of Regulations (CCR), and the following test procedures which are incorporated by reference into Title 13, CCR:

Amendments to Existing Sections of Title 13, California Code of Regulations

- 1956.8(b), 1956.8(d), 1960.1(k), and 2292.6

Amendments to California Exhaust Emission Standards and Test Procedures

- "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engine and Vehicles" adopted April 8, 1985, as last amended October 23, 1992.

- "California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles," adopted April 25, 1986, as last amended May 28, 1993.

- "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles" adopted May 20, 1987, and last amended September 22, 1993.

The proposed amendments to Title 13, CCR, sections 1956.8(b), 1956.8(d), 1960.1(k), and 2292.6 are included in Appendix A. The proposed amendments to the test procedures are included in Appendices B, C, and D.

II.

PROPOSED SPECIFICATIONS FOR DIESEL ENGINE CERTIFICATION FUEL

A. BACKGROUND OF CURRENT COMMERCIAL MOTOR VEHICLE DIESEL REGULATIONS

In November 1988, the Board adopted regulations pertaining to the composition of commercial motor vehicle diesel fuel (Reformulated Diesel Fuel Regulations). These diesel fuel regulations are found in Title 13, CCR, sections 2281 and 2282. The ARB's diesel fuel regulations specify that vehicular diesel fuel sold or supplied on or after October 1, 1993, must have a sulfur content not exceeding 500 parts per million by weight (0.05 weight percent) and an aromatic hydrocarbon content not exceeding 10 percent by volume for large refiners, or 20 percent for small refiners. Independent refiners may meet the less stringent provisions (applicable to small refiners) during the first year, after which they must meet the stricter provisions applicable to large refiners. Under some circumstances, small refiners are not subject to these limits until October 1, 1994.

The Reformulated Diesel Fuel Regulations do not include a requirement for the cetane number of the fuel. However, the California Department of Food and Agriculture, Division of Measurement Standards, has established commercial diesel fuel specifications that include the cetane number requirements specified in the American Society for Testing and Materials (ASTM) Designation D 975. This designation has set a minimum cetane number of 40 for diesel fuel.

Two options are available to refiners that provide flexibility in meeting the aromatic hydrocarbon limit. One option available is an averaging provision, which allows refiners to produce and distribute batches of fuel that exceed the 10 volume percent aromatic hydrocarbon content limit. In producing and distributing diesel fuel that exceeds the aromatic hydrocarbon content limit, the refiner has 90 days in which to transfer sufficient quantities of fuel with a lower aromatic hydrocarbon content that will fully offset the fuel that exceeded the aromatic hydrocarbon limit. The net result of the averaging provision is that, over time, the volume weighted aromatic hydrocarbon content of the fuel produced meets the 10 volume percent requirement. The other option allows the use of alternative formulations, which generally have aromatic hydrocarbon contents greater than 10 volume percent. These alternative formulations are tested against a reference fuel using test procedures specified in the regulation. The requirements of the diesel fuel regulations are summarized in Table 1.

B. CURRENT SPECIFICATIONS FOR DIESEL ENGINE CERTIFICATION FUEL

In July 1991, the Board adopted modifications to the California motor vehicle emissions test procedures which allow the use of low-aromatic hydrocarbon content diesel fuel for the certification of some diesel vehicles and engines. These test procedures incorporate and modify federal test procedures for California use. The low-aromatic hydrocarbon content diesel certification fuel can be used in testing 1995 and subsequent model-year medium-duty diesel vehicles and engines, 1995 and subsequent model-year diesel passenger cars and light-duty trucks, 1996 and 1997 urban bus diesel engines, and utility and lawn and garden engines. Manufacturers of these vehicles and engines can conduct certification testing with either the reference fuel specified in the Reformulated Diesel Fuel Regulations or one of the fuels specified in the federal test procedures.

TABLE 1
REQUIREMENTS OF CALIFORNIA MOTOR VEHICLE DIESEL FUEL REGULATIONS

• Apply to On-Road and Off-Road Motor Vehicles	
• Specifications	
- Sulfur Content[1]	500 ppmw
- Aromatic Hydrocarbon Content (max)[2]	
Large Refiners	10% by volume
Independent Refiners[3]	20% by volume
Small Refiners	20% by volume
• Allows for Certification of Equivalent Formulations	
• Implementation Date	October 1, 1993
• Implementation for Small Refiners Under Suspension of Requirements	October 1, 1994

[1] Required in South Coast Air Basin for large refiners since 1985, for small refiners since 1989.
[2] Averaging of aromatic hydrocarbon content allowed over a period of 90 days.
[3] 20 percent limit applies to independent refiners up to 1996, but only under certain circumstances.

Table 2 presents the federal and state fuel specifications currently available for diesel engine certification and in-use compliance testing in California. The first column of federal specifications represents the fuel requirements for certification of 1990 model year federal diesel engines, while the second column of federal specifications are for certification of 1994 and subsequent model year federal diesel engines. Either of the sets of specifications may be used to certify any 1994 and subsequent model-year California vehicles and engines. The third column contains California's reformulated diesel fuel certification specifications. This fuel may be used in certifying the engines and vehicles identified in the preceding paragraph.

The current reference fuel specifications for reformulated diesel fuel allow the use of fuel with widely varying properties to certify diesel engines. The present specifications do not have a lower limit on the aromatic hydrocarbon or sulfur contents. Additionally, they do not specify an upper limit on cetane number. Recently, engine manufacturers expressed a desire for a more consistent diesel engine certification fuel with better defined properties. Therefore, we are proposing a set of new specifications for fuel to be used in diesel engine certification testing in those instances where manufacturers are allowed to conduct the testing with fuel reflecting the specifications of reformulated diesel.

TABLE 2
CURRENT DIESEL ENGINE CERTIFICATION FUEL SPECIFICATIONS FOR CALIFORNIA 1994 AND SUBSEQUENT ENGINES AND VEHICLES

Property	Units	Fuel Specifications				
		Federal Specifications Applicable to 1990 Federal Engines[1]		Federal Specifications Applicable to 1994 and Later Federal Engines[2]		California Reformulated Diesel Fuel Specifications[3]
Fuel Grade	--	D-1[4]	D-2	D-1[4]	D-2	[5]
Cetane Number	--	48-54	42-50	40-54	40-48	48[6]
Distillation Range						
IBP	°F	330-390	340-400	330-390	340-400	340-420
10% pt	°F	370-430	400-460	370-430	400-460	400-490
50% pt	°F	410-480	470-540	410-480	470-540	470-560
90% pt	°F	460-520	550-610	460-520	560-630	550-610
EP	°F	500-560	580-660	500-560	610-690	580-660
Nitrogen	ppmw	--	--	--	--	10[7]
API Gravity	°	40-44	33-37	40-44	32-37	33-39
Total Sulfur	wt %	0.05-0.20	0.20-0.50	0.03-0.05	0.03-0.05	0.05[7]
Hydrocarbon Composition						
Aromatic	vol %	8[6]	27[6]	8[6]	27[6]	10[7]
Poly aromatic	wt %	--	--	--	--	1.4[7]
Paraffins, naphthenes, and olefins	wt %	[8]	[8]	[8]	[8]	--
Flashpoint (min)	°F	120	130	120	130	130
Viscosity @ 40 °F	cSt	1.6-2.0	2.0-3.2	1.6-2.0	2.0-3.2	2.0-4.1

1 40 CFR, sections 86.1313-90(b), Table N90-2, & 86.113-90(b)(2). These specifications may be used for testing all 1994 and subsequent model California engines and vehicles.

2 40 CFR, sections 86.1313-94(b), Table N94-2 & 86.113-94(b)(2). These specifications may be used for testing all 1994 and subsequent model California engines and vehicles.

3 Title 13, CCR, section 2282(g)(3). These specifications may be used to certify 1995 and subsequent model medium-duty vehicles, 1995 and subsequent model passenger cars and light-duty trucks, and 1996-1997 urban bus engines.

4 Type D-1 fuel is allowed only if the engine manufacturer demonstrates such a fuel would be predominantly used in the vehicle fleet.

5 Only type D-2 fuel is allowed.

6 Minimum.

7 Maximum.

8 Remainder.

C. ANALYSIS OF COMMERCIALLY AVAILABLE MOTOR VEHICLE DIESEL FUEL

The primary regulatory requirement for the low aromatic hydrocarbon content diesel fuels is the 10 volume percent limit. Ten volume percent aromatic hydrocarbon content diesel fuels (10 percent aromatic fuels) serve as the basis for the current commercial diesel fuels available in California. The complying diesel fuels meeting alternative formulations have widely varying properties. This makes it difficult to use the alternative formulation fuels as a basis to set the sort of narrow certification fuel specifications that are necessary to ensure consistency of exhaust emission test results.

In determining the diesel engine certification fuel specifications, we analyzed the characteristics of commercially available 10 percent aromatic fuels. We used data supplied by refiners producing these fuels and determined a volume weighted average for natural cetane number and sulfur content. The volume weighted average sulfur content of 10 percent aromatic fuels is 112 ppmw (0.01 weight percent), and the average natural cetane number is 52. As noted previously, because of the averaging provisions, the average aromatic hydrocarbon content does not vary widely from 10 volume percent. Table 3 summarizes the results of our analysis.

We did not include alternative formulations in determining the average fuel properties of commercial diesel fuel. Unlike the 10 percent aromatic fuels, ARB approved alternative formulations have widely varying properties, such as different aromatic hydrocarbon and cetane levels. In addition, these fuels are still evolving and changing as refiners determine more cost-effective means to comply with the requirements of the low aromatic hydrocarbon diesel fuel regulations. This makes it difficult to determine an average fuel.

TABLE 3
PROPERTIES OF 10 VOLUME PERCENT AROMATIC DIESEL FUELS[1]

	Aromatic Content[2] (vol%)	Natural Cetane Number	Sulfur Content (ppmw)
Maximum	18.9	58	360
Minimum	3.5	42	30
Vol. Weighted Average	9.6	52	112

[1] Values are those as reported in an ARB survey conducted on January 14, 1994, and through conversations between ARB staff and refiners.
[2] From compliance data submitted to ARB.

D. PROPOSED SPECIFICATIONS

For the fuel properties listed below, we are proposing the following specifications for diesel engine certification fuel:

aromatic hydrocarbon content:	8 to 12 volume percent
natural cetane number:	47 to 55
sulfur content:	0.01 to 0.05 weight percent
nitrogen content:	100 to 500 parts per million (ppmw).

Additionally, to define a more consistent fuel, we propose specifications for other properties that have been subject to specifications in the existing test procedures. The complete set of proposed new diesel engine certification fuel specifications is presented in Table 4. We are also proposing that the ASTM Standard Test Methods listed in Table 4 be used in determining the properties of the diesel engine certification fuel (the test methods are the same as those currently used for testing commercial and certification diesel fuel in determining compliance with the existing diesel regulations). In addition, we are proposing amendments providing that the specifications applicable to the diesel fuel used for in-use compliance testing are to be the same as the specifications applicable to the diesel fuel used in certification testing.

In determining the appropriate range for the aromatic hydrocarbon and natural cetane levels, we considered the precision of the test procedures. We believe that the proposed ranges will provide a set of workable specifications for engine manufacturers to use in engine certification. The proposed specifications also closely represent the range of average properties of 10 percent aromatic fuel produced in California. Basing the proposed diesel

TABLE 4
PROPOSED DIESEL ENGINE CERTIFICATION FUEL PROPERTIES

FUEL PROPERTY	UNITS	FUEL SPECIFICATIONS	TEST METHOD (ASTM)
Natural Cetane Number	--	47-55	D 613-86
Distillation Range			
IBP	°F	340-420	D 86-82
10% pt	°F	400-490	D 86-82
50% pt	°F	470-560	D 86-82
90% pt	°F	550-610	D 86-82
EP	°F	580-660	D 86-82
API Gravity	°	33-39	D 287-82
Total Sulfur	wt %	0.01-0.05	D 2622-82
Nitrogen content	ppmw	100-500	D 4629-86
Hydrocarbon Composition			
Total aromatic	vol %	8 - 12	D 1313-83 or D 5186-91
Polycyclic aromatic (max)	wt %	1.4	D 2425-88
Flashpoint (min)	°F	130	D 93-80
Viscosity @ 40°F	cSt	2.0-4.1	D 445-83

engine certification fuel on the characteristics of the 10 percent aromatic fuels that are commercially available enables the Board to identify specifications with the narrow ranges designed to meet the engine manufacturer's need for a more consistent diesel engine certification fuel.

The aromatic hydrocarbon content, natural cetane number, sulfur content, and nitrogen content of the fuel all have a significant effect on emissions from diesel fueled vehicles. These properties are discussed below.

1. Aromatic Hydrocarbon Content

Several studies have shown that aromatic hydrocarbons influence emissions of oxides of nitrogen (NOx) and particulate matter (PM). By reducing aromatic hydrocarbons in diesel fuel, the fuel burns at a lower temperature in the combustion chamber. This then reduces the amount of thermal NOx formed during combustion. Thermal NOx is produced as molecular

nitrogen in the combustion air is oxidized at high temperatures. In addition, reductions in aromatic hydrocarbons also reduce PM emissions by allowing for more complete combustion of the fuel. Incomplete fuel combustion can lead to carbonaceous soot formation in the engine exhaust. Currently, commercial fuel must contain no more than 10 volume percent aromatic hydrocarbons, unless it has been certified as an alternative formulation or has been assigned an alternative limit.

2. Natural Cetane Number

The cetane number is a measure of the ignition quality of the diesel fuel and is influenced greatly by the refining process and the type of crude from which the diesel is produced. The cetane number affects emissions of both NOx and PM. Increases in cetane number reduce the ignition delay, thereby reducing the amount of fuel that is injected into the combustion chamber prior to ignition. This allows for a faster, more even burn at lower combustion chamber temperatures. As with aromatic hydrocarbons, lower combustion temperatures result in lower thermal NOx formation. A higher cetane number also provides more complete combustion. This reduces the amount of soot formed during combustion.

Natural cetane number, which contains no cetane improving additives, is highly correlated with aromatic hydrocarbon content. Generally, natural cetane number will increase as aromatic hydrocarbons are reduced during the hydrotreating process. The aromatic hydrocarbons are typically replaced with components that have better cetane properties, such as paraffins.

3. Sulfur Content

The sulfur content of diesel fuel can affect engine wear and durability, and is also responsible for sulfur dioxide emissions from diesel fueled engines. Sulfur dioxide emitted from internal combustion engines is converted to secondary sulfate particulates in the atmosphere. The degree of conversion depends on several factors, including atmospheric and meteorological conditions. It is estimated that 25 to 75 percent of the sulfur dioxide emitted is converted to secondary particulates.

Much of the fuel-bound sulfur is removed during the hydrotreating process. As a result, the sulfur level in the motor vehicle diesel fuels now commercially available in California tends to be very low. In commercial diesel fuel, the sulfur content may typically range from almost none to near 0.05 weight percent. The average sulfur level of California commercial motor vehicle diesel fuel is estimated at less than 0.03 weight percent.

4. Nitrogen Content

Typical values of nitrogen content in the 10 percent aromatic fuels produced in California range from approximately 100 ppmw to 500 ppmw. We are proposing a similar range for nitrogen content in the proposed diesel engine certification fuel. This range will

allow for flexibility in the fuel's production while keeping it representative of commercial 10 percent aromatic hydrocarbon fuels.

E. REACTION OF AFFECTED PARTIES

We held a public workshop on May 10, 1994 and invited comments on the new specifications for diesel engine certification fuel reflecting California reformulated diesel fuel. The EMA requested that the specifications be based on the fuel properties of 10 percent aromatic fuels. EMA agreed with staff that the average natural cetane number of 10 percent aromatic fuels in California is 52. They requested that the range for the natural cetane number be from 48 to 56. Their need for this wide cetane range is to account for the reproducibility of the test method (at a cetane number of 52, the reproducibility limit is 3.1) as well as the variability in the blending process.

Oil refiners questioned our analyses which did not include alternative formulations or the corresponding reference fuels against which they were tested. They contended that a significant portion of commercial motor vehicle diesel fuels available is sold as alternative formulations. Therefore, they felt that our proposed specifications should take into account the fuel properties of these alternative formulations.

Because alternative formulations are to provide equivalent emission benefits to a 10 percent aromatic fuel, and because alternative formulations have widely varying properties, we believe that the 10 percent aromatic fuels are the appropriate fuels to use as a basis for the diesel engine certification fuel specifications. The data available to us supports the cetane range of 47 to 55.

III.

PROPOSED AMENDMENTS TO THE OXYGEN SPECIFICATION FOR NATURAL GAS CERTIFICATION FUEL

A. BACKGROUND OF CURRENT OXYGEN SPECIFICATION FOR COMMERCIAL COMPRESSED NATURAL GAS FUEL

Following a March 12, 1992, hearing, the Board adopted specifications for alternative fuels for motor vehicles, known as the Alternative Fuels Regulations. These regulations were adopted to ensure that motor vehicles designed to use alternative fuels would have fuels available that are of consistent quality and produce the expected emission benefits. The adopted regulations included specifications for commercial and certification motor vehicle CNG fuel.

Compressed natural gas is a mixture containing mainly methane, along with small amounts of ethane, propane, butane, and some inert gases. Generally, natural gas contains either no oxygen or considerable oxygen. The mean oxygen content of natural gas nationwide is approximately 0.2 mole percent. Oxygen is rarely found in commercially available natural gas originating from pipelines operated by major utilities in California. When oxygen is found in natural gas in California, it is usually from landfill gas production. This gas is produced through the natural anaerobic decomposition of organic materials. Natural gas produced from this source is of high quality with a high methane content. It can also contain as much as one percent oxygen. The 1.0 mole percent oxygen content limit was included in the commercial motor vehicle CNG fuel specifications so as to not preclude this supply of natural gas.

B. CURRENT SPECIFICATIONS FOR COMPRESSED NATURAL GAS CERTIFICATION FUEL

The ARB's Alternative Fuels Regulations included amendments to the specifications for CNG used during certification testing of motor vehicles to determine compliance with the California emissions standards. These new specifications are contained in California's standards and test procedures for new motor vehicles and engines. The specifications apply to emission certification of 1994 and subsequent model year CNG fueled heavy-duty and otto-cycle engines, as well as 1994 and subsequent model year dedicated, hybrid electric and dual-fueled CNG passenger cars and light-duty vehicles. The California test procedures, which incorporate federal test procedures by reference, were amended to require the use of the CNG certification fuel specified in Table 5 for emission testing. In order to keep the certification fuel representative of commercially available CNG, an oxygen content requirement of 0.5 mole percent was included in the CNG certification fuel specifications.

TABLE 5
CURRENT CNG CERTIFICATION FUEL SPECIFICATIONS

PROPERTY	FUEL SPECIFICATIONS (mole percent)
Methane content	90.0 ± 1.0
Ethane content	4.0 ± 0.5
C_3 and higher hydrocarbon content	2.0 ± 0.3
C_6 and higher hydrocarbon content	0.2 (max)
Hydrogen content	0.1 (max)
Carbon monoxide content	0.1 (max)
Oxygen content	0.5 ± 0.1
Inert gas (sum of CO_2 and N_2)	3.5 ± 0.5

C. ANALYSIS OF OXYGEN CONTENT IN CURRENT COMPRESSED NATURAL GAS CERTIFICATION FUEL

Due to safety factors, industry representatives have raised concerns regarding their ability to meet the 0.5 mole percent oxygen content requirement of the CNG certification fuel. The tight tolerances of the certification fuel specifications demand that this fuel be produced through the blending of pure components at high pressures. Blending components of pure oxygen and flammable gases into a mixture has the possibility of explosion at high oxygen levels. Therefore, in the blending process, the oxygen is first mixed with inert gases to dilute its concentration. This mixture is then added to the flammable gases comprising the remainder of the fuel. If oxygen levels in the inert gas stream are too high, localized areas of high oxygen concentrations can form in the blending tank during the blending process, which could result in explosion. Based on current blending procedures, 0.2 mole percent oxygen is the maximum level that can be blended within acceptable safety tolerances.

The blending of oxygen and flammable gases to produce CNG is a different situation than having oxygen present in naturally-occurring CNG. Naturally-occurring CNG can have an oxygen content higher than 0.2 mole percent (i.e., 1.0 mole percent in the case of landfill gas). This is because the oxygen in naturally-occurring CNG is always uniformly mixed, and localized areas of high oxygen concentrations cannot form. However, this fuel cannot be used for engine certification due to the tight tolerances on the CNG certification fuel specifications. Due to these tight tolerances, the CNG certification fuel can only be produced through

blending of pure components, thereby precluding the use of CNG that has a naturally high oxygen content.

Due to the safety concerns of blending pure oxygen and combustible gases, and the inability of engine manufacturers to obtain high-oxygen engine certification test fuels, the ARB issued a Manufacturers Advisory Correspondence (MAC), number 93-05, dated December 14, 1993. The MAC explained the ARB's policy allowing the use of CNG fuel that had a lower oxygen content than was specified in California's test procedures for engine certification. The federal test procedures, which are incorporated by reference in the California test procedures, allow the Executive Officer to prescribe test procedures other than those set forth in the adopted test procedures if it is determined that a vehicle is not susceptible of satisfactory testing by the adopted procedures (40 C.F.R. sec. 86.090-27).

The ARB is currently conducting emissions testing to determine if there is any difference in emissions from CNG fuel with oxygen and CNG fuel without oxygen. Preliminary data suggests that there are no significant differences between the two fuels for emissions of ozone precursors (oxides of nitrogen and reactive organic gases). We believe that modifying the oxygen content requirement in the CNG certification fuel would not result in any reduction or increase in emissions during engine certification testing. If the Board agrees, we will continue to monitor the current testing and will modify our proposal should the emission data prove differently.

D. PROPOSED MODIFICATIONS

To reduce the potential risk of explosion, we are proposing that the 0.5 mole percent oxygen requirement be changed to a maximum value of 0.5 mole percent. Our analysis of preliminary data indicates that there is no significant difference in emissions between a fuel with a 0.5 mole percent oxygen content and a fuel without oxygen. The objective in establishing the specifications for natural gas certification fuel is to ensure that the engine certification testing is performed with a fuel that represents commercially available motor vehicle CNG. Also, to ensure consistent and reliable test results, it is important to have a certification fuel with tight tolerances. Making the recommended change would keep the engine certification fuel representative of marketplace fuels and would reduce the safety concerns during the blending process

E. REACTION OF AFFECTED PARTIES

We held a public workshop on May 10, 1994 and invited comments on the proposal to amend the oxygen specification for CNG certification fuel to a maximum limit of 0.5 mole percent. Affected parties were generally supportive of the proposed change. However, auto manufacturers requested an oxygen content of 0.2 ± 0.1 mole percent. We believe that there is no need for such tight control of oxygen because there is no significant difference in emissions between a fuel without oxygen and a fuel with 0.5 mole percent oxygen content. In addition, our proposed limit would keep California's CNG certification fuel more in line with that of the U.S. Environmental Protection Agency (U.S. EPA). On May 27, 1994, the U.S. EPA Administrator issued a final rule establishing federal specifications for CNG certification fuel including a maximum oxygen content of 0.6 mole percent.

IV.

PROPOSED AMENDMENTS TO THE LIQUEFIED PETROLEUM GAS REGULATIONS

A. CURRENT LIQUEFIED PETROLEUM GAS REGULATIONS

The Board's Alternative Fuels Regulations, adopted following the March 12, 1992 hearing, included specifications for commercially available motor vehicle LPG fuel. When we proposed the original commercial motor vehicle LPG specifications in the Alternative Fuels Regulations, we used two established references as guides. The first is the Gas Producers Association (GPA) Standard 2140, which contains recommended specifications for motor vehicle LPG fuel (referred to as HD-5). These specifications require a fuel composition of "not less than 90 liquid volume percent propane... [and] not more than 5.0 liquid volume percent propene." The second reference is the ASTM Designation D 1835-89, which has set specifications for "special-duty LPG" to be consistent with the HD-5 specifications set by the GPA. The ASTM recommends that special-duty LPG be used as a fuel for "internal combustion engines operating under moderate to high severity."

When these regulations were adopted, the Board set an interim limit of 10.0 volume percent propene and a minimum 80.0 volume percent propane content requirement, applicable from January 1, 1993 through December 31, 1994. Starting on January 1, 1995, the propene content is limited to a maximum value of 5.0 volume percent and the minimum propane content is increased to 85.0 volume percent. The Board adopted the 5.0 volume percent limit because of concerns with the high ozone-forming potential of propene. However, the Board provided a two-year delay for the 5.0 volume percent propene requirement because LPG fuel proponents expressed concerns that LPG fuel meeting the requirement would not immediately be available.

B. ANALYSIS OF CURRENT LIQUEFIED PETROLEUM GAS PRODUCTION

LPG is a mixture of gases composed mainly of propane, with varying amounts of propene and butane. LPG is currently produced as a by-product from two sources, either through the processing of natural gas or through the refining of crude oil. LPG produced through the processing of natural gas constitutes roughly 40 percent of the California production. These processing plants are generally located in Central California, near oil producing sites. This LPG contains little or no propene, and generally meets all the specifications of HD-5 propane.

LPG is also produced through the refining of crude oil, of which less than two percent of a typical barrel of crude oil ends up as LPG. This production accounts for approximately 60 percent of the California total. This source of LPG is concentrated near the refining regions of the state, namely the San Francisco Bay area and the South Coast Air Basin. The availability of LPG in California depends on the production rate of gasoline, the type of crude oil a refiner uses, and the rate of importation of LPG into California. The demand for LPG as a whole peaks during the winter months. Typically, about 50 percent of the LPG produced from refining operations meets the HD-5 fuel specifications. The other 50 percent of the LPG produced that does not meet these specifications typically has an average propene content of greater than 10 volume percent, and is intended for nonvehicular commercial and industrial use. Fuel used for these purposes is known as commercial grade LPG.

C. ISSUES ASSOCIATED WITH A 5.0 VOLUME PERCENT PROPENE CONTENT LIMIT

Recently, the WPGA requested the ARB to reevaluate the 5.0 volume percent propene content limit for motor vehicle LPG fuel that will become effective on January 1, 1995. Several issues have recently been raised by LPG marketers regarding their ability to meet this standard.

Being a by-product, natural gas processors and crude oil refiners have little interest in the composition of the LPG that they produce. Often, LPG marketers have no guarantee that the LPG they purchase will meet the specifications for commercial motor vehicle LPG fuel. Some LPG producers will not sell the LPG they produce as motor vehicle fuel; rather, they sell it to LPG marketers as commercial grade LPG. Commercial grade LPG is used in stationary sources and has no requirements on its composition. If the marketers choose to sell the commercial grade LPG as a motor vehicle fuel, they are responsible for assuring that the fuel they sell meets the motor vehicle fuel specifications. Because motor vehicle LPG is only eight to ten percent of the total amount of LPG sold in California, some marketers may opt not to assume this liability and stop selling LPG motor vehicle fuel, thereby reducing the supply of an established alternative fuel.

Because most LPG marketers purchase LPG directly from refinery sources, it may be difficult to secure adequate supplies of LPG that meet the specifications for motor vehicle fuel as of January 1, 1995. Currently, marketers believe that they can secure adequate supplies of LPG that meet a 10.0 volume percent propene limit. However, they believe that the 5.0 volume percent limit would effectively exclude 50 percent of the refinery based LPG production from the California motor vehicle market. Because of the lack of fuel composition requirements on commercial grade LPG, fuel marketers would also need to segregate the two types of LPG, with separate storage, transport, and delivery facilities. In addition, the production of refinery-based LPG versus natural gas processing LPG is geographically segregated, increasing costs and difficulty for some marketers in obtaining HD-5 grade LPG. As a result, there are concerns that maintaining the lower propene content could lead to regional supply shortages.

Finally, some have suggested that changes to refining facilities as a result of the new Phase 2 reformulated gasoline (RFG) requirements may increase the supply of low propene LPG. Refiners are making major modifications to their refining processes and facilities in preparing to comply with the RFG requirements starting in March 1996. These modifications have the potential to reduce or eliminate propene in the LPG fuel. Specifically, propene could be used to produce alkylate to help meet the Reid vapor pressure (RVP) limit in the RFG requirements. Therefore, depending on a refiner's plan to meet the RVP requirement, there may be a demand for propene from the LPG streams. This would effectively remove much of the propene from LPG sold to marketers which would increase the supply of fuel that meets the HD-5 requirements. LPG marketers believe that if refiners choose to use propene in the production of alkylate, adequate supplies of LPG meeting the 5.0 volume percent propene limit would become available.

Currently, there is no market for excess propene in California. Propene is used in the midwest and Texas for petrochemical production. However, for California refiners, it is generally not cost-effective to extract and ship the excess propene to those markets. Because LPG is a byproduct, producers generally will do what ever is most cost-effective.

The HD-5 fuel specifications were originally established by the GPA to ensure a fuel that would provide consistent engine performance characteristics. Propane has higher research and motor octane numbers than propene. Engine manufactures have indicated that a higher propene content could result in poorer engine performance and durability problems. Gumming of the fuel injection system and deposits in the fuel metering system have been observed in vehicles using LPG with a propene content higher than 5.0 volume percent. Also, propene in the exhaust is 19 times more reactive than propane in terms of ozone formation in the atmosphere. To date, there has been limited testing on the effects of fuel propene content on exhaust emissions of propene. The ARB is currently reviewing a proposal from the WPGA to conduct a testing program to evaluate emissions of propene and other ozone precursors from LPG fueled vehicles.

D. PROPOSED MODIFICATIONS

We are proposing to delay the implementation of the 5.0 volume percent propene content requirement another two years, to January 1, 1997, to allow time to evaluate the potential uses of propene in California RFG production. During these two years, additional testing of the effect propene content has on vehicle performance and exhaust emissions from LPG fueled vehicles can be performed. The delay will also allow time to evaluate and prepare for the possible need for segregation of the LPG storage and distribution system to allow for commercial motor vehicle LPG fuel.

Although propene has a higher reactivity than propane, overall emissions from LPG fueled vehicles are still lower than from vehicles that operate on conventional gasoline or reformulated diesel fuel. The delay will help ensure that there are adequate supplies of LPG to meet current motor vehicle demand. This will allow dual-fueled LPG vehicles to operate

on LPG instead of conventional gasoline or diesel fuel. This will also allow dedicated LPG vehicles to continue to operate, reducing the need for conventional gasoline or diesel fueled replacements. Accordingly, we expect that this delay will not result in increased emissions from LPG fueled vehicles from their current levels.

Engine manufacturers have indicated that a two-year delay in the implementation of a 5.0 volume percent propene content limit would still allow them to design to the HD-5 fuel specifications and would not adversely affect their current programs to produce alternative LPG-fueled motor vehicles for California.

E. REACTION OF AFFECTED PARTIES

We held a public workshop on May 10, 1994 and invited comments on the proposal to postpone the implementation of the 5.0 volume percent propene LPG specifications until January 1, 1997. All affected parties were supportive of the proposal. However, auto manufacturers indicated that they do not support the use of 10.0 volume percent propene LPG as a motor vehicle fuel after January 1, 1997. They felt that the two-year delay will provide sufficient time to resolve any remaining motor vehicle LPG supply issues.

V.

ENVIRONMENTAL AND ECONOMIC IMPACTS

A. ENVIRONMENTAL IMPACTS

The proposed specifications for diesel engine certification fuel and in-use compliance testing should not have an adverse impact on air quality. The proposed specifications are similar to the current specifications, except that the proposed specifications place limits on how "clean" the fuel can be with respect to certain properties. Thus, vehicles that do not meet the emission standards when using the current low-aromatics certification fuel will also not meet the emission standards when using the proposed new specifications. In addition, the specifications are designed to be representative of commercially available 10 percent aromatic fuel. The proposed specifications for certification diesel fuel recognize the unique requirements California has placed on commercial diesel fuels, particularly the requirement for low aromatic hydrocarbon content. Thus, we expect that engines certified on the new certification fuel would have similar emissions when the engines are operated on commercial diesel fuels.

The proposed changes to the CNG certification fuel would not have an adverse impact on air quality. We are currently conducting emissions testing of fuels with 0.5 mole percent oxygen and fuels without oxygen. Preliminary results indicate that there will be no significant difference in exhaust emissions between these two types of fuels.

The proposed amendment to delay the implementation of the 5.0 volume percent limit on propene in commercial motor vehicle LPG fuel would not significantly impact air quality. LPG fueled vehicles are currently running on fuel that is often cleaner than the fuel available prior to the adoption of the Alternative Fuels Regulations. In addition, emissions from LPG fueled vehicles (including LPG with a propene content of 10.0 volume percent) are still lower than from vehicles that operate on conventional gasoline or reformulated diesel fuel. The delay will help ensure that there are adequate supplies of LPG to meet current motor vehicle fuel demand. This will allow dual-fueled LPG vehicles to operate on LPG instead of conventional gasoline or diesel fuel. This will also allow dedicated LPG vehicles to continue to operate, reducing the need for conventional gasoline or diesel fueled replacements. It is likely that emissions from these vehicles could increase if the proposed amendment is not implemented. Although we will not realize the additional benefit of the lower propene content for another two years, the uncertainties regarding supply and the potential impacts on the industry justify the temporary delay.

We do not expect the proposed amendments will result in any significant non-air quality adverse environmental impacts.

B. COST IMPACTS

We anticipate that diesel engine and vehicle manufacturers will, where allowed, use the California diesel engine certification fuel instead of one of the federal certification fuels to certify their engines for use in California. This is because the California diesel engine certification fuel results in somewhat lower emissions. Information submitted by certification fuel suppliers indicates that the price will be approximately $2.50 to $3.50 per gallon. Because the proposed diesel engine certification fuel is similar to the current fuel in use, we estimate that there will be no additional costs involved in diesel engine certification as a result of the proposed new fuel. The costs may actually be less because engine manufacturers will no longer need to secure their diesel engine certification fuel supplies from California feedstocks. In addition, as more testing is undertaken and the demand for this fuel increases, the costs will likely be reduced.

The modifications to the CNG certification fuel would not increase the cost of producing the fuel. In fact, the cost may be reduced because CNG producers will have the option of not adding oxygen, thus potentailly removing one step in the blending process.

The proposed delay in the implementation of the 5.0 volume percent propene limit would not result in any additional costs or have an adverse economic impact on businesses. The two-year delay would help ensure that there is an adequate supply of motor vehicle LPG fuel available in California. A shortage of LPG could cause the price of this fuel to increase. The proposed delay would also keep LPG readily available, ensuring that dual-fueled LPG vehicles do not need to operate on conventional gasoline or reformulated diesel fuel, which is more expensive than LPG. The delay would provide adequate time for industry to evaluate the economic feasibility of implementing the 5.0 volume percent propene limit.

C. SMALL BUSINESS IMPACTS

The Government Code requires the ARB to discuss how complying with a proposed regulatory action could have an adverse impact on small businesses (Small businesses are defined by Government Code, section 11342 et. seq.). Thus, we believe that adoption of the proposed regulatory action would not have significant adverse impacts on small businesses.

We have determined that the amendments pertaining to the propene content of commercial motor vehicle LPG fuel could affect small businesses. However, small businesses should not experience an adverse impact because the proposed action provides them additional time to comply with a requirement which is already part of existing law. None of the other amendments will affect small businesses.

D. GLOBAL WARMING AND OZONE DEPLETION

We do not expect that the proposed new specifications for diesel fuel used for engine certification and in-use compliance testing, the proposed amendments to the specifications for CNG, and the proposed amendments to the LPG regulations would increase emissions of greenhouse gases that may contribute to global warming or pollutants that may contribute to the depletion of the ozone layer.

REFERENCES

1. Air Resources Board, Proposed Adoption of Regulations Limiting the Sulfur Content and the Aromatic Hydrocarbon Content of Motor Vehicle Diesel Fuel, Staff Report, October, 1988.

2. Air Resources Board, Proposed Amendments to the Regulation Limiting the Aromatic Hydrocarbon Content of Motor Vehicle Diesel Fuel, Staff Report, October 1990.

3. Air Resources Board, Proposed Specifications for Alternative Fuels for Motor Vehicles, Staff Report, October 28, 1991.

4. Air Resources Board, Proposed Specifications for Alternative Fuels for Motor Vehicles, Final Statement of Reasons, October 1992.

5. Air Resources Board, Public Hearing to Consider Amendments to Regulations Regarding California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-Engines and Vehicles, to Specify Standards for 1994 and Subsequent Urban Bus Engines, Staff Report, April 23, 1993.

6. Air Resources Board, Public Hearing to Consider Amendments to Regulations Regarding California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel-Engines and Vehicles, to Specify Standards for 1994 and Subsequent Urban Bus Engines, Final Statement of Reasons, August 20, 1993.

7. Leffler, William L., Petroleum Refining for the Non-technical Person, PennWell Books, Tulsa, Oklahoma, 1979.

8. Liss, Bill, written correspondence to Steve Francis, December 16, 1991.

9. Liss, Bill, written correspondence to Kim Nguyen, January 14, 1994.

10. Lowi, Alvin Jr., P.E., Emissions Attributable to Liquefied Petroleum Gas Motor Vehicle Fuel Supply, Distribution and Refueling in California, report prepared for the Western Propane Gas Association, February 20, 1994.

11. Lowi, Alvin Jr., P.E., An Examination of the Liquefied Petroleum Gas Motor Fuel Quality Question, report prepared for the Western Propane Gas Association, March 15, 1994.

12. Mc Carthy, Christopher I., Diesel Fuel Property Effects on Exhaust Emissions from a Heavy Duty Diesel Engine that Meets 1994 Emissions Requirements, SAE No. 922267, Amoco Oil Co., 1992.

13. Nikanjam, Manuch, Development of the First CARB Certified California Alternative Diesel Fuel, SAE No. 930728, Chevron Research and Technology, 1993.

14. Pines, Gregory G., written 15-day comments on the Public Hearing to Consider Adoption of Specifications for Alternative Fuels for Motor Vehicles, September 3, 1992.

15. Platz, Bill, personal communication with Air Resources Board staff, April & May, 1994.

16. Sienicki, Edward J., Diesel Fuel Aromatic and Cetane Number Effects on Combustion and Emissions from a Prototype 1991 Diesel Engine, SAE No. 902172, Navistar International, 1990.

17. Urban, Charles M., written correspondence to John Courtis, August 6, 1993.

APPENDICES

APPENDIX A

Proposed Amendments to Sections 1956.8(b), 1956.8(d), 1960.1(k), and 2292.6 of Title 13 California Code of Regulations

PROPOSED REGULATION ORDER

Note: The proposed new language is shown in underline and the proposed deletions are shown in ~~strikeout.~~

Amend Title 13, California Code of Regulations, section 1956.8(b) and (d), to read as follows:

1956.8 Exhaust Emissions Standards and Test Procedures - 1985 and Subsequent Model Heavy-Duty Engines and Vehicles.

(a) [no change]

(b) The test procedures for determining compliance with standards applicable to 1985 and subsequent heavy-duty diesel engines and vehicles are set forth in the "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engine and Vehicles" adopted April 8, 1985, as last amended ~~March 24, 1994~~ [new date], which is incorporated herein by reference.

(c) [no change]

(d) The test procedures for determining compliance with standards applicable to 1987 and subsequent model heavy-duty otto-cycle engines and vehicles are set forth in the "California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles," adopted April 25, 1986, as last amended ~~May 28, 1993~~ [new date], which is incorporated by reference herein.

(e) through (h) [no change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, 43103, 43104 and 43806, Health and Safety Code; and Section 28114, Vehicle Code. Reference: Sections 39002, 39003, 43000, 43013, 43018, 43100, 43101, 43101.5, 43102, 43103, 43104, 43106, 43204, and 43806, Health and Safety Code.

Amend Title 13, California Code of Regulations, section 1960.1(k) to read as follows:

1960.1 Exhaust Emissions Standards and Test Procedures - 1981 and Subsequent Model Passenger Cars, Light-Duty and Medium-Duty Vehicles.

(a) through (j) [no change]

(k) The procedures for determining compliance with these standards are set forth in "California Exhaust Emission Standards and Test Procedures for 1981 through 1987 Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," adopted by the state board on November 23, 1976, as last amended May 20, 1987, and in "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles," adopted by the state board on May 20, 1987, as last amended ~~September 22, 1993~~ [new date], both of which are incorporated herein by reference.

(l) through (p) [no change]

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, 43101, and 43104, Health and Safety Code. Reference: Sections 39002, 39003, 39667, 43000, 43009.5, 43013, 43018, 43100, 43101, 43102, 43103, 43104, 43105, 43106, 43107, 43204, and 43205.5, Health and Safety Code.

Amend Title 13, California Code of Regulations, section 2292.6, to read as follows:

2292.6 Specifications for Liquefied Petroleum Gas

The following standards apply to liquefied petroleum gas (The identified methods are incorporated herein by reference):

Specifications for Liquefied Petroleum Gas

Specification	*Value*	*Test Method*
Propane	85.0 vol. % (min.) a/	ASTM D 2163-87
Vapor Pressure at 100° F	208 psig (max.)	ASTM D 1267-89 ASTM D 2598-88 b/
Volatility residue: evaporated temp., 95% or butane and heavier,	-37° F (max.) 2.5 vol. % (max.)	ASTM D 1837-86 ASTM D 2163-87
Propene	5.0 vol. % (max.) c/	ASTM D 2163-87
Residual matter: residue on evap. of 100 ml	0.05 ml (max.)	ASTM D 2158-89
oil stain observ.	pass d/	ASTM D 2158-89
Corrosion, copper, strip	No. 1 (max.)	ASTM D 1838-89
Sulfur	120 ppmw (max.)	ASTM D 2784-89
Moisture content	pass	ASTM D 2713-86
Odorant	e/	

---

a/ Propane shall be required to be a minimum of 80.0 volume percent starting on January 1, 1993. Starting on January 1, ~~1995~~1997, the minimum propane content shall be 85.0 volume percent.

b/ In case of dispute about the vapor pressure of a product, the value actually determined by Test Method ASTM D 1267-89 shall prevail over the value calculated by Practice ASTM D 2598-88.

c/ The propene shall be limited to 10.0 volume percent starting January 1, 1993. Starting January 1, ~~1995~~1997, the propene limit shall be 5.0 volume percent.

d/ An acceptable product shall not yield a persistent oil ring when 0.3 ml of solvent residue mixture is added to a filter paper, in 0.1 ml increments and examined in daylight after 2 min. as described in Test Method ASTM 2158-89.

e/ The liquefied petroleum gas upon vaporization at ambient conditions must have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over 1/5 (one-fifth) of the lower limit of flammability.

NOTE: Authority cited: Sections 39600, 39601, 43013, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n v. Orange County Air Pollution Control District*, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975). Reference: Sections 39000, 39001, 39002, 39003, 39010, 39500, 40000, 43000, 43016, 43018, and 43101, Health and Safety Code; and *Western Oil and Gas Ass'n v. Orange County Air Pollution Control District*, 14 Cal. 3d 411, 121 Cal. Rptr. 249 (1975).

APPENDIX B

Proposed Amendments to California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles

Proposed

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL ENGINES AND VEHICLES

Adopted: April 8, 1995
Amended: July 29, 1986
Amended: January 22, 1990
Amended: May 15, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: October 23, 1992
Amended: October 22, 1993
Amended: March 24, 1994
Amended: _____

Note: The proposed new language is shown in underline and the proposed deletions are shown in ~~strikeout.~~

The symbol "# # # # #" means that the remainder of the text in the test procedure is not shown in this document, and is not proposed to be amended.

These Standards and Test Procedures incorporate by reference various sections of the Code of Federal Regulations, some with modifications. California provisions which replace specific federal provisions are denoted by the words "DELETE" for the federal language and "REPLACE WITH" for the new California language. California provisions adding new paragraphs are denoted by "ADD." The symbols "*****" and "..." mean that the remainder of the federal text for a specific section, which is not shown in these procedures, has been included by reference, with only the printed text changed. Federal regulations which are not listed are not part of the procedures.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1985 AND SUBSEQUENT MODEL HEAVY-DUTY DIESEL ENGINES AND VEHICLES

# # # # #

86.1313-90 Fuel Specifications. April 11, 1989.

* * * * *

(b)(2) Except as noted below, petroleum fuel for diesel engines...shall be used. For 1993 and subsequent model-year diesel-fueled engines, the petroleum fuel used in exhaust emissions testing may meet the specifications in Table N94-2 of 40 Code of Federal Regulations section 86.1313-94(b)(2), as adopted August 21, 1990, or substantially equivalent specifications approved by the Executive Officer as an option to the specifications in Table N90-2. For 1995 and subsequent model-year medium-duty diesel-fueled engines, and for 1996 and 1997 model-year urban bus engines only, the petroleum fuel used in exhaust emissions testing may meet the specifications ~~of the general reference fuel in Section 2282(g)(3), Title 13, California Code of Regulations,~~ listed below, or substantially equivalent specifications approved by the Executive Officer, as an option to the specifications in Table N90-2. Where a manufacturer elects pursuant to this subparagraph to conduct exhaust emission testing using the specifications in Table N94-2, or the specifications listed below, the Executive Officer shall conduct exhaust emission testing with the diesel fuel meeting the specifications elected by the manufacturer.

Fuel Property	Limit	Test Method a/
Natural Cetane Number	47-55	D 613-86
Distillation Range, degrees F		D 86-82
IBP	340-420	
10 % point	400-490	
50 % point	470-560	
90 % point	550-610	
EP	580-660	
API Gravity, degrees	33-39	D 287-82
Total Sulfur, wt. %	0.01-0.05	D 2622-82
Nitrogen Content, ppmw	100-500	D 4629-86
Total Aromatic Hydrocarbons, vol. %	8-12	D 1313-83, D 5186-91
Polycyclic Aromatic hydrocarbons, wt. % (max)	1.4	D 2425-88
Flashpoint, degrees F (max)	130	D 93-80
Viscocity @ 40 degrees F, centistokes	2.0-4.1	D 445-83

a/ ASTM specifications.

# # # # #

ADD SUBPARAGRAPH (e) TO READ:

# # # # #

(e)(1)(ii) Natural gas used in service accumulation and in exhaust emission testing for 1994 and subsequent model-year engines shall meet the specifications as follows.

Mileage accumulation fuel: Natural gas meeting the specifications listed in Title 13, CCR, Section 2292.5 shall be used in service accumulation.

Emission-test fuel: Natural gas meeting specifications listed in Title 13, CCR, Section 2292.5 as modified by the following: a) methane content at 90.0 +/- 1.0 mole percent; b) ethane content at 4.0 +/- 0.5 mole percent; c) C_3 and higher hydrocarbon content at 2.0 +/- 0.3 mole percent; d) ~~oxygen content at 0.5 +/- 0.1 mole percent~~ oxygen content at 0.5 mole percent maximum; e) inert gas (sum of CO_2 and N_2) content at 3.5 +/- 0.5 mole percent.

# # # # #

APPENDIX C

Proposed Amendments to California Exhaust Emission Standards and Test Procedures for 1987 and Subsequent Model Heavy-Duty Otto-Cycle Engines and Vehicles

Proposed

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

Adopted: April 25, 1986
Amended: June 2, 1988
Amended: January 22, 1990
Amended: May 15, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: October 23, 1992
Amended: May 28, 1993
Amended: _____

Note: The proposed new language is shown in underline and the proposed deletions are shown in ~~strikeout.~~

The symbol "# # # # #" means that the remainder of the text in the test procedure is not shown in this document, and is not proposed to be amended.

These Standards and Test Procedures incorporate by reference various sections of the Code of Federal Regulations, some with modifications. California provisions which replace specific federal provisions are denoted by the words "DELETE" for the federal language and "REPLACE WITH" for the new California language. California provisions adding new paragraphs are denoted by "ADD." The symbols "*****" and "..." mean that the remainder of the federal text for a specific section, which is not shown in these procedures, has been included by reference, with only the printed text changed. Federal regulations which are not listed are not part of the procedures.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1987 AND SUBSEQUENT MODEL HEAVY-DUTY OTTO-CYCLE ENGINES AND VEHICLES

# # # # #

86.1313-90 Fuel Specifications. April 11, 1989.

# # # # #

ADD SUBPARAGRAPH (e) TO READ:

# # # # #

(e)(1)(ii) Natural gas used in service accumulation and in exhaust emission testing for 1994 and subsequent model-year engines shall meet the specifications as follows.

Mileage accumulation fuel: Natural gas meeting the specifications listed in Title 13, CCR, Section 2292.5 shall be used in service accumulation.

Emission-test fuel: Natural gas meeting specifications listed in Title 13, CCR, Section292.5 as modified by the following: a) methane cotent at 90.0 +/- 1.0 mole percent; b) ethane content at 4.0 +/- 0.5 mole percent; c) C_3 and higher hydrocarbon content at 2.0 +/- 0.3 mole percent; d) ~~oxygen content at 0.5 +/- 0.1 mole percent~~ oxygen content at 0.5 mole percent maximum; e) inert gas (sum of CO_2 and N_2) content at 3.5 +/- 0.5 mole percent.

# # # # #

APPENDIX D

Proposed Amendments to California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles

Proposed

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES

Adopted: May 20, 1987
Amended: December 20, 1989
Amended: January 22, 1990
Amended: December 26, 1990
Amended: July 12, 1991
Amended: August 12, 1992
Amended: October 23, 1992
Amended: August 29, 1993
Amended: September 17, 1993
Amended: September 22, 1993
Amended: _____

Note: The proposed new language is shown in underline and the proposed deletions are shown in ~~strikeout.~~

The symbol "# # # # #" means that the remainder of the text in the test procedure is not shown in this document, and is not proposed to be amended.

The numbering convention employed in this document, in order of priority, is 1.a.1.i.A. Any references within specific sections in the Code of Federal Regulations are denoted in order of priority as : (a)(1)(i)(A) - the same numbering system employed in the Code of Federal Regulations.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1988 AND SUBSEQUENT MODEL PASSENGER CARS, LIGHT-DUTY TRUCKS, AND MEDIUM-DUTY VEHICLES

# # # # #

9. **Test Requirements**

a. Fuel Specifications

In paragraph 86.113-90, 86.113-91, and 86.113-94:

# # # # #

5. Amend subparagraph (b)(2) to read:

(2) Except as noted below, petroleum fuel for diesel vehicles meeting the specifications referenced in 86.113-90(b)(2), or substantially equivalent specifications approved by the Executive Officer, shall be used in exhaust emission testing. The grade of petroleum fuel recommended by the engine manufacturer, commercially designated as "Type 2-D" grade diesel fuel shall be used. For 1993 and subsequent model-year diesel vehicles, petroleum fuel meeting the specifications of 86.113-94(b)(2) may be used in exhaust emission testing as an option to the specifications in 86.113-90(b)(2). For 1995 and subsequent model-year diesel-fueled vehicles, the petroleum fuel used in exhaust emission testing may meet the specifications ~~of the general reference fuel in Section 2256(g)(3) [renumbered as 2282(g)(3)], Title 13, California Code of Regulations~~ listed below, or substantially equivalent specifications approved by the Executive Officer, as an option to the specifications in 86.113-90(b)(2) or 86.113-94(b)(2). Where a manufacturer elects pursuant to this subparagraph to conduct exhaust emission testing using the specifications of 86.113-94(b)(2), or the specifications listed below, the Executive Officer shall conduct exhaust emission testing with the diesel fuel meeting the specifications elected by the manufacturer.

Fuel Property	Limit	Test Method a/
Natural Cetane Number	47-55	D 613-86
Distillation Range, degrees F		D 86-82
IBP	340-420	
10 % point	400-490	
50 % point	470-560	
90 % point	550-610	
EP	580-660	
API Gravity, degrees	33-39	D 287-82
Total Sulfur, wt. %	0.01-0.05	D 2622-82
Nitrogen Content, ppmw	100-500	D 4629-86
Total Aromatic Hydrocarbons, vol. %	8-12	D 1313-83, D 5186-91
Polycyclic Aromatic hydrocarbons, wt. % (max)	1.4	D 2425-88
Flashpoint, degrees F (max)	130	D 93-80
Viscocity @ 40 degrees F, centistokes	2.0-4.1	D 445-83

a/ ASTM specifications.

# # # # #

13. Add new subparagraph (g) to read:

(g) Gaseous Fuel Specifications for 1994 and Subsequent Model Year Vehicles.

# # # # #

(2) Dedicated gaseous- and dual-fueled vehicles and hybrid electric vehicles which use natural gas

Mileage accumulation fuel: Natural gas meeting the specifications listed in Title 13, CCR, Section 2292.5 shall be used in service accumulation.

Emission-test fuel: Natural gas meeting specifications listed in Title 13, CCR, Section 2292.5 as modified by the following: a) methane content at 90.0 +/- 1.0 mole percent; b) ethane content at 4.0 +/- 0.5 mole percent; c) C_3 and higher hydrocarbon content at 2.0 +/- 0.3 mole percent; d) ~~oxygen content at 0.5 +/- 0.1 mole percent~~ oxygen content at 0.5 mole percent maximum; e) inert gas (sum of CO_2 and N_2) content at 3.5 +/- 0.5 mole percent.

# # # # #