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STATE OF CALIFORNIA
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374 Springhouse Lane
Hockessin, DE 19707
TEL: 302-234-2031
FAX: 302-234-1754
November 22, 1994

Board Secretary
Air Resources Board
Post Office Box 2815
Sacramento, California 95812

Dear Board Secretary:

Please find enclosed twenty copies of my testimony, presented on behalf of the American Methanol Institute, to be given at the board meeting on December 8/9th. Reference: Proposed amendments to Title 13, California Code of Regulations, Section 2292.1, entitled "Fuel Specifications for M100 Fuel Methanol."

I have requested that equipment be available so that I may show the Board a short video excerpt, lasting approximately 2 minutes, which demonstrates methanol's relative safety compared with gasoline in a fire situation.

I appreciate the opportunity to explain why it is so important to remove the flame luminosity requirement from the M100 fuel specifications.

Sincerely,

Glyn D. Short

California Air Resources Board

Title 13

Testimony to be presented by the American Methanol Institute to the California Air Resources Board meeting December 8/9th 1994, on the subject of

M100 Fuel Methanol Flame Luminosity Requirement

Preamble

Staff proposes to amend Section 2292-1 of Title 13, California Code of Regulations entitled "Fuel Specifications for M100 Fuel Methanol", by eliminating the flame luminosity requirement for those M100 vehicles possessing automatic fire detection and suppression equipment.
It is the position of AMI that this amendment is both welcome and necessary, but it is not sufficient. We present arguments below which provide a compelling case for removing completely the luminosity requirement from the M100 specification.

Statement

Flame luminosity from fuel combustion is a result of visible radiation emitted from hot particulate matter at the edge of the flame. In the case of organic compounds this matter is composed of carbonaceous material formed from the polycarbon species present in the fuel in areas of the flame where there is insufficient air for complete fuel combustion. This material is known as smoke when it cools to the point where it no longer emits visible radiation.

Clean fuels such as LNG (methane or CH_4), Hydrogen (H_2) or M100 (methanol or CH_3OH) either contain no carbon-containing species or comprise so-called 'C1' compounds containing no carbon-carbon bonds. C1 compounds burn cleanly without smoke because it is difficult for them to form C-C bonds which is the essential first step in the process of producing carbonaceous particles. Because these are clean fuels they have relatively non-luminous flames. Any attempt to add additives conferring luminosity would have the effect of making emissions worse.

Therefore the Board has a choice. To insist on M100 luminosity sentences California to forego a future option for clean fueled land transportation. M100 is the brightest long term candidate for a state-wide clean alternative fuel car. A dedicated M100 light duty vehicle offers extremely high performance, low emissions, and outstanding fuel economy (see *Scientific American,* Nov. 1989, volume 260, no.11). M100 also offers the best chance of achieving a true ZEV as the fuel source for the direct oxidation methanol fuel cell being developed by DCT, based on technology developed in California. However, further development funds are not likely to be readily available for a fuel whose use will, in effect, be declared illegal by CARB.

Moreover, as M100 proponents we are not offering low emissions in exchange for enhanced risk. It is our belief that compared with gasoline, the fire safety benefits resulting from methanol's smokeless combustion and advantageous physical properties in a fire situation completely outweigh any concerns associated with methanol's relatively non-luminous flame. Some of these properties are briefly summarized below:

1) Methanol is difficult to ignite compared to gasoline. The minimum ignition temperature for methanol is 725° F vs 430° F for gasoline.

2) Methanol vapor has virtually the same density as air; it will therefore neither pool like gasoline vapor, nor rise into roof spaces like natural gas, but will diffuse to non-ignitible levels in the atmosphere.

3) Burning methanol generates a cool flame. Methanol has an abnormally low flame temperature, and the low radiance of the flame results in an output of radiant heat energy lower than gasoline by a factor of 8. In turn this means less damage to materials near the fire, easier approach of fire fighting personnel and fewer injuries associated with flame proximity.

4) A smokeless fire is a clean fire. In normal fires far more people suffer injury or death from smoke inhalation than from the effects of flames. Absence of smoke makes it easy to see into

and out of fire areas facilitating rescue or escape. (This is the main reason why M100 is the mandatory fuel for Indianapolis race cars.) Thus a methanol-only fire is safer than any other fire based on a liquid fuel of which we are aware. If it is argued that methanol-only fires would be rare, then it will always be true that any other materials likely to be associated with a fire (e.g., oil, plastics, wood) would produce smoke and luminous flame and so avoid the visibility issue.

5) Methanol, like water, has an abnormally high latent heat of evaporation. This heat has to be supplied in order to vaporize liquid methanol to form a flame. This effect coupled with the low heat output makes the rate of flame propagation lower for methanol than for any other comparable liquid fuel. For these reasons a methanol fire spreads much less quickly than a gasoline fire.

6) Because of methanol's low rate of flame propagation, low flame temperature, and low radiant flux, methanol fires are relatively easy to extinguish, and difficult to reiginite, compared with other liquid fuels.

In summary, we believe the proposed ARB regulation will seriously prejudice the development of M100 vehicles meeting ULEV and ZEV standards, including dedicated methanol cars, methanol hybrid electric vehicles, and methanol fuel cell electric vehicles. In addition AMI believes that occurrences of a methanol-only smokeless fire would be extremely limited. To forego all the fire safety and clean fuel advantages enumerated above for the sake of a rare and relatively low hazard event is in our view unjustified. We therefore request that the flame luminosity requirement for M100 fuel methanol be removed from the M100 fuel specifications.

Glyn D. Short

November 22, 1994

- No realistic alternative method exists for providing flame luminosity to M100 fuel
- The M100 fire risk is minimal; other fuels are much higher risk
- The CARB specification will wipe out M100 technology development
- California jobs depend now on M100
- Adverse public reaction to a M100 fire is possible, but its effects have been much exaggerated

M100

Risk	=	Hazard	Pure methanol fire with non-visible flame
		X	
		Effects	Low flame temperature Low radiant heat Low rate of propagation
		X	
		Probability of Occurrence	Low vapor pressure High ignition temperature

Conclusion: M100 fire risk much lower than fire risk associated with other fuels even when flame luminosity is considered.

(2)

STAFF TESTIMONY OF

DAN FONG, MANAGER
TRANSPORTATION, TECHNOLOGY AND FUELS OFFICE

CALIFORNIA ENERGY COMMISSION

Prepared for the Public Hearing on

a Proposed Amendment to

the Luminosity Requirement for M100 Fuel Methanol

California Air Resources Board

December 8-9, 1994

Introduction

The staff of the California Energy Commission (Commission) is pleased to have the opportunity to testify before the Board on the topic of the proposed amendment to the flame luminosity requirement in specifications for M100 fuel methanol. At the outset I would like to commend the Board for its continuing foresight in identifying alternative fuels and other advanced vehicle technologies as important elements in California's strategic plan to reduce mobile source air pollution and reach attainment goals mandated through state and federal Clean Air Acts.

The development of alternative fuels and advanced motor vehicle technologies is crucial in California's search for solutions to air quality problems, and for energy security reasons as well. The Commission believes that transportation fuels diversity attained through the use of alternative fuels and advanced motor vehicle technologies can meet these co-existing and related needs, and improve California's economic climate in the process.

Support for the staff proposal

With regard to the item before us today, the Commission staff is in support of the ARB staff proposal which would amend Section 2292.1 of Title 13 of the California Code of regulations. The Commission staff believes that the additional regulatory language allowing systems which automatically detect and suppress fires provides the necessary regulatory flexibility to maintain existing transit and bus fleets now operating on M100 in California. As the Board may already know, all of California's transit coaches and school buses operating on M100 had fire suppression systems installed at the time the vehicles were manufactured. Other alternative fueled and advanced diesel school buses involved in the Commission's demonstration program have such a system as well.

Commission staff also believe that additional language which holds open the possibility for use of an on-board luminosity enhancement mechanism could be useful in the future for light duty vehicles, however, no one has designed or tested such a system to date. Conceivably, this latter type of technology might be used in M100 passenger car and light duty truck technology where weight and size limitations might render an on board fire detection and fire suppression system impractical and costly in comparison to other fuels.

Formal Risk Assessment is now required

While the immediate needs of Commission heavy-duty vehicle demonstration programs and the transit bus needs of Los Angeles County Metropolitan Transit Authority (LACMTA) would appear to be satisfied by the proposed amendment, the question of the long term need for the M100 flame luminosity requirement should be explored in the broader context of a fire risk assessment.

As the Board is aware, the multi agency funded Methanol Fuel Additive Demonstration evaluation conducted by Southwest Research Institute for the California Air Resources Board, the South Coast Air Quality Management District , and the California Energy Commission did not identify additives for M100 capable of achieving all study objectives. Progress was made on improving luminosity, however, costs of the additive combinations were high and availability was limited. Other important objectives were beyond the scope of the study (i.e. cold start, upper cylinder lubricity, materials compatibility, and light and heavy-duty vehicle compatibility).

Given this situation, the Commission staff recommends that a formal safety risk assessment be initiated over the next two years and that the issue of M100 flame luminosity be incorporated into that assessment. The most compelling reason for this recommendation is the lack of a definitive comparative fire safety risk assessment for M100 and other alternative fuels relative to gasoline and diesel in motor vehicles. Such an assessment would go beyond the question of luminosity, which is but one of a number of fire and other risk elements to be considered in a risk analysis. The real question that should be answered by such an assessment can be formulated as follows:

Given a fire safety risk assessment of gasoline in conventional light duty vehicles, do *alternative fuels (e.g. M-100) provide a greater or lesser degree of fire risk and human injury in representative accident scenarios?*

The Commission believes that this is the crucial question that needs to be answered. In fact, it is the Commission's belief that in this broader context of a full fire safety risk assessment, the work the Board directed staff to undertake when the M100 fuel specification was adopted on March 12, 1992 would then be completed. In addition, this proposed work would also partially fulfill one of the major environmental health, and safety recommendations of the AB 234 Board on Air Quality and Fuels. That recommendation was to undertake risk assessment for all fuels as a continuing process.

Other entities will testify today on the subject of the fuel properties and why the flame luminosity requirement may not be needed in this broader "safety risk" context. The EPA staff analysis appears to indicate that M100 is a safer fuel when compared to conventional fuels based on their own internal fire safety impact study. As you will hear today, National Renewable Energy Laboratory (NREL) is planning on releasing a formal RFP for development of a universal methanol fuel for both light and heavy-duty vehicle applications. One of the tasks under the proposed program is a safety risk assessment of M100, M85, and intermediate methanol formulation in relation to reformulated gasoline and diesel fuel. Commission staff believes that this proposed work may provide the needed risk assessment to address the uncertainty about the role and importance of luminosity in contributing to fire risk.

<u>Previous Fire Safety Risk Assessment Example</u>

Earlier work in this area of fire safety assessment sponsored by the Department of Energy under the Methane Transportation Research , Development and Demonstration Act of 1980 provided one example of an analytical framework to investigate CNG, LPG and LNG under a variety of scenarios. This study is an illustration of one methodology for a comprehensive safety and fire risk assessment which might be used as a starting point in undertaking a safety comparative for M100 and other fuels as well in relation to conventional fuels.

Summary and Conclusion

In summary, Commission staff believe that adoption of the proposed amendments to the flame luminosity requirement for M100 fuel is adequate for the short term. However, the Board should review this issue in another two years after completion of a formal risk assessment for a variety of alternative fuels. The Commission staff believes that this approach will help quantify the luminosity risk of M100 (and other fuel formulations) in relation to other fire safety risk elements in specific motor vehicle accident and fire scenarios. In addition, two years will allow completion of current (and new) research to identify new luminosity enhancers for M100 and evaluate their impact on heavy and light duty vehicle emissions and performance.

The Energy Commission Staff recommends that the Board direct ARB staff to work with the Commission in this effort and report back to the Board in two years to reexamine this issue.

③

South Coast
AIR QUALITY MANAGEMENT DISTRICT

Testimony of

Paul Wuebben
Clean Fuels Officer

to

California Air Resources Board
on

Proposed Changes to the M-100 Fuel Specification

December 8, 1994

Sacramento, California

Good morning Madam Chairwoman and members of the Board:

I am Paul Wuebben, Clean Fuels Officer for the South Coast Air Quality Management District. I appreciate the opportunity to present the District's comments on the staff proposed changes to your methanol specification regulations related to flame luminosity.

The District strongly endorses the changes proposed by your staff today. The MTA has demonstrated its strong environmental commitment by operating the largest number of methanol buses in the United States. The proposed changes to your M-100 specification are essential if these buses are to continue in operation beyond the end of this year.

The District has worked cooperatively with the ARB staff on this issue for several years. As you know, we cosponsored work with ARB to find an additive to M-100 which would provide adequate flame luminosity. Unfortunately, all additives which were identified ended up increasing emissions.

The District believes it is important to put this issue in a longer-term air quality context. If the proposed commercial restrictions on marketing M-100 are maintained indefinitely, a significant barrier to future M-100 research, development and commercialization will be created. For example, a permanent requirement to utilize on-board fire detection and suppression systems would place a major cost disadvantage on the use of M-100.

Such a commercialization barrier could effectively ban the use of M-100, despite its cleaner burning characteristics compared to M-85. As shown in the attached Figure 1, the use of M-100 reduces NO_x emissions by 25 to 50% compared to the use of M-85 in medium and heavy-duty truck engines. Of course, diesel fueled engines would emit even higher levels of NO_x. These NO_x reductions are of critical value to the District as we continue the implementation of our Air Quality Management Plan.

To help take advantage of such benefits, the District has recently entered into a joint program which includes Cummins and Chrysler to develop and demonstrate a medium-duty M-100 engine, using the popular B series 5.9 liter engine. In light-duty applications, Chrysler Corp. is considering using M-100 in its development and optimization of its 2-cycle engine. Volkswagen has also indicated that they prefer M-100 to M-85, for light-duty vehicles. The District is also co-sponsoring a program with the ARB and FEV on the development of a M-100 light-duty vehicle aimed at meeting your Ultra Low-Emission Vehicle standard. The use of M-100 is also an option under consideration as part of the federal Partnership for a New Generation of Vehicles (PNGV).

Perhaps most importantly, M-100 is a key option for early commercialization of fuel cell vehicles which would reform M-100 into hydrogen on board the vehicle. The District is planning to establish the first fuel cell M-100 refueling station in California next year in support of the Department of Energy/Department of Transportation/Georgetown fuel cell/electric hybrid bus currently under development. Equally exciting is the work underway at Jet Propulsion Labs on the development of a direct methanol fuel cell (DMFC), based on M-100.

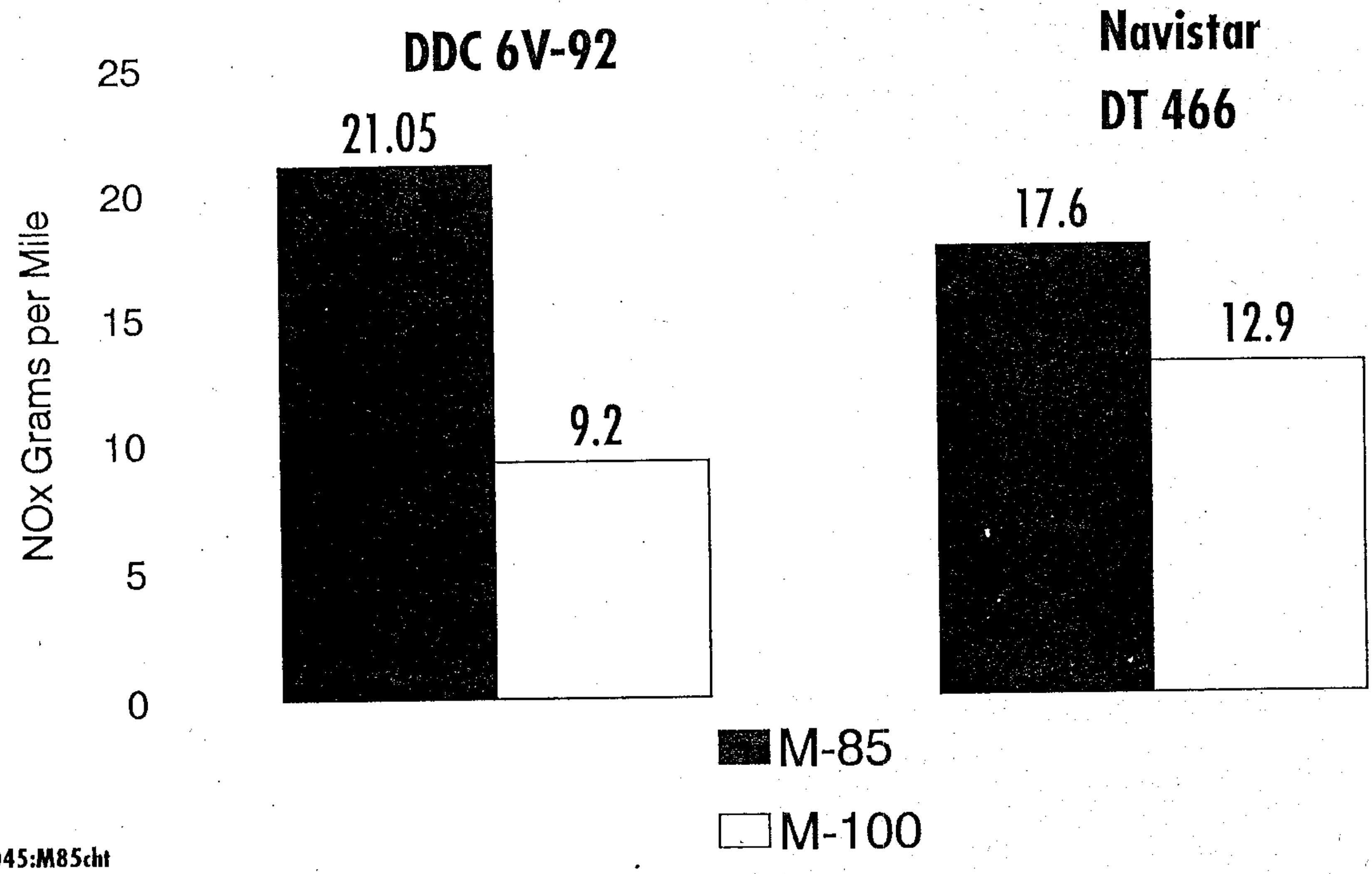
In the interest of long-term air quality progress, it is therefore essential that a permanent barrier to M-100 commercialization not be created. Given the potential long-term importance of M-100, it would be very constructive if a formal technical evaluation, as proposed by the CEC, could be conducted on the relative fire safety of M-100 compared to M-85 and gasoline. This would help provide the Board with a quantitative basis to asses the appropriateness of the proposed luminosity requirement. Clearly, it is harder to start an M-100 fire than one from M-85 or gasoline, due to its lower vapor pressure and higher latent heat of vaporization. If there is a fire, there is less risk from a cooler, slower, smokeless and less toxic M-100 fire. And it is easier to extinguish an M-100 fire relative to other liquid fuel fires. The proposed technical evaluation of these safety issues would therefore help your Board place the issue of luminosity in the most appropriate context. The District would be pleased to join the ARB and the CEC in support of such an evaluation.

The District appreciates the responsiveness of your staff in bringing this issue to you prior to the January, 1995 implementation date. We also believe that the MTA has been very diligent in responding to your regulations, and look forward to working with you and your staff as this issue moves forward. I would be happy to answer any questions that you may have.

PW:fp
11-30-94

Fig. 1

Comparison of M-85 and M-100 NOx Emissions from Heavy-Duty Vehicles



PW045:M85cht

NORMAN D. COVELL
Air Pollution Control Officer

SACRAMENTO METROPOLITAN

AIR QUALITY
MANAGEMENT DISTRICT

RICHARD G. JOHNSON
Assistant Air Pollution Control Officer

4

December 8, 1994

California Air Resources Board
2020 L Street
Sacramento, CA 95812

RE: Amendments to the Fuel Specifications for M100 Fuel Methanol

Thank you for the opportunity to comment on the proposed amendments to the fuel specifications for M100 fuel methanol. Sacramento is a federal and state ozone non-attainment area. Over 70% of ozone precursors are from the mobile source sector. M100 methanol is responsible for approximately 10 tons per year NOx emission reductions in the Sacramento area.

The Sacramento Metropolitan Air Quality Management District does not support the proposed regulation to require all motor vehicles using 100% methanol or M100 as a fuel to be equipped with an automatic fire detection/suppression system. We believe that every fuel should be used in a respectful manner. But fuels by their nature are dangerous and each have different characteristics which need to be considered in determining their safety.

We believe that M100 does not pose an increased danger over the use of gasoline for the following reasons: 1) methanol is much less flammable than gasoline, thus harder to ignite; 2) methanol burns at a lower temperature and produces a lower heat flux than gasoline; and 3) although a methanol flame in a pool fire is hard to detect in direct sunlight the likelihood of other combustible material that would produce smoke and/or flame luminosity being present is good. Some of these materials are tires, paint, underseal, hoses, etc.

The U.S. Environmental Protection Agency has sponsored testing, performed by Southwest Research. A video was produced from the that illustrates these points. I have provided a copy of this video to you as part of my testimony.

Sacramento has also had real-world experience with the use and storage of M100. The Sacramento area currently has four M100 fueling sites. Two are above ground 2,000 gallon tanks and two are public access 10,000 gallon underground tanks. The aboveground tanks and one underground tank have been in use for over one year without incident. These sites have been permitted by their respective fire districts without special conditions.

916-386-6650 • FAX 916-386-6674 • SMAQMD • 8411 Jackson Rd. • Sacramento CA 95826

In addition, Sacramento school districts have been operating 14 buses using M100 for over a year. These buses are equipped with fire suppression systems but not because M100 is more dangerous than other fuels. These buses are part of the California Energy Commission's Clean Safe School Bus Demonstration where all buses are equipped with fire suppression systems regardless of the fuel.

If M100 use is restricted in this way, it may limit the alternative fuel options available to reduce Sacramento's ozone problem. This restriction singles out one particular property of methanol. It should be noted that E100 will have very similar burn characteristics but will not have the same restrictions.

Thank you for the opportunity to address the Board.

Sincerely,

TIMOTHY W. TAYLOR
Director
Clean Fuels Program

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393
(303) 275-3000

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(8)

NREL

December 5, 1994

Board Secretary
California Air Resources Board
2020 "L" Street
Sacramento, CA 95814

Dear Board Secretary:

Enclosed are 20 copies of the National Renewable Energy Laboratory (NREL) Alternative Fuels Utilization Program's comment concerning CARB's methanol (M100) luminosity requirement (Title 13 of the California Code of Regulations, Section 2292.1, entitled "Fuel Specifications for M100 Fuel Methanol"). This statement is representative of NREL's AFUP only, and in no way represents an official United States Department of Energy position. I, Chris Colucci, will represent NREL at the CARB hearings on December 8 and 9. I am not planning to testify at the hearings but will be available to answer any questions concerning our statement.

Sincerely,

Chris Colucci

Chris Colucci
Staff Project Engineer
NREL Alternative Fuels Utilization Program

CC/aw
Enclosures

12/5/94

The Alternative Fuels Utilization Program (AFUP) at The National Renewable Energy Laboratory (NREL)

Statement Concerning The California Air Resources Board's (CARB) Luminosity Requirement in their M100 Specification

In response to CARB's proposed amendments to Title 13, California Code of Regulations (CCR), Section 2292.1, entitled "Fuel Specifications for M100 Fuel Methanol", NREL's Alternative Fuel Utilization Program (AFUP) would like to make the following remarks. These remarks are to be considered representative of NREL's AFUP only, and do not in any manner, represent an official Department of Energy position.

* Before any luminosity requirement becomes a permanent regulation, a thorough assessment of the inherent risks of different fuel formulations should take place. This risk assessment is needed to determine the actual need for a luminosity requirement. The risks associated with each fuel's physical properties are volatility, flammability, fire intensity, flame luminosity, and toxicity. The assessment should determine the risks associated with vehicle use (including on-road accidents and vehicle fires), public refueling, and fuel distribution. The fuel set should include but not be limited to M100, M85, reformulated gasoline, diesel fuel, and any methanol formulations blended specifically for the luminosity requirements. These formulations may include the additives identified in the CARB-funded, methanol project done by Southwest Research Institute. The risk assessment will also need to take into consideration how weathering may effect the fuel and cause the luminosity additive to be less effective in practice then during testing.

* Along with the risk assessment, an engineering analysis of the problems and hazards associated with the transportation, public refueling, and end-use of methanol needs to be done. The analysis should include how refueling system design and user education along with fuel formulation could minimize a fuel's risks. The analysis should also address the potential safety benefits associated with each fuel.

* For any luminosity additive, the additives effect on vehicle emissions, material compatibility, and component durability will need to be investigated. Solving the luminosity requirement at the expense of another area, such as an increase in vehicle emissions, is probably not a viable long term solution.

* To increase the viability of methanol as an alternative fuel it may become necessary to have one methanol formulation for both light and heavy duty vehicles. This common or universal methanol formulation would help alleviate some of the infrastructure problems associated with having two types of methanol fuels (M100 and M85). Also, having one fuel would eliminate the possibility of

somebody refueling with the wrong fuel (i.e. fueling a LDV that has been certified for M85 only with M100 by mistake).

* It is critical to include vehicle hardware as possible solutions to the luminosity requirement. Many of these concepts have great potential. The problem is it takes lots of time and money to design, develop, and test any vehicle component to the auto OEMs satisfaction. If the regulation is written without including possible hardware solutions, then funding of these hardware projects may be discontinued.

* Due to the new regulations for gasoline (lower vapor pressures, reduced aromatics, etc.), even M85 may have a hard time meeting the M100 luminosity requirement of a visible flame throughout the length of the burn. M85's flame may be even less visible if fuel has weathered. What does CARB plan to do if a M85 fuel doesn't meet their luminosity requirement?

* Any methanol formulation will need to consider the issues of cost and complexity. Due to the luminosity requirement, it is likely that a methanol formulation may become quite complicated with specific percentages of different hydrocarbon components. This will have a negative effect on the cost of the fuel. Also, setting specifications and standards, and testing the fuel will become more complicated. These issues might limit methanol's use as an alternative transportation fuel.

Over the next two years the Alternative Fuels Utilization Program at NREL is planning to address many of these issues in a research program they are developing on methanol formulation. The objective of this project is to develop an universal methanol fuel formula that can be used with equal effectiveness in LDVs and HDVs. This formulation must provide satisfactory safety, emissions, performance, durability, and cold start ability for both light and heavy duty vehicles. The methanol fuel formulation will also need to be commercially competitive in terms of cost and distribution.

The first phase of this project will include the risk assessment and engineering analysis mentioned above. Also, a sample set of methanol fuel formulations will be bench tested and evaluated for flame luminosity, flammability, toxicity, vapor pressure, lubricity, and corrosivity. The second phase will include testing the methanol fuel formulations in both light and heavy duty vehicles. The methanol formulations will be tested for their effect on vehicle emissions, engine efficiency, driveability, and cold start ability. The research project will also investigate the use of hardware solutions to the flame luminosity, flammable fuel tank vapors, and cold starting problems.

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of SACRAMENTO-EMIGRANT TRAILS
The Christmas Seal People ®

RECEIVED
DEC 05 1994
Office of the Chairwoman
Air Resources Board

December 1, 1994

Jacqueline Schafer
Chairwoman
California Air Resources Board
2020 L Street
Sacramento, CA 95814

Re: December 8 Public Hearing to Consider Amendments to the Fuel Specifications for M100 Fuel Methanol

Dear Chairwoman Schafer and Members of the Board:

The American Lung Association of Sacramento-Emigrant Trails wishes to comment on this item out of our continued support for an aggressive clean fuels program for California and out of our concern for the unique mobile source emissions problem we face in the Sacramento region.

According to your staff report:

"M100 is a desirable alternative fuel because it promotes energy diversity and because engines which are optimized for M100 have the potential to achieve low exhaust emissions. These engines are especially suited to a heavy-duty application because of their potential to reduce particulate emissions compared to diesel engines."

The report also states that "no additive is currently available which could satisfy the luminosity requirements of M100 fuel without sacrificing emissions performance."

While we certainly share the view that safety of fuel technologies is of critical importance to all of us, we urge that your Board make every effort to avoid impeding or eliminating M100 fuel technology development through such regulations as establishing the luminosity requirement. Rather we would like to see your Board aggressively move forward with a solution to the luminosity issue that does not compromise M100 emission performance.

The Sacramento region is faced with the very difficult task of meeting mobile source emission reduction requirements to comply with the State Implementation Plan recently adopted by your Board. One avenue to reaching compliance might be through more extensive use of M100 fuels, including in light duty vehicles, in our region. Especially in the near term we need to pursue every avenue possible.

We cannot afford to miss any opportunity to advance promising clean fuel technology. We therefore urge your Board to make every effort to support continued M100 technology development, not to impede it.

Thank you for considering our comments.

Sincerely,

Jerry Newman

Jerry Newman
President
Board of Directors

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Summary of the Fire Safety Impacts of Methanol as a Transportation Fuel

Paul A. Machiele
U.S. Environmental Protection Agency
Ann Arbor, MI

Government/Industry
Meeting and Exposition
Washington, DC
May 1-4, 1990

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR AND RADIATION

Board Secretary
Air Resources Board
P.O. Box 2815
Sacramento, CA 95812

Dear Board Secretary:

At the request of the Board we are pleased to offer the following comments for the December 8th public hearing which considers amendments to the fuel specifications for M100 fuel methanol. These comments are offered in the following two areas: the addition of a substance to M100 to enhance its flame luminosity and the need for fire suppression equipment on vehicles fueled by M100.

First, with regard to the need for luminosity enhancing additives, the Board's decision not to require the use of flame luminosity enhancers in M100 fuel appears sound for two main reasons. The first reason is that the chance of a luminous fire occurring is extremely small. It is well understood that M100 burns with a non-luminous flame under certain conditions. The risks associated with non-luminous flames are generally not with fires on vehicles but with separate pool fires in which no other carbonaceous material is burning. EPA funded a study performed by Southwest Research Institute (SwRI) in which the luminosity of M100 and gasoline pool fires was examined along with an investigation of vehicle fuel tank rupture fires with gasoline and M100 vehicles. The results indicated that even with the ignition of a large fuel tank spill other carbonaceous material of the vehicle began to burn after a short time lending luminosity to the flame.

Even if there is a short period of time in which a large vehicle fire could be non-luminous, the incidence of vehicle fires in which there is a major fuel tank rupture as compared to the overall number of vehicle fires is quite low. In fact, an investigation into the National Fire Incident Reporting Service (NFIRS) data base revealed that a vast majority of vehicle fuel fires (over 80%) occur under the hood of the vehicle (which will produce a highly luminous flame because of the other ignitable material under the hood). This leaves a low percentage (less than 20% of all vehicle fires) for other types of fires and of this number only a small percentage are estimated to be major fuel tank rupture fires. Thus, the percentage of total fires, in which there may be a potential for a major amount of fuel to leak and (if M100 is the fuel) produce the potential for an invisible fire for a short time at the beginning of the fire is extremely small. Also, the possibility of producing a sustained invisible flame (throughout the life of the fire) with M100 on a vehicle is a virtual impossibility based on the aforementioned argument that other luminosity producing fuels on the vehicle (paint, rubber, plastic, etc.) will begin to burn.

A second argument that supports the Board's decision not to add flame luminosity enhancers to M100 is the fact that the fire safety benefits of M100 overwhelm any possible added risk due to the luminosity issue. It is poor public policy to restrict a safer fuel from being used because of safety concerns. M100 is far more difficult to ignite than gasoline, because M100 requires a higher concentration of vapor in the air in order to ignite and its volatility is very low so it is not easy for it to achieve this critical concentration. Also, once ignition occurs M100 has a much slower flame speed so it will not spread as quickly nor as vigorously as a gasoline or diesel flame. The radiative and convective heat transfer of an M100 flame to its surroundings is considerably less than that of a gasoline or diesel flame. This will result in less potential for flame spread to other objects or injury to humans. Another important difference between M100 flames and gasoline or diesel flames is the ability to extinguish these flames. A simple application of water (the agent most readily available for most fires) to an M100 flame will serve to cool the flame and dilute the fuel (water and M100 are miscible), thus extinguishing it with relative ease. Gasoline and diesel fuel are much more difficult to extinguish because of the vigor, and heat output of their flames and the fact that these substances do not readily mix with water (see attached SAE paper number 901113 for further information on the relative risks of M100 and gasoline and diesel fires).

Attempts to add luminosity to the M100 flame may result in a change of M100's flammability characteristics. A luminous flame can have greater radiative heat transfer thus increasing the likelihood of ignition of other objects, increasing the burning rate, creating a more vigorous fire and thus posing a greater hazard to humans. Luminosity additives can also increase M100's likelihood of ignition as is the case with the addition of gasoline to M100 to make M85.

The second area we would like to comment on is the proposed use of suppression systems on vehicles using M100 as a fuel. Requiring suppression systems on M100 fueled vehicles is not a luminosity issue (because fires on the vehicle are luminous), but a fire suppression issue. Since M100 is far safer than both gasoline and diesel fuel from the standpoint of ignitability, general flame characteristics, and extinguishment (as discussed previously), if the risks are enough to warrant fire suppression equipment on M100 vehicles they are even more warranted on gasoline or diesel fueled vehicles. If the risks are not great enough to warrant fire suppression systems on all gasoline and diesel vehicles then the decision as to whether to install any fire suppression systems resides with the manufacturer or vehicle purchaser. Thus, we can see little justification of any requirement for suppression systems on M100 powered vehicles while not including gasoline and diesel vehicles.

For all the above reasons we also believe that this issue applies to light duty vehicles as well and we would encourage the consideration of extending the requirement that M100 need not have a luminosity additive to M100 fuel that is used in light duty vehicles due to the inherent safety advantage of M100 over gasoline and diesel fuels. We would also encourage the Board to consider that E100 (neat ethanol) also shares similar properties of flammability with M100. This being the case we believe that it would be sound to include E100 fuel in these specifications.

Thank you for the opportunity to comment on the amendment to the fuel specifications for M100 fuel. If you have any questions, please contact Peter Caffrey of my staff at (313) 741-7829.

Sincerely,

Charles L. Gray Jr.,
Director, Regulatory Programs
and Technology

attachment

Summary of the Fire Safety Impacts of Methanol as a Transportation Fuel

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ABSTRACT

Both for air quality and energy security reasons, a great deal of attention is currently being given to methanol as a candidate to complement petroleum to meet future transportation fuel needs. It is important that safety considerations also be taken into account when analyzing the appropriateness of alternative fuels such as methanol for use in the transportation sector. The current fire safety risk with gasoline is substantial: 216,000 fires resulting in 1,000 fatalities, 7,600 serious injuries, and $430 million in property damage. Due to the lower volatility and higher flammable limit of methanol, pure methanol (M100) is projected to result in as much as a 90 percent reduction in the number of automotive fuel related fires relative to gasoline. A smaller but significant reduction of 40 percent is projected for M85, a blend of 85 percent methanol and gasoline. Assuming that concerns over flame luminosity can be solved with a fuel additive, then due to the greatly reduced heat release rate from a fire, as much as a 95 percent reduction in fire related fatalities and injuries relative to gasoline may result with M100. As much as a 70 percent reduction in fatalities and injuries may be possible with M85. In addition to flame luminosity concerns, fuel tank flammability concerns also exist with M100. While a considerable difference of opinion exists on these issues, it is hoped that by implementing certain vehicle modifications and utilizing fuel additives, these concerns can be greatly reduced or eliminated.

BACKGROUND AND ASSUMPTIONS OF ANALYSIS - This paper addresses the safety aspects of methanol as a fuel, and does not address the feasiblity of the functionality of a methanol powered vehicle. In addition to limitations of the data used as the basis for these comparisons (inaccurate reporting, small sample size for light-duty diesel vehicles, diesel data confounded with other Class II fuel data, no indication of whether the fuel cited as the material first ignited was the fuel on which the vehicle was being operated, differences in vehicle design and usage patterns), the analysis is also limited by our knowledge of the design of future methanol vehicles. It is assumed for purposes of this analysis that fuel leakage and spill rates from methanol vehicles will be no different than from current vehicles. Although material compatibility problems can exist with certain metal, plastic, and rubber components when methanol is substituted for gasoline, it is assumed that these parts will be replaced with methanol compatible parts, yielding no change in fuel release rates. It is further assumed that any other vehicle design changes will not significantly degrade the fire safety of the methanol vehicles relative to their gasoline counterparts. In particular, it is assumed that technology can be developed making cold start of light-duty M100 vehicles feasible, and that this technology will not negatively impact safety. In addition, no effort has been made in this analysis to take into account the possible effects that the increase in fuel consumption associated with the methanol fuels might have on the frequency of fire or the hazard of a fire once it occurs.

VEHICLE FIRES

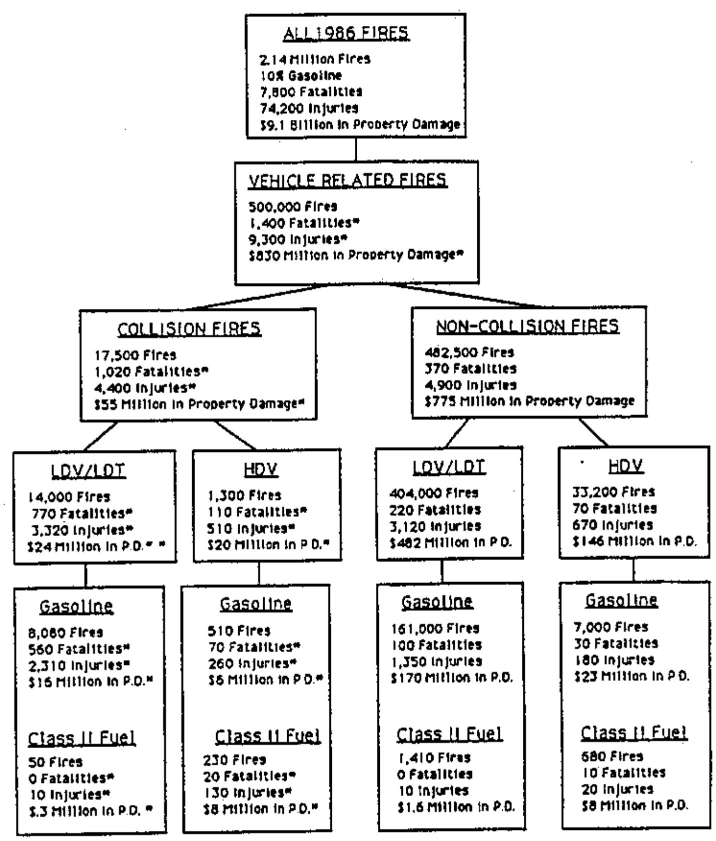
There are an estimated 500,000 collision and noncollision vehicle fires annually in the United States which are unintended, and for which arson is not suspected.(1,2)* These fires result in approximately 1,400 fatalities, 9,300 serious injuries, and $830 million in property damage.(1,2)** The actual cost is much greater due to the lost productivity and medical expenses associated with the injuries and the value associated with the loss of life.

These estimates and those which follow are based primarily on an analysis of the Federal Emergency Management Administration's National Fire Incident Reporting System (NFIRS) for 1986.(1) In the case of collision situations, however, this database underestimates the total number of fires, fatalities, and injuries. A previous EPA report analyzed a number of vehicle fire data reports to develop new estimates for the total number of collision related vehicle fires and the associated fatalities and injuries.(2,4,5) The resulting estimates were based primarily on the National Highway Traffic Safety Administration's (NHTSA) Fatal Accident Reporting System (FARS) and another NHTSA report. The collision results from the NFIRS database used here have been adjusted proportionally upwards to reflect the totals found in the EPA report.

LIGHT-DUTY VEHICLE AND LIGHT-DUTY TRUCK FIRES - Of the 500,000 annual vehicle fires, roughly 84 percent, or 420,000 are associated with light-duty vehicles and light-duty trucks (LDV/LDT).(1) Similarly, roughly 72 percent of the fatalities, 70 percent of the serious injuries, and 60 percent of the property damage is associated with LDV/LDT fires.(1) Figure 1 shows a breakdown of the fires, injuries, fatalities, and property damage into the different vehicle classifications.

FIGURE 1

VEHICLE FIRE DISTRIBUTION (1,2)



* Only those 60 percent assumed to be due to the fire itself (based on a NHTSA report)
* Property Damage.

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* Numbers in parentheses designate references at end of paper.

** Since injuries, fatalities and property damage in vehicle collisions involving fire often occur as a result of the collision, not all of the fatalities, injuries, and property damage can be attributed to the fire. Although it is difficult to assess whether death or injury occurred due to the collision or the fire, it has been estimated in a NHTSA report that as many as 60 percent of the fatalities may be due to the fire, and this is assumed to be true for injuries and property damage as well.(3) The values shown in this paper are thus scaled down by 40 percent.

In roughly 58 percent of collision and 40 percent of noncollision LDV/LDT fires, gasoline is the material reported to be first ignited (See Table 1).(1) These gasoline fires account for roughly 70 percent of the fatalities and injuries in LDV/LDT collision situations, and 45 percent in noncollision situations. Thus, it is apparent that gasoline fires are some of the most hazardous vehicle fires. Figure 1 shows the number of fires which are attributable to gasoline, and the number of injuries, fatalities, and property damage which are in turn attributed to those fires. Even after the extensive improvements over the past few decades to reduce the frequency and size of leaks and spills from light-duty vehicles, fires with gasoline vehicles continue to pose a significant risk. This is attributable in large part to the extreme flammability of gasoline.

Table 1

Percentage of Fires, Fatalities, Injuries, and Property Damage in Which the Fuel was the Material Reported to be First Ignited (1)

	Fires	Fatalities	Injuries	Property Damage
LDV/LDT				
Gasoline				
Collision	58	73	69	68
Noncollision	40	45	43	35
Class II Fuels				
Collision	0.4	0	0.4	1.3
Noncollision	0.4	0	0.3	0.3
HDV				
Gasoline				
Collision	39	61	51	29
Noncollision	21	43	27	16
Class II Fuels				
Collision	18	22	26	38
Noncollision	2	14	3	5

It is likely that the risk due to fire with gasoline is even greater than the estimates made here indicate, since these include only fires where gasoline was the material reported to be first ignited. Gasoline was probably involved in many more of the fires, especially the more severe fires which resulted in injury or death. Unfortunately, no data is presently available which provides any indication as to how many additional fires involved gasoline, or what fraction of the fatalities and injuries were associated with fires where gasoline became involved. As a result, only those fires where the fuel was the material reported to be first ignited are included in any further analysis in this paper. Thus, It should be kept in mind that the projections and estimates in this paper are conservative, and the actual hazard of gasoline may be significantly greater.

Despite the fact that diesel fuel accounted for approximately two percent of our Nation's LDV/LDT travel in 1986, all Class II fuels (the NFIRS database does not distinguish between diesel fuel and other Class II fuels), including diesel fuel were the materials reported to be first ignited in just 1,460 or 0.35 percent of the collision and noncollision LDV/LDT related fires.(1,6) Because of the low number of fires which occur with diesel LDV/LDTs, the database on injuries, and fatalities is extremely limited. No deaths were reported in 1986 to be due to Class II fuel fires, and only approximately 20 injuries. Refer to Figure 1.

In an attempt to quantify just the diesel portion of these Class II fuel fires, actual fire incident reports were obtained. At the time this paper was written, just 35 of the noncollision related LDV/LDT incident reports were obtained which contained enough information to determine the material which was first ignited. Just four, or 11 percent of the fires coded as Class II fuels were actually associated with diesel fuel. The remaining incidents were attributed to motor oil (37%), transmission fluid (17%), gasoline (11%), kerosene (6%), power steering fluid (3%), brake fluid (3%), and other substances (12%). Thus, the LDV/LDT noncollision values in Table 2 for diesel fuel have been scaled down to reflect just 11 percent of the Class II fuel incidences as reported in NFIRS. While similar results could be expected with collision incidences (and heavy-duty vehicle incidents to be discussed later), until such time as the actual incident reports are obtained for these situations, no adjustment will be made. As a result, for LDV/LDT collision (and HDV) situations, diesel fuel fires, fatalities, injuries, and property damage can be considered to be significantly over reported.

Table 2

1986 U.S. LDV/LDT Fires and Deaths, Injuries, and Property Damage Due to Fire* (1,2,3)

Gasoline

	Collision	Noncollision	Total
Fires	8,080	161.000	169,000
Fatalities	560**	100	660
Injuries	2,300**	1,350	3,600
Property Damage ($\$ \times 10^6$)	16**	170	186

Diesel

	Collision	Noncollision	Total
Fires	50	155	205
Fatalities	0	0	0
Injuries	10**	1	11
Property Damage ($\$ \times 10^6$)	0.3**	0.1	0.4

* Only those where the fuel was the material reported to be first ignited.(1)

** Only those estimated to be due to the fire - Assumed to be 60 percent based on a NHTSA report.(3)

Table 2 shows the breakdown of diesel fuel fires, fatalities, injuries, and property damage. Although there are a number of differences in the usage patterns of diesel fuel and gasoline, the low frequency of fire can be mostly attributed to the extremely low volatility of diesel fuel.

HEAVY-DUTY VEHICLE FIRES - Although the majority of the concern with vehicle fires resides with LDV/LDT fires, heavy-duty vehicle (HDV) fires also represent a significant concern. In 1986 there were approximately 180 fatalities, 1180 serious injuries, and $166 million in property damage as a result of the roughly 34,500 HDV fires (See Figure 1).(1,2) In roughly 39 percent of the collision and 21 percent of the noncollision HDV fires, gasoline was reported to be the material which was first ignited.(1) As shown in Table 1, these gasoline fires accounted for roughly 61 percent of the fatalities and 51 percent of the injuries in HDV collision situations, and 43 percent of the fatalities and 27 percent of the injuries in noncollision situations. As with LDV/LDTs, many more HDV fires may ultimately have involved gasoline, but no estimate which incorporates these fires can be made at this time. Figure 1 shows the number of HDV fires, fatalities, injuries, and property damage for which gasoline was the material reported to be first ignited.

Diesel fuel accounted for two-thirds of our Nation's HDV travel in 1986. Despite this, all Class II fuels, including diesel fuel were the material reported to be first ignited in just 31 percent of the collision and 9 percent of the noncollision HDV transportation fuel fires.(1,6) Based on a review of actual incident reports for LDV/LDTs, only about 11 percent of these Class II fuel incidents may be attributable to diesel fuel, due to reporting of other substances as Class II fuels. However, until such time as the heavy-duty incident reports can actually be reviewed, all of these Class II fuel fires will be assumed to be diesel fuel. While vehicle design and driving patterns may be somewhat different between gasoline and diesel HDV types, the vast difference between the numbers of fires is probably best explained by the extreme flammability of gasoline and the low flammability of diesel fuel. Figure 1 shows the total number of HDV fires and associated fatalities, injuries, and property damage annually for which Class II fuels were the material reported to be first ignited, and thus the total number which may potentially be attributed to diesel fuel

PROJECTED METHANOL VEHICLE FIRES

FUEL PROPERTY DISTINCTIONS - Since there are no historical data with methanol fuels, comparisons between the fuels must be done theoretically, based on the characteristics of the fuels. As history with diesel fuel has shown, various fuel flammability characteristics can significantly impact the rate at which vehicle fires occur. A number of the properties of methanol cause it to be both less likely to ignite than gasoline, as well as less likely to cause injury if it does ignite. These properties include the volatility, lower flammable limit (LFL), vapor density, diffusivity in air, and a number of properties which affect the rate at which it gives off heat when it burns.

The issues of flame luminosity and fuel tank flammability are discussed in later sections. While a considerable difference of opinion exists on these issues, due to the belief that the overall hazard associated with them is small in comparison to the overall fire risk, and to the hope that these concerns can be minimized or eliminated entirely, no effort has been made to incorporate the risks associated with these issues into the following projections.

The fuel volatility determines in large part the rate at which vapor is produced from exposed fuel, and thus, the area surrounding a spill where a flammable concentration of fuel vapor may exist. This has a strong effect on the frequency with which ignition occurs.(3,7)

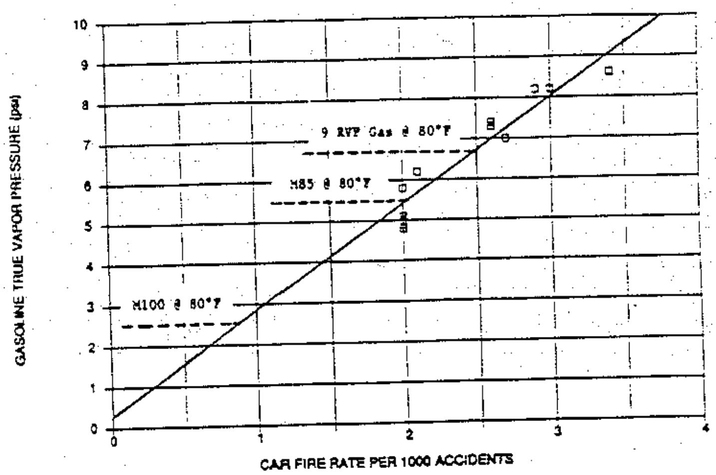
The volatility of pure methanol (M100) is 4.6 psi Reid vapor pressure (RVP) compared to 8 to 16 psi for gasoline, and 7 to 16 psi for a mixture of 85 percent methanol and 15 percent gasoline (M85).(7) Diesel fuel has an extremely low volatility, estimated to range from 0.04 to 0.4 psi RVP.(7) Gasoline is and M85 will be seasonally blended in order to allow for acceptable cold vehicle operation in winter, thus causing the wide range in fuel volatility. In future years, it is anticipated that the majority of gasoline marketed in the summer months will have a volatility of 9.0 psi, and if splash blended, M85 would then have a volatility of approximately 7.5 psi.(7)

In order to quantify the impact of fuel volatility, vehicle fire rate data as a function of the month of the year for the years 1978-84 were obtained for the State of Maryland from a recent NHTSA report.(3) As shown in Figure 2, by utilizing gasoline RVP survey data for the same region and average daily high temperatures for each month, the vehicle fire rate could be plotted as a function of the true vapor pressure (TVP) of the fuel.(8,9) The correlation with an r^2 of 0.89 is remarkable given the possible sources of error in such an analysis.

Extrapolation from the data in Figure 2 shows that the roughly 50 percent decrease in volatility of M100 relative to gasoline may result in as much as a 70 percent reduction in collision related vehicle fires. Due to the much higher volatility of M85, the reduction in the frequency of fire may only be as great as 20 percent relative to that of gasoline.* While the data used in this analysis were from collision situations, it should apply equally well to noncollision situations. This is supported by a comparison of the historical gasoline and diesel fire data. The ratio of diesel to gasoline fires was even lower in noncollision situations than in collision situations.(1)

Figure 2

Effect of Fuel Volatility on the Car Fire Rate (3,8,9)



The LFL determines the minimum concentration of fuel vapor in air which is required for ignition. The higher the LFL, the more unlikely that ignition will occur. The LFL for M100 is roughly 6.0 volume percent in air

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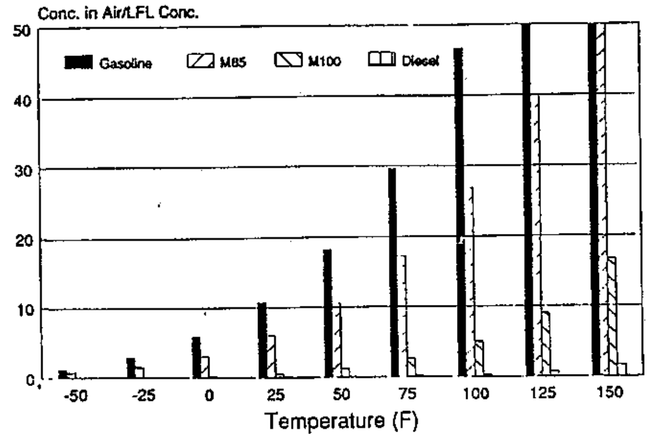
* For the purposes of this paper, the volatility of M85 is determined by assuming that M85 is produced by merely splash blending methanol and gasoline. If M85 is instead specially blended for cold start and driveability purposes to have a volatility which matches that of typical gasoline, as is currently being suggested, then there will be no volatility related safety benefit for M85 relative to gasoline. Cold start questions have also not been addressed in this paper with respect to M100 vehicles.

compared to 1.4 percent for gasoline, 0.6 percent for diesel fuel, and roughly 2 percent for M85.(7) Thus, a concentration in air of more than four times that with gasoline and 10 times that with diesel fuel is required with M100 to achieve ignition. This alone could have a significant effect on the rate of occurrence of fire, and in combination with the low volatility of methanol, could have a dramatic effect on the frequency of fire.

The volatility and LFL can be combined and expressed as the flammability index (the ratio of the amount of vapor produced by exposed fuel to the minimum amount of vapor which is required to achieve ignition - a value greater than one is considered flammable). On a relative basis, the flammability index represents the area surrounding a fuel spill where a flammable vapor concentration might exist. As shown in Figure 3, the flammability index at common ambient temperatures for M100 is roughly 10 percent of that for gasoline. The flammability index for M85 is roughly 60 percent of that for gasoline. At common ambient temperatures the vapor produced by exposed diesel fuel is not flammable, while at temperatures below roughly 50°F M100 is not flammable. (Here the flammability index of diesel fuel in approximated by that of undecane.(10)) M100 and diesel fuel are, however, combustible at these temperatures. If an ignition source comes into direct contact with the fuel, and is of sufficient intensity to vaporize the fuel without being extinguished, then ignition is likely.

The high vapor density of gasoline (2 to 5 times that of air) and diesel fuel (5 to 10 times that of air) causes its vapor to travel along the ground to ignition sources, and settle into low areas, whereas the low vapor density of M100 (1.1 times that of air) causes it to disperse more evenly.(7) This tends to decrease the likelihood of ignition with M100. The vapor density of M85 ranges from 1.1 to 5, and most closely resembles that of gasoline, since roughly 60 percent (on a volume basis) of the vapor initially emitted from exposed M85 is gasoline hydrocarbon.(11)

Figure 3
Flammability Index

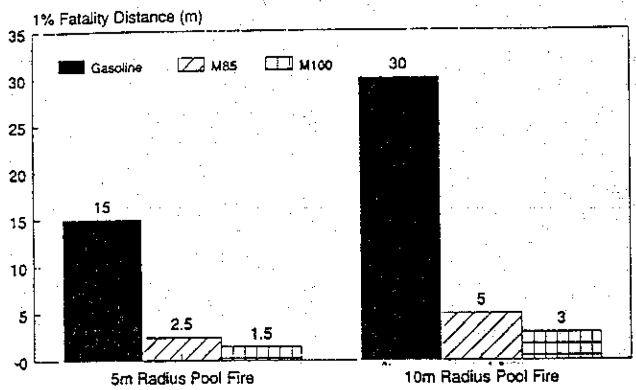


The diffusivity of a fuel vapor determines how rapidly a flammable concentration of vapor will disperse to harmless levels in situations where natural and artificial ventilation are limited. The diffusion coefficient is roughly 2 1/2 times greater for M100 than for gasoline and diesel fuel (0.5 ft^2hr vs 0.2 ft^2hr). However, since in most situations ventilation dominates natural diffusion, this is seldom a significant factor.(7)

In addition to having properties which reduce the frequency with which fire might be expected to occur, methanol's properties also cause it to be less likely to result in injury, death, and property damage, should a fire occur. These properties include: the heat of combustion, the heat of vaporization, the volatility, boiling point, and a number of other properties. These properties combine to cause M100 to burn at a rate roughly 40 percent of that for gasoline and 50 percent that for diesel fuel, and release heat at a rate which is estimated to be just 20 percent of that for gasoline and diesel fuel.(7) Similarly, M85 is estimated to burn at a rate roughly 50 percent of that for gasoline and 60 percent of that for diesel fuel, and release heat at a rate just 30 percent of that for gasoline and diesel fuel.(7) The result of this is that even if a fire occurs, the rate of death, injury, and property damage resulting from the fire should be much lower with the methanol fuels than with gasoline.

Modeling performed for Transport Canada demonstrates this fact.(12) As shown in Figure 4, the distance from a pool fire where one percent of the people exposed will be killed is roughly just 10 and 17 percent, respectively, of that with gasoline when M100 and M85 are the fuel. Although diesel fuel was not included in this analysis, based on its heat release rate when it burns, the one percent fatality distance should be very similar to, if not slightly greater than for gasoline.

Figure 4
1% Fatality Distance
From Fire's Edge [12]



In addition to the much lower heat release rate, M100 also produces no smoke when it burns, further decreasing the likelihood of property damage should a fire occur. In many cases the property damage produced by the smoke is more extensive than that of the fire itself. The lack of a visible flame under certain circumstances, however, will add to the hazard of some M100 fires. This will be discussed in a later section.

PROJECTION BASED ON DIESEL FUEL - In order to estimate the overall risk of fire with M100, the overall fire risk associated with diesel fuel can serve as a surrogate. The significant reduction in vehicle fire rates associated with diesel fuel relative to gasoline is attributed to the extreme low volatility of diesel fuel. A similar effect is expected with M100 due to its low volatility. Although the volatility of methanol is not as low as that of diesel fuel, the lower flammabiltiy limit is approximately 10 times that of diesel fuel. Thus, as shown in Figure 3, relative to gasoline the flammability index for methanol is very similar to that of diesel fuel. The lower vapor density and higher diffusion coefficient of methanol relative to diesel fuel may make the actual likelihood of fire even more similar to that of diesel fuel. In addition, due to the much lower heat release rate of methanol from a fire relative to that of diesel fuel, should a fire occur, the fatalities, injuries, and property damage should be much less likely and severe than with diesel fuel. Thus, while M100 may be slightly more flammable than diesel fuel, the overall fire risk with diesel fuel may be very similar, and may serve as a reasonable projection for the risk with M100. As seen in Figures 5 and 6, the frequency of vehicle fires and associated property damage with M100 (assuming equivalence with diesel fuel) could be 94 percent lower than that with gasoline.*,** Similarly, as seen in Figures 7-10, the number of injuries and fatalities could be reduced by 83 percent.*,** Thus, including only those fires where gasoline was reported to be the material first ignited, replacing the use of gasoline as our transportation fuel with M100 could result in a reduction of 166,000 vehicle fires, 630 fatalities, 3,400 serious injuries, and $202 million in property damage annually.

PROJECTION BASED ON GASOLINE - Relative to gasoline, methanol is a fairly nonflammable fuel. As shown in Figure 2, based on fuel volatility alone, as much as a 70 percent reduction in vehicle fires may occur with M100 relative to gasoline, and as much as a 20 percent reduction for M85. As shown in Figure 3, when the effects of

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* The values shown in Figures 5-10 reflect only those fires where gasoline or diesel fuel (Class II fuels) were the material reported to be first ignited.

** These estimates are probably conservative, since only in the case of noncollision LDV/LDT fires could diesel fuel incidents be separated from all Class II fuel incidents.

Figure 5
1986 LDV/LDT Fire Comparison
(Normalized) [1,2,3,6]

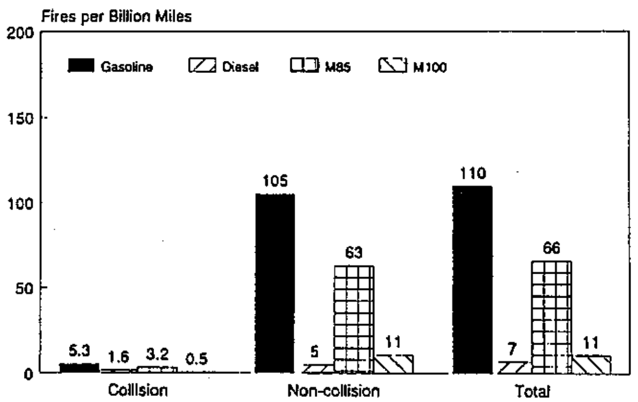


Figure 6
1986 HDV Fire Comparison
(Normalized) [1,2,3,6]

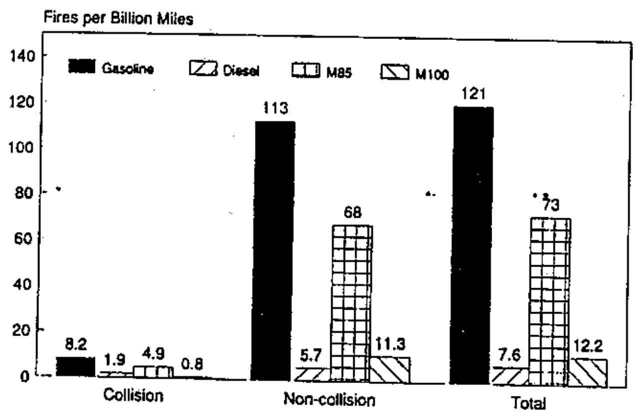


Figure 7
1986 LDV/LDT Fire Fatality Comparison
(Normalized) [1,2,3,6]

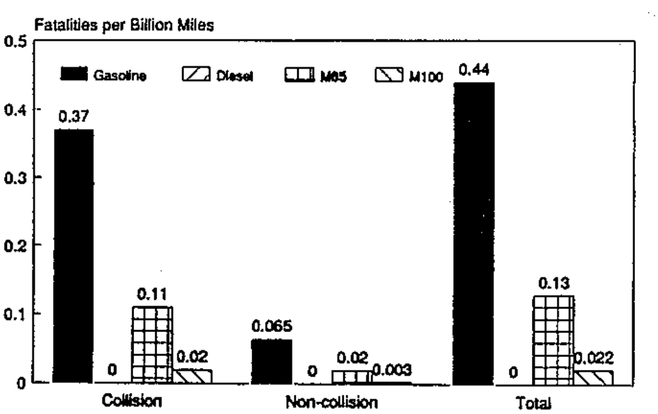


Figure 8
1986 HDV Fire Fatality Comparison
(Normalized) [1,2,3,6]

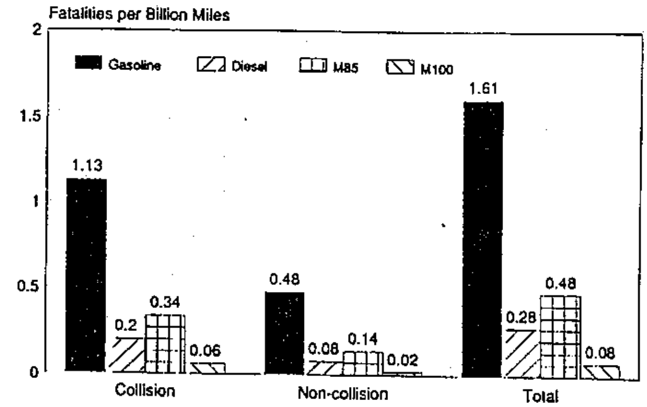


Figure 9
1986 LDV/LDT Fire Injury Comparison
(Normalized) [1,2,3,6]

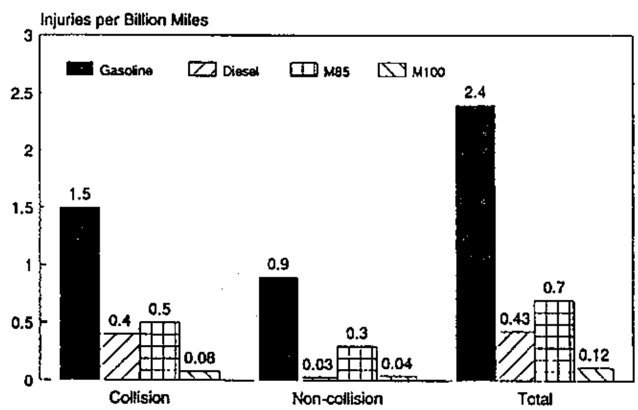
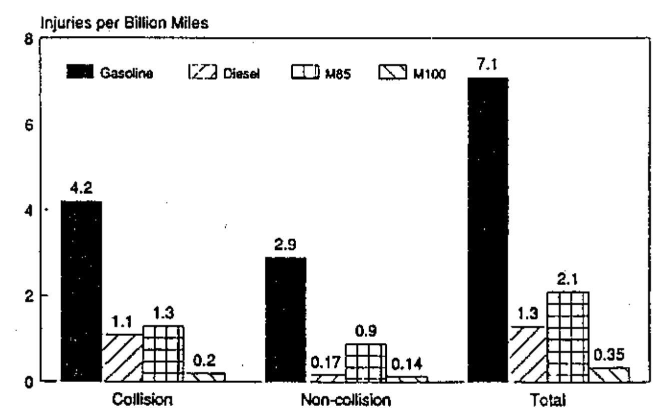


Figure 10
1986 HDV Fire Injury Comparison
(Normalized) [1,2,3,6]



methanol's much higher LFL are combined with the effects of volatility, as much as a 90 percent reduction in the number of vehicle fires may be possible with M100 relative to gasoline, while for M85 as much as a 40 percent reduction may result. The lower vapor density and higher diffusion coefficient of the methanol fuels may argue for even greater reductions, but no attempt has been made here to quantify the effect of these properties.

In addition to being much less likely to ignite, as demonstrated by Figure 4, methanol fires are also much less likely to result in fatalities, injuries, and property damage. Although difficult to quantify, a reduction of 50 percent in the fatality, injury, and property damage rates per fire occurrence are assumed here due to the dramatic reduction in fire severity.

As shown in Figures 7 and 10, based on the assumptions made above, as much as a 95 percent reduction in fatalities, injuries, and property damage associated with fuel related vehicle fires is possible with M100 relative to gasoline. Similarly, for M85 as much as a 70 percent reduction may be possible. Thus, including only those fires where gasoline was reported to be the material first ignited, replacing the use of gasoline as our transportation fuel with M100 could result in a reduction of 159,000 vehicle fires, 720 fatalities, 3,900 serious injuries, and $204 million in property damage annually. For M85 the potential annual reductions are smaller, though also significant: 71,000 fires, 530 fatalities, 2,900 serious injuries, and $151 million in property damage.

NONVEHICLE FIRES

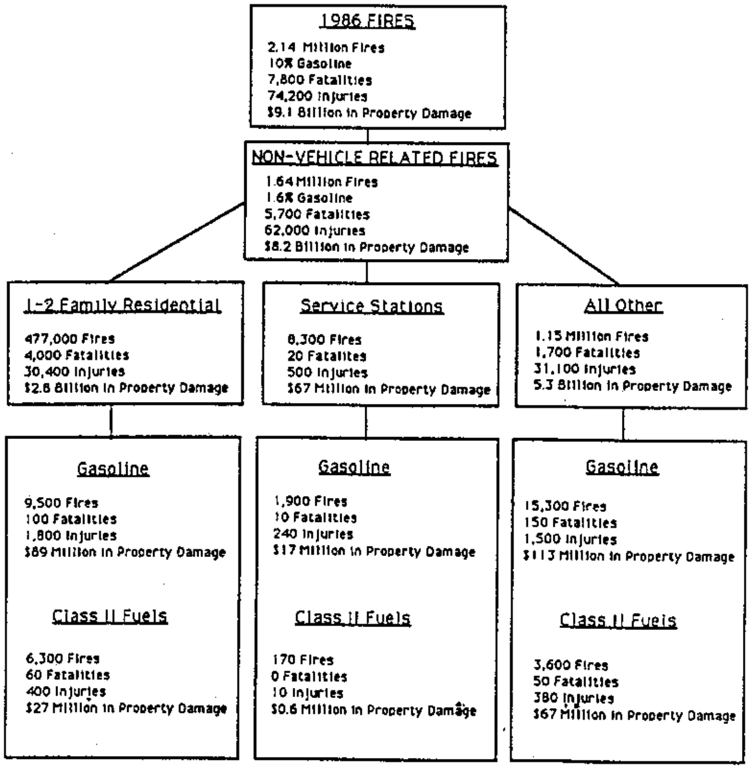
In 1986, there were approximately 1.64 million nonvehicle related fires in the United States.(1) These fires were responsible for an estimated 5,700 fatalities, 62,000 injuries, and $8.2 billion in property damage.(1) In roughly 1.6 percent, or 26,000 fires of these fires, gasoline was the material reported to be first ignited, and in another 0.6 percent, or roughly 10,000 fires Class II fuels such as diesel fuel, kerosene, and home heating fuel were the material first ignited.(1)

ONE AND TWO FAMILY RESIDENTIAL FIRES - As shown in Figure 11, nearly 30 percent, or 477,000 of the nonvehicle fires occur in one and two family residential homes.(1) Roughly 50 percent of the injuries and 70 percent of the fatalities each year in nonvehicle fires occur in one and two family residential homes.[1) In roughly two percent, or 9,500 of the residential fires gasoline was the material reported to be first ignited.(1) As shown in Figure 11, associated with these fires are roughly 100 fatalities, 1,800 injuries, and $89 million in property damage.(1) When all of the different sources of ignition in residential homes are considered, it is remarkable that such a significant number are due to gasoline. This can probably be attributed to the extreme flammability of gasoline. Although a significant fraction of these fires are likely attributable to automotive uses of gasoline (spills and leaks from vehicles, carelessness during vehicle repairs, and misuse as a grease and oil solvent for cleaning automotive parts), many are also attributable to nonautomotive uses such as for lawn and garden equipment and watercraft. Unfortunately the available data did not allow for distinguishing between the uses of the gasoline which caused the fire.

Despite the fact that Class II fuels such as kerosene and home heating fuel are likely used in greater quantities in and around the home than gasoline, they were the material first ignited in just 1.3 percent, or 6,300 of the one and two family residential fires reported in 1986 in the United States.(1) Diesel fuel likely represented only a very small portion of these fires since there are few uses for it in and around the home, and since light-duty diesel vehicles represented only approximately 1.8 percent of the light-duty vehicle fleet in 1986, causing little need to bring it into the home for automotive purposes.(6) Associated with these Class II fuel fires were roughly 60 fatalities, 400 injuries, and $27 million in property damage.(1)

FIGURE 11

NON-VEHICLE FIRE DISTRIBUTION [1,2]



SERVICE STATION FIRES - In 1986, there were approximately 8,300 reported service station fires. Associated with these fires were approximately 20 fatalities, 500 injuries, and $67 million in property damage. As shown in Figure 11, in roughly 23 percent, or 1,900, of these fires gasoline was the material first ignited, resulting in 10 fatalities, 240 injuries, and $17 million in property damage. These compare to approximately 170 fires, no fatalities, 10 injuries, and $0.6 million in property damage with all Class II fuels. In comparison to residential situations, a greater fraction of the Class II fuel fires at service stations were likely to have been diesel fuel, due to its much greater use and presence at service stations. Nevertheless, based on the review of Class II fuel fire incident reports for LDV/LDTs discussed earlier, it is likely that only a small fraction of all of the Class II fuel fires were actually diesel fuel fires. Despite this, even if all service station fires where Class II fuels were the material reported to be first ignited are assumed to have been with diesel fuel, gasoline is still much more hazardous. Figures 12-14 show the gasoline and Class II fires, fatalities, and injuries normalized based on 1986 nationwide gasoline and diesel fuel consumption.(6)

Figure 12
1986 Service Station Fire Comparison
(Normalized) [1]

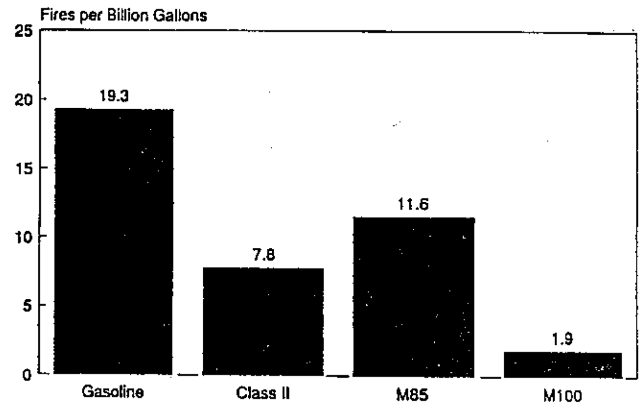


Figure 13
1986 Service Station Fatality Comparison
(Normalized) [1]

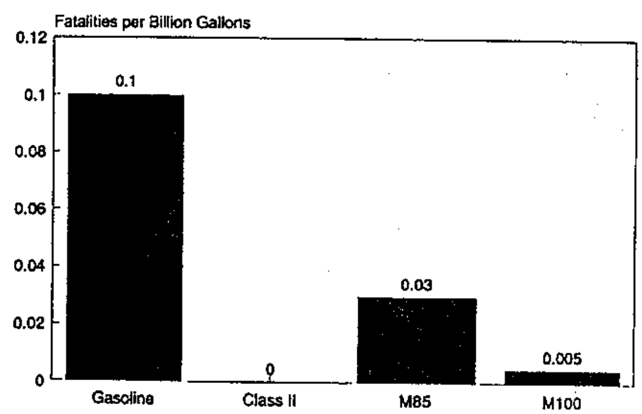
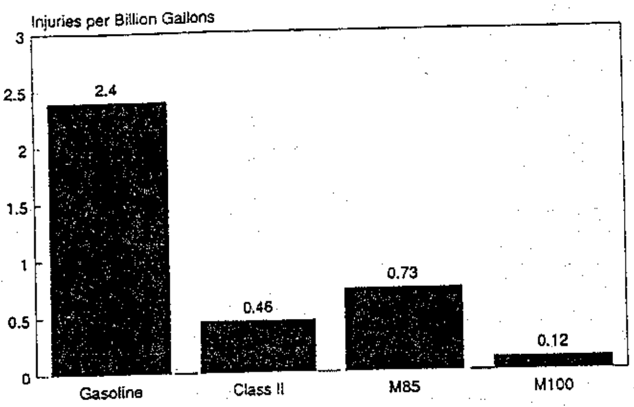


Figure 14
1986 Service Station Injury Comparison
(Normalized) [1]



PROJECTED NONVEHICLE METHANOL FIRES - No actual fire reduction estimates can be made for nonvehicle fires, since the available data does not distinguish between the automotive uses of gasoline which are replaced with the use of methanol, and the nonautomotive uses of gasoline which, at least at present will remain unaffected by an alternative fuels program. In addition, no comparison can be based on the differences in the frequency of historical fires with gasoline and diesel fuel, since the data does not allow for distinguishing between diesel fuel and the other Class II fuel fires. Based on the earlier evaluation of the vehicle fires, the methanol fuels should result in a significant reduction in the number and hazard of nonvehicle automotive fuel related fires as well, but no projections are made here.

FUEL TANK FLAMMABILITY

Concern has been expressed with regard to the potential for a fuel tank explosion with M100, and the extreme hazard which that might represent. Methanol is in the flammable range inside fuel tanks at temperatures ranging from 45 to 109°F. Summer grade gasoline and M85 enter the flammable range inside fuel tanks at temperatures less than approximately -4 and 6°F respectively.(7) For winter grade fuels these temperatures range from -20 to -30°F. Recent information from Phillips 66 Company, however, suggests that gasoline may be somewhat more likely to exist in its flammable range inside fuel tanks.(13) The temperature ranges identified by them were roughly 10°F higher than those listed above, and in addition, they pointed out that weathering of the fuel (reduction in fuel volatility due to preferential evaporative loss of the higher volatility components of the fuel) during use may raise the temperature range an additional 4°F.(13) Weathering likely has an even greater effect on M85, since such a small portion of the fuel is comprised of highly volatile components. M100, since it is a pure compound, does not weather. Phillips also pointed out that summer fuels which are stored for several months may easily exist in the flammable range if they are not used until the winter.(13) In addition, new low volatility reformulated gasolines currently being considered by the oil industry may also exist in the flammable range in fuel tanks during periods of low temperature. On average diesel fuel is not in its flammable range inside fuel tanks until the temperature reaches 130°F, however, this ranges from 70°F to 205°F depending on the particular fuel sample.(1)

Despite the increased potential for a fuel tank explosion with M100, it is, nevertheless, not expected to be a frequent occurrence. Fuel tanks are isolated environments with only a limited number of possible ignition sources. Ethanol, which is also in the flammable range at common ambient temperatures, has been used as a transportation fuel in Brazil for a number of years, apparently without any major safety problems. Even if ignition does occur, limited testing of methanol fuel tanks has shown that the "explosion" is minor and often contained by the fuel tank with no residual fire, and is not the huge fireball which has been suggested.(15)

Nevertheless, due to the potential hazard, precautions should be taken to mitigate the possibility for fuel tank ignition. Fortunately, this is not a difficult task. A number of simple vehicle design modifications can greatly reduce the chance of fuel tank ignition. These include: the use of flame arresters on tank fill necks and vents, modification of in-tank fuel pumps and fuel level sending units to prevent electrical sparks, and the use of foam fillers in the fuel tank to prevent a flame from propagating through the tank. Foam fillers may be the most effective option since they prevent an explosion regardless of the ignition source. These foams are currently used in many military and racing applications with today's fuels, and with some development work should be available for use with methanol fuels as well.

Since safety precautions such as these are likely with widespread use of methanol fuels, there does not appear to be any justification for projecting additional fires or fatalities and injuries due to M100's potential for ignition inside fuel tanks. We would expect this aspect of fuel safety to be comparable to that with today's vehicles.

FLAME LUMINOSITY

The possibility that M100 fires would be invisible to the naked eye is another issue which has raised a great deal of concern with M100 and, in fact, is one of the reasons for the use of M85 today. Pure methanol burns with a flame which is not easily seen under well lit or daylight conditions, provided nothing else is burning along with it. Thus, there is the possibility that in situations where methanol is burning on a surface such as concrete in daylight conditions, a person may unknowingly enter the fire. Although situations such as this should be rare, the emotional and potential liability concerns may overwhelm the actual hazard associated with the fires. Heat radiation and visible heat waves from the fire should provide some warning of its existence, but it is not yet known if these alone would be adequate. To enhance the visibility of the flame, additives in low concentrations are being considered. Early efforts to find acceptable additives focused on various hydrocarbons.(16,17) However, preliminary results from more recent efforts by one of the larger oil companies indicate that various organic compounds at relatively low concentrations may be effective. Assuming continued success at developing these additives, it seems likely that they could be used in M100 should it be used on a widespread scale as a transportation fuel. Thus, there would appear to be no reason to project any increased hazard due to flame visibility concerns if M100 replaces gasoline as a transportation fuel.

SUMMARY AND CONCLUSIONS

No fuel can be made to be perfectly safe, but significant fire safety improvements over the current situation with gasoline can be expected with the use of methanol fuels. The greatest benefits occur with the use of M100. As much as a 95 percent reduction in fatalities, injuries, and property damage associated with fuel related vehicle fires is possible with M100 relative to gasoline. For M85 as much as a 70 percent reduction may be possible. Thus, including only those fires where gasoline was reported to be the material first ignited, replacing the use of gasoline as our transportation fuel with M100 could result in a reduction of 159,000 fires, 720 fatalities, 3,900 serious injuries, and $204 million in property damage annually. For M85 the potential annual reductions are smaller, though also significant: 71,000 fires, 530 fatalities, 2,900 serious injuries, and $151 million in property damage.

By implementing vehicle design modifications and by utilizing fuel additives, most of the concerns over the unique safety hazards of M100 can be eliminated or greatly reduced. Thus, in these areas we would expect the safety of methanol vehicles to be comparable to that with today's gasoline vehicles, and overall a significant improvement in fire safety.

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901113

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STATE OF CALIFORNIA
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05 December 1994

Ms. Pat Hutchens
Board Secretary
Office of External Affairs
Air Resources Board
2020 L Street
Sacramento, CA 95812

Dear Ms. Hutchens:

Enclosed are 20 copies of the Volkswagen statement for distribution at the Board hearing on December 8 and 9 this week. The hearing item is:

"Amendments to the Fuel Specifications for M100 Fuel Methanol".

Please distribute these written comments to the Board. Volkswagen does not plan to make an oral statement.

Volkswagen of America, Inc.

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December 2, 1994

Board Secretary
California Air Resources Board
P.O. Box 2815
Sacramento, California 95812

Dear Board Secretary:

Enclosed please find written comments from Volkswagen of America pertaining to the Board's consideration to amend the specifications for M100 fuel methanol. Volkswagen's comments will specifically address the luminosity issue of M100 fuel.

Due to safety concerns over the visibility of a methanol flame and the Board's position that a luminosity additive that does not sacrifice emissions has not been identified for M100 fuel, the Board has proposed to only allow the sale of M100 fuel in vehicles that are equipped with systems to suppress on-board fires or enhance luminosity. The search for a suitable luminosity additive also continues. It is Volkswagen's position that a luminosity regulation for M100 fuel that requires an additive or additional equipment on a vehicle is not necessary, and will serve to inhibit development of a promising fuel technology.

By their very nature and chemical composition, clean fuels such as Hydrogen, M100, LNG, CNG and produce little visible flame. These are the properties that make these fuels attractive as environmentally responsible, future transportation energies. Volkswagen is interested to hear if CARB has concerns with the luminosity of other clean fuels, as it appears that M100 has been singled out as a fuel that requires extra caution. It is Volkswagen's belief that M100, being liquid and not requiring storage under pressure, has safety merits in terms of handling, transportation and vehicle applications.

It is also Volkswagen's belief that in the event of a methanol fire, M100's burning characteristics can offer safety advantages. Compared to gasoline, methanol is more difficult to ignite, has less dangerous vapor characteristics, propagates a flame more slowly, burns with a cooler flame and is easier to extinguish. In addition, methanol's cleaner flame is easier to see into and through, making a methanol fire emergency easier to contain and reducing the risk of smoke inhalation.

The concern of the Board is focused on vehicle fires. As an automobile manufacturer, Volkswagen is not concerned that an M100

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05 December 1994

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vehicle would offer additional fire risk compared to a gasoline vehicle. Any vehicle fire, regardless of fuel type, that is ultimately feeding from the fuel system is a serious issue. Volkswagen believes that in the case of M100, a fuel related fire would quickly generate visible flame or smoke due to the ignition of other materials on the vehicle (plastic, rubber, paint, etc.).

The potential for M100 as an ULEV fuel for combustion engines and as a ZEV energy source in fuel cells is too important to overlook. All of the transportation fuels, conventional as well as the clean alternatives, have obvious trade-offs. To restrict the development of M100 on luminosity alone seems short-sighted in Volkswagen's view. While transit and school buses may have additional safety concerns not necessarily related to flame luminosity that warrant fire suppression systems, Volkswagen does not share CARB's concern with M100 flame luminosity. Our recommendation is to eliminate the luminosity requirement from M100 fuel.

It is Volkswagen's perception that the public knows very little about alternative fuels. The public will be better served and safer if more energy is spent on programs that increase the awareness of the characteristics and properties of all the future alternative fuels. When Volkswagens that use alternative fuels arrive on the market, educating our consumers on the particular personality of their alternative fuel choice will be one of our highest priorities.

Sincerely,

Stuart Johnson

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