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Summary and Analysis of Comments
on the
Notice of Proposed Rulemaking
for
Emission Standards and Test Procedures
for Methanol-Fueled Vehicles and Engines

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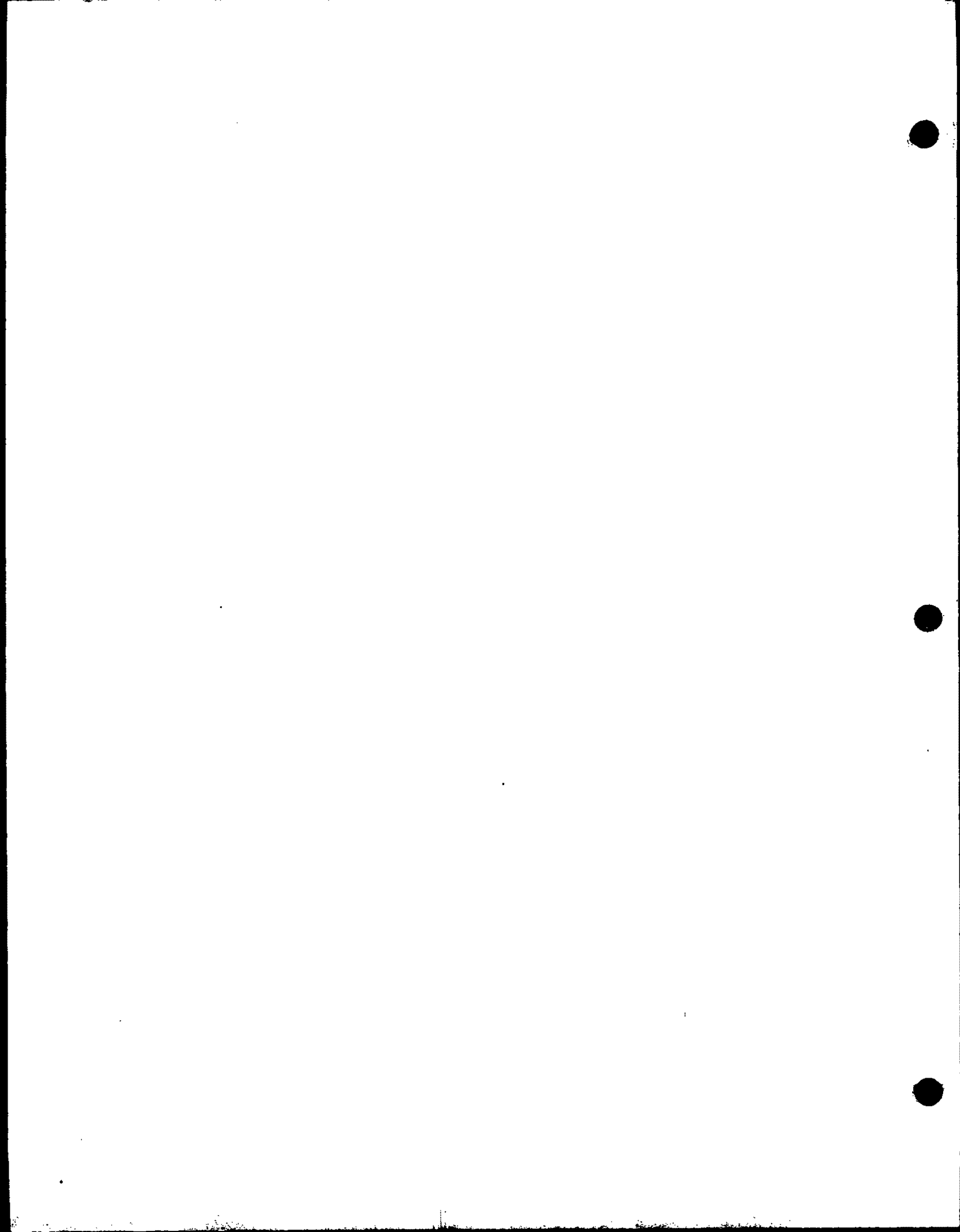
January 1989

Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Sources
Office of Air and Radiation
U.S. Environmental Protection Agency

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Introduction

On April 10, 1984 EPA published an Advanced Notice of Proposed Rulemaking (ANPRM), which announced the Agency's intention to establish emission standards and test procedures for methanol-fueled engines and vehicles of every currently regulated class (51 FR 14244). A workshop was held on May 30, 1984 allowing for public interaction with the Agency on the major issues of the rulemaking. Written comments were also solicited and received. These comments were fully considered by the Agency during its preparation of a Notice of Proposed Rulemaking (NPRM), which was published August 29, 1986, and which put forward EPA's proposed emission standards and test procedures (51 FR 30984). Comments on specific topics as well as general comments were solicited in the NPRM.

A public hearing was held on October 30, 1986 at which oral comments to the NPRM were received and recorded. Written comments were also received from 24 parties following publication of the rulemaking.

This document presents a staff analysis of all relevant comments received in response to the NPRM. Where appropriate, recommendations are made based on this analysis regarding the format of the final rules for methanol engines and vehicles. While the analysis serves to facilitate fulfillment of EPA's legal requirement to consider public comment in the rulemaking process, it also serves in several cases to update the technical analysis presented originally in the Regulatory Support Document (RSD) to the NPRM. The RSD is located in the official rulemaking docket.

A list of commenters, showing date of receipt of comments by the Central Docket Section, is provided below. Common abbreviations for the organization names which are used throughout this document are also listed. It is noted that many of the comments were received subsequent to the deadline (announced in the Federal Register notice) of November 28, 1986. Legally, EPA is not required to consider these comments in formulating the final rules. In fact, it needs to be cautious about considering them, because late commenters may be able to unilaterally rebut arguments put forward by earlier ones. All but two of the late comments were received prior to December 17, within three weeks of the official deadline. Given the significant number of commenters submitting in this time period and considering the minimal period of delay in submission, staff sees no overwhelming reason not to consider their comments. Two of the commenters (MECA and Crowell & Mooring for Brooklyn Union Gas Company) were, however, significantly later in their submissions and would have had substantially greater opportunity to analyze earlier comments in preparing their own. It was, however, the determination of

the authors of this document that consideration of these late comments would not unfairly compromise the opinions of those whose responses were more timely, nor would it materially affect the formulation of the final rule. On this basis, therefore, the authors have chosen to include these comments in the present analysis and to respond to them. In considering the recommendations put forward in this document, the Agency need not be concerned that it is acting inappropriately in response to late comments.*

The comments have been organized into major topic areas which are addressed sequentially. Concerns about EPA's goals in the present rulemaking are addressed first. Due to the number of comments received in response to EPA's proposed organic emission standards, and the overall importance of this issue to the rulemaking, this topic is handled in the next set of discussions. These are followed by sections on the other emission standards that were proposed (carbon monoxide, nitrogen oxides, smoke/particulate, crankcase emissions), emissions averaging and fuel economy programs, test procedures, certification fuel and treatment of flexible fuel vehicles.

* California Air Resources Board's comments were received by EPA in Ann Arbor on or before December 17, 1986, but the copy sent to the docket by the Board was not received. The Office of Mobile Sources sent another copy in March; this explains the late date of receipt on the list of commenters.

List of Written Commenters
to the NPRM*

<u>Docket Item Number</u>	<u>Date Received at Docket</u>	<u>Date of Document</u>	<u>Commenter</u>	<u>Abbreviation</u>
IV-D-1	11-12-86	10-29-86	CNG Services of Pittsburgh, Inc.	-
IV-D-2	11-19-86	11-12-86	Harry H. Hovey, Jr., P.E. (N.Y. Div. of Air Resources)	-
IV-D-3	11-19-86	11-14-86	American Gas Association	AGA
IV-D-4	11-26-86	11-18-86	Caterpillar, Inc.	Cat
IV-D-5	11-26-86	11-21-86	Fiat	-
IV-D-6	11-26-86	11-24-86	Chrysler Corporation	-
IV-D-7	11-28-86	11-26-86	Jenner & Block (Engine Manufacturing Asso.)	EMA
IV-D-8	11-28-86	11-26-86	Volkswagen of America, Inc.	VW
IV-D-9	11-28-86	11-26-86	Nissan Research & Devel., Inc.	-
IV-D-10	11-28-86	--	California Energy Commission	CEC
IV-D-11	11-28-86	11-25-86	Cummins Engine Co.	-
IV-D-12	11-28-86	11-28-86	Nat'l Automobile Dealers Asso.	NADA
IV-D-13	11-28-86	11-25-86	Chevron U.S.A., Inc.	-
IV-D-14	11-28-86	11-28-86	Dept. of Energy	DOE
IV-D-15	12-02-86	11-25-86	George S. Dominguez (Oxygenated Fuels Asso.)	OFA
IV-D-16	12-03-86	11-26-86	General Motors	GM
IV-D-17	12-05-86	11-26-86	Ford	-
IV-D-18	12-05-86	11-20-86	M A N Nutzfahreuge Gmbh	MAN
IV-D-19	12-17-86	12-10-86	Mercedes-Benz Truck Co.	-

IV-D-20	12-17-86	12-08-86	Toyota Tech. Center, USA, Inc.	Toyota
IV-D-21	12-17-86	11-26-86	Chevron	-
IV-D-22	01-21-87	01-08-87	Manufacturers of Emission Controls Asso.	MECA
IV-D-23	03-20-87	03-18-87	Crowell & Moring (Brooklyn Union Gas Co.)	-
IV-D-24	04-14-87	11-26-86	California Air Resources Board	* CARB

* Oral comments were received from Ford, Chrysler, General Motors, and the Oxygenated Fuels Association at the public hearing on October 30, 1986.

Issue: Goals of the Rulemaking

EPA decided to provide emission standards for methanol vehicles in response to public and private interest in methanol as a future motor fuel. The purpose of the rulemaking was to remove a potential impediment to the introduction of methanol as a motor fuel by providing auto manufacturers with an understanding of the regulatory requirements to which methanol vehicles would ultimately be subjected. The Agency's regulatory approach was to provide standards that are comparable in stringency for petroleum-fueled and methanol vehicles. This section of the analysis addresses any comments received which are related generally to the stated purpose and goals of the rulemaking.

Summary of Comments

Several of the commenters felt that EPA should be creating standards for other alternative fuels in addition to methanol, or they felt that methanol vehicles should be regulated to a different degree of stringency than gasoline or diesel vehicles.

The state of New York commented that there is "a substantial research effort being conducted world-wide to produce mixed alcohols from synthesis gas." Such a mixture might contain 50 percent methanol and 50 percent higher alcohols such as ethanol, isopropanol, and tert-butanol, and be economical to produce, while maintaining acceptable performance in combustion processes. New York argued that oxygenated fuels will cause emissions to vary from those resulting from gasoline fuel in a manner related to total oxygen content. This is because of two factors. Incremental additions of oxygen serve 1) to lean out the combustion process incrementally, and 2) to increase the quantity of oxygenated species in the emissions. New York therefore felt that the current regulations should be broadened to include all oxygenated fuels by setting standards that vary with oxygen content; this would eliminate any future need to create separate regulations for each new oxygenated fuel that might make its way to market.

CNG Services of Pittsburgh felt that EPA should recognize natural gas' potential as a clean burning, economically viable alternative to gasoline and set emission standards for natural gas-fueled vehicles as well as methanol vehicles.

General Motors (GM) felt EPA's proposed standards and test procedures constituted "rigid and complex regulation." GM suggested society might be willing to accept higher emissions from methanol vehicles than existing vehicles in order to encourage their introduction on an economically competitive basis with existing technology. They also recommended that manufacturers be allowed to self-certify their methanol vehicles to avoid formal and costly EPA certification. Any

differences in the stringency of requirements for methanol vehicles and existing vehicles could be reconsidered after the new technology had gained a foothold in the market.

Volkswagen and Chrysler expressed the concern that there is potential for much optimization in methanol technology and that the current rulemaking should not inhibit progress through overly restrictive requirements.

Despite generally agreeing with EPA's proposals, both the Department of Energy (DOE) and the Oxygenated Fuels Association (OFA) wished EPA to set standards on an interim basis, to be revisited after several years. DOE noted that the proposed standards will require essentially the same technology as is used on current gasoline vehicles and "do not appear to impose any undue economic burden on potential methanol vehicle manufacturers relative to gasoline vehicle manufacturers." DOE felt, however, that it is too early to determine that the proposed standards represent the maximum control stringency applicable as identified by the Clean Air Act and as achievable using existing or anticipated technology. Interim standards would allow a phase in of maximum control and encourage continued development of methanol engine technology.

Other commenters, such as Chevron, NADA, and MECA, agreed with EPA's position that final rules, comparable in stringency to those currently existent should be established. MECA felt that standards of comparable stringency to gasoline vehicle standards should be technologically feasible and not create a disincentive to the development of methanol-fueled vehicles. MECA argued (similarly to DOE) that if in future it is determined that more stringent standards can be achieved with methanol vehicles in a cost effective manner, they should be established.

Analysis of Comments

With regard to the inclusion of other alternative fuels, such as higher alcohols and natural gas, in the present rulemaking, staff notes that the express purpose of this rulemaking, as first stated in the ANPRM, has always been to establish standards specific to methanol. The rulemaking was initiated in response to congressional, executive, and private sector interest in methanol because of its environmental benefits, its engine performance advantages, and its relative production economics and energy policy implications. Such broad based interest in other fuels has not been demonstrated to date. If, however, such interest develops, the Agency could consider setting standards for these fuels as well. The analyses developed in connection with the present rulemaking are specific to methanol, and it is appropriate that the rulemaking go forward with its focus on that fuel alone. It is noted that if the Agency did wish to expand the scope of this

rule, specific proposals would first have to be issued for comment. Thus it would not be possible for EPA to finalize any approach today that was substantively different than that which was proposed. Finalizing the rules with their present scope, however, does not prevent the Agency from acting in the future to address other fuels with specific proposals.

It is noted that the standards being finalized with this action essentially include methanol vehicles under the same framework of standards that already exist for current Otto-cycle and diesel vehicles, and the Agency could adopt the same approach in regulating other alternative fuels (taking into account factors unique to them as appropriate). Such evenhanded treatment of alternative fuels would provide equitable environmental protection. It would also expedite the process of including other alternative fuels under the regulatory umbrella, since it will not necessarily require returning to square one to derive appropriate standards. Thus while the present rulemaking does not address fuels other than methanol, it does lay the groundwork for an expedited approach to addressing them as it becomes apparent that a lack of standards is hindering their ability to enter the market.

The concerns of various commenters that EPA should not establish regulations which might be too stringent and hinder the development or sale of methanol vehicles are noted. Methanol offers many potential benefits to society, as GM points out, and the Agency has a strong interest in recognizing these benefits wherever possible under the law. By the same token, the Agency is bound to treat methanol vehicles equitably with existing technologies. EPA's goal in this rulemaking has been to apply standards of comparable stringency and environmental benefit to methanol vehicles as currently exist for other technologies. This philosophy is especially warranted if, as DOE and, by inference, MECA point out and as other discussions in this document will show more conclusively, similar control technology (in cost and complexity) can be utilized with methanol vehicles as with gasoline-fueled or diesel vehicles. Thus, the feasibility and relative cost of the standards are not at issue, and there is no basis for setting relaxed requirements for methanol vehicles. The proposed standards do not represent disincentives to produce methanol vehicles, as GM suggests, but merely equitable application of existing environmental protection to a new technology. Furthermore, by providing final, as opposed to interim, standards of comparable stringency to those already existent, EPA will eliminate uncertainty over further potential restrictions. Manufacturers can clearly estimate, under this approach, the regulatory burden to be placed on methanol vehicles and plan their development programs accordingly. This argument is not intended to suggest that once a final standard is established, EPA may not revisit it later. The Agency may revisit any standard not specifically determined by law.

Setting interim standards would, however, require a revisitation, and for EPA to leave the final standards open in this manner would result in uncertainty that could of itself affect manufacturers' willingness to develop methanol vehicle technology.

Conclusions

With regard to the question of including other fuels in this rulemaking, staff believes that EPA's initial focus on methanol was a proper response to the interests of both the public and private sectors. It is therefore recommended that this rulemaking continue to be oriented towards methanol exclusively. Staff does suggest, however, that EPA continue to monitor the potential of other fuel alternatives and take regulatory action in their regard as may be appropriate in the future.

The Agency's initial goal of providing final standards that are comparable to those currently applicable to gasoline-fueled and diesel technology has several advantages. First, it treats methanol vehicles on an equal basis with alternative technologies, allowing the market to operate more efficiently. Second, it removes uncertainty from the minds of key decision makers in the automotive industry. Given the state of development of methanol engine technology and its similarity in terms of emission control technology and cost to gasoline-fueled and diesel engine technology, staff sees no reason to either promulgate less stringent standards for methanol engines or to promulgate interim standards that need to be revisited after a period of time. Staff, therefore, recommends that EPA maintain its previously stated philosophy of providing final emission standards of comparable stringency for petroleum-fueled and methanol-fueled vehicles.

Issue: Basis of Organic Standards

Summary of the Issue

EPA proposed organic emission standards that would limit the amount of carbon allowed to be emitted from methanol vehicles (in the form of methanol, formaldehyde and non-oxygenated hydrocarbon*) to that allowed from current vehicles under their applicable HC standards. Based on the results of computer modeling and the known scientific link between the photochemical oxidation of carbon and ozone levels, EPA concluded that these standards would be sufficient to protect against increases in ambient ozone. The NPRM also discussed the relative merits of proposing standards, based upon photochemical modeling, that would ideally result in equivalent ozone producing potential from methanol and gasoline vehicles. The Agency recognized two major problems with this latter approach. First, there existed significant uncertainty regarding how best to translate modeling results into meaningful standards. Second, EPA was uncertain as to whether photochemical modeling-based standards, which appeared to be less stringent based on a single modeling study of Los Angeles, would provide any real cost advantage to the manufacturer of methanol vehicles. EPA specifically requested comments in both of these areas and stated that "should public comment ... or further scientific inquiry establish a much superior cost effectiveness and demonstrate an acceptable environmental risk, EPA would consider performing further photochemical modeling in order to promulgate such standards in the final rule." The major issue related to this discussion is therefore whether further consideration of photochemical modeling-based standards is necessary. Another issue is whether it is appropriate to regulate the organics under one combined standard, as proposed, or whether there is a need for a separate formaldehyde standard to prevent increases in ozone.

Summary of the Comments

Most commenters found EPA's proposed carbon-based standards acceptable. Many stated that there is currently not sufficient modeling data to support standards based on photochemical modeling. The California Air Resources Board (CARB) supported the carbon standards not only because it believed them to be more scientifically reasonable, but also

* Technically, hydrocarbons are compounds containing only hydrogen and carbon and by definition such compounds are non-oxygenated. The term non-oxygenated hydrocarbon is used here to distinguish the traditional hydrocarbon emissions of petroleum-fueled vehicles from the organic emissions of methanol-fueled vehicles. Hereafter, the term hydrocarbon will be used.

because it believed them to be more stringent than photochemical modeling standards. As a result such standards would do more to ensure that methanol vehicles would be environmentally favorable.

Those who felt that there is currently insufficient photochemical modeling available to provide a basis for standards include CARB, Chevron, Chrysler, GM, Toyota, and the Department of Energy. Three main concerns were raised by the commenters in this regard. First, it was noted that modeling to date has been simplified box or trajectory modeling, which is less accurate than airshed modeling. Second, there were concerns that the available data are all for single-day modeling, which does not provide information on the effect of methanol on multi-day episodes. General Motors explained that:

"Since methanol reacts very slowly, its total effect on air quality cannot be seen accurately in single-day situations."

Finally, Chevron noted that the photochemical modeling based standards discussed in the NPRM were based on a single city-specific study. Variations in local meteorology, ambient conditions, and HC to NOx ratios could cause substantial variations between any two given cities. In addition, CARB suggested that there could be substantial variations from day to day, even within a single city. They stated:

"Since the equivalence of methanol and formaldehyde reactivities to hydrocarbon reactivity depends on atmospheric and meteorological parameters which vary continuously, any factor that would convert formaldehyde and methanol reactivities into equivalent hydrocarbon reactivity would be unreliable."

This statement indicates a lack of confidence not only in the currently available data base, but also in the concept of using photochemical modeling as the basis of setting emission standards.

In addition to the issues of environmental impacts, there are also economic issues. DOE stated:

"The proposed [carbon-based] methanol vehicle emission standards do not appear to impose any undue, economic burden on potential methanol vehicle manufacturers relative to gasoline vehicle manufacturers."

Similarly, MECA stated that the proposed standards "should be technologically feasible and should not create a disincentive to the development of methanol-fueled vehicles."

Ford, GM, and Caterpillar, who felt that EPA should more strongly consider the possibility of photochemical modeling based standards, felt that such standards would be less stringent and therefore less expensive than the carbon-based alternative. Although, GM noted that they were unable to estimate the economic benefits of this approach. The only real data provided in this regard came from Ford; data for 17 methanol vehicles showed that only 65 percent of prototype vehicles could meet the proposed exhaust standards, while 82 percent could meet the photochemical modeling-based standards which were discussed in the NPRM. They did not provide any data on evaporative emissions but did agree that the carbon-based evaporative standards would be feasible. Caterpillar stated that they expect organic emissions from the heavy-duty methanol engine that they are currently developing will exceed the carbon-based standards by at least a factor of two. However, no commenter was able to provide data which would enable a quantitative estimate of the dollar value of any decreased stringency of photochemical modeling-based standards.

Ford emphasized that all of its data was from vehicles with fairly low mileage, and thus did not resolve issues of durability. They did qualify this claim by stating in their oral testimony that they had "not had the benefit of the full development capability of the Ford Motor Company" in the design of their methanol prototypes.

With respect to such concerns about feasibility and durability, MECA stated:

"we expect fully optimized systems with excellent durability will be available and that the standards proposed by EPA will be achievable over the applicable useful life of the various vehicles covered."

In order to compensate for the fact that there may not be enough modeling information to promulgate photochemistry-based standards, Chrysler suggested that the carbon-based standards could be adjusted to make them equivalent in stringency to photochemistry-based standards. As an alternative, General Motors suggested that multi-day airshed modeling of six cities (Los Angeles, Philadelphia, St. Louis, Denver, Washington DC and Houston) or regional modeling would provide sufficient basis to promulgate standards based on photochemistry.

Ford, who presented the results of their own modeling study of 20 cities, was the only commenter to state that there is already enough modeling data to promulgate final photochemistry-based standards. Their analysis showed methanol to be 38 percent as reactive as hydrocarbons, and formaldehyde to be 4.8 times as reactive.

Several commenters (AGA, Brooklyn Union Gas, CARB and Chevron) were concerned about the photoreactivity of formaldehyde. They felt that a separate formaldehyde standard would be necessary to prevent increased ozone formation. AGA argued that formaldehyde is different from other organic emissions. They stated that "formaldehyde is photosensitive and, in sunlight, reacts in such a way that it becomes a key component of smog."

Both CARB and Chevron cited the study by the University of California, Riverside, which indicated that the formaldehyde content of emissions from methanol-fueled vehicles must be less than 10 percent of the organic emissions to prevent an increase in ozone. CARB suggested numerical standards that would limit the amount of formaldehyde emitted to that of current gasoline and diesel vehicles. CARB also listed the toxicity and carcinogenicity of formaldehyde (discussed in a later section) as reasons for these standards. These standards are shown in Table 1. They stated, "based on favorable input from (two) manufacturers and CARB data, CARB believes that a 15 mg/mi formaldehyde emission standard for certification is feasible by 1990."

Nissan warned, however, that:

"If a separate formaldehyde standard is established using formaldehyde emissions data from gasoline fueled vehicles, Nissan anticipates difficulties complying with the standard using currently available technology."

CEC felt that while these standards might not be feasible at this time, they should be imposed as soon as possible.

EMA, however, felt that, in the absence of adequate ozone modeling, it would be inappropriate to promulgate a separate formaldehyde standard based upon photochemical reactivity concerns.

Brooklyn Union Gas felt that it is not sufficient to assess the ozone impacts of formaldehyde using data from prototype vehicles, which, they stated, "cannot be reliably translated into in-use performance."

Analysis of Comments

Based on an analysis performed for the NPRM it was concluded that the carbon-based standards will be sufficient to prevent any increases in urban ozone levels. This analysis was

Table 1

CARB's Recommended Formaldehyde Emission Standards

<u>Vehicle</u>	<u>Cert. Standard</u> (1990 and later)	<u>In-Use Compliance</u>
Passenger Cars	15 mg/mi	23 mg/mi (1990-1993)
LDT, MDV 0-3999 lbs.*		15 mg/mi (1994 and later)
LDT, MDV 4000-5999 lbs.	18 mg/mi	27 mg/mi (1990-1993)
		18 mg/mi (1994 and later)
MDV 6000-8500 lbs.	22 mg/mi	33 mg/mi (1990-1993)
		22 mg/mi (1994 and later)
Heavy-Duty Engines & Vehicles	0.05 g/BHP-hr	0.1 g/BHP-hr (1990-1993)
		0.05 g/BHP-hr (1994 and (later)

* Equivalent inertia weight.

repeated using more recent emissions data (see [1]), as well as newly available photochemical modeling data (discussed below). The results (Table 2) indicate that methanol vehicle emissions under the carbon-based standards will have between 54 and 95 percent of the ozone forming potential of gasoline vehicle emissions, depending on the city and study. The fact that many additional cities have now been modeled (which means a range of conditions were modeled) offers some additional assurance that EPA's earlier conclusion was fairly accurate and that these standards can be expected to be sufficient to generally prevent ozone increases. No commenter disagreed with EPA's earlier finding in this regard.

It should be noted that estimation of the emissions from gasoline vehicles represents emissions of 1990 and later vehicles at 50,000 miles and is based on the assumption that the problems of misfueling (using leaded gasoline in a catalyst vehicle) and excess volatility are corrected. This approach is reasonable for two reasons. First, it results in a much more conservative estimate of the relative ozone forming potential of methanol vehicles than would assuming that these problems are not corrected for gasoline vehicles. (Estimates of the ozone forming potential of methanol vehicles would be about 20 percent lower than those in Table 2 if it were assumed that these problems were not corrected.)

Second, it would not be appropriate to base the analysis on actual current gasoline vehicle emissions which include emissions due to misfueling and excess volatility when these problems may very well be eliminated in the future, and possibly even before methanol vehicles achieve a significant market penetration. The incidence of misfueling has been declining in recent years, and it is not unreasonable to assume that this trend will continue as the availability of leaded gasoline declines in response to lower numbers of non-catalyst vehicles in the fleet. EPA's more stringent controls on addition of lead to fuel may also reduce the incidence and severity of the problem. Therefore, it is appropriate to assume that by time methanol vehicles represent a large fraction of the market, misfueling will be only a minor problem at worst. It is also reasonable to assume, conservatively, that the problem of excess gasoline volatility will be addressed in a similar time frame. On August 19, 1987, the Agency proposed limiting the volatility of in-use fuels to more closely match that of the certification fuel. This action would do much to eliminate the problem of excess volatility.

Assuming that both of these problems that currently affect gasoline vehicle emissions are eliminated is consistent with the approach taken in EPA's earlier analysis as presented in the Regulatory Support Document for the NPRM.

Table 2

Relative Ozone Potential of Methanol Vehicles
Certified to Carbon Based Standards
Relative to Gasoline Vehicles

<u>Study</u>	<u>City</u>	<u>Relative Ozone</u>
SAI	Los Angeles	0.54
SAI	Philadelphia	0.89
Ford	Allentown	0.80
	Atlanta	0.80
	Baltimore	0.88
	Boston	0.76
	Chicago	0.80
	Cincinnati	0.95
	Dallas	0.93
	Detroit	0.81
	El Paso	0.94
	Fort Worth	0.90
	Houston	0.95
	Milwaukee	0.86
	Nashville	0.88
	Philadelphia	0.86
	Phoenix	0.87
	Pittsburgh	0.79
	Scranton	0.83
	St. Louis	0.77
	Washington, D.C.	0.86
	Youngstown	0.93

It was also concluded in the earlier analysis that the proposed carbon-based standards would be feasible, using technology similar to that used for current gasoline vehicles. Ford and Caterpillar argued otherwise, but their arguments are not convincing. They did not demonstrate that there would be any significant hardware burden associated with the carbon standards. To date there has not been extensive development work done on emissions from methanol vehicles. Ford's testimony makes this clear. In Ford's case the only emissions goal was to meet the current gasoline standards. Caterpillar's development goals were not stated. Prototype methanol vehicle emission control systems are not generally optimized with respect to a set of design standards specific to methanol engine technology. Based on the data that is available (including that submitted by Ford, as will be discussed later in this section), it is still expected that the carbon-based standards will be feasible, and as DOE stated, will not "impose any undue burden on potential methanol vehicle manufacturers." This is further supported by MECA's comments.

Thus, the available information continues to suggest that carbon based standards are adequate both to protect against increases in ozone and to be technologically feasible at costs similar to today's standards.

In order to appropriately decide, however, whether to recommend promulgation of such standards or to recommend continued consideration of photochemical modeling-based standards, staff decided to consider the comments in the light of these three relevant questions:

- (1) Is there a sufficient modeling basis for promulgating photochemical standards?
- (2) Would the environmental impacts of these standards be acceptable?
- (3) Would there be a significant cost savings with standards based on modeling?

Before assessing the adequacy of the available modeling base, it would be useful to briefly review photochemical modeling and how EPA suggested it would use it as a basis for standards.

The usual approach to modeling assumes that air parcels can be viewed as completely mixed boxes (or cells) of air, with emissions of pollutants from ground level, dilution by the aloft layer, and, in some models, exchange between the different cells of air. There are two basic types of models: airshed and trajectory. Airshed models use a large number of cells to cover an entire area, and usually have two or three vertical layers in each cell. These cells do not move, but air is moved from cell to cell based on meteorological data. In trajectory modeling, a single cell (or several cells stacked

vertically) moves across the modeled area. Often the path followed is determined from a previous airshed run; however, in some cases it is simply assumed. Chemical reactions are modeled by a chemical mechanism, which is a system of rate equations. By modeling the mass transfer and chemical kinetics simultaneously, the model is able to predict concentrations of various pollutants inside an air parcel as a function of time. The inputs to these models include meteorology, emissions (amount and speciation), and initial and boundary conditions. The outputs can be concentration profiles for various compounds, but usually just the maximum hourly ozone concentration is reported. Results for a set of emission scenarios, defined by the amount and chemical composition of the emissions used as input to the model, are typically included in a photochemistry study, along with appropriate sensitivity runs to vary background and initial conditions.

EPA has found it useful, when using photochemical models to evaluate the impact of methanol fuel use on ambient ozone levels, to divide mobile source organic emissions into three groups: hydrocarbons, methanol, and formaldehyde. By assuming that peak hourly ozone levels for the modeled area are linear functions of each of these groups of emissions, the Agency developed a simple model which can predict changes in the maximum ozone levels from changes in emissions. This assumption of linearity simply means that the reduction in maximum ozone level is proportional to the reductions in the emissions of each group, weighted by its relative reactivity.

In EPA's model, the relative reactivity for a group of emissions is defined as the peak hourly ozone produced by those emissions divided by the peak hourly ozone produced by the same amount of mobile source hydrocarbon emissions. For example, a relative reactivity of 0.50 would mean that emissions of a certain type (e.g., methanol) would produce only 50 percent as much ozone as the same amount (in carbon) of mobile source hydrocarbons.

In order to calculate the relative reactivities for methanol and formaldehyde it is necessary to have modeling results for at least four different emissions scenarios. Of these one must be a base case (i.e., current emissions), one must be a blank case (i.e., mobile source hydrocarbons removed), and the other two must include some combination of methanol and formaldehyde emissions. The peak ozone produced by mobile source hydrocarbons can be found by subtracting the maximum ozone concentration of the blank case from the maximum concentration of the base case. The blank case concentration is also subtracted from the other cases, and the peak ozone produced by the methanol and formaldehyde is found algebraically. This type of model was developed in Appendix A of the Regulatory Support Document, where it was shown to

accurately predict ozone levels for various substitution scenarios for Los Angeles, as modeled by SAI.

Many of the commenters agreed that the single study used to develop the example of a photochemical modeling-based standard for the NPRM was not a sufficient basis for promulgating final standards. To date there have been only a limited number of studies involving photochemical modeling of methanol substitutions. Of these, EPA finds that only three are appropriate for purposes of developing standards; they are:

- (1) SAI's study of Los Angeles for ARCO, February 1983[2]
- (2) SAI's study of Philadelphia for EPA, March 1986[3]
- (3) Ford's study of 20 non-Californian cities 1985[4]

The first study was considered in the NPRM, but the other two have become available more recently. These studies all included runs for the base case, no mobile sources, and at least two combinations of methanol and formaldehyde emissions. A study of Los Angeles by Jet Propulsion Laboratory[5] was not used because it did not have a "no mobile sources" case.

The three studies that were appropriate for EPA's current purpose have some similarities. For example, the two SAI studies both included some airshed modeling, and all three studies used some form of the Ozone Isopleth Plotting with Optional Mechanisms (OZIPM) model which incorporated a modified version of the Carbon-Bond Mechanism for kinetics.[6] The OZIPM is a single-cell trajectory type model. As was mentioned previously, this type of modeling only provides the ozone values for one air parcel, while airshed modeling predicts values for the entire modeled domain. The Carbon-Bond Mechanism simulates chemical kinetics using reactions between types of chemical bonds, and not between explicit compounds. This is done to limit the number of rate equations in the mechanism.

The SAI study of Los Angeles modeled a 24-hour period of June 26th and 27th, 1974. The study included a base case run of the entire airshed that was validated against monitor data. This run was used to identify the trajectory of the air parcel which had the maximum one-hour ozone concentration. Additional scenarios were run for this trajectory only, since it is much less expensive to model a trajectory than it is to model an entire airshed. Considerable effort was put into developing the input for this study, including the base case emissions, which were projected to 1987. Scenarios with replacement of emissions from gasoline vehicles by various amounts of methanol and formaldehyde were investigated by SAI. Selected results of this modeling are shown in Table 3.

Table 3
Selected Results of SAI Study of Los Angeles

<u>Scenario*</u>	<u>Maximum 1-hour O₃(ppm)</u>
Base Case	0.273
Mobile Sources Replaced with 100% Methanol**	0.188
Mobile Sources Replaced with 80% Methanol & 10% Formaldehyde	0.213
Mobile Sources Replaced with 80% Methanol & 20% Formaldehyde	0.237
Mobile Sources Replaced with 180% Methanol & 20% Formaldehyde	0.273
Mobile Sources Replaced with 135% Methanol & 15% Formaldehyde	0.263
No Mobile Sources	0.186

* All scenarios use base case NO_x emissions.

** All percentages are with respect to moles of carbon.

The SAI study of Philadelphia was similar to its study of Los Angeles. In this study SAI modeled a 16-hour period of July 13, 1979 with emissions projected to the year 2000. The airshed modeling was used in a similar fashion as in the LA study to identify the trajectory of the peak ozone parcel. Trajectory modeling was then used to identify the effect of various methanol substitution scenarios on peak ozone concentrations in this parcel. EPA later performed additional trajectory simulations, extending the modeling period to 19 hours.[7] Two of these additional runs were duplications of the "base case" and "zero mobile source hydrocarbon case" runs performed by SAI. The "base case" duplication after 16 hours showed good agreement with SAI's results (0.202 ppm of ozone versus SAI's 0.204 ppm), but the "zero mobile source hydrocarbons case" did not (0.171 ppm versus SAI's 0.156 ppm). Discussions with SAI have failed to resolve this discrepancy. Additionally, in each simulation performed by EPA the ozone concentration in the parcel was still increasing after 16 hours, and reached its maximum between 16 and 19 hours. For these reasons, only the results of EPA's simulations are used here. These results are shown in Table 4.

Ford's study modeled ozone exceedances in 20 non-attainment cities outside of California using the City Specific EKMA Model. This approach does not use an airshed model to generate trajectories; instead simplified trajectories are assumed. This assumption precludes the use of information about the actual trajectory, such as the velocity, whether it passes over any distinct sources which may or may not be affected by methanol substitution, and whether the air parcel undergoes significant local stagnation. Emissions data for this study were obtained primarily from state SIPs, but default values were used to speciate organic emissions. Some cities, however, may have organic emissions which are different from default emissions (perhaps due to a particular industry's local predominance). The model's assumptions do not allow situations such as this to be addressed. These two assumptions could have a significant effect on the accuracy of the study and thus, the results must be used with some caution. That is, for any given city in the study, the results might not be representative of what would typically or, for that matter, ever happen in use in that city.

In each of the cities four scenarios were modeled:

- (1) Base case.
- (2) All LDV hydrocarbons replaced with methanol on a one-to-one carbon basis.
- (3) All LDV hydrocarbons replaced with a 90 percent methanol, ten percent formaldehyde mixture on a one-to-one carbon basis.
- (4) Blank case; where all LDV hydrocarbons are removed.

Table 4
Selected Results of SAI's Study of Philadelphia

<u>Scenario*</u>	<u>Maximum 1-hour O₃(ppm)</u>
Base Case	0.2267
Mobile Sources Replaced with 15% Methanol**	0.1951
Mobile Sources Replaced with 25% Methanol	0.1965
Mobile Sources Replaced with 50% Methanol	0.1999
Mobile Sources Replaced with 75% Methanol	0.2033
Mobile Sources Replaced with 1% Formaldehyde	0.1951
Mobile Sources Replaced with 5% Formaldehyde	0.2032
Mobile Sources Replaced with 10% Formaldehyde	0.2126

* All scenarios use base case NO_x emissions.

** All percentages are with respect to moles of carbon.

The results are shown in Table 5.

As stated before, if one assumes that ozone production is a linear function of emissions, then one can use these modeling results to create a linear model for ozone formation, as was done previously with the results of SAI's study of Los Angeles. This approach was found to accurately predict ozone levels for a few other scenarios in the Los Angeles study. It is now shown to also work very well with the Philadelphia study. Unfortunately, it was not possible to test the appropriateness of the linear approach using the data from the Ford study, since results were presented for only enough cases to allow calculation of the relative reactivities. EPA's calculated reactivities, from these three studies, are shown in Table 6.

Ford used an alternate method to translate their modeling results into reactivities. While EPA calculated reactivities for each city, Ford chose to combine all 20 of the maximum ozone concentrations for each of the four scenarios, to obtain an average maximum ozone concentration for each scenario. They then calculated a single reactivity for methanol and a single reactivity for formaldehyde based on these average ozone results. The Agency felt that this approach was not the most appropriate, however, since ozone values for different cities are not necessarily similar, and thus average ozone values for each scenario lack practical significance. It seems more reasonable to calculate reactivities for each city individually, and to compare these reactivities, as EPA has done. Admittedly, EPA's approach does not produce dramatically different results, on the average across all 20 cities, than Ford's in this case, but could do so given a different modeling base. EPA's approach does allow the relative reactivities of methanol and formaldehyde in different cities to be compared to one another, whereas Ford's approach does not.

As several commenters noted, there are significant limitations to the modeling described by EPA in the NPRM. Even given the additional modeling described here, there is still concern about the sufficiency of the available data. For example, while Ford's study does address the question of city-to-city variations, it does not do so conclusively. In order to adequately account for such variations, modeling of all (or many more) ozone non-attainment cities would be necessary before a standard could be set. Additionally, there is uncertainty in the assumptions regarding emissions and trajectory data, as discussed previously. Modeling using more detailed input data could change the reactivity factors developed for each modeled city. Finally, Ford did not perform its modeling with EPA's linear ozone model in mind, and thus did not run enough emission scenarios to allow the linear assumption to be tested in each city.

Table 5

Peak Hourly Ozone Concentrations*
Reported in Ford's Modeling Study

<u>City</u>	<u>Base Case</u>	<u>100% Methanol Replacement</u>	<u>90% Methanol 10% Formaldehyde</u>	<u>No Mobile Sources</u>
Allentown	0.162	0.136	0.153	0.122
Atlanta	0.145	0.135	0.141	0.129
Baltimore	0.173	0.166	0.171	0.158
Boston	0.211	0.135	0.184	0.112
Chicago	0.148	0.128	0.142	0.119
Cincinnati	0.141	0.139	0.141	0.136
Dallas	0.202	0.188	0.201	0.170
Detroit	0.143	0.111	0.132	0.092
El Paso	0.139	0.132	0.139	0.123
Ft. Worth	0.204	0.183	0.203	0.168
Houston	0.281	0.272	0.281	0.257
Milwaukee	0.126	0.120	0.124	0.114
Nashville	0.126	0.101	0.119	0.075
Philadelphia	0.232	0.213	0.227	0.198
Phoenix	0.159	0.148	0.157	0.140
Pittsburgh	0.147	0.098	0.133	0.081
Scranton	0.144	0.119	0.137	0.104
St. Louis	0.200	0.149	0.185	0.135
Washington, D.C.	0.177	0.157	0.172	0.141
Youngstown	0.122	0.120	0.122	0.118

* All concentrations in ppm.

The other concerns mentioned by the commenters also remain valid. The concern about the reliability of trajectory modeling is justified, since such modeling gives only the peak concentration in the modeled air parcel, and not the peak for an entire area as airshed modeling would. Since the peak parcel is identified using only the base case airshed run, it is possible, perhaps even likely, that the modeled parcel is not the peak parcel for all of the emissions scenarios, especially those that are very different from the base case (e.g., 100 percent methanol substitution). Also, airshed modeling is more sophisticated than trajectory or box modeling, and thus if performed properly can be more accurate.

The concern about the effects of methanol emissions in multi-day episodes is also justified. As GM noted, methanol reacts slowly and thus could possibly accumulate in the atmosphere or be transported downwind. If methanol accumulates to a high enough concentration its effect on ozone could increase in significance. Also, transported methanol could lead to increased ozone levels downwind. The extent of these multi-day effects cannot be reasonably predicted from the single-day modeling that is currently available.

CARB's comment that day-to-day variations in atmospheric and meteorological parameters could make it difficult to reliably characterize the relative reactivities of methanol and formaldehyde, even in a given city, is also relevant. Staff does recognize the need for caution, because of concerns such as this, when considering the results of a limited set of modeling runs.

Given the limitations in the existing data base, as discussed above, staff concludes that an insufficient amount of modeling has been performed to justify the elaborate analytic manipulations that would be necessary to promulgate meaningful standards based directly on empirical photochemistry relationships. Standards based on the existing modeling data would have to be developed using a conservative methodology, as will be discussed below.

Some of these limitations could be addressed by further modeling, as noted by General Motors. In fact, Carnegie Mellon University is currently performing multi-day airshed modeling of Los Angeles, under contract for the California Air Resources Board; however, it is doubtful that the results will be applicable to other cities, because of the unique meteorology of the South Coast Air Basin. The basin is bounded by the ocean to the west and mountains to the east, and thus it experiences a great number of severe stagnations, which is not representative of meteorology in most non-attainment areas. A sufficient amount of multi-day modeling studies, even for just six cities as GM suggested, could take years to complete.

Even if EPA were confident that enough modeling data were available to address all of these concerns, or if a method could be developed by which uncertainty in the modeling data base could be accounted for (e.g., the use of a safety factor), there would still be other issues related to how to set standards based on photochemical modeling.

Since the NPRM was published and additional modeling data made available, EPA has examined several examples of how photochemical modeling could be used to set standards. Each of these takes a different approach to choosing the relative reactivities for methanol and formaldehyde for use in the mathematical expression of the standard. (In the NPRM, reactivities based only on Los Angeles modeling were used by way of example.) These could be average values for the reactivities of methanol and formaldehyde for several cities, reactivities for a single worst case city, or worst case reactivities for each pollutant (regardless of city). These three approaches are discussed below. In addition, the question of whether it would be necessary to include a margin of safety, due to the uncertainty concerning photochemical modeling, is considered.

Average values for the 22 relative reactivities in Table 6 (which includes data for each of the three relevant studies discussed previously) are 0.41 for methanol and 4.76 for formaldehyde. These numbers could be used to set standards simply by replacing the numbers used to weight emissions in the photochemical modeling-based standards discussed in the NPRM (0.02 and 2.95 for methanol and formaldehyde respectively). A major problem with this approach, however, is that it would probably result in methanol vehicles in some cities producing more ozone than the gasoline vehicles which they replace. An example of this can be seen by assuming that exhaust emissions are 37 percent hydrocarbons, 58 percent methanol, and five percent formaldehyde and that evaporative emissions are 47 percent hydrocarbons (all percentages are on a carbon basis), as appears to be likely based on EPA's emission data base for prototype methanol vehicles (see [1]); according to Ford's data, Houston, already in non-compliance with the ozone NAAQS, would have a 17 percent increase in mobile source related ozone for complete methanol substitution, and other cities would experience smaller increases as well. This approach cannot, therefore, be recommended.

The second approach would be to use the reactivities of the worst case city in the modeling data base. Unfortunately, which city would be considered the worst case city is dependent upon the amount of formaldehyde co-emitted with the methanol, since the ratio of formaldehyde reactivity to methanol reactivity varies from city to city. While the ratio between

Table 6

Calculated Reactivities of
Methanol and Formaldehyde
(Relative to Hydrocarbons)

<u>Study</u>	<u>City</u>	<u>Methanol Reactivity</u>	<u>Formaldehyde Reactivity</u>
SAI	Los Angeles	0.02*	2.95
SAI	Philadelphia	0.413	5.873
Ford	Allentown	0.350	4.600
	Atlanta	0.375	4.125
	Baltimore	0.533	3.867
	Boston	0.232	5.180
	Chicago	0.310	5.138
	Cincinnati	0.600	4.600
	Dallas	0.563	4.625
	Detroit	0.372	4.490
	El Paso	0.563	4.938
	Ft. Worth	0.417	5.972
	Houston	0.625	4.375
	Milwaukee	0.500	3.833
	Nashville	0.520	4.120
	Philadelphia	0.441	4.588
	Phoenix	0.421	5.158
	Pittsburgh	0.258	5.560
	Scranton	0.375	4.875
	St. Louis	0.215	5.754
	Washington D.C.	0.444	4.611
	Youngstown	0.500	5.500

* For substitutions less than 100 percent only. For substitutions beyond 100 percent the reactivity is 0.481.

methanol and formaldehyde emissions differs from vehicle to vehicle, it is possible to estimate a fleet average formaldehyde fraction based on prototype methanol vehicle performance; however, an accurate fleet average formaldehyde fraction would require in-use emissions data for all types of vehicles, as well as data on the relative market fraction of each type of vehicle. Furthermore, as the relative numbers of each type of vehicle change, then the city considered to be worst case could change, and as a result the standard may need to be changed. The standard may also need to be modified as vehicle technology changes result in variations in the formaldehyde to methanol ratio. For these reasons, this approach also seems inadequate.

The final approach would be to use the highest value for each of the reactivities. Based on the existing data, this would mean using the methanol reactivity for Houston (0.625) and the formaldehyde reactivity for Ft. Worth (5.972). Assuming the same relative emissions as before, this approach would allow the amount of carbon emissions to be essentially equivalent to those under the carbon-based standards, and ozone reductions might still be expected to occur in each of the cities modeled to date. This approach seems to be the most reasonable of the three, since it would adequately protect against ozone increases, assuming that the the current modeling data base is sufficient. It should also be noted that this approach would not result in true ozone equivalence between methanol and gasoline vehicles, which was the stated goal of considering photochemical modeling-based standards. Rather, this approach would serve to limit methanol vehicle ozone potential to that of gasoline vehicles. However, there is no apparent alternative to ensure that no city would have an increase in ozone due to methanol vehicles. Thus, as is the case for the carbon-based standards, there is no need for an additional margin of safety since this approach is already conservative.

Thus, with regard to the second question posed in the introduction to this analysis, staff concludes that it may be possible to design environmentally acceptable standards based on photochemical modeling but that such standards are not likely to be any less stringent (in terms of total carbon emissions) than carbon-based standards. Additionally, it is noted that the standards may need to be revised as new modeling studies are performed, reflecting changes in modeling techniques and/or real world parameters.

The final and perhaps most relevant question to be answered is whether photochemical modeling-based standards would provide a significant benefit to the manufacturers. To answer this question, the third approach described above is compared to the proposed carbon-based standards. While it is true that the two alternatives will allow roughly equal amounts

of total carbon to be emitted, it is not true that the two would be identical. Due to differences between individual vehicles, and the differences between the makeup of exhaust and evaporative emissions, there could still be economic benefits from standards based on photochemical modeling.

For exhaust emissions, the relative stringency of these two alternatives depends on the relative amounts of hydrocarbons, methanol and formaldehyde in the emissions. If the formaldehyde to methanol ratio (as carbon) in the exhaust was greater than 0.075,* then exhaust standards based on the third photochemical modeling approach (without any additional safety factor) would be more stringent than the proposed carbon-based standards. That is, a vehicle could potentially meet the carbon-based standard but not the photochemical modeling based standard. Since the average formaldehyde to methanol ratio has been determined to be around 0.0943 for current methanol vehicles (based on [1]), on average the carbon-based standards are the least stringent. An additional point to note is that carbon based standards would allow more flexibility for manufacturers if formaldehyde emissions are found to be difficult to reduce selectively, since they are weighted less heavily under this approach than under the photochemical modeling-based approach.

Ford presented exhaust data for light-duty vehicles which they claimed showed a significant benefit resulting from the photochemical-based exhaust standards discussed in the NPRM; however, there are two issues which Ford may not have fully considered and which are significant enough to invalidate their conclusions. First, they included in their analysis vehicles which did not meet the proposed CO standard. Further analysis of Ford's data shows that only eight of 17 vehicles were capable of meeting the CO standard. Each of these eight vehicles could also meet the carbon-based exhaust organics standards (see Table 7). This indicates that lessening the stringency of the exhaust organics standards may not reduce the control costs greatly, since the available (albeit limited) data indicate that the CO standard is the limiting factor for catalyst-equipped vehicles.

Second, Ford based their finding on the photochemical modeling-based standards that were based only on data for Los Angeles. The more recent data, as discussed in the foregoing

* This is the critical ratio, above which the photochemical modeling-based standards become more stringent than the carbon-based standards. It can be derived by setting the equations for the carbon-based and modeling-based standards equal to one another and solving for it. See Table 7 for equations. The ratio equals one minus the reactivity of methanol, divided by the reactivity of formaldehyde minus one (0.375/4.972).

Table 7

Comparison of Standards Using Ford's Emissions Data

<u>Vehicle*</u>	<u>Carbon Equivalent**</u>	<u>Photochemical Equivalent***</u>
18/83/Escort(LAX/5030)	.344	.316
19/83/Escort(LAX/5531)	.295	.301
24/83/Escort(EFI/7559)	.306	.356
08/81/Escort/14600	.185	.180
22/83/Escort(EFI/138)	.412	.524
02/81/Rabbit/4490	.187	.160
04/81/Rabbit/4500	.206	.207
31/85/Toyota/475	.215	.192

* Vehicle designations are Ford's, last number is the odometer reading.

** Carbon equivalent = $HC(g/mi) + \frac{13.876}{32.042} MeOH(g/mi) + \frac{13.876}{30.026} Form(g/mi)$.

*** Photochemical
Equivalent = $HC(g/mi) + (.625) \frac{13.876}{32.042} MeOH(g/mi) + (5.972) \frac{13.876}{30.076} Form(g/mi)$.

analysis would result in more stringent standards. As noted before, the relative stringency depends on the formaldehyde to methanol ratio. Only seven of the eight vehicles met the most stringent photochemical modeling-based exhaust standards (without a margin of safety), while all eight met the carbon based exhaust standards. (Admittedly, the vehicle which did not meet the photochemical modeling-based standard just barely met the carbon-based standard.) The four vehicles for which the carbon-based standard was the less stringent standard all had formaldehyde to methanol ratios greater than the critical ratio of 0.075. The cost of this increased stringency of photochemical modeling-based standards is difficult to determine, since no commenters provided any relevant cost data in this regard. GM's comment that it was unable to provide an estimate in this regard is particularly relevant.

Since evaporative emissions do not contain formaldehyde, the evaporative standard based on photochemical modeling (without a margin of safety included) will always be less stringent than the carbon based standard. This is because a mixture of only hydrocarbons (reactivity of one) and methanol (reactivity less than one) will always have an average reactivity that is less than one (relative to an equal amount of carbon as gasoline hydrocarbons). Thus, standards based on photochemical modeling would allow methanol vehicles to emit more carbon than gasoline vehicles in order to result in equal ozone. For example, if one assumes that 47 percent (as carbon) of the evaporative emissions from a methanol vehicle are hydrocarbons (as was calculated in [1]), then using the methanol reactivity from the most stringent standards based on photochemical modeling, the average reactivity of the mixture would be 0.80. The amount of carbon allowed relative to that allowed by the carbon-based standards equals the inverse of the reactivity ($1.0 / 0.80 = 1.25$). Therefore, this approach would allow 25 percent more carbon to be emitted than the carbon-based standards would. It is noted that methanol's low volatility tends, depending on the nature of any additive packages, to reduce evaporative emissions, making it unclear whether a relaxed limit on evaporative carbon emissions represents reduced stringency.

A reduction in stringency for evaporative emissions would likely result in some economic benefit, but no commenters provided data which would allow a quantitative estimate of this benefit. The only comment received specifically in regard to evaporative emission standards feasibility was from Ford, who agreed with EPA's conclusion in the Regulatory Support Document that the carbon-based standards were feasible. Whether the benefit of photochemical modeling-based evaporative emission standards would be substantial, or even whether it would be sufficient to offset the expected increase in stringency of modeling-based exhaust standards cannot be determined due to the general lack of cost data. Nevertheless, it is obvious

that the relative stringency of the carbon and photochemical modeling-based options are generally similar and therefore, in response to the third question, compliance costs ought also to be similar.

To summarize the foregoing analysis, the available modeling base upon which standards could be founded is insufficient to allow development of environmentally acceptable standards with other than a conservative approach. Using such an approach results in standards that are generally similar to carbon-based standards, both in terms of environmental impact and stringency. Any difference between the two approaches in this latter regard which might weigh in favor of the modeling-based approach need to be balanced by a concern for the weak philosophical foundation of such standards. These standards rely upon elaborate manipulation of empirical data and are subject to change as further modeling is performed. Carbon-based standards, on the other hand, rely on the known scientific link between oxidation of organic carbon and ozone formation, and are equivalent to existing HC standards in this regard. For these reasons, carbon standards are superior to modeling-based standards.

Some commenters were also concerned that formaldehyde emissions from methanol vehicles could lead to increases in ozone levels, and felt that separate formaldehyde standards are necessary. They raised several valid points about the reactivity of formaldehyde. However, as mentioned earlier, based on the results of available modeling studies it is expected that fleet average emissions from methanol-fueled vehicles certified for carbon-based standards will have 54 to 95 percent of the ozone forming potential of those of gasoline vehicles (see Table 2). These results do not indicate that the arguments (of AGA, CARB, and Chevron) for a separate formaldehyde standard are incorrect; formaldehyde is a very reactive compound, and can be a key component of atmospheric reactions. However, the results do show that these arguments are not sufficient to require a separate (ozone based) formaldehyde standard, since the carbon-based standards will limit average formaldehyde emissions to acceptable levels.

The emissions data upon which this conclusion and all other ozone projections made in this discussion are from [1]. Brooklyn Union Gas, however, argued that these data cannot be reliably translated into in-use emissions. As is discussed in that reference, it is true that more data are needed to precisely quantify the impacts of different methanol fuel compositions, vehicle types, and mileage accumulation on the ratios of organic emissions from methanol vehicles. It is also true that availability of such data, as well as data on the types of fuels and vehicles that will be found in-use, would

allow more accurate predictions of the emission factors. However, in the absence of such data, the data base is still sufficiently large* and adequately qualified to give EPA confidence that, at least as far as first generation methanol technology is concerned, the data base is representative of real, expected emissions. This finding is also based upon EPA staff's past experience in estimating in-use emissions from gasoline and diesel vehicles. Additionally, it should be noted that because substantial penetration of methanol vehicles into the market is not expected to occur in the very near future, there will be sufficient time to verify the estimated in-use emission factors before methanol vehicles could have any significant impact on the environment. Thus, staff is confident that the estimated emission factors are sufficiently accurate.

Conclusions

The environmental analysis of the impact of the carbon-based standards shows that they are sufficient to prevent any increase in ambient ozone levels. In fact, as the results in Table 2 show, the standards will have a margin of safety between 5 and 46 percent. It is also concluded that these standards will be technologically feasible using controls similar to current vehicles, and thus will have similar costs. For these reasons, the carbon-based standards are determined to be an acceptable alternative. The question EPA considered in this analysis was whether standards based on photochemical modeling would be more appropriate.

There are many problems associated with basing standards on photochemical modeling. Most notable are the problems of reliability and sufficiency of the available modeling data base and the possibility that future studies would indicate different reactivities for methanol and formaldehyde, requiring the standards to be changed. The problems of reliability include concerns about trajectory modeling, the multi-day effects of methanol, and city-specific analyses. These uncertainties could be addressed through further modeling, use of a conservative methodology to translate available modeling into standards, or by using a margin of safety, though it is not presently known how much more modeling, which is expensive and time consuming, would be necessary, or how large a safety margin would be needed. Also, more recent studies, including Ford's, greatly reduced the expected compliance benefits of photochemistry-based standards from the levels suggested in the

* Exhaust data were available from 457 city FTP tests, including 64 distinct vehicle configurations. Evaporative data were available for 35 tests including 18 vehicles.

NPRM. In fact, based on the amount of formaldehyde found to be co-emitted with methanol from prototype vehicles, the carbon-based standards and conservatively chosen photochemical modeling-based standards are essentially equivalent in stringency.

As discussed, the photochemical modeling-based standards could provide economic benefits for evaporative emissions, but could also result in increased costs for controlling exhaust emissions. Therefore, without much more detailed cost information, it is not obvious that standards based on photochemical modeling would provide any net economic benefit at all.

The major difference between conservatively chosen photochemical modeling-based standards and the carbon-based standards may be philosophical in nature. The carbon-based standards rely philosophically on the known scientific link between the oxidation of organic carbon and ozone production to account for the chemical differences between emissions from methanol and gasoline vehicles; the modeling-based standards, on the other hand, rely on elaborate analytic manipulations of limited photochemical modeling data. Considering the absence of a more complete understanding of photochemical reactivity, it is recommended that EPA maintain its previous position that carbon-based standards are the most appropriate alternative to protect against increases in ambient ozone levels and to provide a firm basis for emission standards that will not be subject to change with each new modeling study performed.

As mentioned before, the environmental analysis of the proposed standards demonstrated that they are sufficient to prevent increases in ambient ozone levels. Thus, it is concluded that there is no need for separate formaldehyde standards to account for the very reactive nature of formaldehyde in the atmosphere. It is therefore recommended that the carbon-based organics standards be promulgated as proposed.

Issue: Separate Health Effects-Based Standards for Methanol and Formaldehyde

Summary of the Issue

In the NPRM, EPA discussed the possibility of promulgating separate standards for methanol and formaldehyde based upon toxic and carcinogenic effects. The Agency performed analyses to estimate concentrations of these pollutants in driving-related scenarios where the public might be routinely exposed to high levels of methanol and formaldehyde. It was concluded that the proposed carbon-based total organics (hydrocarbons, methanol, formaldehyde) standard would be sufficient to protect the public from toxic concentrations of methanol and formaldehyde due to methanol vehicles in every situation considered except the personal garage. Here, toxic levels of formaldehyde could only be reached with a malfunctioning methanol vehicle idling inside a personal garage, but it was concluded that it was not the Agency's responsibility to set standards to protect against such an obviously unsafe practice. The level of concern was also predicted to be reached in the severe tunnel scenario, but, for several reasons, it was concluded that the analytical assumptions leading to the prediction were extreme and unlikely to be realized; thus no standards relating to this scenario were proposed.

The analysis noted that an increase in overall ambient formaldehyde concentrations could potentially occur due to methanol vehicles, with an attendant increase in any cancer risk associated with formaldehyde. It was unclear, however, whether formaldehyde should actually be considered a human carcinogen, whether the level of cancer risk due to formaldehyde from existing mobile sources was acceptable, and how much, if any, methanol vehicles would exacerbate the situation. Additionally, it was noted that it would be at least several years before methanol vehicles could penetrate the market sufficiently to affect ambient formaldehyde levels. It was concluded, therefore, that cancer-related formaldehyde standards targeted at methanol vehicles would be inappropriate at present and that the Agency should regulate mobile source formaldehyde only after a more detailed consideration of the relative contributions of all potential emitters.

The major issue of this section is whether the proposed carbon-based organics standards are indeed sufficient to prevent adverse health effects to the public due to methanol and formaldehyde from methanol vehicles, or whether separate emission standards are necessary.

Summary of the Comments

The Agency did not receive any comments opposed to its decision not to propose separate standards based on methanol's health effects, but five of the commenters (AGA, Brooklyn Union Gas Company, CARB, CEC and Chevron) did oppose EPA's position that no separate health effects-based formaldehyde standard is necessary.* The American Gas Association felt that this issue was so important that the rule should not be promulgated until formaldehyde emissions and their associated health effects are better characterized. Other commenters (Chrysler, Cummins, DOE, GM, Toyota, and Volkswagen), however, were supportive of EPA's position that a separate formaldehyde standard is not necessary at this time.

Several organizations felt that EPA's level of concern for formaldehyde (0.50 mg/m^3), was inadequate to protect the public health. CARB cited the findings of the National Research Council, which stated that sensitive individuals will encounter eye irritation at formaldehyde levels as low as 0.05 ppm ($1 \text{ ppm} = 1.16 \text{ mg/m}^3$ at 70° F), and in the presence of other pollutants, certain individuals will detect and react to formaldehyde as low as 0.01 ppm. AGA cited the same study, stating that as much as 10 to 20 percent of the nation's population may react to low levels ($0.25 \text{ ppm} - 0.50 \text{ ppm}$) of formaldehyde in the atmosphere. Brooklyn Union Gas also cited the study, saying that 10 to 12 percent of the population has no threshold at all to the effects of formaldehyde.

General Motors stated that the levels of concern chosen by EPA are reasonable and should prevent unsafe levels of methanol and its metabolites from occurring in the blood of the exposed persons. They also stated that at the level of concern for formaldehyde, most health effects would be minor and reversible. This position was supported by Chrysler who also stated that it is not the Agency's responsibility to protect against reversible and slight irritant effects. Chrysler, Volkswagen, General Motors, and the Department of Energy (DOE) all agreed with EPA that the proposed carbon-based standards will adequately protect the public from risk of exposure to toxic levels of methanol and formaldehyde.

* These commenters also suggested that the ozone forming potential of formaldehyde supported the need for a separate standard. This aspect of the comments was addressed in the "Basis of the Organics Standards" section. The present section addresses only the health effects issues.

Chrysler agreed with EPA that vehicle owners should be expected to assume primary responsibility to ensure that methanol vehicles are not operated in personal garages; such an expectation would be analogous to the case of CO emissions from current vehicles. Cummins disagreed; they stated:

"We do not believe it is good public policy to assume that the public would take the necessary precautions to insure his or her own personal safety where exposure to formaldehyde and methanol emissions are concerned. The analogy that EPA draws with exposure to CO in non-ventilated areas is not valid when dealing with substances whose health effects and threshold limit values are unknown."

Cummins felt that this and other personal exposure scenarios warrant additional study, but they supported EPA's position that separate standards are not necessary at this time. Related to the issue of owner responsibility, GM felt that it would be appropriate for EPA to issue a warning about the severe risks of tampering with the emission systems of methanol vehicles. (A malfunctioning system would allow much higher emissions of formaldehyde.)

A concern about the emission data used for EPA's analyses was raised by Chevron, who claimed that "formaldehyde emissions are typically underestimated ... due to the very reactive nature of formaldehyde and the difficulty in maintaining exhaust sample integrity." They cited a study by Southwest Research Institute that showed losses of 40 percent in the exhaust sampling system.[8] This would result in underprediction of concentrations, and thus underestimation of the risk. AGA was also concerned about the limited amount of emissions data available at this time. Further, Brooklyn Union Gas discussed the validity of the emission factors used in EPA's analyses. They cited "EPA's disclaimer that the limited prototype vehicle testing emissions data now available for methanol and upon which the proposed rule is based cannot be reliably translated into in-use emissions." They, as well as Chevron, were particularly concerned about the durability of catalytic converters on methanol vehicles. Chevron indicated the potential risk of an ineffective catalyst system by stating that without a catalyst "formaldehyde levels in exhaust are in the order of several thousand PPM."

The commenters also addressed the carcinogenic risk of formaldehyde exposure. AGA cited the National Academy of Sciences again, stating that formaldehyde has been shown to create mutagenic activity in living organisms, and that the severity of the response is dependent upon the severity of the dosage. CARB stated that according to the 1986 EPA Guidelines for Carcinogen Risk Assessment, formaldehyde would be

considered a probable human carcinogen because of the results of animal tests. CARB, AGA, and Brooklyn Union Gas all agreed that the most appropriate approach to deal with formaldehyde's cancer risk would be to limit emissions of formaldehyde to the minimum level possible. CARB suggested specific standards which were discussed in the "Basis of Organics Standard" section of this document.

Both Chrysler and GM were unconvinced of the cancer risk. They cited the National Cancer Institute Study of 26,000 industrial workers exposed to formaldehyde, which they claimed showed no excess cancer mortality due to formaldehyde exposure. General Motors also noted that methanol vehicles would not be expected to significantly affect the ambient formaldehyde concentrations, especially considering the small number of vehicles expected to be produced initially. They stated that there is adequate time to further investigate the cancer risks before methanol vehicles enter the fleet in numbers significant enough to substantially affect ambient formaldehyde levels. They therefore felt that a separate formaldehyde standard is not necessary at this time to prevent increased cancer risks. DOE noted that there is currently no ambient standard for formaldehyde, and thus felt it would be inappropriate to have a separate emission standard based on the effect on ambient formaldehyde concentrations.

Analysis of Comments

There are two aspects of the commenters' major concern, that use of methanol vehicles could lead to the occurrence of toxic concentrations of formaldehyde in situations involving routine exposure to motor vehicle emissions, that require analysis. The first relates to the concentration, or level of concern, at which formaldehyde should be considered a potential health risk. The second is whether expected emissions are anticipated to result in the level of concern being achieved.

The Agency decided in the NPRM that the appropriate level of concern for formaldehyde is 0.50 mg/m^3 , stating that:

"The studies indicate that at 0.50 mg/m^3 the odor of formaldehyde should be noticeable by most people, and any health effects experienced (i.e., eye, nose, or throat irritation or discomfort) should be minor and reversible for the vast majority of the populace."

Among the studies used as a basis for this conclusion was the report by the National Research Council which was cited by AGA, Brooklyn Union Gas, and CARB. It is noted that the arguments presented by the commenters were addressed previously by the Agency in the NPRM and the Regulatory Support Document. It was concluded that these concerns were not sufficient to justify implementing a lower level of concern, especially considering

the fact that exposures to elevated levels of mobile source formaldehyde are expected to be brief (usually less than 15 minutes). Studies of non-sensitized individuals usually involved exposures of greater duration and it is not known whether the adverse effects would generally have occurred given a shorter control period. Further, it was noted that the severity of these individuals' responses at levels below the level of concern was minor. For example, in one study, respondents characterized the effect of formaldehyde at 0.25 mg/m³ as barely noticeable, similar to a light windy touch or dry feeling which elicited conscious blinking. While it is noted that there is a wide variability in human response to formaldehyde such that some individual may just notice irritation at levels below 0.50 mg/m³, the conclusion that health effects below the level of concern are expected to generally be minor and reversible continues to be valid, and the Agency should not, as Chrysler commented, necessarily be involved in protection against them. With regard to the data which indicate a portion of the population which may be sensitive to concentrations as low as 0.01 to 0.05 ppm, emission standards may be of little benefit, since typical urban concentrations are presently of this order of magnitude. Additionally, it should be noted that these data from studies of occupational exposures, and not brief exposures like those discussed here. Addressing exposures at this level is clearly beyond the scope of this rulemaking. EPA is in fact pursuing an Agencywide approach to deal with ambient exposures to formaldehyde. An intra-Agency task force will coordinate activities related to formaldehyde, including the development and implementation of a formaldehyde control strategy that will account for issues such as sensitive populations.

Since the commenters presented no new data to challenge the Agency's previous logic in determining a level of concern for formaldehyde, it would be inappropriate to alter the level of concern in response to the comments. It should be noted, however, that the Agency did consider, in its previous analysis, what effect a 0.25 mg/m³ level of concern would have had on the need for standards and found none.

The Agency chose 260 mg/m³ as the level of concern for methanol. This is the Threshold Limit Value (TLV) for eight-hour exposures set by the American Conference of Governmental Industrial Hygienists (ACGIH). The TLV incorporates a fairly large margin of safety against toxic effects. No comments were received opposing this level of concern. It is worthwhile to note that an extensive review of methanol health effects and the implications of methanol vehicles was recently completed by the Health Effects Institute.[9] This study's conclusions included the finding that the mobile source-related exposures to methanol predicted by EPA as a result of methanol vehicles, would not cause toxic effects. For example, they stated:

"A 70 kg person breathing at a ventilation rate of 20 m³/day (twice resting) who is exposed to 200 mg/m³ methanol vapor for 15 minutes (as in a worst-case hot-soak garage scenario), accumulates a methanol body burden of 0.0006 g/kg - at least 500 times lower than doses of acute clinical significance."

HEI did, however, note that these conclusions were in regard to ocular toxicity due to formate (which is a metabolic intermediate of methanol), and that there could be other toxic mechanisms. This possibility needs to be investigated in the future.

The availability of new emissions data has enabled EPA to update its analysis of methanol and formaldehyde concentrations in driving-related scenarios in which people could commonly encounter elevated concentrations of mobile source pollution. It would be appropriate to present this analysis prior to considering comments related to the earlier analysis. The analysis is based upon mathematical models developed by Southwest Research Institute (SwRI). The scenarios modeled were:

- 1) Street canyons (urban corridors bounded by tall buildings)
- 2) Tunnels
- 3) Expressways
- 4) Public parking garages
- 5) Personal garages

These scenarios are discussed in more detail in the Regulatory Support Document for the NPRM. Both typical and more severe situations were modeled; however this analysis focuses on the severe situations, except as otherwise noted.

It was concluded earlier that the only modeling situation in which unacceptable formaldehyde concentrations (i.e., concentrations significantly above the level of concern) might occur involves idling of a severely malfunctioning vehicle in a personal garage. Formaldehyde concentrations were also predicted to be near the level of concern in the severe tunnel scenario. Methanol was found never to exceed its level of concern, but it did approach the level of concern in the personal garage - hot soak (trip end) scenario (235.6 mg/m³). The results of the updated analysis are shown in Tables 8 through 13. These new results do not differ substantially from the previous ones, except for those scenarios involving hot soak emissions, and those involving cold idling (idling immediately after starting the engine). The scenarios affected are the public parking garage and personal garage trip start and trip end scenarios.

In the previous analyses of the trip end scenarios it was estimated that maximum certification level hot soak emissions of methanol would be 3.0 grams per test. Based on more data, it now appears that 2.0 grams per test is a better estimate.[1] Using this newer estimate, the models predict maximum concentrations of 100.9 mg/m³ and 152.8 mg/m³, for the public parking and personal garage scenarios, respectively (Tables 12 and 13). Both of these predictions are well below the level of concern, and are based on worst case assumptions so that it does not appear that hot soak methanol emissions pose any significant threat to the public. It should be noted that the malfunction-based offsets* used in Tables 12 and 13 were based on limited and somewhat questionable data. However, because the margins of safety for these two scenarios are so great, and because, for the public parking garage scenario, other offsets based on fleetwide gasoline vehicle performance can be adopted as surrogates, this should not be a significant concern in that scenario. For the personal garage, the margin between the predicted concentration and the level of concern is also large, even considering a 2.0 safety margin on emissions.**

The scenarios using cold start emission factors also involve exposure in public and personal garages. Several changes were made to the analyses that were discussed in the proposal. The first is related to the exposure model used for the public parking garage. The previous analysis focused on a model that was based on an actual underground garage, which was poorly ventilated. However, this model is no longer considered representative, since pollutant concentrations inside the actual garage were so high that it had to be completely reventilated. Additionally, there is some concern that the garage model might be inaccurate. The model of the severe scenario was tested (for validation purposes) using ambient data from a 1978 study which measured a CO concentration of 374 mg/m³ during a parking episode in the actual garage on which the physical parameters defining the severe scenario analysis were based. Using an average CO emission factor of 7.7 mg/min based on an EPA study (how this estimate was obtained from EPA's emission factors was not discussed in detail in the SwRI document), the model predicted a concentration of 430 mg/m³. SwRI claimed that this analysis validated the model, but there is concern that actual in-use emissions of CO in 1978 could have been much higher. Using the same EPA study as was used by SwRI, and making reasonable assumptions about the overall mostly catalyst equipped fleet's model year distributions, the

* Offset is the expected ratio of in-use emissions to certification level.

** Since the gasoline vehicle offsets were developed based on fleetwide performance and only one vehicle is present in the personal garage, a 2.0 safety margin on the predicted emission level is used as a surrogate for an in-use offset.

Table 8

In-Use Formaldehyde Concentrations for
Canyon, Tunnel, and Expressway (mg/m³)
(Level of concern for formaldehyde is 0.50 mg/m³)

	Likely Cert. Level (g/mi)	Offsets			
		Meet Std.*	2.2	2.6	25% Malfunction**
Canyon					
30% Penet	0.0482	0.012	0.020	0.022	0.020
100% Penet	0.0482	0.022	0.048	0.057	0.050
Tunnel					
30% Penet	0.0482	0.12	0.20	0.23	0.20
100% Penet	0.0482	0.22	0.49	0.58	0.50
Expressway					
30% Penet	0.0072	0.0076	0.010	0.010	0.027
100% Penet	0.0072	0.0059	0.013	0.015	0.069

* Offset = 1.0.

** Offset = 2.26 canyon, 2.26 tunnel, 11.75 expressway.

Table 9

In-Use Methanol Concentrations for
Canyon, Tunnel, and Expressway (mg/m³)
(Level of concern for methanol is 260 mg/m³)

	Likely Cert. Level (g/mi)	Meet Std.*	Offsets		
			2.2	2.6	25% Malfunc**
Canyon					
30% Penet	0.546	0.07	0.16	0.19	0.17
100% Penet	0.546	0.25	0.55	0.65	0.57
Tunnel					
30% Penet	0.546	0.75	1.7	2.0	1.7
100% Penet	0.546	2.5	5.5	6.5	5.7
Expressway					
30% Penet	0.025	0.006	0.013	0.016	0.24
100% Penet	0.025	0.020	0.044	0.052	0.79

* Offset = 1.0.

** Offset = 2.28 canyon, 2.28 tunnel, 39.40 expressway.

Table 10
In-Use Concentrations in Public Garages

Vehicle Type	In-Use Methanol Emission Factor (g/min)	Predicted Methanol (mg/m ³)	In-Use Formaldehyde Emission Factor (mg/min)	Predicted Formaldehyde (mg/m ³)	In-Use CO Emission Factor (g/min)	Predicted CO (mg/m ³)
Methanol Escort* (20°F)	10.7	147	203.0	2.78	66.5	914
Methanol Carina** (78°F)	NA	NA	17.6	0.24	3.9	55
Catalyzed Gasoline*** (20°F)	---	---	17.9	0.25	42.6	586
Non-Catalyzed**** Gasoline(70°F)	---	---	37.1	0.51	71.3	981
Diesel (20°F)*****	---	---	63.2	0.87	5.7	79

* Based on average emissions from three vehicles, uses a 2.2 in-use offset.

** Based on average emissions from one vehicle, uses a 2.2 in-use offset.

*** Based on average emissions of eight vehicles, uses a 2.6 in-use offset.

**** Based on average emissions of a 1971 Galaxie, uses a 1.0 in-use offset.

***** Based on average emissions of a diesel pickup truck, uses a 2.6 in-use offset.

Table 11
In-Use Concentrations in Private Garages*

Vehicle Type	Methanol Emission Factor (g/min)	Predicted Methanol mg/m ³	Formaldehyde Emission Factor (mg/min)	Predicted Formaldehyde mg/m ³	CO Emission Factor (mg/min)	Predicted CO mg/m ³
Methanol Escort (20°F)	4.9	325-650	122.0	8-16	41.3	2,800-5,500
Methanol Carina (78°F)	NA	NA	8.0	0.5-1.1	1.8	120-330
Catalyzed Gasoline (20°F)	---	---	20.0	1.3-1.7	47.1	3,000-6,000
Non-Catalyzed Gasoline (70°F)	---	---	76.0	5-10	121.4	8,000-16,000
Diesel (20°F)	---	---	24.3	1.6-3.3	2.2	150-300

* Predicted concentrations are based on highest emitting vehicles for each technology. Upper estimates include a factor of safety of 2.0 to account for in-use deterioration and other analytic uncertainties.

Table 12

In-Use Methanol Concentrations
for Hot Soak, Parking Garage (mg/m^3)
(Level of Concern for Methanol is $260 \text{ mg}/\text{m}^3$)

	Likely Cert. Level (g/hr)	Offsets			
		Meet Std.*	2.3	4.4	10% Malfunc**
30% Penet	1.3-2.0***	4.6-6.9	10.7-15.8	20.4-30.3	7.7-11.5
100% Penet	1.3-2.0	15.4-22.9	35.5-52.8	68.0-100.9	25.8-38.3

* Offset = 1.0.

** Offset = 1.67.

*** 1.3 is estimated fuel injected emissions and 2.0 is estimated carbureted emissions.

Table 13

In-Use Methanol Concentrations for
Hot Soak, Personal Garage (mg/m³)
(Level of Concern for Methanol is 260 mg/m³)

	Likely Cert. Level (g/hr)	Offsets		
		Meet Std.*	2.0 Safety Margin	100% Malfunc**
20 CFM	1.3-2.0***	12.0-17.8	24.0-35.6	57.5-85.4
No Vent	1.3-2.0	21.4-31.8	42.9-63.7	102.9-152.8

* Offset = 1.0.

** Offset = 4.8.

*** 1.3 is estimated fuel injected emissions and 2.0 is estimated carbureted emissions.

average CO emission factor could be estimated to be more than twice as high as the estimate used by SwRI. If this is true, then the severe model is overestimating concentrations. This concern is supported by the fact that the model of the severe scenario would have predicted very high CO concentrations, on the order of more than 2000 mg/m³, for earlier, pre-catalyst gasoline vehicles emitting 40 g/min or more in-use at cold idle, and this level would likely have been considered unacceptable. Furthermore, recent gasoline vehicle data indicate that cold idle formaldehyde emissions might be high enough to produce concentrations as high as twice the level of concern in this scenario. However, the fact that complaints of eye irritation from frequent garage users are not received in this regard lends further evidence that the model is not representative. Therefore, the current analysis is focused on a model of a more typical garage. The model predicts the maximum concentrations that would occur under congested traffic conditions, in which the garage is emptied in a short period of time, such as that after a concert. Individuals would be exposed to the highest predicted concentrations in the garage for about four minutes, and to concentrations that are 28 percent as high for another four minutes. For comparison, the concentrations predicted for the severe model, which was previously the focus of EPA's analysis, would be about four times the maximum predicted concentrations of the typical model. It should be noted that validation data were not available for the typical model, thus its accuracy must also be considered somewhat uncertain.

The second problem with the previous analyses of the trip start scenarios relates to the emission factors that were used. First, the analysis did not use actual cold start idle data for methanol vehicles; the emissions were estimated based on hot idle data (idling after the engine has been warmed up). It was assumed that the ratio of cold idle formaldehyde emissions to hot idle formaldehyde emissions would be the same for methanol vehicles as it is for gasoline vehicles (2.25, based on limited testing). Using this ratio, and hot idle data from four methanol vehicles, the upper limit for cold idle emissions was estimated to be 2.03 mg/min. There are now four studies available which have reported cold start idle emission data for methanol vehicles (three studies involved 1983 Escorts, the other involved a 1986 Carina). [10,11,12,13] These cold idle data now indicate that the previous approach was not appropriate. The new data (Table 14) suggest that cold idle formaldehyde emissions are 4-60 times the previous estimation.

Three of the studies which had cold start idle data for methanol vehicles also investigated the effect of ambient temperature on the formaldehyde emissions, and found similar results. Idle formaldehyde emissions at 20°F were found to be 2.4-4.0 times the idle emissions at FTP temperatures. Therefore, analysis of health effects based on emissions data at FTP conditions is not sufficient to ensure that cold

Table 14

Methanol Vehicle Emission Factors
(Cold Idle)

Study	Vehicle	Temperature (°F)	Methanol (g/min)	Formaldehyde (mg/min)	CO (g/min)	CO to Formaldehyde
EPA[10]	'83 Escort*	70	0.847	44.3	6.91	156
EPA	'83 Escort*	40	2.619	25.0	16.4	658
EPA	'83 Escort**	40	2.166	57.2	9.5	167
EPA	'83 Escort**	20	4.850	105.9	19.0	179
EPA[11]	'83 Escort	75	---	30	---	---
EPA	'83 Escort	60	---	48.4	---	---
EPA	'83 Escort	40	---	93	---	---
EPA	'83 Escort	20	---	122	---	---
NIPER[12]	'83 Escort	20	---	49.0	41.3	843
EPA[13]	'86 Carina	78	---	8.0	1.8	225

* Used summer grade fuel.

** Used winter grade fuel.

Ratio of levels of concern of CO and formaldehyde is 880.

temperature emissions will not be unsafe, and the 20°F emissions data are used in the analysis.*

Second, other new data also enabled EPA to update its estimates of gasoline vehicle contributions to formaldehyde exposure in garages. The data show that gasoline vehicles contribute more than was previously thought, such that low mileage, well maintained vehicles gasoline vehicles alone could result in fairly high levels of formaldehyde (see Tables 10 and 11).

A final problem relating to the emissions factors used in the previous analysis in the Regulatory Support Document concerns the three offsets used to estimate in-use parking garage (see Tables 2-7 and 2-8 of the Regulatory Support Document) idle emissions of methanol and formaldehyde. The malfunction offset was originally based on hot idle data. It assumed that 25 percent of the methanol fleet is malfunctioning, with malfunction emissions being represented by non-catalyst vehicle emissions. Hot idle formaldehyde emissions from a non-catalyst vehicle were determined to be 7.6 times those from catalyst vehicles; the ratio was determined to be 34.0 for methanol emissions. However, hot idle emissions would be expected to be affected by catalyst function much more than cold idle emissions would be, since catalysts do not become effective until they are warmed up. Thus, the malfunction offset based on hot idle data is probably too high, resulting in an overestimate of concentrations. Malfunction based offsets were not used in the present analysis. The other offsets used as alternatives were based on performance over the urban driving cycle of the FTP at FTP temperatures (i.e., 2.2 and 2.6). There are two potential problems with this. First, since cold start idle emissions at low temperatures are not necessarily affected by the modifications that are relevant to emissions performance at 70°F, it is not obvious that offsets for low temperature cold start idle emissions from well maintained vehicles will be similar to offsets for the same engines operated at FTP temperatures. Second, the relevance of performance over the FTP driving cycle to that at idle is not clear. It is possible that small changes in engine or catalyst parameters may significantly affect the optimized FTP emissions, but not cold start idle emissions. However, since it would not be appropriate to assume that the fleet average offset for idle emissions would be unity, the parking garage cold idle offset will be assumed

* As was noted in the Regulatory Support Document, this phenomenon could also affect the results of analyses of other scenarios, however the margin of safety between calculated concentrations based on 70°F emissions and the level of concern was so great that the effect could be disregarded.

to range between 2.2 and 2.6 as was done for the other offsets for exhaust emission scenarios. It is recognized that there are weaknesses to this approach, however, it is the best one available; thus it is appropriate, especially considering other sources of uncertainty in the analysis. Similarly, there is not sufficient information to accurately calculate an offset for the personal garage scenario. Here a 2.0 margin of safety will be used in place of an offset.

Using these newer data, the SwRI models predict formaldehyde concentrations of up to 2.78 mg/m³ for the public parking garage scenario and 16.3 mg/m³ for the severe personal garage scenario assuming worst case methanol vehicle emissions; these concentrations are both greater than the level of concern (0.50 mg/m³). Thus, the concern about exposure to toxic concentrations of formaldehyde is reasonable. Tables 10 and 11 also show the impacts of other types of vehicles. The impacts of mixed fleets on exposures in public garages can be predicted by averaging the predicted values for these vehicles.

Similarly, recent cold idle data for methanol (from one of the studies shown in Table 14) indicate that actual cold idle emissions of methanol are 8 to 110 times the previous estimate. As before, the data from the tests at 20°F are used, as a worst case. Using these data, the models predict concentrations of up to 147 mg/m³ for the parking garage scenario and 650 mg/m³ for the severe personal garage scenario. Here only the concentration for the personal garage scenario is above the level of concern. It is useful to note that in these scenarios, based on ratios of emission factors and levels of concern, formaldehyde concentrations would exceed the level of concern by a greater margin than methanol concentrations. Therefore, formaldehyde concentrations can be considered the more serious concern, and as such are the focus of the following discussions.

There are several possible problems with the public parking and personal garage analyses which could make them invalid. This discussion will begin with a consideration of the public garage, but several of the concerns with that analysis apply to the personal garage scenario as well. First, the maximum concentrations represent a worst case analysis, based on the highest emitting vehicle tested at 20°F (three 1983 carbureted Ford Escorts were tested at this temperature). None of these vehicles was apparently near the compliance level for the proposed CO or total organics standards for the FTP (they were emitting at roughly two to three times the standard). If they had, it can be anticipated that their idle emissions would be somewhat lower as well. It is not obvious however, the degree to which compliance with the total organics standard would affect cold idle emissions. If the weighted FTP emissions were reduced by any adjustment which affected emissions from a warmed-up engine, then the cold idle

emissions, which pass through a cold, hence ineffective catalyst during much of the idle period, might not be affected. If on the other hand, the FTP emissions were reduced by affecting bag 1 (cold) emissions, then it is likely that cold idle emissions would be affected.

Second, the emission performance of 1983 carbureted Escorts is not likely to be representative of the future methanol fleet. As is discussed elsewhere in this document, the development effort on this vehicle, with respect to emissions performance, was limited. The Toyota Carina, a more advanced technology methanol vehicle, emitted only 16-27 percent as much formaldehyde at FTP temperatures as the early Escorts, and was in the range of emissions of gasoline vehicles. Cold temperature data for this vehicle were not available.

Finally, as was noted before, the accuracy of the modeling is uncertain. It is used here to give a reasonable approximation of exposures in public garages; the results should not be taken as the final word on such exposures. Rather work may need to be done to improve the reliability of the model.

Because of concerns such as these, it is difficult to conclude with any certainty that methanol vehicles will cause unsafe levels of formaldehyde or methanol in public garages, especially at the expected low initial market penetrations. Additional investigation of emission data for advanced methanol engines tested at low temperatures is warranted as is further validation of the model itself.

Many of the previous concerns are also applicable to the analysis of the personal garage scenario (see Table 11). Since the same cold idle data that were used for the analysis above are also used for the personal garage analysis, the data-related uncertainties discussed above (concerning the effects of non-compliance with the FTP CO and organics standards, and the fact that low temperature data are only available from early model carbureted Ford Escorts) are also applicable to this analysis. Also, as before, there is concern about model validity, since the personal garage model was not tested using data from an actual garage. The recently published gasoline vehicle cold idle data indicate that many of us would even today experience discomfort from starting our vehicles in our garages on cold mornings due to concentrations in the range of 1.5 mg/m^3 as predicted by the garage model. The personal garage analysis is similar to the analysis of the public parking garage scenarios since in both analyses there is sufficient uncertainty to make the accuracy of the predicted concentrations somewhat questionable.

The two analyses differ greatly, however, in two important respects. While the driver in the public parking garage analysis has no control over the severity of the exposure (i.e., the concentration to which the driver is exposed), the driver in the personal garage analysis has the ability to control the severity by limiting the time that the vehicle is operated in the garage; the difference between severe and typical personal garage scenarios only reflects a difference in the amount of time the vehicle spends in the garage (five minutes for severe and 30 seconds for typical), and not any altered physical parameters. For example, the situation could be avoided altogether simply by idling the vehicle outside of the garage. This is widely acknowledged to be a safe vehicle handling practice; most owner's manuals warn against idling vehicles in garages, and some even warn against idling next to buildings. Thus, since the driver may voluntarily avoid the severe scenario, it is appropriate to consider both the severe and typical scenarios in this analysis. In addition to his ability to control the exposure concentration, the driver in the personal garage scenario also has the ability to limit the duration of the exposure and thus prevent any irreversible toxic effects. For example, while he may allow his vehicle to idle in his garage for five minutes to warm up, he need only be present in the garage at the beginning and end of the idle period. Chrysler agreed that drivers should assume primary responsibility for avoiding such obviously unsafe situations.

Additionally, because the formaldehyde concentrations in this scenario would lead to some irritation, and owners would be discouraged from remaining in the garage, they would also be warned of poor ventilation before CO levels reach the level of concern. In fact, the limited data that are currently available (see Table 14) indicate that the CO to formaldehyde ratio in exhaust for methanol vehicles at cold idle ranges from 150 to 850. The values in this range are less than the ratio of the levels of concern which is 880. (The level of concern used here for carbon monoxide is 440 mg/m³ which is the ACGIH Short Term Exposure Limit (STEL), designed to limit concentrations during exposures of 15 minutes length.) Thus, formaldehyde would be expected to reach its level of concern before CO would, and when the vehicle is removed from the garage immediately after formaldehyde reaches its level of concern, the STEL for CO would not be reached. Similarly, since (as noted earlier) formaldehyde concentrations would reach the level of concern before methanol would, the irritation from the formaldehyde would provide a warning for methanol exposure as well.

Cummins argued that it is inappropriate to assume the public will avoid exposure in personal garage scenarios. They claimed that the health effects from formaldehyde exposure are not adequately known, making EPA's (and by extension,

Chrysler's) parallel of formaldehyde to the carbon monoxide situation inappropriate. In response, it is true that the current knowledge is limited, but it is nevertheless sufficient to conclude that exposures to formaldehyde at levels around the level of concern will cause only minor and reversible effects. Further, even when the concentration does briefly exceed the level of concern during idling on cold winter days, as discussed above, exposures could produce brief irritation, but almost certainly would not cause any irreversible or otherwise more severe health effects to a healthy driver. The driver has the ability to prevent dangerous exposures to formaldehyde in a personal garage, and it is not unreasonable to expect that drivers will avoid such scenarios if 1) they are known to be unwise, and 2) concentrations reach the irritant level. Regulations cannot substitute for common sense.

GM's suggestion that EPA warn the public about the possible effects of tampering with a methanol vehicle's emission control system is well taken, and if such tampering is found, after methanol vehicles begin to be sold, to affect formaldehyde concentrations sufficiently in any common scenario (not just the personal garage), such a warning may be appropriate. At this time, however, sufficient evidence is not available to justify the Agency taking such action. It is, however, reasonable to expect that manufacturers will show the same sense of responsibility with formaldehyde as they currently do with CO, such that they may feel compelled include a discussion of formaldehyde in the owner's manual if necessary. It would be difficult to justify more stringent treatment of formaldehyde than CO by EPA in this situation since the worst case formaldehyde concentrations predicted would result in severe irritation for the general population, while the concentrations of CO predicted could induce death, which occurs after exposure to 10,000 mg/m³ for 10 minutes or so. Further, concentrations of 5,000 mg/m³, which would precede these higher levels, would result in headaches and nausea for most individuals.

To summarize, while there may be cause, after further investigation, for concern about exposure in public parking garages, the evidence given by the present analysis is somewhat weak. The results indicate that there is a very low risk that the public will be involuntarily exposed to toxic levels of methanol or formaldehyde in the near future because concentrations will be low at very low market penetrations. Exposures in personal garages can be avoided altogether, just as they are today in regard to CO exposure, and those that do occur will be too brief to cause serious health effects. It would be appropriate, however, to investigate the issue of cold idle emissions further, especially with regard to the public parking garage scenario.

Chevron felt that formaldehyde emissions are undermeasured. EPA staff agrees that care needs to be taken to avoid sampling losses and therefore will require a heated transfer tube and sample lines. Nevertheless, it has been shown that even without a heated transfer tube collection efficiencies range from 79 to 94 percent,[14] and that unheated sample lines can have efficiencies up to 98 percent.[15] Staff does not consider the data cited by Chevron to be valid, because an improper procedure was used. This issue is discussed in more detail in the test procedures sections in this document. Thus, the formaldehyde data used in this analysis are considered sufficiently accurate.

In regard to concerns that EPA's estimated emission factors are inaccurate, staff agrees that the emissions data base has limitations; however, because it contains data from 13 different studies (screened for appropriate measurement techniques) and from many different types of vehicles, it was concluded to be robust enough to be appropriate for the purposes of this analysis. Additionally, staff is confident that recent additions to the emissions data base have significantly improved the reliability of the projected in-use emission factors beyond those estimated earlier. Staff is convinced that any errors introduced as a result of the nature of the data base will be small and thus not significantly affect the validity of this analysis. An exception here may be necessary for cold idle emissions, which were previously discussed. In this case, the uncertainties argue for continued research by EPA and automobile manufacturers as methanol vehicles are developed. It is impossible to determine actual emission factors based on the prototype vehicle developed to date, but directionally, data for the newer, more advanced Toyota Carina are reassuring.

Both Chevron and AGA were concerned about catalyst durability affecting formaldehyde emissions. To the extent that adverse health effects are avoided due to the action of the catalytic converter, the issue of its durability is important to this discussion. As is discussed in more detail in the "Basis of the Organics Standard" section of this document, however, staff believes that sufficiently durable catalysts will be available.

The second major concern of those commenters supporting a separate standard for formaldehyde was the potential increased cancer risk due to increased formaldehyde concentrations in the atmosphere. With respect to the carcinogenicity of formaldehyde, CARB was correct; EPA has classified formaldehyde as a "Probable Human Carcinogen" (Group B1) under its Guidelines for Carcinogen Risk Assessment. As was stated by

EPA's Office of Pesticides and Toxic Substances (OPTS) [16], this classification is based on the following:

- ° limited evidence of carcinogenicity in humans (i.e., several epidemiologic studies show positive associations between respiratory site-specific cancers and exposure to formaldehyde);
- ° sufficient evidence of carcinogenicity in animals (i.e., formaldehyde induced an increased incidence of rare, malignant nasal squamous-cell carcinoma in mice and rats, and in multiple experiments); and
- ° additional supportive evidence (i.e., studies demonstrating formaldehyde's mutagenic activity in numerous test systems using bacteria, fungi, and insects, and ability to transform cells in culture and cause DNA damage in other in vitro assays for mutagenicity. Also, structure-activity analysis indicates that formaldehyde is one of several carcinogenic aldehydes.)

Included among this body of evidence was the National Cancer Institute study noted by Chrysler and GM. This study showed an excess of cancer among workers exposed to formaldehyde; however, the study's authors argued that this provided little evidence of an association with formaldehyde. OPTS disagreed, and argued that these results are meaningful. This position is supported by the other evidence of the carcinogenicity of formaldehyde.

Since methanol vehicles have the potential to increase ambient formaldehyde levels, it would be useful to approximate the magnitude of any increased risk they might represent. Unfortunately, no detailed work in this area has been performed. One study, admittedly limited in scope, of the Los Angeles airshed during an ozone episode predicted that the peak hourly formaldehyde concentration of the modeled air parcel would rise from 26 ppb to 31 ppb if 100 percent of the fleet in Los Angeles were converted to methanol.[2] Another study, modeling Philadelphia, showed similar results (formaldehyde rose from 22.5 ppb to 25.9 ppb).[3] These estimates can be considered worst case to some extent since the models assumed 10 percent of the mobile source organic carbon emissions were formaldehyde, but data indicate that the formaldehyde fraction would be closer to four percent.[1] In addition, preliminary results of another modeling study indicate that the lower reactivity of methanol may even result in a slight decrease in formaldehyde levels.[17] Thus, at low penetration levels the increase in ambient formaldehyde concentrations would be very small, and in some areas negligible. Accordingly, the effect on the cancer risk would also be very small or negligible. However, formaldehyde concentrations depend on a number of variables related to meteorology and emissions. Thus, given

the limited work available on this topic to date, it is not possible at this time to determine the exact magnitude of this increase, or whether there would even be an increase.

It should be noted that it is incorrect to assume that ambient formaldehyde concentrations will increase proportionate to any increase in formaldehyde emissions. This is at least in part because an unknown amount of ambient formaldehyde is formed by photooxidation of other organic emissions, and not from direct emission of formaldehyde. The fraction which is photochemically produced has been estimated to be 60 to 90 percent.[18] This issue is currently being investigated by EPA's Office of Research and Development.

Furthermore, the effect of methanol vehicle substitution on overall formaldehyde exposure will be even less dramatic than on outdoor ambient formaldehyde concentrations. This is because exposure to indoor sources of formaldehyde is very significant compared to that due to outdoor sources. Typical outdoor concentrations of formaldehyde are on the order of 10 ppb.[19] Typical indoor levels vary from 50 ppb for houses and workplaces to over 1000 ppb for occupational exposure in certain industries.[20] Given the large amount of time spent in indoor environments, any potential increase in ambient formaldehyde levels caused by methanol vehicles would represent a much smaller increase in the overall risk represented by all sources. Thus the question of equity regarding the relative level of control desirable for all sources of formaldehyde, including current mobile sources, becomes an important concern. It would not be appropriate to address the cancer risk of formaldehyde from methanol vehicles without allowing the Agencywide task force on formaldehyde, as mentioned previously, to formulate and interpret results from a larger, more comprehensive point of view. What can be concluded in the light of the low expected market penetrating for methanol vehicles is that, as GM noted, there is adequate time to assess this issue before there is any significant increase in the cancer risk due to formaldehyde from methanol vehicles.

As a final note, while it is true, as DOE noted, that there is currently no NAAQS for formaldehyde, this does not justify a decision not to regulate formaldehyde (or formaldehyde precursor) emissions. EPA has the authority, under Section 112 of the Clean Air Act, to regulate compounds on the basis of cancer risk without an NAAQS.

Conclusion

Based on the available data, it appears that separate standards for methanol or formaldehyde are not necessary at this time to prevent adverse environmental impacts with respect to either methanol or formaldehyde exposure. Nevertheless, the

Agency should continue to investigate this concern to accurately determine the potential effects of high penetration levels of methanol vehicles into the fleet.

There does appear to be justification for some concern about the impact of methanol vehicles on concentrations of formaldehyde in public parking garages. However, because of a very limited emission data base and questions about the validity of the analytical model of the garage, there is a significant concern that the analysis may be inaccurate, and that no action would ever necessary. Therefore, it is recommended that no additional action should be taken in this rule, but that cold idle emissions and the garage modeling itself be investigated further to ascertain the accuracy of the current analysis. This approach does not endanger the public, since the risk of exposure to toxic levels of formaldehyde in public parking garages is not significant until there is a substantial market penetration.

With regard to risk in personal garages, it is currently widely acknowledged that idling a vehicle in a garage is an unsafe practice, and thus formaldehyde and methanol exposures from methanol vehicles would represent nothing new in this regard. In addition, the odor and eye irritation from formaldehyde exposure would discourage owners from idling their vehicles in a personal garage, and serve as a warning of impending excess CO exposure. Since vehicle owners can, and should, voluntarily avoid the risks of exposure, additional regulations are not called for. There are numerous emission and modeling related uncertainties that call for resolution in regard to this scenario, and EPA and industry should expend effort to resolve them.

With regard to cancer risk due to increased ambient levels of formaldehyde, not enough is known about the impact of methanol vehicles on ambient concentrations to justify a standard. Preliminary modeling, however, does suggest a negligible impact, given existing outdoor levels due to current mobile and other sources and overall levels of exposure due to indoor concentrations.

The Agency should include methanol vehicle impacts in its continued consideration of formaldehyde's cancer impacts, and any mobile source-related studies in this area should consider methanol and petroleum vehicle technology at the same time. It would not, however, be appropriate to use this rule, intended to establish a level playing field for methanol vehicles, to regulate formaldehyde cancer risk from methanol vehicles alone.

Issue: Optional Combined Exhaust and Evaporative Standards

Summary of the Issue

EPA discussed the possibility of creating an optional combined exhaust and evaporative emission standard that would allow increases in evaporative emissions to be offset by decreases in exhaust emissions. Comments were specifically requested concerning the expected size and associated value of the increase in evaporative emissions that this alternative would permit, the environmental risks that might accompany this alternative, and methods for establishing a basis of equivalency between exhaust and evaporative emissions. No action was proposed.

Summary of Comments

Comments received on this issue fall into three areas: those concerning the heavy-duty industry, those concerning the light-duty industry, and those concerning the issue without regard for any particular class of manufacturers or vehicles.

The comments from the heavy-duty industry (Caterpillar, Cummins, and EMA) were in agreement that a combined standard would not be appropriate for heavy-duty vehicles since the industry is non-integrated (i.e., engines, from which exhaust emissions emanate, and vehicles, from which much of the evaporative emissions emanate, are manufactured separately). They felt that a combined standard would, therefore, cause "an unnecessary administrative burden."

Some of the commenters from the light-duty industry were more supportive of the concept. Chrysler, Ford, and GM all expressed moderate interest, though none of them were able to provide any specific information concerning the expected amounts of the offsets which might occur, or the value of the option. GM stated that this program would cause no environmental risks; Ford agreed, provided that photochemically reactive exhaust emissions are not allowed to increase by lowering less reactive evaporative emissions. GM also commented that assuming the typical vehicle makes 3.05 trips and travels 31.1 miles per day (these numbers were presented by way of example in the NPRM) would overestimate evaporative emissions. Toyota was the only commenter from the light-duty industry that did not support the option of a combined standard; they felt it would not be cost effective to utilize this option because it would require an increase in the number of evaporative tests required per vehicle family.

Chevron opposed the concept of a combined standard in general, citing environmental concerns. They stated "that there are many unresolved questions about the proper

characterization of vehicle evaporative emissions," and felt that as a result, establishment of an environmentally benign equivalence between evaporative and exhaust emissions would be difficult. For this reason, they suggested that the Agency should deepen its understanding of evaporative emissions before this type of regulation is undertaken.

Analysis of Comments

The Agency considered this option in the belief that it might provide some measure of regulatory relief by enabling manufacturers to decide the most cost-effective combination of exhaust and evaporative emission controls to limit a vehicle's total organic emissions. For example, this option could allow the manufacturers to use smaller evaporative control systems than would normally be required, provided that exhaust emissions are sufficiently low. The comments received from the heavy-duty engine industry, though, indicate that this option would not be desirable to the industry. It is not obvious, however, that implementation of such a program would cause any significant administrative burden for non-integrated engine manufacturers, since they are currently responsible for evaporative certification, and since the program would be optional.

Most comments from the light-duty industry did support the option, but manufacturers were unable to provide any specific estimates for the amount or associated value of the flexibility this program would provide, making it difficult to judge the program's potential benefits.

EPA remains concerned that the benefits of such a program may be inconsequential since, as discussed in the NPRM, the evaporative standards were designed to be non-fuel standards, that is they were "intended to encourage manufacturers to focus their efforts on eliminating fuel emissions." The two grams per test allowance was implemented to account for background sources of organics (such as interior materials or lubricants), to accommodate some degree of test-to-test and vehicle-to-vehicle variability, and to provide some compliance cushion. This is supported by the fact that vehicles that exceed the standard often exceed the standard by a very large amount, because the canister becomes saturated and ceases to effectively absorb the emissions. Thus, allowing slight exceedances of the evaporative standard may have little practical value, since slight exceedances rarely occur. The lack of comments in this area, despite EPA's specific request, suggests a lack of genuine interest in this type of program on the part of the manufacturers and makes it difficult for the Agency to proceed.

Toyota's concern that this alternative might be disadvantageous if it resulted in a need for more evaporative emission testing is noted; however the alternative need not be used by any manufacturer who would be harmed by its application.

A more significant concern with this alternative is that, as was acknowledged in the NPRM, EPA is not certain how to reconcile light-duty vehicle exhaust and evaporative emissions to a common basis for comparison, to ensure that there would be no increase in total emissions. Since total evaporative emissions are a function of driving patterns (hot soak emissions occur after engine shutdown, thus the more trips per day, the greater the expected evaporative emissions), these patterns must be carefully accounted for in establishing an equivalence between exhaust and evaporative emissions. The method presented as an example in the NPRM was to combine the emissions from the hot soak test (HS) with the emissions from the diurnal test (DI) using the following formula:

$$\begin{array}{lcl} \text{emissions} & = & \frac{(\text{trips per day})(\text{HS}) + (\text{DI})}{\text{per mile} \quad (\text{miles per day})} \end{array}$$

This approach, however, may not be appropriate because it assumes that average emissions can be estimated with average values for the number of trips per day and miles per day which occur in use. Driving patterns can vary greatly from vehicle to vehicle however. For example, some vehicles may not be driven every day and would undergo repeated diurnals without the canister being purged. Other vehicles operate continuously during the diurnal period and thus the canister would generally be well purged. While average values can be derived for the relevant driving related parameters, it is not clear that they would correctly weight the different emission levels associated with different driving habits. Thus, an accurate assessment of all typical driving patterns and their associated emissions effects would be necessary in order to convert evaporative emissions test data to in-use emission factors. EPA discussed this issue in the NPRM and asked for input from the public, but no commenter was able to provide data which could be used to overcome the deficiencies in the current analysis.

Another concern in this regard relates to the fact that the hot soak and diurnal tests might not be generally accurate representations of actual in-use evaporative emissions. As mentioned previously, the evaporative emission standards were designed such that the majority of the emissions from vehicles meeting their standards should be from non-fuel sources. These emissions will typically change with age as background vehicle organics "boil off" and lubricants and road sludge accumulate on the vehicle surfaces. Additionally, hot soak and diurnal emissions are affected by local climate and time of year; the same is true for exhaust emissions, though to a differing

degree. An equivalence established between evaporative and exhaust emissions at FTP conditions, therefore, may not be realistic at other conditions. Given the limited amount of methane vehicle emissions data available at FTP conditions (much less at other conditions) and given that the gasoline content which greatly affects evaporative emissions) of future methane fuels is unknown, it is impossible to assess the potential for such errors at this time.

GM comment that the example approach to establishing equivalency that EPA gave in the NPRM would overstate evaporative emissions seems to illustrate the uncertainties discussed here but does not help to establish a more workable evaporative comparison. Given the lack of data made available to the Agency, staff must agree with Chevron's statement that the issue of equivalency between exhaust and evaporative emissions is still unresolved. This makes application of a combined standard in a manner that would provide flexibility without the possibility of adverse consequences to the environment very difficult.

Finally, the Agency has noted elsewhere that the goal of this rulemaking is to provide a "level playing field" for methane vehicles. Promulgating a combined exhaust and evaporative standard could have far reaching implications which relate to other types of vehicles as well, and would be more appropriately addressed separately at a point when better information on emissions tradeoffs is available.

Conclusion

The concept of a combined exhaust and evaporative standard did not receive strong support from the commenters in general. While the comments from the light-duty industry were somewhat supportive, the comments from the heavy-duty industry were all opposed to it. None of the manufacturers provided any information which indicated that the benefits would be significant. In fact, some of them suggested there would be a net cost associated with them. Given the fact the evaporative standards were designed as non-fuel standards, it is not obvious that significant benefits from the program are even possible. Therefore since: 1) designing an appropriate combined program would be very complicated, 2) the state of knowledge with respect to emissions modeling is not sufficient to give EPA confidence that negative environmental impacts would be avoided with such a program, and 3) the present rulemaking was intended to establish a level playing field for methane vehicles, not to explore new regulatory concepts that might apply to all vehicle types, it is recommended that action on this concept be deferred at this time.

Issue: Application of Particulate and Smoke Standards

Summary of the Issue

EPA proposed applying the current diesel particulate and smoke standards to all non-throttled methanol engines. EPA also asked for comments on the likelihood of heavy-duty methanol engines automatically complying without the use of trap oxidizers with the 0.60 g/BHP-hr particulate standard which takes effect in 1988 and the 0.25 g/BHP-hr particulate standard effective in 1991.

Summary of Comments

Mercedes Benz Truck Company (MBTC) disagreed with EPA's engine classification scheme for applying smoke/particulate standards to methanol engines. MBTC claimed that the throttled/non-throttled differentiation is irrelevant to a methanol engine's soot forming potential. Rather, the important factor is the kind of lubrication used. MBTC notes that so far particulates have been found in the emissions of a two stroke, non-throttled methanol engine, and points out that a two stroke throttled methanol engine might also emit higher levels of particulate but under the proposed classification scheme would not be subject to the particulate standard. MBTC strongly supported EPA's proposal to allow for waivers of test requirements wherever applicable.

Citing preliminary data, DOE commented that "the by-products of lubricating oil combustion in a compression ignition engine included a significant quantity of engine out particulate matter," regardless of fuel type. Since non-throttled methanol engines are derived from compression ignition technology, DOE found the proposed standards appropriate.

The state of New York stated that the throttled/non-throttled distinction may be ambiguous. It noted the Daimler-Benz OM 407 hGO methanol engine which uses a throttle at low and medium load ranges but operates non-throttled in the upper load range.

General Motors stated that, based on a few tests of its light-duty methanol vehicles, particulate emissions should be well below the proposed (for non-throttled vehicles) 0.20 g/mi standard and that this standard is unnecessary.

With regard to heavy-duty engines, GM felt that their M100 methanol engines should have no problem complying with the 1988 and 1991 heavy-duty engine standards without any aftertreatment (although they note that driveability testing has not been

performed). They were less confident, however, about the prospects for automatic compliance with the 0.10 g/BHP-hr standard, proposed to apply to bus engines in 1991 and all HDME's in 1994. GM's data on HDME's fueled with M100 suggests a possible range of uncontrolled particulate emissions from 0.12 to 0.22 g/BHP-hr. With catalytic aftertreatment, GM noted that this level has been limited to 0.05 g/BHP-hr in one test. Smoke levels were reported below 0.1 on the Bosch scale over the 13-mode test.

GM noted that if M85 fuel becomes the fuel of choice for heavy-duty methanol engines, they may not be able to comply with 1988 and 1991 particulate standards as easily.

Caterpillar and EMA both argued that smoke levels ought to be very low for methanol engines and that EPA ought to allow for waivers of this standard in a fashion similar to that allowed for current CO standards for HDDE's. Neither party commented on the need for a particulate standard.

Analysis of Comments

In order to appropriately analyze the comments on this issue it would be useful to review the logical context of EPA's proposed rules for particulate and smoke emissions from methanol engines. It has long been acknowledged that methanol combustion produces lower particulate and smoke levels than petroleum combustion in diesel engines. Recently promulgated particulate and smoke standards, however, will lower emissions from heavy-duty diesel engines to levels which are below the measured emissions from at least one prototype methanol engine. As long as the possibility exists for methanol engines to emit particulate or smoke above the diesel standard, it would be inappropriate to avoid limiting particulate emissions on methanol engines. On the other hand, in developing its proposed standards, the Agency wished to avoid unnecessarily burdening manufacturers with regulations for engines that clearly would not emit at levels in excess of the diesel standards. EPA's goal was to apply the diesel standards to methanol-fueled vehicles with characteristics similar to those of current diesel vehicles. Some criteria were therefore needed by which engine type could be evaluated.*

* The discussion focuses on particulate emissions. The potential for emission of smoke, which is not often reported in the literature for methanol engines, is assumed to be related to that for emissions of particulate. The discussion recognizes that the absence of smoke in engine exhaust does not necessarily imply the absence of particulate matter.

Particulate formation, in a practical sense, has been considered a fuel related phenomenon. As general rule fuel oil has been used in diesel (compression ignited, heterogeneous fuel air mixtures) engines and gasoline has been used in Otto-cycle (spark ignited, homogeneous charge) engines. However, with the emergence of methanol as a fuel this categorization breaks down. Methanol can be combusted in engines derived from diesel engines, gasoline-fueled engines, and engines which are hybrids of the two. Certain methanol engines have demonstrated the potential to emit significant levels of particulate; thus it became necessary to consider engine parameters other than fuel type to apply particulate standards.

One criterion considered as a possible basis for predicting particulate formation potential for methanol engines was method of ignition. Current diesel engines, with higher particulate, are compression ignited, while gasoline engines are spark ignited. With regard to neat methanol, compression ignition has been difficult to achieve under the range of possible operating conditions, and therefore ignition assistance, such as use of spark or glow plugs has generally been found necessary. (Cetane improvers can allow compression ignition to occur but have been found less practical due to their high cost.) For example, MAN's heavy-duty methanol engine uses spark plugs as do the majority of all light-duty methanol engines developed to date, while the GM Detroit Diesel Allison (DDA) heavy-duty methanol engine uses glow plugs over part of its operating cycle. The particulate emissions from the MAN have been generally lower than the new diesel standards, but those from the DDA have been higher, as is confirmed by GM's comments. Particulate emissions from light-duty engines have not been generally reported, although GM states that its light-duty engines are very low emitters.

While the evidence summarized here suggests that spark ignited methanol engines are low particulate emitters and engines utilizing glow plugs over a portion of the normal operating cycle are potentially higher particulate emitters, the data are simply too empirical and far too limited to serve as the basis for any sort of regulatory decision. A more fundamental understanding of particulate formation potential was therefore sought in order to develop criteria for regulating methanol engines.

Particulate nucleation is thought to occur in localized fuel rich areas of the combustion chamber. A series of pyrolytic reactions rearranges the hydrocarbons into molecules of lower molecular weight and level of hydrogen saturation. Acetylene is apparently the last stable species present as a result of this process. Acetylene reacts through polymerization and continued branching to form polycyclic hydrocarbon structures of high carbon/hydrogen ratio. These

structures are thought to account for the crystalline nucleus of the particulate matter.* Diesel combustion is generally characterized by a fuel droplet distribution within the chamber, enabling combustion to occur at numerous localized sites more or less simultaneously as a result of the heat built up through compression of the mixture. The outer layers of the droplets combust properly, but the insides are carbon rich, resulting in incomplete combustion (carbon combusts only at temperatures above those achieved in the cylinder) and facilitating the nucleation process discussed above. This process is followed by agglomeration of carbonaceous and other organic materials, resulting in particulate matter.

In contrast, Otto-cycle engines rely on a homogeneous charge through which a flame front, initiated by a high energy ignition source (spark plug), propagates. Since fuel air ratio is fairly uniform and within the flammability limits almost everywhere in the cylinder, particles do not form as readily.

The theory of nucleation suggests that the effectiveness of the mechanisms which result in particulate formation depends, at least in part, on the presence of hydrocarbon chains in the fuel; methanol's simple chemical structure thus deters particulate formation to some degree, although probably not entirely, since the products of methanol combustion include some hydrocarbons of higher molecular weight. Additionally, the presence of lubricating oil, as MBTC and DOE point out, in the combustion chamber, and the as yet unresolved question of whether there will be any gasoline additive, as mentioned by GM, all add to the engine's particulate formation potential by providing hydrocarbon chains for the nucleation process. In fact, the excess particulate emissions of the Detroit Diesel Allison engine were ultimately attributed to the combustion of oil which had been leaking past the seal between the piston crown and skirt. A seal design change appears to have corrected this problem and reduced engine-out particulate levels significantly, to the level of approximately 0.06 g/BHP-hr.**

Thus while combustion of pure methanol would probably, according to nucleation theory, not result in particulate levels of regulatory concern, combustion of methanol

* Other theories exist to explain the nucleation phenomenon, which, though less popular than the one discussed here, also depend on the presence of hydrocarbon molecules of higher molecular weight than methanol.

** This information has become available in the time since GM submitted its comments and thus is not discussed in those comments. These data are available for review in the rulemaking docket (number A-84-05).

containing hydrocarbon chains (due to the presence of lube oil, gasoline, or other fuel additives) might. This is especially true when one considers such combustion in a heterogeneously charged cylinder, which would contain numerous fuel rich sites to facilitate nucleation, as occurs in the diesel engine. It was for this reason that EPA selected the throttle criterion as a basis for regulating methanol engine particulate and smoke emissions, since the lack of a throttle implies that power will be controlled by varying the fuel rate through injection, and this is likely to result in fuel droplets or mist dispersion in the cylinder, with the attendant possibility of particulate formation.

DOE, which like MBTC, whose comment will be addressed below, implicated lube oil combustion as a particulate precursor, went further in its analysis to focus on lube oil combustion in, specifically, a compression ignited (i.e., diesel type) engine. While, as will be discussed, it is apparent that excess lube oil combustion in a throttled, or Otto-cycle, engine may also cause elevated particulate levels, DOE's comment seems to recognize EPA's logic and supports the proposed action.

MBTC argued that since two stroke engines utilize more oil than four stroke engines, they should be the focus of EPA's regulations. Such a focus was seen to have two advantages; it would prevent throttled two stroke methanol engines from emitting excessive particulates, and would eliminate burdens for non-throttled four stroke methanol engines. In regard to the first point, higher oil consumption would indeed suggest the possibility of increased particulate emissions, even in the case of throttled (homogeneous charge) engines. This is aptly demonstrated by the performance of older motorcycle engines which were often of two-stroke cycle design and which were noted for the smoky nature of their exhaust. Incomplete combustion of lube oil, containing long chains of hydrocarbons, in the oil mist that was inducted into the chamber resulted in particulate formation, most likely according to a similar mechanism to that in diesel engines from fuel droplets. Additionally, it is anticipated that oil washed from the walls by the high energy air induction stream characteristic of two stroke engines may result in particulate formation in the fuel rich quench zones near walls and in crevices. This sort of gasoline engine is too rare now within regulated classes of vehicles to warrant present consideration of particulate standards. Nevertheless, methanol engine regulations developed on the basis of particulate formation potential, as discussed previously, ought probably in the broadest sense take into consideration the particulate formation potential of two stroke methanol engines as well. It is however, noted that there is no apparent effort underway to develop or commercialize a two stroke throttled methanol engine. Thus promulgation of standards applicable to these engines would be premature at

present. Additionally, the premise of this rulemaking is to create a level playing field for methanol engines. Therefore it is noted that consideration of standards applicable to all two-stroke methanol engines ought only occur concurrent with consideration of such standards for two-stroke gasoline engines in a separate rule.

Regarding the second point, there is simply not enough data to show conclusively that all non-throttled four stroke methanol engines will not have lube oil combustion, and/or combustion of other fuel additives sufficient to cause significant particulate emissions. (These factors are known to contribute to particulate formation even in today's four stroke diesels.) The proposal recognized that the possibility exists that some non-throttled engines may not emit particulate at levels exceeding the standard without any aftertreatment and that, as Caterpillar and EMA pointed out, smoke levels may not be significant for any methanol engine. Unfortunately, however, at least until it becomes clear which type of methanol engines are practical in the marketplace, and whether actual particulate emissions are in line with what the theory discussed here suggests they should be, it is important for EPA to regulate on the basis of emission potential, including a consideration of what types of engines appear practical market contenders. Any engine which falls into a regulated category but which proves to be a low emitter of particulate or smoke would be able to use the waiver process to avoid a testing requirement. This process, supported by several commenters and opposed by none, is a very simple one as it applies currently to diesel engine CO emission testing. It should be just as simple and nonburdensome in the case of methanol engine smoke and particulate testing.

In response to the State of New York's comment about the Daimler-Benz engine, an engine which is non-throttled during a significant portion of its duty cycle, such that potential for significant particulate emissions exists, would have to be considered a non-throttled engine for purposes of this regulation.

The comments by DOE, MBTC, and New York point out that while the throttle criterion is appropriate at this time, it may not be complete. To guard against the possibility that developments in emerging methanol technology that may be unforeseen today result in engine characteristics for which the throttle criterion is insufficient, the Administrator should be provided with the flexibility to consider other engine parameters to determine the applicability of the existing gasoline (Otto-cycle) or diesel standards: While the throttle criterion is expected to be important one, other characteristics such as intended in-use duty cycle, engine thermodynamics, and compression ratio may also be important and the Administrator should be able to use them in making the classification.

GM was the only commenter to address the feasibility of the proposed standards, and they found that, at worst, a catalytic converter might be necessary to ensure compliance with the most stringent standard, that applicable to 1994 heavy-duty engines and 1991 bus engines. Since catalytic converters are an established technology and are acknowledged to be a less expensive technology than particulate trap oxidizers (which diesel engines may need in order to comply), the standards are economically reasonable.

Conclusions

The limited data on particulate and smoke emissions from methanol engines, taken together with particulate formation theory, indicate that the conditions necessary to form particulate are extant in the combustion process of non-throttled engines. Thus, at this time, it is appropriate to focus on the non-use of a throttle to apply the current diesel standards to methanol-fueled engines. It is noted that, for any regulated engine which proves to be a low emitter, the process EPA proposed for obtaining a waiver from testing would be a simple one. The proposed standards are feasible and control costs should be no more than those of current diesels.

The analysis also suggests, however, that EPA should broaden its approach to application of current standards to allow for the future consideration of engine parameters other than the use of a throttle. The Administrator should retain the flexibility to consider other engine characteristics to determine if a methanol-fueled engine would have emissions more similar to current diesels or to current Otto-cycle engines. Further, all references in the proposed rule to throttled and non-throttled methanol engines should be altered to use the more general Otto-cycle and diesel nomenclature.

Issue: CO and NOx Standards

Summary of the Issue

The Agency proposed applying current gasoline-fueled standards for CO and NOx to throttled methanol vehicles, and current diesel standards to non-throttled vehicles. EPA also proposed idle CO standards for all methanol-fueled light-duty trucks and heavy-duty engines, though the current idle CO standard applies to gasoline-fueled light-duty trucks and heavy-duty engines only. This was done to account for methanol vehicles that are non-throttled over much of their normal operating range, but throttled at idle. EPA mentioned that manufacturers of engines that are expected to always remain below the level of the idle CO standard would be able to apply for a waiver to avoid testing (this is currently done with the CO standard for heavy-duty diesel engines). For clarification, such a waiver only relieves the manufacturer from undergoing certification tests, it does remove liability for complying with the standard. The issue is whether the Agency's approach in setting CO and NOx standards is appropriate.

Summary of the Comments

The Agency received comments from Caterpillar and Chevron, which were generally supportive of the CO and NOx standards proposed for methanol vehicles. With regard to the proposed standards for throttled methanol engines DOE specifically stated that available data indicate:

"that methanol vehicles have little or no difficulty complying with current exhaust standards for CO and NOx if they are equipped with the same emission control systems as certified gasoline-engine vehicles."

No commenter beside MAN specifically discussed the feasibility or appropriateness of the standards for non-throttled engines. MAN suggested standards of 7.5 g/BHP-hr be adopted for heavy-duty methanol engines for the transition period between 1988 and 1991. They stated that it appears that spark-ignition methanol engines with turbochargers and intercoolers will be capable of meeting the proposed NOx limits. They argued that fuel economy would suffer if NOx emissions are reduced to 6.0 or 5.0 g/BHP-hr as was proposed for 1988 and 1991, respectively, and that this would delay the acceptance of methanol engines.

EPA received only one comment opposing the approach taken to setting idle standards. Ford stated that it was not necessary to have an idle CO standard for methanol-fueled vehicles that are non-throttled at idle. They felt it would be more appropriate to have a standard only for vehicles that are

throttled at idle, than to "arbitrarily set standards which then put a burden on the manufacturer to either comply or apply for a waiver."

Analysis of Comments

As was discussed in the previous section, the two types of methanol engines may be more appropriately referred to as Otto-cycle and diesel, instead of throttled and non-throttled.

That so few comments were received in regard to EPA's proposed CO and NOx standards is interpreted as an indication that the proposals were generally reasonable and that EPA's use of the throttle criterion as the basis for application of diesel and gasoline standards is appropriate. The support of Caterpillar, Chevron, and DOE for the proposed emission standards is noted.

Since it is EPA's goal to create a "level playing field", there is no reason to create special benefits for methanol engines by decreasing the stringency of their NOx standard as MAN suggested. Since methanol's flame temperature, which is less than that of gasoline or diesel oil, inherently limits NOx formation to lower concentrations, staff is confident that methanol engines will be able to comply with the 6.0 g/BHP-hr (1990 model year) and 5.0 g/BHP-hr (1991 and later model years) standards at least as easily as current gasoline-fueled and diesel engines will. Thus, the acceptance of methanol vehicles will not be affected by promulgation of equivalent NOx standards.

The Agency chose to propose idle CO standards for all (both Otto-cycle and diesel) methanol-fueled light-duty trucks and heavy-duty engines to ensure that none of these methanol engines emit high levels of CO at idle. It was concluded that this would not place any significant burden on manufacturers since they would be allowed to apply for a waiver from testing if an engine type was expected to not have significant CO emissions at idle. Ford's argument, that since EPA's primary concern is to ensure that engines throttled at idle are subject to CO testing then standards should apply only to those engines, is noted. The proposed approach will accomplish this and will additionally ensure that no other engine emits potentially harmful levels of CO at idle. This approach recognizes the fact that methanol vehicles are a new technology, and EPA has an incomplete understanding of emissions performance of all methanol engine designs. Given this, it seems prudent to apply the standards as proposed where testing is not necessary because levels are anticipated to be low, a waiver would be available. Ford, however, argued that application for a waiver to the idle CO standard would be a burden to the manufacturer. Staff does not consider the

application process to be a significant burden to the manufacturer; waiver applications are easily and routinely processed with regard to the diesel engine CO standard today. Thus there is no reason to change the proposed standards.

Conclusion

The CO and NOx standards proposed to apply over the transient engine dynamometer test cycles for heavy-duty engines and the chassis dynamometer test cycles for light-duty vehicles and trucks are equivalent in stringency to those for gasoline and diesel engines, vehicles, and trucks and should not cause any unnecessary burden for manufacturers.

With respect to the idle CO standards, it is concluded that the proposed standards will not create any significant burden to manufacturers of methanol-fueled diesel engines, and that in the general absence of data showing negligible CO emissions from these engines, the most prudent approach is to promulgate idle standards for all methanol engines.

Therefore, it is recommended that all CO and NOx standards be promulgated as proposed, with slight language change regarding engine type (i.e., Otto-cycle and diesel).

Issue: Control of Crankcase Emissions From Heavy-Duty Engines

Crankcase emissions are currently not allowed from any heavy-duty engine or vehicle, except for diesel engines using turbochargers, pumps, blowers, or superchargers for air induction (i.e., non-naturally aspirated diesel engines). Under the proposed methanol regulations no crankcase emissions would be allowed for any methanol-fueled vehicle or engine, including non-naturally aspirated non-throttled heavy-duty engines. EPA proposed classifying methanol engines into throttled (gasoline-like) and non-throttled (diesel-like) categories in order to apply particulate and heavy-duty HC and CO standards. Some manufacturers of heavy-duty engines therefore felt that a universal prohibition of crankcase emissions from non-throttled methanol engines represented an extension of control beyond current requirements. At issue, therefore, is whether it is appropriate to restrict crankcase emissions from non-naturally aspirated, non-throttled, heavy-duty methanol engines.

Summary of Comments

EPA received comments from Caterpillar, EMA, and GM all of whom opposed control of crankcase emissions from non-naturally aspirated, non-throttled, heavy-duty methanol engines. They argued that crankcase controls are not currently required for non-naturally aspirated heavy-duty diesel engines because crankcase emissions from these diesels are insignificant compared to the associated cost of control. In support of this position Caterpillar discussed the combustion and scavenging process in non-throttled engines to show why crankcase emissions can be expected to be low. The manufacturers referred to a 1979 analysis and a 1983 analysis (which referred to the 1979 analysis) by EPA staff[21,22] which showed that it was not cost effective to control these emissions.

The commenters argued implicitly that the cost of controlling non-throttled methanol engines would be the same as for diesels because of similar emissions characteristics and required control technology. Control on a turbocharged engine for example would require a pump to route the crankcase gas either into the exhaust in front of a catalyst, or into the intake manifold after a turbocharger. The manufacturers felt that these pumps would be prohibitively expensive. Routing the gases into the turbocharger would result in fouling due to oil mist, which would cause maintenance problems and associated high costs, and therefore should not be a regulatory option. The commenters presented no emissions or cost data on either diesel or methanol engines with which the 1979 study could be updated or extended to methanol engines.

Analysis of Comments

The commenters based their argument, that crankcase emissions should not be controlled for non-naturally aspirated, non-throttled (diesel), heavy-duty methanol engines because it would be unnecessarily expensive, on EPA's 1979 analysis relating to diesel engines. The commenters claimed that this analysis is also valid for non-throttled methanol engines, but did not provide any new emissions data or cost estimates to justify this.

The previous analysis, however, is not applicable to methanol engines. It is expected that control costs for methanol-fueled diesel engines will be much lower than the estimated cost used in the original analysis of diesel control cost, for several reasons. First, methanol-fueled diesels are expected to have lower particulate emissions than petroleum-fueled diesels, and thus blow-by gases should be cleaner, easier to filter, and less of a concern with respect to turbocharger fouling. Because of these low levels of particulates, it may be more appropriate to compare crankcase emissions from methanol engines to crankcase emissions from gasoline engines which have been routinely routed through turbochargers for years. A similar control technology could be applied to any methanol engine configuration, including those using pumps, blowers, or superchargers. Therefore, it is likely that control costs of non-naturally aspirated methanol-fueled diesel engines would be similar to those of turbocharged gasoline engines, whose control costs are much lower than those of petroleum-fueled diesels.

Second, the earlier analysis is outdated and represents a worst-case cost effectiveness for petroleum-fueled diesels. Since the time the analysis was done, two manufacturers (Daimler-Benz and Isuzu) have begun voluntarily controlling crankcase emissions from turbocharged diesel engines by routing the emissions through an oil separator, and into the turbocharger. Actual control costs for the Daimler-Benz engine are much lower than EPA's 1979 estimate of \$100 (1979 dollars).[23] Admittedly the estimate EPA received was for the cost of controls for one engine model and may not be representative of costs for heavy duty engines in general. However, if even only a moderate rate of inflation is applied to the 1979 estimate, it seems likely that current costs would on average be lower than those EPA estimated in the earlier analysis. Thus, even if the petroleum-fueled diesel/methanol-fueled diesel comparison were valid, the 1979 analysis would still not be applicable.

Finally, the validity of the 1979 analysis with respect to this rulemaking is questionable because since that time the Agency has found it necessary to consider progressively more costly VOC control programs to bring U.S. cities into attainment with the ambient ozone standard. Thus, what was not

considered to be cost effective in 1979 could be cost effective today. In fact, given current air quality priorities the Agency could eventually decide to reconsider its earlier decision to allow non-naturally aspirated petroleum-fueled diesel engines to emit crankcase gases.

An additional point, which was not mentioned in the comments, is EPA's concern about emissions of nitrosamines, which are known carcinogens, formed by reaction of amines in the lubrication oil with oxides of nitrogen. Nitrosamines were noted as a health concern in the 1979 analysis. Since then it has been shown that significant amounts of nitrosamines are found in the crankcase emissions of petroleum-fueled diesel engines.[24] It is highly likely that they are also present in methanol crankcase emissions (because the same basic formation circumstances exist regardless of the fuel type), though possibly at lower concentrations due to the lower NOx emissions expected with methanol-fueled engines. Control of crankcase emissions would essentially eliminate emissions of nitrosamines.

Conclusion

Crankcase emissions from methanol-fueled diesel engines can potentially represent a significant source of organics, carbon monoxide, oxides of nitrogen, and nitrosamines; thus, closing the crankcase would provide significant environmental benefits. The argument that controlling crankcase emissions from non-naturally aspirated methanol-fueled heavy-duty engines will be as expensive as controlling crankcase emissions from petroleum-fueled diesels is not valid. The control technology for methanol-fueled diesels should be simpler than for petroleum-fueled diesels because of lower particulate emissions and costs will likely be more like those for gasoline engines. Therefore, it is recommended those no crankcase emissions be allowed from any methanol engine, as was proposed.

Issue: Emissions Averaging Programs

As noted in the ANPRM, EPA originally considered allowing manufacturers the option of including methanol-fueled diesel vehicles and petroleum-fueled diesel vehicles within a single combined particulate averaging program. Several commenters to the ANPRM noted, however, that methanol-fueled diesel vehicles might not compete directly with petroleum-fueled diesel vehicles, and that including methanol vehicles within the averaging programs could therefore result in an overall increase in particulate emissions. EPA decided not to propose this option in the NPRM but requested comments on the likelihood of direct market competition between methanol-fueled diesels and petroleum-fueled diesels, and the desirability of including methanol-fueled diesels with petroleum-fueled diesels in a combined particulate averaging program.

Summary of Comments

The Agency received three comments on this issue. GM supported inter-fuel averaging, but both Caterpillar and Cummins felt that such averaging should not be allowed.

GM felt that averaging should be allowed between different fuel types as an incentive to produce methanol engines. However, they did maintain that if fuel prices remain as they are now, it would be unlikely that methanol HDEs would compete directly with diesels, except for urban bus engines. GM stated that they did not believe that an adequate trap system would be developed in time to meet the 0.10 g/BHP-hr standard for buses in 1991, and that use of methanol engines will be required to meet the standard. They argued that providing for averaging across fuels for bus engines would allow areas without particulate problems to purchase less expensive diesel buses (which would be unable to meet the standard), while areas with particulate problems could be required to purchase methanol-fueled buses or diesel buses with traps in order to receive operating subsidies from the Federal government. They also stated that because of the stringency of the 1991 standard, a substantial number of methanol buses would have to be produced to provide averaging credits sufficient to allow production of a single diesel bus without a particulate trap.

Caterpillar and Cummins argued that it would not be possible to predict direct competition between methanol engines and diesels. Cummins agreed with EPA that without direct competition, inter-fuel averaging could result in increased particulate levels. Additionally, Caterpillar argued that averaging between different fuel types would give an unfair advantage to manufacturers of smaller urban type engines, since methanol will be more available in urban areas initially. Therefore, they felt that averaging should be allowed only

after methanol is readily available in both urban and non-urban areas. Similarly, Cummins argued that inter-fuel averaging would create inequities for manufacturers who do not produce many methanol-fueled vehicles.

Analysis of Comments

The position of both Caterpillar and Cummins that allowing averaging between the fuel types could give an initial advantage to manufacturers that produce methanol engines or small urban engines may be valid. However, it is not necessarily true that providing regulatory flexibility, which might be more advantageous for some manufacturers than others, would be anti-competitive. The Agency's main concern regarding such averaging is the possible air quality degradation that could result if methanol engines did not compete directly with diesel engines.

This problem was discussed in the Regulatory Support Document to the NPRM, where a detailed analysis was presented for light-duty vehicles. This analysis showed that unless methanol and diesel vehicles compete directly, particulate emissions could be greatly increased. For example, in one scenario it assumed that 200,000 light-duty methanol vehicles are produced and included in the averaging program, but that only 30,000 replace petroleum-fueled diesels (out of 60,000 light-duty petroleum-fueled diesel vehicles), while the rest replace gasoline vehicles. The analysis showed that light-duty particulate emissions would double if averaging were allowed. The analysis simplistically assumed methanol engines emit no particulate; however the conclusions remain directionally valid even if, as is now known to be possible, methanol vehicles do emit a small amount of particulate. On the other hand, if methanol-fueled diesels and petroleum-fueled diesels did compete well, then total particulate emissions would not increase because each methanol-fueled diesel produced would replace a petroleum-fueled diesel, and the total number of vehicles averaged would not increase. This analysis can be easily extended to heavy-duty engines to show that unless heavy-duty methanol-fueled diesel engines compete directly with petroleum-fueled diesel engines, allowing cross-fuel averaging could lead to increased particulate levels. In summary, if methanol engines or vehicles which replaced gasoline engines or vehicles were allowed to be averaged with petroleum-fueled diesels, then particulate emissions would increase.

It was stated in the NPRM that it is "impossible to predict with any certainty the degree to which the two vehicle types will be competitors." However, this early analysis was somewhat limited in scope. Since publication of the NPRM, the Agency has to reconsidered its approach to regulating all heavy-duty engines, including methanol engines. There is now reason to believe that it may be possible to develop an

integrated program allowing cross-fuel averaging in some cases as well as some form of banking and trading of emission credits among manufacturers. Because the scope of such a program is clearly beyond that of this action, it is more appropriate for this issue to be addressed in a separate action. EPA is, in fact, already doing so, and therefore, complete analysis of the comments received will be deferred to that action.

Conclusion

Since the issue of cross-fuel averaging is much broader in scope than this rulemaking, it would be inappropriate to address it here. Analysis of the comments should be deferred to a separate action. There is no apparent reason, however, not to allow averaging within classes of methanol engines, as is currently allowed for diesels, and as was proposed in the NPRM for this regulatory action.

Issue: Determination of Fuel Equivalency

EPA originally discussed, in the ANPRM, alternative approaches to determining a fuel equivalency factor (FEF) for methanol, to be used in connection with the Gas Guzzler and Corporate Average Fuel Economy (CAFE) programs. However, it was determined in the NPRM that establishment of such an equivalency factor would be premature prior to a discretionary decision by the Secretary of the Treasury, in the case of Gas Guzzler, or the Secretary of Transportation, with reference to CAFE, to include methanol in their respective programs. Since neither Secretary had taken this action, EPA proposed no action in this regard in the NPRM.

Summary of Comments

Several commenters (Ford, GM, Chrysler, CARB, Nissan and NADA) felt that EPA should pursue the issue of an FEF further. In general, the reasons given were that establishment of an FEF, and inclusion of methanol in the CAFE and Gas Guzzler programs, could provide an incentive for production of methanol vehicles through CAFE and Gas Guzzler credits. Conversely, failure to establish an equivalency would be an impediment to production of methanol vehicles, due to uncertainty among manufacturers as to how or if methanol will be included in these programs.

Ford noted that the type of methanol vehicle produced would depend on how methanol is handled with respect to CAFE and Gas Guzzler. If methanol were excluded from CAFE and Gas Guzzler, it would be beneficial to produce large methanol vehicles instead of smaller, more fuel efficient vehicles. This is because removing fuel efficient vehicles from a CAFE calculation (by substitution of a methanol vehicle) would lower a manufacturer's CAFE, while excluding less efficient vehicles would raise it. If a petroleum-based FEF were used, then production of all methanol vehicle types would be encouraged since methanol vehicles use very little gasoline, and production of any model, regardless of its fuel efficiency, would boost a manufacturer's CAFE. If, however, methanol vehicles were included in CAFE and Gas Guzzler based on the measured methanol fuel economy, then there would be a disincentive to produce any methanol vehicles, since the lower energy content of methanol results in lower per gallon fuel economy for a methanol vehicle than an equivalent gasoline vehicle.

Ford suggested that EPA establish fuel equivalency on the basis of the petroleum content of the fuel only, because the CAFE and Gas Guzzler programs "were established with the intention of reducing petroleum usage." Ford referred to

Congress' handling of electric vehicles, noting especially the 1980 Chrysler Corporation Loan Guarantee Bill which stated that the fuel economy of electric vehicles, for CAFE purposes, should be based only on the estimated petroleum used in generating the electrical energy used by the vehicle. Ford also stated that manufacturers will need cost incentives to offset the higher costs of production of methanol vehicles, and also to offset the potential higher operating costs and limited resale value for methanol vehicles. Such an incentive could be provided by establishing a petroleum-based fuel equivalency factor, which would result in CAFE credits. Under Ford's petroleum based approach, for example, a vehicle which achieved ten miles per gallon (mpg) on an 85 percent methanol, 15 percent gasoline fuel (M85) would have a fuel economy of 67 miles per gallon. This is equivalent to ten miles per .15 gallon of gasoline.

GM also approved of a petroleum-based fuel equivalency, but felt that use of an interim zero gallon/mile basis of inclusion would provide a useful production incentive. The zero gallon/mile basis implies that methanol vehicles use an equivalent of zero gallons of gasoline per mile regardless of whether any gasoline is actually present in the fuel. GM estimates that if a manufacturer initially produces 4,500,000 gasoline-fueled vehicles with a CAFE of 26.5 mpg and replaces 20,000 average vehicles with methanol-fueled vehicles (getting 20 miles per gallon on M85), then a petroleum-based equivalency would effectively increase CAFE by 0.095 mpg, and a zero gallon/mile basis would increase it by 0.112 mpg.

Chrysler noted that since a vehicle's fuel economy and emissions are related, it is necessary to know the regulatory requirements for fuel economy in order to optimize both fuel economy and emissions performance. They stated that this uncertainty regarding the regulatory treatment of methanol fuel economy has already hindered their methanol vehicle development program. Chrysler favored a fuel equivalency based on energy content of the fuel "to assure the most economical allocation of resources."

CARB and Nissan both recommended establishing an FEF, but did not support a particular approach. CARB stated that action by EPA would not create an incentive without action by the Department of Transportation (DOT) and/or the Treasury, but that without EPA action a potential impediment would exist. Nissan felt that establishment of a fuel equivalency factor would promote research and development of methanol-fueled vehicles.

Finally, NADA encouraged EPA to pursue dialogue with the Treasury and DOT concerning fuel equivalency.

Analysis of Comments

Staff believes that inclusion of methanol vehicles into these programs could provide an economic incentive for manufacturers to produce methanol vehicles if a petroleum based fuel equivalency were used, as was suggested by Ford and GM. The incentive would be slightly greater if a zero gallon/mile basis was used, as GM suggested, on an interim basis. However, if the fuel equivalency were based on energy content of the fuel, as was suggested by Chrysler, then it is likely that there would be no significant economic incentive or disincentive since producing a given vehicle to run on methanol or on gasoline would have a roughly equivalent impact on CAFE. (Admittedly, methanol engines will likely be more efficient than gasoline engines, and thus there may still be some small CAFE advantage, under this approach, to producing a methanol vehicle over a similar gasoline vehicle.) Finally, staff agrees with Ford that exclusion of methanol vehicles from CAFE will favor production of larger methanol engines, since it would remove less fuel efficient gasoline vehicles from CAFE calculations. It is further recognized that inclusion under any of these approaches has implications for energy policy in that the petroleum-based equivalency favors conservation of petroleum resources, where as an energy-based equivalency values methanol and petroleum equally as conservable resources.

The issue of whether a fuel equivalency factor should be based on the petroleum content to conserve petroleum, or on energy content to conserve energy resources in general is very important. From reviewing the comments, it is obvious that there is no public consensus on which approach is superior at present. This issue clearly must be resolved, taking into consideration all relevant statutory language, before an FEF can be developed.

More importantly though, staff believes that present action by EPA, irrespective of the approach used, will not provide any incentive or disincentive to produce methanol vehicles unless the Department of Transportation or the Treasury acts to include methanol in their respective programs. Nor will it allow manufacturers, as Chrysler has suggested, to optimize their design strategies to a greater degree than they can at present. Admittedly, the absence of an established position on inclusion of methanol vehicles into such programs creates uncertainty for manufacturers. This uncertainty could affect how methanol vehicle development programs will be operated and what types of vehicles are developed. However, it is not obvious that action by EPA alone would eliminate this uncertainty, since DOT and the Treasury have not yet acted (and may never act) to include methanol in their respective programs. (In fact, EPA's choice of one fuel

equivalency factor over another might influence the decision whether or not to include methanol.) As a result, present action will not remove any regulatory uncertainty from the minds of key decision makers in the automotive industry. If and when methanol were included in the various fuel economy programs, it would become appropriate for EPA to initiate action to establish a fuel equivalency factor.

NADA's suggestion that EPA pursue dialogue with DOT and the treasury on this issue is appreciated and staff believes that EPA should remain open to such dialogue.

Conclusions

The points raised by the commenters are generally valid. However, staff believes that EPA's statement in the NPRM also remains valid:

"To date, neither DOT nor the Treasury have determined that methanol should be included under the respective programs. EPA therefore believes that determining a fuel equivalency between methanol and gasoline would be premature at present. If and when methanol were included in either program, EPA would initiate action to establish such an equivalency."

It would be premature to act at this time because action by EPA alone would not create an incentive or eliminate uncertainty for manufacturers. Therefore, it is recommended that EPA take no further action in this regard with the present rulemaking.

EPA should remain open to dialogue with other federal agencies on the question of including methanol in the CAFE and Gas Guzzler programs, and should be prepared to initiate action to establish an FEF following a decision on the part of either the Secretary of Transportation or the Secretary of the Treasury to include methanol in either program.

Issue: Certification of Flexible Fuel Vehicles*

Summary of the Issue

Since flexible fuel vehicles (FFVs) are designed to operate on any mixture of gasoline and methanol, EPA proposed requiring manufacturers to "demonstrate compliance with applicable standards when tested on any of those fuels." Comments were requested on the appropriateness of this approach. Comments were also requested on any other aspect of this rulemaking which may be affected by the sale of FFVs.

Summary of the Comments

No commenter argued against EPA's philosophy that FFVs need to be capable of meeting standards on fuels they encounter in-use. Most of the commenters were concerned that EPA's proposed approach to certifying FFVs would require tests on a range of certification fuel mixtures and felt that this would be burdensome and unnecessarily complicated.

A variety of possible alternative approaches were provided in the comments. Ford suggested that EPA should require certification testing and mileage accumulation on only one fuel determined by EPA for each vehicle at the time of testing. Ford also argued that it is not necessary to test vehicles with intermediate mixtures between methanol and gasoline, because owners would habitually use one fuel.

DOE also felt that FFVs should only be tested on one fuel but did not believe testing should be limited to gasoline or methanol only. They felt EPA should specify the fuel mixture following a manufacturer's request for certification.

Chrysler felt that FFVs should be tested on both methanol and gasoline to ensure that the vehicles are not optimized for only one of the extremes of possible fuels. GM, however, suggested that initially testing should be required on gasoline only, since it will be the predominant fuel choice in the near future, then on both methanol and gasoline once methanol becomes readily available to the public.

Chevron felt that, in addition to testing on both methanol and gasoline, it is necessary to test FFVs on intermediate mixtures. They were especially concerned about evaporative emissions in this regard since methanol-gasoline mixtures can have higher vapor pressures (and hence higher resultant emissions) than either methanol or gasoline separately.

* Flexible fuel vehicles are also referred to as multi-fuel vehicles, dual-fuel vehicles, variable-fuel vehicles, etc.

There were three other concerns that were not directly related to certification fuel specification. First, the state of New York felt that the NPRM did not clearly state which standards (methanol vehicle or gasoline vehicle) would be applicable when a vehicle is operating on a fuel mixture that contains less than 50 percent methanol, which could commonly occur in use. Next, Toyota expressed concern that the proposed regulations might be interpreted to mean that vehicles designed to accept low-level methanol blends would be considered multi-fueled vehicles and thus would be more difficult to certify. Finally, Ford was concerned about how FFVs would be treated with respect to fuel economy and labeling. They suggested that a single petroleum equivalency factor (PEF), based on the actual amount of petroleum expected to be used by the vehicles should be established for use in the CAFE and Gas Guzzler programs. They also felt that while both methanol and gasoline fuel economy estimates should be available to the consumer via the labeling program, the two estimates should not be compared to one another, but instead to typical ranges for vehicles in the same class.

Analysis of the Comments

The Agency stated in the NPRM that it expects FFVs to be able to demonstrate compliance on any mixture of methanol and gasoline that could be used in the field and no commenters explicitly argued against this concept. To ensure that this occurs for each vehicle, it is necessary that at a minimum the certification test be performed on the worst case fuels (for both exhaust and evaporative tests, which could necessitate use of different fuels for exhaust and evaporative testing,) because as Chrysler implied, vehicles will probably be optimized for the fuel(s) they are to be tested on. For similar reasons, it is also necessary to use a worst case fuel for mileage accumulation.

The alternatives suggested by Ford, GM, and Chrysler, which require use of only methanol and/or gasoline, will not necessarily ensure use of the worst case fuel for certification purposes. This is especially true for evaporative emissions because of the effects of gasoline/methanol mixtures on fuel volatility, as noted by Chevron. Chevron was referring to the fact that a few percent methanol added to gasoline raises the fuel's volatility dramatically. This volatility tends to remain above that for pure gasoline until a substantial amount of methanol (50 to 70 percent) has been added. Since evaporative emissions are correlated with volatility, it is likely that the worst case fuel, for evaporative testing purposes, is an intermediate blend. Ford stated that owners will generally use one fuel extreme or the other, and that testing on intermediate mixtures is not necessary; however it

would be difficult to prove the premise of Ford's argument, especially given the vagarious nature of the fuel market over the last 15 years. EPA must continue to assert that as long as operation on intermediate blends is a reasonable possibility, FFVs should be capable of meeting standards when fueled by such blends. Chevron's suggestion, testing on gasoline, methanol, and intermediate blends, would be environmentally prudent, though it would require several certification tests per vehicle and this increased testing burden might be a disincentive to produce FFVs. Since it is the Agency's goal in this rulemaking to remove impediments to the development of methanol vehicles, this alternative is inappropriate.

The alternative mentioned by DOE, using only one fuel mix specified by EPA at the time of the certification test, would allow vehicles to demonstrate compliance over the range of fuels, without increasing the number of certification tests from that necessary for gasoline vehicles. This approach is appropriate, though a slight modification would be useful. Under this modified approach the manufacturer would recommend a specification, for Administrator approval, of whichever mixture of fuels (of those which could occur in use) would produce the highest emissions. This modification is useful because the manufacturers will likely be more familiar than the Agency with the specific emissions characteristics of each vehicle. This approach would not relieve the manufacturer of his liability to meet the standards on any potential in-use mixture. EPA would retain the right to use any representative in-use mixture for its own certification and recall testing.

The state of New York felt that the NPRM did not clearly indicate which standards would be applicable to an FFV operating on a fuel with less than 50 percent methanol. However, it is stated in the NPRM that:

"EPA considers it reasonable to subject vehicles tested on a mixed fuel containing methanol to the emission standards for methanol-fueled vehicles."

This is appropriate because the standards for methanol-fueled vehicles are designed such that they become essentially equivalent to those for gasoline vehicles when the vehicle is operated on gasoline; the methanol and formaldehyde terms become negligible.

In response to Toyota's concern about the definition of a flexible-fueled vehicle, the approach taken in the NPRM was to consider a vehicle designed to operate on gasoline, methanol, and intermediate mixtures to be an FFV. Thus, a gasoline vehicle would not be considered an FFV solely because it is capable of accepting low level methanol blends. Also, the NPRM

clearly distinguished between mixed fuels (such as those to be used in an FFV) and blended fuels (with small amounts of alcohol) which have received EPA waivers under section 211 of the Clean Air Act and which are treated like gasoline. Thus, again, a vehicle specifically designed to accept a low level methanol blend fuel would be considered a gasoline vehicle, not an FFV.

The issue of inclusion of methanol into the CAFE and Gas Guzzler programs is discussed in detail in a separate section. As is noted there, methanol is currently not included in either program. Thus it is appropriate to treat FFVs strictly as gasoline vehicles with respect to CAFE and Gas Guzzler. With respect to labeling, since EPA did not specify a methodology for calculating the fuel economy of methanol vehicles in this rulemaking, inclusion of a methanol fuel economy number on the label would be inappropriate.

Conclusion

It is the Agency's goal to remove impediments to the development of methanol-fueled vehicles. Therefore, it is recommended that, with regard to FFVs, EPA not require tests over the range of possible in-use gasoline/methanol mixtures for each vehicle, but instead allow the manufacturers to recommend, for Administrator approval, the worst case fuels (one each for the exhaust emissions, evaporative emissions, and mileage accumulation). In this way compliance over the range of possible in-use fuels can be assured, consistent with EPA's consideration of FFVs in the NPRM. The act of specifying a fuel would not relieve the manufacturer of his liability to meet the standard on any other reasonable in-use fuel mixture; it would simply allow him to avoid an increased number of compliance tests relative to dedicated gasoline or methanol vehicles. The methanol standards would be applicable for all possible mixtures of gasoline and methanol used by FFVs.

With respect to the CAFE and Gas Guzzler programs, EPA has no authority to establish any fuel equivalency factor for FFVs or to account for methanol fuel economy in its treatment of FFVs. It therefore follows that EPA should treat FFVs as gasoline vehicles. Since EPA is not defining a methanol fuel economy test procedure, it is logical that the labels of FFVs should include the fuel economy for gasoline only.

Issue: Complexity of the Procedure for the Determination of Organic Emissions

Summary of the Issue:

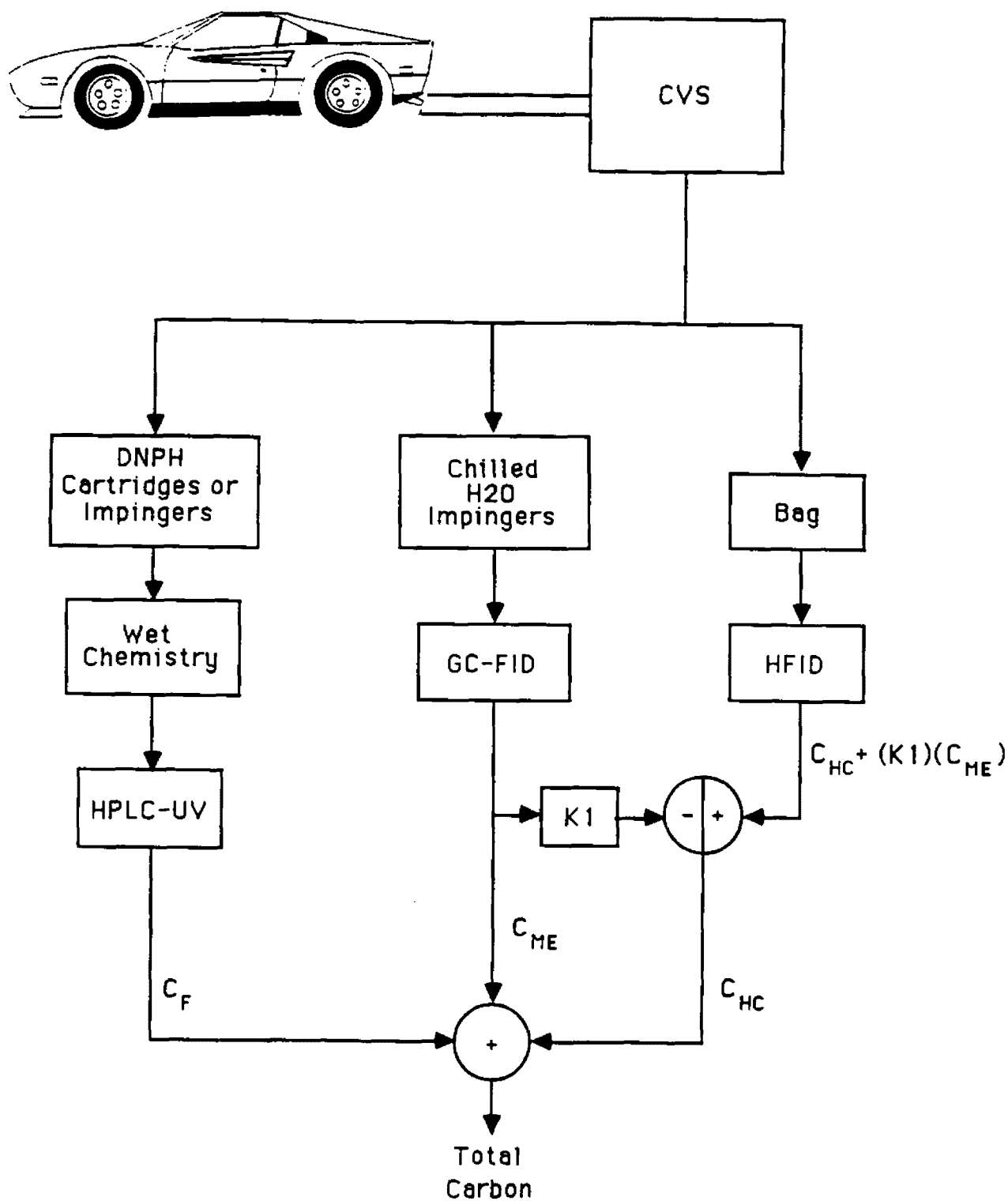
Pollutant gases from methanol-fueled engines and vehicles consist of a mixture of hydrocarbons, methanol and formaldehyde together with other exhaust species such as carbon monoxide, carbon dioxide etc. As was discussed in the NPRM and in detail previously in this document, EPA determined that measurement of each of the primary organic materials (hydrocarbons, methanol and formaldehyde) would be required to secure the necessary level of emission control. To avoid what EPA believed would be an unnecessary level of complexity in the emission standards, EPA proposed a single, carbon-based standard for the organic compounds, comprising the three measured pollutants.

In the development of the NPRM, EPA made every effort to limit the complexity of the procedures necessary for the measurement of these materials. In the proposal, EPA noted that a flame ionization detector (FID)* (the instrument presently used for measurement of hydrocarbons), can be used to directly and correctly measure either hydrocarbon emissions or methanol emissions separately but not both of these pollutants simultaneously. EPA also noted in the proposal that a FID is unsuitable for the measurement of formaldehyde because of its very low (approaching zero) response to formaldehyde. While the FID could, with appropriate adjustments of its measurements, continue to be used in measurements of hydrocarbon emissions from methanol fueled vehicles and engines it was necessary to include additional procedures for the measurement of methanol and formaldehyde.

Very briefly, the procedures proposed were as follows (see figure 1). For methanol, the procedure was to dissolve the methanol in water and to separate the methanol from the water using a gas chromatograph (GC). The methanol is then measured by a heated FID. For hydrocarbons, the procedure consisted of the collection of dilute bag samples, measurement of the hydrocarbons plus methanol with a heated FID calibrated on propane followed by subtraction of the methanol fraction (previously determined in the methanol analysis) from the total FID measurement. This analysis would need to account for the FID's response factor to methanol. For formaldehyde, the procedure employed the collection of formaldehyde from the exhaust sample by reaction with 2,4-dinitrophenylhydrazine (DNPH), followed by analysis with a high pressure liquid chromatograph using an ultraviolet detector.

* EPA proposed the use of a FID that is heated. As presented in this discussion the term FID refers equally to the heated FID.

Figure 1.
Schematic of Measurement Procedures for
Methanol Vehicle Exhaust Organics



EPA recognized in the proposal that less costly measurement procedures would be desirable. One procedure considered by EPA was the use of a FID calibrated on methanol to develop a single measurement for HC and methanol. While this approach would be simpler than the proposed procedure and would accurately measure methanol, it would overmeasure hydrocarbons. While this approach would have been environmentally conservative as well as simpler EPA believed that the overmeasurement would cause manufacturers to oppose its use.

Summary of the Comments:

Seven commenters provided comments on this issue. The commenters were the Department of Energy, the Engine Manufacturers Association, General Motors, Mercedes Benz Truck Company, Nissan, Toyota and Volkswagon.

DOE stated that the proposed procedure would require the use of expensive equipment and that the measurement procedure is cumbersome. DOE felt that the HC overmeasurement characteristic of the single measurement procedure which was not proposed by EPA supported its use because it would provide a larger safety margin with respect to ozone control.

EMA believed that the techniques proposed by EPA for measuring the non-oxygenated hydrocarbons, methanol and formaldehyde, would require instrumentation which is overly complex and costly for the developing methanol-fueled engine and vehicle industry. Due to the presently small size of the methanol-fueled engine industry, EMA felt that it is not necessary at this time to separate the organic compound emissions from methanol-fueled engines and vehicles into their three components. If, in the future, there are many more methanol-fueled engines and vehicles in operation, EMA suggested that EPA might again consider a requirement that manufacturers provide the individual component information. For the initial certification of methanol-fueled engines and vehicles however, EMA recommended the use of a FID calibrated with methanol to determine the organic emissions. In addition, EMA recommended that factors should be applied to the FID-indicated values so as to account for the differences in FID response to the carbon in the hydrocarbon (high response when calibrated on methanol) and to the carbon in the aldehydes (very low). EMA stated that such a method would be the most cost-effective option, and would require no new instrumentation for certification. However, if a manufacturer believed the standardized factors to be inappropriate for its technology, EMA suggested that manufacturer-specific factors could be determined and employed.

Nissan felt that the proposed procedure is overly complicated, the costs for new test equipment are high and the experimental burden would be increased. Nissan felt that indirect measurement of methanol using the current FID (FID calibrated on propane) is acceptable. Nissan stated that the sensitivity of the FID to methanol when calibrated on propane is roughly 85 percent of its sensitivity to hydrocarbon, and the overall sensitivity of the FID to exhaust emissions from an M85 methanol-fueled vehicle is about 94 percent. This information led Nissan to conclude that the exhaust emissions results obtained with a FID (calibrated on propane) are only about 6 percent lower than actual exhaust emissions from a M85 methanol-fueled vehicle. Nissan believed, therefore, that organic emissions from methanol-fueled vehicles can be measured with sufficient accuracy using the current FID, if an appropriate sensitivity correction factor is employed.

Toyota stated that while catalyst equipped vehicles exhibit very low levels of formaldehyde emissions (formaldehyde is readily oxidized in the catalyst), non-catalyst vehicles can have higher formaldehyde emissions. Toyota felt, therefore, that formaldehyde should be included in the oxygenated HC standard. Toyota requested, however, that actual measurement of unburned methanol and formaldehyde be exempt from the requirement. Toyota recommended using an optional calculational method for methanol and formaldehyde using an assigned correction coefficient. Toyota also requested that manufacturers be allowed the option to use their own coefficient instead of an assigned one.

GM recommended calibrating the FIDs with methanol and applying a factor to correct for the fact that total carbon in the hydrocarbon/methanol mixture of emissions would be reported high while the carbon in the aldehydes would be reported very low. The factor would account for the photochemical reactivity differences between hydrocarbon, methanol and aldehydes.

While there is no apparent technical obstacle to the proposed procedure for formaldehyde, Ford felt that its use will significantly impact conventional certification testing as well as end of line and in-use testing because of the need for a wet chemistry laboratory, trained laboratory personnel and the time required to analyze samples (3 hours minimum was cited).

Nissan stated that the proposed procedure for the measurement of formaldehyde can not provide continuous test result outputs whereas a FID or NDIR can. Also, the DNPH procedure requires extra equipment, is time consuming and necessitates great care in its performance in order to achieve accurate results. Nissan hoped that the use of a less demanding test procedure will be allowed in the future.

Mercedes Benz stated that despite the inherent problems, a FID calibrated with methanol is the simplest and lowest cost method of measuring the organic compounds, and should be given further consideration. If this approach is not adopted as the official measurement procedure, Mercedes Benz recommended that it be allowed as an option to the gas-chromotograph method for methanol measurement, because of its simplicity and practicability for in-line continuous measurements which are a necessary tool for further developing available methanol engine technology.

Analysis of Comments:

In developing the proposal, EPA sought measurement procedures which would provide accurate measurements of hydrocarbons, methanol and formaldehyde without unduly increasing test procedure complexity and cost. Since the ratios between pollutants in pollutant streams, i.e. exhaust emissions and evaporative emissions, can vary widely between vehicles and between fuels, procedures which either failed to measure one or more of the constituents or provided inaccurate results could lead to deleterious environmental effects. This ruled out the possibility of developing correction factors to allow the FID to be used as a procedure which could be presumed to be accurate for characterizing total organics. EPA selected the procedures which were proposed because they provided the information necessary for the control of the pollutants of concern without unreasonable increase in test procedure complexity.

While the need to accurately control the effects of exhaust emissions on the environment has in no way diminished since publication of the NPRM, it is apparent that, because of their limited numbers, methanol-fueled vehicles will be only minor contributors to atmospheric pollution during their introduction into the marketplace. In light of the preceding and the commenters' concerns with respect to the potentially negative impact of the proposed measurement procedure on the development of methanol-fueled vehicles, a less complex procedure may be warranted on an interim basis. Since the control of the pollutants entering the environment is of paramount importance, any simplified interim procedure should, if it contains a measurement weakness, tend to err on the side of overmeasurement. One such procedure which has been supported by a number of the commenters is the use of a FID calibrated on methanol. Since calibration on methanol would result in an overmeasurement of the hydrocarbons by the FID, this would be an environmentally acceptable interim approach because the error would tend to be on the conservative side (for the pollutants measured by the FID). Some commenters suggested the use of correction factors to account for the

overmeasurement of hydrocarbons if the simplified measurement procedure were to be allowed. This approach is not warranted for several reasons. First, the highly photochemically reactive formaldehyde, which is produced in relatively large amounts by methanol engines, is not measured by the FID. Even on an interim basis when there are very few methanol-fueled vehicles in service it would be prudent to view the overmeasurement of hydrocarbons as a compensating factor for the failure of the FID to detect the formaldehyde constituents of the exhaust gases. DOE's comment is consistent with this logic. Second, while the manufacturers noted that FID correction factors can be developed, they did not discuss the fact that in order to accurately utilize them, different factors would need to be developed for each vehicle/fuel/instrument (response factors do vary even between similar instruments by the same manufacturer) combination. Thus the application of correction factors would of itself be a very complex procedure.

Nevertheless, it appears reasonable to view the use of a heated FID, calibrated on methanol, as an acceptable interim procedure for the measurement of the subject emissions from methanol fueled vehicles. Because the purpose of allowing the use of this simplified procedure is to reduce testing costs during the development of a methanol fueled vehicle fleet, without incurring any significant negative impact on the environment, there is a need to limit the period of time wherein the simplified procedure can be used. Presently a five year period would appear to be sufficiently long to allow initial development of a methanol fleet without posing the potential of any significant environmental harm.

Should such a period for the use of the simplified measurement procedure be allowed, EPA would need to monitor the organic material composition of the pollutant gases from methanol-fueled engines and vehicles. This monitoring would be performed to enhance the Agency's knowledge of the organic material composition (and its potential health effects) of methanol-fueled vehicle exhaust gases. The Agency would be able to expect that manufacturers would collect similar data under the provisions of section 202(a)(4) of the Clean Air Act and make it available to EPA. The manufacturers currently provide much useful information on unregulated pollutants and on emissions research under this section, and provision of test results for methanol and formaldehyde would be a logical application of the requirements of that section.

As correctly pointed out by Ford, the sampling and analytical procedures for the measurement of formaldehyde emissions do introduce new laboratory requirements to vehicle emissions measurements. Elimination of the requirement for the

measurement of formaldehyde emissions on the basis of laboratory costs or complexity is, however, not warranted because of the relatively high concentrations of formaldehyde in methanol-fueled vehicle exhaust and the high photochemical reactivity of formaldehyde and its toxic potential.

Nissan's comment that the proposed DNPH procedure for characterizing formaldehyde emissions does not allow for continuous measurement whereas other procedures might do so is well taken. It is EPA's understanding that the FID and NDIR techniques referred to by Nissan have key drawbacks related to sensitivity and, in the case of NDIR, cost. Nevertheless, manufacturers are always allowed to substitute technically equivalent test procedures for those required by the regulations. Through such an allowance it is hoped that superior measurement techniques will eventually emerge. Thus Nissan is free to use the suggested alternatives if it can demonstrate their equivalence to the procedures promulgated in today's rule.

The recommendation by Mercedes Benz that a FID be allowed as an optional measurement procedure in engine development work, suggests a misunderstanding with respect to the overall applicability of a regulation. For testing performed to determine compliance with an emission standard, compliance with the procedures specified in the regulation is necessary. For all other test purposes, a manufacturer may freely choose to use the test procedure that it finds most appropriate. Use by a manufacturer of test procedures and test equipment during engine development which did not conform to the requirements for emission testing would not, however, excuse the manufacturer from the requirement of compliance with the emission standards when using the specified test procedures and equipment.

Conclusions

The arguments favoring use of the less demanding measurement procedure which employs a heated FID calibrated with methanol to measure total organics during the very early stages of the development of a methanol-fueled vehicle fleet are compelling. Such an option should allow continued development of these vehicles without posing any significant environmental threat. It is recommended, therefore, that the simplified measurement procedure be allowed for certification and recall testing of methanol-fueled vehicles and engines for five model years starting with the effective date of the methanol-fueled vehicle standards.

Issue: Sampling and Analytical Procedures for the Measurement of Methanol Emissions, Hydrocarbon Emissions and Formaldehyde Emissions

Summary of the Issue:

Comments were provided on only a few of the details of the sampling and analytical procedures which were proposed. For the sake of brevity and to avoid confusion, those details addressed by the commenters will be identified and underlined in this issue summary.

EPA proposed that the sampling system for non-throttled methanol vehicles include a dilution tunnel configured like that presently used for testing diesel vehicles. Though this is more complex than the system used for gasoline vehicles and throttled methanol vehicles, it was judged necessary to allow for the sampling of particulate emissions.

For the determination of methanol emissions, EPA proposed that the methanol sample be collected from the dilute exhaust stream or from the SHED by bubbling the sample through impingers containing chilled deionized water. The use of heated ($235^{\circ}\pm 15^{\circ}\text{F}$) sample collection probes and sample collection lines leading to the impingers was proposed for the dilute exhaust samples. The samples collected would be analyzed using a gas chromatograph with flame ionization detector.

For the determination of exhaust hydrocarbon emissions from methanol-fueled vehicles, EPA proposed that the dilute exhaust sample be collected using the bag sampling procedure as presently employed with gasoline fueled vehicles. Analysis of bag samples was proposed to be performed using a heated FID ($250^{\circ}\pm 10^{\circ}\text{F}$). For hydrocarbon measurements of evaporative emissions in the SHED, the sampling procedure proposed was the same as that presently used with gasoline fueled vehicles (the sample goes directly to the FID) except that a heated FID would be employed. Calibration of the FID would be performed using propane as is present practice. A FID so calibrated fully measures the hydrocarbons present in the sample but only partially measures the methanol present. The hydrocarbons present in the samples would be calculated by subtracting from the FID measurement the product of the FID response factor to methanol and the concentration of methanol as determined by the methanol measurement procedure.

For formaldehyde emissions determinations, the proposed procedure consisted of the collection through a heated sample probe and line of a proportional exhaust formaldehyde sample by bubbling a sample of the dilute exhaust gas stream through

glass impingers containing a solution of 2,4-dinitrophenylhydrazine (DNPH) in acetonitrile (ACN). The resultant solution is then analyzed in a high pressure liquid chromatograph (HPLC) with an ultraviolet (UV) detector. As an alternative to the preceding wet method of sample collection, EPA proposed the use of cartridges containing silica gel coated with DNPH. The remainder of the sample separation and analysis procedure would be similar to that used with the wet method of sample collection.

The proposal also required determinations of the accuracy, with corrections if required, of the sample dilution and collection systems. The procedures proposed for this function consisted of the injection of a known amount of propane (present practice) into the system, sample collection and analysis, followed by a determination of the amount of injected propane which is recovered, i.e., losses in the system are detected. For systems which would be used with methanol fueled vehicles, the system would also be tested for losses of methanol which would be injected as a gas (the methanol would be vaporized by heating).

Summary of the Comments:

Comments on sampling and analytical procedural details were provided by VW, Chevron, Ford, General Motors, and Toyota.

VW stated that the proposed procedures for the measurement of HC, methanol and formaldehyde are overly complex. VW suggested that the single dilution-tunnel sampling system proposed for the testing of non-throttled methanol-fueled engines and vehicles (necessary for particulate measurement) be allowed to be used with all methanol-fueled vehicles. This approach would allow a manufacturer to test both throttled and non-throttled vehicles (engines) using a single test site.

Chevron felt that the wet chemistry procedure for measuring methanol is relatively accurate. Chevron stated however, that methanol losses may occur due to condensation in unheated sample lines used in FID measurements of organics (HC plus methanol) from throttled methanol-fueled vehicles. Chevron also stated that a sample line temperature of 375°F will cause inaccuracies in measurements for unthrottled methanol-fueled vehicles and engines because of methanol decomposition. As a consequence of methanol lost in the hydrocarbon plus methanol analysis, Chevron felt that non-oxygenated hydrocarbon (hydrocarbon) results will be low because this value is determined by subtraction of the methanol result (accounting for the FID response factor to methanol) from the FID result.

General Motors felt that some methanol loss may be associated with condensation on the walls of unheated sample bags employed in the HC plus methanol analysis. GM stated that the use of continuous heated FID analysis would give the correct results. GM did not believe that the use of continuous FID analysis would pose any problems because the procedure is already in use in many emission facilities of the motor vehicle industry (i.e., is employed with diesels). GM stated that the FID should be heated to about 200°F rather than the 375°F presently used with diesels. GM did not believe that a heated FID would be required for evaporative emissions measurements because of the absence of condensation. GM recommends allowing the use of a heated FID for evaporative emissions if a manufacturer so desires.

Toyota felt that a heated FID control temperature of 121°C (250°F) is too low for use with diesel engine testing and recommended a heated FID control temperature of 191°±6°C (375°±10°F) for use with both methanol-fueled and "diesel" engine testing. Toyota felt that there is a minimal loss in measured methanol emissions between heated FID control temperatures of 121°C and 191°C.

Chevron also felt that the proposed procedures would underestimate formaldehyde emissions. In support of this position, Chevron referenced a study conducted by Southwest Research Institute (SwRI) for the Coordinating Research Council (CRC).[8] The report showed that significant losses of formaldehyde (approximately 40 percent) occurred in dilution tunnels upstream of the sampling point. Chevron believes that similar losses may occur in the proposed sampling system. Chevron recommended additional investigation of the problem and study of possible solutions.

While Ford does not use the impinger - gas chromatograph (GC) procedure for methanol collection and analysis, Ford felt that the procedure should not pose any technical problems. Ford suggested that heated collection lines (methanol and formaldehyde samples) need not be used since the transfer efficiency of formaldehyde in unheated lines is on the order of 95 percent (test results provided showed a range of from 94 to 97 percent) and pointed out that formaldehyde is more reactive than methanol. Ford suggested two alternative procedures for measuring methanol. These alternative approaches are: (1) the use of adsorbent traps, and (2) the use of Fourier Transform Infrared (FTIR) spectroscopy.

For formaldehyde measurements, Ford stated that they have used both the impinger and cartridge methods for sample collection. Under ideal conditions, the two procedures produce equivalent results. However, the cartridges are not

commercially available and reproducibility of the coating may vary from laboratory to laboratory with resulting variability in collection efficiency. If cartridges are not uniformly coated and properly dried, erroneous emission measurements will result. Ford expressed the opinion that the alternative cartridge approach for sample collection, while being simpler in the sample collection phase is actually more labor intensive when all phases, from cartridge preparation through analysis, are considered.

Analysis of Comments:

The commenters did not significantly disagree with the overall sampling and analytical procedures as proposed. Rather the comments on this issue addressed procedural details.

The recommendation made by VW was to allow the use of a single type of sample dilution and collection equipment for methanol fueled vehicles whether Otto-cycle or diesel. While the type of equipment recommended by VW (dilution tunnel) is the more complex of the two types proposed by EPA it was selected by VW because it provides the capability for particulate sample collection from diesel engines as well as the capability to omit particulate sample collection when Otto-cycle engines are undergoing testing. Since the emission results obtained by either procedure, exclusive of particulate emissions, should be equal, there is no fundamental reason for precluding the use of the single dilution tunnel type of equipment recommended by VW.

On the basis of the wording used in both Chevron's and GM's comments, it appears probable that these commenters did not note the 250°F temperature specification for the heated FID for use with methanol-fueled vehicle/engine emission measurements. Chevron also appears not to have noted the 235°F temperature which was proposed for all sample lines. Both of these commenters pointed out, however, that decomposition of methanol can be expected to occur if the 375°F temperature specification used with petroleum-fueled diesels were applied to methanol sampling. EPA agrees with this position and therefore selected the lower (235° and 250°F) temperatures so as to avoid this problem.

The use of a common temperature for both diesel and methanol fuel testing (Toyota recommended 375°F) would simplify laboratory procedure. Losses in measurement accuracy, either through the use of the lower temperature with diesels or the higher temperature with methanol is not an acceptable trade-off for the small simplification in laboratory procedures that would result. Since the temperature at which the sample collection lines operate is adjustable, and since the FID's

operating temperature is either presently adjustable or the FID can be retrofitted to provide adjustability, laboratory problems would center on the time required to change and stabilize the FID and line temperatures between tests on different fuel types (assuming the use of a single sampling/analytical system). This problem can be readily addressed by scheduling groups of tests on one fuel type followed by a single temperature adjustment before going to another group of tests on another fuel type.

Prior to publication of the proposal, EPA evaluated the response of a heated FID and an unheated FID to samples containing both methanol and hydrocarbons. This evaluation showed that an unheated FID responded slowly to a sample containing both methanol and hydrocarbons while the heated FID responded at a much higher rate. The response rate of the heated FID was comparable to that of an unheated FID when analyzing only hydrocarbons. EPA proposed the use of a heated FID for analyses of samples containing methanol and hydrocarbon to avoid 1) errors due to premature data collection, or 2) test voiding due to sample bag depletion prior to instrument stabilization. While there is agreement with GM that methanol sample loss due to condensation would not be a problem with evaporative emission samples, there is disagreement, for the reasons given above, that an unheated FID can be used with evaporative emissions samples as suggested by GM.

Both GM and Chevron expressed concern with respect to the loss of methanol sample due to condensation. GM's concern focused on losses in an unheated sample bag while Chevron's focused on unheated sample lines leading to the sample bag. Since the use of heated sample lines was proposed, the concern expressed by Chevron was addressed in the proposal. Chevron's comment therefore, must have been the result of an oversight. As a first step in addressing the concern expressed by GM, EPA has analyzed one sample bag (unheated sample collection lines were used) with the bag at both room temperature and at a temperature of between 95° and 100°F. A higher FID reading was obtained when the bag was warmed. However, the FID measurement made when the bag was warmed also occurred when the volume of sample contained in the bag was almost depleted. It is, therefore, not possible to determine what significance should be attached to the observed difference. Lacking data with which to quantify the significance of the GM comment, it is recommended that the sample collection procedure be retained as proposed. The concern raised by GM should, however, be investigated in detail and, if warranted, the sample collection procedure should be modified at a future date.

While there were no comments on the proposed heating of sample probes on constant flow venturi - constant volume

sampling systems (CFV-CVS), evaluation of the proposed procedure as part of ongoing testing of methanol-fueled vehicles by EPA has shown that heating of the sample probes for the methanol and formaldehyde samples results in some heating of the sample as it passes through the probe.[25] This heating of the sample causes a loss in proportionality between the sample volume and the total diluted volume. As a result an error is introduced in the test results. Since the probe is very short, and its temperature will be that of the dilute gas stream, condensation in an unheated probe would not be expected to pose a problem. Heating of the probe will, therefore, not be required in the final rule. Heating of the sample line from the probe to the impingers will, however, continue to be a requirement to avoid any losses in the lines (the Ford comment indicated that for its particular system, the losses could be on the order of three to six percent). Care must be taken, however, in the construction of sampling systems to thermally insulate the heated sample lines from the unheated probes. As an option, heating of the sample line may be avoided provided the methanol and formaldehyde sample collectors are close coupled to the probe; i.e., the sample line is either omitted or its length is so short as to preclude significant cooling of the sample and any associated condensation.

As noted by Ford, formaldehyde emission measurements results obtained with properly prepared DNPH cartridges (dry collection procedure) are equal to those obtained with the wet collection procedure, while the use of improperly prepared cartridges will cause incorrect measurement results. Also as noted by Ford, there is presently no commercial source for DNPH cartridges. This lack of commercially available DNPH cartridges is not surprising because there is presently little demand for this product (given the limited amount of methanol vehicle emission testing being performed at present). It is reasonable to expect, however, that one or more manufacturers of DNPH cartridges could enter the market as demand grows for this product. In the meantime, manufacturers will either have to prepare their own cartridges or use the impinger collection technique. There is no disagreement, however, that if cartridges are used, they need to be accurately prepared. Procedures for the preparation and checking of the cartridges have been developed by EPA.[26]

With respect to the comment by Chevron pertaining to loss of formaldehyde in the dilution and sample collection systems, the referenced report has been carefully reviewed. In the work referenced by Chevron, the formaldehyde was injected into the exhaust gases as an aqueous solution. Since the dilution tunnel used in exhaust emissions measurements is designed to dilute and mix gases, injection of formaldehyde in aqueous solution into the tunnel can reasonably be expected to pose significant vaporization and mixing problems and as a

consequence sample loss. This is apparently what was exhibited by the low formaldehyde recovery (high loss) rate reported in the Chevron reference. As part of EPA's evaluation of sampling procedures for methanol fueled vehicles, EPA investigated the potential for the loss of formaldehyde in the sampling system. In this work, the formaldehyde was injected into the exhaust duct in gaseous form. Loss of formaldehyde sample was not detected in this evaluation of the sampling system. It can be concluded, therefore, that the concern expressed by Chevron is not attributable to the sampling system but to the procedure used in the referenced testing to quantifying the performance of the sampling system.

With respect to the suggestion by Ford that alternative procedures be allowed, EPA's position on alternative procedures has in the past and continues to be that they will be allowed provided equivalent results are obtained. This position is stated in existing regulations. In the case of the two procedures suggested by Ford, (the FTIR procedure and adsorbent traps), they are presently in the development stage and are not generally available to all potential users. Specific inclusion of these procedures in the regulations for use at this time would, therefore, be inappropriate. Exclusion of the suggested procedures does not, however, preclude their use once they have been shown to provide equivalent results.

Conclusions

While the dilution tunnel procedure must be used with diesel engines, there is no technical basis for precluding its use with Otto-cycle engines. It is recommended, therefore, that language be included in the regulations signifying that a manufacturer may use a dilution tunnel in the testing of Otto-cycle methanol fueled vehicles/engines if the manufacturer so desires.

Since there is very little data which would support the concerns pertaining to methanol loss in sample bags and there is no data to indicate an appropriate sample bag temperature, if heating were required, the regulations should be finalized as proposed. EPA should, however, collect data which would resolve the concerns raised by GM with respect to the loss of methanol sample in sample bags. If warranted by the data, the regulations should be amended at the earliest possible date.

The use of heated probes which rely on constant flow venturi for maintaining sample flow proportional to main tunnel flow will cause measurement inaccuracy. This proposed requirement should be removed. The heated sample lines must be thermally isolated from the probes to prevent heating of the

probes. Close coupling of sample collection systems to the probes should be allowed, if desired, so as to avoid the requirement for the use heated methanol and formaldehyde sample lines.

The regulations need to be carefully reviewed prior to final publication to remove any ambiguities with respect to the use of heated FID and heated sample lines.

Careful preparation of DNPH cartridges is a prerequisite to obtaining accurate formaldehyde test results if cartridges are employed. Laboratories using this method of sample collection should be encouraged to use the procedures detailed in the EPA report.

It should be clearly stated in the preamble to the Final Rule that manufacturers may use procedures which have been demonstrated to produce results equal to those specified. Procedures which are presently not readily available for widespread use in emissions testing should, however, not be specified by EPA as required procedures.

No change in the previously specified line or FID temperatures is recommended. Those proposed should be appropriate to ensure adequate collection and detection of organic materials. Use of the heated FID is still recommended over use of the unheated FID due to response time considerations.

Some test facilities find that use of DNPH cartridges provides time and space flexibility in the testing process. The present lack of suppliers of DNPH cartridges and Ford's preference for the impinger technique in collecting formaldehyde should not affect EPA's decision to allow use of cartridges as an alternative technique.

Finally, accurate qualification of the measurement system for formaldehyde recovery efficiency is good laboratory practice. EPA would expect that test facilities would conduct experiments in this regard as appropriate to demonstrate the validity of their measurement techniques.

Issue: Determination of Formaldehyde Background Levels

Summary of the Issue:

As with the background level determination of all other measured emissions, EPA proposed that background samples for formaldehyde be collected for each phase (cold start/hot start) in the case of heavy-duty engine testing, or for each bag, in the case of light-duty testing, of the test procedure. Analysis of these background samples would employ the same procedures as were described for the analyses of the formaldehyde in exhaust emissions samples.

Summary of the Comments:

Toyota was the only commenter on this issue. Toyota stated that while it is using the recommended procedure, it requested that the measurement of background formaldehyde levels be made optional because of inherent low background levels and the complexity of the analytical procedures. Toyota viewed its request as a conservative one, simulating worst-case conditions, since background would be assumed to be zero and there would, as a result, be a higher than actual indication of emissions from the test vehicle.

Analysis of Comments:

Toyota's request to make the measurement of background formaldehyde levels optional appears at first glance to be a desirable test procedure simplification because of its conservative nature. On closer inspection, however, implementation of this option would pose problems in areas such as emission standards compliance determinations and lab to lab correlation testing. Problems could arise in these determinations when the formaldehyde background level in a laboratory was high but was not recognized as such. Measurement of formaldehyde background levels appears, therefore, to be necessary. Reducing the number of samples collected and consequently the number of analyses which have to be performed was considered, however, to be desirable. Background sample collection periods which were considered as methods whereby the test procedure could be simplified were 1) a single sample for the total test, 2) a daily sample, and 3) a weekly sample. Because of potential short term fluctuations in formaldehyde levels in the background air which could impact test results and which would not be detected by the daily or weekly samples, these sampling periods appear to be excessive. To avoid possible problems in lab to lab correlation and to facilitate correct determinations of vehicle compliance with emission standards, while allowing a degree of test procedure simplification, the collection of a single formaldehyde background sample covering the total test period should be allowed.

Conclusion:

Replacing bag by bag background sampling and analysis for formaldehyde with a single sample and analysis covering the total test period will simplify testing without significant loss of testing accuracy. The regulations should incorporate this provision. Bag by bag or phase by phase background sampling should be allowed as an alternative since this would lead to increased accuracy.

Issue: Duct Connecting Vehicle Tailpipe (Engine Exhaust) to CVS (Dilution Tunnel)

Summary of the Issue:

For methanol-fueled vehicles, it was proposed that the duct connecting the vehicle tailpipe to the CVS, and in the case of heavy-duty methanol-fueled engines, the duct connecting the engine to the dilution tunnel, be heated to $235^{\circ}\pm 15^{\circ}\text{F}$ ($113^{\circ}\pm 8^{\circ}\text{C}$) to prevent adsorption or condensation and the associated loss of exhaust gas constituents (methanol and formaldehyde) in the duct.

Summary of the Comments:

Caterpillar and Toyota provided comments on this issue. Caterpillar believed that heating of the duct is not necessary. Caterpillar stated that while momentary condensation following a cold start will modify real time indications of emissions, overall test results would not be affected.

Toyota stated that the heating requirement will make testing equipment complicated, decrease duct flexibility thereby causing handling difficulties. Toyota felt that both heating and cooling capability of the duct will be necessary to maintain duct temperature at $235^{\circ}\pm 15^{\circ}\text{F}$ because of changes in exhaust gas temperature during testing.

Toyota suggested either the elimination of the heating requirement for short ducts (identified 3.65 meters (12 feet) maximum length based on diesel engine practice) or turning the heater off once the duct is preheated to 121°C (250°F).

Analysis of Comments:

Caterpillar's comment that emission losses will be corrected for as the exhaust system heats up during the course of the test, causing vaporization of any condensate, is noted. Unfortunately it rests on the assumption that losses during one phase of the test are recovered during that phase. If this is not the case, potential for significant test result error exists. There is presently no data at EPA's disposal which can be used to resolve this question. It seems prudent therefore to take steps which would eliminate or at the least minimize any losses.

Prior to and since publication of the NPRM, EPA has conducted test projects to investigate the effects of duct heating on the loss of methanol and formaldehyde emissions in the duct. The first of these projects was conducted at EPA's Research Triangle Park laboratory.[14]

The exhaust duct used in that evaluation was approximately 20 feet long and constructed of corrugated tubing. Tests were conducted both with the duct heated and unheated. The results of the investigation are summarized below:

	<u>Formaldehyde Recovery</u>	
	<u>Unheated Exhaust Duct</u>	<u>Heated Exhaust Duct</u>
Cold Start	79%	94%
Hot Start	94%	96%

The conclusion drawn from the experimental results was that the high formaldehyde losses on the cold start tests with the unheated duct were the result of water of combustion condensing in the duct which resulted in some formaldehyde being dissolved in the condensate. The dissolved formaldehyde would as a result not be measured as part of the gaseous sample. These results supported the requirement for heating of the duct, especially a long duct constructed of corrugated tubing, prior to the initiation of testing.

Subsequent to publication of the NPRM, EPA has performed tests which validate Toyota's concerns that follow from the requirement of the heated duct. These tests involved methanol-fueled vehicles and were designed to monitor the temperature of the duct during emissions tests (data is as yet unpublished). The duct used in this testing was heated and, to minimize the energy demand of the heating elements, insulated. During the tests, duct wall temperatures as high as 300°F were recorded. Some decomposition of the methanol and possibly the formaldehyde in the exhaust gases can reasonably be expected to occur at this elevated temperature. It appears, therefore, that Toyota's concern pertaining to the need for both heating and cooling of the duct may be warranted. Since the need to cool the duct (when insulation is employed) would greatly complicate testing, the use of insulation on heated ducts should either be avoided or provisions made for the removal of the insulation whenever the engine is in operation.

Another test project was conducted at the Motor Vehicle Emission Laboratory, (MVEL). The duct used in this testing was constructed mainly of smooth wall pipe and was 5 feet in overall length including two 8 inch sections of corrugated tube and one 45° bend; i.e., this duct was short and smooth relative to the previously used 20 foot long duct which was constructed entirely of corrugated tubing. A 350 cfm Philco CVS was used. The test vehicle used in the MVEL evaluation was a full size automobile (Ford Crown Victoria, 5.0 liter engine, 4500 lb inertia weight, actual dynamometer hp at 50 mph=11.9). Statistical analysis of the test data collected at MVEL showed that there was no statistical difference between emission

results obtained with a heated or unheated duct of the configuration employed.[27]

Since the vehicle used in this evaluation was relatively heavy, the rate at which the temperature of the unheated duct increased following the start of a test would have been faster than would have occurred with a lighter vehicle. Therefore, the test data from this evaluation may not precisely define the emissions effects with a small vehicle. The main conclusion that EPA has drawn from this test, however, is that short ducts constructed primarily from smooth wall pipe, with a minimum of flexible (corrugated) piping should minimize any losses. Toyota's suggestion of heating the transfer tube until the test begins has some merit, especially when coupled with the use of such optimized duct configurations.

Some test facility configurations may preclude relocation of the CVS close enough to the test vehicle, or test engine, to allow use of a short duct. In these cases, relocation of the point at which the exhaust gases and dilution air are mixed is considered to be a viable alternative. This alternative could be achieved by routing the dilution air from the filter housing of the CVS to a mixing point either at, or very close to, the vehicle tailpipe or engine exhaust and returning the diluted exhaust to the CVS unit. Alternatively, the dilution air filter assembly could be moved from the CVS and located close to the vehicle tailpipe or engine exhaust. Since the proposal called for heating of the tube between the exhaust and the dilution point, eliminating this would obviate the need to provide heating.

Conclusions:

As a result of the preceding, it is reasonable to conclude that the duct connecting the vehicle tailpipe or engine exhaust to the CVS or dilution tunnel should be as short as practical within the constraints of the test cell and be constructed of smooth wall tubing with a minimum of both bends and flexible tubing. While the only data available at this time showing statistically equivalent results between heated and unheated ducts was collected on a five foot long duct, such a short length of tubing may be difficult to work with logistically. Therefore, the following recommendations are made. First, ducts conforming to the above design specifications should be allowed. Second, where these are not practical, smooth walled ducts of up to 12 feet in length should be allowed provided they are heated to $235^{\circ} \pm 15^{\circ}\text{F}$ ($113^{\circ} \pm 8^{\circ}\text{C}$) prior to the start of testing and during any periods of the test when the engine is off. Heating of the duct should be allowed during the test for any length of duct, provided the temperature of the duct

wall does not exceed 250°F (121°C). If insulated, long, heated ducts are employed, provisions should be made either to remove the insulation during engine operation or if necessary to cool the duct to prevent duct wall temperature exceeding 250°F. As an alternative, the mixing duct may be essentially eliminated by moving the mixing point of the dilution air and exhaust gases to a point immediately adjacent to the vehicle tailpipe or engine exhaust.

Issue: Vehicle Preconditioning for Evaporative Emissions Testing

Summary of the Issue:

EPA proposed that vehicle preconditioning for methanol-fueled vehicles be the same as that presently specified for gasoline-fueled vehicles. EPA requested comment, however, on whether or not a different preconditioning procedure should be employed for methanol-fueled vehicles because of potential variability in evaporative emission results stemming from relative differences in the affinity between the charcoal in the canister for methanol fuel vapor vs. gasoline vapor.

Summary of the Comments:

Comments on this issue were provided by Ford and General Motors. Ford felt that canister purging during the preconditioning drive is heavily influenced by vehicle operation and storage conditions prior to the initiation of the preconditioning drive. Ford felt, therefore, that any alternative preconditioning provisions should be allowed for all vehicles whether methanol or gasoline fueled to preclude unrepresentative purging requirements during the preconditioning drive.

GM felt that fuel type should not dictate the degree of vehicle preconditioning. GM felt that preconditioning should approximate a typical day of vehicle usage and that the current preconditioning procedure is inadequate.

Analysis of Comments:

Neither Ford nor GM provided any information indicating that the purge/load characteristics of an evaporative control system for a methanol-fueled vehicle would be different than those for a gasoline-fueled vehicle. It appears reasonable to conclude, therefore, that any differences which may exist between the relative affinity of the charcoal in the canister for methanol fuel vapors and gasoline vapors will be accounted for in the design of the evaporative control systems on methanol-fueled vehicles. Comments by Ford and GM on the appropriateness of the preconditioning procedure fall outside of the scope of this proposal and are, therefore, not analyzed here.

Conclusion:

Since no information was provided in support of preconditioning procedures for methanol-fueled vehicles different to those used for gasoline-fueled vehicles, the preconditioning procedures, as proposed, should be retained.

Issue: Lean Flammability Limit in SHED

Summary of the Issue:

EPA proposed the use of the same upper limit (15,000 ppm C) for the concentration of combustible materials in the SHED for testing of methanol-fueled vehicles as is used in the testing of gasoline-fueled vehicles. Use of a common limit value for both types of fuel was judged to be desirable because while it would provide about the same safety margin relative to the lean flammability limit for both fuels, it would also avoid the introduction of a new factor which could cause confusion during the performance of tests.

Summary of the Comments:

Ford and GM provided comments on this subject. Ford supported continued utilization of the 15,000 ppm C safety limit in the SHED since a 4:1 safety factor beyond the lean flammability limit for pure methanol corresponds to a concentration of approximately 17,500 ppm C. Ford pointed out that a different monitor would, however, have to be employed with methanol fuel because present monitors are insensitive to methanol.

GM did not believe that there will be any explosion hazard in a SHED during an evaporative emission test with M-100 fuel because the boiling point of pure methanol (148°F) is significantly higher than the normally experienced maximum tank temperature of 90°-92°F. GM felt that use of M-85 fuel could increase organic levels in the SHED but not to dangerous levels. GM pointed out that the FID used to measure VOC concentrations in the SHED would provide warning of high concentrations. A combustible gas sensor should, however, be used to monitor concentrations in the SHED. While GM did not believe that a safety hazard will develop in the SHED, GM was somewhat concerned about the development of an explosive mixture inside of the vehicle fuel tank when M-100 is the fuel.

Analysis of Comments:

Analysis suggests that the commenters are correct in that it is unlikely that a hazardous mixture could develop in a SHED during testing and that continued utilization of a 15,000 ppm C upper limit would provide a reasonable safety margin relative to the lower flammability limit for the fuels used in testing. Good laboratory practice, as pointed out by Ford and GM, will necessitate the use of combustible mixture monitors which are sensitive to the vapors being monitored.

GM's comment pertaining to the development of explosive mixtures in the fuel tanks of vehicles using M-100 fuel is relevant to the safe operation of these vehicles both on the street and during testing. Since there is a potential hazard posed by these vehicles during road operation, it is expected that manufacturers will resolve this possible hazard prior to testing a vehicle. It is also expected that laboratories will use good practice in preventing ignition sources beyond the vehicle manufacturer's control from entering a closed fuel tank. Incorporation of additional safety precautions into the test procedures does not, therefore, appear to be necessary.

Conclusion:

An upper concentration limit of 15,000 ppm C for combustible materials in the SHED should be retained as a warning note in the regulations. Laboratories should use good engineering practice both in the selection of combustible gas monitors sensitive to the materials being monitored and in the handling of methanol-fueled vehicles. These precautions will ensure the safety of laboratory personnel during testing of methanol-fueled vehicles.

Issue: Test Fuel Specification

Summary of the Issue:

EPA proposed that methanol fuel used in emissions testing be representative of commercially available methanol fuel. This was necessary to ensure that emissions would be representative of vehicle operation in the real world. Recognizing that methanol-fueled vehicles were at an early stage of development and that, as a result, manufacturers' fuel specifications for those vehicles that will ultimately be marketed have not yet been determined, EPA chose not to propose a detailed specification for methanol test fuel. EPA proposed that a fuel must contain a minimum of 50 percent methanol by volume before that fuel could be classified as methanol fuel.

Summary of the Comments:

Comments on this issue were provided by thirteen organizations. The organizations were: California Air Resources Board, Chevron, Chrysler, Department of Energy, Engine Manufacturers Association, Ford, General Motors, Manufacturers of Emission Controls Association, Oxygenated Fuels Association, State of New York, Nissan, Toyota and Volkswagen.

Four commenters expressed the opinion that EPA's establishment of methanol test fuel specifications would not be appropriate at this time. Chevron suggested that, initially, the test fuel specification should be provided by the vehicle/engine manufacturer with later development of a specification corresponding to commercial methanol fuel. Similarly, VW stated that, in the short term, vehicle/engine manufacturers must specify the fuel because only the fuel for which the vehicle is designed can be used. Flexibility in selecting the fuel must be provided to facilitate research into the development of the optimum fuel and engine combination. In the long term a precise fuel specification, representative of commercial fuel, must be developed. EMA recommended that test fuel correspond to the fuel specified by the engine manufacturer for its production engines. GM also believed that certification fuel should be the fuel for which the vehicle is designed and which, in GM's opinion, would also be the commercial fuel. GM stated that M-85 and M-100 are distinctly different fuels from the perspective of vehicle design and should not be viewed as different grades of methanol fuel.

Eight of the commenters (CARB, Chrysler, DOE, Ford, MECA, OFA, Nissan and Toyota) believed that EPA should establish a fuel specification as part of the rulemaking. Reasons provided by the commenters for this position are given below.

A fuel specification would provide vehicle and engine manufacturers with a basis for making engineering decisions on fuel system and engine design. Vehicle design parameters are dependent on fuel specification, and a range of M-50 through M-100 is too broad for design purposes. Further, it would be unwise for manufacturers to invest resources on the development of a vehicle for a fuel of the manufacturers' choice when that fuel may not be used commercially. Methanol fuel which contains a different percentage mix of methanol and gasoline than the vehicle was designed for could adversely affect an emission control system. Also certain additives to methanol fuel designed to enhance startup and performance could adversely affect emission control performance of vehicles designed to a different fuel specification.

A fuel specification would also provide fuel suppliers with a single design target and prevent proliferation of fuel specifications. Finally, a fuel specification would establish limits on fuel contaminants which would cause engine wear, corrosion, and materials compatibility problems (e.g., chlorine, sodium). OFA provided, in tabular form, a proposed specification for methanol fuel showing limits for contaminants such as chloride, organic sulfur, iron, sodium and other metals.

Nissan recommended the specification of a single test fuel which must contain gasoline or other additives to achieve a visible flame in the event of a fire and to ensure cold start performance. More specific fuels which were recommended by other commenters were M-85 and M-100. The commenters taking these positions and the reasons for their positions were as follows:

- Ford is using M-85 (15 percent unleaded gasoline) because the gasoline content is expected to provide a visible flame in the event of a fire, to aid in cold starting and cold weather driveability, to provide RVP equal to that of indolene, and to provide fuel tank vapor concentration richer than the combustible limit. While M-85 is presently being used by Ford, Ford felt that other formulations may offer future advantages and should be allowed.
- Chrysler recommended M-85, using 15 percent standard test gasoline, since it will probably be available as commercial methanol fuel.
- OFA recommended M-85 on an interim basis since the majority of work has been performed on this fuel. Establishment of a final specification would follow as more knowledge was gained.

- DOE recommended both M-100 ("neat chemical-grade" methanol) and M-85 containing 15 percent high-octane indolene by volume.
- CARB recommended M-85 for spark ignition engines and M-100 for compression ignition engines.

New York stated that lacking specifications, commercial methanol fuels may not meet the fuel specifications for which vehicles are designed. New York then queried what parameters would be employed to determine the representativeness of certification methanol-fuel with respect to commercial methanol-fuel.

Analysis of Comments:

While some of the commenters believed it is too early for EPA to establish fuel specifications, others were obviously in favor of the agency moving now to take that action. Both arguments have merit. On the one hand there are numerous aspects of engine and fuel design which will not be resolved without detailed analysis and the pressure of the marketplace. This argues for EPA's avoiding a detailed specification, and Volkswagen's and Chevron's comments recognized this point of view. On the other hand, as various commenters pointed out, provision of a specification could force a degree of standardization within the vehicle and fuel industries which would be difficult to otherwise presently obtain.

Given the Agency's concern that any fuel used to certify vehicles for environmental purposes be representative of in-use fuels, there would be two potential problems associated with selection of a fuel specification before a market for methanol vehicles and fuel is established. First, as several commenters noted, the manufacturers would tend to optimize vehicles' emissions performance around the specified fuel. This is consistent with GM's and EMA's comments that testing should be done with the fuel for which a vehicle was designed. GM's comment that M-85 and M-100 are different fuels, not just different grades of methanol, is a useful one, demonstrating how important the choice of a test fuel is. From an emissions perspective, use of one of these fuels or the other can be expected to result in significant differences in the fractions of HC, methanol, and formaldehyde in the organics, and perhaps in levels of particulate emissions from diesel engines. From a performance perspective, use of one or the other in a given vehicle will likely affect cold stability, overall driveability, fuel efficiency and other performance criteria. Furthermore, choice of one fuel or another would likely result in engine design modifications to take advantage of that formulation's properties. These changes might affect

compression ratio, method of ignition or ignition assist, even possibly cooling capacity, to give some examples. Thus, a specification provided now could have the effect of deterring vehicle optimization around a fuel which might be superior for technical and/or economic reasons. EPA's establishment of a fuel specification would, under these circumstances, amount to interference in the marketplace.

Second, EPA's establishment of a specification might also be at odds with decisions made by fuel suppliers, who are not bound to market a fuel simply because EPA specifies it for purposes of environmental testing. If such were the case, EPA would need to change its specifications to obtain test results representative of in-use emissions.

Therefore, the development of the in-use fuel market should remain the concern of vehicle manufacturers and fuel suppliers. It seems clear that no overwhelming logic has been presented to demonstrate that the decision rightfully belongs to EPA. As long as vehicles are able to comply with emission standards when tested on the fuels that are eventually marketed, and as long as no other overriding environmental concern not addressed by the emission standards accompanies use of those fuels, the Agency should remain neutral with respect to the emerging fuel market.

New York's comment that without specifications, commercial methanol fuels may not meet the fuel specifications for which the vehicles are designed assumes that the process described above will not take place. It implies that vehicle manufacturers will market vehicles incompatible with available fuel supplies or that fuel suppliers will market fuels inappropriate for use with the vehicle population. This logic is faulty since if manufacturers expect to have to certify and comply in-use using representative fuels, they will have a strong, market-based incentive to coordinate with the fuel suppliers in advance. Such cooperation is common even with regard to today's fuel market. The American Society for Testing and Materials specifications for gasoline fuel volatility classes and fuel property test criteria are salient examples of this. It is very reasonable to assume that such cooperation will exist with regard to an emerging methanol fuel market.

New York's question regarding EPA's intended criteria for selection of representative fuels is a worthwhile one. EPA's goal in choosing certification fuels is to ensure that in-use emissions are below the level of the standards. Thus, the Agency would consider any fuel properties that it would expect to affect emissions. Unfortunately, without a developed market for methanol fuels, it is not possible to completely specify these properties at this time.

It is recognized that in the initial sales years of methanol vehicles, the fuel market may be more uncertain than after some degree of market equilibrium and vehicle and fuel standardization is reached. In this regard, those comments suggesting that EPA adopt the fuel for which a vehicle was designed as the test fuel are useful. In fact, the Agency could take advantage of the manufacturers' understanding of the emerging fuel market by requiring manufacturers to recommend test fuels and to provide justification for their selection as reasonably available future fuels. While final specifications should remain the responsibility of the Agency, this procedure could benefit all parties concerned through the increased flexibility it offers. In the longer run, when a fuel market has been established, the Agency will be able to specify fuels without this required input.

Conclusion:

Development by EPA of one or more precise methanol fuel specifications at this time would tend to focus development work only on the specified fuel(s) and could hamper development of optimum vehicle/fuel designs. Potential fuel-to-vehicle and vehicle-to-fuel compatibility problems are more appropriately resolved by cooperative efforts between the fuel suppliers and the vehicle manufacturers than by EPA interference. EPA should retain the broad methanol fuel specification which was proposed until vehicle/fuel optimization is completed and commercial methanol fuel specifications have been developed. At that time EPA should act to specify representative test fuels.

Until such a time, the Agency should require manufacturers to submit recommended test fuel specifications along with justification for their selection as reasonably available in-use fuels. These recommendations would be used by the Agency in determining test fuels.

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